Analysis of indication for laparoscopic right colectomy and conversion risks

Ann. Ital. Chir., 2016 87: 544-552
pii: S0003469X16026026

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Laparoscopic surgery developed continuously over the past years becoming the gold standard for some surgical interventions. Laparoscopic colorectal surgery is well established as a safe and feasible procedure to treat benign and malignant pathologies. In this paper we studied in deep the role of laparoscopic right colectomy analysing the indications to this surgical procedure and the factors related to the conversion from laparoscopy to open surgery. We described the different surgical techniques of laparoscopic right colectomy comparing extra to intracorporeal anastomosis and we pointed out the different ways to access to the abdomen (multiport VS single incision). The indications for laparoscopic right colectomy are benign (inflammatory bowel disease and rare right colonic diverticulitis) and malignant diseases (right colon cancer and appendiceal neuroendocrine neoplasm): we described the good outcomes of laparoscopic right colectomy in all these illnesses. Laparoscopic conversion rates in right colectomy are reported as 12-16%; we described the different type of risk factors related to open conversion: patient-related, disease-related and surgeon-related factors, procedural factors and intraoperative complications. We conclude that laparoscopic right colectomy is considered superior to open surgery in the short-term outcomes without difference in long-term outcomes.

KEY WORDS: Conversion risks, Indication to treatment, Laparoscopy, Post-operative pain, Right colectomy

Introduction

Laparoscopic surgery developed continuously over the past years because of its evident advantages such as minimal trauma of the abdominal wall, faster recovery, reduced pain, reduced hospital stay, better cosmesis and quicker return to normal activities. Laparoscopic right hemicolectomy is a relatively routine surgical procedure characterized by well-defined indications (colon cancer, inflammatory bowel disease, appendiceal neuroendocrine neoplasm and right colon diverticulitis) and by different surgical techniques (intra VS extracorporeal anastomosis and single VS multiport incision). Even if the laparoscopic approach in a lot of right colon diseases is considered superior to open surgery in the short-term outcomes, it is sometimes not applicable because some factors could obstruct its feasibility and safety.

Laparoscopy

Laparoscopic surgery exists since the development of diagnostic laparoscopy in 1960s [1]. The pioneers of laparoscopic surgery, Semm K and Muehe E, changed it from a diagnostic to a surgical procedure at the beginning of the 1980s [2] and it became a frequently applied

Pervenuto in redazione Giugno 2016. Accettato per la pubblicazione Settembre 2016
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technique for a wild field of indications. Laparoscopic surgery developed continuously over the past years: ongoing training experience, development in imaging and laparoscopic instruments facilitated extension of the applications of laparoscopic surgery that became safe and feasible across different medical fields [1]. Minimal trauma of the abdominal wall, faster recovery, reduced pain, reduced hospital stay, better cosmesis and quicker return to normal activities are the most evident advantages of the laparoscopic surgery [1]. Some laparoscopic applications, e.g. cholecystectomy, reflux surgery, surgery of adrenal glands and appendicectomy, became the gold standard for surgical intervention because of the better outcome, efficiency, decreased incidence of wound infections and reduced perioperative morbidity [1,3-9]. The laparoscopic surgery in gastric and oesophageal cancer is applied with increasing frequency nowadays [1] and, even if a number of noticeable Asiatic studies (where gastric cancer occurs more often and the proportion of early gastric cancer is high) reported satisfactory results [10,11], many studies had a small number of patients and no randomized controlled trials are now available to verify the data +. Laparoscopic resection of the liver is performed mainly in the treatment of colorectal cancer metastasis or in primary hepatocellular carcinoma [1] and particularly when diseases are in segments II – IV that are better suited for laparoscopic approach. Left lateral resection is described as safe and feasible and some Authors claimed that it should be used as a standard technique for left resection [1]. Although laparoscopic liver resection is described as reliable and alternative to open surgery, with favourable outcomes, there is a need for future randomized controlled trials because the studies in literature didn't provide enough support [14,15]. Laparoscopic surgery of the pancreas is a challenging procedure for experienced surgeons and it isn't a standardized procedure: most of the studies had a small sample size, patients were highly selected and there is a lack of randomized controlled trials [16,17].

