

Recent results of laparoscopic surgery in inflammatory bowel disease

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Abstract

Inflammatory bowel diseases are an ideal indication for the laparoscopic surgical approach as they are basically benign diseases not requiring lymphadenectomy and extended mesenteric excision; well-established surgical procedures are available for the conventional approach. Inflammatory alterations and fragility of the bowel and mesentery, however, may demand a high level of laparoscopic experience. A broad spectrum of operations from the rather easy enterostomy formation for anal Crohn's disease (CD) to restorative proctocolectomies for ulcerative colitis (UC) may be managed laparoscopically. The current evidence base for the use of laparoscopic techniques in the surgical therapy of inflammatory bowel diseases is presented. CD limited to the terminal ileum has become a common indication for laparoscopic surgical therapy. In severe anal CD, laparoscopic stoma formation is a standard procedure with low morbidity and short operative time. Studies comparing conventional and laparoscopic bowel resections, have found shorter times to first postoperative bowel movements and shorter hospital stays as well as lower complication rates in favour of the laparoscopic approach. Even complicated cases with previous surgery, abscess formation and enteric fistulas may be op-

erated on laparoscopically with a low morbidity. In UC, restorative proctocolectomy is the standard procedure in elective surgery. The demanding laparoscopic approach is increasingly used, however, mainly in major centers; its feasibility has been proven in various studies. An increased body mass index and acute inflammation of the bowel may be relative contraindications. Short and long-term outcomes like quality of life seem to be equivalent for open and laparoscopic surgery. Multiple studies have proven that the laparoscopic approach to CD and UC is a safe and successful alternative for selected patients. The appropriate selection criteria are still under investigation. Technical considerations are playing an important role for the complexity of both diseases.

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INTRODUCTION

Laparoscopic techniques have rapidly gained acceptance since their first introduction into surgery for cholecystolithiasis. Other pathologies of the gastrointestinal tract have become indications within a short period of time. First attempts in minimally invasive approaches to colorectal surgery date back to the early 1990s. Potential benefits are evident: smaller incision size, improved

cosmesis, less postoperative pain, earlier return of bowel movements and tolerance to diet. These factors may be translated into a faster recovery of the patient in general with reduced floor costs, and earlier return of the patient to normal activity^[1].

In inflammatory bowel diseases, Crohn's disease (CD) and ulcerative colitis (UC) have to be distinguished clearly regarding the introduction of laparoscopy as the operative procedures are varied. In CD, there is a wide range of potential procedures whereas in UC, restorative proctocolectomy is the standard operation in elective situations. Early reports about the introduction of laparoscopy to CD demonstrated the feasibility of laparoscopic surgery for the creation of stomas and for limited segmental bowel involvement. Rapidly, more complex procedures like ileocelectomies or subtotal colectomies were attempted successfully. First results of laparoscopic restorative proctocolectomy and ileal pouch-anal anastomosis (IPAA) for selected patients with UC or indeterminate colitis were not encouraging. Only around the year 2000, with newly-developed instruments, refined technique, and in specialized treatment centers, this comprehensive procedure was reappraised with improved results. Also, subtotal colectomies for acute inflammatory bowel diseases may be managed laparoscopically.

Complicated cases of CD may still be a special challenge, even for surgeons with excellent experience in operations for IBD and intensive laparoscopic training. Rates of conversion from laparoscopic to conventional surgery are comparatively high^[2,3]. There are high rates of unexpected findings like proximal strictures, stenoses, abscesses or phlegmons^[4]. In this article, an overview of the current status of the special surgical approach to CD and UC is provided.

CD

In CD, in general, surgery is normally reserved for patients who develop complications of the disease such as strictures and fistulas or who are unresponsive to or develop complications from aggressive medical therapy. The laparoscopic approach should be an ideal indication since it is a benign disease and the concerns related to laparoscopic cancer surgery do not apply. Additionally, it may provide an improved cosmetic result, which is an important factor in this mostly young patient population^[5]. Thickened bowel loops, thickened and friable mesentery, inflammatory phlegmons and masses, enteric fistulas, abscesses, and multiple adhesions from previous conventional surgeries have deterred surgeons from considering a laparoscopic approach. However, as most patients are aware of the fact that there is a high risk of further surgeries becoming necessary at some later point in their lives, they are motivated to prefer a type of surgery that offers them minimal scarring and faster recovery^[6,7]. Even cases with complications may be attempted and completed laparoscopically, depending on the individual situation and the surgeon's expertise.

Early postoperative results

The decision to perform a laparoscopic procedure in an individual case as well as the conversion rates during surgery are influenced by the expertise of the surgeon which also determines the immediate postoperative outcome. After a number of years of application of the new technique, several studies about short and long-term results have been published.

The purpose of a study at the University of Chicago^[8] was to compare short-term outcomes of laparoscopic colectomy (LC) *vs* open colectomy (OC) in patients with Crohn's colitis. Data on all patients undergoing colectomy for primary or recurrent CD confined to the colon during 6 years were collected. Patient and disease-specific characteristics and perioperative and short-term postoperative outcomes were prospectively collected and analyzed. A total of 125 patients underwent colectomy during the study period, 55 (44%) LC. There were six conversions (10.9%). Median operative time was shorter in the LC group ($P = 0.032$). Earlier return of bowel function was noted in the LC group (3 d *vs* 4 d, OC). Length of postoperative stay was shorter in the LC group ($P = 0.001$). There was one death in the OC group. Postoperative complications occurred in 8 (14.5%) LC patients *vs* 16 (22.9%) OC patients. Disease recurrence rate was 16%, 10.9% LC and 20% OC, respectively.

