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TOPIC HIGHLIGHT

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Minimally invasive approaches for the treatment of inflammatory bowel disease

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Abstract

Despite significant improvements in medical management of inflammatory bowel disease, many of these patients still require surgery at some point in the course of their disease. Their young age and poor general conditions, worsened by the aggressive medical treatments, make minimally invasive approaches particularly enticing to this patient population. However, the typical inflammatory changes that characterize these diseases have hindered wide diffusion of laparoscopy in this setting, currently mostly pursued in high-volume referral centers, despite accumulating evidences in the literature supporting the benefits of minimally invasive surgery. The largest body of evidence currently available for terminal ileal Crohn's disease shows improved short term outcomes after laparoscopic surgery, with prolonged operative times. For Crohn's colitis, high quality evidence supporting laparoscopic surgery is lacking. Encouraging preliminary results have been obtained with the adoption of laparoscopic restorative total proctocolectomy for the treatment of ulcerative colitis. A consensus about patients' selection and the need for staging has not been reached yet. Despite the lack of conclusive evidence, a wave of enthusiasm is pushing towards less invasive strategies, to further minimize surgical trauma, with single incision laparoscopic surgery being the most realistic future development.

Key words: Laparoscopic surgery; Inflammatory bowel disease; Ulcerative colitis; Crohn's disease

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INTRODUCTION

The past 20 years have seen dramatic improvements in the treatment of inflammatory bowel disease (IBD)[1]. Medical therapy, especially with the advent of biologics, has significantly increased efficacy of disease control, even if the actual reduction of the need for surgery is still debated, and concerns have been raised about po-

tential negative impact on postoperative outcomes[2,3]. In this setting, the introduction and implementation of minimally invasive surgical techniques has substantially improved outcomes and quality of life in this particularly frail patient population[4,5]. After the first description of laparoscopic colectomy about 20 years ago, laparoscopic surgery slowly has gained wide acceptance for the treatment of colorectal diseases, showing several advantages in short-term outcomes over open surgery in randomized trials and meta-analysis, with comparable safety and long-term results[6-9]. However, the diffusion of laparoscopy for IBD is proceeding particularly cautiously, given the magnitude of the procedures required for the most complex cases and the difficulty in handling severely inflamed tissues, as proven by the high conversion rates observed even in the hands of surgeons with documented experience in IBD and laparoscopic surgery[10,11]. Cronh's disease (CD) and ulcerative colitis (UC) represent real surgical challenges, due to thickened mesentery, strictures, abscesses, inflammatory masses, and enteric fistulae in CD, and intense inflammation leading to colonic distension and high risk of bleeding and accidental perforation in UC[12,13]. The quest for further reduction of surgical trauma is ongoing, and if the natural orifice transluminal endoscopic surgery has unsolved issues related to the violation of uninvolved hollow viscera, costs and specific training, single incision laparoscopic surgery (SILS) seems to be a reasonable approach capable of minimizing the overall trauma and extent of incisions, with benefits in short term outcomes and cosmesis[14-17].

The aim of this article is to provide a comprehensive review of the state of the art in minimally invasive approaches to IBD, highlighting the current standard of care, with a glance at the most promising future directions.

CD

Approximately 70% of patients with a diagnosis of CD will eventually require a surgical treatment, due to failure of medical therapy, septic complications, recurrent intestinal obstruction, and malnutrition[18]. The treatment of CD has traditionally represented a challenge even in open surgery, with just two prospective randomized trials comparing laparoscopic *vs* standard approach published to date[19,20], and with the long-term results of these studies only recently available[21,22]. The panintestinal involvement and inflammatory complications, along with the additional risk for postoperative complication, increased by the aggressive medical management, make CD patients particularly poor laparoscopic candidates[23]. Concerns have been raised about missing occult segments of disease and critical strictures due to the lack of tactile sensation, technical difficulty due to inflamed bowel mesentery and the presence of adhesions, fistulas, and abscesses[24]. In order to overcome this issues, some authors have advocated the use of laparoscopic-assisted or hand-assisted laparoscopic surgery procedures, with the rationale that an incision is needed for specimen extraction, and the handling of inflamed Crohn's tissue is easier and safer when an assisted method is used, while maintaining the advantages of a minimally invasive approach[25]. The intrinsic difficulty of this surgery is further confirmed by a study by Hamel *at al*[26], that showed no differences in morbidity or conversion between the earlier and the latter time periods of the experience, thus negating the effects of the learning curve. Alves *et al*[27] looked at the risk factors of conversion in a prospective study on 69 patients undergoing primary laparoscopic ileocecal resection, observing a conversion rate of 30%, with recurrent CD, intra-abdominal abscess and fistula independent risk factors on multivariate analysis. Even if minimally invasive surgery for CD is technically complex, requiring specific training and longer operating time[28], data in the literature confirm the safety and efficacy of this approach in terms of postoperative pain, cosmesis, return to normal activity, and, more importantly, surgical recurrence rates[29]. Despite this evidence, in a recent study by Lesperance *et al*[30] on 49 609 patients admitted for CD that required surgical treatment from the 2000-2004 Nationwide Inpatient Sample, only 2826 cases (6%) underwent a laparoscopic resection, demonstrating that the vast majority of CD patients are still undergoing open conventional surgery, with a minimal invasive approach mostly reserved for patients who are younger (< 35 years old), female, admitted to a teaching hospital, with ileocecal, uncomplicated disease. The increased adoption of the laparoscopic approach for the treatment of CD in teaching hospitals confirms the peculiar technical complexity of minimally invasive procedures in this setting, requiring more skilled colorectal surgeons, as can be found in referral centers where specific laparoscopic training programs are implemented.

