Operative Management of Small and Large Bowel Crohn's Disease

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KEYWORDS

• CD • Surgery • Mesenteric excision • Ileocolic resection • Ileostomy

KEY POINTS

- Surgery for small-bowel and large-bowel Crohn's disease is common, with the majority requiring surgery during their lifetime.
- Intestinal resections for small-bowel and large-bowel Crohn's disease are often staged using temporary ileostomies.
- Bowel-preserving surgery for jejunoileal Crohn's disease includes strictureplasties and small bowel resection with a handsewn enteroenterostomy.
- The optimal anastomosis after ileocolic resection should have low leak and recurrence rates.
- Segmental resection, total colectomy with ileorectal anastomosis, and total proctocolectomy are all appropriate for patients with Crohn's colitis.

INTRODUCTION

Crohn'd disease (CD) is a chronic, incurable inflammatory disorder that can affect any segment of the gastrointestinal (GI) tract, as well as extraintestinal sites.[1,2] Since the inception of infliximab (a Tumor Necrosis Factor inhibitor) for treating CD in 1998, significant progress has been made, leading to the development of advaned therapies including next generation biologics and small molecules.[3] Biologics broadly fall into categories such as anti-Interleukins, anti-integrins, and small molecule Janus Kinase (JAK) inhibitors. The goal of managing CD has shifted from controlling symptoms to altering the natural course of the disease and improving long-term outcomes.

The introduction of biologics coincided with a demonstrated 44% to 50% decrease in cumulative intestinal resection rates for CD diagnosed in the 21st century compared to the 20th century.[4] Surgery rates, a surrogate measure for the impact of these medications, has showed an inverse association between biologic use and the likelihood of

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intestinal resection.[5] Recent evidence suggests a role for early surgical intervention in limited CD, moving away from the previous dogma that surgery should be reserved for enteric complications or therapeutic failure.[6] There is mounting evidence that implicates the mesentery in development of CD and this has led to developing surgical techniques like Kono-S anastomosis (KSA), extended mesenteric excision (EME), and most recently mesenteric excision and exclusion (MEE) as prophylaxuis to prevent recurrence by excision and exclusion of mesentery.[7–11]

DEMOGRAPHICS AND ETIOPATHOGENESIS

The prevalence of CD is 322 per 100,000 in Europe and 319 per 100,000 in North America.[12] The incidence of CD has plateaued in industrialized countries.[13] The incidence of pediatric and early onset inflammatory bowel disease (IBD) continues to increase, and given this, the prevalence is expected to reach 1% of the population.[14,15] CD has a bimodal distribution with one peak occurring between the ages 18 and 35 years and a smaller peak between the ages 50 and 60 years.[13] The causes of CD are multifactorial and currently centers around the hygiene hypothesis. It is hypothesized that an alteration in luminal gut microbiota (decreased diversity due to being raised or living in an "overly" hygienic environment) and environmental factors (smoking, physical activity, antibiotic exposure, ultra-processed foods) in a genetically susceptible host incite a dysregulated immune response to luminal triggers.[16–22]

Indications for Surgery

Surgery for intestinal CD is typically limited to the treatment of CD complications, most commonly fibrostenotic disease associated with obstruction, and penetrating disease with abscesses and fistulae. It is important to note that most patients initially present with an inflammatory phenotype but may progress to stricturing and/or fistulizing disease.[23] Surgery is also indicated for patients with limited or no response to standard medical therapies.[24] The decision to proceed with surgery is straightforward when acute complications necessitate urgent intervention, such as hemorrhage, intra-abdominal sepsis, obstruction, or perforation.[25–27] Chronic CD sequelae requiring elective surgical intervention include repeated or partial small bowel obstructions due to fibrotic strictures, fistulizing disease, extraintestinal manifestations, growth retardation, and neoplasia. Surgery for small-bowel and large-bowel CD can broadly be classified as non-resection, segmental resection, or extended resection (**Table 1**). For patients with risk factors for anastomotic leak (malnutrition, steroids, and anemia), a staged approach to bowel resection may be indicated (**Table 2**).

OPERATIVE INTERVENTION ACCORDING TO DISEASE LOCATION

Upper Gastrointestinal Tract: Esophageal CD

Esophageal CD (E-CD), first described in 1950, is exceedingly rare, with only a few hundred cases documented in the literature.[28,29] The incidence and prevalence of esophageal involvement range from 1.2% to 1.8% and 3.3% to 6.8%, respectively, in adults with CD.[30] Most patients have extraesophageal disease at the time of E-CD diagnosis. The most common phenotype affecting the esophagus is inflammation, followed by stricturing and fistulizing diseases. The presenting symptoms often mimic those of erosive esophagitis or reflux disease and include dysphagia, odynophagia, epigastric pain, heartburn, and chest pain. Any patient with a known diagnosis of CD presenting with upper GI complaints should undergo an upper endoscopy. Endoscopic findings included hyperemia, aphthous ulceration, friability, and cobblestoning.

Table 1
Types of abdominal surgery for CD

Non-resectional	Segmental Resections	Extended Resections
Strictureplasty	Small bowel resection	Total colectomy + EI
Diverting ostomy	Ileocolic resection	Total colectomy + IRA
Intestinal bypass	Segmental colectomy (ie,sigmoid) Proctectomy with ISD	Total proctocolectomy + EI Total proctocolectomy + IPAA

Abbreviations: EI, end ileostomy; IRA, ileorectal anastomosis; ISD, intersphincteric dissection; IPAA, ileal pouch-anal anastomosis.

Inflammatory E-CD is treated with advanced therapies and topical budesonide, often with the addition of antacids.[30,31] Less commonly, patients present with stricturing or fistulizing disease. Endoscopy with bougie dilation or balloon dilation may be performed for stenotic esophageal lesions. Dilation therapy can be combined with corticosteroid injections. In the era of biologics, this is usually done in combination with biologics and proton pump inhibitors (PPIs).[32–34] In rare cases, esophagectomy (partial or total) may be performed for CD esophagitis with fistula, obstruction, or to rule out or treat malignancy. Historically, fistulas communicating with the respiratory tract have been treated with esophagectomy, which carries a morbidity rate of around 25%.[29]

Table 2
Stages of surgery for inflammatory bowel disease

Ileocolic Resection and Anastomosis[a]				
	3-stage	*2-stage*	*1-stage*	*Modified 2-stage*
Stage 1	ICR-EI	ICA-DLI	ICA	ICR-EI
Stage 2	ICA-DLI	DLI-R	-	ICA
Stage 3	DLI-R	-	-	-
Ileorectal Anastomosis				
Stage 1	*3-stage*	*2-stage*	*1-stage*	*Modified 2-stage*
Stage 2	TAC-EI	TAC-IRA-DLI	TAC-IRA	TAC-EI
Stage 3	IRA-DLI	DLI-R	-	IRA
	DLI-R	-	-	-
Total Proctocolectomy with End Ileostomy				
	3-stage	*2-stage*	*1-stage*	
Stage 1	-	TAC-EI or CI	TPC-EI or CI	
Stage 2	-	CP	-	
Restorative Total Proctocolectomy with IPAA				
	3-stage	*2-stage*	*1-stage*	*Modified 2-stage*
Stage 1	TAC-EI	TPC-IPAA-DLI	TPC-IPAA	TAC-EI
Stage 2	CP-IPAA-DLI	DLI-R	-	CP-IPAA
Stage 3	DLI-R	-	-	-

Abbreviations: EI, end ileostomy; CP, completion proctectomy; DLI, diverting loop ileostomy; DLI-R, diverting loop ileostomy reversal; CI, continent-ileostomy; ICA, ileocolic anastomosis; ICR, ileocolic resection; IPAA, ileal pouch-anal anastomosis; IRA, ileorectal anastomosis; TAC, total abdominal colectomy; TPC, total proctocolectomy.

