

Accepted Manuscript



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Camran Nezhat, MD, FACOG, FACS, Anjie Li, MD, Rebecca Falik, MD, Daniel Copeland, MD, Gity Meshkat Razavi, MD, Alexandra Shakib, BS, Catalina Mihailide, BA, Holden Bamford, BA, Lucia DiFrancesco, MD, Salli Tazuke, MD, Pejman Ghanouni, MD ACS, Homero Rivas, MD, FACS, Azadeh Nezhat, MD FACOG, Ceana Nezhat, MD FACOG, FACS, Farr Nezhat, MD FACOG FACS

PII: S0002-9378(17)31180-8

DOI: [10.1016/j.ajog.2017.09.023](https://doi.org/10.1016/j.ajog.2017.09.023)

Reference: YMOB 11855

To appear in: *American Journal of Obstetrics and Gynecology*

Received Date: 25 May 2017

Revised Date: 19 July 2017

Accepted Date: 27 September 2017

Please cite this article as: Nezhat C, Li A, Falik R, Copeland D, Razavi GM, Shakib A, Mihailide C, Bamford H, DiFrancesco L, Tazuke S, Ghanouni P, Rivas H, Nezhat A, Nezhat C, Nezhat F, Bowel Endometriosis: Diagnosis and Management, *American Journal of Obstetrics and Gynecology* (2017), doi: 10.1016/j.ajog.2017.09.023.

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Authors: Camran Nezhat MD, FACOG, FACS,^{1,2,3} Anjie Li MD,^{1,2} Rebecca Falik MD,^{1,2} Daniel Copeland MD,³ Gity Meshkat Razavi MD,¹ Alexandra Shakib BS,⁴ Catalina Mihailide BA,⁵ Holden Bamford BA,⁶ Lucia DiFrancesco MD,⁷ Salli Tazuke MD,^{1,2,8} Pejman Ghanouni MD ACS,² Homero Rivas MD, FACS,² Azadeh Nezhat MD FACOG,^{1,2,3} Ceana Nezhat MD FACOG, FACS,⁹ and Farr Nezhat MD FACOG FACS*^{10, 11, 12, 13}

*Corresponding Author: Farr Nezhat MD FACOG FACS (farr@farrnezhatmd.com)

1. Camran Nezhat Institute and Center for Special Minimally Invasive and Robotic Surgery
2. Stanford University Medical Center
3. University of California, San Francisco, School of Medicine
4. University of California, Santa Cruz
5. University of California, Berkeley
6. Stanford University
7. Università La Sapienza, Obstetrics and Gynecology, Rome, Italy
8. Colorado Center for Reproductive Medicine, San Francisco
9. Atlanta Center for Minimally Invasive Surgery and Reproductive Medicine
10. Nezhat Surgery for Gynecology/Oncology
11. Weill Cornell Medical College, Cornell University
12. Gynecology and Reproductive Medicine, School of Medicine, Stony Brook University
13. Minimally Invasive Gynecologic Surgery and Robotics, Winthrop University Hospital

Abstract

The most common location of extra-genital endometriosis is the bowel. Medical treatment may not provide long-term improvement in patients who are symptomatic, and consequently most of these patients may require surgical intervention. Over the past century, surgeons have continued to debate the optimal surgical approach to treating bowel endometriosis, weighing the risks against the benefits. In this expert opinion we will describe how the recommended surgical approach depends largely on the location of disease, in addition to size and depth of the lesion. For lesions approximately 5-8cm from the anal verge, we encourage conservative surgical management over resection to decrease the risk of short and long-term complications.

Key Points

- Endometriosis affects up to 10% of all reproductive-aged women, and affects approximately 35-50% of women with pelvic pain and infertility.
- The bowel is the most common site of extra-genital endometriosis and is most frequently seen along the rectum, rectovaginal septum, and sigmoid colon.
- Surgical management is recommended for symptomatic patients with bowel endometriosis who have failed medical therapy, or in whom medical therapy is not indicated.
- Laparoscopy with or without the use of the robotic platform can be used for treatment of bowel endometriosis.
- Acute obstruction due to bowel endometriosis is rare and should generally be managed with segmental resection.

- Lesions along the low rectum should generally be preferentially managed conservatively with shaving excision first rather than with disc or segmental resection, to avoid extensive dissection of the retro-rectal space and lateral spaces along the pelvic side wall to minimize nervous and vascular injury.

BACKGROUND

Endometriosis is a chronic, estrogen-dependent inflammatory condition affecting approximately 10% of all reproductive-aged women and approximately 35-50% of women with pelvic pain and infertility.¹ Endometriosis can be classified as genital versus extra-genital.² Endometriosis along the bowel is the most common site for extragenital endometriosis.^{3,4} Endometriosis of the bowel can manifest as deeply infiltrative lesions of the muscularis or mucosa, or as superficial disease that line the bowel serosa or subserosal area. It is estimated to affect 3.8%-37% of patients with known endometriosis.^{5,6} Such significant differences in the estimated incidence may be due to differences in opinion regarding the definition of bowel endometriosis, or a reflection of missed diagnosis. Furthermore, a number of women with bowel endometriosis are diagnosed with other disorders such as irritable bowel syndrome and may never actually be diagnosed with or treated for endometriosis of the bowel.⁷

Multiple theories exist regarding the true pathogenesis of endometriosis, which is complex and likely multifactorial (See Table 1). Nezhat and Mahmoud have suggested that the Allan Masters peritoneal defect may act as a potential pathway to deep infiltrative endometriosis in rectovaginal endometriosis.⁸ Deposits of retrograde menstruation may lead to an inflammatory process thereby causing increased risk of adhesion formation and, ultimately, cul-de-sac obliteration.⁹

Bowel endometriosis is most frequently found on the rectosigmoid colon, followed by the rectum, ileum, appendix, and cecum,^{4, 10} with case reports of lesions found in the upper abdomen including the stomach¹¹ and transverse colon.¹² Although isolated bowel involvement can be seen, the majority of patients with bowel endometriosis have evidence of disease elsewhere.⁴

Endometriosis, although generally considered a benign disease, may be associated with an increased risk of cancer. The overall risk for an endometriosis-associated neoplasm is thought to be up to 1%, with a quarter of these cases involving extra-ovarian tissue.¹³ There have been several published cases of endometriosis-related gastrointestinal tumors, of which half involve primary adenocarcinoma of the rectosigmoid colon.¹⁴ There remains a paucity of data on how endometriosis may specifically increase the risk of colorectal malignancy; however, evidence demonstrates an increased risk of malignant transformation in patients with endometrioid or clear cell ovarian carcinoma.^{15, 16} Thus, benefits of excisional surgery include not only pain relief and a potential increase in fertility, but also potential cancer prophylaxis.

Bowel resection has been performed to treat bowel endometriosis since the early 1900's.¹⁷ Even though over a century has passed, many surgeons have not advanced their practices, with some surgeons still routinely performing segmental resection for bowel endometriosis.¹⁸ Patients thus may be at increased risk of morbidity, including possible permanent ostomy, for a benign disease process that could have been managed conservatively with more modern surgical techniques. In an effort to decrease post-operative morbidity, conservative approaches including shaving excision and disc resection have been developed, but still all too many surgeons resort to overly aggressive bowel resection. Given the recognized importance for treatment of deeply infiltrative

endometriosis of the bowel, surprisingly the current medical literature offers a variety of surgical approaches without an established guideline for which surgical approach is recommended for different patient presentations. This lack of clarity may unfortunately contribute to all too many patients still undergoing unnecessary segmental bowel resection. We recognize the confusion that surrounds the surgical management of deeply infiltrative endometriosis of the bowel.

Whereas one size does not fit all, there are principles and approaches that may guide the surgeon to perform the most effective and least harmful procedure in particular cases. The aim of this expert review is to help clinicians navigate the management of this complex disease.