Terminal ileal CD

The small samples size and selection bias explain the conflicting results in the initial published series of ileocolonic CD treated by laparoscopic surgery[28,31-34]. In our series of selected consecutive patients with elective, complex and even recurrent terminal ileal CD, laparoscopic patients had faster postoperative recovery - partially related to less postoperative pain and consequent decreased need for intravenous narcotics - and similar operating times compared to the open cohort, without increased complication and recurrence rates, with potential overall cost savings[35]. In regards to the issue of costs associated with laparoscopy, Young-Fadok *et al*[36], in a case match study comparing 33 cases of laparoscopic ileocolic resections with 33 open, showed significantly lower direct and indirect costs in the laparoscopic group. The strongest evidence available comes from the only two prospective randomized trials present in the literature, both conducted on small samples of highly selected patients. Although such populations might be far from the reality of a tertiary referral center, it is the only way to randomize CD patients given the panintestinal, relenting nature and often unpredictable presentation of the disease. In the trial by Maartense *et al*[19], patients with

a fixed palpable inflammatory mass, prior median laparotomy, earlier bowel resection, or pregnancy were excluded. In this study, the laparoscopic approach showed longer median operating time, shorter hospital stay, lower 30-d post-operative morbidity, but no differences in quality of life, the primary endpoint of this study. After a median follow-up of 6.7 year, there were no differences in recurrence rate and need for reoperation between open and laparoscopic group, with a 58% relapse free rate and no patients in the laparoscopic group requiring a reoperation for incisional hernia or adhesive small bowel obstruction[21]. Even if a minimal invasive approach did not impact the overall quality of life, body image and cosmesis scores were significantly higher after laparoscopy[21]. These data differ from the previous observation by Thaler and colleagues, that found long-term quality of life significantly reduced in patients with CD compared to general healthy population, irrespective of the surgical approach, with recurrence identified as the only significant predictor of poor quality of life[37]. In the other randomized trial, Milsom *et al*[20] included only patients with isolated Crohn's disease of the terminal ileum with or without cecal involvement. The results of this study demonstrated that laparoscopy offers faster recovery of pulmonary function, fewer minor complications, and a trend towards shorter length of stay compared with conventional surgery, even if no differences in the amount of morphine equivalents, return of bowel function and length of stay were found. After a mean follow-up of 10.5 years there were no significant differences between groups with regard to use of medications to treat CD and recurrence rates, both clinical and surgical. Furthermore, two laparoscopic patients underwent lysis of adhesions while none did in the open group, with an incidence of incisional hernia repair of 4% in the laparoscopic group *vs* 14% in the open (both differences were not statistically significant)[22]. Recently, Dasari *et al*[38] conducted a meta-analysis of the aforementioned trials, and found that laparoscopic patients had a trend towards less wound infection and shorter hospital stay, with comparable incidence of other postoperative complications, duration of postoperative ileus, incidence of anastomotic leak and intraabdominal abscess, 30-d reoperation rate, and actuarial disease recurrence rates. To date, three meta-analysis comparing laparoscopic and open surgery for ileocolonic CD have been conducted, all demonstrating that laparoscopic surgery is associated with prolonged operative time, shorter duration of postoperative ileus, shorter hospital stay and lower incidence of early postoperative complications[39-41]. Other significant findings from these studies also include similar intraoperative blood loss and complications[41], with a trend toward lower overall costs with laparoscopic surgery[39], and no differences in the rate of disease recurrence[40]. With regard to the long-term outcomes, the study from Washington University, comparing 63 CD patients treated laparoscopically with 50 open ileocolic resections, found that the two groups had a recurrence rate of 9.5% and 24%, respectively (difference not statistically significant), with the laparoscopic group having shorter mean follow-up, thus confirming the non-inferiority of the laparoscopic approach. Interestingly, 50% of the recurrences in the laparoscopic group and 33% in the open group were able to be retreated laparoscopically[29].

Laparoscopy in complicated/recurrent CD

In complicated CD laparoscopy is even more challenging. Seymour and Kavic analyzed their series of 17 patients managed with laparoscopic approach for complicated CD (defined as for the presence of fistulas, multiple or long-segment disease, abscesses and previous operations). In this study, conversion to open procedures was not always required, but operative time and postoperative hospital stay were longer compared to laparoscopic ileocecal resections for uncomplicated disease, with major complications occurring in 18% of patients[42]. In the literature, surgical recurrence rates are reported as high as 70% to 90%, and multiple procedures are required in more than 30%[12]. In a recent study from France, of 62 reoperations for CD recurrence in 57 patients, 29 were performed laparoscopically. While no differences between the two groups were observed in terms of use of a temporary stoma, mean operating time, postoperative mortality (nil in both groups), overall morbidity rate, severe complications, median hospital stay, and conversion rates, a higher number of intraoperative intestinal injuries was reported in the laparoscopic group (5 *vs* 0) (P = 0.01). The occurrence of fistulizing disease was a risk factor for conversion, and conversion did not seem to affect complication rate[43]. A study from Japan looked at 16 laparoscopic procedures for CD recurrence at the anastomotic site out of 61 attempted laparoscopically by experienced surgeons in 52 patients. The result of this study showed that while the operating time was significantly longer in the recurrent group, there were no differences in the rates of postoperative complications and hospital stay, with the repeated laparoscopic operations performed using the same small incision as that of the primary operation. The advantage of a minimally invasive primary approach are supported by the fact that the operating time was shorter and blood loss was less in patients who underwent the primary procedure laparoscopically[44]. Finally, in the experience by Goyer *et al*[45] on 54 complex CD (defined as recurrent or complicated by abscess and/or fistula) compared with 70 patients with uncomplicated CD, the complex group had increased operative time, conversion rates and use of temporary stoma. Conversely, no differences were noted in overall postoperative morbidity, including major surgical postoperative complications and hospital stay, leading to the conclusion that complex CD should not be considered an absolute contraindication to a laparoscopic approach in experienced hands.

