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Laparoscopy in Diagnosis and Treatment of Small Bowel Diseases

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1. Introduction

Laparoscopy is defined as the technique of examining the abdominal cavity and its contents by creating a pneumoperitoneum. The first description of a laparoscopic approach goes back to 1901, by Kelling, who showed on a dog model that it was possible to look inside the abdomen by introducing a cystoscope after high-pressure insufflation (Kelling, 1901). The development of the technique over the next 50 years, passed through the creation of specific instruments that made easier accurate and complete examination of the peritoneal cavity, such as the Verres needle, first described to create pneumothorax for treating tuberculosis but successfully used in 1937 for the induction of the pneumoperitoneum (Veress, 1938) and the Hasson trocar (Hasson, 1974). In September 1985 Erich Muhe performed the first laparoscopic cholecystectomy in humans (Litynski, 1998). Muhe used a Veress needle to create a pneumoperitoneum, introduced a laparoscope through the umbilicus, and completed laparoscopic cholecystectomy in 2 hours. The technique was presented at the Annual Congress of the German Surgical Society held in Munich on April 1986, and rapidly became the gold standard in the treatment of symptomatic gallstones. Fast and worldwide success of laparoscopic cholecistectomy was based on the analysis of results in terms of hospitalization, bowel function resumption, wound-related complications and return to daily activities, which were much more satisfying as compared to those obtained with the open technique, thus causing rapid acceptance by surgeons and increasing demand by patients. The laparoscopic approach was widely applied in abdominal surgery, for the treatment of a great number of benign disease, from MRGE to hernia, and even to procedures in which dissection and extraction of solid organs was contemplated, as safe and easy techniques rapidly developed. This affected transplantation surgery in the way that people who accept to donate the kidney rapidly increased after the diffusion of the laparoscopic approach, because of the decreased morbidity of the operation. Although first met with skepticism, laparoscopy have been applied to malignancies, especially to colon cancer. Many multicenter prospective randomized trials comparing laparoscopic and open technique in colon cancer surgery, unequivocally demonstrated the same favorable short term results of laparoscopic colectomy shown when this approach was adopted for other benign diseases (less intra-operative bleeding, less post-operative pain, morbidity and

immunological stress, early bowel movement, shorter hospital stay, early return to daily activities and better cosmetic results). The laparoscopic technique demonstrated also effective considering some pathological parameters of oncological radicality, as number of lymph node removed and cancer-free margins. Non differences about long-term results, in terms of incidence of recurrence and overall survival, were shown between open and laparoscopic approach in any prospective randomized trial (Nelson et al., 2004), Another area where laparoscopy found a place in the last two decades is bariatric surgery. This, in part, is because of the results of the laparoscopic Roux-en-Y gastric bypass procedure, especially the minimally invasive surgical benefits and the resolution of obesity-related comorbidities (Robinson et al., 2004). The Lap-Band (BioEnterics Lap-Band System; Inamed Health, Santa Barbara, CA) also has become a popular minimally invasive tool with less morbidity than the gastric bypass. Despite the improvement in outcomes with laparoscopy, the technique has limitations. The video images are projected in a 2-dimensional plane. The stability, focus and tilt depends on camera operator, and the ability to follow the natural movement of the surgeon's eyes is limited. The use of trocars anchored to the abdominal wall limits the range of motion of the long straight instruments and often induces awkward ergonomics (Ballantyne, 2002). This conditions, combined with the counteracting vectors generated by the abdominal wall (which require force to overcome), can lead to surgeon fatigue or, worse, neurapraxia. Another problem of laparoscopic technique is represented by the learning curve that must be substantial, especially for more complex procedures (Berguer, 1998; Ehrmantraut & Sardi, 1997).

2. General considerations about diagnostic and therapeutic potential of laparoscopy in small bowel diseases

Small bowel diseases are rare and difficult to identify with traditional diagnostic tools. Diagnosis is often late, based on the appearance of occult rectal bleeding, occlusive syndrome or, more rarely, intestinal perforation. The exact identification and location of small bowel lesions were made easier in recent years by the development of more detailed diagnostic tools, such as double balloon enteroscopy and videocapsula (Gerson, 2009). The laparoscopic approach to the small bowel diseases may include resection or not. Well recognized examples of the first group are benign or malignant tumours; inflammatory bowel disease; Meckel's diverticulum; bleeding small bowel angiodysplasia; small bowel ischemia and stricture (postradiation, postischemic, etc). Non resectional laparoscopic small bowel procedures include laparoscopic enterolysis for acute small bowel obstruction, diagnostic laparoscopy for possible ischemic disease and laparoscopic palliative enteroenterostomy for bypassing obstructing nonresectable tumors. When dealing with small bowel pathologies, performing laparoscopy may be extremely challenging, as a consequence of the technical difficulties in the mobilization of the intestinal loops, especially if dilated as a consequence of an occlusion, or in identifying and localizing the lesions. Many difficulties were recently overcome with the help of technological development of instrumentation, such as the laparoscopic model of Ultracision®, Harmonic scalpel® or Ligasure®, so that nowadays laparoscopic diagnosis and treatment of small bowel diseases are to be considered feasible (Carrasco Rojas, 2004), although not easy to perform. In addition, endoscopic tattooing of the lesion, can make location of tumors easier.

3. Small bowel neoplasms

Small bowel neoplasms represent 0.3% of all tumors, fewer than 2% of all gastrointestinal malignances, with an age-adjusted incidence of 1 per 100,000 and a prevalence of 0.6%. Approximately, almost forty different histological types of both benign and malignant tumors have been identified (Neugut et al., 1998). Seventy five percent of tumors are benign at histologic diagnosis by biopsy and include leiomyomas, adenomas, lipomas and hamartomas. Malignant neoplasms, frequently symptomatic, include adenocarcinomas, carcinoids and lymphomas. Stromal tumors are considered as tumors with variable malignant power. Other type of small bowel malignant neoplasms are metastatic diseases by malignant melanoma, bronchogenic tumors, breast cancer and intrabdominal cancers. Surgery, is considered the first line therapy for most of the small bowel neoplasm, especially malignant and complicated benign tumors (Gill et al., 2001; Coco et al. 2010). Laparoscopic surgery represents a valid and feasible approach for the treatment of these neoplasms.

3.1 Benign neoplasms

Benign neoplasms are usually asymptomatic and only incidentally discovered, when complicated by obstruction or hemorrhage (more frequently occult). Despite the term "benign", exists a risk of malignant change for adenomas (malignant changes at presentation over 40%, expecially in large adenomas with villous component or atypia,) and leyomiomas (risk for malignancy related to the tumor size and number of mitosis); because of their potential to undergo malignant transformation, these neoplasms should be removed (Witteman et al., 1993). Lipoma, hemangioma, Bunner's gland hamartoma and intestinal nodular lymphoid hyperplasia have no risk of malignant evolution and indication for surgery is limited to symptomatic lesions (intussusceptions, obstruption, bleeding) (Morgan et al., 2000). These neoplasm are often multiple; a carefully inspection of the entire small bowel is recommended before the treatment. Surgical options are different: endoscopic treatment (endoscopic polypectomy or mucosectomy especially for benign neoplasms of duodenum or proximal jejunum), excision via enterotomy (especially for small lesions) and small bowel segmentary resection. In the last two cases the laparoscopic approach is advisable not only becasuse the resection is safe and effective but also becasuse the mandatory examination of the entire small bowel can be performed acording to a mini-invasive approach which consent to avoid laparotomy for treating benign diseases.