[a] Also applies to segmental colon resection for Crohn's colitis.

Upper Gastrointestinal Tract: Gastroduodenal CD

Gastroduodenal (GD) CD is a rare, high-risk phenotype with a prevalence of 0.5% to 4% among those with CD. The majority of patients have concurrent small bowel and/or ileocolonic disease.[29,35,36] Isolated gastric or duodenal CD is extremely rare, accounting for less than 0.07% of all cases of CD.[37] The most common phenotype of duodenal CD is fibrostenotic, and strictures are typically short and solitary, with an incidence of multiple strictures of 12% to 30%.[29,38] All 4 segments of the duodenum can be affected, as well as the proximal jejunum.[39] Symptoms include upper abdominal pain, nausea, vomiting, weight loss, and early satiety.[29,40] Imaging consists of computed tomograpy (CT) enterography and magnetic resonance (MR) enterography. Upper GI studies may also be helpful in identifying fistulas in the distal small bowel and/or colon and provide a road map to which surgeons can easily refer. Upper GI endoscopy is considered the gold standard for the diagnosis of GD-CD. Endoscopic findings in the stomach include aphthae, longitudinal erosions, and a bamboo joint appearance that is characterized by swollen longitudinal folds transversed by erosive fissures or linear furrows. In the duodenum, longitudinal erosions and notch-like appearances can be observed.[41] Medical management includes acid suppression with PPI and advanced therapies (biologics and small molecules) in a top-down approach to prevent further stricturing. Interventions to treat GD-CD strictures are often required. Short pyloric or duodenal strictures are amenable to serial endoscopic balloon dilation (EBD), and most patients subsequently require surgery.[42,43] Evidence suggests a lower risk of recurrence when steroid injection was performed during EBD.[44]

Surgery is indicated for duodenal obstruction secondary to strictures that are too long for EBD, failure of EBD to relieve symptoms, refractory obstructive symptoms despite maximum medical therapy and EBD, and less commonly, fistula and suspected or known malignancy.[35,45,46] The 3 surgical options are resection, bypass, and strictureplasty. Surgical resection for proximal duodenal involvement is largely of historic interest, as the morbidity of the Whipple procedure for duodenal CD is presently felt to be risk prohibitive for this otherwise benign disease, and other options exist.[47] Distal to the ampulla of Vater, a limited resection with handsewn anastomosis may be performed. Bypass and stricturoplasty are 2 options for duodenal obstruction non-amenable to resection. There is no consensus on which technique is superior.[35,48] It is the authors' institutional preference to perform stricturoplasty (see section on strictureplasties) over bypass whenever possible due to the higher risk of marginal ulceration dumping syndrome and delayed gastric emptying after bypass).[48,49] There is no clear benefit for performing routine vagotomy in this group and is not generally performed in the era of PPIs.[40,50]

Strictureplasties are the mainstay of surgical intervention for GD-CD. Short strictures <10 cm in the first through third portions of the duodenum may be suitable for Heineke–Mikulicz (HM) stricturoplasty, while longer strictures ranging from 15 to 25 cm may be amenable to Finney or Jaboulay strictureplasty. Careful attention must be paid to avoid ampullary structures during mobilization that required for these procedures. A short Jaboulay may be used for strictures of the second portion of the duodenum to avoid encroaching on the Ampulla of Vater (**Fig. 1**).

Long strictures, dense scarring around the stricture, 2 or more strictures, and those involving the third and fourth portions of the duodenum may require duodenojejunal (DJ) bypass (preferred) or gastrojejunal (GJ) bypass (**Table 3**). For DJ or GJ bypasses, the authors strongly prefer *not* to use a Roux limb, which requires an additional suture line that can become a nidus for recurrence. For GJ bypasses, we prefer a loop of

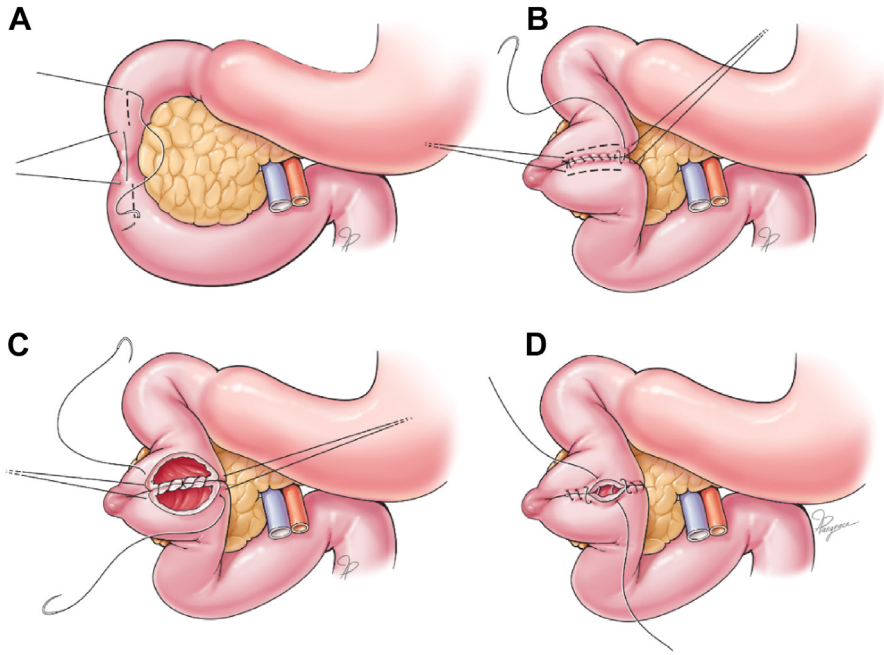


Fig. 1. Jaboulay strictureplasty for strictures of the second portion of the duodenum. (*A*) stay sutures are placed amd longitudional enterotomies performed; (*B*) the bowel proximal and distal to the stricture approximated transversrely; (*C*) backwall inerrupted outer later, and running inner layer; (*D*) front wall running inner layer and interrupted outcter layer (not shown). (*Reprinted with permission*, Cleveland Clinic Foundation ©2024. All Rights Reserved.)

proximal jejunum brought proximal to the stricture in an *antecolic* manner, and for a DJ bypass, in a *retrocolic* manner. A detailed step-by-step approach to DJ bypass for CD is available online DJ Bypass.[51]

Upper tract fistulae, typically ileo-duodenal or colo-duodenal fistulae, may be treated by resecting the distal segment from which the fistula originates and debridement and primary repair of the duodenal side of the fistula. If the fistula originates from the duodenum, the fistula may be excised leaving a duodenostomy which can be used for strictureplasty or bypass. When closing or manipulating the duodenotomy, special attention should be paid to the proximity of the ampulla of Vater that must be avoided. To prevent luminal narrowing, the duodenum is closed in a transverse handsewn manner, similar to HM strictureplasty. For larger defects, a loop duodenojejunoplasty or serosal patches may be required.