It was stated that LC was a safe and effective technique in the hands of experienced surgeons. Benefits of LC in CD included reduced operative blood loss, quicker return of bowel function, and shorter hospital length of stay. Very similar results were found in studies published by Soop *et al*^[9], Tanaka *et al*^[10] and Kroesen *et al*^[11] who investigated the results of laparoscopic proctocolectomies with an incisionless technique.

For a long time it has been known that there is a higher leak rate in bowel resections for CD than for other benign conditions. In order to investigate the safety of laparoscopic (Lap) colorectal surgery as reflected by the anastomotic bowel leak (ABL) rate compared with that seen in open surgery, the Cleveland Clinic Foundation has recently evaluated its data^[12]. Between 2000 and 2007, 1516 consecutive patients undergoing laparoscopic surgery with bowel anastomosis were covariate-adjusted to 3258 patients undergoing open surgery by pathology and site of anastomosis using the institutional review board-approved laparoscopic, diverticular, Crohn's, and colorectal cancer databases. Of these patients, 643 patients in each group were equally matched by pathology, site of anastomosis, date of surgery, age, gender, and body mass index (BMI). The clinical ABL rate was compared between the two groups by the location of bowel anastomosis and year of surgery. A total of 4774 patients (1516 laparoscopic, 3258 open; mean age, 55.8 ± 17.4 years; BMI, 27.8 ± 6.2 kg/m²) underwent colorectal resection with bowel anastomosis (cancer 45.3%, Crohn's 29.6%, diverticulitis 12.3%, other 12.8%). There were no differences in the overall clinical ABL rates between laparoscopic (2.6%) and open procedures (2.1%, $P = 0.5$), between laparo-

scopic right *vs* open right ($P = 0.6$), between laparoscopic left *vs* open left ($P = 0.8$), and between patients operated on during different time periods ($P = 0.4$). For the case-matched 643 patients, there were no differences in clinical ABL rates between laparoscopic *vs* open groups based on site of anastomosis, pathology, and year of surgery. A laparoscopic colorectal approach was not associated with a higher risk of clinical ABL.

The largest unicentric study published until now comes from the Mount Sinai Hospital in New York City^[13]. The authors reviewed their experience with 335 laparoscopic resections for CD over the past 15 years in a retrospective analysis of a prospective database. The mean age of the patients was 39 years, 54% of the patients were women. In most cases, the indication for surgery was intestinal obstruction (73%) or abdominal pain (16%). The most common operation was primary ileocolic resection, performed for 178 cases (49%). Secondary ileocolic resections were performed for 20% and small bowel resections for 11% of the cases. Of the 117 patients with enteric fistulas, 45% had multiple fistulas. There were 80 enteroenteric, 51 ileosigmoid, 33 enteroabdominal wall, and 22 ileovesical fistulas. Multiple resections were performed for 33 patients (9%). Eight conversions occurred (2%), primarily because of large inflammatory masses involving the intestinal mesentery. The mean length of hospital stay was 5 d, and the mean operative time was 177 min (range, 62-400 min). There were no mortalities. The complications were primarily bowel obstruction, anastomotic leak, and postoperative bleeding, resulting in a postoperative complication rate of 13%.

Long-term results

The question has been raised for a long time if in laparoscopic resection for CD occult segments of disease may be missed at surgery and if the long-term result may be impaired this way. There had also been concerns if less of an immune response may be induced by laparoscopic methods compared with conventional surgery.

Long-term results of laparoscopically assisted *vs* open ileocolic resection for CD were evaluated in a randomized trial by Eshuis *et al.*^[14]. Sixty patients who underwent ileocolic resection between 1999 and 2003 were followed prospectively. Primary outcomes were reoperation, re-admission and repeat resection rates for recurrent CD. Secondary outcomes were quality of life (QOL), body image and cosmesis. Median follow-up was 6.7 years (interquartile range, 5.7-7.9 years). Sixteen of 29 and 16 of 26 patients remained relapse free after ileocolic resection in the laparoscopic and open groups, respectively. Resection of recurrent CD was necessary in two of 29 *vs* three of 26 patients. Overall reoperation rates for recurrent CD, incisional hernia and adhesion-related problems were two of 29 *vs* six of 26. QOL was similar, whereas body image and cosmesis scores were significantly higher after laparoscopy ($P = 0.029$ and $P < 0.001$, respectively). It was concluded that laparoscopic assisted ileocolic resection resulted in better body image and cosmesis, whereas open surgery was more likely

to produce incisional hernia and obstruction.