3.2 Malignant neoplasms

A recent epidemiologic study concerning small bowel malignant neoplasm, conducted in the United States on 67843 patients from 1973 to 2005 by Bilimoria et al (Bilimoria et al 2009), showed an overall increase, in the last thirty years, of small bowel cancer (22.7 cases per million in 2004). In particular, the proportion of patients with carcinoid tumors increased significantly (from 27.5% to 44.3%) whereas the proportion of patients with adenocarcinoma decreased (from 42.1% to 32.6%). However, incidence rates is low and similar for both men and women before the age of 40. In the last 30 years, there is a parallel increase between 40 and 55 yrs in both sexes and a more rapidly growth in men than in women. The sites at major risk for malignant neoplasm are duodenum, for adenocarcinoma, and ileum, for carcinoids and lymphomas (Lepage et al., 2006). Treatment modality and oncologic outcome differs considering the various histological types.

3.2.1 Small bowel carcinoid

Small bowel, especially terminal ileum, represents the most frequent location of neuroendocrine tumors (Fig. 1) in the gastrointestinal tract (among 30%). Peak incidence is between the 6th and 7th decades of life. Clinical manifestations are vague or absent, and tumors are often incidentally detected at the time of surgery for other gastrointestinal diseases or during exploration for liver metastases. In approximately 20% of cases these neoplasms secrete bioactive mediators and give rise to the characteristic "carcinoid syndrome" (intermittent abdominal cramps, diarrhea, flushing, bronchospasm and cyanosis) (Kulke & Meyer, 1999).

Nodal metastases after carcinoids are frequent (over 40% of cases) with no relations to tumor's dimensions, whereas liver metastases are usually associated to tumors > 2 cm in diameter (over 60% of cases). Resection of primary tumor with associated extensive mesenteric lymphadenectomy is appropriate, even in the presence of liver metastases. If diagnosis of intestinal carcinoid tumor is made after a limited resection of a small lesion, further surgery for extensive mesenteric lymphadenectomy is to be considered (Sutton et al., 2003). The indications for potentially curative liver resection are similar to those applicable to metastatic colorectal cancer. Disease unsuitable for partial hepatectomy unresponsive to alternative therapies, producing life-threatening complications and carcinoids with low proliferation index could be considered for liver transplantation (Yao et al., 2001). After radical resection of carcinoid tumors the 5yr-OS is good, with an OS rate of 70-80% in case of localized disease, 60-75% in case of nodal involvement and 30-50% in case of liver metastases. In patients with liver metastases who underwent to hepatectomy or liver transplantation 5y-OS is respectively 70-80% and 60-70% (Shebani et al., 1999).

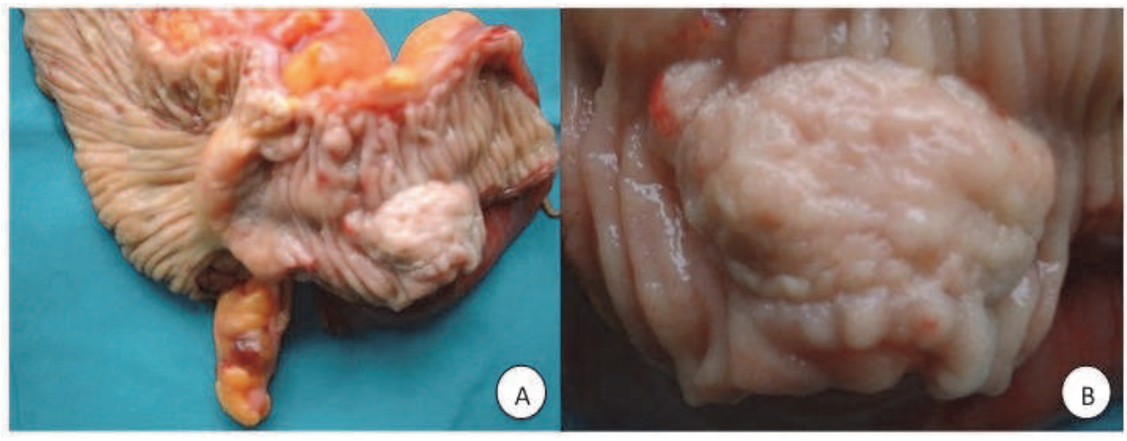

Fig. 1. A,B - Small bowel carcinoid

3.2.2 Small bowel adenocarcinoma

Adenocarcinoma (Fig. 2) represents the commonest histological type of small bowel tumors in the western world (30-50% of small bowel malignant tumors). Duodenum and jejunum are the most frequent location sites. Peak incidence is in the 7th decade of life and there is a male preponderance. Adenomas, either single or multiple as expression of multiple polyposis syndromes are to be considered lesions at risk of developing

malignancies. Small bowel adenocarcinomas, because of the presence of lymphatic tissue in small intestinal mucosa, early metastasize to regional lymph node. The most common symptoms at presentation are obstruction, bleeding, jaundice and weight loss. Surgical radical resection followed by adjuvant chemotherapy represent the therapy of choice (Neugut et al., 1997). For jejunal and ileal tumors, curative resection (R0) is to be intended as complete removal of the neoplastic mass with macro- and microscopically clear margin and regional lymphnode dissection. If infiltration of continuous organs is detected, en bloc resection is indicated as well as right colectomy should be considered in case of distal ileal lesion, to obtain a complete nodal dissection. For duodenal tumors located in the II or III duodenal portions, duodenopacreatectomy is indicated, while for IV portion lesions, pancreas-preserving segmental resection will be the treatment of choice; in both cases clear resection margins are mandatory to obtain satisfing long term results. For locally advanced unresectable or metastatic adenocarcinoma a palliative treatment should be considered to avoid complication as obstruction (by-pass or stent) or bleeding (limited resection of the bleeding mass). In case of single hepatic metastasis, the role of liver resection is unknown (Hutchins et al., 2001). Despite radical resection, the 5yr-OS rate is low. In a large landmark study conducted by the American College of Surgeons Commission on 5,000 small bowel adenocarcinomas, the overall 5-year disease-specific survival was 30.5%, with a median survival of 19.7 months (Howe et al., 1999). Survival was lower in patients with duodenal tumors and in those over 75 years old, also because many surgeons are reluctant to perform radical resection in these cases (North & Pack, 2000).