Diagnosis

Clinical Presentation

Clinical suspicion for DIE and bowel endometriosis starts with a thorough clinical history. It should be suspected in women who report dysmenorrhea, deep dyspareunia, chronic pain, and/or dyschezia. Some women have catamenial diarrhea, blood in the stool, constipation, bloating, pain with sitting, and radiation of pain to the perineum. The pathogenesis of pain related to endometriosis is complex and multifactorial, with evidence suggesting that there may be an autonomic component explaining why symptoms may mimic that of irritable bowel syndrome.¹⁹ Endometriotic lesions involving the enteric nervous system may cause significant damage; for example if they involve Auerbach's plexus, Meisner's plexus, or the interstitial cells of Cajal, they may cause nausea, vomiting, or a sub-occlusive crisis.^{20, 21} The differential diagnosis for these symptoms can be broad, including conditions such as inflammatory or ischemic colitis, radiation colitis, diverticulitis, malignancy, or pelvic inflammatory disease. If bowel

endometriosis is not on the clinician's differential, the diagnosis may be missed and patients may go many years before adequate treatment.^{7, 21}

Physical examination, specifically rectovaginal examination, is often helpful in diagnosis, especially if performed at the time of menstruation, during which time lesions may be more inflamed, tender, and palpable. Findings may include a palpable nodule or a thickened area along the uterosacral ligaments, uterus, vagina, or rectovaginal septum. Visualization of the vagina may reveal a laterally displaced cervix or a blackish-blue lesion²². Bowel endometriosis may also be diagnosed incidentally at the time of surgery performed for other indications. Monitoring of CA-125 levels to diagnose and evaluate disease progression in DIE has been proposed but is of little utility and is not recommended.^{23, 24}

Imaging Modalities

Transvaginal ultrasound (TVUS) can be used in conjunction with physical exam with an overall high sensitivity and specificity. Details regarding the size, location, depth of infiltration, presence of bowel lumen stenosis, and quantification of nodules are important in preoperative planning. In a meta-analysis published in 2011, Hudelist et al found the overall specificity of TVUS was high (92-100%), with a sensitivity of 71-98%. Similarly, Exacoustos et al found the accuracy of detection to range from 76-97%, with the greatest accuracy (97%) found in the detection of bladder lesions and cul-de-sac obliteration.²⁵ Accuracy of diagnosis is correlated with sonographer experience and even in the best of sonographers' hands. In an effort to address this, the International Deep Endometriosis Analysis (IDEA) group has published on methods to obtain quality images, with several published image examples.²⁶ However, with transvaginal ultrasound, the problem remains that lesions on the sigmoid may be missed as these are typically outside of the field of view.²⁷ The use of CT-based modified virtual colonoscopy to help

predict severity of bowel endometriosis is a novel approach where 25mmHg of CO₂ is introduced into the rectum and CT guided images are used to re-create a 3-D model of the bowel.²⁸ It remains experimental but does have promising preliminary findings.²⁸ Additional imaging options, including MRI (See Image 1) and barium enema, are listed in Table 2.

Medical Management

Medical management may be utilized for symptomatic patients with bowel endometriosis, with the understanding that patients may still require subsequent future surgery. Ovulatory suppression can improve some patients' symptoms, and may be advisable for those who are not surgical candidates or who prefer to avoid surgery. Hormonal suppression has been shown to significantly improve pain and GI symptoms in patients whose degree of bowel stenosis is less than 60%.²⁹ It is especially useful to prevent recurrence; after surgery, women who do not desire immediate fertility can be placed on hormonal suppression post-operatively to prevent regrowth of the endometriosis.²²

To date, there is no established optimal hormonal regimen for the treatment or prevention of DIE or bowel endometriosis. General principles for treatment include the emphasis on long-term hormonal suppression and optimization to minimize the side effect profile in order to improve patient compliance.³⁰ Low-dose progestins or combined oral contraceptives are generally well tolerated, and are the first-line medical treatment due to efficacy, minimal side effects, and low cost. Data from a randomized control trial by Vercellini et al demonstrated that both progestins alone or combined with low dose estrogen have been shown to decrease symptoms of dysmenorrhea, dyspareunia, and dyschezia.³¹ Ferrero et al showed that low dose norethindrone (2.5mg daily) can significantly decrease diarrhea, cramping, and cyclic rectal bleeding in women

with histologically proven endometriosis, with 53% of the forty participants reporting significant improvement in GI symptoms. By the end of the 12-month study period, 33% of patients opted to have surgical treatment of their bowel endometriosis due to overly bothersome symptoms.³²

Several other medical therapies have shown promise, but have been studied on a smaller scale. Fedele et al reported improvement of dysmenorrhea, dyschezia and pelvic pain in a series of 11 women who received a levonorgestrel intrauterine device.³³ Razzi et al reported use of danazol 200mg per vagina daily to be well tolerated among a cohort of 21 women with rectovaginal endometriosis, with a significant reduction of pain at the 12-month followup.³⁴ Leuprolide acetate, a GnRH agonist, can also help mitigate symptoms in women with rectovaginal endometriosis and can be used with add-back norethindrone therapy.³⁵ Leuprolide can also be useful pre-operatively to decrease disease burden at the time of surgery. Extensive use of GnRH agonists is often limited by their side-effect profile, namely vasomotor symptoms, as well as concern for decreased bone mineral density if used for more than six months.³⁶

Surgical Management

Introduction

The exact mode of surgery will depend on surgeon expertise and experience, as well as availability of proper instrumentation. Cases of bowel endometriosis must often be managed in a multi-disciplinary fashion, often with a minimally invasively trained gynecologic surgeon and involvement of a gastrointestinal surgeon familiar with endometriosis.³⁷⁻⁴⁴ As determined by the surgeon's experience and access to instrumentation, we recommend video-assisted laparoscopic surgery, with or without robotic assistance⁴³⁻⁴⁸

Several authors have demonstrated the superiority of the laparoscopic approach as compared with laparotomy for the treatment of bowel endometriosis. Studies have consistently shown that minimally invasive approaches result in lower blood loss, shorter length of hospital stay, and few postoperative complications⁴³⁻⁴⁸ with about a three percent conversion rate to laparotomy in the hands of a trained expert.³⁸ Darai et al published a randomized controlled trial for endometriosis in which 52 patients with colorectal endometriosis were randomly assigned to undergo laparoscopic-assisted or open colorectal resection. There were no differences in long-term outcomes related to post-operative diarrhea, bowel pain, cramping, dyspareunia, or dysmenorrhea. Blood loss was significantly lower in the laparoscopic group (1.6 mg/L versus 2.7 mg/L, $P < 0.05$), and this group incurred fewer complications (9 patients vs 15 patients $P < 0.16$).³⁹⁴⁰ There was also a greater increase in postoperative desired fertility in the laparoscopic group.²⁹ In another prospective study comparing laparoscopic colorectal resection (n=33) versus colorectal resection via laparotomy (n=13) for bowel endometriosis, Ruffo et al demonstrated that those who underwent laparoscopic resection had a significantly higher postoperative pregnancy rate (57.6% versus 23.1%, $p < 0.035$).

Surgical approaches fall into three general categories: shaving excision, disc resection, and segmental resection. The choice of technique has been the subject of extensive debate and depends on the location of the bowel lesion, depth of infiltration, number of nodules, and presence or absence of stricture.^{38, 40, 48-51} Generally speaking, there are two points of view with regard to the choice of surgical technique for bowel endometriosis. Some practitioners advocate more radical approaches with the primary goal of ensuring the complete removal of any possible

endometriotic lesions within the bowel. This often achieves excellent outcomes with a relatively low rate of recurrence, but may come at the expense of increased risk of morbidity through lengthy recovery and untoward side effects or complications.⁵²

There are an increasing number of surgeons who stress the risk of short and long-term complications that radical segmental resection and even the more conservative disc excision entail, specifically when there is significant disruption of the surrounding neurovascular structures along the low rectum.⁵⁰ Especially at the level of the low rectum, aggressive resection requires extensive dissection of the retro-rectal space, where extensive vascular and sympathetic and parasympathetic nerve bundles are located, including the pelvic splanchnic nerves, the superior and inferior hypogastric plexus [See Figures 1 and 2]. Damage to these structures can lead to short and long-term morbidity such as bowel stenosis, bowel ischemia resulting in fistula formation, severe constipation, and urinary retention, etc.^{53, 54} In other areas of the intestine such as near the ileocecal valve, complete excisional techniques do not carry as severe risks and may more often be indicated and beneficial to the patient. Our group stresses the importance of evaluating the balance between complete removal of the endometriosis and operative risk to the patient. In fact, no matter the surgical approach, whether it be more conservative shaving, or more radical disc or segmental resection, surgical treatment of bowel endometriosis can lead to long-term beneficial outcomes including increased fertility and pain relief.^{55,54,49, 50}

Those who advocate complete resection irrespective of the anatomical location cite the benefit of reduced recurrence. However, even with radical segmental resection, occult microscopic endometriosis has been shown to be present in 15% of specimen resection margins.⁵⁶ There are

multiple documented cases of bowel endometriosis recurring after radical segmental resection. Roman et al estimates that to avoid recurrence in one patient at 75 months, 11 patients would need to undergo segmental colorectal resection rather than shaving of the lesion. Moreover, to prevent the risk of a single recurrence that would necessitate repeat operation with a segmental resection, 23 patients would need to be treated initially with segmental resections.⁵⁰ Radical surgery, therefore, may not improve overall long-term outcomes as compared with conservative surgery yet is associated with a higher risk of complications.⁵⁰