Laparoscopic colorectal surgery is well established as a safe procedure and must be differentiated between the surgical treatment of the benign (ulcerative colitis, Crohn's disease, diverticular disease) and malignant disease (colon adenocarcinoma) [1]; in literature a lot of studies described an ongoing learning curve and an improvement in the management of post-operative care such as developing of fast-track concepts and pathways in "enhanced recovery after surgery" (ERAS) [1]. This combination of the laparoscopic surgical procedure with minimally invasive access and the standardized postoperative treatment concepts led to satisfying outcome for patients undergoing colorectal surgery [1,18,19]. In regard to the perioperative morbidity and convalescence, there is evidence that laparoscopic surgery is favoured over open surgery for the treatment of inflammatory bowel disease [20,21]. For colon and rectal cancer, the laparoscopic approach is regarded safe and feasible without compromising the oncological outcome [1] and it is considered superior to open surgery in the short-term outcome [1,22,23]. In patients with rectal cancer minimally invasive total mesorectal excision can be performed safely and efficiently after neoadjuvant radiochemotherapy, with a rate similar to open surgery for postoperative complications and sexual function and a comparable rate of positive circumference resection margin [24,25].

Laparoscopic right colectomy: surgical tecnicques

Over the last decades, different minimally invasive surgery techniques emerged and the combination of new technologies with the improvement of skills and knowledge of surgeons encouraged many groups to converge techniques and technology to develop new strategy.

Intracorporeal Vs. Extracorporeal Anastomosis

Right hemicolectomy is a relatively routine surgical procedure characterized by well-defined indications and specific procedural steps. In 1991, Jacobs performed the first laparoscopic right hemicolectomy [26]. After right colectomy the ileocolic anastomosis cannot be performed "in a natural way" as in left hemicolectomy or anterior resection of the rectum; for this reason, different kind of laparoscopic right colectomies were proposed [27]:

– "Video-assisted" or laparoscopically assisted right hemicolectomy with only the vascular ligation done intracorporeally and with ileocolic anastomosis extracorporeally fashioned. This technique was introduced by Estour in 1993 and successively standardized by Semagore, Nelson and Estour [27].

– True or totally laparoscopic right colectomy with both dissection and anastomosis done intracorporeally. This technique was introduced by Azagra in 1994 and successively standardized by Lechaux, Bergamaschi and Ghavami [27].

– "Laparoscopically facilitated right colectomy" or right hemicolectomy with only the colonic dissection performed laparoscopically in which vascular ligations and the anastomosis were performed extracorporeally through a mini-laparotomy [27].

Regarding the ileocolic anastomosis, it could be performed using different techniques and devices depending on the intracorporeal and/or extracorporeal approach and sometimes even using a combination of different ways. The two main anastomotic techniques are: mechanic or manually iso/antiperistaltic latero-lateral ileocolic anastomosis or end-to-end ileocolic anastomosis [27].

Because of its technical difficulty and because its advantages are also matter of controversy, totally laparoscopic right colectomy with intracorporeal anastomosis is performed only by a small number of surgeons [16,28-30]. A lot of studies compared extracorporeal and intracorpore-