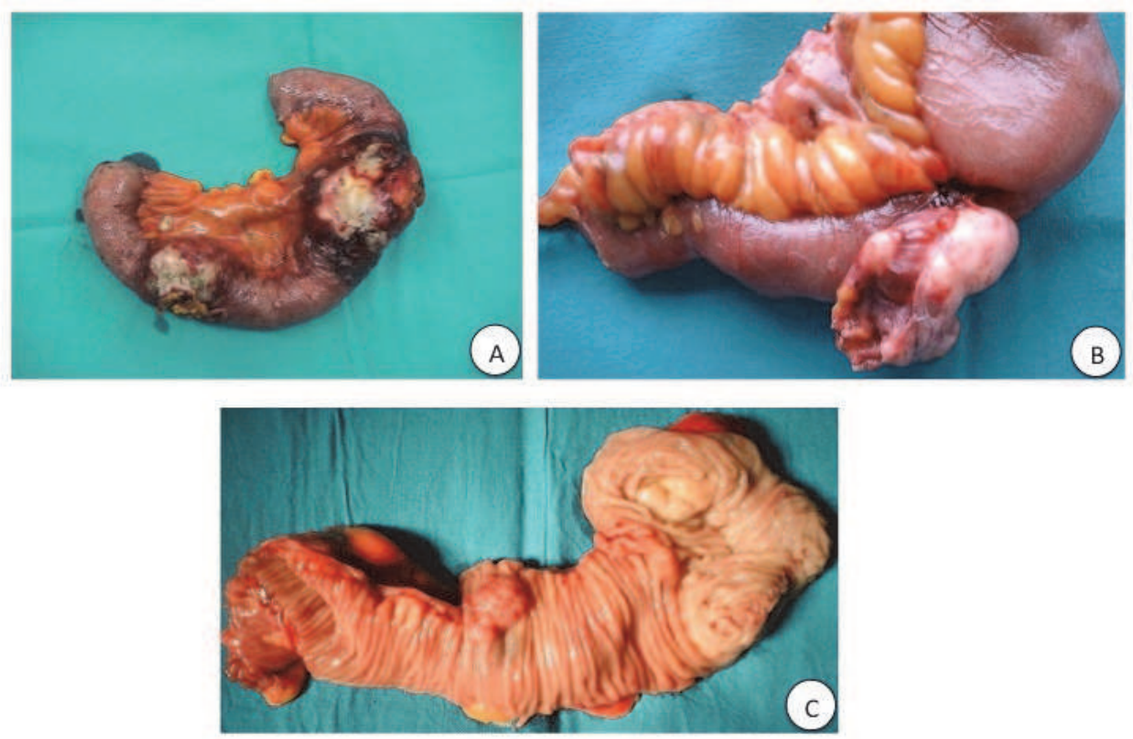

Fig. 2. A, B, C – Small bowel adenocarcinomas

3.2.3 Small bowel lymphoma

Small bowel lymphoma (Fig. 3) can be primary or secondary. Primary lymphoma accounts for 15% to 20% of all malignant small bowel tumors and ileum represents the most common location site. The usual clinical presentation of gastointestinal lymphoma includes intermittent abdominal pain, fatigue, diarrhea, weight loss, and, occasionally, fever; less commonly, gastrointestinal bleeding, obstruction, or even perforation (up to 25%). Chemoradiation is the therapy of choice for these neoplasms. In a clinical setting in which palpable adenopathy and hepatosplenomegaly are absent, with no evidence of disease on chest CT, diagnosis of primary intestinal lymphomas requires histologic confirmation. Only in this case, surgical exploration and resection of involved segments with regional lymph node dissection is requested to confirm diagnosis of lymphoma. Surgical treatment is required also in cases of complications as obstruction, bleeding and perforation. The overall prognosis of the more advanced stages of primary small intestinal lymphoma is poor, with an expected 5-year survival of 25% to 30% (Crump et al., 1999).

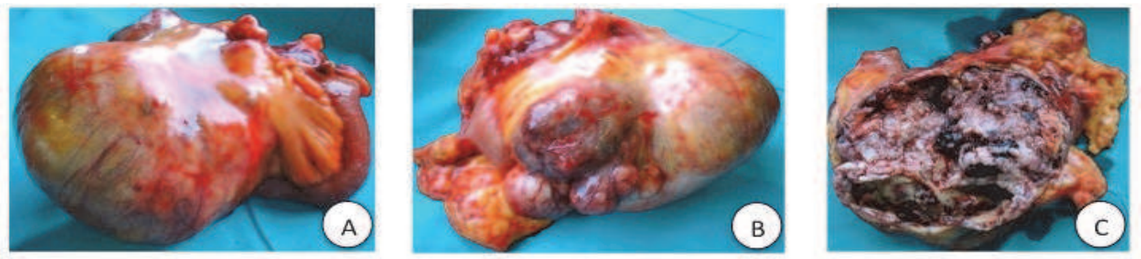

Fig. 3. A, B, C – Small bowel lymphomas

3.2.4 Small bowel stromal tumor

Stromal tumors account <1% of all gastrointestinal tumors. GISTs (Gastro Intestinal Stromal Tumors) represents the most common stromal tumors with malignant power of the gastrointestinal tract (over 90%) (Fig. 4). Many GISTs are discovered incidentally. When exist, symptoms of GISTs are obstruction, hemorrhage or, rarely, peritonitis. Malignant power of GIST depend by mitotic index and tumor size. Surgical complete gross resection with an intact pseudocapsule (non-disruptive techniques) and negative macroscopic margins (R0 or ”R1” resection) is the definitive treatment for primary GISTs without evidence of peritoneal seeding or metastasis. En bloc resection is requested in case of infiltration of continuous organs (Demetri et al., 2004). Because GISTs rarely metastasize to lymph nodes, routine lymph node dissection is not warranted except when there is evidence of gross nodal involvement (Blay et al, 2005). In advanced cases surgery alone is not curative. Resection of intraperitoneal metastases should be considered if they are prone to intralesional bleeding, which may result in severe blood loss, peritonitis, and interference with Imatinib therapy but most metastatic lesions from GIST, particularly those to the liver, are multifocal, diffuse, and technically difficult to resect (Everett & Gutman, 2008). The 5-year survival rate after the surgical resection of GIST was 43–95% in the pre-Imatinib era variable from 95% for low-risk GISTs to 0%-30% for high-risk GISTs. After the introduction of molecular targeted therapy with Imatinib and Sunitinib improvement in survival seems to be granted, but most prospective randomized studies are needed.

Fig. 4. A, B, C - Small bowel GISTs

3.2.5 Metastatic neoplasms

Secondary neoplastic involvement of the small intestine is more frequent than primary lesions. Primary tumors of colon, ovary, uterus, and stomach usually involve the small bowel, either by direct invasion or by intraperitoneal spread, whereas primaries of breast, lung, and melanoma, the malignancy which more frequently metastasize to the bowel, spread hematogenously. (Fig. 5). Surgical resection does not improve prognosis but is sometimes requested in case of complications.