Shaving Excision

Shaving excision refers to the removal of disease layer-by-layer until healthy, underlying tissue is encountered, and can be considered the most conservative approach to surgical management of bowel endometriosis.^{41, 42, 57, 58} Shaving excision can be performed by ablation or resection of invasive and fibrotic endometriotic implants without entering the lumen of the bowel. The aim is to restore the normal soft-tissue anatomical architecture that may have otherwise been distorted by endometriosis and fibrosis. In the case of bowel endometriosis, the aim of shaving excision is to excise all or at least the majority of endometriotic and fibrotic lesions on the bowel while leaving the bowel mucosa and a portion of the muscularis intact while preserving bowel integrity.^{42, 43, 57-59}

Outcomes following Shaving Excision

Shaving excision has been advocated by experts as a delicate and precise technique to thoroughly treat extra-genital endometriosis.^{42, 57, 58} Long-term outcomes following shaving excision are quite favorable, and the complication rate is the lowest among the surgical treatment options for

bowel endometriosis. Our group has reported excellent post-operative outcomes since the 1980s.^{42, 43, 54, 57, 59} We have described patient outcomes following shaving excision in 185 women aged 25-41, including 80 patients who had complete cul-de-sac obliteration. Of the 174 patients available for follow-up up to five years post-operatively, 162 (93%) achieved moderate to complete pain relief.⁴²

Donnez et al performed a retrospective analysis describing 3298 surgeries for deep rectovaginal endometriotic nodules, in which the shaving technique was utilized in all but 1% of the patients. The complication rate was low, with one case of rectal perforation, 3 cases of ureteral injury, and one case of fecal peritonitis.⁶⁰ In Donnez's earlier series of 500 patients who underwent shaving of rectovaginal endometriotic nodules, thirty-nine patients (8%) experienced recurrent pelvic pain.⁶¹ Out of the 388 patients in his case series who wished to conceive, 221 (57%) became pregnant spontaneously and 107 (28%) conceived with IVF.⁶¹

Roman et al have also reported on the application of rectal shaving using both plasma energy as well as laparoscopic scissors in 54 and 68 women respectively, with two cases of postoperative rectal fistula formation.⁶² Following shaving excision, Roman's study demonstrated excellent outcomes, with 4% of patients experiencing symptom recurrence, a pregnancy rate of 65.4% among patients with pregnancy intention, with 59% of those women conceiving spontaneously.⁶²

Disc Excision

Laparoscopic disc excision with and without the use of the linear or circular stapler for treatment of bowel endometriosis has been described by our group and others since the late 1980's^{38, 44, 39-}

41, 44, 48, 49, 54, 63-66 and is considered a well-established and feasible surgical option.^{67, 65, 66, 68} It entails full-thickness excision of the diseased portion of the bowel wall with the resultant defect stapled or sutured. To be considered for disc excision, a lesion should be limited to only a portion of the bowel wall, usually less than half of the maximum circumference of the bowel.⁵²

Outcomes Following Disc Excision

Disc excision yields very good outcomes, and results in fewer post-operative complications compared to segmental resection, but has greater risk of complications than shaving excision.^{38,}

^{39, 49, 66, 69} In 1994, our group first described a series of eight women who underwent disc excision for bowel endometriosis. Mean length of hospital stay was 3 days, mean lesion size was 4.6cm, and one patient achieved pregnancy.³⁹ We have subsequently published a series of 141 women who underwent treatment of endometriosis including laparoscopic disc excision of the bowel. There were no cases of conversion to laparotomy, post-operative rectovaginal fistula formation, ureteral damage, bowel perforation, or postoperative pelvic abscess. GI and pain symptoms had improved by the end of the first postoperative month in 87% patients.⁴⁹

In 2016, Afors et al performed an observational study describing patients who underwent shaving (n=47), disc (n=15), and segmental resection (n=30; for all cohorts, they reported a significant reduction in short and long-term pain including dysmenorrhea, dyschezia, and dyspareunia three months post-operatively. Those who underwent shaving excision and disc resection, however, were more likely to experience recurrence of symptoms requiring re-operation as compared with segmental resection (shaving: 27.6%; disc: 13.3%; segmental: 6.6%).⁷⁰ Although the sample size is limited, the study suggests that disc excision may be

performed safely with very good results, though results may not be as permanent as with segmental resection.

In a 2011 retrospective study by Moawad et al comparing low anterior disc (n=8) versus low anterior segmental (n=14) resection; the disc resection cohort had shorter surgical times (4 hours vs 7 hours), lower blood loss (134 versus 276cc), and shorter length of hospital stay (3 days vs 5 days). There were no intra-operative complications in either cohort. There was no significant difference in size of lesion excised, and neither group had visceral complications, although there were three patients in the segmental resection cohort who had post-operative anastomotic strictures, with two patients requiring subsequent rectal dilation. In contrast, there were no perioperative complications in the disc resection group. Both groups reported high levels of patient satisfaction post-operatively.⁷¹ Moawad's study, although based on a small cohort, suggests that both disc and segmental resection improve patients' symptoms, but that disc excision is a more technically straightforward surgical procedure with fewer complications, especially when the lesion is located lower down in the intestinal tract. Further discussion of the location of lesions in determining which excisional technique a surgeon should consider will be reviewed below.

Segmental Resection

Segmental resection of endometriosis has been documented in the medical literature since 1907,^{17, 72, 73} and has the largest body of data regarding post-operative outcomes. As the name suggests, this approach involves the complete resection of a diseased segment of bowel with subsequent reanastomosis. Segmental resection is indicated for large, circumferential, obstructive

or multifocal lesions. Primary end-to-end or side-to-side anastomosis can be performed following segmental resection. Segmental resection was once considered too difficult to complete without an open abdominal incision; however with the introduction of video-assisted laparoscopy, specialized laparoscopic instruments, and increasing surgical sub-specialization and training, many trained surgeons are able to utilize minimally-invasive approaches to improve clinical outcomes.^{37, 44, 46, 48, 54, 71, 74, 21, 54, 74-77} For segmental resections, a multi-disciplinary approach is recommended with the involvement of a gastrointestinal surgeon or gynecologic oncologist who is trained in performing bowel resections.

Outcomes Following Segmental Resection

Since the late 1980's and early 1990's, our group has performed laparoscopic rectosigmoid resection of pathology-proven endometriosis.^{21, 37, 40, 41, 44, 54, 57} Given favorable outcomes and fewer complications associated with disc and shaving excision, we now avoid segmental resection whenever possible, especially for lesions close to the anal verge. In 2005 our group reported on a cohort of 178 women who underwent laparoscopic treatment of deeply infiltrative bowel endometriosis utilizing shaving excision (n=93), disc excision (n=38), and segmental resection (n=47). The rate of major complications was significantly higher among those who underwent segmental resection ($P<0.001$); 6/48 (12.5%) had the following complications: ureterovaginal fistula (1/48, 2%), anastomotic stricture (2/48, 4%), intra-operative bladder perforation (1/48, 2%), rectal bleeding requiring transfusion (1/48, 2%), and anastomotic leak requiring temporary colostomy (1/48, 2%). Of those who underwent disc excision, in contrast, only 3/39 (7.7%) developed a serious complication, including 2/39 (5%) who developed a pelvic abscess, and 1/39 (3%) who developed a rectovaginal fistula. Notably, there were no major

complications encountered among patients who underwent shaving excision. Pregnancy among infertility patients who had either shaving or disc excision was higher (13/36, 36% and 4/9, 44% respectively) than those who had segmental resection (2/11, 18%).⁵⁴

In 2011, De Cicco et al performed a systematic review of 1,889 bowel resections for deep endometriosis. Mean operating time varied from 101 to 436 minutes, with hospitalizations ranging from 4-14 days. Major complications occurred in 11% of women, including a leakage rate of 2.7%, a fistula rate of 1.8%, severe obstruction rate of 2.7%, and a hemorrhage rate of 2.5%.⁵⁵ Location of the lesion was inconsistently documented in the studies that De Cicco reviewed, but he noted that many of these complications correlated with lower rectal location of the segmental resection; the lower the resection, the higher the probability of postoperative leakage.⁷⁴ Riiskjær et al published a prospective analysis of 128 patients who underwent segmental resection for bowel endometriosis and found long-term improvement in urinary and sexual function one-year after surgery. However, the rate of anastomotic leakage was 7.4%.⁷⁷