Small Bowel CD

Jejunoileitis, excluding the terminal ileum, is another high-risk phenotype that occurs in 3% to 10% of patients with CD.[52,53] The most common phenotype is inflammatory (56%–81%) followed by stricturing and penetrating.[53] The cumulative risk of developing a stricture or penetrating intestinal complications in CD is 22% at 1 year, and 51% at 20 years after diagnosis.[54] Inflammatory disease is treated with medical therapy, while surgery is the mainstay of therapy for fibrostenotic CD; EBD and insulated needle knife (iNK) stricturotomy may be considered for short (<5 cm), non-penetrating, fibrostenotic symptomatic small bowel, or anastomotic strictures.[55] Interestingly, the frequency of

Table 3
Steps of gastroduodenal or duodenojejunal bypass for duodenal Crohn's disease

Step	Techniques
Exposure	After medial visceral rotation with Kocher maneuver, a loop of unaffected proximal jejunum is brought through a mesocolic fenestration between the ileocolic and transverse colon pedicles.
Approximation	Unaffected portions of duodenum and jejunum are lined up with a backwall of interrupted 3-0 seromuscular sutures.
Jejunotomy/ Duodenotomy	A mirror image longitudinal jejunotomy and duodenotomy (or gastrotomy) are made with electrocautery.
Inner Layer	Full thickness running 3-0 sutures starting posteriorly in the middle and ending anteriorly in the middle to completely the inner layer.
Outer Layer	A front wall of interrupted seromuscular 3-0 sutures is then placed. The senior author prefers hozizontal mattress sutures instead of Lembert sutures.
Omentoplasty	Tongue of omentum is put on top of anastomosis.
Retrocolic Defect	Retrocolic mesenteric defect is loosely re-approximated.
Gastrostomy Tube	A Stamm gastrostomy tube may be constructed to decompress the chronically dilated stomach.
Drain	A surgical drain is left in the right upper quadrant in proximity to the anastomosis.
Radiographic Assessment	An upper GI series is typically performed on postoperative day 3, after which the diet may be advanced.

Abbreviation: GI, gastrointestinal.

strictureplasties has remained consistent overtime, with an average of 6.4 procedures per year before the introduction of biologics and 6.5 procedures per year after at a single center.[56] Surgical options include resection, stricturoplasty, and bypass.

A bowel-preserving surgery approach, first described by Lee in 1982, uses a combination of strictureplasties and limited resections, typically with handsewn enteroenterostomies, and is the *sine qua non* of surgery for small intestinal CD and employed whenever possible to forestall or prevent short-bowel syndrome.[57,58] There is a high incidence of recurrence after surgery, with 30% requiring subsequent surgery. The incidence of short bowel syndrome (SBS) 20 years after index surgery has been reported to be as high as 8.5%.[59] In a series of 240 patients undergoing abdominal surgery for indications other than CD, the mean length of the small bowel was 506 $\pm$ 105 cm, with men on average having an additional 50 cm compared to women, and increased height being the only multivariable predictor associated with small bowel length.[60]

Strictureplasties (**Table 4**) are indicated for single or multiple strictures, particularly in cases of recurrence at a previous strictureplasty or resection suture line. Resection is recommended in cases involving perforation, an inflammatory mass (eg, abscess or phlegmon), fistula, suspicion of malignancy, or malnutrition. Prior to surgery, the number, length, and characteristics of strictures are assessed radiographically, and risk factors (eg, malnutrition, steroids, and anemia) are optimized. Contraindications to strictureplasty include the presence of phlegmon, adjacent abscess, gross perforation, or stricture with an associated fistula.[61–63] Currently, the most commonly performed strictureplasty techniques are the HM, Finney, Jaboulay, and side-to-side isoperistaltic strictureplasties (also known as Michelassi strictureplasty).

Although the sensitivity and specificity of imaging modalities in identifying strictures are high, at approximately 90%, some strictures may be missed, emphasizing the

Table 4
Adjuncts to strictureplasties

Step	Techniques
Selection of Strictureplasty Technique(s)	Tailors the surgical approach to the specific characteristics of each stricture and patient.
Measurement	The length of the bowel measured before and after stricturoplasty and/or resection.
Surgical Clips	Use surgical clips adjacent to strictureplasties to aid in radiographic localization in the event of hemorrhage (to fascilitate embolization) or if malignancy is detected. One clips is placed adjascent to the most proximal stricture, two on the 2nd, three on the third, etc.
Frozen Sections	Selective frozen sections on suspicious/long-standing strictures.
Temporary Proximal Diversion	Selective temporary diversion based *not* on the number of strictureplasties, but on number of risk factors for anastomotic leak, such as acute SBO, steroids, malnutrition, anemia, smoking, or at the surgeon's discretion.

Abbreviation: SBO, small bowel obstruction.

importance of employing intraoperative strategies to find all strictures and avoid postoperative non-resolving small bowel obstruction. The methods to identify the disease include careful palpation, trawling the bowel with a Foley catheter inflated with 5-7 mL of water, and use of calibration spheres (preferred) with diameters between 20 and 25 mm (**Fig. 2**).[64–66] The use of intraoperative ultrasound to identify strictures that are not detected through manual inspection.[67] A video of the use of calibration spheres is available online http://links.lww.com/DCR/B942.[68]

Types of strictureplasties for short and long strictures are presented in **Tables 5** and **6**, respectively.[69–76]

Stricturoplasty Types For Short Strictures

Heineke-Mikulicz (HM)

HM is the most commonly performed stricturoplasty (**Fig. 3**) performed in patients with CD.[58] It is particularly suited for short-segment (<10 cm) chronic intestinal strictures. The overall concept is a longitudinal enterotomy over the stricture, which is then closed transversely. A single longitudinal enterotomy is made over the antimesenteric side of the affected small bowel, extending approximately 1 cm beyond both the proximal and distal thickened portions, when a "pop" is felt as the stricture releases, and is then closed transversely using interrupted or running sutures, typically in 2 layers, to create a wider lumen without resection. The senior author prefers horizontal mattress sutures, instead of Lembert suture, for the outer layer. Biopsies of luminal ulcers and strictures may be obtained to assess for occult malignancy in long-standing strictures. The leak rate after HM strictureplasty is approximately 6%, with a recurrence rate of 25% at 2 years, usually away from the original site.[76] Proximal diversion is not needed routinely, as it will often be a low or high jejunostomy, and is *not* based on the number of strictureplasties, but on the number of risk factors for anastomotic leak. A detailed step-by-step approach to MK strictureplasty for CD is available online (otz002_suppl_Supplement_B) and in a video https://pubmed.ncbi.nlm.nih.gov/38331585/.[51,77]

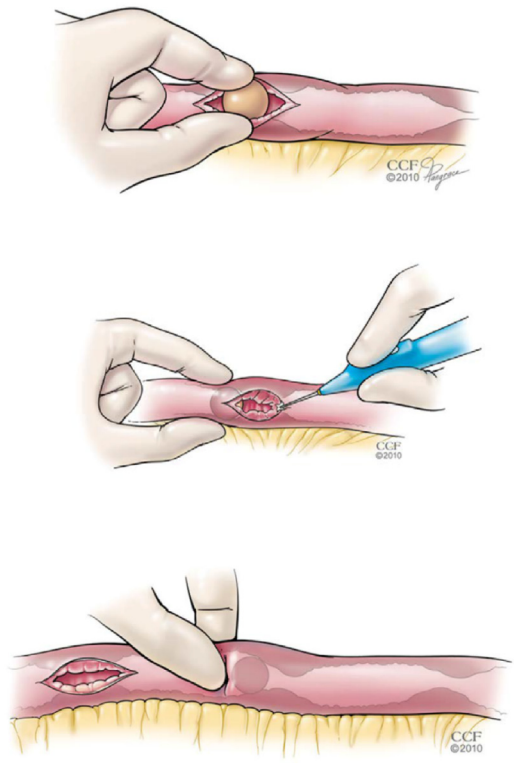


Fig. 2. Intraoperative calibration spheres for detecting occult small bowel strictures in jejunoileal Crohn's disease. (*Reprinted with permission*, Cleveland Clinic Foundation ©2024. All Rights Reserved.)