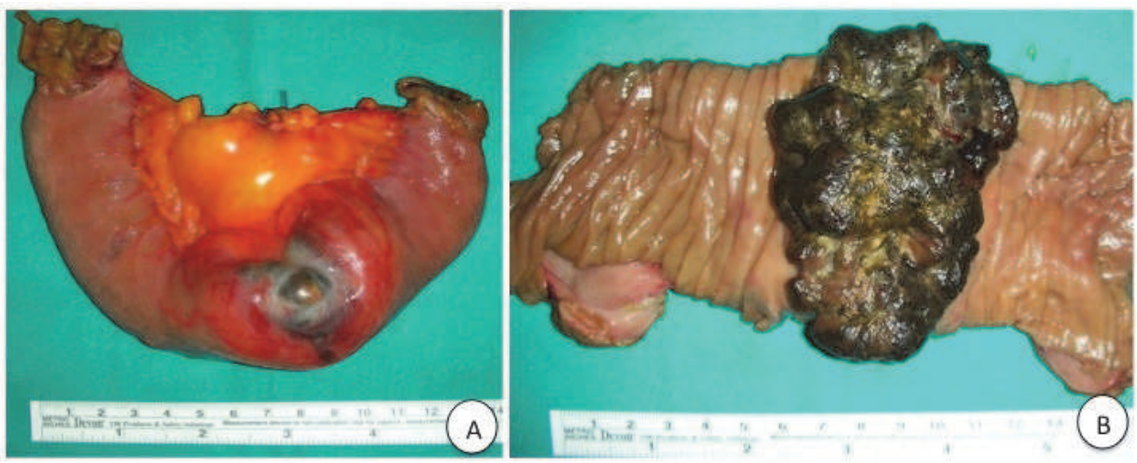

Fig. 5. A, B - Small bowel metastatic melanoma

3.2.6 Role of laparoscopic surgery

Among small bowel tumors, the mini-invasive approach is clearly accepted only for GISTs. The 2004 NCCN Task Force Report generally discouraged laparoscopic or laparoscopy-assisted resection for GIST, limiting its use for tumors smaller than 2 cm at low risk of intraoperative rupture (Demetri et al., 2004). However, two years later, Novitsky et al. (Novitsky et al., 2006) analyzing the results of their series of 50 laparoscopically operated GISTs of mean size of 4.4 cm (range, 1.0–8.5 cm), showed that efficacy and recurrence rate were similar or even better than what reported in historical open-surgery control series, and suggested a revision of the 2004 NCCN guidelines. So the 2007 update stated that laparoscopic resection was acceptable for tumors measuring up to 5 cm in diameter and that tumors larger than 5 cm might be resectable by hand-assisted laparoscopic techniques

(Demetri et al., 2004). Although there are no guidelines to state the feasibility of laparoscopic surgery for carcinoid, lymphoma, adenocarcinoma and other malignancies of the small intestine, we believe that this technique is feasible in these cases, especially with the help of the same useful devices used in laparoscopic colorectal cancer surgery (sterile drape ®, etc.).

4. Small bowel Crohn's disease

Crohn's disease (CD) is a common chronic inflammatory disease usually characterized by patchy, whole thickness, granulomatous lesions, that can affect any part of the gastrointestinal tract (Fig. 6). The incidence of CD is 5-10 per 100 000 per year with a prevalence of 50-100 per 100 000 (Carter et al., 2004). Clinical patterns include combined small and large intestinal pattern (26% to 48%), small intestine only pattern (11% to 48%) and colon only pattern (19% to 51%) (Munkholm & Binder, 2004). Involvement of terminal ileum and colon is the most common pattern (55%), while involvement of mouth, oesophagus, stomach and duodenum, is uncommon and rarely occurs without concurrent disease activity in the small bowel and/or colon (Thoreson & Cullen, 2007). Patients with small bowel CD commonly present with an acute symptomatic picture, characterized by abdominal cramps, diarrohea, malaise and loss of weight that is primarily managed using steroids, immunomodulators (Azathioprine, Mercaptopurine, Methotrexate) or biological therapy (anti-TNF agents) (Travis et al, 2006). Surgical treatment is required in approximately 70 percent of patients for failed medical therapy, recurrent intestinal obstruction, malnutrition and for septic complications (free perforation, abscess). Reoperations are required in 70 to 90 percent of all patients and multiple procedures in more than 30 percent (Duepree et al, 2002). Resection and anastomosis is indicated for short segment with multiple strictures or active disease, diseased bowel with fistula, abscess or phlegmon. Strictureplasty is a safe and effective alternative to bowel resection as multiple ones are often required for the same patient, with high risk of a short bowel syndrome.

Laparoscopy has gained wide acceptance in gastrointestinal surgery with potential advantages in early post-operative outcome and cosmesis (Duepree et al, 2002; Dunker et al, 1998; Milsom et al., 1993; Reissman et al, 1996; Albaz et al., 2000) and its use is accepted in benign and malignant colorectal diseases. The first laparoscopic intestinal resection for CD was reported by J. Milsom in 1993 (Milsom et al., 1993). Laparoscopic surgery offers additional advantage of smaller abdominal fascial wounds, low incidence of hernias, and decreased rate of adhesive small-bowel obstruction (Albaz et al., 2000) than conventional surgery. The main concerns about laparoscopic approach to small bowel CD are: missing occult segments of disease and critical proximal strictures due to absence of tactile sensitivity; earlier recurrence due to possible reduced immune response, technical difficulties due to fragile inflamed bowel and mesentery and the presence of adhesions, fistulas, and abscesses (Uchikoshi et al., 2004; Lowney et al., 2005). A Cochrane review about the role of laparoscopic surgery in CD was recently published (Bobby et al., 2011). Two randomized controlled trials (Maartense et al., 2006; Milsom et al., 2001) comparing laparoscopic and open surgery for small bowel CD were identified for a total of 120 patients. About post-operative morbidity less patients in the laparoscopic group (2/61; 3.27%) suffered wound infection compared to the open group (9/59; 15.25%) but the difference was not statistically significant (p=0.23). There was no significant difference in the incidence of other postoperative complications (postoperative pneumonia, prolonged postoperative ileus

and urinary infections). The incidence of anastomotic leak, intra abdominal abscess and 30-day reoperation rates were comparable. The operation time was shorter in open surgery and the amount of intra operative blood loss was lesser in the open group (133 +/- 70 ml/case) compared to laparoscopic group (173 +/- 123 ml/case) although the difference was not statistically significant [P=0.25].. There was no significant difference in postoperatve pain as defined by the amount of opioids requested by patients. Hospital stay was shorter in laparoscopic group compared to open group but the difference was not statistically significant [P=0.90]. Conversion rates were similar in both the trials [3 out of 30 in Maartense 2006 and 2 out of 33 in Milsom 2001]. There was no significant difference in the reoperation rates for disease recurrence. Laparoscopic surgery for abdominal conditions is known to have associated with lesser incidence of adhesions and incisional hernias. Better cosmesis and body image obtained with the laparoscopic approach are well establisehd and are particularly relevant dealing with Crohn's disease, because of the young age of patients. Quality of Life (QoL) was not evaluated in this Cochrane review (Bobby et al., 2001), although a randomized control trial (Eshuis et al., 2010) reported similar QoL in both groups.