Although the complication rate may be higher with segmental resection, it is location-dependent. Segmental resection remains a critical tool for treating bowel endometriosis in certain circumstances, such as in patients whose symptoms persist after shaving or disc excision. De Cicco et al noted complete pain relief to be 81.5% (111/135) with segmental resection patients,⁵⁵ and some studies suggest shaving excision may be less effective in the symptomatic relief of dysmenorrhea and dyspareunia.⁷⁰ Our group has found complete pain relief to be high with segmental resection but also with the other surgical excision techniques: 80% (74/93) after shaving excision, 95% (36/38) following disc excision, and 89% (42/47) following segmental resection.⁵⁴

Nerve-Sparing Surgery

Whether shaving, disc, or segmental resection of bowel endometriosis is performed, a surgeon's complication rate may depend on adequately avoiding involved nerves. Deeply infiltrative endometriosis can invade the superior and inferior hypogastric plexus, as well as the sympathetic and parasympathetic nerve bundles (see Image 2, Figures 1 and 2). Disruption of these structures may worsen reproductive, genitourinary and gastrointestinal symptoms and negatively affect quality of life.^{2, 78} The incidence of postoperative urinary tract disorders following surgery for bowel endometriosis is estimated to be as high as 19.5% due to interruption of the nervous plexus, especially the hypogastric plexus.^{75, 76} Nerve-sparing techniques have therefore been introduced to preserve bowel, bladder, and sexual function.^{79, 80} One successful nerve-sparing method, which we utilize in our practice, is the Tokyo method, in which the surgeon separates and ligates the vascular portion of the cardinal ligament while preserving the branches of the pelvic splanchnic nerves.⁸¹ Kockel et al introduced a different technique, using liposuction to expose the autonomic peripheral nerves in order to minimize damage to the pelvic plexus, whereas Possover et al have utilized electrostimulation to identify and preserve these nerves.⁸² However, increased severity of disease leads to increased risk of dense nervous plexus involvement which may preclude nerve-sparing.

Long-term results of nerve-sparing techniques in regards to bowel endometriosis surgery are limited but favorable. With the nerve-sparing technique, Ceccaroni et al performed a single-center prospective study of 126 patients, and found reduced incidence of bowel and bladder dysfunction as well as higher rates of patient satisfaction, with similar rates of intra-operative

complications as compared to traditional methods for surgical excision of bowel endometriosis.⁷⁹

Although data is limited, nerve-sparing techniques appear promising for decreasing post-operative complications. More research is needed to make the practice more widespread.

Decisions Involved in Surgical Approach

We emphasize foremost that asymptomatic patients do not warrant surgical intervention. For symptomatic patients, the choice between surgical techniques depends upon the anatomic location, size and depth of the endometriotic bowel lesion. We categorize lesions by location. The physiologic attachments of the sigmoid colon and peritoneal reflection along the left pelvic sidewall are the anatomic landmarks we recommend using when deciding on surgical approach. We categorize lesions as 1. Above the sigmoid colon; 2. On the sigmoid colon; 3. On the rectosigmoid colon; and 4. On the rectum. In addition to location, lesion size, depth of involvement (when the endometriotic lesion either compresses or invades the lumen of the bowel), and extent of bowel wall circumferential invasion are taken into account.

Location is paramount in deciding on excisional technique because ideally a surgeon will avoid dissection of the retro-rectal space and lateral pelvic sidewall (See Table 3). Dissection of these spaces risk disruption of the superior and inferior hypogastric plexus, parasympathetic and sympathetic nerve branches, and local vascularity. Such injuries can lead to long-term autonomic dysfunction of the bowel and bladder, which may ultimately necessitate long-term self-catheterization or permanent colostomy.⁵³ Specifically, dissection of the retro-rectal space puts the patient at higher risk for ureterovaginal fistula, anastomotic stricture, intra-operative genitourinary complications, rectal bleeding requiring transfusion, and anastomotic leakage

requiring temporary ostomy.^{21, 54, 74-77} With severe disease, nerve involvement may be encountered, and complete resection may render damage to these structures unavoidable. However, we emphasize the importance of prudence, and strongly advise conservative surgery whenever possible. These potential harms rarely outweigh the benefits of a radical excision of bowel endometriosis.

Lesions Found Incidentally

When bowel lesions are found incidentally at the time of another surgery, extensive dissection during the initial surgery is not generally advisable, especially if the patient has endorsed minimal gastro-intestinal symptoms. For surgeons capable of performing shaving excision, lesions that are amenable to safe excision can be removed and sent to the pathologist for histological analysis. This can serve to prove the presence of endometriosis of the bowel in symptomatic patients, may in fact fully treat the patient's symptoms, and is used to rule out malignancy. It is reasonable to subsequently plan for a future surgery with the assistance of a multidisciplinary team including a gastrointestinal surgeon should a patient's symptoms persist.

Lesions Above the Sigmoid Colon

Dissection above the sigmoid colon typically does not require extensive retroperitoneal interruption, and risk of injury to the nervous and vascular plexuses is lower. As such, segmental or disc resection is feasible with a lower risk of intraoperative and postoperative complications. Dissection should be performed preferentially along the anti-mesenteric surface of the bowel to spare the vascular and nervous plexuses housed in the mesentery itself.

Segmental resection with a tension-free anastomosis is preferred for multifocal lesions, or for lesions larger than 3 centimeters. Segmental resection for lesions involving more than one-third of the lumen of the upper bowel is generally advisable.^{40, 55, 65, 66, 79} Disc resection can be considered for lesions smaller than 3 centimeters even if the bowel lumen is involved.^{65, 66, 83} We have found that laparoscopic disc excision using the linear stapler is more straightforward with minimal leakage complications, peri-operative pain, and morbidity.⁴⁹

For lesions on the distal small bowel, ileo-colic region, right hemi-colon, and appendix, segmental resection is recommended as the surgery itself is relatively straightforward, and risk of nerve damage is very low (See Image 3).^{4, 53, 54, 84} If endometriosis is encountered in any location along the bowel, appendectomy can be performed even if there is no visible disease on the appendix due to the high incidence of occult appendicular endometriosis.^{85, 86}

Lesions Along the Sigmoid Colon

Along the sigmoid, we emphasize the importance of limiting dissection of the retro-rectal space to minimize the risk of long-term morbidity (Refer to Video). Segmental resection at or below the sigmoid, and even the relatively more conservative disc excision that involves bowel mobilization laterally and posteriorly, has been associated with significant risk of post-operative surgical-site leakage,⁷⁴ as well as long-term bowel and bladder dysfunction with risk of permanent colostomy.^{87, 88}

We primarily utilize shaving excision for disease on the sigmoid colon. Whenever shaving technique is utilized, especially along the sigmoid and recto sigmoid colon, thorough evaluation

of the bowel wall thickness should be performed for defects along the bowel wall. Significant defects should be reinforced with suture. Should the surgeon feel more extensive excision to be necessary, disc excision can be performed for lesions smaller than 3cm or involving less than one-third of the lumen without significant retroperitoneal and lateral pelvic wall dissection. Segmental resection can be performed if colonic obstruction is encountered, if lesions are multifocal, greater than 3cm, involve more than $2/3^{\text{rd}}$ of the bowel lumen, or if patients have a history of failed conservative surgical management. The patient must be counseled, however, regarding the higher risk for post-operative bowel dysfunction. If resection is performed, entry into the retro-rectal space and lateral pelvic wall should be minimized and a tension-free anastomosis is paramount.

Lesions Along the Rectosigmoid Colon

At the level of the rectosigmoid colon, surgeons must exercise extreme caution. Here, segmental resection can be approached through the natural orifices of the rectum or vagina.^{40, 44, 83}

Resection requires significant lateral mobilization and entry into the retro-rectal space to allow for adequate bowel mobilization. To avoid significant postoperative complications as previously described, we recommend using shaving excision whenever possible, and avoiding segmental resection in this area even with lesions greater than 3cm unless prior surgeries have failed. Disc excision can be done, but must be performed with caution. The Rouen technique has been introduced as a feasible trans-anal approach for the disc resection of large lesions.⁸³

Complications following disc excision include pelvic abscess and rectovaginal fistula, although with less frequency than with segmental resection.^{21, 54, 89} The lower the dissection, the higher the risk.

Lesions Along the Rectum

Although others have suggested disc resection or even segmental resection at this level,^{70, 90, 91} we use shaving excision as much as possible due to the higher post-operative risk to the patient. There is no evidence that benefits of segmental resection outweighs the risks when compared with conservative surgery at this level,^{50, 60, 92} with evidence suggesting aggressive surgery 5-8 cm from the anal verge (See Image 4a and 4b) may be predictive of post-operative complications.⁹³ These lower endometriotic lesions typically cannot be accessed by the linear stapler, and although a trans-rectal approach to disc excision has been suggested,^{40, 90} the necessary extensive dissection of the bowel can lead to serious neurologic and vascular complications as described above. Theoretically, patients with acute obstruction of the low rectum due to deeply infiltrative endometriosis would require segmental resection with subsequent ostomy; however, this scenario is very rare.

