REVIEW ARTICLE

Surgical management of Crohn's disease

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Abstract

Introduction Crohn's disease is an inflammatory bowel disease that can affect the entire gastrointestinal tract. It is chronic and incurable, and the mainstay of therapy is medical management with surgical intervention as complications arise. Surgery is required in approximately 70% of patients with Crohn's disease. Because repeat interventions are often needed, these patients may benefit from bowel-sparing techniques and minimally invasive approaches. Various bowel-sparing techniques, including strictureplasty, can be applied to reduce the risk of short-bowel syndrome.

Methods A review of the available literature using the PubMed search engine was undertaken to compile data on the surgical treatment of Crohn's disease.

Results and conclusion Data support the use of laparoscopy in treating Crohn's disease, although the potential technical challenges in these settings mandate appropriate prerequisite surgical expertise.

Keywords Crohn's disease · Treatment · Surgery · Laparoscopy

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Crohn's disease is an inflammatory bowel disease that can affect the entire gastrointestinal tract. It is characterized by patchy granulomatous inflammation of the whole thickness of the bowel. The incidence of Crohn's disease is 5–10 per 100,000 people per year, and the prevalence is 50–100 per 100,000 people [1]. Disease patterns include small-bowel and large-bowel disease (26–48%), small intestine disease only (11–48%), and colon disease only (19–51%) [2]. The most common pattern is terminal ileum and cecal involvement (55%). Crohn's disease is chronic and incurable, and the mainstay of therapy is medical management and surgical management as complications arise. Surgical treatment is required in approximately 70% of patients with Crohn's disease [3]. Unfortunately, 30–70% of all patients require repeat operations [4]; these patients in particular may benefit from bowel-sparing techniques and a minimally invasive approach when resection is required.

Bowel-sparing techniques

The treatment of Crohn's disease is primarily medical therapy, with surgery often reserved for complications. Surgery can be divided into resection procedures and bowel-sparing procedures. Traditionally, resection was performed to leave disease-free margins for anastomosis. Subsequently, it has been established that the presence or absence of disease-free margins does not affect recurrence rate [5]. The preferred method is limited resection, removing the most diseased portions of bowel and leaving other disease behind. Alternatively, the most common bowel-sparing procedure is strictureplasty. Katariya et al. (1977) reported a series of nine patients who were treated with strictureplasties for obstructive symptoms of tuberculosis [6]. In 1982, Lee and Papionannou

subsequently reported their results for obstructive symptoms in nine patients with Crohn's disease [7].

The main advantage of strictureplasty is the preservation of small bowel and avoidance of short-bowel syndrome. The length of remaining small bowel is a very important consideration in decisions about whether to pursue traditional resection or strictureplasty. Patients with less than 100–200 cm of bowel are at risk of malabsorption, malnutrition, and dependence on parenteral nutrition. It was originally believed that only strictures under 25 cm were appropriate for strictureplasty; however, Michelassi and others have described various techniques that can be used for longer strictures [8, 9]. Traditionally, strictureplasty was only used for fibrotic nonactive strictures. This approach has been challenged, and strictureplasty has been shown to be safe and efficacious in active disease [10]. In the setting of Crohn's disease, the main indications for strictureplasty are multiple strictures with diffuse involvement of the small bowel; previous extensive resections (>100 cm) of small bowel; short-bowel syndrome; duodenal strictures; strictures at previous anastomotic sites, especially ileorectal or ileocolic sites; and rapid recurrence of disease with obstruction. Contraindications to strictureplasty include perforation of bowel, with or without peritonitis; malnutrition with albumin <2.0 g/dL; stricture a short distance from the area of resection; and multiple strictures over short lengths of bowel [11].

The choices for types of strictureplasty are greatest in jejuno-ileal disease. The procedure of choice for short segment disease of less than 5–10 cm is the Heineke–Mikulicz strictureplasty [12]. Longer segment strictures can be treated with a Finney or Jaboulay strictureplasty. Modifications have been described, including Judd, Moskel–Walske–Neumayer strictureplasties and side-to-side isoperistaltic strictureplasty [10]. In the Finney procedure, the strictured portion is positioned like a "U" and an enterotomy is performed. The mesenteric borders are opposed together using interrupted absorbable sutures or a stapling device. For a Jaboulay strictureplasty, the bowel is positioned the same way; subsequently, two separate incisions in healthy facing sections of bowel are made and an enteroenterostomy is performed. The Judd procedure is used when a fistula has formed in a short segment of stricture. If a Heineke–Mikulicz procedure might result in excessive tension, a Moskel–Walske–Neumayer strictureplasty can be performed. In a side-to-side isoperistaltic strictureplasty or Michelassi strictureplasty, the diseased bowel segment is isolated and the proximal loop is placed over the distal loop in a side-to-side fashion. An enteroenterostomy is performed with closure in two layers [10].

A meta-analysis of 15 studies involving 506 patients who underwent 1,825 strictureplasties showed that the complication rates of these approaches were similar to those associated with resection [13]. In the studies included in this meta-analysis, 56% of patients underwent strictureplasty alone, and the remaining patients underwent a concurrent resection. The most common procedure was a Heineke–Mikulicz strictureplasty (85% of patients). Subsequent studies have reported outcomes for 461 patients who underwent 1,408 strictureplasties [10, 14–19]. Additionally, a follow-up study has revealed jejuno-ileal recurrence in 26% and 29% of patients at 5 and 10 years, respectively. Six of the ten patients underwent a second strictureplasty, and three patients had repeat strictureplasty and resection [20]. This study suggested that repeated strictureplasty was safe. Interestingly, when complications that are not specific to resection are excluded [21], the morbidity associated with strictureplasty is higher than that associated with resection [10]. More studies are needed to determine whether this finding holds true for a large number of patients.

When bowel-sparing techniques are not possible and resection is necessary, patients with Crohn's disease may benefit from minimally invasive techniques. The first laparoscopic-assisted colectomy was reported in 1991 [22]. Since that time, laparoscopy has been used to treat both benign and malignant colorectal diseases. In 1993, Milsom reported the first laparoscopic resection for patients with Crohn's disease. The indications for laparoscopy in Crohn's are similar to those for open conventional surgery. These indications include fulminant inflammation refractory to medical therapy, intolerable side effects, hemorrhage, or obstruction. There has been hesitancy in the widespread use of laparoscopy in Crohn's disease, mainly due to disease factors such as severe mesenteric thickening, multifocal pattern of disease and widespread inflammation. Often, patients with Crohn's disease may present very ill with urgent need of surgical intervention. This situation may deter the use of a laparoscopic approach. Some surgeons also contend that the longer operative times outweigh the benefits of a faster postoperative recovery.

Operative indications

Operative indications for Crohn's disease include chronic complications, acute complications and failed medical therapy. Chronic complications can include neoplasia, bowel obstruction, steroid-induced osteoporosis, or other side effects. Acute complications of Crohn's disease include toxic megacolon, hemorrhage, perforation, and bowel obstruction. The reasons for failed medical therapy can vary from medication noncompliance to lack of treatment response.