In conclusion, despite there are no potential benefits of laparoscopic surgery over open surgery, this approach for small bowel CD is feasible and as safe as the pen one, but with better cosmetic results and short-term post-operative outcome.

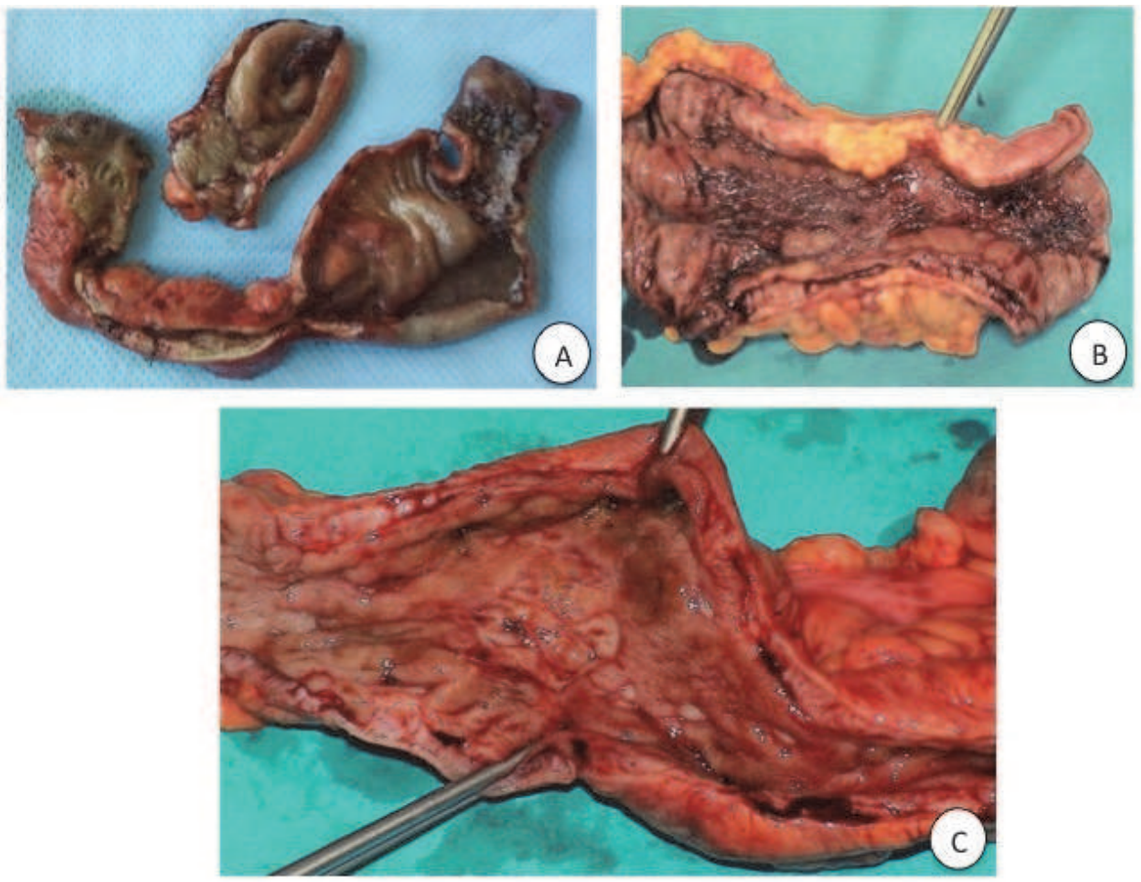

Fig. 6. A, B, C – Small bowel Crohn's Disease

5. Meckel's diverticulum

Meckel's diverticulum is the most common congenital malformation of the gastrointestinal tract (incidence of between 0.6% and 4%) due to persistence of the congenital vitello-intestinal duct. It is a true diverticulum, typically located on anti-mesenteric border, 60 cm from the ileo-caecal junction, and contains all three coats of intestinal wall with its separate blood supply from the vitelline artery. In the fetal life, the omphalo-mesenteric duct connects the yolk sac to the intestinal tract and usually it obliterates in the 5th to 7th week of life. If obliteration fails, the congenital anomalies develop, leading to residual fibrous cords, umbilical sinus, omphalo-mesenteric fistula, enterocyst and, most commonly, Meckel's diverticulum. The range of incidence of complications due to Meckel's diverticulum is 4%–16%. Its occurrence in males and females is equal, but incidence of complications is three to four times greater in males. The risk of complications decreases with increasing age, with no other predictive factors. Bleeding from Meckel's diverticulum due to ectopic gastric mucosa is the most common clinical presentation, especially in younger patients. The main mechanism of bleeding is the acid secretion from ectopic mucosa, leading to ulceration of adjacent ileal mucosa. It is possible that the recurrent intussusception may cause trauma, inflammation, mucosal erosion and bleeding. Others complications in adults include: obstruction, intussusceptions, ulceration and, rarely, vescico-diverticular fistulae and tumours (Heinicke et al., 1997; Wong et al., 2005; Tan et al., 2005; Puliglandla et al., 2001).

Due to the rarity of cases in adults, it is still misdiagnosed preoperatively. Preoperative diagnosis of symptomatic Meckel's diverticulum is difficult; so, it is imperative to differentiate Meckel's diverticulum from other surgical conditions. This is particularly true in patients presenting with symptoms other than bleeding. In a study by Higachi et al. about 776 patients affected by Meckel's diverticulum, a correct preoperative diagnosis was made in 88% of those presenting with bleeding but only in 11% of cases when other symptoms were reported (Higaki et al., 2001). In doubtful cases, laparoscopy is an excellent diagnostic tool (Shalaby et al., 2005). However, technetium-99m pertechnate scan is the most common and accurate non-invasive investigation performed for these cases. In children, it has a sensitivity of 80%–90%, a specificity of 95% and an accuracy of 90% (Kong et al., 1993) but in adults it is less reliable, with a sensitivity of 62.5%, a specificity of 9% and an accuracy of 46% (Lin et al., 2002). As the technetium-99m pertechnate scan is specific to ectopic gastric mucosa and not to Meckel's diverticulum, it may be positive in gut duplication cysts with ectopic gastric mucosa (Kumar et al., 2005). The false negative scans may be due to the rapid dilution of radioactive secondary to fast bleeding from the ectopic mucosa, impaired vascular supply or insufficient gastric mucosa. The false negatives are also more common in patients presenting with other symptoms than bleeding. Other diagnostic method suggested to supplement the Meckel's scan is angiography but it is usually negative unless the bleeding rate is 40.5 mL/min. The treatment of choice for symptomatic Meckel's diverticulum is surgical resection. It can be achieved either by diverticulectomy or by segmental bowel resection, especially when there is palpable ectopic tissue at the junction between diverticulum and intestinal wall, intestinal ischaemia or perforation. It has long been stated that the risk of developing complications following the incidental removal of Meckel's diverticulum can offset the potential benefits of this procedure (Leijonmarck et al., 1996) and the subject is still object of debate. Opponents to incidental diverticulectomy often cite Soltero and Bill (Soltero & Bill, 1976) who, in 1976, estimated that the life-time risk of complications from an untreated MD was 4.2%, decreasing this risk to zero with increasing