al ileocolic anastomosis using the following outcomes: anastomotic leak, operating time, return to bowel function, length of hospital stay, time to start normal diet, overall 30-days post-operative mortality, conversion rate to open, estimated intraoperative blood loss, cosmetic results (length of the larger incision, site of minilaparotomy), post-operative pain and its control, operative oncologic outcomes (number of dissected lymph nodes, length of the specimen), long term oncological outcomes (local and distant recurrence) [27-33]. In a retrospective study including 105 patients, Grams et al 31 found that resection and creation of the anastomosis intracorporeally produced superior results with earlier return to bowel function, decreased postoperative narcotic use, decreased length of stay and morbidity in comparison to the extracorporeal technique. *Scatizzi* et al [32] reported that advantages of intracorporeal anastomosis were improved cosmesis and higher rates of early regular diet tolerance. A recent meta-analysis of observational studies conducted by *Carnuccio et al* [28] included six case-control studies with 484 patients undergoing right laparoscopic colectomy, 272 with intracorporeal anastomosis and 212 with extracorporeal anastomosis: the best outcomes were associated with intracorporeal anastomosis especially in terms of return of bowel function, length of hospital stay and cosmetic results. However, this meta-analysis didn't show a real and significant difference between the two techniques for anastomotic leakage and overall short-term morbidity; only the study conducted by *Fabozzi et al* found a significant difference in the leak rate and it was in favour of intracorporeal anastomosis [28]. These Authors concluded that the meta-analysis didn't allow to draw definitive conclusions. *Cirocchi et al* [27] conducted a systematic review and meta-analysis considering seven studies publishing between 2004 and 2012 with a total of 945 patients who underwent laparoscopic right colectomy for malignant and benign disease. This work was unable to solve the controversies between intra and extracorporeal anastomosis after laparoscopic right colectomy: anastomotic leak rate resulted similar in intracorporeal and extracorporeal anastomosis groups in line with the incidence reported in literature; the mortality rate was lower in the intracorporeal anastomosis group but without statistical significance difference; post-operative recovery was enhanced in intracorporeal anastomosis group; intraoperative complications were the same; post-operative pain and analgesia requirements were lesser in intracorporeal anastomosis groups but without statistically significance. This meta-analysis confirmed the better cosmetic results in totally laparoscopic right colectomy: the smaller dimension of the incision, its sovrapubic position and the absence of muscular sections reduced post-operative pain and the risk of incisional hernias. The supposed advantages of the no-touch technique of the intracorporeal anastomosis was not demonstrated because in literature no studies evaluated exactly a long-term follow-up. Clinical controlled trials are needed to determine the long term outcomes of these different surgical anastomosis after laparoscopic right colectomy.

Multiport VS single incision laparoscopic right colectomy

From the first laparoscopic right colectomy [26], new techniques emerged to improve this procedure thanks to a rapid development of minimally invasive abdominal surgery. In literature some Authors reported laparoscopic right colectomy performed with five trocars and two assistants [34] and with four trocars [35] or three ports with only one assistant/camera operator [36,37]; these data confirm that laparoscopic right resection is a relatively accessible technique. In literature no study confirms how many trocars are better to use: the procedures with three, four or five ports resulted all safe and feasible to perform laparoscopic right colectomy. Single incision laparoscopic surgery (SILS) is a relatively new and in evolution technique in which only one port is used, usually in the umbilicus. The development of this approach is primarily intended to achieve these main objectives: to minimise the potential risks of trocar-related complications, to improve the cosmetic results and to reduce the inflammatory response to surgical trauma [29,36,38].
SILS was first reported in 1992 by *Pelosi et al* [29]: they performed an appendicectomy with an only transumbilical approach; some years later *Navarra et al* [29] performed the first transumbilical cholecystectomy. The first colonic resections *via* SILS were performed ten years later and this approach resulted particularly feasible in right colectomy. The first studies that compared SILS to conventional laparoscopy in terms of early complications, wound complications, lymph node retrieval and mortality showed that the two procedures were similar but these papers had a lot of bias related to very selected populations and to very expertise surgeons [29,39,40]. In 2012, two randomized studies were published comparing SILS with conventional laparoscopy: one concluded that SILS for colon cancer was feasible and safe as conventional laparoscopy without differences in terms of postoperative morbidity, first time oral intake and length of hospital stay [36]; by contrast *Poon et al* showed that SILS was associated with lesser pain and shorter hospital stay [41]. One special issue of SILS is cost: it is more expensive than conventional laparoscopy because new instruments and the development of new trocars are needed [42].

Indications to treat

The indication for laparoscopic right colectomy are similar to those for open colectomy.