Using the shaving technique along the rectum, we excise as much disease as possible without compromising the bowel lumen, and limiting lateral dissection that could compromise the sympathetic and parasympathetic nervous plexus. We err on the side of leaving disease on the rectum rather than risk perforating the bowel. For patients who do not desire fertility, a risk-benefit discussion regarding bilateral salpingo-oophorectomy with or without hysterectomy should be considered in lieu of aggressive segmental or disc resection of the rectum.^{94, 95} We emphasize that infertility is not an indication for aggressive bowel surgery. In fact, for patients interested in fertility, successful pregnancy is very often achieved even in cases of severe disease with bowel stricture treated using the shaving technique.⁵⁴ For a subset of these patients who

require second-look laparoscopy following their delivery (often for subsequent infertility), we have frequently encountered notable regression of rectal endometriosis well beyond what shaving from their prior surgery alone could explain. We do not have a clear explanation as to why there seems to be regression of bowel endometriosis spontaneously following pregnancy. We recognize that using pregnancy as an endpoint is difficult to correlate definitively with surgical management as there are many confounders, including use of IVF, age, male factor, and ovarian surgery. For now, we reiterate that this finding may also reflect the enigmatic nature of endometriosis.

Complications

Complications are a reality for surgeons, especially for those who perform complex procedures. Our rate of adverse outcomes has been very low, and by avoiding aggressive surgery at the level of the low rectum, we have decreased our rate of complications even further. Nonetheless, we have successfully diagnosed and managed a variety of post-operative complications, and all surgeons who perform bowel endometriosis surgery should be prepared to do likewise.

During the preoperative consent process, patients should be well-informed of the immediate operative risks and risk for long-term functional changes.⁹⁶ Potential perioperative complications should be discussed include stricture, obstruction, infection, perforation, fistula formation, anastomotic leakage, and perioperative hemorrhage.^{55, 74} With any bowel surgery, risk of intestinal perforation and leakage are possible, although to a much lesser extent with superficial shaving excision. Proper surgical technique maintains well-vascularized, tension-free anastomoses to minimize risk of an anastomotic leak.^{4,21, 46, 55}

For better postoperative recovery, we advocate the enhanced recovery after surgery (ERAS)⁹⁷ protocol and close communication with the patient by daily phone calls and as-needed in-office exams. With every passing day, the patient should experience overall symptom improvement. Table 4 outlines a brief list of possible post-operative complications, and guidelines surrounding proper post-operative management.

Conclusions

Deep infiltrative endometriosis of the bowel may have various presentations. Unfortunately, it often goes under-diagnosed, while in other instances it continues to be over-aggressively treated. Bowel endometriosis can be encountered incidentally at the time of surgery performed for another indication, or it may be suspected when a premenopausal woman has significant pelvic pain, bloating, cyclic dyschezia, blood in the stool, changes in stool caliber, or IBS-like symptoms. If a patient is relatively asymptomatic, close monitoring with long-term hormonal ovarian suppression is preferred over surgical management.

In the symptomatic patient who are not candidates for or who have failed medical therapy, a multi-disciplinary surgical approach with the involvement of gynecologic and gastrointestinal specialists familiar with bowel endometriosis is encouraged. Some surgeons advocate for segmental resection of the bowel as the treatment of choice for endometriosis at all levels of the bowel. Based on our extensive experience in conjunction with thorough and frequent review of current literature, we preferentially perform shaving excision for lesions below the sigmoid colon to avoid extensive lateral mobilization and dissection of the lateral and retro-rectal spaces and

avoid compromise of long-term bowel and bladder function. Indeed, patient results and satisfaction remain high following shaving excision and the complication rate following shaving excision is the lowest among the surgical options,^{49,60,62} with favorable long-term outcomes.^{42,61,62} We employ the shaving technique as much as possible for the treatment of endometriosis located below the sigmoid colon, especially for lesions on the low rectum.^{42, 57} For lesions above the sigmoid colon, including the small bowel, segmental resection or disc resection remains our preference.

FIGURE LEGEND

Figure 1: Innervation of the Bowel

Figure 2: Innervation of the Bowel

Image 1: T2 weighted MRI image revealing bilateral endometriomas. The ovaries are tethered to the upper rectum by T2 hypointense fibrotic material consistent with deeply infiltrative endometriosis and cul-de-sac obliteration

Image 2: Dissection of Inferior Hypogastric Nerves

Image 3: Bowel Endometriosis along the Ileocecal Junction

Image 4a: Endometriosis of the Rectovaginal Septum

Image 4b: Initiation of shaving technique for treatment of deeply infiltrative Endometriosis of the Rectovaginal Septum

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Table 1: Theories Surrounding the Pathogenesis of Bowel Endometriosis

Theory	Explanation
Retrograde Menstruation	Most commonly cited theory involving retrograde flow during menses
Coelomic Metaplasia ¹	Metaplastic extra-uterine cells aberrantly differentiate into endometrial cells along the visceral or abdominal peritoneum
Benign Metastasis	Where endometrial tissue spreads through the lymphatic or hematologic system to ectopic anatomic sites
Genetic and Immune Dysfunction	Includes possible apoptosis suppression, greater expression of invasive mechanisms, greater expression of neuro-angiogenesis factors, genetic alterations of endometrial cellular function, and oxidative stress and inflammation ^{2,3}
Iatrogenic Causes	For example, endometrial cells can be spread after surgical procedures that involve endometriosis or the endometrium itself, with lesions presenting along scars such as laparoscopic port sites and C-section hysterotomies ⁴
Anatomical Shelter Theory ⁵	Rectosigmoid colon may act as an anatomic barrier that prevents retrograde menstrual flow from spreading cephalad from the pelvis, so that more endometriotic implants imbed along the pelvis and rectosigmoid than along upper abdominal structures

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Table 2: Imaging Options for the Diagnosis of Bowel Endometriosis

Imaging Modality	Description	Comments	Sensitivity	Specificity
Transvaginal Ultrasound ¹ (TVUS)	Areas of tenderness should be evaluated closely as they may point to subtle disease. ²	Accuracy of diagnosis correlated with sonographer experience. ³ Lesions above the sigmoid generally are outside of the view. ³	71-98% ³	92-100% ³
Rectal water contrast transvaginal sonography (RWC-TVUS) ^{1,4}	100-300cc water instilled into the rectum prior to TVUS.	Provides enhanced imaging with transvaginal ultrasound probe. ⁵	95.7% ⁵	98% ⁵
Rectal Endoscopic Sonography (RES) ¹	Specialized high-frequency transducer coupled with colonoscope placed into rectum to the level of the sigmoid. Enema and anesthesia often required. ⁶	Accuracy of diagnosis correlated with sonographer experience. ⁷ Gives information regarding depth of invasion of lesion. ⁷	88.2% ⁵	96% ⁵
Magnetic Resonance Imaging (MRI) ¹	An endo-luminal coil can be placed in the rectum to better visualize rectal lesions but use can be limited by patient discomfort.	Not operator dependent. Provides information for lesions above the sigmoid colon. Lacks sensitivity for measuring depth of invasion of lesion.	88% ⁸	97.8% ⁸
Double Contrast Barium Enema (DCBE)	Distends colon with barium, draining colon, and filling lumen with air prior to taking AP radiographs.	Evaluates degree and length of bowel occlusion at the level of the sigmoid. ⁹ Difficult to distinguish between other bowel pathologies (neoplasm, pelvic abscess, diverticulitis). ⁹	87.5% ⁵	94.2% ⁵

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Table 3: Guidelines Surrounding the Surgical Management of Bowel Endometriosis