Crohn's colitis

In contrast with the data available on minimally invasive

surgery for terminal ileal CD, very few series have been published on CD of the colon. The feasibility and safety of a laparoscopic approach to subtotal colectomy for CD was addressed by Hamel *et al*[46], who observed a higher rate of intraoperative complications compared to ileocolic resection, while hospital stay and postoperative complication rate did not differ between the two groups. Contrasting results come from a recent case match study by the Cleveland Clinic group on 27 laparoscopic and 27 open cases, with a conversion rate of 26%. In this series, laparoscopic colectomies took longer with similar blood loss and postoperative complications, along with a trend towards shorter time to first bowel movement and length of stay, which became statistically significant in favor of laparoscopy when overall length of stay included 30-d readmissions[47]. In our own personal experience on 125 patients who underwent colectomy for CD, 44% by a laparoscopic approach, the conversion rate was 10.9%, median operative time, blood loss, return of bowel function and length of post-op stay were reduced in the laparoscopic group, while postoperative complications and disease recurrence rates were similar, suggesting that a laparoscopic approach for CD of the colon is safe and feasible in the hands of experienced surgeons[48].

Laparoscopy has a role also in creating diverting stomas for severe perianal CD, reducing the number of incisions to few trocars and the ostomy site. In a study by Liu *et al*[49] on 80 patients who underwent laparoscopic stoma creation over a 10-year period (ileostomy 30, colostomy 49, conversion 1), the overall morbidity rate was 11% with five major complications requiring re-operation, and no further stoma complications recorded within a 1-year follow-up.

UC

Despite significant advances in the medical treatment of UC, surgery remains definitive cure for these patients after failure of medical management or diagnosis of neoplastic degeneration[50,51]. A restorative procedure with the creation of an ileal pouch anal anastomosis (IPAA) is universally considered the standard of care. The earliest reports of a laparoscopic approach to ulcerative colitis was published in 1992 by Peters *et al*[52], who described the technique of laparoscopic proctocolectomy for two UC patients. The same year, Wexner and colleagues reported the first case-controlled series on the outcome of laparoscopic-assisted proctocolectomy with IPAA, showing a longer operative time compared to open procedure, and comparable postoperative ileus and hospital stay, with no shot-term benefits in favor of laparoscopy[53]. Since then, numerous series have been reported both in the adult and pediatric patient populations[54-56], but only from single institutions with short follow-ups[5,57]. Universally, these initial studies showed that laparoscopy took longer, with the exception of the series published by Araki *et al*[58]. In these studies only the colonic mobilization was performed laparoscopically, with vessel transection and rectal mobilization carried out through a mini laparotomy[53,58-61], with the exception of the series reported by Marcello *et al*[55], where a totally laparoscopic techniques was adopted, reserving a mini laparotomy only for specimen extraction. Subsequently, in a study from the Netherlands, 60 patients were randomized for hand assisted or laparoscopic restorative proctocolectomy with IPAA. The results from this study failed to show statistically significant differences in terms of morbidity, postoperative stay, quality of life at 3 mo after surgery, and overall costs, but the operative time for laparoscopy was significantly longer[62]. In a subsequent study, Polle *et al*[63] observed that female patients reported higher body image and cosmesis scores compared to open group, while there were no differences in functional outcome, morbidity, and overall quality of live. Similarly, Dunker *et al*[59] compared 16 patients who underwent restorative surgery with laparoscopic technique with 19 open patients. The authors found that laparoscopic patients showed significantly higher satisfaction with the cosmetic results and better body image, but once again functional outcome and quality of life were similar between groups. It seems evident, as it may have been expected, that laparoscopic IPAA offers significant advantages over the open conventional procedure in terms of body image and cosmesis, important factors in the acceptance of surgery in this young patient population, while conflicting results have been reported in terms of postoperative recovery. Faster return of bowel function after laparoscopy and decreased use of narcotics have been reported by some authors, not always translating into shorter hospital stay[57,62]. On the other hand, concerns have been raised regarding the duration of surgery often noted to be longer than open surgery even by very experienced laparoscopic surgeons, often resulting in higher costs. In regards to long-term pouch function, quality of life and complications, very few studies are available with adequate follow-up[5,57,62,63,59]. These observations were confirmed in a Cochrane review on 607 patients from 12 studies, only one randomized, which did not found any significant differences in complications, readmission, reoperation rates and mortality. However, once again, it showed that laparoscopic IPAA is associated with a significantly longer operating time, along with the inability to confirm conclusively the presumed short-term benefits of laparoscopy, with length of follow-up too short for evaluating long-term outcomes[64]. Similar results were obtained in a subsequent meta-analysis on 16 studies, only one randomized, by Wu *et al*[13]. Postoperative fasting time and hospital stay were shorter for laparoscopy, and overall complication rates were higher after open surgery. Once again, laparoscopy took significantly longer and no advantages were demonstrated in terms of recovery of bowel function, postoperative septic complications, anastomotic leakage, postoperative bowel obstruction, blood loss, and mortality[13]. In our personal experience with 73 laparoscopic IPAA with a mean follow-up of 24 mo, the minimally invasive ap-

proach offered a statistically significant earlier return of flatus and resumption of diet, less intraoperative blood loss, and lower incidence of incisional hernias compared to 106 open IPAA, with no differences in overall complication rate, pouch function and quality of life[65].