Stricturoplasty Types for Longer Strictures

Finney

A Finney strictureplasty (Fig. 4) is used for segments of 10 to 25 cm and performed in an estimated 5% to 10% of cases. The diseased bowel is folded into a U shape and opened longitudinally at the antimesenteric border, extending 1 cm onto the normal bowel on either side of the stricture, and sutured closed in a side-to-side antiperistaltic manner. The back wall is typically constructed using a seromuscular running 3-0 absorbable suture, and a running inner layer. The anterior bowel wall is then closed using running or interrupted full-thickness sutures, and an outer front wall of seromuscular interrupted sutures. A stapled Finney may also be performed by making a short enterotomy at the apex of the strictured segment, approximating the 2 limbs of the bowel, inserting an appropriate length linear stapled, one arm into each limb (thick tissue load), and then stapling the 2 lumens together as in an ileal pouch; however, given the variable thickness of the diseased bowel and fixed staple height, this is *not* recommended. A significant limitation of the Finney is the formation of an antiperistaltic loop, which may lead to luminal stasis, bacterial overgrowth, and blind loop syndrome. A meta-analysis has shown a lower rate of recurrence less than 25% and reoperation in cases with Finney stricturoplasty when compared to HM.[76] A step-by-step video of the Finney strictureplasty is available online (https://pubmed.ncbi.nlm.nih.gov/38282139/).[78]

Table 5
Types of strictureplasties for short (<10 cm) strictures

Strictureplasty	When to Use/Notes	Technique
Heineke–Mikulicz	Short strictures	Stricture is opened longitudinally and closed transversely.
Judd Stricturoplasty	Fistula at center of stricture	Fistula is excised using an longitudinal elliptical incision. The remaining stricture site is opened longitudinally. The defect is closed as in HM.
Moskel–Walske–Neumayer	Extremely dilated bowel proximal to the stricture	A Y-shaped longitudinal enterotomy is made across the stricture with a top of Y pointing toward the dilated portion. The portion is then closed similar to a HM. The reported benefit is a gentle transition from dilated to non-dilated bowel.
Double Heineke–Mikulicz	Multiple short strictures within a short segment	Combining 2 HM strictureplasties by suturing the proximal to the distal bowel transversely.
Widening Ileocolic Stricturoplasty	Strictures near ileocecal valve	An incision was made along the antimesenteric border, extending across the ileocecal valve over the medial site of the cecum. Open ends are rotated over each other pivoting over the ileocecal valve and ileum is sutured to cecum creating one large lumen.

Abbreviation: HM, Heineke–Mikulicz strictureplasty.

Table 6
Types of strictureplasties for long (>10 cm) strictures

Strictureplasty	When to Use/Notes	Technique
Finney	Strictures 10–25 cm in length	The bowel is folded into a U shape, and an antimesenteric longitudinal enterotomy along the diseased segment, extending 1 cm onto the normal bowel on either side, and closed in a side-to-side anti-peristaltic, handsewn manner.
Jaboulay	Strictures 10–25 cm in length	The stricture is left in place (example a D2 stricture), and anti-mesenteric longitudinal enterotomies made proximal and distal to the stricture, and the bowel edges sewn together transversely similar to an HM strictureplasty.
Modified Finney	Based on Fazio's principle of preventing afferent limb recurrence	Involves fashioning an isoperistaltic side-to-side diseased to disease-free bowel stricturoplasty with side-to-side anastomosis at the inlet of the Finney loop.
Combined Finney-HM	Developed by Fazio and Tjandra	A longitudinal enterotomy is made over both strictures and extended 3 cm on to normal bowel on either side. Interrupted intraluminal mattress sutures are used to re-approximately the bowel, starting at the midpoint of the enterotomy posterolaterally, through the "normal" bowel between the strictures. This creates a new posterior layer, reducing the size of the anterior defect. The anterior defect is subsequently closed transversely with interrupted seromuscular sutures, progressing from each end toward the middle, similar to the approach used in HM strictureplasty.
Ileocolic Finney	Ileocolic strictures	The diseased loop is folded into a U shape, a longitudinal enterotomy performed starting 2 cm upstream from the stenosis, through the ileocecal valve, onto the cecum for 2–3 cm. The 2 limbs were then sutured together side to side.

Isoperistaltic side-by-side (Michelassi)	Strictures >25 cm in length	Involves dividing the bowel and its mesentery at the midpoint of the strictured segment. The proximal and distal ends were then advanced side-by-side over each other. An outer interrupted backwall suture line is created. Subsequently, long antimesenteric longitudinal enterotomies are performed. An inner row of running sutures is placed anteriorly after making a Cornell transition stitch at apex, finishing with an interrupted outer row.
Poggioli	Modification of Michelassi	The bowel and mesentery are divided at the proximal portion of the stricture, and the non-diseased bowel advanced over the strictured segment. A longitudinal antimesenteric enterotomy is made on both overlapping segments, and a side-to-side enteroenterostomy was performed in the usual manner. The use of proximal, non-diseased bowel offers better laxity of mesentery and better laxity of mesentery and better suture line integrity.

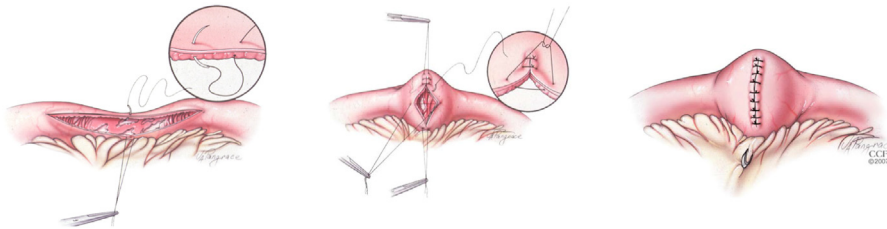


Fig. 3. Heineke–Mikulicz strictureplasty for Crohn's disease. (*Reprinted with permission*, Cleveland Clinic Foundation ©2024. All Rights Reserved.)

Jaboulay

This technique was first described in the late nineteenth century by Jaboulay, as a bypass for a strictured pyloric segment that was complicated by peptic ulcer disease. This technique is suitable for medium-sized (>10 cm and <25 cm) strictures. Similar to the Finney loop, the intestine containing the stricture was positioned in a U shape. Two separate longitudinal incisions are made on the healthy section of the bowel facing each other, and a transverse enteroenterostomy completed. With this technique, bowel length is spared; however, a lateral diverticulum is created with a resulting blind loop and stasis in the strictured segment. Caution should be exercised when applying this technique to bypass long, strictured segments of the bowel because of the increased morbidity associated with blind loops, malnutrition, and malabsorption in an already nutritionally compromised patient.

Isoperistaltic side-to-side strictureplasty

Dr Fabrizio Michelassi proposed a novel technique of performing strictureplasties on long strictured segments (>20 cm) or a long portion of the bowel containing multiple short strictures in tandem, making the creation of multiple HM strictureplasties impractical.[79] This technique has been performed on segments as long as 90 cm. The technical aspect of this procedure involves dividing the bowel *and mesentery* at the midpoint of the strictured segment. The proximal and distal ends are then advanced side by side to each other. An outer backwall interrupted suture line is created. Subsequently, a longitudinal enterotomy is performed. An inner row of running sutures is placed anteriorly after making a Cornell stitch transition at the apex. The finished anterior suture line is reinforced with interrupted stitches (**Fig. 5**).[79,80] This technique avoids resection of long segments of bowel, relieves obstruction, and avoids the creation of blind loops and bypassed loops. Notwithstanding obvious advantages, this technique is inherently difficult to perform, and even more so in instances where the mesentery is thickened and foreshortened. In some cases, a portion of the bowel typically measuring less than one quarter of the total enterotomy length must be resected from the middle of the affected segment to allow tension-free anastomosis. Side-to-side isoperistaltic strictureplasty can be safely performed in patients with extensive small-bowel CD in the absence of inflammatory masses or a very thickened mesentery with satisfactory postoperative outcomes and recurrence rates, while avoiding extensive intestinal resection and SBS. However, this is a technically challenging task. Moreover, there is a risk of 2 fold bowel loss if the repair fails or a complication arises, but the authors note that the bowel would otherwise be sacrificed by resection anyway. Other variants of Michelassi include modifications by Poggioli, Sasaki, Hotokezaka.[71,81,82]