age, and so incidental diverticulectomy was not advisable. Twenty years later, the results of a large population-based study in Olmsted County, Minnesota, provided data in support of prophylactic diverticulectomy (Cullen et al., 1994). This study reported a 6.4% cumulative rate of developing complications from untreated MD that required surgery over a life-time, especially in male patients up to 80 years of age. Diverticulectomy for complicated MD carried an operative mortality and morbidity of 2% and 12%, and a cumulative risk of long term complications of 7%. The corresponding rates for incidental diverticulectomy are 1%, 2% and 2%, respectively (Cullen et al. 1994). A subsequent report from the Mayo Clinic recommended MD resection only in male patients younger than 50 years of age, when the diverticulum length is greater than 2 cm, or when abnormal features are detected within the diverticulum: carcinoid tumors was found in 2.2% of the symptomatic patients and in 2.1% of the asymptomatic ones in this series (Park et al., 2005). More recently, however, a systematic review of the English literature on this subject shown that there is no compelling evidence to support prophylactic resection (Zani et al., 2008). In fact, resection of incidentally detected MD has a significantly higher early complication rate than that potentially occurring leaving the diverticulum in situ (5.3% *vs* 1.3%, $P < 0.0001$) (Cullen et al., 1994). With the advent of gastrointestinal stapling devices, excision has become safer, faster, and more efficient. Another advantage of stapling is that it closes the bowel lumen as it cuts, thereby completely reducing the chance of peritoneal contamination. The contraindications for stapler excision is a very broad-based or too short diverticula, because in these cases, the risk of including too much of the ileum during stapling or leaving behind part of the diverticulum is high. Another way to perform the excision is to exteriorize the diverticulum throgh a mini-laparotomy, resect it by stapler and close the enterotomy. It is of crucial importance that the direction of the staple line lies perpendicular to the longitudinal axis of the ileum so that the bowel lumen will not be compromised while the stapler is positioned at the base of the diverticulum. The reticulating head of the stapler is invaluable in these situations because it can be maneuvered precisely at the base of the diverticulum.
Laparoscopy was succesfully used to diagnose and treat patients with MD complicated by small bowel obstruction or bleeding caused by occult heterotopic gastric mucosa (Sanders, 1995; Rivas et al., 2003). Successful resection of a Meckel's diverticulum can also be accomplished through laparoscopy, using endostapling devices. The advantages and benefits of minimal access surgery can be truly appreciated in children with symptomatic Meckel's diverticulum. A recent study demonstrate that laparoscopic stapler resection of asymptomatic diverticulum during surgery for unrelated disease has been shown to produce no added morbidity (Ruh et al., 2010).

6. Small bowel angiodysplasia and management of obscure-occult gastrointestinal bleeding

Angiodysplasia (Fig. 7) is a vascular malformation that can be located in all gastrointestinal tract. When symptomatic, it causes gastrointestinal bleeding, frequently obscure and occult, and anemia. Small bowel cases are often difficult to localize because traditional endoscopic tools (EGDS and colonoscopy) are not helpful. (Sass et al., 2004; Bodner et al., 2005; Martinez-Ares et al., 2004). Small intestine enteroscopy (double-balloon enteroscopy) is the most specific method for diagnosis but its application is limited because it is a time-consuming procedure, causes great discomfort to the patient, is often complicated by bleeding and perforation and has high false positive rate (Nguyen et al., 2005; Keuchel &

Hagenmuller, 2005; Warneke et al., 2004; Hartmann et al., 2005; Ell et al., 2002; Jones et al., 2005; Lewis & Swain, 2002). Capsule endoscope is a valid diagnostic tool but histological diagnosis through biopsy and cannot be achieved (Hartmann et al., 2005; Ell et al., 2002; Jones et al., 2005; Lewis & Swain, 2002). During the active stage of small intestinal bleeding, selective angiography can find the contrast medium flowing from the lesion into the intestinal tract, showing local shadow with a slightly high density, and concomitant embolic treatment can be performed (Yamaguchi et al., 2003). Scintigraphy with 99mTc-sestamibi marks the eritrocytes and is sensitive to mild intestinal bleeding, while it has no diagnostic value in the resting phase of bleeding or when it is less than 0.05 mL/min (Rerksuppaphol et al., 2004). So, diagnosis of massive obscure gastro-intestinal bleeding is usually made by laparotomy, which is invasive with a false positive rate of 5%. Laparoscopy can clearly, directly and conveniently observe the whole intestinal serosa and mesentery (Ell et al., 2002; Rerksuppaphol et al., 2004; Lee et al., 2000; Abbas et al., 2001; Loh & Munro, 2003; Kok et al., 1998) so that many authors agree that it is a very promising tool in the diagnosis and treatment of acute massive small intestinal bleeding and can be used as a routine method (Ell et al., 2002; Rerksuppaphol et al., 2004; Abbas et al., 2001; Kok et al., 1998).

Laparoscopic exploration of small intestinal hemangiomas or vascular deformity should be extremely careful. The intestinal wall should be carefully explored for local prominence, pitting, overlapping and abnormal mensentery. The suspected bleeding segment should be palpated carefully with clamps to feel its hardness, flexibility, and activity. In case of active massive bleeding, intestinal peristalsis is active and blood often accumulates in the distal segment which is dark blue under laparoscope. In cases in which the bleeding site is not individuated by laparoscopy, perioperative enteroscopy generally allow to reach the goal (Ell et al., 2002; Lee et al., 2000; Loh & Munro, 2003; Kok et al., 1998).

After the bleeding site was found by laparoscopy, laparoscopy-assisted bowel resection and enteroanastomosis were performed, by exploratory incision about 5 cm in length at the umbilicus level on the midline. The resected part of the small intestine should be 5 cm longer than the bleeding site that may result in a fast and reliable excision with light contaminations in the abdominal cavity. Enterectomy and enteroanastomosis can be performed, sometimes, with laparoscopic technique (Rerksuppaphol et al., 2004; Lee et al., 2000; Abbas et al., 2001; Loh & Munro, 2003; Kok et al., 1998).

In conclusion, laparoscopy in diagnosis and treatment of massive small intestinal bleeding is a minimally invasive procedure with potentially grants less pain, short recovery time and definite therapeutic efficacy than open approach. Randomized studies are necessary.