Toxic colitis is a severe and potentially life-threatening complication of Crohn's disease. One simple way to diagnose toxic colitis is a disease flare with two of the following:

hypoalbuminemia (<3.0 g/dL), leukocytosis (>10.5×10^9), tachycardia (>100 beats/min), or temperature increase (>38.6°C) [23]. The usual indications for emergent surgery apply; these include peritonitis, free perforation, increasing colonic dilation, hemorrhage, and septic shock. Ideally, the patient should be adequately resuscitated with intravenous hydration, blood products as necessary, and correction of electrolytes.

Free perforation, although rare, can occur in patients with Crohn's disease. In the small intestine, free perforation can occur just proximal to a stricture or obstruction. Typically, resection of the involved bowel with a proximal diversion is necessary given the patient's malnourished state, sepsis, and other comorbidities at the time of surgery. Hemorrhage can be a life-threatening complication of Crohn's disease. As in cases of other lower gastrointestinal bleeds, hemorrhage in patients with Crohn's disease is treated according to typical algorithms with attempts to localize the bleeding site. If the bleeding is from a colonic source, judicious use of colonoscopy is advocated because hemorrhage usually accompanies severe colitis. If the bleeding is from a small-bowel source, every effort should be made angiographically to stop the bleeding. If this is not possible, angiography should be used to guide as limited a resection as possible.

Some population-based studies have supported the idea that patients with Crohn's disease are at increased risk for colorectal carcinoma [24]; however, other studies do not support this view. Despite this controversy, some argue that increased surveillance protocols should be implemented for patients with Crohn's disease. This would include screening endoscopy 8–10 years after the onset of symptoms and four quadrant biopsies as well as biopsies of suspicious lesions every 1–2 years [23].

Bowel obstructions of both an acute and chronic nature can occur in patients with Crohn's disease. They can result from stricturing disease, which may require resection or strictureplasty, depending on length and location. Some patients may require repeated surgical interventions, which increase the risk for bowel obstructions from adhesions. Often, these obstructions resolve with nasogastric tube decompression, bowel rest, and intravenous hydration. However, if they increase in frequency or severity, surgical intervention is needed.

Surgical options

Surgical treatment of colonic Crohn's disease can include subtotal colectomy with ileorectal anastomosis, segmental colectomy, or total proctocolectomy, depending on the distribution and severity of disease and the patient's general condition. A meta-analysis was conducted on studies that compared segmental resection (SC) vs. subtotal/total colectomy with ileorectal anastomosis (IRA), investigating recurrence, postoperative complications, or need for a permanent stoma [25]. Six studies consisting of 488 patients were included in the analysis (223 and 265 patients underwent IRA and SC, respectively). These studies demonstrated no significant difference in the incidence of surgical recurrence between the two types of operations. However, there was a significant difference in mean time to recurrence, with the SC group presenting 4.43 (95% CI 3.08–5.78) years earlier. The groups did not differ in incidence of postoperative adverse events. In this meta-analysis, there was no difference in the incidence of permanent stoma between the two groups; however, no study of more than 50 patients reported the incidence of permanent stoma formation [25].

A single-institution study gathered information on patients with primary colonic disease and compared different surgical approaches by location and extent of disease [26]. Patients in this study (N=179) underwent segmental colectomy (30.2%), total abdominal colectomy (27.4%), or total proctocolectomy (42.4%). The segmental colectomy group was significantly younger than the total proctocolectomy group, but there was no difference in gender distribution or disease duration. Patients with more than two involved colonic segments, diffuse colonic involvement, or distal colonic involvement were less likely to undergo a segmental resection than a total abdominal colectomy or total proctocolectomy (P<0.0001). In this study, there was a significant difference in time to first recurrence between the three surgical groups (P=0.017). The segmental resection group had a greater risk of recurrence than the total proctocolectomy group, with an adjusted hazard ratio of 5.76 (CI 1.65–20.11; P=0.006). However, on follow-up, the need for a permanent stoma was not significantly different between the two groups (P=0.75). A permanent stoma was required by 11.5% and 54.2% of patients with isolated proximal and isolated distal colonic involvement, respectively. Patients with distal colonic involvement were more likely to require a permanent stoma than those with isolated proximal colon involvement (P=0.004). Extent of disease did not affect the rate of permanent stoma creation [26].

A more recent analysis investigated recurrence-free survival and stoma-free survival after segmental or subtotal colectomy for Crohn's colitis [27]. In this large single-institution study, 49 patients underwent segmental colectomy and 59 patients underwent subtotal colectomy. There was no difference in incidence of postoperative complications or readmission rates between the groups. However, at 5 years of follow-up, recurrence-free survival was significantly lower in the segmental resection group (61.5%) than in the subtotal colectomy group (84.2%; P=0.032). This was not significant on multivariate analysis of recurrence-free survival. There was no difference in stoma-free survival between the segmental resection group (76.8%) and the

subtotal colectomy group (84.2%). The only factors associated with reduced stoma-free survival on multivariate analysis were current or past perianal sepsis at time of resection and presence of more than one comorbidity. Quality-of-life scores, measured using the Cleveland Global Quality of Life instrument, indicated no significant differences between the two groups. Overall, segmental colectomy was not found to be an independent factor associated with recurrence or stoma formation, and the authors advocated the use of segmental colectomy in selected patients [27].

Perianal disease

A combination of medical and surgical therapy offers the best chance of success in the treatment of perianal Crohn's disease. The combination of an exam under anesthesia and MRI or endorectal ultrasound can offer the best chance of diagnosis of complex disease [28]. Abscess and fistula are the most common presentations. Incision and drainage of an abscess is required and a noncutting seton in the presence of a fistula can facilitate drainage and prevent recurrence.

Definitive medical therapy usually requires immunosuppression. Evidence from the ACCENT-2 trial indicates that, with infliximab maintenance therapy, 36% of patients had a complete response at week 54 of treatment ($P=0.009$) [29]. Topstad et al. reported their experience combining seton placement and infliximab for patients with perianal Crohn's disease [30]. Of the 29 patients who participated in the study, 21 had perianal fistulas, four had rectovaginal fistulas, and four had combined rectovaginal and perianal fistulas. Eighteen patients with perianal fistulas had a clinical response after three doses of infliximab, and ten of these patients had complete response with no relapse at 8.6 months of follow-up. Four patients with complete response relapsed and required two more doses of infliximab. They showed no evidence of relapse at an additional 9.5 months of follow-up. Four patients were complete responders; two remained stable at follow-up and two required additional infliximab infusions to control symptoms. The rectovaginal fistula group had worse results. Only one patient with an isolated rectovaginal fistula had a complete response. One patient remained stable for more than 1 year, while two patients required repeated infliximab infusions to control symptoms. Two other patients relapsed, with one requiring additional infliximab for symptoms and one patient had a major adverse reaction to repeated infusions and required a colectomy [30].