Colon cancer

Laparoscopic right colectomy is well established as a safe procedure and must be differentiated between the surgical treatment of the benign and malignant disease.
For right colon cancer, the laparoscopic approach is regarded as safe and feasible procedure without compromising the oncological outcome [1,22,43,44]; expert opinion in the literature showed a growing acceptance of laparoscopic surgery for treatment of right colon cancer, which is further supported by the large randomized clinical trials [1,22,43,45]. The short-term outcome benefits are lower blood loss, earlier recovery of bowel movement, earlier resumption of oral intake, reduced hospital stay and lower overall morbidity, with comparable post-operative complications [1,22,43]. Short-term oncological outcomes (including lymph node harvest and the length of specimen) and long-term oncological outcomes (including occurrence of port site metastasis/wound recurrence, cancer-related mortality, tumor recurrence and overall mortality) are similar to open surgery; thus, laparoscopic right colectomy is considered in literature superior to open surgery in the short-term outcomes of right colon cancer [22,43,46,47].
Large randomized controlled trials demonstrated that laparoscopic surgery for right and left colon cancer (excluding transverse colon cancer) was not inferior to open surgery in the long-term oncological outcomes; there was no significant difference in overall mortality, total recurrence rate, 5-year disease-free survival and overall survival [1,48,49].
Laparoscopic right colectomy is also the treatment of choice also for adenomatous polyps not amenable to colonoscopic resection because of their size and/or site [1].

Inflammatory bowel disease

Despite the general benefits for patients undergoing laparoscopic surgery, the application of laparoscopy to patients with inflammatory bowel disease (IBD) was for long time slowly adopted. This is probably due to technical difficulty in IBD, i.e., the frequent presence of chronically thickened/inflamed mesentery, friable tissues, abscesses, phlegmonous inflammatory masses, strictures, enteric fistula and chronically dilated loops of bowel [50]. Patient with IBD often have complex reoperative anatomy (multiple anastomoses, stomas, adhesion from previous operations) and have sequelae of their chromic illness such as anaemia, malnutrition and immunosuppression [50].
A full of 70% to 83% of patients with Crohn's disease will require surgery at 10 years from diagnosis with the most commonly affected site as ileocecal valve and in addition to the primary surgery, postoperative symptomatic relapse rate is as high as 44% at 10 years after resection and between 25% and 45% of those who have previously a resection will require surgical intervention [50,51].
Early reports of the introduction of laparoscopy in the treatment of patients with Crohn's disease demonstrated the feasibility of the laparoscopic approach for the formation of the stomas and for ileocecal/right colon resection [29]. Despite the difficulties related to the surgery of Crohn's disease, several case-control studies and randomized trials demonstrated that the laparoscopic approach was effective as open surgery with many short-term benefits and with reduced total hospital costs [50,52].
For patients with uncomplicated Crohn's disease, several studies reported the results of the comparison between laparoscopic and open approach: although laparoscopy was associated with longer operative times, post-operative was shorter and faster return to work was demonstrated in the laparoscopic group [53,54].
Two meta-analyses reported lower postoperative morbidity, a faster return to bowel function and a shorter postoperative stay after laparoscopic surgery as compared to open approach [55,56].
In patients with complicated Crohn's disease (presence of fistulas, abscesses, previous operations, multiple or long segment disease) and in patients with recurrent ileocolic Crohn's disease no differences were noted in overall postoperative morbidity and operative times were longer, conversion rates to open surgery were higher and the use of a temporary stoma was increased [57].
Considering the shorter hospital stay, lower postoperative morbidity and shorter duration of postoperative ileus and reduced hospital costs, the laparoscopic ileocecal/right colon resection for ileocolic Crohn's disease is firmly established as being a safe, effective and practical approach and these patients should not undergo open surgery unless deemed to have an absolute contraindication to laparoscopy [50].

Right colonic diverticulitis

Although right colonic diverticulitis is a rare disease in Western countries with a frequency of 1,5%, it is very common in Asia where the frequency is reported to be 55-70% and an incidence per 2,9-17 cases of appendicitis; it is more frequent in males [58]. Surgical treatment is often necessary to solve the diverticulitis of right colon and even if a diverticulectomy is the recommended approach for cases with single diverticulum, it is only sometimes applicable [58,59]. Right hemicolectomy is the treatment of choice in patients with complicated diverticulitis and in patients with multiple diverticula interesting all right colon: laparoscopic approach is safe and feasible in these cases [50].

