Restorative Operations for Crohn's Disease

Benjamin Person, M.D.¹ and Marat Khaikin, M.D.¹

ABSTRACT

Restoration of the continuity of the intestinal tract is one of the key concepts for maintaining the quality of life in patients with Crohn's disease. Restorative procedures have an important role in the scope of operative modalities for these patients. The authors review operative options aimed at fulfilling these goals including restorative partial small bowel resection; segmental, subtotal, and total colectomies; and ileal pouch anal anastomosis in patients with Crohn's disease.

KEYWORDS: Crohn's disease, small bowel resection, segmental colectomy, ileal pouch anal anastomosis

Objectives: Upon completion of this article, the reader should be familiar with the variety of restorative operations in patients with Crohn's disease, and should understand the advantages and disadvantages of each surgical option.

Crohn's disease is a chronic, relapsing, incurable inflammatory condition that can affect the entire digestive tract, which is characterized by transmural inflammation and skip lesions. Indications for surgical intervention include acute and chronic complications of the disease such as toxic colitis, megacolon, perforation, hemorrhage, fistula, obstruction, stricture, carcinoma, and cases of failed medical therapy.^{1,2} Whenever surgical treatment is indicated, it is crucial to consider that the disease cannot be cured medically or surgically. Consequently, any type of treatment (medical or surgical) is directed at appropriately controlling symptoms, improving quality of life, and preserving the length and continuity of the intestinal tract.

The majority of patients with Crohn's disease ultimately require surgical intervention at some point in their life. In 1979, the National Cooperative Crohn's Disease Study³ reported that the risk of a patient with Crohn's disease to undergo any surgical procedure was 78% and 90% at 20 and 30 years from diagnosis, respectively. These numbers may have decreased

slightly with the widespread use of newer medical agents; however, this risk has not yet been eliminated. The relapsing and chronic nature of the disease is also demonstrated by the substantial recurrence rates following surgical procedures. Froehlich et al⁴ reported that one year following the initial resection, up to 80% of patients have endoscopic signs of recurrence, 10 to 20% have clinical relapse, and ~5% of patients have surgical recurrence.

Excluding anorectal procedures, surgical options in patients with Crohn's disease can be broadly divided into procedures in which a segment of intestine is resected, or nonresectional procedures (internal bypass, fecal diversion, strictureplasty). The resectional procedures can be further divided into restorative or nonrestorative procedures. Nonrestorative procedures (construction of a stoma) are preferred by most surgeons in emergency operations, in cases of fecal peritonitis, and in cases in which the patient is hemodynamically unstable, severely malnourished, or otherwise critically ill.

¹Department of Colorectal Surgery, Cleveland Clinic Florida, Weston, Florida.

Address for correspondence and reprint requests: Benjamin Person, M.D., Department of Colorectal Surgery, Cleveland Clinic Florida, 2950 Cleveland Clinic Blvd., Weston, FL 33331 (e-mail: personb@ccf.org).

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The focus of this review is restorative operations in patients with Crohn's disease.

CLASSIFICATION

The Vienna Classification⁵ is the most widely accepted classification scheme for Crohn's disease. It incorporates age at diagnosis (A1: <40 years, A2: ≥40 years), location (L1: terminal ileum, L2: colon, L3: ileocolon, L4: upper gastrointestinal), and behavior of the disease (B1: nonstricturing, nonpenetrating, inflammatory; B2: stricturing; B3: penetrating). Approximately 20 to 30% of patients have Crohn's colitis, 20 to 30% of patients have Crohn's ileitis, and 50% of patients have ileocolitis—disease that involves both the terminal ileum and the colon. When surgical treatment is indicated, all of these factors should be taken into consideration.

RESTORATIVE SMALL BOWEL RESECTION

Isolated disease of the small bowel that necessitates surgical resection should theoretically be approached in a routine manner: The diseased segment of small bowel should be resected, with construction either of an anastomosis or of a stoma. However, there are several issues that require special consideration.