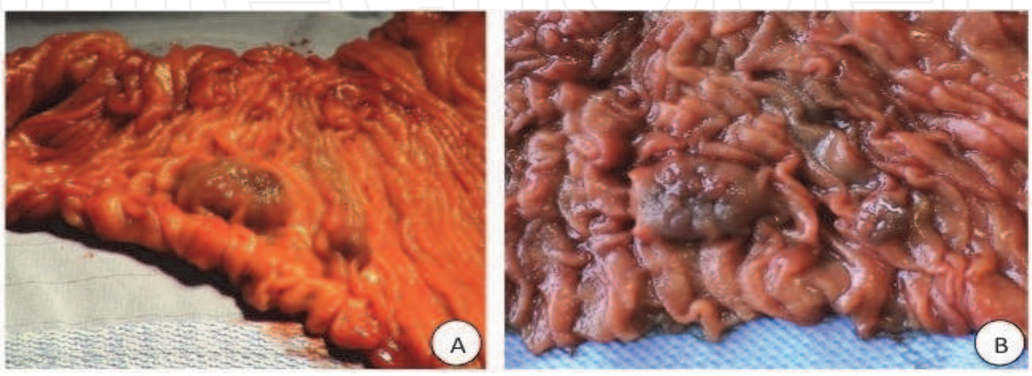

Fig. 7. A, B – Small bowel angiodysplasia

7. Other disease

Several other rare diseases which can cause obstruction (internal hernia, small bowel bezoar, intussusception, pseudo-obstruction) and bleeding (arteriovenous malformations, Delafoy's ulcer) are described in literature. In many of these cases laparoscopic surgery could represents a safe alternative to traditional open approach.

8. Adhesions and small bowel obstruction

Adhesions represent the most frequent cause of small bowel obstruction (SBO). Foster et al. in 2005, reported that in 1997, the 85% of the 32,583 unscheduled admissions for SBO in California were secondary to adhesions (Foster et al., 2006). In a recent Canadian study, of 552 patients admitted for SBO, 74% were secondary to adhesions (Miller et al., 2000). Treating adhesive SBO by surgery could seem a paradox because laparotomy is the most common cause of adhesive SBO. The cumulative recurrence rate of SBO after one open adhesiolysis for SBO is 7% at 1 year, 18% at 10 years, and 29% at 25 years. In patients who underwent a second open laparotomy for SBOs, recurrence rate is higher: 17% at 1 year, 32% at 10 years, and 40% at 20 years (Fevang et al., 2004). In the management of SBO conservative management is unanimously acccepted in the absence of signs of strangulation for a period varying from 12 hours to 5 days (Seror et al., 1993). CT scan is considered the ideal diagnostic tool to detect complicated SBO as it can show not only site, level and cause of obstruction but also sign of strangulation (Mak et al., 2006). About treatment of SBO two most large studies were performed. In the Canadian study by Foster et al (Foster et al., 2006) on 35,000 people admitted to the hospital for SBO, 75% were managed successfully conservatively with a 1-year mortality of 23% and 81% of surviving patients had no additional SBO readmissions over the subsequent 5 years. Small bowel obstruction was initially considered a condition not suitable for laparoscopy, as a consequence of the limited view of the abdominal cavity due to the dilated bowel, with high risk of accidental enterotomies. As surgeon's experience increased and better technological devices were produced, laparoscopic treatment of SBO became possible and it was rapidly evident that, in experienced hands, it could be a viable alternative to laparotomy as it allowed to decrease potential additional adhesions, together with the well known advantages of this approach. Selection criteria for laparoscopy (Duh, 1998) may be helpful: proximal obstruction, partial obstruction, anticipated single band, localized distension on radiography, no sepsis, and mild abdominal distension. A review published in 2007 show that laparoscopic management of SBO was successful in 66% of patients with a conversion rate of 33.5% (Ghosheh & Salameh, 2007) mostly due to dense adhesions (28%) followed by the need for bowel resection (23%) for injury, ischemia, gangrene, and other causes. The rate of success was significantly higher ($p<0.001$) in patients operated in the first 24 h and in patients with bands (54%), than in those with matted adhesions (31%). A recent review reported a morbidity rate of 15.5% and a mortality rate of 1.5% (Ghosheh & Salameh, 2007). Operative time longer than 120 minutes, intraoperative perforation, bowel necrosis, and conversion to laparotomy were significant predictors of post- operative morbidity (Strickland et al., 1999). Several animal studies (Riesman et al., 1996) supporting the hypothesis that laparoscopy leads to a decreased rate of adhesion formation as compared to laparotomy. This should be the main rationale to propose laparoscopy, rather than immediately recognizable benefits. It is not

really clear, however, if laparoscopic adhesiolysis for SBO would lead to a decrease in recurrence rate. Ghosheh and Salameh (Ghosheh & Salameh, 2007) reported an early recurrence of SBO in 22 (2.1%) of 1,061 patients. However, no conclusion can be drawn regarding the true rate of recurrence of SBO since adequate follow-up is lacking in most of the published studies.

9. Surgical techniques

9.1 General principles

Mechanical bowel preparation antibiotic prophilaxis before laparoscopic surgery of the small bowel are the standard practice. Nasogastric tube and urinary catheter are commonly used, especially the last one as it is extremely useful in obtaining more space in the surgical field and decreasing chances of accidental injury by keeping the bladder empty during the procedure. The operation is performed under general anesthesia. The patient is positioned supine with tucked arms opened legs. The surgeon should stand facing the lesion: between the legs (our preferred position), on patient's right side, for lesions involving the proximal small bowel, or on the left side, for lesions involving the terminal ileum. The camera operator stands on surgeon's right side, if he is positioned between the legs of the patient or on the same side, if the surgeon is positioned laterally to the patient. The assistant stands on the opposite side of the operator. The surgeon should stand in line with the view of the laparoscope, with comfortable handling of ports and instruments with each hand. The monitor should be in front of the surgeon and facing the line of view of the telescope. The first trocar, used to introduce the laparoscope, should be placed in the umbilical region. Despite continuous evolution of both laparoscopic instruments and techniques, injuries to the intraabdominal structures are still a common complication of laparoscopy. Many of these injuries are related to the blind placement of the Veress needle or sharp first trocar into the abdomen,when performing the technique referred to as "closed" laparoscopy. Open laparoscopy, where the peritoneal cavity is opened before placing a blunt trocar into the abdomen, was then proposed and widely adopted, with remarkable success in avoiding major vessel injuries but not bowel ones. In response "optical-access" trocars were developed. These trocars were designed to decrease the risk of injury to intrabdominal structures by allowing the surgeon to visualize abdominal wall layers during placement. Two "optical-access" trocar systems are available: the first one uses a blade that strikes the fascia and peritoneum under laparoscopic visualization (Visiport, United States Surgical, Norwalk, CT), and the other one has a conical clear tip that is rotated under laparoscopic vision as it penetrates the fascia and peritoneum (Optiview, Ethicon Endo-Surgery, Cincinnati, OH). An angled (30- or 45-degree) camera gives the best view of the small bowel mesentery and is much preferred over a 0-degree scope. Additional trocars (5 mm or 10-12 mm, depending on instruments that will be used) are placed in the left and in the right abdomen, just below the level of the umbilicus. Other essential equipment includes atraumatic graspers for safely handling the bowel, laparoscopic scissors with attachment to monopolar cautery and laparoscopic intestinal staplers, both linear dividing (gastrointestinal anastomosis [GIA]-type) and linear closing (TA-type). Mesenteric section may be accomplished by using a combination of vascular endoscopic staplers, clips, or Ultracision Harmonic Scalpel® or Ligasure® which allow a proper dissection with minimal blood loss.