A recent cohort study explored the efficacy of surgical treatment combined with local perifistular infliximab injections in treating Crohn's perianal fistulas [31]. Before infliximab treatment, all abscesses were identified and drained. Fistulectomies were performed as indicated. Infliximab (20–25 mg diluted in 5% glucose) was injected along the fistula tract and around both the internal and external orifices. The injections were repeated every 4–6 weeks. Twelve patients were included in the study, all of whom were refractory to medical therapy with immunomodulators and/or IV infliximab. Ten patients remained on immunomodulators for luminal Crohn's disease. In this study, four patients interrupted treatment for personal reasons, pregnancy, or relapse of intestinal symptoms. Of the remaining patients, clinical healing was observed in 66.7% within a median period of 19 weeks. Persistent healing for at least 12 months after treatment completion was reported for 87% of patients. However, at 35 months of follow-up, only 42% were still clinically healed [31]. This was a small cohort of patients; thus, the role of perifistular infliximab injections still needs to be explored in a larger study.

Endorectal advancement flaps have also been used in the treatment of perianal Crohn's disease. In one study of 26 patients treated with endorectal flap, seven had recurrences after the initial procedure. Two were treated conservatively and five underwent an additional flap procedure. Four of the five healed and one re-recurred [32]. Two patients had fecal diversion at the time of data collection. Small-bowel disease was associated with a higher rate of recurrence in this study ($P<0.05$) [32].

Fecal diversion can help alleviate symptoms from severe perianal disease. This can be indicated when the perianal disease is progressive, despite aggressive drainage and medical therapy. A study of 102 patients investigated the overall risk of a permanent stoma in patients with severe perianal Crohn's disease [33]. Thirty-one percent of patients with perianal Crohn's disease eventually needed a permanent stoma. On multivariate analysis, complex perianal fistulas ($P<0.03$), fecal incontinence ($P<0.02$), rectal resection ($P<0.002$), and temporary fecal diversion ($P<0.02$) carried an increased risk for permanent fecal diversion [33]. Another study with 356 patients investigated factors predictive of needing a permanent stoma [34]. In a multivariate model, the presence of anal canal stricture and the presence of colonic disease were significantly associated with a need for a permanent stoma ($P=0.0105$ and $P=0.0035$, respectively). The odds ratio for requiring a permanent stoma in presence of perianal Crohn's disease and colonic disease was 5.4 (CI 1.8–20.6). In the presence of colonic disease and anal canal stricture, the risk for permanent stoma was increased (OR 33.0; CI 4.9–672) [34]. Fecal diversion may help alleviate symptoms of severe perianal disease and provide an improved environment for healing of local measures. Unfortunately, permanent diversion or proctectomy may be needed in patients who fail both surgical and medical therapy.

Laparoscopy vs. open conventional surgery: randomized trials

Two randomized clinical trials have been performed comparing outcomes of laparoscopy and open conventional surgery in Crohn's disease. In the first trial, conducted by Milsom (2001), intraoperative randomization was undertaken and patients were stratified by gender and body mass index (BMI) [35]. In the second trial, Maartense (2006) preoperatively randomized patients and used sealed envelopes to allocate them to groups [36]. Primary outcomes included wound infection, pneumonia, urinary tract infection, anastomotic leak, intra-abdominal abscess, and reoperation rates within the first 30 days. Secondary outcomes were duration of surgery, intraoperative blood loss, postoperative pain, duration of postoperative hospital stay, duration of postoperative ileus, mortality, conversion rates, long-term outcomes, reoperation rates for disease recurrence, and reoperation rates for nondisease-related complications. A total of 120 patients participated in the two trials.

In a meta-analysis of the two trials, there were no significant differences in incidence of wound infections or pneumonia between patients in the open and laparoscopic groups [37]. However, Milsom reported fewer cases of minor complications in the laparoscopic group (ileus >7 days [$n=2$] and wound infection [$n=2$]) versus the open conventional group (ileus [$n=3$], bowel obstruction [$n=1$], wound infection [$n=2$], incisional hernia [$n=1$], and postoperative pneumonia [$n=1$]) [35]. Maartense reported no difference in the incidence of urinary tract infections between the open and laparoscopic groups; however, there were fewer overall complications in the laparoscopic group [36]. Both trials reported no significant differences between the two groups for incidence of anastomotic leaks, intra-abdominal abscess rates, and reoperation rates within the first 30 days. Milsom reported faster recovery of pulmonary function (FEV1 and FVC) to preoperative values in the laparoscopic group [35].

In analyses of secondary outcomes, both studies reported that operating time was significantly shorter in the open group ($P<0.003$ and $P<0.0001$ in the studies by Maartense and Milsom, respectively). Milsom reported no significant difference in intraoperative blood loss between groups [35]. In a meta-analysis of the two studies, there were no significant differences in length of stay, postoperative narcotic use, reoperation rates for Crohn's recurrence, or reoperation rates for nondisease-related complications [37]. However, Maartense reported a shorter length of stay in the laparoscopic group (5 vs. 7 days; $P=0.008$) and lower median costs ($P<0.001$) [36]. Milsom also reported a shorter length of stay in the laparoscopic group (5 vs. 6 days), but this difference was not significant ($P=0.14$) [35].

A Cochrane review of these two randomized clinical trials concluded that laparoscopic surgery in Crohn's disease is feasible; however, it has not demonstrated a clear advantage [37]. Fewer patients in the laparoscopic groups suffered from wound infections, but the difference was not significant. As expected, the operative time was shorter in the open groups, which also experienced less intraoperative blood loss, although the difference was not significant. There are some concerns that other sites of disease may be missed with laparoscopy; however, reoperation rates for disease recurrence were the same for the open conventional surgery groups and the laparoscopic groups. The studies by Maartense and Milsom were relatively small, making it difficult to draw strong conclusions from their data. Another clinical trial reported that quality-of-life measures were similar in an open conventional surgery group and a laparoscopic group [38].

The use of diagnostic laparoscopy

Some surgeons advocate the use diagnostic laparoscopy in rare cases [39]. It is particularly advocated in diagnostic dilemmas, such as the case of a patient with unexplained abdominal pain and an otherwise negative workup. Laparoscopy may also be useful in cases of an unusual clinical presentation or when another disease process, such as lymphoma, must be ruled out before commencing potent immunologic therapy. Diagnostic laparoscopy can also be used as an adjunct to assess the feasibility of proceeding with a laparoscopic approach.

Ileocolic disease

Ileocolic disease is the most common presentation of Crohn's disease. Although combined data from two randomized clinical trials failed to demonstrate a significant benefit of laparoscopy for ileocolic disease, increasing evidence suggests that it is associated with good short-term results. A meta-analysis of 15 nonrandomized studies (two prospective and 13 retrospective) found that laparoscopy was feasible, safe, and associated with shorter hospital stay and shorter duration of ileus compared with open surgery [40]. The most common procedure in these studies was ileocolic resection; however, seven studies reported results on patients undergoing synchronous procedures such as left or transverse colectomy, small-bowel resection, strictureplasty, drainage of intra-abdominal abscess, and fistula closure. The pooled rate of conversion was 7% (95% CI 4–10%). Laparoscopic surgery required more operating time than open surgery by 26.8 min (95% CI 6.4–47.2 min). There was no significant difference in blood loss. The laparoscopic group had significantly shorter times to first flatus (−0.82 days; 95% CI −1.30 to −0.33 days), first bowel

movement (−0.75 days; 95% CI −1.32 to −0.17 days), and first oral intake and solid diet. This meta-analysis revealed no significance difference between the two procedures for early reoperation or complications. However, the laparoscopic groups had fewer total and major complications. Six studies included in this meta-analysis reported long-term patient follow-up. Analysis of these studies revealed fewer small-bowel obstructions in patients treated with laparoscopy versus open procedures (OR 0.24; 95% CI 0.14–0.41). The laparoscopic surgery group also had lower rates of surgery for recurrences (OR 0.51; 95% CI 0.28–0.93). Of note, this result was primarily driven by one study [41]. Additionally, laparoscopy was associated with a lower rate of late reoperations for Crohn's recurrences (OR 0.46, 95% CI 0.27–0.80) and with a trend toward lower overall costs [40].