Lesions Found Incidentally	<ul style="list-style-type: none"> - Extensive dissection not advisable - Recommendation is for shaving excision and biopsy - Patient to be followed and evaluated clinically and hormonally - Reasonable to expect and plan for future surgery with a multidisciplinary team if patient becomes symptomatic and non-responsive to medical therapy
Lesions Above the Sigmoid Colon	<ul style="list-style-type: none"> - Segmental resection or disc excision can be performed safely - Segmental resection is preferable for multifocal lesions, for lesions larger than 3 centimeters, or for lesions involving >1/3 of the bowel lumen - Segmental resection is a straightforward approach for disease located on the ileocecal region, as well as the small bowel in cases of stricture - For singular lesions which was <3 centimeters in size or smaller than 1/3 of the bowel lumen, disc excision can be considered
Lesions Along the Sigmoid Colon	<ul style="list-style-type: none"> - When possible, we prefer utilizing shaving excision - Starting at this level, surgeons should be aware that extensive lateral dissection may lead to short and long-term complications - For lesions smaller than 3cm, or involving less than one-third of the bowel lumen, disc excision can be performed - Segmental resection can be performed if obstruction is encountered, if there is multifocal disease, if the lesion is >3 centimeters in size, or if the patient has a history of failed conservative surgical management
Lesions Along the Rectosigmoid Colon	<ul style="list-style-type: none"> - When possible, we prefer to utilize shaving excision - Additional options include disc resection or segmental resection (via laparoscopy, laparotomy or natural orifice) However, surgeons must exercise extreme caution to minimize dissection of the lateral and retro-rectal space
Lesions Along the Rectum	<ul style="list-style-type: none"> - We strongly advocate for shaving excision at this level due to risk of complications when aggressive surgery is performed within 5-8 centimeter of the anal verge - We err on the side of leaving disease on the rectum, with consideration made for post-operative hormonal suppression, rather than risk injuring the rectum itself the or neurovascular structures surrounding the rectum - We minimize lateral dissection, as well as dissection of the retro-rectal space - Theoretically, patients with acute obstruction at this level still require segmental resection, but this clinical scenario is very rare

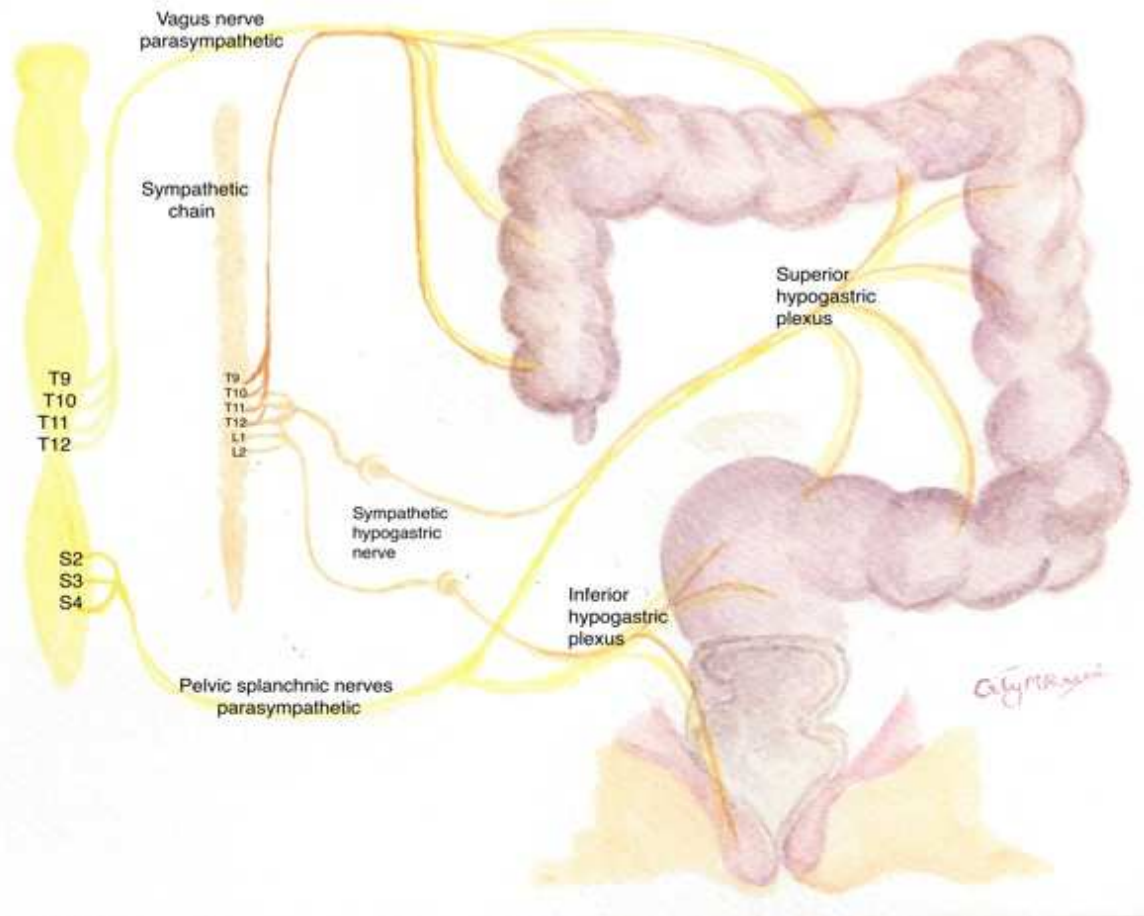
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Table 4: Post-Operative Complications and Management Guidelines

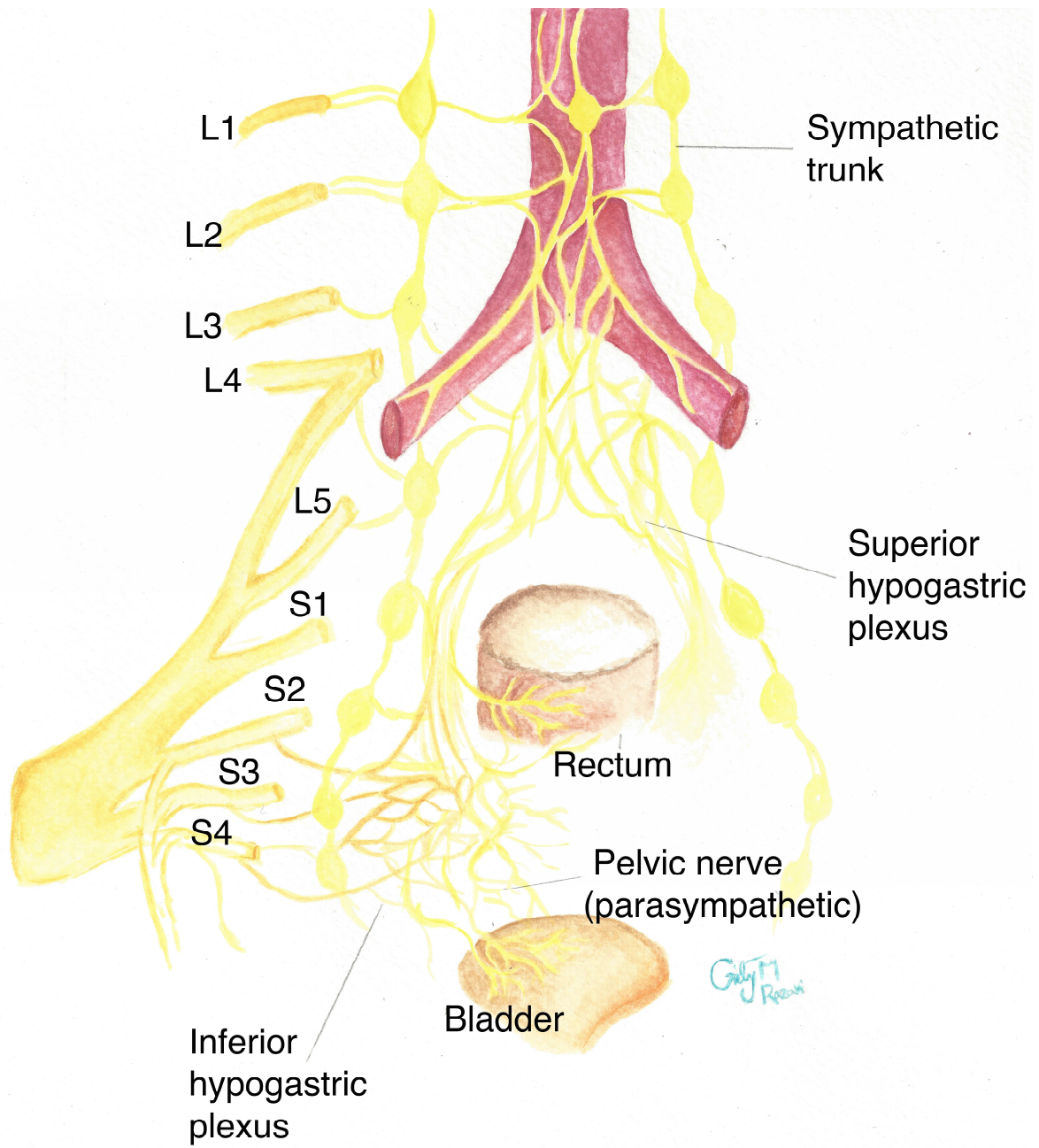
Complication	Management Guidelines
Intestinal perforation or anastomotic leak	<ul style="list-style-type: none"> • history and physical exam, with hospital admission • with a low threshold for laboratory evaluation including complete blood count, basic metabolic panel, coagulation studies, and lactic acid • CT with IV contrast and oral gastro-graffin is recommended • If the CT reveals an abscess, this can be drained either by interventional radiology or by second-look laparoscopy with thorough wash-out and IV administration of broad-spectrum antibiotics and possible surgical repair • Even if the CT does not demonstrate pathology, the surgeon must still maintain a high index of suspicion if the clinical exam is concerning. We recommend starting broad-spectrum antibiotics and placing the patient on bowel rest if the patient is febrile, has pain out of proportion to routine postoperative soreness, has abdominal distension, or if leukocytosis is present. When antibiotics are initiated, sites of micro-perforation may seal spontaneously without need for further intervention.¹ • Should the patient not exhibit clinical improvement quickly, or if laboratory values stagnate or worsen, a second-look laparoscopy can be done if there is an expert surgeon available for a thorough washing or possible bowel repair. • If an expert laparoscopist is not available for a second-look surgery, a gastrointestinal surgeon specializing in endoluminal surgery can be consulted for endoscopic repair of the defect.² • If the second-look surgery does not cure the patient, or if the patient is septic at the time of her second-look laparoscopy, temporary ostomy (preferably loop ileostomy) should be considered.
Bleeding from anastomotic site	<ul style="list-style-type: none"> • On the differential diagnosis if the patient reports rectal bleeding or becomes hemodynamically unstable. • The patient should be evaluated immediately, hemoglobin level trended, and transfusion may be required. If brisk bright red bleeding is encountered, hospital admission should be arranged. • Control of bleeding at the surgical bed can be approached laparoscopically or via colonoscopy by a gastrointestinal specialist. • Once the site of bleeding is localized, it can be controlled using suture, laparoscopic stapling device, clip, or hemostatic agents.
Rectovaginal Fistula	<ul style="list-style-type: none"> • Conservative therapy can be considered in an otherwise healthy patient with a rectovaginal fistula when the patient is not febrile or ill,³ including usage of stool-firming medications with a low residue diet to add bulk to the stool, with avoidance of stool