Appendiceal neuroendocrine neoplasm

Neuroendocrine neoplasms (NEN), previously named "carcinoid" tumors, most frequently occur in the

gastrointestinal tract with an estimated incidence in the range of 2-5 cases/100000/year [60]. The appendix is the third more frequent site of gastro-intestinal neuroendocrine neoplasms (16,7%) after the small bowel (44,7%) and the rectum (19,6%); in the appendix approximately 60-80% of this tumor is located at the tip of the appendix, 5-21% in the body and 7-10% at the base [60,61]. Considering that NEN of the appendix are usually very small lesions, their diagnosis generally coincides with their resection. The appendicectomy for appendiceal NEN seems to have a slightly higher rate of inadequate resection because of high percentage of local recurrence in tumor of the base and right colectomy is generally performed after the histological diagnosis [60]: laparoscopic approach is safe and feasible in these cases and it is the treatment of choice unless absolute contraindications to laparoscopy [60]. Laparoscopic right colectomy should be performed in all stages IIa, IIb appendix NENs, in all incomplete resections and in tumor located at the base of the appendix [60,62,63].

Conversion Risks

Conversion in commonly defined as stopping the laparoscopic procedure prematurely and continuing the procedure *via* a laparotomy, usually when the operating surgeon decides that the laparoscopic approach cannot be continued without risks [64]. Laparoscopic conversion rates in right colectomy are reported as 12 – 16 % [64,65].

Several factors are believed to influence the need to convert a laparoscopic to open colorectal operation: patient-related factors (e.g. gender, ethnicity, high BMI, previous abdominal surgery), disease-related factors (malignancy, Crohn's disease, diverticulitis), surgeon-related factors (e.g. learning curve, experience, technical ability), procedural factors (e.g. site of resection, anatomy) and intra-operative complications such as poor visualization, equipment malfunction and bleeding [65]. Generally, surgeon-related and procedural-related reasons for conversion can be controlled by adequate training and experience; patient-related factors remain largely outside the control of the surgeons [65,66].

Certain patient characteristics define a higher risk for conversion in laparoscopic right colectomy. A recent study [65] showed that Native American race and male gender were independent risk factors for laparoscopic conversion to open surgery: male patients often have android body habitus and increased intra-abdominal obesity that can contribute to the technical difficulty of the procedure. Obesity is an independent risk factor for conversion: conversion rate is significantly higher for obese patients with BMI exceeding 30 kg/m^2 compared with non-obese patients [65,67,68]. *Tan et al.* found that the most common reason for the conversion of laparoscopic right colectomy was adhesions [68]. Previous abdominal surgery is an important predisponding risk factor for conversion: *Masoomi et al* showed that patients who underwent lysis of abdominal adhesions had approximately 2.5 times higher risk conversion compared with patients without lysis of adhesions [65]. The presence of prior abdominal surgery is not an absolute contraindication but a relative contraindication to laparoscopic right colectomy.

Type of disease is an other important risk factor for conversion to open surgery: a lot of studies found that compared with benign tumor pathology, IBD and malignancies were associated with a higher rate of conversion [65] and particularly Crohn's disease had the highest rate [65,69]. *Li et al.* [64] showed on univariate analysis that stage IV disease, tumor length > 5 cm and T4 tumor resulted associated with higher risk of conversion during laparoscopic right colectomy [70].

One of the identified risk factor for conversion is surgeon's experience [64,65,71]: the rate of conversion is higher in the initial phase of the learning curve of laparoscopic colorectal surgery and it will decrease with experience. *Tekkis* reported improvement in the conversion rate after 55 cases for right-side laparoscopic procedure [71]. Centre's volume procedures, that is related to surgeon's experience, is a consequent risk factor for conversion.

Anatomical location appears to be a useful predictive factor for determining risk of conversion and some studies showed that laparoscopic right colectomy had a lower rate of open conversion than surgery on the other portions of the colon and rectum [65,68]. However, during laparoscopic right colectomy the vascular control can be difficult because of vascular variations of ileocolic, right superior and right middle colic vessels. The dissection and the ligation of superior colic vessels could be complicated when the right mesocolon is strongly affixed posteriorly or broad and short: these conditions make the identification of the vessels somewhat difficult [72]. The gastrocolic trunk of Henle, performed by the confluence of the right superior colic vein, the gastroepiploic and the anterosuperior pancreaticoduodenal veins, can be damaged during these proceedings and the consequent bleeding is difficult to control with laparoscopic approach and it often requires conversion to open surgery [26,72].