Long-term results of a prospective randomized study previously conducted at the Cleveland Clinic Foundation comparing laparoscopic (LC) and open ileocelectomy (OC) for ileocolic CD were published by Stocchi *et al.*^[15]. The purpose was to analyze long-term recurrence rates and complications. Follow-up data were available on 56 of 60 patients. Demographic data, recurrence rates, need for additional surgery related to primary procedure, and medication uses were recorded. Mean follow-up for 56 patients (27 LC *vs* 29 OC) was 10.5 years and comparable between LC and OC (10.0 *vs* 11.0, respectively, $P = 0.64$). One patient died 8 years after OC of causes unrelated to CD. One patient underwent incisional hernia repair after LC (4%) *vs* 4 patients (14%) after OC ($P = 0.61$). Two patients in the LC group underwent adhesiolysis *vs* none after OC ($P = 0.23$). Incidences of anorectal disease, anorectal surgery, endoscopic or radiologic recurrence, and medication use were also similar between LC and OC. OC patients requiring operation during follow-up were significantly more likely than LC to require multiple operations ($P = 0.006$). As a conclusion, long-term data confirmed that LC is at least comparable to OC in the treatment of ileocolic CD.

Complex CD

Goyer *et al.*^[16] analyzed in a prospective study the feasibility of laparoscopic ileocolonic resection for complex CD, i.e. recurrence or complication from abscess and/or fistula, and compared postoperative outcomes in patients with and without complex CD. During 10 years, 124 laparoscopic ileocolonic resections were attempted for CD: 54 patients with complex CD (group I) and 70 patients without complex CD (group II). Indications for surgery in group I included fistula (43%), abscess (30%), and recurrent disease after ileocolonic resection (27%). Complex CD was significantly associated with increased mean operative time (214 min *vs* 191 min, $P < 0.05$), increased conversion rate to open procedure (37% *vs* 14%, $P < 0.01$), and increased use of temporary stoma (39% *vs* 9%, $P < 0.001$). No patients died. Overall postoperative morbidity was similar between both groups (17% *vs* 17%), including major surgical postoperative complications (7% *vs* 6%, $P = \text{NS}$). Mean hospital stay was not statistically different between both groups (8 d *vs* 7 d, $P = \text{NS}$). This large comparative study suggested that laparoscopic ileocolonic resection for complex CD was feasible and safe with good postoperative outcomes.

Recurrent disease

Laparoscopic surgery is increasingly performed for primary, especially ileocolic CD, but its application in patients with recurrent disease is less well described. The aim of a study of the Mayo Clinic^[17] was to assess the safety, feasibility and potential short-term benefits of a laparoscopic approach. Patients undergoing laparoscopic surgery for recurrent ileocolic disease were identified using a prospectively maintained database. Potential risk factors for con-

version to open surgery and overall patient outcomes were assessed with univariate analysis. Forty patients were identified, of which 30 (75%) were completed laparoscopically and 10 (25%) were converted to open surgery. The groups did not differ with respect to clinicopathological features. Converted patients were significantly more likely to require adhesiolysis (100% *vs* 67%, $P = 0.04$). The groups did not differ with respect to incidence of postoperative complications or frequency of readmission within 30 d. There was no mortality. Conversion increased the length of stay in the hospital. Similar results were found by other authors^[18-20].

Hand-assisted surgery

Hand-assisted laparoscopic surgery (HALS) has gained clinical acceptance as a practical alternative to purely laparoscopically assisted surgery (LAP) for the surgical treatment of complex colorectal diseases like in IBD. Its role in challenging operations for CD (subtotal or total colectomy) has yet to be established. A recent study of Nakajima *et al*^[21] aimed to evaluate the feasibility, safety, and potential benefit of HALS subtotal and total colectomy for Crohn's colitis. Thirty-eight consecutive patients who underwent subtotal or total colectomy as their initial abdominal surgery for Crohn's extensive colitis (involvement of 3 or more colonic segments) were evaluated. The patients were divided into three groups (open, LAP, and HALS), and their background and postoperative data were retrospectively analyzed. The reviews included 14 open, 6 LAP, and 18 HALS cases. The groups were comparable in terms of age at surgery, gender, BMI, extent and type of disease, indications, and procedures. The median operative time was significantly longer for LAP (330 min; range, 154-540 min) than for HALS (251 min; range, 165-340 min) or open surgery (200 min; range, 172-315 min). The blood loss was significantly less with LAP (170 mL; range, 115-257 mL) and HALS (225 mL; range, 35-890 mL) than with open surgery (438 mL; range, 280-780 mL). No difference was seen in postoperative complications, and no mortality occurred in the series. The authors concluded that HALS subtotal and total colectomies were feasible and safe. The HALS procedure seemed potentially beneficial for patients with extensive Crohn's colitis by reducing the operative time for laparoscopic surgery while retaining its less invasive nature.

Laparoscopic resection and transcolonic specimen retrieval

Recently, in numerous surgical meetings, "natural-orifice transluminal endoscopic surgery" and "single-incision laparoscopic surgery" have moved into the focus of interest. Either no or maximally one abdominal port incision are necessary for this. It has been demonstrated that ileocolic resection for CD is feasible entirely laparoscopically. However, normally, an incision is needed for specimen extraction (minilaparotomy). Eshuis *et al*^[22] recently reported an early observational study assessing the feasibility of endoscopic transcolonic specimen removal avoiding any type of minilaparotomy. Endoscopic specimen removal was attempted in a consecutive series of ten

patients scheduled for laparoscopic ileocolic resection. Primary outcomes were feasibility, operating time, reoperation rate, pain scores, morphine requirement and hospital stay. To assess applicability, outcomes were compared with previous data from patients who had laparoscopic assisted operations. Transcolonic removal was successful in eight of ten patients; it was considered not feasible in two patients because the inflammatory mass was too large (7-8 cm). Median operating time was 208 min and median postoperative hospital stay was 5 d. After surgery, two patients developed an intra-abdominal abscess, drained laparoscopically or percutaneously, and one patient had another site-specific infection. The operation took longer than conventional laparoscopy, with no benefits perceived by patients in terms of cosmesis or body image. The authors concluded that transcolonic removal of the specimen in ileocolic CD was feasible in the absence of a large inflammatory mass but infection might be a problem. It could not be stated that the technique offered any benefits compared with conventional laparoscopic surgery.