Small bowel resection

A limited small bowel resection (SBR) of only macroscopically diseased segment is required when contraindications (eg, fistula, abscess) to strictureplasty exist and is

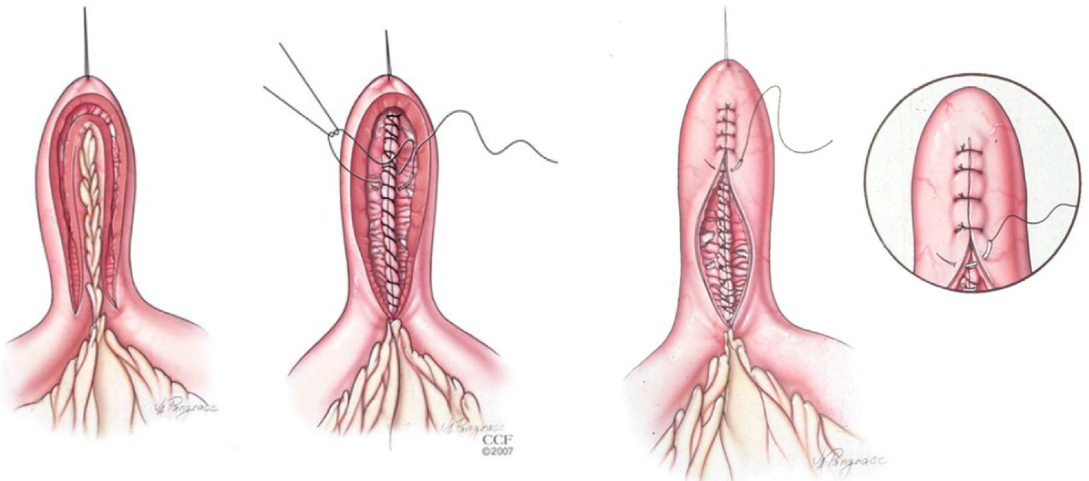


Fig. 4. Finney strictureplasty for Crohn's disease. (*Reprinted with permission*, Cleveland Clinic Foundation ©2024. All Rights Reserved.)

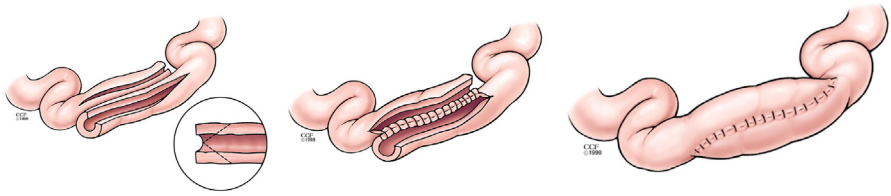


Fig. 5. Isoperistaltic side-by-side strictureplasty for Crohn's disease. Two adjacent segments of the stricture bowel are opened longitudinally, overlapped, and handsewn in an isoperistaltic manner. (*Reprinted with permission*, Cleveland Clinic Foundation ©2024. All Rights Reserved.)

often performed concurrently during strictureplasties cases for segments not amenable to strictureplasty, or if a given strictureplasty is deemed technically inadequate at the time it is performed.[83] An SBR is also an efficient method to restore health and quality of life (QoL).[84] The authors prefer a handsewn 2 layer enteroenterostomy, as it sacrifices the least length of bowel in the face of a leak or recurrence, using 3-0 (although the senior author has recently switched to 4-0) absorbable suture with a running continuous inner layer and interrupted seromuscular outer layer on both the back and front walls. The key to a successful anastomosis is adequate blood supply, no tension or torsion, and roughly equal lumen size.

Ileocolic crohn's disease

Approximately 50% of patients with CD have ileocolonic involvement, and ileocolonic resection (ICR) is the most commonly performed operation for intestinal CD. In the case of ileocolonic disease, the cumulative clinical recurrence rates are 30% after 5 years, 50% after 10 years, and 55% after 15 years.[85] The role of surgery in ileocolonic disease is firmly established for "cold" fibrotic stenoses that are not amenable to endoscopic intervention, penetrating disease with symptomatic internal or external fistulas, Crohn's associated neoplasia including small and large bowel adenocarcinomas and lymphomas, or medically refractory disease in the form of primary or secondary nonresponse to biologics.

Early surgery for ileocolic crohn's disease

Early surgery for limited inflammatory terminal ileal CD is currently in favor. Abundant retrospective evidence has demonstrated a substantial benefit of earlier (as opposed to later after complications have developed) surgery for limited CD, with lower reoperation rates and lower requirement for postoperative immunosuppression.[86–90] The landmark LIR!C trial was an open-label randomized controlled trial (RCT) that allocated patients with non-stricturing ileocecal CD refractory to conventional treatment to undergo laparoscopic ICR or infliximab treatment. They found that there was no difference in QoL measured at 12 months by the Inflammatory Bowel Disease Questionaire (IBDQ) and SF-36 in the ICR versus infliximab group $P = .25$.[6] The most recent publication from the same group that examined long-term outcomes found that in the resection group, 26% of patients needed to start a tumor necrosis factor (TNF) inhibitor (TNFi) agent and none required resection, 48% received prophylactic immunomodulators, and 42% did not require any additional medications. In the infliximab group, 48% of patients underwent CD-related ICR, and the remaining patients were kept on biologic therapy.[91] Another study from the same group found that the mean total direct health care costs per patient at 1 year were lower in the early ICR group than in the infliximab group.[92]

A meta-analysis that pooled results from 7 studies with 1,863 patients compared overall and surgical relapse in patient who underwent early ICR compared with initial medical therapy and found that the early ICR group had a higher improved relapse-free survival compared to medical therapy (hazard ratio [HR], 0.62; 95% CI, 0.52, 0.73; $P<.001$), despite a lower rate of maintenance of biologic therapy (odds ratio [OR], 0.24; 95% CI, 0.14, 0.42; $P<.0001$).[93] Another systematic review and meta-analysis that examined the resection rate at 5 years were 7.8% versus 25.45 (95% CI: 0.19, 0.54; $P<.0001$), which was lower in the early ICR group, and resection-free survival was higher in the early ICR group (HR 0.56, 95% CI 0.38, 0.83; $P = .004$).[94]

A population-based study using Danish national registries compared ICR with TNFi found that early ICR was associated with a reduced risk of systemic corticosteroid exposure and CD-related surgery.[95] In view of this, multiple studies have compared outcomes after ICR for complicated CD (CCD) disease and early CD disease. The Surgical IBD Latam Consortium compared CCD with early ICR with emphasis on short-term outcomes of surgery; patients with CCD had increased requirement of urgent surgery, longer operative time, lower rates of primary anastomosis, increased rate of postoperative complications, more reoperation, and higher rate of major anastomosis fistula and hospital stay.[96] Another study that compared early ICR with to ICR for CCD found a statistically significant lower rate of laparoscopic surgery and higher conversion rates in CCD group. The early ICR group had lower rates of major postop complications, shorter hospital stays, and lower rates of anastomotic leak that were not statistically significant.[97]

A more recent retrospective multicenter comparative analysis that compared surgery for inflammatory CD with the CCD phenotype found that patients with CCD had lower albumin levels, lower body mass indexes, and more anemia. This underscores the fact that inflammatory CD can progress to other phenotypes and result in bowel damage and worse surgical outcomes. Patients with CCD had longer operative times, lower laparoscopic rates (84.3% vs 93.1%, $P = .001$), and higher conversion rates (9.3% vs 1.9%, $P<.001$). Patients with CCD had a longer hospital stay and higher postoperative complication rate (26.1% vs 21.3%, $P = .08$). Anastomotic leakage and reoperations were more frequent in this group. More patients in the CCD group required an extended bowel resection (14.1% vs 8.3%, $P = .02$). In multivariate analysis, CCD was associated with prolonged surgery (OR 3.44, $P = .001$) and the requirement for multiple intraoperative procedures (OR 8.39, $P = .03$).[90]

Configuration of anastomosis: stapled side to side, handsewn end to end, and stapled end to side

When configuring and constructing an anastomosis (Fig. 6), 2 key indices for assessing its utility are safety, which is measured by the anastomotic leak rate and disease recurrence.