Fig. 8. Technical aspects of small bowel laparoscopic resection

Because of the potential for multifocal or unsuspected lesions, a careful exploration of the abdomen and all small bowel (from Treitz to ileo-cecal valve) is performed as the first step of the procedure, to exactly define the site and the extent of disease. Putting the patient on Trendelenburg position, the surgeon locates and grasps the transverse colon and maintains upward traction; then he changes the patient's position to reverse Trendelenburg, to slip down the small intestine away from the transverse colon, allowing identification of the Treitz ligament. The surgeon runs the small intestine between a pair of atraumatic clamps and identifies the segment that has to be resected. The location of the lesion will be more simple if previous spotting (during enteroscopy) has been performed. Adhesiolysis is often necessary. After identification and mobility evaluation of the small bowel tract involved by disease, a 4 cm midline peri-umbilical incision is performed, pneumoperitoneum is evacuated and the small bowel loop affected by disease, is pulled out from the abdominal cavity together with its mesentery (Fig. 8). Using a wound protection is mandatory if neoplasm is suspected. A V-shaped incision is performed on mesentery related to the small bowel loop affected by disease, using standard technique, and ligation of vascular pedicle is performed. Wide mesenteric excision is appropriate only when treating malignant lesions. The bowel is divided extracorporeally, by using an intestinal stapler. A mechanical or hand-sewn side-to-side or end-to-end anastomosis is usually performed extracorporeally. After performing the anastomosis, the mesenteric defect is closed (if possible) and the bowel is reintroduced into the abdominal cavity. After closure of the small incision and the reestablishment of the pneumoperitoneum, the surgeon must confirm hemostasis, and control the anastomosis. A para-anastomotic drainage is positioned using a trocar incision (Fig. 8). Mesenteric vessels ligation, bowel resection and anastomosis could also be performed intracorporeally.

9.2 Surgical techniques for small bowel resection for Crohn's disease

Under general anesthesia, the patient is placed in a supine position with both arms tucked at his or her sides. Three 5/10/12 mm trocars respectively, a 30° angled laparoscope and an intra-abdominal insufflation of 12 mmHg are used. The pneumoperitoneurn is established following open Hasson trocar placement through an infraumbilical incision. Under laparoscopic vision, the other two trocars are placed in the patient's left flank, lateral to the rectus sheath. After a careful exploration of the abdomen to assess the site and extent of disease, the right colon, terminal ileum, and the inflammatory mass are fully mobilized, mainly with blunt dissection from the lateral to medial direction. The hepatic flexure is mobilized in most cases. No attempt should be made to transect the thick mesentery at this time. The right colon and the terminal ileum are extracted through a small (5—7 cm) right lower quadrant incision, using Pfannestiel or a midline incision. The terminal ileum and the cecum are transected with a linear stapler. An hand sewn side-to-side anastomosis is performed extracorporeally. In very simple cases, the ileocolic vascular pedicle is transected first with a 30-mm vascular stapler; transection and formation of the ileo-colic anastomosis are then performed intracorporeally. Mobilization of ascending colon is required if neoplasm is located in terminal ileum.

9.3 Surgical techniques for the treatment of adhesions

The patient should be secured with a bean bag, and a modified lithotomy position should be considered for posssible intraoperative endoscopy. Two monitors are ideal for this surgery. The site of first trocar placement should be carefully planned away from existing scars. The 30° scope provides excellent visualization. The pneumoperitoneum should never exceed 15 mmHg. The bowel should be examined for perforation and signs of ischemia. Free fluid should be aspirated and sent for gram staining, amylase, bilirubin, and culture. To facilitate exposure, table tilt, and external manual compression of the abdominal wall can be used. Second and third ports can be added to avoid excessive tenting of the abdominal wall. One of the most dreaded complications in laparoscopic management of small bowel obstruction is enterotomy. In a single comparative study (Wullstein & Gross, 2003), the risk of perforation was 27% in the laparoscopic group which was clearly higher than in the open group. The real concern, however, is that the bowel injury may be missed at the time of operation, with potential devastating consequences. The risk of bowel injury can be diminished by following good surgical technique. Bowel graspers with non-locking handles should be used gently to run the bowel. Exposure can be achieved by pushing with closed instruments rather than by grasping. The small bowel should be inspected in a retrograde fashion beginning from the caecum and decompressed bowel until the point of transition is identified. Energy-based devices should be avoided to divide adhesions. There should be a low threshold for conversion and it is not to be considered as a sign of failure but just a good clinical judgement. Conversion is not correlated to the number of previous surgeries (Navez et al., 1998). However, it may be predicted by bowel distension over 4 cm, a documented history of dense adhesions, and the presence of complete distal obstruction (Navez et al., 1998).

10. Conclusions

Small bowel diseases are rare and difficult to identify because diagnosis is late and often made on the base of the evidence of their complications. Small bowel laparoscopic surgery is extremely challenging, due to technical difficulties during mobilization of the intestinal

loops, especially if dilated as a consequence of an occlusion. Nevertheless, after an adequate learning curve and with the help of small bowel endoscopic diagnostic tools, laparoscopic surgery of the small bowel can be considered as a feasible, safe and extremely accurate diagnostic and therapeutic choice for several small bowel diseases.

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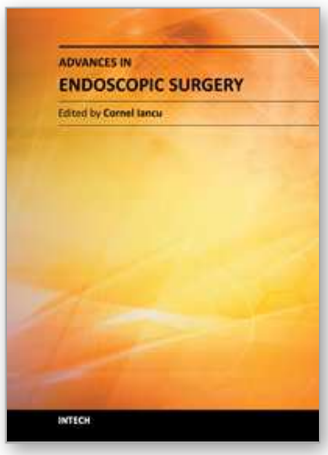

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Surgeons from various domains have become fascinated by endoscopy with its very low complications rates, high diagnostic yields and the possibility to perform a large variety of therapeutic procedures. Therefore during the last 30 years, the number and diversity of surgical endoscopic procedures has advanced with many new methods for both diagnoses and treatment, and these achievements are presented in this book. Contributing to the development of endoscopic surgery from all over the world, this is a modern, educational, and engrossing publication precisely presenting the most recent development in the field. New technologies are described in detail and all aspects of both standard and advanced endoscopic maneuvers applied in gastroenterology, urogynecology, otorhinolaryngology, pediatrics and neurology are presented. The intended audience for this book includes surgeons from various specialities, radiologists, internists, and subspecialists.

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