Influence of body weight

In obese patients, laparoscopic techniques may be impaired by difficulties in creating a sufficient pneumoperitoneum and by worse visualisation of the regular anatomy caused by masses of fatty tissue. At the Cleveland Clinic Florida^[23] a retrospective study of prospectively collected data was designed to evaluate the results of laparoscopic colorectal resections in normal weight patients compared with overweight and obese patients with IBD. All consecutive patients with IBD who underwent laparoscopy in 8 years were reviewed. BMI, age, gender, comorbidities, ASA classification, and surgical- and disease-related variables, including 60-d postoperative complications, were reviewed. A total of 213 patients were analyzed. Group I comprised 127 normal-weight patients (BMI, 18.5-24.9 kg/m²), and group II included 67 overweight patients (BMI, 25-29.9 kg/m²) and 19 obese patients (BMI ≥ 30 kg/m²). Procedures performed included ileocolic resection in 56% of patients in each group. Total colectomy with or without proctectomy was undertaken in 39.4% in group I and 40.7% in group II. The conversion rate was 18% for group I and 22.09% for group II ($P > 0.005$; not significant). The most common reason for conversion was failure to progress due to adhesions or phlegmon. There were no differences in major postoperative complication rates (wound infection, abscess, anastomotic leakage, or small-bowel obstruction) or mean hospital stay (6.7, 6.8, respectively), and there was no mortality. These results demonstrated that the benefits of laparoscopic bowel resection should not be denied to overweight or obese patients based strictly on their BMI.

Nationwide study

The fact that the laparoscopic approach to CD has demonstrated benefits in several small series was an incentive for Lesperance *et al*^[24] to examine its use and outcomes on a national level in the United States. A variety of patient-

and system-related factors were identified to influence the utilization of laparoscopy in CD. All admissions with a diagnosis of CD requiring bowel resection were selected from the 2000-2004 Nationwide Inpatient Sample. Regression analyses were used to compare outcome measures and identify independent predictors of undergoing laparoscopy. Of 396 911 patients admitted for CD, 49 609 (12%) required surgical treatment. They were predominantly Caucasian (64%), female (54%), and with ileocolic disease (72%). Laparoscopic resection was performed in 2826 cases (6%) and was associated with lower complications (8% *vs* 16%), shorter length of stay (6 d *vs* 9 d), lower charges (\$27 575 *vs* \$38 713), and mortality (0.2% *vs* 0.9%, all $P < 0.01$). Open surgery was used more often for fistulas (8% *vs* 1%) and when ostomies were required (12% *vs* 7%). Independent predictors of laparoscopic resection were age < 35 [odds ratio (OR) = 2.4], female gender (OR = 1.4), admission to a teaching hospital (OR = 1.2), ileocecal location (OR = 1.5), and lower disease stage (OR = 1.1, all $P < 0.05$). Ethnic category, insurance status, and type of admission (elective *vs* non-elective) were not associated with operative method ($P > 0.05$). In conclusion, laparoscopic resection was associated with excellent short-term outcomes compared to open surgery.

Meta-analyses

Several meta-analyses about the impact of laparoscopic surgery in CD have been published^[25-29]. Tan's most recent study was designed to determine the safety and feasibility of laparoscopic surgery in CD. A search of published studies in English between January 1990 and February 2006 was performed by using the MEDLINE and PubMed databases and the Cochrane Central Register of Controlled Trials. The studies were reviewed by two independent assessors. The rate of conversion from laparoscopic to open surgery was 11.2%. Laparoscopic procedures took longer to perform compared with open procedures, with a weighted mean difference of 25.54 min ($P = 0.03$). Patients who underwent laparoscopic surgery had a more rapid recovery of bowel function, with a weighted mean difference of 0.75 d ($P = 0.02$) and were able to tolerate oral intake earlier, with a weighted mean difference of 1.43 d ($P = 0.0008$). The duration of hospitalization was shorter, with a weighted mean difference of 1.82 d ($P = 0.02$). Morbidity was lower for laparoscopic procedures compared with open procedures (OR = 0.57, 95% CI: 0.37-0.87, $P = 0.01$). The rate of disease recurrence was similar for both laparoscopic and open surgery.

In all meta-analyses published to date, laparoscopic surgery for CD took longer to perform, but significant short-term benefits to the patient were observed. The morbidity was lower and the rate of disease recurrence was similar. Therefore, laparoscopic surgery for CD proved to be safely feasible.