Most literature on anastomotic techniques is retrospective, with the exception of the CAST trial. This study compared handsewn end-to-end (HS-ETE) anastomosis and stapled side-to-side (SSTS) anastomosis. The trial found a higher recurrence rate in the handsewn group (42.5%) than in the stapled group (37.9%) after a mean follow-up of 11.9 months, although this difference was not statistically significant ($P = .55$), and was before the era of advanced therapies, which are often employed for postoperative prophylaxis against disease recurrence. Another limitation of the CAST trial was that the study was underpowered due to slow patient accrual, leading to premature closure.[98]

Retrospective data suggest that SSTS anastomosis may be superior to HS-ETE anastomosis, with lower rates of complications and recurrence.[99] A systematic review

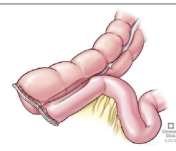
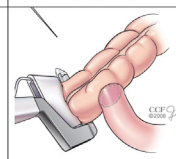
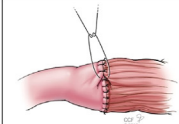
Anatomosis	Stapled Side-to-Side	Stapled End-to-Side	Handsewn End-to-End	Kono-S Anastomosis
				
Attribute				
Common?	Very	No	No	No
Extra skill?	5 min.	10 min.	30 min.	40 min.
Costly?	$$$$$	$$$$$	cents	$$$
Length of ileum used	8 – 10 cm	1 cm	1 cm	7 cm
Crossing staple lines?	Yes	No	No	No
Anatomic?	Not unless isoperistaltic	Yes	Yes	Yes
Easy to intubate?	No	Yes	Yes	Yes
Excludes mesentery?	Maybe	No	No	Yes
Level 1 evidence?	No	No	No	Yes

Fig. 6. Types of ileocolic anastomoses for terminal ileal Crohn's disease. (*Reprinted with permission*, Cleveland Clinic Foundation ©2024. All Rights Reserved.)

and meta-analysis, which pooled results from 8 studies involving 661 patients who underwent 712 anastomoses, found that while recurrence rates were similar between the 2 techniques, SSTS anastomosis was associated with a lower rate of anastomotic leaks and fewer postoperative complications.[100]

However, 2 recent systematic reviews demonstrated no difference in anastomotic leak rates between SSTS and HS-ETE anastomoses. In terms of surgical recurrence, Guo[101] reported no differences between the 2 anastomoses, whereas Feng[102] reported the superiority of the SSTS anastomosis. However, there is also conflicting evidence favoring HS-ETE anastomoses, particularly when examining long-term functional outcomes, and health care utilization at the end of 2 years namely emergency room visits, hospitalization, abdominal imaging, and repeat bowel resection for CD.[103] Several important criticisms of SSTS qualities that are not addressed in the literature include that the SSTS is an antiperistaltic pouch and may be prone to develop small intestinal bacterial overgrowth, and the increased difficulty of endoscopically intubating the distal ileum, which requires retroflexion, exactly where the disease is prone to recurrence. One solution to this conundrum is the stapled end-to-side ileocolic anastomosis which, similar to SSTS is fast to perform, yet uses minimal ileum and is easy to endoscopically intubate like an HS-ETE and is preferred anastomosis at the authors' institution.[104,105]

The difficulty in comparing anastomoses involves factoring in the surgeons' experience with individual techniques. With the ubiquitous availability of surgical staplers, surgeons may be less facile at sewing anastomoses, which may result in higher complication rates for HS-ETE anastomoses. The main principle is to create a wide-lumen anastomosis that prevents fecal stasis while optimizing blood supply to the proximal bowel. The European Crohn's and Colitis Organisation (ECCO) guidelines recommend SSTS, while American Society of Colon and Rectal Surgeons (ASCRS) guidelines favor an individualized approach as all data are retrospective in nature, although the ECCO guideline suggested the KSA as an alternative in ileocolic CD.[2,106]

Kono-S Anastomosis

The KSA has been a major advancement in recent years. This anastomotic technique centers on bowel resection, with a linear stapler placed across the proximal and distal bowel perpendicular to the mesentery. The purported benefit focuses on preservation

of the mesenteric vasculature, innervation, and formation of a posterior column created by suturing the 2 staple lines together. It is hypothesized that a supporting column located behind the anastomosis by 1 cm "*excludes*" the mesentery, and attenuates its subsequent influence on postoperative recurrence.[107]

In the original paper that reported 69 patients with CD who underwent KSA compared with historic controls who underwent conventional anastomosis, the median endoscopic recurrence score at 5 years was significantly lower after the KSA (2.6 vs 3.4, P=.008) and had a lower probability of anastomotic surgical recurrence in the KSA group at 5 years (0% vs 15%; P<.0013).[107] Two large multicentric studies reported similar findings with 5 year and 10 year surgical recurrence-free survival of 98.6%, and Shimada and colleagues[108] reported a surgical recurrence rate of 3.4% in the KSA group versus 24.4% in the HS-ETE group, as well as an increased risk of anastomotic leak in the HS-ETE group (17.3% vs 5.1%).[7]

In the first trial (SuPREMe) comparing KSA with SSTS, the primary endpoint was endoscopic recurrence, which at 6 months was 22.2% versus 62.8%, P<.001 in the 2 groups. At 24 months, clinical recurrence rates were 11.1% versus 30.2% in the control group and surgical recurrence rates were 0 versus 4.5%.[8] The major criticism for this study was that SSTS was constructed using staplers, with staple lines being prone to anastomotic ulcerations, and the endpoint of Rutgeerts >i2a ulcerations was biased against SSTS due to an overdiagnosis of endoscopic recurrence at the anastomotic site.[109]

In a systematic review and meta-analysis of 9 studies, including the trial described earlier, the KSA was associated with a lower incidence of endoscopic (25 vs 67%) and surgical recurrence (0%–3.4% vs 15%–24.4%) compared with other types of anastomoses. Complications, particularly anastomotic leakage, were also lower (1.8 vs 9.3%).[110] Recently, a nationwide propensity score-matched study found that KSA did not decrease endoscopic recurrence compared to other anastomoses; however, postoperative morbidity was lower in the KSA group. Due to the short follow-up duration, endoscopic and surgical recurrence could not be ascertained for the KSA group.[111] A recently published multicenter study that included 262 patients who underwent KSA reported a lower rate of postoperative complications (anastomotic leak, 1.5%; surgical-site infection, 6.1%). With a median follow-up of 49.4 months, 7.6% were found to have surgical recurrence.[112]

The authors' institutional experience that compared 83 patients with KSA with 91 SSTS cases found that at 12 months, endoscopic recurrence was not statistically significant (P = .81).[113] However, the KSA was independently associated with a decreased rate of endoscopic or surgical intervention for perianastomotic recurrence. Interestingly, SSTS isoperistaltic anastomosis is also considered an antimesenteric anastomosis, which may reduce the mesenteric influence on anastomotic recurrence.[114]