The controversy about the safety of a single-stage procedure has not been resolved yet. Since long-term functional outcomes after IPAA are threatened by the occurrence of pouch-related septic complications, every effort should be made to reduce such complications and to identify patients at risk for pouch-related sepsis[66]. In a study by Marcello *et al*[67] on 59 patients who underwent laparoscopic proctocolectomy for UC, where only 9 patients received a diverting stoma at the primary procedure, 9 patients, all on high dose immunosuppressors or elevated body mass index, required a secondary ileostomy for postoperative complications. Better results were reported by Ky *et al*[68], with only one out 32 patients with an anastomotic leak requiring secondary diversion after one-stage laparoscopic restorative proctocolectomy. It is hard to analyze these data since these results can be influenced by patients' selection; pelvic sepsis is reported to occur in up to 23% of patients after IPAA for UC, especially after the introduction of biologic therapy for IBD, in most cases secondary to an anastomotic leak[66,69-72]. In a recent study on 118 UC patients treated with a minimally invasive approach, we compared a 3-stage approach (laparoscopic abdominal colectomy followed by pouch surgery with a diverting loop ileostomy, 50 patients) with a 2-stage approach (laparoscopy colectomy with IPAA and diverting stoma at the initial operation, 68 patients). We observed a significant higher rate of septic complications in the 2-stage group (38.2% *vs* 21%, $P < 0.05$), despite 3-stage patients had been receiving a more aggressive medical therapy in the immediate preoperative period[73].

The role of laparoscopy for the treatment of ulcerative colitis in the emergency setting has been investigated by two studies. In the study by Bella and Seymour, 18 patients underwent laparoscopic-assisted restorative proctocolectomy for fulminant colitis, reporting a postoperative complication rate of 33%, with a length of stay of 5.0 d, which was shorter compared to the 8.8 d reported for the 6 open cases analyzed in the study[74]. The other study, by Marcello *et al*[67], reviewed the data from 19 laparoscopic and 29 conventional total colectomies with end ileostomy and mucous fistula buried within subcutaneous tissue for acute, not fulminant, UC, demonstrating longer operative time (210 *vs* 120 min) but lower complication rates (16% *vs* 24%), earlier return of bowel function (1 *vs* 2 d) and shorter length of stay (4 *vs* 6 d) for the laparoscopic group.

SILS IN IBD

During the last few years an increasing number of reports and case series on SILS colorectal resections for both benign and malignant diseases have been reported. Few studies have been published comparing SILS to standard laparoscopy, showing potential for improved short-term outcomes[75-78]. Besides the obvious cosmetic advantage resulting from a reduced number and size of scars - particularly important in a young IBD patient population - limiting the incisions seems to result in less postoperative pain, less use of narcotic pain medications, with consequent faster recovery and earlier discharge, along with a lower incidence of wound-related complications[17,76,78-80]. These data are still preliminary, with only few cases of SILS for UC published to date[4,16,17,75-78,81-92]. We believe that particularly for total abdominal colectomy (TAC) the SILS approach is a very attractive option in this patient population, representing a true "scarless" procedure, with the only access to the abdominal cavity at the site of the future stoma. Our preliminary results with the adoption of a well-standardized SILS approach to TAC confirm the potential of this technique in improving the postoperative recovery in selected patients, without significant increases in operative time and costs[93].

CONCLUSION

During the past three decades the evidence has been accumulating in favor of a minimally invasive approach to IBD. Crohn's disease is probably one of the most challenging diseases to treat laparoscopically for the colorectal surgeons, especially when the disease is located in the colon and involves multiple segments, thus explaining the fact that in the United States the majority of CD patients are still approached with open surgery. Laparoscopic IPAA for UC has been shown to be feasible, but to date the evidence present in the literature is still not conclusive. Current data suggest a shorter length of stay, shorter ileus, faster recovery and less postoperative pain, along with better cosmesis with minimally invasive surgery. On the other hand, significantly longer operative times with laparoscopy are universally reported. Our goal and responsibility is to explore new avenues for a true minimally invasive approach to IBD and to train the next generation of surgeons to facilitate wide spread acceptance of laparoscopy.

REFERENCES

1 **Baumgart DC**, Sandborn WJ. Inflammatory bowel disease: clinical aspects and established and evolving therapies. *Lancet* 2007; **369**: 1641-1657
2 **Cohen RD**, Tsang JF, Hanauer SB. Infliximab in Crohn's disease: first anniversary clinical experience. *Am J Gastroenterol* 2000; **95**: 3469-3477
3 **Kunitake H**, Hodin R, Shellito PC, Sands BE, Korzenik J, Bordeianou L. Perioperative treatment with infliximab in patients with Crohn's disease and ulcerative colitis is not associated with an increased rate of postoperative complications. *J Gastrointest Surg* 2008; **12**: 1730-1736; discussion 1736-1737
4 **Reissman P**, Salky BA, Pfeifer J, Edye M, Jagelman DG, Wexner SD. Laparoscopic surgery in the management of inflammatory bowel disease. *Am J Surg* 1996; **171**: 47-50; discussion 50-51
5 **Larson DW**, Davies MM, Dozois EJ, Cima RR, Piotrowicz K,