UC

Under elective conditions, today, restorative procto-

colectomy with ileal J-pouch formation is the standard of surgery. In the early 1990s, initial experiences with a laparoscopic management were reported. However, these first results did not seem very promising, the laparoscopic technique in these comprehensive operations appeared too difficult to apply, too time-consuming, and comorbidity was too high^[30-33]. In the meantime, multiple technical innovations which have been introduced and increased surgical experience have advanced the field of complex surgery. In recent studies, more favourable results have been stated. Earlier return of bowel movements and shorter hospital stays have been observed in patients undergoing laparoscopy^[34-37]. In other studies, even more benefits like reduced pain, decreased morbidity and hospital stay, improved nutrition, preservation of immune response and decreased short and long-term complications have been observed. Functional outcomes and quality-of-life measurements have been comparable^[38-40]. Long operative times and learning curves, however, are still delaying a universal application of laparoscopy in the surgical management of UC^[41]. Boller *et al.*^[42] suggested breaking down comprehensive operations like the IPAA procedure in a stepwise fashion to simplify their complexity and allow the young surgeon to effectively reproduce this operation. The approach becomes viable by outlining the single steps in a systematic manner.

Early postoperative results

Total proctocolectomy with Brooke ileostomy has remained the classical traditional operation, also as a reserve for cases where an ileal pouch is not feasible or advisable. However, hardly any studies describe outcomes after the minimally invasive approach. Holubar *et al.*^[43] analyzed the safety and feasibility of these procedures by examining short-term (30-d) outcomes. Using a prospective database at the Mayo Clinic, a cohort of patients who underwent laparoscopic total proctocolectomy with Brooke ileostomy during 8 years was identified. Forty-four patients were included. Colitis duration was 66 mo (24-240 mo), and 40% had prior surgery. The indication for surgery was refractory colitis (82%) and neoplasia (18%). Factors influencing choice of total proctocolectomy with permanent ileostomy were advanced age in 18 (41%), lifestyle in 13 (30%), medical comorbidities in 11 (25%), fecal incontinence in 10 (23%), oncologic reasons in 3 (6.8%), and obesity in 3 (6.8%). Twenty-three (52%) operations were hand-assisted laparoscopic surgeries, 13 (30%) were laparoscopic-assisted, and 8 (18%) were "laparoscopic-incisionless" with transanal specimen extraction. Two laparoscopic-assisted cases (4.6%) were converted. Operative time was 329 (272-402) min, and length of stay 5 (4-6) d. Major post-operative complications occurred in 4 (9%); there were no perioperative mortalities.

At the same institution, a study was designed to compare short-term outcomes after laparoscopic IPAA with those of open IPAA in patients with both sclerosing cholangitis and UC^[44]. Sixteen patients with sclerosing cholangitis and UC undergoing laparoscopic IPAA were

matched with 16 open ileal pouch control subjects by sex, American Society of Anesthesiologists' score, age, and BMI. Operative mortality was zero. Operative time was longer in the laparoscopic group. Thirty-day complications were not significantly different between groups, but length of stay was significantly shorter in the laparoscopic group. Average return of gastrointestinal function was 2.5 d in the laparoscopic group and 4.8 d in the open group ($P = 0.001$). Time to soft diet was 3 d in the laparoscopic group and 6 d in the open group ($P < 0.001$). All patients were alive and all pouches were intact at last follow-up.

Satisfying mid-term outcomes have been reported in a series by Berdah *et al*⁴⁵. His prospective study aimed to analyze the functional outcome after a two-stage laparoscopic total proctocolectomy with IPAA. Over 9 years, 68 consecutive two-stage laparoscopic total proctocolectomies with IPAA were performed (UC: $n = 61$; familial adenomatous polyposis: $n = 7$). A covering ileostomy was used in all patients. Forty patients whose covering ileostomy had been closed for a minimum of 2 years were included in this series. Conversion to laparotomy was necessary in 4 of 40 patients (10%). Thirteen postoperative complications occurred in 13 of 40 patients (30%). At a median follow-up of 38 mo (range, 26-90 mo), the median number of bowel movements was 4 per 24 h (range, 2-10); 15 patients (38%) had no nighttime bowel movements. None of the patients had fecal incontinence or urgency. Thirty-four of the 40 patients (85%) experienced no soiling. Seven patients (18%) took regular antidiarrheal medication. All patients were able to resume all activities practiced prior to illness onset, and 36 of 40 (90%) were satisfied with their overall QOL (very good or good).

Long-term results

In contrast to short term results, long-term outcomes after laparoscopic IPAA have not been evaluated thoroughly. In a study published by Fichera *et al*⁴⁶, short- and long-term results were compared prospectively. During 5 years, 73 laparoscopic and 106 open IPAA patients were enrolled. There were no differences in demographics, treatment, indication, duration of surgery, and diversion between groups. Laparoscopic patients had faster return of flatus ($P = 0.008$), faster resumption of a liquid diet ($P < 0.001$), and less blood loss ($P = 0.026$). While complications were similar, the incidence of incisional hernias was lower in the laparoscopic group ($P = 0.011$). Mean follow-up was 24.8 mo. The average number of bowel movements was 6.8 ± 2.8 per day for laparoscopy and 6.3 ± 1.7 for open ($P = 0.058$). Overall, 68.4% of patients were fully continent at 1 year, up to 83.7% long term without differences between groups. Other indicators of defecatory function and QOL remained similar over time.