Margins of Resection

For decades, the “appropriate” margin of resection was a debatable issue. Initially, only margins that were pathologically free of Crohn's disease were considered adequate; surgeons sent resected specimens for intraoperative frozen section examination until clear histologic margins were ultimately achieved. Such practice resulted in extensive resections, especially of small bowel, with significant risk of subsequent short bowel syndrome. The length of the resected specimen and the margins of resection are more important when resecting small bowel because the issue of short gut syndrome usually does not apply to the length of the large bowel. In 1980, Pennington et al⁶ compared the anastomotic recurrence rates of Crohn's disease in patients in whom the histologic margins were free, to the rates of recurrence in patients in whom the margins had histologic signs of Crohn's disease, and demonstrated that recurrence rates were similar in both groups irrespective of the histopathology of the resected margin. The authors concluded that the findings supported conservative resection to achieve grossly uninvolved margins rather than sacrificing functional intestine in an attempt to achieve histopathologically uninvolved margins. Subsequently, similar findings were reported by other groups^{7–9}; with the realization that Crohn's disease is a panenteric inflammatory process, most surgeons who currently operate on patients with Crohn's disease,

perform intestinal resection in macroscopically normal margins.

Management of the Mesentery

The characteristic thickened Crohn's mesentery can preclude optimal visualization and control of the mesenteric vessels during the resection, which may increase the risk of a mesenteric hematoma. This potential problem can be managed either by serial overlapping clamping of the mesentery of the excised bowel, or by dividing the mesentery with an energy-based vascular sealing device. The thick mesentery can also make laparoscopic resection difficult.

Anastomotic Technique

The most common configurations of a small bowel and a small-to-large bowel anastomosis are a stapled side-to-side or a sutured end-to-end anastomosis, according to the surgeon's preference. Several studies have reported that stapled anastomoses resulted in significantly lower rates of disease recurrence^{10,11} and anastomotic leaks¹²; however, stapling may not be possible or safe in cases where the intestinal wall is significantly thickened, in which case suturing may be a better option.

Adhesions and Fistulas with Adjacent Normal Structures

It is not uncommon that adjacent normal bowel and other structures (bladder, uterus) are affected by adhesions or internal fistulas, and it is sometimes very difficult to distinguish the diseased loop of bowel from the “innocent bystander.” As a general principle, normal small bowel should not be resected. A fistulous tract targeting a normal structure should usually be excised either by a simple wedge resection and closure, or by a limited segmental resection and anastomosis. An extensive adhesiolysis usually is not required unless treatment of an interloop abscess is attempted.

ILEOCOLIC RESECTION

The terminal ileum is the most common site of Crohn's disease and concomitant cecal involvement is not uncommon. In cases where the cecum is not involved, the diseased terminal ileal segment might be too distal to allow a safe stapled enteroenterostomy with macroscopically normal distal margins. Therefore, a handsewn enteroenterostomy or a stapled ileocolic (or ileocecal) resection should be performed, with the latter being the most commonly performed procedure for this distribution of the disease. The principles of resection and anastomosis that were described in the previous section apply to ileocolic resection as well. Nonaffected

ascending colon usually should not be resected, and the newly constructed anastomosis should be physically separated from the underlying duodenum to reduce the risk of complex fistulas in cases of recurrent anastomotic disease; this goal can be accomplished by positioning the omentum between the anastomosis and the duodenum.

COLONIC RESECTION

Approximately one third of patients with Crohn's disease have isolated colitis or proctocolitis. The optimal surgical approach in these patients is controversial. It seems logical that patients with relative rectal sparing and limited segmental, localized colitis should undergo a segmental colectomy; however, due to the recurrent nature of the disease, additional subsequent operations may be required. Conversely, patients with diffuse proctocolitis should undergo a total proctocolectomy, which will eliminate the possibility of future colitis, but will also subject the patient to a permanent ileostomy. In addition to the extent of the disease, important factors to be considered are the patient's nutritional status, number and extent of prior resections, and whether the patient has fecal incontinence. Variables such as patient's age, comorbidities, and urgency of the procedure should also be taken into account.

Segmental versus Total or Subtotal Colectomy

As mentioned above, the decision as to which procedure to perform is an individualized process that should be independently tailored to each patient. A hypothetical elderly patient with localized colitis and preexisting fecal incontinence may have worse functional outcomes following a segmental colectomy, whereas a young patient with diffuse colitis, adequate anorectal function, and relative rectal sparing may benefit most from a total colectomy with an ileorectal anastomosis.

Colitis limited to the ascending and/or proximal transverse colon is best treated by a right or extended right colectomy. Colitis of the left and distal transverse colon potentially could be treated by a segmental resection with a colocolic anastomosis, or by a total or subtotal colectomy with an ileorectal or ileosigmoid anastomosis.