Anderson K, Barnes SA, Harmsen WS, Young-Fadok TM, Wolff BG, Pemberton JH. Sexual function, body image, and quality of life after laparoscopic and open ileal pouch-anal anastomosis. *Dis Colon Rectum* 2008; **51**: 392-396
6 **Jacobs M**, Verdeja JC, Goldstein HS. Minimally invasive colon resection (laparoscopic colectomy). *Surg Laparosc Endosc* 1991; **1**: 144-150
7 **Guillou PJ**, Quirke P, Thorpe H, Walker J, Jayne DG, Smith AM, Heath RM, Brown JM. Short-term endpoints of conventional versus laparoscopic-assisted surgery in patients with colorectal cancer (MRC CLASICC trial): multicentre, randomised controlled trial. *Lancet* 2005; **365**: 1718-1726
8 **Veldkamp R**, Kuhry E, Hop WC, Jeekel J, Kazemier G, Bonjer HJ, Haglind E, Påhlman L, Cuesta MA, Msika S, Morino M, Lacy AM. Laparoscopic surgery versus open surgery for colon cancer: short-term outcomes of a randomised trial. *Lancet Oncol* 2005; **6**: 477-484
9 **Bonjer HJ**, Hop WC, Nelson H, Sargent DJ, Lacy AM, Castells A, Guillou PJ, Thorpe H, Brown J, Delgado S, Kuhrij E, Haglind E, Påhlman L. Laparoscopically assisted vs open colectomy for colon cancer: a meta-analysis. *Arch Surg* 2007; **142**: 298-303
10 **Casillas S**, Delaney CP, Senagore AJ, Brady K, Fazio VW. Does conversion of a laparoscopic colectomy adversely affect patient outcome? *Dis Colon Rectum* 2004; **47**: 1680-1685
11 **Pandya S**, Murray JJ, Coller JA, Rusin LC. Laparoscopic colectomy: indications for conversion to laparotomy. *Arch Surg* 1999; **134**: 471-475
12 **Duepree HJ**, Senagore AJ, Delaney CP, Brady KM, Fazio VW. Advantages of laparoscopic resection for ileocecal Crohn's disease. *Dis Colon Rectum* 2002; **45**: 605-610
13 **Wu XJ**, He XS, Zhou XY, Ke J, Lan P. The role of laparoscopic surgery for ulcerative colitis: systematic review with meta-analysis. *Int J Colorectal Dis* 2010; **25**: 949-957
14 **Bresadola F**, Pasqualucci A, Donini A, Chiarandini P, Anania G, Terrosu G, Sistu MA, Pasetto A. Elective transumbilical compared with standard laparoscopic cholecystectomy. *Eur J Surg* 1999; **165**: 29-34
15 **Marescaux J**, Dallemagne B, Perretta S, Wattiez A, Mutter D, Coumaros D. Surgery without scars: report of transluminal cholecystectomy in a human being. *Arch Surg* 2007; **142**: 823-826; discussion 826-827
16 **Leroy J**, Cahill RA, Asakuma M, Dallemagne B, Marescaux J. Single-access laparoscopic sigmoidectomy as definitive surgical management of prior diverticulitis in a human patient. *Arch Surg* 2009; **144**: 173-179; discussion 179
17 **Chambers WM**, Bicsak M, Lamparelli M, Dixon AR. Single-incision laparoscopic surgery (SILS) in complex colorectal surgery: a technique offering potential and not just cosmesis. *Colorectal Dis* 2011; **13**: 393-398
18 **Fazio VW**, Tjandra JJ, Lavery IC, Church JM, Milsom JW, Oakley JR. Long-term follow-up of strictureplasty in Crohn's disease. *Dis Colon Rectum* 1993; **36**: 355-361
19 **Maartense S**, Dunker MS, Slors JF, Cuesta MA, Pierik EG, Gouma DJ, Hommes DW, Sprangers MA, Bemelman WA. Laparoscopic-assisted versus open ileocolic resection for Crohn's disease: a randomized trial. *Ann Surg* 2006; **243**: 143-149; discussion 150-153
20 **Milsom JW**, Hammerhofer KA, Böhm B, Marcello P, Elson P, Fazio VW. Prospective, randomized trial comparing laparoscopic vs. conventional surgery for refractory ileocolic Crohn's disease. *Dis Colon Rectum* 2001; **44**: 1-8; discussion 8-9
21 **Eshuis EJ**, Slors JF, Stokkers PC, Sprangers MA, Ubbink DT, Cuesta MA, Pierik EG, Bemelman WA. Long-term outcomes following laparoscopically assisted versus open ileocolic resection for Crohn's disease. *Br J Surg* 2010; **97**: 563-568
22 **Stocchi L**, Milsom JW, Fazio VW. Long-term outcomes of laparoscopic versus open ileocolic resection for Crohn's disease: follow-up of a prospective randomized trial. *Surgery* 2008; **144**: 622-627; discussion 627-628