Self-reported sexual function, body image and QOL after laparoscopic and open IPAA were compared and analyzed in a study by Larson *et al*⁴⁷. At the Mayo Clinic, between 1978 and 2004, 100 laparoscopic and 189 open operations were performed in patients who were identi-

fied from a previously published cohort. Patients were surveyed 1 year after operation to evaluate sexual function, body image, and QOL. A total of 125 of 289 patients (43%) returned completed surveys. There were no significant differences in terms of demographics, complications, or long-term functional outcomes between those who completed the surveys and those who did not. There were no clinical differences in results between laparoscopic and open patients using the three survey instruments. Orgasmic function scores were lower in men who underwent laparoscopic IPAA ($P < 0.05$) compared with open IPAA. Overall, sexual function scores were equal to or better than normal values for men but were lower in women. Finally, overall body image and QOL scores were above the means published for the United States.

Postoperative adhesions are an expected outcome for the majority of open abdominal operations. Adhesions are responsible for more than 75% of small bowel obstruction cases. Another study from the Mayo Clinic⁴⁸ was initiated to evaluate adhesions to the anterior abdominal wall and adnexal organs after laparoscopic IPAA. Patients who underwent laparoscopic IPAA for UC had laparoscopic evaluation of adhesions at loop ileostomy closure for assessment of adhesions to the anterior abdominal wall and for adhesions to the adnexae in the case of women. Adhesions to the adnexae were quantified using the American Fertility Society adhesion score. Data were maintained prospectively. In this study, 34 patients (21 women) ranging in age from 19 to 78 years (median, 36 years) underwent laparoscopic IPAA. Twenty-three patients (68%) had no adhesions to the anterior abdominal wall, and the remaining 11 patients had few adhesions (filmy, avascular). No patients had dense adhesions to the abdominal wall. Of the 21 women, 15 (71%) had no adnexal adhesions, 5 had filmy adhesions enclosing less than one-third one adnexa, and one had filmy adhesions enclosing one-third to two-thirds of one adnexa. No patient had adhesions affecting both adnexae. It was concluded that laparoscopic IPAA results in few adhesions to the anterior abdominal wall or to gynecologic organs. These adhesions were significantly fewer than previously reported for open operations with or without the use of a glycerol hyaluronate/carboxymethylcellulose bioresorbable adhesion barrier.

Hand-assisted surgery

The role of hand-assistance in laparoscopic restorative proctocolectomies has not yet been defined. In a few comparative and randomized studies, hand-assisted laparoscopic restorative proctocolectomy (HALS-RP) maintained the advantages of a minimally invasive approach with some potential benefits. The aim of a study by Tsuruta *et al*⁴⁹ from Keio University in Tokyo was to evaluate the effectiveness of HALS-RP compared with a conventional laparoscopic restorative proctocolectomy (LAP-RP) in patients with UC. A retrospective study was conducted using a prospectively maintained database to compare a consecutive series of 30 patients who underwent HALS-

RP during 3 years with 40 patients who underwent LAP-RP during 10 years. Both groups were well matched. The median operative time was significantly shorter for HALS-RP [356 min (range, 176-590 min)] than for LAP-RP [505 min (range, 360-785 min), $P < 0.001$]. The median length of incision was significantly longer for HALS-RP [8 cm (range, 7.5-8 cm)] than for LAP-RP [5.5 cm (range, 5-8 cm)]. The estimated blood loss and the length of hospital stay were similar between the two groups. The incidence of postoperative complications including anastomotic leakage did not differ between the both groups ($P = 0.437$).

Hand-assistance in emergency subtotal colectomies for cases of severe UC was analyzed by Watanabe *et al*^[50]. The medical records of 60 patients who underwent emergency subtotal colectomy with hand-assisted laparoscopic technique (30 cases) or open technique (30 cases) were reviewed. One patient in the laparoscopic group required conversion to open surgery. The median operative time was significantly longer in the laparoscopic group (242 min *vs* 191 min, $P < 0.001$). The rate of early postoperative complications in the laparoscopic group was significantly less than that in the open group (37% *vs* 63%, $P = 0.041$). In the open group, four patients required relaparotomy because of peritoneal abscess or strangulation ileus, whereas no patient required relaparotomy in the laparoscopic group ($P = 0.040$). HALS was found to be an acceptable alternative to conventional open surgery.

Fulminant colitis and emergency surgery

Several institutions have published their data about their experience with minimally-invasive procedures applied in emergency cases. At the Mayo Clinic, safety, feasibility, and short-term outcomes of three-stage minimally invasive surgery for fulminant UC were evaluated^[51]. All patients with UC who underwent minimally invasive surgery for both subtotal colectomy and subsequent IPAA from 2000 to 2007 were identified. Fifty patients underwent minimally invasive subtotal colectomy for fulminant UC; 50% were male, with a median age of 34 years. All patients had refractory colitis: 96% were taking steroids, 76% were recently hospitalized, 59% had ≥ 5 kg weight loss, 57% had anemia that required transfusions, 30% were on biologic-based therapy, and 96% had ≥ 1 severe Truelove and Witts' criteria. Of these 50 procedures, 72% were performed by using laparoscopic-assisted and 28% with hand-assisted techniques. The conversion rate was 6%. Subsequently, minimally invasive completion proctectomy with IPAA was performed in 42 patients with a 2.3% conversion rate. Median length of stay after each procedure was 4 d. There was one anastomotic leak and no mortality.