TARGETING THE MESENTERY

In recent years, there has been a growing body of evidence that CD may be a primary mesenteropathy.[115,116] The traditional surgical approach involves transection of the mesentery close to the bowel wall (**Fig. 7**). However, new translational research that implicates mesenteric adipose tissue in the pathogenesis of CD has sparked interest in EME along the principles of routine lymphadenectomy for right-sided colon cancer with high ligation of the ileocolic pedicle.[115,117,118] Pathobiological events are hypothesized to primarily occur along 2 major axes in the circumferential (submucosal) and radial (mesenteric axes), and recurrence when it occurs on the mesenteric side of

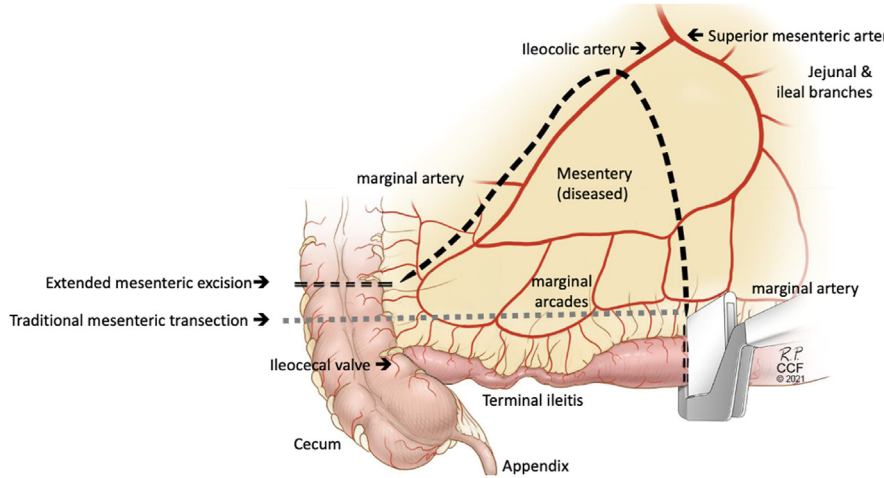


Fig. 7. Extended versus traditional mesenteric excisions for terminal ileal Crohn's disease. (*Reprinted with permission*, Cleveland Clinic Foundation ©2024. All Rights Reserved.)

the bowel with corresponding creeping fat. Although the exact mechanism of the development of mesenteric hypertrophy and creeping fat has yet to be elucidated, it is known that bacterial translocation to the mesentery, submucosal muscular hypertrophy, and lymphatic dysfunction with extravasation of lipid-rich lymphatic fluid and subsequent accumulation are key features.[115,119] It is postulated that this sets up a positive feedback loop, with ongoing mesenteric inflammation leading to subsequent luminal recurrence after ICR for CD.

Dr Calvin Coffey was the first to report surgery that directly targeted the mesentery and reported that extended mesenteric resection (EME) compared with the a historic cohort who underwent traditional mesenteric sparing (MS) approach was associated with a lower reoperation rate (2.9% vs 40%) with a mean follow-up of (12.0 +- 10.15 months).[9] Another study that compared MS versus EME found that the rate of surgical recurrence after a mean follow-up time of 4 years, surgical recurrence was higher at 30.0% after MS compared to 10.6% after EME.[120] The senior author has examined the effects of combining both techniques of the KSA with EME in a variation dubbed *mesenteric excision and exclusion* (MEE) and found it to be safe and feasible with comparable postoperative complications to KSA or EME.[10,11] Most recently in the SPICY trial, surgery naïve patients were randomized to either EME or MS approaches at the time of ICR. After a median follow-up of 6 months, there was no difference at 6 months for endoscopic recurrence.[121,122] However, these are preliminary data with a short-term follow-up, did not resect the ileocolic pedicle, and a long-term follow-up must be conducted before any conclusion is drawn. Similar to the KSA, there are multiple ongoing RCTs examining EME, including the MEErKAT trial, which includes both EME and KSA (and thus MEE) in a single, 4 armed trial.

EXTENDED RESECTIONS FOR CROHN'S COLITIS AND PROCTOCOLITIS

Colectomy Versus Total Proctocolectomy Versus Segmental Colectomy

Crohn's disease confined to the large bowel accounts for one-third of cases.[123,124] The symptoms of Crohn's colitis are diarrhea, abdominal pain, and rectal bleeding. The most common phenotype observed in CD that affects the colon is inflammatory, followed by stricturing and fistulization. The progression of inflammatory to other

phenotypes increases with disease duration.[125] The extent and type of surgery performed vary and depend on several indications, such as fulminant colitis not responding to medical management, persistent abdominal pain that is nonresponsive to medical therapy (including primary nonresponders and those who lose response to medical treatment), fistulas and abscesses, colonic strictures, and colitis-associated colorectal dysplasia and cancer.

In an elective setting for medically refractory disease, the extent of colonic involvement is the primary factor in deciding among segmental colectomy, extended colectomy, or total proctocolectomy. Diversion with loop ileostomy has been used because it can distally reduce the disease burden. Although it may temporarily improve QoL, diversion is ineffective in achieving a clinical response.[126]

Segmental resection is recommended for patients with segmental colitis (eg, isolated sigmoiditis). For disease involving the entire right colon, a standard right hemicolectomy with ileum-to-transverse colon anastomosis is performed. As the anastomosis is near the duodenum, there is a risk of duodenal fistula. To mitigate this, the omentum may be interposed between the duodenum and ileocolonic anastomosis, when feasible. The ECCO guidelines recommend 2 separate segmental resections if 2 segments are affected.[1,127] In contrast, the ASCRS guidelines advocate for total colectomy or proctocolectomy, depending on rectal involvement, if 2 or more segments are affected.[106] The incidence of permanent stoma is low with segmental colectomy.[128] Surgical and overall recurrence rates are similar between the 2 groups, although the time to recurrence is longer in the segmental colectomy group.[128]

For fulminant colitis or perforation, the indicated surgery is total abdominal colectomy (TAC) with an end ileostomy (EI). If the rectum is involved, a rectal tube may be left for decompression to reduce the risk of stump blowout, or the rectal staple line can be implanted subcutaenously or matured as a mucus fistula. Evidence from 2 systematic reviews suggests that subcutaneous implantation of the rectal stump (**Fig. 8**) at the time of TAC for IBD is associated with the lowest morbidity.[129,130] The authors institutional preference is for subcutaneous implantation of the rectal stump as although it results more frequently in superficial wound infections (12%), it minimizes the risk of pelvic sepsis requiring intervention (11%) associated with an intraperitoneal stump; pelvic sepsis also increases the morbidity of subsqeuent proctectomy if required.[129,131,132]

For pancolitis with rectal sparing, after or at the time of TAC, an ileorectal anastomosis (IRA) may be indicated.[133,134] Ideally, the rectum should be disease free with a compliant wall of good capacity (as opposed to a "lead-pipe" rectum), the patient should be fecally continence, and with limited perianal disease. However, the recurrence rate is high at 30%, and redo IRA may be required.[135] Total proctocolectomy (TPC)-EI is indicated when 2 or more segments are involved, in severe perianal disease, colonic high-grade dysplasia, or cancer in the background of colitis. Patients with Crohn's colitis or proctocolitis are 2 to 4 times likely to progress to colectomy than the general population.[1,106]

Fistulizing complications such as enterocolic, colocutaneous, and cologastric fistulas can arise from full-thickness inflammation or complications of surgical resection, often originating from the anastomotic site. Surgical principles involve resecting the actively diseased segment and repairing or resecting the secondarily involved segment. The most common sites for abscesses are the right lower quadrant, sigmoid colon, and pelvis. Initial treatment included image-guided drainage and antibiotics, followed by surgical resection of the affected segment after medical optimization.