Similar to small bowel resections, surgeons speculated that limited or segmental colonic resections when clinically appropriate could be advantageous for patients with limited Crohn's colitis. More than two decades ago, Sanfey et al¹³ reported their experience with 41 patients with various degrees of Crohn's colitis. Twelve patients had a total proctocolectomy with a permanent ileostomy, and 29 patients had segmental resections. Of these 29 patients, 13 had a subtotal colectomy with 7 having an ileorectal anastomosis and 6 had an ileostomy. Only 3 of these 13 patients (23%) had the continuity of the bowel eventually restored. The remaining 16 patients

had limited colectomies; in 12 patients (75%) the continuity was restored in the long term. Despite the fact that these patients required more subsequent operations due to recurrent disease, the authors concluded that limited colitis should be treated by a limited resection, and that diffuse or distal colitis should be treated with total colectomy or proctocolectomy, and that these patients had a low chance of having their stomas reversed. Longo et al¹⁴ noted that after 5.5 years of follow-up, 62% of patients who had segmental colectomy and 67% of patients who had total colectomy had recurrent disease compared with 20% recurrent small bowel disease in patients who had total proctocolectomy. Intestinal continuity was maintained in 81% of the patients treated by segmental resection. The authors concluded that although recurrence was likely, segmental colectomy improved the quality of life by delaying the need for a stoma and by preserving functioning bowel. Prabhakar et al¹⁵ from the Mayo Clinic described 49 patients who underwent a segmental or a total colectomy and were followed for a mean of 14 years. In 22 patients (45%) no further treatment was required; of the remaining 27 patients, 16 required additional surgical procedures due to recurrent disease that occurred after a mean of 51 months, and 5 had a third procedure. After 14 years of follow up, 42 patients (86%) remained stoma-free, and 7 (14%) ultimately required permanent ileostomy, with a mean stoma-free interval of 23 months.

A recent meta-analysis¹⁶ compared the results of segmental and total or subtotal colectomy for Crohn's colitis. No prospective randomized trials compared these procedures, so the authors reviewed six comparative trials, which included 488 patients of whom 223 underwent a total colectomy with an ileorectal anastomosis and 265 had a segmental colectomy. There were no differences in rates of postoperative recurrence, postoperative complications, or need for a permanent stoma between the two groups, however, the time to recurrence of Crohn's disease was significantly shorter in the patients who underwent a segmental resection by a mean of 4.4 years ($p < 0.001$). The authors concluded that both procedures were equally effective as treatment options for colonic Crohn's disease, with recurrence occurring significantly earlier in patients who undergo limited resections. The choice of operation should be dependent on the extent of colonic disease; however, because no prospective randomized studies have been undertaken, a clear view about which approach was more suitable for localized colonic Crohn's disease could not be determined.

With the introduction and widespread use of more aggressive and effective agents for postoperative maintenance and prophylaxis, recurrence may be reduced and delayed even more than previously reported. Surgeons should keep in mind that depending on the extent of the colonic inflammation, a limited resection should

Table 1 Outcomes of Restorative Proctocolectomy and Ileal Pouch-Anal Anastomosis in Patients with Crohn's Disease

Study	Year	n	Pouch Excision (%)	Pouch Failure* (%)	Follow-Up (M)
Hyman et al ²¹	1991	25	28	36	38
Deutsch et al ²²	1991	9	44	66	NA
Grobler et al ²³	1993	20	30	NA	NA
Fazio et al ²⁴	1995	67	25	31	35
Sagar et al ²⁵	1996	37	27	45	120
Peyregne et al ²⁶	2000	7	14	43	84
Mylonakis et al ²⁷	2001	23	48	52	122
de Oca et al ²⁸	2003	12	16	25	76
Braverman et al ²⁹	2004	32	22	28	153
Hartley et al ³⁰	2004	60	10	12	46
Brown et al ¹⁹	2005	36	45	56	83
Tekkis et al ²⁰	2005	26	54	58	70

*Pouch excision or permanent diversion.

be considered and supplemented with appropriate maintenance therapy. This may significantly delay recurrence, potentially reduce the need for subsequent surgical interventions, and potentially reduce the risk of a permanent stoma, which is one of the major factors that influence the quality of life, especially in this young patient population.