23 **Appau KA**, Fazio VW, Shen B, Church JM, Lashner B, Remzi F, Brzezinski A, Strong SA, Hammel J, Kiran RP. Use of infliximab within 3 months of ileocolonic resection is associated with adverse postoperative outcomes in Crohn's patients. *J Gastrointest Surg* 2008; **12**: 1738-1744
24 **Uchikoshi F**, Ito T, Nezu R, Tanemura M, Kai Y, Mizushima T, Nakajima K, Tamagawa H, Matsuda C, Matsuda H. Advantages of laparoscope-assisted surgery for recurrent Crohn's disease. *Surg Endosc* 2004; **18**: 1675-1679
25 **Milsom JW**. Laparoscopic surgery in the treatment of Crohn's disease. *Surg Clin North Am* 2005; **85**: 25-34; vii
26 **Hamel CT**, Pikarsky AJ, Wexner SD. Laparoscopically assisted hemicolectomy for Crohn's disease: are we still getting better? *Am Surg* 2002; **68**: 83-86
27 **Alves A**, Panis Y, Bouhnik Y, Marceau C, Rouach Y, Lavergne-Slove A, Vicaut E, Valleur P. Factors that predict conversion in 69 consecutive patients undergoing laparoscopic ileocecal resection for Crohn's disease: a prospective study. *Dis Colon Rectum* 2005; **48**: 2302-2308
28 **Bemelman WA**, Slors JF, Dunker MS, van Hogezand RA, van Deventer SJ, Ringers J, Griffioen G, Gouma DJ. Laparoscopic-assisted vs. open ileocolic resection for Crohn's disease. A comparative study. *Surg Endosc* 2000; **14**: 721-725
29 **Lowney JK**, Dietz DW, Birnbaum EH, Kodner IJ, Mutch MG, Fleshman JW. Is there any difference in recurrence rates in laparoscopic ileocolic resection for Crohn's disease compared with conventional surgery? A long-term, follow-up study. *Dis Colon Rectum* 2006; **49**: 58-63
30 **Lesperance K**, Martin MJ, Lehmann R, Brounts L, Steele SR. National trends and outcomes for the surgical therapy of ileocolonic Crohn's disease: a population-based analysis of laparoscopic vs. open approaches. *J Gastrointest Surg* 2009; **13**: 1251-1259
31 **Benoist S**, Panis Y, Beaufour A, Bouhnik Y, Matuchansky C, Valleur P. Laparoscopic ileocecal resection in Crohn's disease: a case-matched comparison with open resection. *Surg Endosc* 2003; **17**: 814-818
32 **Bergamaschi R**, Pessaux P, Arnaud JP. Comparison of conventional and laparoscopic ileocolic resection for Crohn's disease. *Dis Colon Rectum* 2003; **46**: 1129-1133
33 **Huilgol RL**, Wright CM, Solomon MJ. Laparoscopic versus open ileocolic resection for Crohn's disease. *J Laparoendosc Adv Surg Tech A* 2004; **14**: 61-65
34 **Alabaz O**, Iroatulam AJ, Nessim A, Weiss EG, Nogueras JJ, Wexner SD. Comparison of laparoscopically assisted and conventional ileocolic resection for Crohn's disease. *Eur J Surg* 2000; **166**: 213-217
35 **Fichera A**, Peng SL, Elisseou NM, Rubin MA, Hurst RD. Laparoscopy or conventional open surgery for patients with ileocolonic Crohn's disease? A prospective study. *Surgery* 2007; **142**: 566-571; discussion 571.e1
36 **Young-Fadok TM**, HallLong K, McConnell EJ, Gomez Rey G, Cabanela RL. Advantages of laparoscopic resection for ileocolic Crohn's disease. Improved outcomes and reduced costs. *Surg Endosc* 2001; **15**: 450-454
37 **Thaler K**, Dinnewitzer A, Oberwalder M, Weiss EG, Nogueras JJ, Wexner SD. Assessment of long-term quality of life after laparoscopic and open surgery for Crohn's disease. *Colorectal Dis* 2005; **7**: 375-381
38 **Dasari BV**, McKay D, Gardiner K. Laparoscopic versus Open surgery for small bowel Crohn's disease. *Cochrane Database Syst Rev* 2011; (1): CD006956
39 **Rosman AS**, Melis M, Fichera A. Metaanalysis of trials comparing laparoscopic and open surgery for Crohn's disease. *Surg Endosc* 2005; **19**: 1549-1555
40 **Tan JJ**, Tjandra JJ. Laparoscopic surgery for Crohn's disease: a meta-analysis. *Dis Colon Rectum* 2007; **50**: 576-585
41 **Tilney HS**, Constantinides VA, Heriot AG, Nicolaou M, Athanasiou T, Ziprin P, Darzi AW, Tekkis PP. Comparison