At Washington University in St. Louis, short-term outcomes of laparoscopic *vs* open total abdominal colectomy and end ileostomy for severe UC were investigated^[52]. The impact of the initial surgical approach on subsequent operations for three-stage restorative proctocolectomy was evaluated. Thirty-seven patients underwent laparoscopic, 41 open total abdominal colectomy at the initial stage of

a three-stage restorative proctocolectomy. Each stage was analyzed independently by using two-tailed *t*-tests and analysis of covariance. The laparoscopic total abdominal colectomy patients underwent subsequent restorative proctectomy 49 d sooner ($P = 0.0044$) and ileostomy closure 17 d sooner ($P = 0.00003$) than the open total abdominal colectomy patients. Laparoscopic abdominal colectomy for severe UC in selected patients was safe and associated with short-term benefits that may lead to faster recovery and progression to completion of restorative proctocolectomy.

In a very similar retrospective review of 90 patients at the Mount Sinai Hospital in New York City, laparoscopic subtotal colectomy was safely feasible and conferred the benefits of improved cosmesis, reduced intraoperative blood loss and shorter hospital stay^[53].

Comparing patients' outcome after laparoscopic IPAA with and without previous emergency subtotal colectomy, McAllister *et al*^[54] found the pouch procedure not only safely feasible in the virgin abdomen but also in patients with previous OC.

Several studies suggested that infliximab may increase postoperative complication rates for patients who later require a restorative proctocolectomy with IPAA. This question was investigated in a study by Coquet-Reinier *et al*^[55] aimed to assess the postoperative course of patients after laparoscopic IPAA, comparing those who had and those who had not received infliximab before surgery. No significant difference was found between patients treated with and those treated without infliximab for mean operative time (353 min *vs* 355 min), complication rate (23% *vs* 38%), and mean hospital stay (22 d *vs* 25 d). No adverse impact from previous infliximab therapy on the laparoscopic IPAA postoperative course was detected.

Meta-analysis and cochrane review

Wu *et al*^[56,57] published a meta-analysis comprising sixteen controlled trials. There was only one prospective randomized study among the studies selected. Outcome effects of laparoscopic and open surgery were pooled. A fixed effect model or random effect model was respectively used depending on the heterogeneity test of trials. Postoperative fasting time and postoperative hospital stay were shorter in laparoscopic surgery for UC [-1.37 (-2.15, -0.58), -3.22 (-4.20, -2.24), respectively, $P < 0.05$]. The overall complication rate was higher in open surgery, compared with laparoscopic surgery (54.8% *vs* 39.3%, $P = 0.004$). However, duration of laparoscopic surgery for UC was extended compared with open surgery (weighted mean difference 69.29 min, $P = 0.04$). As to recovery of bowel function, as indicated by peritoneal abscess, anastomotic leakage, postoperative bowel obstruction, wound infection, blood loss, and mortality, laparoscopic surgery did not show any superiority over open surgery. Re-operation rate was almost even (5.2% *vs* 7.3%). The whole conversion to open surgery was 4.2%.

The presumed benefits of the laparoscopic approach were analyzed systematically in a Cochrane review by

Table 1 Overview of most important study results dealing with laparoscopic and open surgical management of inflammatory bowel diseases