RESTORATIVE PROCTOCOLECTOMY AND ILEAL POUCH-ANAL ANASTOMOSIS

Restorative proctocolectomy (RPC) and ileal pouch-anal anastomosis (IPAA) is the procedure of choice for patients with ulcerative colitis (UC) and familial adenomatous polyposis (FAP). However, most surgeons consider Crohn's colitis to be an absolute contraindication for performing a RPC and IPAA due to high complication and failure rates, which may lead to excision of the pouch and result in a permanent ileostomy and short bowel syndrome. Currently, few centers offer a RPC and IPAA to patients with an established preoperative diagnosis of Crohn's disease.^{17,18} In one recent report,¹⁸ the authors selected 41 patients with isolated Crohn's proctocolitis without anal manifestations to undergo a RPC with IPAA. After 10 years of follow-up, 14 patients (35%) had Crohn's-related complications and 4 patients (10%) had their pouch excised. The authors suggested that due to the relatively low complication rates, this procedure could be offered to selected patients with Crohn's disease; it may delay the need for a permanent ileostomy. Despite these rather promising results, most studies reported significantly worse outcomes. Brown et al¹⁹ described 36 patients who were followed up for a mean of 83 months. The pouch failure rate in this report was 56% (20 patients), with 16 patients (45%) having their pouch excised; 64% of patients had pouch-related complications and 4 additional patients (11%) required permanent diversion. Tekkis et al²⁰

reported on 26 patients who had RPC and IPAA for Crohn's disease. After 70 months of follow-up, 14 patients (54%) underwent a pouch excision, and another patient was permanently diverted for a total pouch failure rate of 58% (15 patients). These patients also were 2.6 times more likely to develop pouch-related fistulae compared with patients who had a diagnosis of UC. The authors of these reports concluded that Crohn's disease should remain a contraindication to RPC and IPAA. The outcomes reported in these and other studies are summarized in Table 1.¹⁹⁻³⁰ The reported overall pouch failure rates range from 12 to 66% with pouch excision rates ranging from 10 to 54%. In a recent meta-analysis, Reese et al³¹ compared the outcomes of RPC and IPAA in patients with UC, Crohn's disease, and indeterminate colitis. Ten studies comprising 3,103 patients (Crohn's disease, $n = 225$; ulcerative colitis, $n = 2,711$; indeterminate colitis, $n = 167$) were included. Patients with Crohn's disease had significantly more anastomotic strictures ($p = 0.05$), higher pouch failure rates ($p < 0.001$), higher rates of pouch inflammation after closure of protective ileostomy ($p = 0.05$), higher rates of urgency ($p = 0.02$), and higher rates of incontinence ($p = 0.01$) compared with patients with non-Crohn's diagnosis. The pooled pouch failure rate in this study was 35% in patients with Crohn's disease compared with 4.8% in patients with UC and indeterminate colitis combined ($p < 0.001$); the overall postoperative complication rates were significantly higher and functional outcomes were worse in patients with Crohn's disease. The authors recommended that patients with an established preoperative diagnosis of Crohn's disease who are planning to undergo a RPC and IPAA should be fully aware of these results and their consequences. Nevertheless, they also suggested that a carefully selected, special subset of patients, who have isolated Crohn's colitis without any evidence of small intestinal or perianal manifestations, may benefit from RPC and

IPAA with acceptable complications and function. Similarly, patients who undergo a RPC and IPAA for presumed UC or indeterminate colitis, whose diagnosis is subsequently changed to Crohn's disease, but do not have perianal or terminal ileal manifestations, also may have acceptable outcomes and function. Hartley et al³⁰ described a series of 60 such patients in whom the pouch failure rate was only 12%; in the 53 patients with functioning pouches, the median number of daily bowel movements was 7 (3 to 20) with 50% of patients rarely or never experiencing urgency and 59% (35 patients) reporting perfect or near-perfect continence. The authors suggested that such results could potentially be improved even further with the continued development of medical strategies for the long-term maintenance and suppression of Crohn's disease.

Currently, RPC and IPAA is not considered as the standard of care for patients with an established diagnosis of Crohn's disease; however, it may be followed by a successful outcome.

LAPAROSCOPY

Since the first laparoscopic colectomy nearly 17 years ago, almost every abdominal procedure has been laparoscopically attempted; the scope of indications is constantly increasing. Currently, a mounting body of evidence demonstrates the advantages of laparoscopy over traditional laparotomy: Smaller incisions cause less postoperative pain, earlier recovery of bowel function and toleration of diet, shorter hospitalization, and reduced costs.³²⁻³⁴ Early reports of the application of laparoscopy in patients with inflammatory bowel disease (IBD) discussed mainly the feasibility of creating stomas and performing limited resections laparoscopically,³⁵ but the indications were gradually broadened to include ileocolic resections, other segmental resections, and subtotal and total colectomies in patients with Crohn's disease, and even laparoscopic RPC and IPAA in selected patients with UC, and emergency operations.