A subsequent meta-analysis included the same studies (as in reference [30]) with the exception of three excluded studies and two additional, older studies [42]. Operative time was longer in the laparoscopic groups than in the open resection groups by 25.59 min (95% CI 11.27–47.90 min). Operative blood loss was not significantly different across groups ($P=0.58$). In pooled analyses, there were no significant differences between the laparoscopic and open surgery groups for the following early postoperative complications: anastomotic leak rate (seven studies), chest infection/pneumonia rate (five studies), wound infection rate (ten studies), bowel obstruction rate (four studies), and intra-abdominal abscess rate (six studies). Studies in this meta-analysis also reported times to tolerating oral fluid (two studies), tolerating oral diet (seven studies), first flatus (four studies), and first bowel movement (five studies). The laparoscopic groups had shorter times to the following outcomes: first liquid intake (−2.66 days; 95% CI −3.44 to −1.89 days), first solid diet (−1.47 days; 95% CI −2.18 to −0.76 days), first flatus (−0.68 days; 95% CI −1.20 to −1.17 days), and first bowel movement (−0.58 days; 95% CI −1.12 to −0.03 days). Length of stay was shorter in the laparoscopic groups than in the open conventional surgery groups (−2.97 days; 95% CI −3.89 to −2.04 days). However, there was no difference in postoperative narcotic use. A pooled analysis of two studies that reported on hospitalization costs revealed no significant difference between the laparoscopic and open surgery groups [42].

In a third meta-analysis, which was based on all of the studies included in the two previously reviewed meta-analyses, the authors reached the same conclusion that laparoscopy is safe and feasible for patients with Crohn's disease [43]. One of the criticisms of the previous studies was the small numbers in the series; thus, a larger series was subsequently published. The authors of a large single-institution series investigating laparoscopically assisted primary ileocolic resection for Crohn's disease concluded that

a laparoscopic approach is the procedure of choice at their institution because it is safe, feasible, and associated with better short-term outcomes [44]. This study reported on outcomes of 109 patients over a 12-year period. Laparoscopy was offered to patients presenting for elective or urgent primary ileocolic resection, except for those with known frozen abdomens or those presenting emergently with peritonitis or complete bowel obstruction. The most frequent indication for surgery was medically refractory disease, and a majority of patients had at least one preoperative risk factor. This included steroid use (72%) and previous abdominal surgery (41%); 18% of patients had undergone two or more previous abdominal surgeries. Conversion from laparoscopy to laparotomy was needed in 6% of cases due to technical difficulties. The two cases with a preoperative diagnosis of ileosigmoid fistula were converted to laparotomy. However, 18 procedures in which fistulizing disease was found were laparoscopically completed. Twelve patients had postoperative complications; these included ileus, wound infection, urinary retention, sigmoid perforation, superior mesenteric vein thrombosis, hemorrhage, wound hematoma, or wound seroma. The most common complication was prolonged ileus, and morbidity was not more common in patients with previous abdominal surgeries. One patient required reoperation on postoperative day (POD) 3 for a sigmoid leak. On average, patients tolerated a soft diet and had a bowel movement on POD 3. There were no readmissions within 30 days of surgery. As one of the larger series published, this study reported good results for laparoscopically assisted primary ileocolic resection for Crohn's disease. There were few morbidities, and the approach was successful even in several patients with fistulizing disease and in patients with previous abdominal surgery [44].

Another series of consecutive patients examined the feasibility and safety of a laparoscopic approach to ileocecal Crohn's disease [45]. This was a retrospective study that spanned 10 years and included 50 consecutive patients with Crohn's disease. The most common indication was progressive obstructive symptoms. In this study, the mean operating time was 150 min, and the mean blood loss was 130 ml. One patient required conversion to laparotomy due to adhesions and fistula to the sigmoid colon. Bowel function returned at a mean of 3 days, and mean length of stay was 8 days. Ten patients had minor postoperative complications such as wound infection, urinary tract infections, pneumonia, postoperative ileus, fever of unknown origin, or postoperative bleed with no surgical intervention. Four patients experienced a major postoperative complication, specifically anastomotic leak ($n=3$) or leak after fistulectomy ($n=1$). The surgeons involved in this study used a low threshold for diagnostic laparoscopy if a leak was suspected. Three patients underwent a diagnostic laparoscopy, and a new

laparoscopic ileocolic resection was performed for one patient. Based on their series of 50 consecutive patients, the authors concluded that laparoscopy is feasible, safe, and associated with acceptable postoperative outcomes [45].

Nguyen et al. (2009) published the largest series of laparoscopic resections for Crohn's disease and concluded that laparoscopy was safe and could be managed with acceptable morbidity [46]. These researchers examined 335 cases in 15 years. The most common indication was intestinal obstruction (73%) or abdominal pain (16%). The most common operation performed was primary ileocolic resection. Secondary ileocolic resection was performed for 20% of cases. Eight patients required conversion to laparotomy for large mesenteric inflammatory masses. The series included patients who had undergone a previous bowel resection (33%), had previous abdominal surgery (42%), or required multiple resections (9%). There were 117 patients with enteric fistulas, and 31% of patients had received immunosuppressive medications near the time of surgery. Six cases were diverted after resection, and diversion was more common after multiple resections, associated abscesses, and poor nutrition or healing. The most common type of fistula was enteroenteric, usually with the terminal ileum fistulizing to another segment of small bowel. There were 24 cases of bladder fistulas, most originating from the small bowel.

The mean operative time was 170 (range, 62–400) min, and the mean length of stay was 5 (range, 3–18) days [46]. Eight patients required conversion to laparotomy, with a conversion rate of 2%. Three conversions were due to dense adhesions and inflammation. One primary ileocolic resection that was converted to open was secondary to a long segment of mesentery that was extremely inflamed and thickened, precluding safe vascular control. One case with a coloduodenal fistula could not be repaired laparoscopically. The complication rate was 13%, with the most common complication being postoperative bowel obstruction. There were five wound infections, and 13 patients required reoperation for a postoperative complication. In two cases, a 360-degree anastomotic twist was found on re-exploration. In four cases, there was a kink at the anastomosis, and revision was required. Two cases had adhesive bands as the cause of the obstruction. Four anastomotic leaks required reoperation and intestinal diversion. Four cases of subclinical leaks resolved with nonoperative therapy. Four cases of postoperative bleeding required reoperation. Two bleeds were from the staple line, and one required revision of the anastomosis. The two other bleeds, which were mesenteric, required reoperation. Based on their extensive experience in this series, Nguyen et al. concluded that patients with Crohn's disease should initially be laparoscopically approached even if they have had previous resections or have intestinal fistulas [46].