	<p>softeners and laxatives.</p> <ul style="list-style-type: none"> • As a vaginal outflow drainage site is typically present, patients generally feel well otherwise. Usually, the rectovaginal fistula will heal spontaneously.⁴ • Fistulas which persist longer than 3-6 months are unlikely to resolve without intervention and typically need surgical repair. Referral to the proper specialist(s), including but not limited to gastrointestinal, urogynecologic, colorectal, or a gynecologic-oncologist, is appropriate. • Repair options include but are not limited to, patching the area with a biologic tissue specimen, using an autologous tissue graft, and/or sewing of an anal fistula plug.⁵⁻⁷ • For certain complex or recurrent cases such as with concomitant inflammatory bowel disease, temporary ostomy, preferably ileostomy, can be considered prior to definitive surgical correction.
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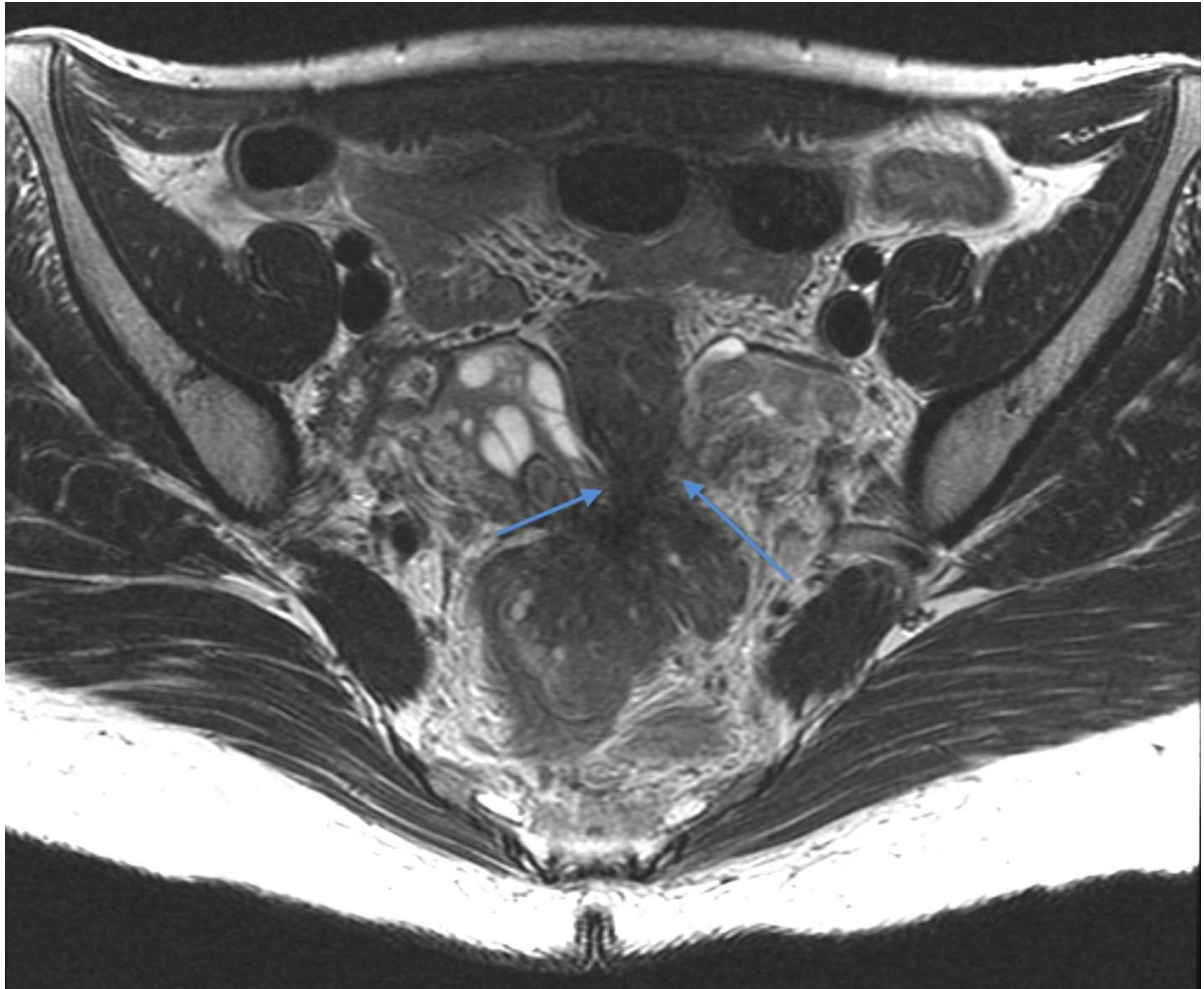
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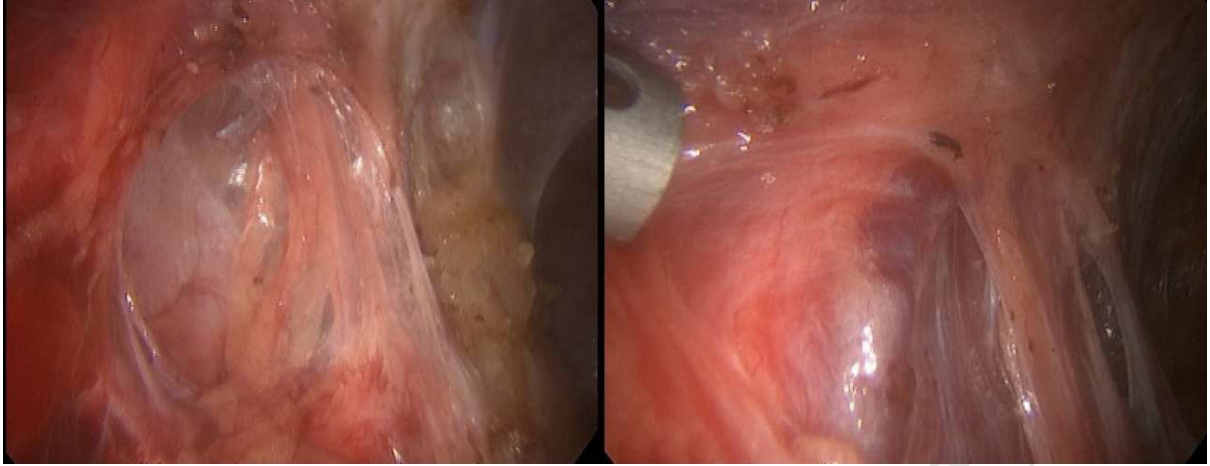
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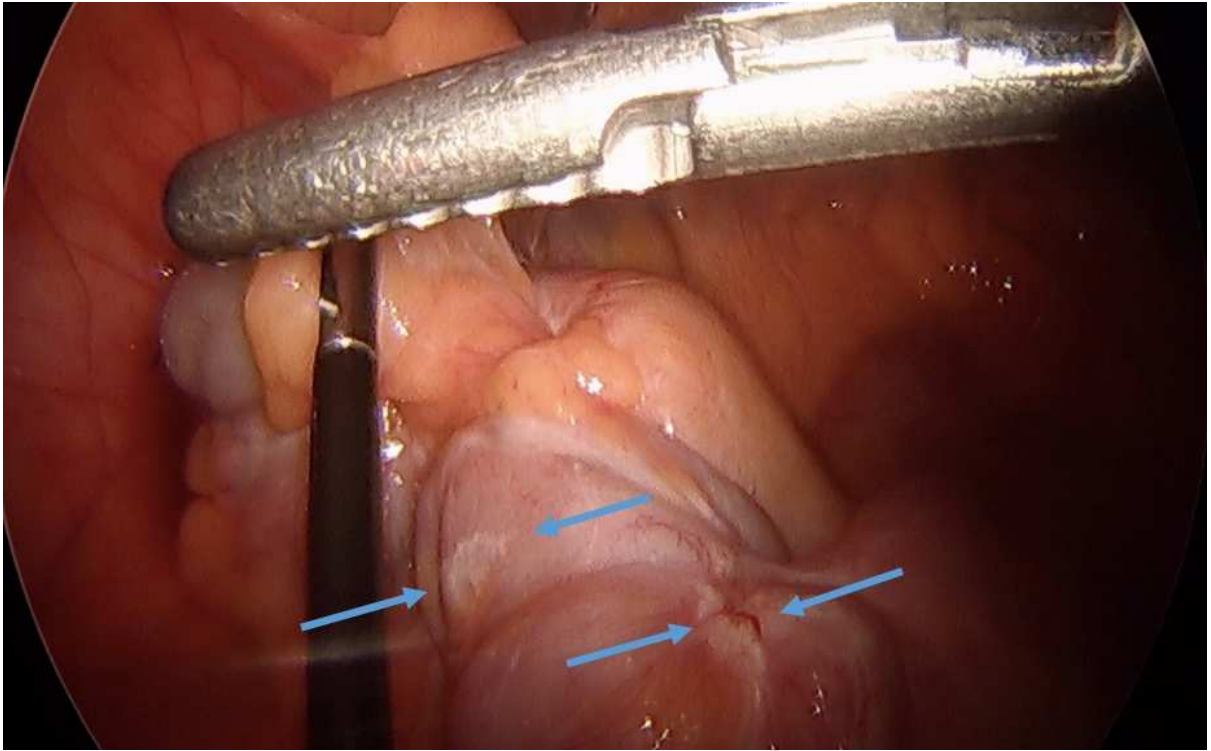
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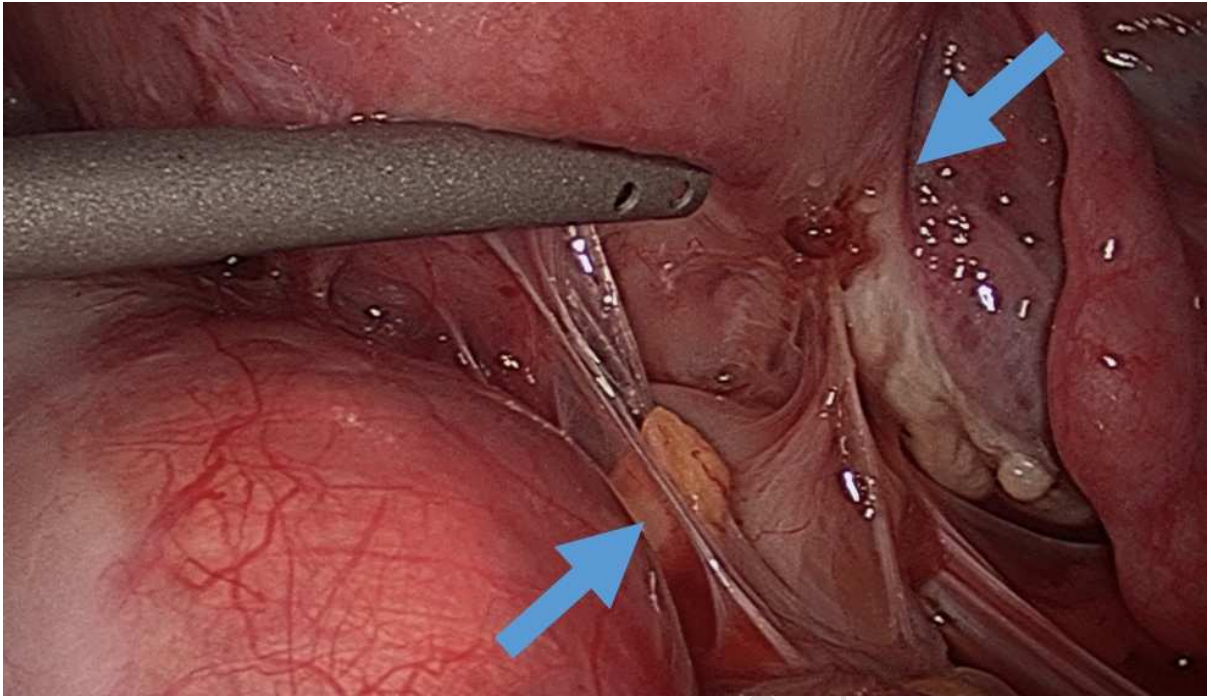
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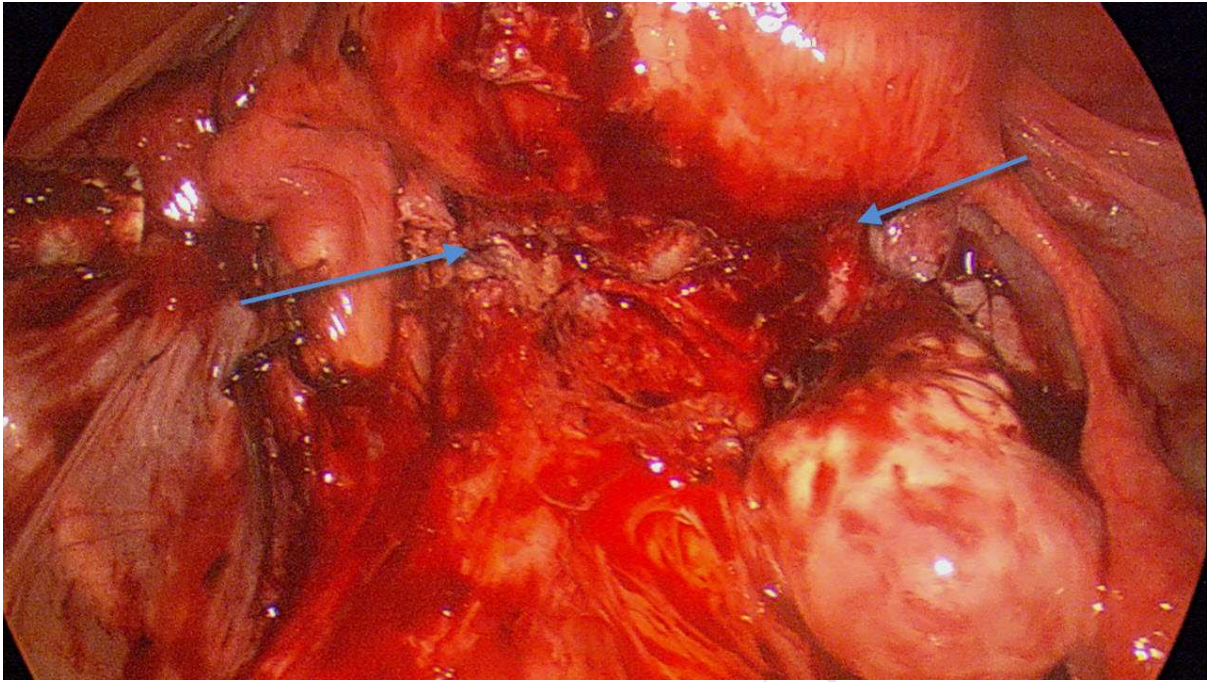
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