Isolated proctitis is rare in patients with CD. Surgical management often involves proctectomy; however, the extent of proximal colon resection is debatable. TPC

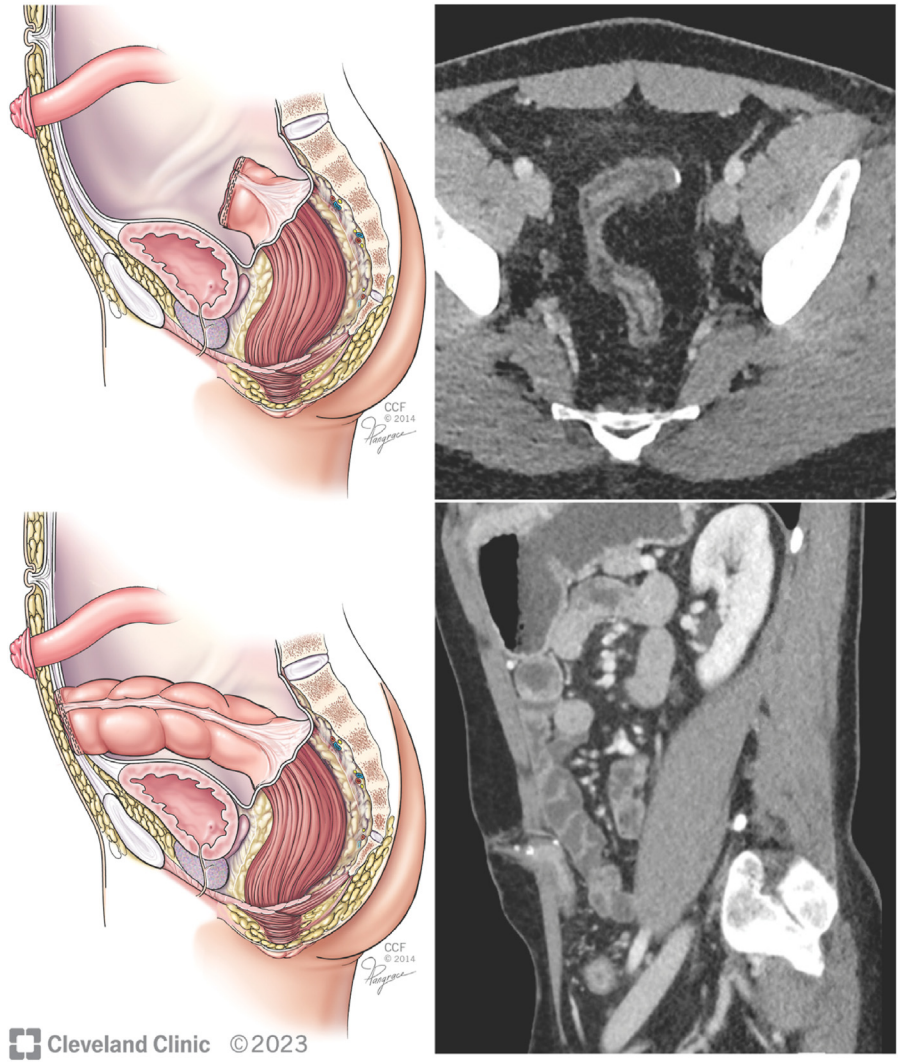


Fig. 8. Intraperitoneal (*top panel*) and subcutaneous (*bottom panel*) placement of the rectal stump after total colectomy for IBD. (*Reprinted with permission*, Cleveland Clinic Foundation ©2024. All Rights Reserved.)

with EI is often recommended because of the risk of recurrent colitis after abdominoperineal resection.[136] However, elderly patients, those with prior SBR at risk for high ileostomy output or SBS, and those without abdominal colon disease, may benefit from proctectomy with end sigmoid colostomy to preserve the colonic absorptive capacity. When a proctectomy is required for CD, an intersphincteric dissection is preferred.[137] Perineal wound complications including nonhealing wounds and presacral sinuses are the Achilles' heel of these operations and have recently been categorized by the TOpClass Consortium as Class 4 perineal disease, which occurs in 30% of these patients with CD after proctectomy.[138,139]

Ileal Pouch-Anal Anastomosis

The ileal pouch-anal anastomosis (IPAA) was conceived by Park and Nichols in 1978 for ulcerative colitis and familial adenomatous polyposis.[140] In 1996, Panis and colleagues[141] published work on patients with CD who underwent IPAA. Since then, multiple series have shown that a pouch is possible for patients with isolated Crohn's colitis without ileitis or perianal disease, as recommended by ECCO-European Society of Coloproctocology (ESCP) statements.[142,143] Melton and colleagues[144] reported that patients with an incidental diagnosis of CD based on pathologic examination of the resected colon had a similar pouch survival to patients with ulcerative colitis, while those with a delayed diagnosis had a significantly lower pouch survival rate (87% vs 53%, $P<.0001$). A recent study by Eyal and colleagues of 46 patients with Crohn's colitis who underwent IPAA reported a 48% incidence of postoperative CD and a 9% incidence of pouch failure.[145] Additionally, a meta-analysis by Lightner and colleagues[146] reported a 15% pouch failure rate in patients with preoperatively diagnosed CD.

Patients with CD limited to the large bowel and without anoperineal disease should be advised regarding their surgical options. Proctocolectomy with IPAA has an 85% retention rate at 10 years with a function similar to that of patients with ulcerative colitis. In contrast, proctocolectomy with ileostomy is associated with a 23% rate of long-term perineal wound issues and possible stoma-related complications and is more cost-effective.[147,148] An individualized approach with tailored counseling and shared decision-making is essential. For highly motivated patients, a redo IPAA for CD is an option but risks the loss of additional bowel and SBS.[149] For patients who develop pouch inlet stricture consistent with Crohn's-like disease of the pouch, reimplantation of the afferent limb is an option to salvage the pouch.[150] For failing pouches, rediversion may be the first step to restore QoL and may reduce the morbidity of pouch excision.[151–153]

Kock (continent ileostomy)

For patients who refuse conventional ileostomy and have adequate intestinal length with no active small bowel CD, a continent ileostomy (CI) may be considered. This involves creating an internal reservoir (or pouch) from the ileum eliminating the need for an external ileostomy bag. A prerequisite is no small bowel disease.[154,155] A Cleveland Clinic study found a 48% failure rate for CI, *that is,* excision of the CI and conversion to EI.[156] In a population-based study from Sweden, 45.7% of CD patients with CI underwent reoperation within 5 years, and 58.35% within 15 years. After 5 years, 5.5% of the patients still had CI in place, and 85.8% retained their CI after 15 years.[157] A critical consideration is the risk of CI pouch failure, which may necessitate pouch excision. Losing the small bowel (approximately 60 cm) used to create the CI can put patients at risk for SBS.

There were no sources of data in the current study.

CLINICS CARE POINTS

- Optimal management of Crohn's disease requires close collaboration among gastroenterologists, surgeons, psychologists, and nutritionists for comprehensive patient care.
- Ensure perioperative nutritional support to enhance healing and reduce postoperative complications.

- Implement venous thromboembolism prophylaxis to lower the risk of thrombotic complications, especially in high-risk patients.
- Consider the patient's surgical history and future needs to minimize bowel loss and ensure optimal recovery.
- Use diverting stomas or ureteral stents liberally to prevent anastomotic leaks or damage to surrounding structures.
- Be cautious with complex anatomy, especially in patients with cachexia or obesity or those with prior surgeries.
- If there are risks to mesenteric vessels, involve vascular or transplant specialists early.

DISCLOSURE

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