Indications for laparoscopic surgery in patients with Crohn's disease are the same as for conventional surgery as mentioned in the beginning of this review. Potential contraindications for the laparoscopic approach include diffuse peritonitis, multiple previous laparotomies with known diffuse intraabdominal adhesions, acute intestinal obstruction with massive dilation of bowel loops, and uncorrectable bleeding disorders. The laparoscopic approach can and should be utilized in the same manner as conventional open surgery: (1) for establishing diagnosis—diagnostic laparoscopy, (2) for fecal diversion—laparoscopic creation of a colostomy or ileostomy, and (3) for performing bowel resections. However, the characteristic features of Crohn's disease—skip areas; thick and short mesentery; large, friable inflammatory masses; enteric fistulae and adhesions from

previous operations—make the laparoscopic approach in these cases significantly more challenging, even for the most experienced surgeons. Nevertheless, because most patients with Crohn's disease are relatively young, and most will require surgery at some point,³ the laparoscopic approach is very appealing for patients and surgeons alike, despite these difficulties.

The most extensive data about laparoscopic restorative procedures in patients with Crohn's disease are about ileocolic resection. Since the first report of laparoscopic ileocolic resection,³⁶ numerous studies compared its outcomes to the equivalent open procedure; interestingly, only two of these reports were prospective, randomized trials.^{37,38} Milsom et al³⁷ prospectively randomized 60 patients to undergo either a laparoscopic (31 patients) or a conventional (29 patients) ileocolic resection. In 2 patients (6.5%) the laparoscopic procedure was converted; there were significantly less minor complications in the laparoscopic group (4 versus 8 in the open group; $p < 0.05$); the operative time was significantly longer in the laparoscopic group (145 minutes versus 85 minutes in the open group; $p < 0.0001$); recovery of pulmonary function as measured by forced expiratory volume in the first second (FEV₁) and forced vital capacity (FVC) was significantly faster in the laparoscopic group (2.5 days versus 3.5 days in the open group; $p = 0.03$). There were no significant differences between the two groups in terms of postoperative opiate requirements, recovery of normal bowel function, and length of hospital stay. The authors concluded that the laparoscopic approach offered some benefits without any apparent disadvantages other than the longer operative time. In a more recent study, Maartense et al³⁸ also randomized 60 patients for laparoscopically assisted (30 patients) or conventional (30 patients) ileocolic resection. Primary outcome parameter was postoperative quality of life during 3 months of follow-up, and secondary parameters were operating time, morbidity, hospital stay, postoperative morphine requirement, pain, and costs. Conversion to an open procedure was required in 3 patients (10%). There was no statistically significant difference in quality of life between the groups during the follow-up period. Median operating time was longer in laparoscopic compared with open surgery (115 versus 90 minutes; $p < 0.003$). Hospital stay was shorter in the laparoscopic group (5 versus 7 days; $p = 0.008$). The number of patients with postoperative morbidity within the first 30 days was lower in the laparoscopic group (10% versus 33%; $p = 0.028$). Median overall costs during the 3 months of follow-up were significantly lower in the laparoscopic group ($p = 0.042$). The authors concluded that although there were no differences in the quality of life between the two groups, laparoscopy did offer obvious advantages over open surgery in terms of lower morbidity, shorter length of stay, and reduced costs. Long-term quality of life in patients with Crohn's