Poor visualization, equipment malfunction or instrumental failure and difficult localization of the tumor can determine conversion to laparotomy [64,65].

In more recent studies, advanced age is not associated with higher risk of conversion and old people draw advantage from laparoscopy because of less post-operative morbidity [65].

Pain Control

Reducing postoperative pain after abdominal laparoscopic surgery is a goal for the whole medical equipe. The role of anaesthesiologist is pivotal for this purpose and should not be limited as a postoperative prescription on the anaesthesia chart but should continue with a teamwork

for monitoring and relieve pain and eventually treat complications.

A good pain management permits not only patient comfort, but it can also enhance recovery of bowel function, enteral feeding and early mobilization.

The choice of laparoscopic technique is one of the factors affecting favourably postoperative pain and stress response; indeed, as for open surgery, pain management needs a multimodal approach, that is the use of different techniques and drugs with different mechanism and site of action in order to reduce side effects and limit opioid use.

The optimal analgesic modality for abdominal laparoscopy is still debated, and should take in consideration the type of surgery and patient comorbidities. Thoracic epidural analgesia, a cornerstone in open surgery, is not considered the first choice and there is less evidence to support its use: it has shown to have low pain scores for the first 24 hours after surgery and seems to facilitate recovery of bowel function but still is associated to a prolonged hospital stay [73,74]. In conclusion, its use should be considered in those patients in which there is a high risk of conversion to open procedure or in those at risk of severe postoperative respiratory complications [75].

Alternative techniques, in combination with intravenous drug administration, have shown to provide analgesia without complication of epidural analgesia. Intrathecal morphine with local anaesthetic is a preoperative single-shot drug injection into the cerebrospinal fluid [75]. It has a rapid onset but limited duration of action, but in laparoscopic surgery wound pain is limited and its use can be logical. In recent years the advent of ultrasound use in anaesthesia has permitted to reduce risk of complications in abdominal trunk blocks: Transverse abdominal plane block is the injection of local anaesthetic between internal oblique muscle and transverse abdominal muscle. Transverse abdominal plane block can also be performed under laparoscopic guidance and has recently been successfully used. It has shown to reduce pain scores, morphine consumption, post-operative nausea and vomiting. Its efficacy can be prolonged with intermittent boluses or continuous infusion through multi-hole catheters [77,78].

Opioid sparing analgesia is crucial in abdominal surgery; the use of opioid analgesics in some cases can be unavoidable, but the excess of its use can lead to a undesirable side effects such as delayed return of gastrointestinal function. If morphine is used, it is often because other methods have failed. In this case, the best approach is patient controlled analgesia instead of continuous infusion.

Systemic analgesics are part of multimodal analgesic approach, in combination with a loco-regional technique. Paracetamol, anti-inflammatory drugs (both selective COX inhibitors or non selective), gabapentinoids, intravenous lidocaine, alpha 2 agonist, magnesium and ketamine can be used in different combination, at different time (pre-emptive analgesia) [78].

Conclusions

Laparoscopic right colectomy is the treatment of choice for right colon cancer, for adenomatous polyps not amenable to colonoscopic resection, for Crohn's disease, for right colonic diverticulitis and for appendiceal neuroendocrine neoplasms. In literature a lot of studies and clinical trials confirm that laparoscopic right colectomy is considered superior to open surgery in the short-term outcomes without difference in long-term outcomes. Also thanks to the association with fast-track - "enhanced recovery after surgery" (ERAS) post-operative treatment laparoscopic right colectomy resulted associated to lower blood loss, earlier recovery of bowel movement, earlier resumption of oral intake, reduced hospital stay, better post-operative pain control, reduced total hospital costs and faster return to work. For right colon cancer the laparoscopy is regarded safe and feasible without compromising the oncological outcome. Laparoscopic approach must be properly weighted by the surgeons considering all possible conversion risks such as high BMI, previous abdominal surgery, surgeon's experience and technical ability, bulky T4 tumor and complicated Crohn's disease.

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