In the study reported by Nguyen et al., intracorporeal vascular division and anastomosis were performed unless the mesentery was too thick. Bergamaschi et al. (2009) specifically investigated the safety and efficacy of intracorporeal vascular division and anastomosis in Crohn's disease [47]. Patients in this study were excluded if they had a frozen abdomen, large fixed mass, recurrent Crohn's following previous resections, or perforated disease requiring emergency surgery. Eighty laparoscopic ileocolic resections with intracorporeal anastomosis were attempted in a 14-year period. A side-to-side anastomosis was fashioned with a laparoscopic stapler using a 60-mm-long cartridge. Three stay sutures were placed at the enterotomy, which was closed with one to two fires of a laparoscopic stapler. The specimen was removed in an endoscopic bag. One patient was converted to laparotomy because laparoscopy revealed three internal fistulas. This patient developed an anastomotic leak on POD 4. The leak was oversewn, and a loop ileostomy was made. This was closed 4 months later without complication. There was one intraoperative bladder perforation, which was recognized and repaired laparoscopically. The patient had a history of radiation for uterine cancer. She was readmitted for abdominal pain on POD 14 and underwent a nondiagnostic exploratory laparotomy. One patient with multiple comorbidities was readmitted for abdominal pain on POD 14 and underwent conventional right hemicolectomy for ascending colon ischemia. A patient with terminal ileal disease and two internal fistulas was readmitted for abdominal pain and free air on POD 52. At reoperation, he was found to have recurrent terminal ileal disease with peritoneal contamination but no macroscopic perforation. The patient was diverted, and the stoma was closed 12 months later with no complication. Mean operating time was 155 (range, 130–210) min. Mean estimated blood loss was 250 (range, 50–600) ml. Patients with complications or reoperation took longer to resume diet (4.0 ± 1.5 days vs. 2.8 ± 0.6 days) and had longer lengths of stay (8.0 ± 6.5 days vs. 3.9 ± 0.9 days). The recurrence rate was 30%, and median time to recurrence was 64 months. Based on these findings, Bergamaschi et al. concluded that intracorporeal vascular division and anastomosis are safe even in a thickened and foreshortened mesentery such as in Crohn's disease [47]. Some possible advantages include avoiding manipulation of abdominal organs, decreasing the length of the midline incision, and avoiding mobilization of the proximal right colon.

A similar total intracorporeal laparoscopic technique for Crohn's disease has been described in the pediatric population [48]. This study included 15 patients, aged 9–17 years, who underwent laparoscopic resection for ileocolic Crohn's disease in a 4-year period. One patient had previously undergone an open appendectomy for presumed appendicitis, and a second patient underwent a diagnostic laparoscopy for

presumed appendicitis; however, no resection was performed because Crohn's pathology was found. In this study, the anastomosis was fashioned using a laparoscopic stapler to produce a side-to-side, functional end-to-end anastomosis. The remaining enterotomy was closed with a running suture, and the mesenteric defect was closed with interrupted sutures. The resected specimen was removed in an endoscopic specimen bag though the umbilical port. The mean length of stay was 4 days (range, 3–8 days). One patient with an anastomotic leak, but no associated collection improved with bowel rest and antibiotics. Another patient developed an anastomotic stricture 9 months postoperatively. This was re-resected laparoscopically with a good outcome [48]. This was a small study, but it had favorable results when compared with those in the existing literature.

A prospective study published in 2005 investigated factors that were predictive of conversion in patients undergoing laparoscopic ileocecal resection for Crohn's disease [49]. The 6-year study enrolled 69 consecutive patients. Twenty-one patients (30%) required conversion to laparotomy. Multivariate analysis identified two independent risk factors for conversion: recurrent medical acute episodes of Crohn's (OR 2, 95% CI 1–4) and unexpected intraperitoneal abscess or fistula (OR 15, 95% CI 4–78). The combination of these two risk factors increased the odds for conversion to 54% [49].

Although there is evidence that laparoscopy is safe and feasible in Crohn's disease, a variety of patient and system factors contribute to its potential utility. A 2009 study [50] used data from the Nationwide Inpatient Sample (NIS), an administrative database maintained by the US Department of Health and Human Services to determine national trends in the use of laparoscopy in Crohn's disease. Inclusion criteria identified patients with a primary admission diagnosis of Crohn's disease; patients who did not undergo resection or who had isolated anal surgeries were excluded from the study. The variables investigated included admission type, race, comorbidities, disease severity, age, and insurance status. The main outcome measures included hospital charges, length of stay, complications, mortality, and type of discharge. In this study, 396,911 patients were admitted with the diagnosis of Crohn's disease, and 49,609 (12%) patients required resection during their admission. The mean age was 41.6 ± 17 years. The majority of operations occurred in urban settings (90.7%) or at teaching hospitals (57.0%); most patients (74.6%) had private insurance. The complication rate was 15%, with a mortality rate of 0.9% for the cohort. A laparoscopic approach was performed in 2,826 patients (6%), whereas 46,783 patients (94%) underwent open resection. Univariate analysis revealed that the laparoscopic group had a shorter length of stay (6 days vs. 9 days), lower hospital charges ($27,575 vs. $38,713), a lower rate

of in-hospital complications (8% vs. 16%), and lower mortality (0.2% vs. 0.9%; $P<0.01$ for all comparisons). In addition, laparoscopic surgery was associated with significantly fewer pulmonary (0.4% vs. 2.6%), gastrointestinal (5.3% vs. 10.6%), and cardiovascular (0.2% vs. 0.9%) complications. The incidence of intraoperative and wound complications or infectious complications did not differ between the two groups. Of the elective resections, only 5% were approached laparoscopically. Open repair was associated with more cases of ostomy placement (12% vs. 7%) and fistula repair (8% vs. 1%; $P<0.01$ for both comparisons). Multivariate logistic regression was performed to identify factors that influenced whether an operation was performed with laparoscopic or open techniques. Predictors of undergoing a laparoscopic operation for Crohn's disease were age less than 35 years, female gender, ileocecal disease, and procedure performed in a teaching hospital. Patients with advanced disease stage or with Medicare were less likely to undergo a laparoscopic procedure. Admission type and race did not appear to have a significant association with surgical approach. A separate analysis was performed to determine predictors of wound, infectious, gastrointestinal, pulmonary, and cardiovascular complications. Open surgery (OR 3.4, 95% CI 1.4–8.1; $P<0.01$), fistula repair (OR 5.2, 95% CI 1.7–16.1; $P=0.05$), and ostomy placement (OR 2.3, 95% CI 1.9–2.7; $P<0.01$) were independently associated with in-hospital complications. In this study, the laparoscopic approach to Crohn's disease resulted in favorable outcomes; however, there were several patient- and institution-related factors that influenced whether laparoscopy was used [50].