Table 2 Outcomes of Ileocolic Resection for Crohn's Disease

Study	Year	n L/O	Op Time (Minutes) L/O	Conversion (%)	Morbidity (%) L/O	LOS (Days) L/O
Bauer et al ⁴¹	1995	18/24	—	22.2	11/0	6.6/8.5*
Wu et al ⁴²	1997	22/70	139/202*	9.1	10/21*	4.5/7.9*
Dunker et al ⁴³	1998	11/11	—	—	—	5.5/9.9*
Alabaz et al ⁴⁴	2000	26/48	150/90.5*	11.6	15.4/16.7	7/9.6*
Bemelman et al ⁴⁵	2000	30/48	138/104*	6.6	10/14.6	5.7/10.2*
Kishi et al ⁴⁶	2000	18/7	214/193	0	28/18	—
Diamond et al ⁴⁷	2001	12/11	146/137	8.3	8.3/18.1	5.4/7.6*
Milsom et al ³⁷	2001	31/29	140/85*	6.5	12.9/27.6*	5/6
Young-Fadok et al ³²	2001	33/33	147/124	5.9	—	4/7*
Dupree et al ³³	2002	21/24	75/98*	4.8	14.3/16.7	3/5*
Benoist et al ⁴⁸	2003	24/32	179/198	16.7	20/10	7.7/8
Shore et al ⁴⁹	2003	20/20	145/133.5	5	0/5	4.25/8.25*
von Allmen et al ⁵⁰	2003	12/16	166/185	0	8.3/12.5	5.5/11.5*
Bergamaschi et al ⁵¹	2003	39/53	185/105*	0	10.2/9.4	6.5/11.2*
Huilgol et al ⁵²	2004	21/19	136/119.5	4.8	19/15.8	6.4/8.2*

* $p < 0.05$.

L, laparoscopic; O, open; LOS, length of hospital stay; Op Time, operative time.

disease has been shown to be reduced compared with the general population; recurrent disease was the only factor adversely affecting it, irrespective of the operative technique applied.³⁹ Tilney et al⁴⁰ recently conducted a meta-analysis of the results of 15 studies (one prospective randomized trial, six prospective observational trials, and eight retrospective trials) that compared the outcomes of laparoscopic with open ileocolic resection in Crohn's disease. The studies included 783 patients, 338 (43.2%) of whom had undergone laparoscopic resection, with an overall conversion rate of 6.8% (23 patients). The operative time was significantly longer in the laparoscopic group, by nearly 30 minutes ($p = 0.002$); the blood loss and complication rates in the two groups were similar. The patients who had laparoscopic surgery had a significantly shorter time for recovery of their bowel function and a shorter hospital stay, by 2.7 days ($p < 0.001$). For selected patients with uncomplicated ileocecal Crohn's disease, laparoscopic resection offered substantial advantages in terms of faster resolution of postoperative ileus and shortened hospital stay, with equivalent rates of morbidity compared with open procedures (Table 2).^{32,33,37,41–52} Lowney et al⁵³ studied the effect of laparoscopy on the long-term anastomotic recurrence after ileocolic resection in a retrospective study that included 113 patients. Recurrence was defined as development of new anastomotic Crohn's disease requiring surgical intervention. There was no statistically significant difference in the recurrence rates between the two groups; hence, the anastomotic recurrence is probably a feature of Crohn's disease, which is not dependent on the surgical technique that was used for the bowel resection.

SUMMARY

The ultimate goals of both the medical and surgical treatment Crohn's disease are optimal control of symptoms and maintenance of quality of life. Because the presence of a stoma is detrimental to quality of life, avoidance of creating stomas by performing restorative procedures is a key feature in maintaining a better quality of life. However, patients and physicians should keep in mind that it is natural for Crohn's disease to relapse, especially at or near previous anastomoses, and that recurrence has a negative impact on quality of life. Patients should be fully aware that at some point, creation of a stoma may be a better option for controlling symptoms and improving lifestyle.

REFERENCES

- Strong SA. Surgery for Crohn's disease. In: Wolff BG, Fleshman JW, Beck DE, Pemberton JH, Wexner SD, eds. *The ASCRS Textbook of Colon and Rectal Surgery*. New York, NY: Springer; 2007:584–600
- Mahadevan U, Young-Fadok T. Crohn's disease of the colon. In: Wexner SD, Stollman N, eds. *Diseases of the Colon*. New York, NY: Informa Healthcare Inc; 2007:625–646
- Mekhjian HS, Switz DM, Watts HD, Deren JJ, Katon RM, Beman FM. National Cooperative Crohn's Disease Study: factors determining recurrence of Crohn's disease after surgery. *Gastroenterology* 1979;77(4 Pt 2):907–913
- Froehlich F, Juillerat P, Felley C, et al. Treatment of postoperative Crohn's disease. *Digestion* 2005;71:49–53
- Gasche C, Scholmerich J, Brynskov J, et al. A simple classification of Crohn's disease: report of the Working Party for the World Congresses of Gastroenterology, Vienna 1998. *Inflamm Bowel Dis* 2000;6:8–15