of laparoscopic and open ileocecal resection for Crohn's disease: a metaanalysis. *Surg Endosc* 2006; **20**: 1036-1044
42 **Seymour NE**, Kavic SM. Laparoscopic management of complex Crohn's disease. *JSLS* 2003; **7**: 117-121
43 **Brouquet A**, Bretagnol F, Soprani A, Valleur P, Bouhnik Y, Panis Y. A laparoscopic approach to iterative ileocolonic resection for the recurrence of Crohn's disease. *Surg Endosc* 2010; **24**: 879-887
44 **Hasegawa H**, Watanabe M, Nishibori H, Okabayashi K, Hibi T, Kitajima M. Laparoscopic surgery for recurrent Crohn's disease. *Br J Surg* 2003; **90**: 970-973
45 **Goyer P**, Alves A, Bretagnol F, Bouhnik Y, Valleur P, Panis Y. Impact of complex Crohn's disease on the outcome of laparoscopic ileocecal resection: a comparative clinical study in 124 patients. *Dis Colon Rectum* 2009; **52**: 205-210
46 **Hamel CT**, Hildebrandt U, Weiss EG, Feifelz G, Wexner SD. Laparoscopic surgery for inflammatory bowel disease. *Surg Endosc* 2001; **15**: 642-645
47 **da Luz Moreira A**, Stocchi L, Remzi FH, Geisler D, Hammel J, Fazio VW. Laparoscopic surgery for patients with Crohn' s colitis: a case-matched study. *J Gastrointest Surg* 2007; **11**: 1529-1533
48 **Umanskiy K**, Malhotra G, Chase A, Rubin MA, Hurst RD, Fichera A. Laparoscopic colectomy for Crohn's colitis. A large prospective comparative study. *J Gastrointest Surg* 2010; **14**: 658-663
49 **Liu J**, Bruch HP, Farke S, Nolde J, Schwandner O. Stoma formation for fecal diversion: a plea for the laparoscopic approach. *Tech Coloproctol* 2005; **9**: 9-14
50 **Järnerot G**, Hertervig E, Friis-Liby I, Blomquist L, Karlén P, Grännö C, Vilien M, Ström M, Danielsson A, Verbaan H, Hellström PM, Magnuson A, Curman B. Infliximab as rescue therapy in severe to moderately severe ulcerative colitis: a randomized, placebo-controlled study. *Gastroenterology* 2005; **128**: 1805-1811
51 **Rutgeerts P**, Sandborn WJ, Feagan BG, Reinisch W, Olson A, Johanns J, Travers S, Rachmilewitz D, Hanauer SB, Lichtenstein GR, de Villiers WJ, Present D, Sands BE, Colombel JF. Infliximab for induction and maintenance therapy for ulcerative colitis. *N Engl J Med* 2005; **353**: 2462-2476
52 **Peters WR**. Laparoscopic total proctocolectomy with creation of ileostomy for ulcerative colitis: report of two cases. *J Laparoendosc Surg* 1992; **2**: 175-178
53 **Wexner SD**, Johansen OB, Nogueras JJ, Jagelman DG. Laparoscopic total abdominal colectomy. A prospective trial. *Dis Colon Rectum* 1992; **35**: 651-655
54 **Larson DW**, Dozois EJ, Piotrowicz K, Cima RR, Wolff BG, Young-Fadok TM. Laparoscopic-assisted vs. open ileal pouch-anal anastomosis: functional outcome in a case-matched series. *Dis Colon Rectum* 2005; **48**: 1845-1850
55 **Marcello PW**, Milsom JW, Wong SK, Hammerhofer KA, Goormastic M, Church JM, Fazio VW. Laparoscopic restorative proctocolectomy: case-matched comparative study with open restorative proctocolectomy. *Dis Colon Rectum* 2000; **43**: 604-608
56 **Meier AH**, Roth L, Cilley RE, Dillon PW. Completely minimally invasive approach to restorative total proctocolectomy with j-pouch construction in children. *Surg Laparosc Endosc Percutan Tech* 2007; **17**: 418-421
57 **Larson DW**, Cima RR, Dozois EJ, Davies M, Piotrowicz K, Barnes SA, Wolff B, Pemberton J. Safety, feasibility, and short-term outcomes of laparoscopic ileal-pouch-anal anastomosis: a single institutional case-matched experience. *Ann Surg* 2006; **243**: 667-670; discussion 670-672
58 **Araki Y**, Ishibashi N, Ogata Y, Shirouzu K, Isomoto H. The usefulness of restorative laparoscopic-assisted total colectomy for ulcerative colitis. *Kurume Med J* 2001; **48**: 99-103
59 **Dunker MS**, Bemelman WA, Slors JF, van Duijvendijk P, Gouma DJ. Functional outcome, quality of life, body image, and cosmesis in patients after laparoscopic-assisted and conventional restorative proctocolectomy: a comparative study. *Dis Colon Rectum* 2001; **44**: 1800-1807
60 **Hashimoto A**, Funayama Y, Naito H, Fukushima K, Shibata C, Naitoh T, Shibuya K, Koyama K, Takahashi K, Ogawa H, Satoh S, Ueno T, Kitayama T, Matsuno S, Sasaki I. Laparascope-assisted versus conventional restorative proctocolectomy with rectal mucosectomy. *Surg Today* 2001; **31**: 210-214
61 **Schmitt SL**, Cohen SM, Wexner SD, Nogueras JJ, Jagelman DG. Does laparoscopic-assisted ileal pouch anal anastomosis reduce the length of hospitalization? *Int J Colorectal Dis* 1994; **9**: 134-137
62 **Maartense S**, Dunker MS, Slors JF, Cuesta MA, Gouma DJ, van Deventer SJ, van Bodegraven AA, Bemelman WA. Hand-assisted laparoscopic versus open restorative proctocolectomy with ileal pouch anal anastomosis: a randomized trial. *Ann Surg* 2004; **240**: 984-991; discussion 991-992
63 **Polle SW**, Dunker MS, Slors JF, Sprangers MA, Cuesta MA, Gouma DJ, Bemelman WA. Body image, cosmesis, quality of life, and functional outcome of hand-assisted laparoscopic versus open restorative proctocolectomy: long-term results of a randomized trial. *Surg Endosc* 2007; **21**: 1301-1307
64 **Ahmed Ali U**, Keus F, Heikens JT, Bemelman WA, Berdah SV, Gooszen HG, van Laarhoven CJ. Open versus laparoscopic (assisted) ileo pouch anal anastomosis for ulcerative colitis and familial adenomatous polyposis. *Cochrane Database Syst Rev* 2009; (1): CD006267
65 **Fichera A**, Silvestri MT, Hurst RD, Rubin MA, Michelassi F. Laparoscopic restorative proctocolectomy with ileal pouch anal anastomosis: a comparative observational study on long-term functional results. *J Gastrointest Surg* 2009; **13**: 526-532
66 **Heuschen UA**, Allemeyer EH, Hinz U, Lucas M, Herfarth C, Heuschen G. Outcome after septic complications in J pouch procedures. *Br J Surg* 2002; **89**: 194-200
67 **Marcello PW**, Milsom JW, Wong SK, Brady K, Goormastic M, Fazio VW. Laparoscopic total colectomy for acute colitis: a case-control study. *Dis Colon Rectum* 2001; **44**: 1441-1445
68 **Ky AJ**, Sonoda T, Milsom JW. One-stage laparoscopic restorative proctocolectomy: an alternative to the conventional approach? *Dis Colon Rectum* 2002; **45**: 207-210; discussion 210-211
69 **Mor IJ**, Vogel JD, da Luz Moreira A, Shen B, Hammel J, Remzi FH. Infliximab in ulcerative colitis is associated with an increased risk of postoperative complications after restorative proctocolectomy. *Dis Colon Rectum* 2008; **51**: 1202-1207; discussion 1207-1210
70 **Selvasekar CR**, Cima RR, Larson DW, Dozois EJ, Harrington JR, Harmsen WS, Loftus EV, Sandborn WJ, Wolff BG, Pemberton JH. Effect of infliximab on short-term complications in patients undergoing operation for chronic ulcerative colitis. *J Am Coll Surg* 2007; **204**: 956-962; discussion 962-963
71 **Lim WC**, Hanauer SB. Emerging biologic therapies in inflammatory bowel disease. *Rev Gastroenterol Disord* 2004; **4**: 66-85
72 **Heuschen UA**, Hinz U, Allemeyer EH, Autschbach F, Stern J, Lucas M, Herfarth C, Heuschen G. Risk factors for ileoanal J pouch-related septic complications in ulcerative colitis and familial adenomatous polyposis. *Ann Surg* 2002; **235**: 207-216
73 **Pandey S**, Luther G, Umanskiy K, Malhotra G, Rubin MA, Hurst RD, Fichera A. Minimally invasive pouch surgery for ulcerative colitis: is there a benefit in staging? *Dis Colon Rectum* 2011; **54**: 306-310
74 **Bell RL**, Seymour NE. Laparoscopic treatment of fulminant ulcerative colitis. *Surg Endosc* 2002; **16**: 1778-1782
75 **Adair J**, Gromski MA, Lim RB, Nagle D. Single-incision laparoscopic right colectomy: experience with 17 consecutive cases and comparison with multiport laparoscopic right colectomy. *Dis Colon Rectum* 2010; **53**: 1549-1554
76 **Champagne BJ**, Lee EC, Leblanc F, Stein SL, Delaney CP. Single-incision vs straight laparoscopic segmental colectomy:

a case-controlled study. *Dis Colon Rectum* 2011; **54**: 183-186
77 **Gandhi DP**, Ragupathi M, Patel CB, Ramos-Valadez DI, Pickron TB, Haas EM. Single-incision versus hand-assisted laparoscopic colectomy: a case-matched series. *J Gastrointest Surg* 2010; **14**: 1875-1880
78 **Ross H**, Steele S, Whiteford M, Lee S, Albert M, Mutch M, Rivadeneira D, Marcello P. Early multi-institution experience with single-incision laparoscopic colectomy. *Dis Colon Rectum* 2011; **54**: 187-192
79 **Dunker MS**, Stiggelbout AM, van Hogezand RA, Ringers J, Griffioen G, Bemelman WA. Cosmesis and body image after laparoscopic-assisted and open ileocolic resection for Crohn's disease. *Surg Endosc* 1998; **12**: 1334-1340
80 **Munro MG**. Laparoscopic access: complications, technologies, and techniques. *Curr Opin Obstet Gynecol* 2002; **14**: 365-374
81 **Remzi FH**, Kirat HT, Kaouk JH, Geisler DP. Single-port laparoscopy in colorectal surgery. *Colorectal Dis* 2008; **10**: 823-826
82 **Geisler DP**, Condon ET, Remzi FH. Single incision laparoscopic total proctocolectomy with ileopouch anal anastomosis. *Colorectal Dis* 2010; **12**: 941-943
83 **Remzi FH**, Kirat HT, Geisler DP. Laparoscopic single-port colectomy for sigmoid cancer. *Tech Coloproctol* 2010; **14**: 253-255
84 **Bucher P**, Pugin F, Morel P. Single-port access laparoscopic radical left colectomy in humans. *Dis Colon Rectum* 2009; **52**: 1797-1801
85 **Cahill RA**, Lindsey I, Jones O, Guy R, Mortensen N, Cunningham C. Single-port laparoscopic total colectomy for medically uncontrolled colitis. *Dis Colon Rectum* 2010; **53**: 1143-1147
86 **Boni L**, Dionigi G, Cassinotti E, Di Giuseppe M, Diurni M, Rausei S, Cantore F, Dionigi R. Single incision laparoscopic right colectomy. *Surg Endosc* 2010; **24**: 3233-3236
87 **Brunner W**, Schirnhofer J, Waldstein-Wartenberg N, Frass R, Weiss H. Single incision laparoscopic sigmoid colon resections without visible scar: a novel technique. *Colorectal Dis* 2010; **12**: 66-70
88 **Leblanc F**, Makhija R, Champagne BJ, Delaney CP. Single incision laparoscopic total colectomy and proctocolectomy for benign disease: initial experience. *Colorectal Dis* 2011; **13**: 1290-1293
89 **Pietrasanta D**, Romano N, Prosperi V, Lorenzetti L, Basili G, Goletti O. Single-incision laparoscopic right colectomy for cancer: a single-centre preliminary experience. *Updates Surg* 2010; **62**: 111-115
90 **Leblanc F**, Champagne BJ, Augestad KM, Stein SL, Marderstein E, Reynolds HL, Delaney CP. Single incision laparoscopic colectomy: technical aspects, feasibility, and expected benefits. *Diagn Ther Endosc* 2010; **2010**: 913216
91 **Law WL**, Fan JK, Poon JT. Single-incision laparoscopic colectomy: early experience. *Dis Colon Rectum* 2010; **53**: 284-288
92 **Uematsu D**, Akiyama G, Matsuura M, Hotta K. Single-access laparoscopic colectomy with a novel multiport device in sigmoid colectomy for colon cancer. *Dis Colon Rectum* 2010; **53**: 496-501
93 **Fichera A**, Zoccali M, Gullo R. Single incision ("scarless") laparoscopic total abdominal colectomy with end ileostomy for ulcerative colitis. *J Gastrointest Surg* 2011; **15**: 1247-1251

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