To adjust for possible confounding variables, Kirat et al. (2010) compared outcomes after laparoscopic ileocolic resection and open resection [51]. These researchers analyzed data from the National Surgical Quality Improvement Program (NSQIP). All patients with Crohn's disease who underwent an ileocolic resection, either laparoscopic or open, were included in this study. Variables of interest included preoperative risk factors, intraoperative variables, postoperative 30-day morbidity, and mortality outcomes. Preoperative data included age, BMI, gender, American Society of Anesthesiologists (ASA) class, smoking history, steroid use, and pulmonary, neurologic, or cardiac comorbidities. Intraoperative outcomes were operating time, urgency of procedure, surgeon, and probability of morbidity. Postoperative complications included unplanned intubation, pneumonia, pulmonary embolism, deep venous thrombosis, sepsis, renal failure, myocardial infarction, major neurologic deficit, urinary tract infection, wound dehiscence, return to the operating room, bleeding requiring transfusion, and surgical site infection [51].

For the 307 patients included in the study by Kirat et al., there were 104 laparoscopic resections and 203 open resections. The two groups had similar preoperative

characteristics such as age, BMI, race, history of smoking, steroid use, diabetes, chronic obstructive pulmonary disease history, ASA class, and levels of albumin, bilirubin, and creatinine. History of cardiac and neurologic comorbidities was also comparable. The laparoscopic group had significantly more women. Probabilities of morbidity, operative time, and rate of urgency were similar between the two groups. Moreover, the groups were comparable with regard to complications including surgical site infection, pulmonary embolism, urinary tract infections, and return to the operating room. However, the mean length of stay was significantly shorter for the laparoscopic group than the open surgery group (4 days [range, 2–18 days] vs. 7 days [range, 1–76 days]; $P<0.001$). This study used a probability of morbidity model to emphasize that the two groups were similar in disease severity and comorbidities. Indeed, there was no difference in overall complications or morbidity. The only significant difference between groups was in length of stay, which offers the potential advantage of cost savings [51].

Colonic disease

Beyond ileocecal disease, minimally invasive techniques have been applied to a myriad of Crohn's disease complications. Compared with the existing research on patients with ileocecal disease, fewer studies have investigated the efficacy of laparoscopic techniques in colonic Crohn's disease. In a single-institution study on patients with colonic Crohn's, researchers concluded that minimally invasive colectomy was safe and associated with excellent postoperative outcomes [52]. The study was based on a prospectively maintained institutional database of patients with Crohn's disease who underwent a colonic resection. Patients were excluded if they had an open resection, isolated small-bowel or terminal ileal resection, or a completion proctectomy. The patients were divided into two subgroups. Group 1 comprised patients who underwent a total colectomy, including cases of total proctocolectomy, total abdominal colectomy, and subtotal colectomy; all three of these procedures included cases with or without anastomosis or stoma. Group 2 comprised patients who underwent a segmental colectomy. The researchers abstracted perioperative variables, short-term outcomes, demographics, type and number of Crohn's medications, radiologic imaging, and history of perianal disease. Additional analyses were based on conversion rate to laparotomy and intraoperative variables such as duration of surgery and blood loss [52].

Over an 11-year period, 92 patients underwent a laparoscopic colectomy for Crohn's colitis [52]. The procedures included total colectomy ($n=43$; 47%), subtotal colectomy ($n=17$; 18%), and segmental colectomy ($n=32$; 35%). The most common segmental resection performed was a sigmoid colectomy ($n=16$), and the most common procedure performed was a total proctocolectomy with end ileostomy ($n=27$). The least common procedure, which was performed on only six patients, was a transverse colectomy. The median age was 40 (range, 26–51) years; 56 patients (61%) were women, and the mean BMI was 22.9 (range, 19.3–26.4). The two subgroups did not differ significantly on these measures. However, compared with the segmental colectomy group, the total colectomy group tended to be older (43 vs. 31 years; $P=0.08$) and more likely to have a higher ASA class (ASA class 3, 33% vs. 9%; $P=0.04$). Ten patients had prior abdominal surgery for Crohn's disease. The patients' recent disease-related medications included infliximab (35%), immunomodulators (62%), and corticosteroids (54%). The total abdominal colectomy group was more likely to receive preoperative steroids compared with the segmental colectomy group. Ninety percent of patients had refractory colitis, and 10% had neoplasia. Of the patients with refractory colitis, 20% had evidence of obstruction on preoperative imaging. Eight patients presented with dysplasia, and one patient had cancer [52].

Laparoscopic-assisted technique and hand-assisted technique were used in 57% and 43% of cases, respectively [52]. There was no significant difference in operative times between the laparoscopic-assisted and hand-assisted groups (overall median operative time was 248 min [range, 190–292 min]). Three patients (3.3%) had intraoperative complications, including a colostomy in a patient with fulminant colitis (not converted), pelvic bleeding (converted), splenic capsular tear (converted), and ureteral injury in a patient with phlegmonous colovesical fistula (converted). There were 15 cases (16%) of conversions to laparatomy. A total of 31 patients (34%) had some type of complication, the most common of which was a surgical site infection. The total colectomy subgroup was more likely than the segmental group to suffer a complication (42% vs. 19%; $P=0.04$). Seven patients (7.6%) required reintervention for anastomotic leak ($n=2$), recurrent vesicovaginal fistula ($n=1$), obstruction ($n=3$), or perineal wound dehiscence ($n=1$). Five patients required readmission within 30 days for partial small-bowel obstruction ($n=2$), small-bowel obstruction ($n=1$), recurrent vesicovaginal fistula ($n=1$), or rectal stump bleeding ($n=1$). In the examination of variables that predicted complications in the 92-patient cohort, total colectomy was significantly associated with an increased rate of complications ($P=0.04$). Interestingly, perianal disease was also associated with an increased complication rate ($P=0.02$). On multivariate logistic regression, only perianal disease was independently associated with an increased risk of postoperative complication (OR 2.6, CI 1.0–6.6). In this study, conversion to laparotomy was not associated with increased complications or longer stay [52]. This study more

fully described the outcomes of a minimally invasive approach at a single institution; however, laparoscopy was not offered to patients with pneumoperitoneum, toxic megacolon, peritonitis, obliterative peritonitis, or large ventral hernias. Thus, these results may not fully apply to more complex Crohn's cases. Despite this limitation, the study reports the largest case series of patients with Crohn's disease undergoing laparoscopic colectomy and demonstrates that the approach is safe and feasible, with good postoperative outcomes.

A case-matched study of patients with Crohn's disease undergoing laparoscopic or open colectomy showed that a laparoscopic approach is both safe and feasible [53]. When 30-day readmission was included in the analysis, length of stay was significantly shorter for patients who underwent laparoscopic colectomy versus open colectomy.