6. Pennington L, Hamilton SR, Bayless TM, Cameron JL. Surgical management of Crohn's disease. Influence of disease at margin of resection. *Ann Surg* 1980;192:311-318
7. Fazio VW, Marchetti F, Church M, et al. Effect of resection margins on the recurrence of Crohn's disease in the small bowel. A randomized controlled trial. *Ann Surg* 1996;224:563-571
8. Adloff M, Arnaud JP, Ollier JC. Does the histologic appearance at the margin of resection affect the postoperative recurrence rate in Crohn's disease? *Am Surg* 1987;53:543-546
9. Cooper JC, Williams NS. The influence of microscopic disease at the margin of resection on recurrence rates in Crohn's disease. *Ann R Coll Surg Engl* 1986;68:23-26
10. Ikeuchi H, Kusunoki M, Yamamura T. Long-term results of stapled and hand-sewn anastomoses in patients with Crohn's disease. *Dig Surg* 2000;17:493-496
11. Munoz-Juarez M, Yamamoto T, Wolf BG, Keighley MR. Wide-lumen stapled anastomosis vs. conventional end-to-end anastomosis in the treatment of Crohn's disease. *Dis Colon Rectum* 2001;44:20-25
12. Resegotti A, Astegiano M, Farina EC, et al. Side-to-side stapled anastomosis strongly reduces anastomotic leak rates in Crohn's disease surgery. *Dis Colon Rectum* 2005;48:464-468
13. Sanfey H, Bayless TM, Cameron JL. Crohn's disease of the colon. Is there a role for limited resection? *Am J Surg* 1984;147:38-42
14. Longo WE, Ballantyne GH, Cahow CE. Treatment of Crohn's colitis. Segmental or total colectomy? *Arch Surg* 1988;123:588-590
15. Prabhakar LP, Laramie C, Nelson H, Dozois RR. Avoiding a stoma: role for segmental or abdominal colectomy in Crohn's colitis. *Dis Colon Rectum* 1997;40:71-78
16. Tekkis PP, Purkayastha S, Lanitis S, et al. A comparison of segmental vs subtotal/total colectomy for colonic Crohn's disease: a meta-analysis. *Colorectal Dis* 2006;8:82-90
17. Panis Y, Poupard B, Nemeth J, Lavergne A, Hautefeuille P, Valleur P. Ileal pouch/anal anastomosis for Crohn's disease. *Lancet* 1996;347:854-857
18. Regimbeau JM, Panis Y, Pocard M, et al. Long-term results of ileal pouch-anal anastomosis for colorectal Crohn's disease. *Dis Colon Rectum* 2001;44:769-778
19. Brown CJ, Maclean AR, Cohen Z, Macrae HM, O'Connor BI, McLeod RS. Crohn's disease and indeterminate colitis and the ileal pouch-anal anastomosis: outcomes and patterns of failure. *Dis Colon Rectum* 2005;48:1542-1549
20. Tekkis PP, Heriot AG, Smith O, Smith JJ, Windsor AC, Nicholls RJ. Long-term outcomes of restorative proctocolectomy for Crohn's disease and indeterminate colitis. *Colorectal Dis* 2005;7:218-223
21. Hyman NH, Fazio VW, Tuckson WB, Lavery IC. Consequences of ileal pouch-anal anastomosis for Crohn's colitis. *Dis Colon Rectum* 1991;34:653-657
22. Deutsch AA, McLeod RS, Cullen J, Cohen Z. Results of the pelvic-pouch procedure in patients with Crohn's disease. *Dis Colon Rectum* 1991;34:475-477
23. Grobler SP, Hosie KB, Affie E, Thompson H, Keighley MR. Outcome of restorative proctocolectomy when the diagnosis is suggestive of Crohn's disease. *Gut* 1993;34:1384-1388
24. Fazio VW, Ziv Y, Church JM, et al. Ileal pouch-anal anastomoses complications and function in 1005 patients. *Ann Surg* 1995;222:120-127
25. Sagar PM, Dozois RR, Wolff BG. Long-term results of ileal pouch-anal anastomosis in patients with Crohn's disease. *Dis Colon Rectum* 1996;39:893-898
26. Peyregne V, Francois Y, Gilly FN, Descos JL, Flourie B, Vignal J. Outcome of ileal pouch after secondary diagnosis of Crohn's disease. *Int J Colorectal Dis* 2000;15:49-53
27. Mylonakis E, Allan RN, Keighley MR. How does pouch construction for a final diagnosis of Crohn's disease compare with ileoproctostomy for established Crohn's proctocolitis? *Dis Colon Rectum* 2001;44:1137-1142
28. de Oca J, Sanchez-Santos R, Rague JM, et al. Long-term results of ileal pouch-anal anastomosis in Crohn's disease. *Inflamm Bowel Dis* 2003;9:171-175
29. Braveman JM, Schoetz DJ Jr, Marcello PW, et al. The fate of the ileal pouch in patients developing Crohn's disease. *Dis Colon Rectum* 2004;47:1613-1619
30. Hartley JE, Fazio VW, Remzi FH, et al. Analysis of the outcome of ileal pouch-anal anastomosis in patients with Crohn's disease. *Dis Colon Rectum* 2004;47:1808-1815
31. Reese GE, Lovegrove RE, Tilney HS, et al. The effect of Crohn's disease on outcomes after restorative proctocolectomy. *Dis Colon Rectum* 2007;50:239-250
32. Young-Fadok TM, Hall Long 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
33. Duepre 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
34. Chen HH, Wexner SD, Weiss EG, et al. Laparoscopic colectomy for benign colorectal disease is associated with a significant reduction in disability as compared with laparotomy. *Surg Endosc* 1998;12:1397-1400
35. Ludwig KA, Milsom JW, Garcia-Ruiz A, Fazio VW. Laparoscopic techniques for fecal diversion. *Dis Colon Rectum* 1996;39:285-288
36. Milsom JW, Lavery IC, Bohm B, Fazio VW. Laparoscopically assisted ileocelectomy in Crohn's disease. *Surg Laparosc Endosc* 1993;3:77-80
37. Milsom JW, Hammerhofer KA, Bohm 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
38. Maartense S, Dunker MS, Slors JF, et al. Laparoscopic-assisted versus open ileocolic resection for Crohn's disease: a randomized trial. *Ann Surg* 2006;243:143-149
39. Thaler K, Dinnewitzer A, Oberwalder M, Weiss EG, Noguera 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
40. Tilney HS, Constantinides VA, Heriot AG, et al. Comparison of laparoscopic and open ileocecal resection for Crohn's disease: a meta-analysis. *Surg Endosc* 2006;20:1036-1044
41. Bauer JJ, Harris MT, Grumbach NM, Gorfine SR. Laparoscopic-assisted intestinal resection for Crohn's disease. *Dis Colon Rectum* 1995;38(7):712-715
42. Wu JS, Birnbaum EH, Kodner IJ, Fry RD, Read TE, Fleshman JW. Laparoscopic-assisted ileocolic resections in patients with Crohn's disease: are abscesses, phlegmons, or recurrent disease contraindications? *Surgery* 1997;122(4):682-688
43. Dunker MS, Stiggelbout AM, van Hogeand 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(11):1334-1340
44. Alabaz O, Iroatulam AJ, Nessim A, Weiss EG, Noguera JJ, Wexner SD. Comparison of laparoscopically assisted and