Author	Yr	Patients	Findings
Crohn's disease			
Umanskiy <i>et al</i> ^[8]	2010	55 lap colect 70 open colect	Early postop. results favourable for laparoscopy
El-Gazzaz <i>et al</i> ^[12]	2010	643 matched cases open and laparosc	Anastomotic leak rates even for open and lap surgery
Nguyen <i>et al</i> ^[13]	2009	335 laparoscopic	Postop compl. rate 13% (leaks, obstruction, bleeding)
Eshuis <i>et al</i> ^[14]	2010	29 laparoscopic 26 open	Better cosmesis for laparoscopy, more hernias and obstructions in open surgery
Stocchi <i>et al</i> ^[15]	2008	Follow-up, randomized study 27 lap, 29 open	Open colectomy patients significantly more frequently requiring multiple reoperations, otherwise results similar
Goyer <i>et al</i> ^[16]	2009	54, complex CD 70, uncomplicated	In complex disease, significantly longer OR time, conversion rate and stoma frequency
Holubar <i>et al</i> ^[17]	2010	30 lap completed 10 converted	Significantly more adhesions and length of stay in conversion, complication rates even
Nakajima <i>et al</i> ^[21]	2010	14 open 6 lap 18 hand-assisted	Significantly longer OR time in laparoscopic cases, significantly less blood loss in lap. and hand-assisted cases
Canedo <i>et al</i> ^[23]	2010	127 BMI < 25 kg/m ² 67 BMI > 25 kg/m ² , < 30 kg/m ² 19 BMI > 30 kg/m ²	More conversions in obesity, no differences in postop. complications and hospital stays
Lesperance <i>et al</i> ^[24]	2009	Nationwide study 49.609 surg. cases 2.826 lap cases	Less complications, shorter hospital stays, lower charges and mortality in laparoscopy, applied mainly in younger female patients with ileocecal disease at lower stage
Tan <i>et al</i> ^[25]	2007	Metaanalysis 14 studies 881 patients	Conversion rate 11.2%, lap. surgery with significantly longer OR time, more rapid recovery, shorter hospital stay and lower morbidity, similar recurrence rates
Ulcerative colitis			
Holubar <i>et al</i> ^[43]	2009	Total proctocolect 23 hand-assisted 13 lap-assisted 8 lap-"incisionless"	Median OR time 329 min, hospital stay 5 d, major complications in 9%, no mortality
Berdah <i>et al</i> ^[45]	2009	68 RPC + pouch	30% complication rate, all patients resuming preop. grade of activity, 90% satisfaction "good/very good"
Fichera <i>et al</i> ^[46]	2009	RPC + pouch 73 lap, 106 open	In laparoscopy, faster resumption of bowel function, less blood loss and lower rate of hernias in follow-up
Larson <i>et al</i> ^[47]	2008	RPC + pouch 100 lap, 189 open	Long-term data, worse sexual functional results in lap. cases, better body image and quality of life
Indar <i>et al</i> ^[48]	2008	34, RPC + pouch	Adhesion evaluation at ileostomy closure : 68% no and 32% few adhesions, lower than in open surgery
Tsuruta <i>et al</i> ^[49]	2009	30, HALS-RPC 40, Lap-RPC	OR time significantly longer for lap-RPC, incision length significantly longer for HALS-RPC
Watanabe <i>et al</i> ^[50]	2009	Emergency colect 30 HALS, 30 open	For HALS, OR time significantly longer, postop. complication rate significantly lower
Holubar <i>et al</i> ^[51]	2009	Fulminant colitis, 36 lap-assist. colect	Conversion rate 6%, median lengths of stay 4 d in both 14 HALS colect. groups, subsequent completion proctectomy in 42 pat
Chung <i>et al</i> ^[52]	2009	Severe UC 37 lap., 41 open	Faster recovery and progression to completion of RPC in lap. colectomies patients
Wu <i>et al</i> ^[56,57]	2008	Metaanalysis	Overall complication rate higher in open surgery duration of lap surgery significantly extended
Ahmed Ali <i>et al</i> ^[58]	2010	16 controlled trials	OR time significantly longer in lap. surgery, no differences in postop. course or recovery between lap. and open procedures
Ahmed Ali <i>et al</i> ^[58]	2009	Cochrane review 11 studies, 607 pat 253 laparoscopic	

CD: Crohn's disease; UC: Ulcerative colitis; OR: Operation room; BMI: Body mass index; HALS: Hand-assisted laparoscopic surgery; RPC: Restorative proctocolectomy.

Ahmed Ali *et al*^[58]. The aim was to compare the beneficial and harmful effects of laparoscopic *vs* open IPAA for patients with UC and FAP. The authors searched The Cochrane IBD/FBD Group Specialized Trial Register (April 2007), The Cochrane Library (Issue 1, 2007), MEDLINE (1990 to April 2007), EMBASE (1990 to April 2007), ISI Web of Knowledge (1990 to April 2007) and the

web casts of the American Society of Colon and Rectal Surgeons (up to 2006) for all trials comparing open *vs* laparoscopic IPAA. All trials in patients with UC or FAP comparing any kind of laparoscopic IPAA *vs* open IPAA were included. No language limitations were applied. Two authors independently performed selection of trials and data extraction. The methodological quality of all included

trials was evaluated to assess bias risk. Analysis of randomized and non-randomized controlled trials was performed separately. Analyses were based on the intention-to-treat principle. Sensitivity and subgroup analyses were performed if appropriate. Eleven trials were identified which included 607 patients, of whom 253 (41%) were in the laparoscopic IPAA group. Only one of the included trials was a randomized controlled trial. There were no significant differences in mortality or complications between the two groups. Reoperation and readmission rates were not significantly different. Operative time was significantly longer in the laparoscopic group both in the randomized and meta-analysis of non-randomized controlled trials (weighted mean difference 91 min). There were no significant differences between the two groups regarding postoperative recovery parameters. Total incision length was significantly shorter in the laparoscopic group, while two trials evaluating cosmesis found significantly higher cosmesis scores in the laparoscopic group. Short-term advantages of the laparoscopic approach seemed to be limited and their clinical significance arguable.

Table 1 summarizes the most important study results dealing with laparoscopic and open surgical management of inflammatory bowel diseases.

CONCLUSION

Laparoscopic surgery for CD has been established in numerous major centers. A wide range of procedures may be performed laparoscopically from stoma formation to extended colon and small bowel resections. The minimally-invasive approach shows short-term advantages in complex cases with previous conventional operations, recurrences, enteric fistula and abscess formations. Only limited indications or contraindications may be seen in cases like ileus where no sufficient visualization is obtained during laparoscopy and in acute and fulminant cases demanding a quick and safe surgical solution of the emergency situation. The size of the specimen which needs to be removed may restrict any type of minimally-invasive approach in extended disease.

In UC, laparoscopic restorative proctocolectomy with IPAA is carried out in major surgical centers for elective surgery, but also in cancer and emergency cases. Short and long-term results are comparable to open surgery; in some studies shorter hospital stays and earlier postoperative recovery have been observed. Long operative times and the long learning curve are still factors restricting a broad use of the minimally-invasive approach. A considerable variety of individual laparoscopic techniques is still being observed among different institutions. An important task for future studies will be the analysis of which case selection has the best benefit from a laparoscopic approach in inflammatory bowel diseases.

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