A comparative study of patients undergoing colectomy for Crohn's disease concluded that laparoscopy was associated with favorable outcomes for reduced blood loss, return of bowel function, and length of stay [54]. Fifty-five patients who underwent laparoscopic colectomy were compared with 70 patients who underwent open resection during a 6-year period. In addition to perioperative variables, analyses of intraoperative and postoperative outcomes included operative time, estimated blood loss, return of bowel function, and length of stay. The groups were similar in age, gender, duration of disease, and use of corticosteroid therapy at the time of surgery. Patients in the laparoscopic group were less likely to have had previous abdominal surgery (34.5% vs. 65.7%; $P<0.001$), but they had higher BMI values (25.0±6.5 vs. 22.9±5.1; $P=0.028$). There were no significant differences in incidence of comorbidities. The most common procedure performed was a total proctocolectomy with end ileostomy. Twelve of 17 open proctectomies were completion proctectomies. The most common indication for surgery was failure of medical therapy. Median operative time was significantly shorter in the laparoscopic group versus the open resection group (212 [range, 180–315]min vs. 286 [range, 231–387]min; $P=0.032$). When completion proctectomies were excluded, the trend remained, but was no longer significant. Transfusion requirement did not differ between the two groups, but there was less operative blood loss in the laparoscopic group (100 [range, 90–250]ml vs. 250 [range, 100–400]ml; $P=0.002$). Bowel function, defined by passage of flatus per anus or ostomy, returned earlier in the laparoscopic group (3 [range, 2–5] days vs. 4 [range 3–5] days; $P=0.036$). Length of stay was also shorter for the laparoscopic group (6 [range 5–8] days vs. 8 [range 6–10] days; $P=0.001$). There were six (10.9%) conversions due to bleeding, dense adhesions, large inflammatory masses, or multiple strictures. Incidence of complications did not differ between the laparoscopic and open groups. However, follow-up was shorter for

the laparoscopic group (9 vs. 27 months), and there was no difference in recurrence rates. This study suggests that a laparoscopic approach for Crohn's colitis is associated with less blood loss, faster return of bowel function, shorter length of stay, and similar rates of complications compared with open resection [54]. Moreover, the study indicated that operative times were shorter for laparoscopy, but these patients were less likely to have had previous abdominal surgery as compared with the open surgery group.

One of the criticisms of laparoscopy for colonic Crohn's disease has been the lack of tactile feedback to assess the extent of disease, as well as the lack of manual retraction needed for good exposure. Hand-assisted laparoscopic surgery (HALS) is an alternative to laparoscopic-assisted and open surgery. With HALS, the surgeon regains tactile sensation and manual retraction. A comparison of HALS, laparoscopic-assisted surgery, and open surgery demonstrated that HALS offers the potential benefit of reducing operative time while maintaining benefits of minimally invasive surgery [55]. This study involved 38 consecutive patients, over a 14-year period, who underwent a subtotal or total colectomy for extensive Crohn's colitis. They were divided into three groups depending on surgical technique: open, laparoscopic-assisted, or HALS. There were 14 open colectomies, six laparoscopic-assisted colectomies, and 18 hand-assisted colectomies. For the laparoscopic-assisted group, five ports were used for mobilization, and the anastomosis was performed extracorporeally through an enlarged laparoscopic incision. In the HALS group, a 7- to 8-cm lower midline minilaparotomy was made, and a hand-access device used.

There were no conversions to open laparotomy in this series, and the three groups had comparable backgrounds [55]. Median operative time was longest in the laparoscopic-assisted group (330 min; range, 154–340 min), followed by the HALS group (251 min; range, 165–540 min), and the open group (200 min; range 172–315 min). Blood loss was less in the laparoscopic group (170 ml; range, 115–257 ml) than in the HALS group (225 ml; range 35–890 ml) and the open group (438 ml, range 280–780 ml). There were no major differences in morbidity. Resumption of diet and length of stay data were not provided because it was believed these factors were affected by the Japanese social insurance coverage system and diet therapy policy [55]. The researchers concluded that HALS is a safe and feasible technique in complex Crohn's colitis and that it potentially decreases the operative time as compared with laparoscopic-assisted surgery.

Complex disease: recurrent disease, abscess, and fistulas

As summarized thus far, evidence indicates that laparoscopy is safe and feasible and that it may have some additional

benefits in managing Crohn's disease. However, what is the role of laparoscopy in complex or recurrent Crohn's disease? A recent prospective study compared postoperative outcomes between patients with Crohn's disease undergoing a laparoscopic ileocolic resection for uncomplicated disease and those undergoing a laparoscopic resection for recurrent or complicated disease [56]. In a 9-year period, 124 consecutive patients underwent elective laparoscopic ileocolic resection; no exclusion criteria were applied. Vascular division and the anastomosis were fashioned extracorporeally through a 6-cm incision.

The complex and uncomplicated disease groups comprised 30 and 33 patients, respectively. Of those in the complex disease group, 23 (43%) had either ileosigmoid or bladder fistulas, 16 (30%) had an intra-abdominal abscess, and 15 (27%) had recurrence. Indications in the uncomplicated disease group included ileal stenosis or disease refractory to medical treatment [56]. The groups were comparable in perioperative variables and demographics. Thirty (24%) patients required conversion to laparotomy; the conversion rate was higher in the complex group (37% vs. 14%; $P<0.01$). Mean operative time was longer in the complex group (214 vs. 191 min; $P>0.05$). Overall morbidity was comparable in the two groups. Minor complications, which included wound infection, ileus, urinary tract infection, and pulmonary complications, were comparable. Mean length of stay was also comparable between the complex group (8 days; range, 4–15 days) and uncomplicated group (7 days; range, 4–18 days). This prospective study of consecutive, unselected patients suggests that laparoscopy in complex Crohn's disease is safe and feasible [56]. Although operative times were longer and the conversion and ileostomy rates were higher in the complex group as compared with the uncomplicated group, overall morbidity and hospital stay were similar.

Ileocolic disease can recur and necessitate a second operation. Depending on surgeon preference and experience, the approach can be laparoscopic or open. Brouquet et al. [57] compared the laparoscopic approach to the traditional open approach in redo ileocolic resections for Crohn's disease. Their study included 57 patients who underwent 62 reoperations, 29 of which were laparoscopic. Selection criteria specified no more than three previous abdominal operations and no history of diffuse peritonitis. A previous laparotomy was not a contraindication for laparoscopy. Preoperatively, the open group had significantly more associated perianal disease and lower preoperative hemoglobin. ASA class, BMI, and indications for resection were similar between groups. The type of lesions discovered intraoperatively were similar in both groups, but the open group had a more frequent need for associated procedures ($P=0.003$). Intestinal injuries were more frequent in the laparoscopy group (5 vs. 0; $P=0.01$). There were no differences in morbidity or length of stay between the two groups. There were nine conversions to open surgery. Two risk factors were associated with conversion to open: internal fistula and intraoperative intestinal injury. There was also a trend toward an increased risk of conversion for patients with a longer interval since the previous resection. Reoperation in Crohn's disease can be challenging. In this study, a laparoscopic approach was feasible and had similar morbidities and complications than an open approach, although there were more intraoperative intestinal injures in the laparoscopic group [57].