- conventional ileocolic resection for Crohn's disease. *Eur J Surg* 2000;166(3):213–217
45. Bemelman WA, Slors JF, Dunker MS, et al. Laparoscopic-assisted vs. open ileocolic resection for Crohn's disease. A comparative study. *Surg Endosc* 2000;14(8):721–725
46. Kishi D, Nezu R, Ito T, et al. Laparoscopic-assisted surgery for Crohn's disease: reduced surgical stress following ileocelectomy. *Surg Today* 2000;30(3):219–222
47. Diamond IR, Langer JC. Laparoscopic-assisted versus open ileocolic resection for adolescent Crohn disease. *J Pediatr Gastroenterol Nutr* 2001;33(5):543–547
48. 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(5):814–818
49. Shore G, Gonzalez QH, Bondora A, Vickers SM. Laparoscopic vs conventional ileocelectomy for primary Crohn disease. *Arch Surg* 2003;138(1):76–79
50. von Allmen D, Markowitz JE, York A, Mamula P, Shepanski M, Baldassano R. Laparoscopic-assisted bowel resection offers advantages over open surgery for treatment of segmental Crohn's disease in children. *J Pediatr Surg* 2003;38(6):963–965
51. Bergamaschi R, Pessaux P, Arnaud JP. Comparison of conventional and laparoscopic ileocolic resection for Crohn's disease. *Dis Colon Rectum* 2003;46(8):1129–1133
52. Huilgol RL, Wright CM, Solomon MJ. Laparoscopic versus open ileocolic resection for Crohn's disease. *J Laparoendosc Adv Surg Tech A* 2004;14(2):61–65
53. 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