Another study on laparoscopy in recurrent ileocolic Crohn's disease compared patients who had their surgery completed laparoscopically and those who were started laparoscopically and were converted to laparotomy. Forty patients were identified from a prospectively maintained institutional database in a 10-year period. Patients with fistulizing, phlegmonous disease, enterocutaneous fistula, ventral hernias, or known obliterative peritonitis were not offered laparoscopic surgery [58]. Thirty procedures were completed using laparoscopic techniques, and ten underwent conversion to open. Overall baseline patient and clinical characteristics were similar between groups. Postoperative complications were also similar in both groups. The laparoscopic completed group had shorter median times to soft diet (3 days vs. 4 days, $P=0.03$) and length of stay (4 days vs. 7 days, $P=0.002$) [58].

A much larger retrospective analysis of a prospectively maintained database was performed over a 7-year period and compared results of laparoscopy for primary and recurrent Crohn's disease [59]. This study included 130 patients ($n=80$ primary resections and $n=50$ reoperations for Crohn's disease). Pulmonary disease and hypertension were the most common comorbidities. The reoperative group was older and had longer duration of disease than the primary resection group. The most common previous operation was ileocolic resection. Surgical outcomes were similar in the two groups, but the length of incision was longer in the reoperative group. The most common reasons for conversion in the reoperative group were adhesions, inflammation, and fistula formation. In the primary resection group, the most common reasons for conversion were phlegmon and abscess [59]. Overall, complication rate did not differ significantly between the two groups (8.7% in the primary surgery group vs. 12% in the reoperative group). Conversion rates were also not significantly different (18.7% vs. 32%; $P=0.095$). The recurrence rates were 3.7% and 4%, respectively, for the primary and reoperative groups, but the follow-up period was longer for the reoperative group [59]. In this study, laparoscopy yielded similar results in primary and recurrent resection.
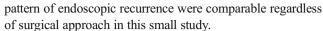
Long-term results, quality of life, recurrence

Most studies on laparoscopy and Crohn's disease have focused on short-term results; long-term outcomes have been studied to a lesser extent. A retrospective review of 113 patients over a 6-year period at a single institution found no difference in recurrence rates among patients who underwent a laparoscopic ileocecal resection ($n=63$) versus an open resection ($n=50$) [60]. Duration of Crohn's disease and age at diagnosis were similar across groups. There was a 10% conversion rate from laparoscopy to laparotomy ($n=7$) [60]. A recurrence developed in six of 63 patients in the laparoscopic group (mean follow-up, 60.4 months) and in 12 of 50 patients in the open group (mean follow-up, 81.2 months; P=NS). Median time to recurrence and chemoprophylaxis rates were similar between the 2 groups. At 1, 2, and 3 years follow-up, the recurrence rates were comparable in the two groups regardless of surgical approach. Laparoscopic treatment for surgical recurrence was possible in half of the patients with recurrence in the laparoscopic group, and 1/3 of patients with recurrence in the open group were retreated with a laparoscopic resection. Overall, recurrence rates were not significantly different between the laparoscopic and open resection group [60].

Recurrence after resection decreases quality of life in patients with Crohn's disease. Over an 8-year period, Thaler et al. (2005) evaluated recurrence and quality of life in patients who underwent elective laparoscopic or open ileocecal resection [61]. Quality of life was assessed by the Short Form 36 (SF-36) Health Survey and the Gastrointestinal Quality of Life Index. The groups were matched for age, ASA class, gender, and BMI within the study population. Thirty-eight percent of patients developed recurrent disease during the follow-up period; this proportion was distributed equally between the groups. There was no difference in satisfaction rates on cosmesis between the laparoscopic and open surgery groups. Quality-of-life scores were significantly lower in the patients with Crohn's disease than the general healthy population even though all patients were in remission at the time of assessment. On multivariate analysis, recurrent disease was the only predictor of lower quality-of-life scores; this was independent of surgical approach [61].

Frequency and pattern of recurrence in Crohn's disease do not appear to be affected by surgical approach. Twenty-two patients with Crohn's disease undergoing an ileocolic resection were studied and followed for development of recurrence [62]. Ten were laparoscopically resected, and 12 underwent laparotomy. Clinical characteristics were comparable in the two groups. Recurrence was assessed at 12 months by ileocolonoscopy. At 12 months, all patients maintained clinical remission on mesalazine, but they showed evidence of endoscopic recurrence [62]. The frequency and pattern of endoscopic recurrence were comparable regardless of surgical approach in this small study.

Laparoscopy results in better cosmesis and body image than open conventional surgery in patients with Crohn's disease. Eshuis et al. [38] followed 55 patients who underwent ileocecal resection in a 4-year study period. Quality of life was measured using the SF-36 Health Survey and Gastrointestinal Quality of Life Index and Body Image Questionnaire (GIQLI). Twenty-six patients underwent an open resection, and 29 patients underwent a laparoscopic resection. Baseline patient characteristics were similar across groups. Three patients in the open group and two patients in the laparoscopic group needed further resection. There were no significant differences in reoperation rate for recurrence, incisional hernia, and adhesional obstruction after open or laparoscopic resection. Quality-of-life measures by the SF-36 and GIQLI were comparable between the two groups. However, patients in the laparoscopy group scored significantly better on the body image and cosmesis scale [38].

Single-port laparoscopic surgery and robotic surgery

Single-port laparoscopic surgery (SILS) is a fast-growing aspect of minimally invasive surgery. It has been applied to various operations such as appendectomy, cholecystectomy, and gastric banding in small series. There are a few reported cases of the use of SILS in Crohn's disease. Kawahara et al. [63] report using the technique to perform a laparoscopic right hemicolectomy for recurrent ileocolic disease. Single-port access has also been used in Crohn's disease with an ileovesical fistula [64]. Additionally, SILS has been used in Crohn's disease complicated by an enterocutaneous fistula [65]. These are case reports with good results; however, to date, no series have been reported. In addition, there are no reported series of Crohn's being treated with robotic surgery.

Conclusion

Crohn's disease is a chronic inflammatory disease characterized by transmural inflammation of gastrointestinal mucosa. It is incurable, and the mainstay of therapy is medical management with surgery reserved for the treatment of complications. Because of its relapsing nature, a majority of patients eventually require surgical intervention. Often, multiple operations are required throughout the patient's lifetime. These patients are at risk for developing short-bowel syndrome with repeat resections. Increasingly, bowel-sparing techniques such as strictureplasty have been employed to reduce this risk. Most studies have shown acceptable complications rates with strictureplasty, but more

studies are needed to evaluate the complications with strictureplasty compared with resection. Additionally, with the advent of laparoscopy, increasing numbers of surgeons are applying a laparoscopic approach to Crohn's disease. Data on short-term results appear promising and suggest similar benefits as in other areas of minimally invasive surgery. However, the two largest trials did not show any differences in outcomes between laparoscopy and conventional open resections for Crohn's disease. Data are also available to show that laparoscopy is safe and has reasonable outcomes when used in complex Crohn's disease. Long-term data are more sparse, but recurrence rates appear equal regardless of approach. The data support adding laparoscopy as the preferred approach to Crohn's disease. However, because laparoscopy may be difficult in these situations, appropriate surgical expertise is a mandatory prerequisite.

Conflicts of interest   None.

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