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Nonvisualized palpable bowel endometriotic satellites

H. Roman[1,2], B. Merlot[1], D. Forestier[1], M. Noailles[1], E. Magne[1], T. Carteret[1], J.-J. Tuech[3], and D.C. Martin[4,5,*]

[1]Endometriosis Center, Clinique Bordeaux Tivoli-Ducos, Bordeaux, France [2]Department of Gynecology and Obstetrics, Aarhus Medical University, Aarhus, Denmark [3]Department of Surgery, Rouen University Hospital, Rouen, France [4]School of Medicine, University of Tennessee Health Science Center, Memphis, TN, USA [5]Office of Research Subjects Protection, Institutional Review Board, Virginia Commonwealth University, Richmond, VA, USA

*Correspondence address. Office of Research Subjects Protection, Institutional Review Board, Virginia Commonwealth University, 201 Wakefield Road, Richmond, VA 23221-3258, USA. Tel: +1 (901) 761-4787; E-mail: danmartinmd@gmail.com

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STUDY QUESTION: What is the prevalence of laparoscopically nonvisualized palpable satellite bowel nodules at or near the planned stapler site in women undergoing segmental bowel resection for endometriosis?

SUMMARY ANSWER: Overall, 13 (25.5%) of 51 patients who underwent resection had nonvisualized palpable satellite lesions as small as 2 mm, including seven (14%) who had nonvisualized palpable lesions at or beyond the planned stapler site.

WHAT IS KNOWN ALREADY: Both laparoscopy and laparotomy for bowel resection are standard of care in Europe and the USA. Reoperation rates after laparoscopic bowel procedures are 1–16%. Endometriotic lesions at the stapler margin of bowel resections are associated with increased repeat surgery. Nodules of 0.1 mm to 1 cm in size were not recognized during laparoscopic bowel surgery but were recognized on histological examination. Up to 20 nodules not visualized at laparoscopy have been recognized and excised at laparotomy. Tenderness is found at up to 27 mm from a recognized lesion. The size of a lesion does not always predict its symptoms or behavior.

STUDY DESIGN, SIZE, DURATION: This single-arm, observational study focused on the presence of nonvisualized palpable satellite lesions of the bowel. Fifty-one patients scheduled for laparoscopic-assisted bowel resection for deep infiltrating endometriosis with suprapubic incision for placement of the stapler's anvil and removal of the specimen in the course of routine clinical care were included. There were no additional inclusion or exclusion criteria.

PARTICIPANTS/MATERIALS, SETTING, METHODS: Laparoscopic-assisted segmental bowel resection for endometriosis was performed in a private referral center on women aged 24–49 years.

MAIN RESULTS AND THE ROLE OF CHANCE: Forty-nine (96.1%) of the 51 patients underwent segmental resection of the sigmoid or rectum, and 14 (27.5%) underwent segmental resection of the ileum for large nodule(s) recognized on MRI. Twelve patients underwent both procedures. Eleven (22.4%) of the 49 patients with recognized sigmoid or rectal lesions and 5 (35.7%) of the 14 patients with recognized ileal lesions had nonvisualized, palpable, satellite lesions. All the large lesions and none of the satellite lesions had been recognized preoperatively on MRI. Five (10%) of 49 patients with lesions of the large bowel and 4 (28.6%) of the 14 patients with lesions of the ileum had nonvisualized palpable satellite lesions at or beyond the planned stapler site. Lesions as small as 2 mm were palpable.

LIMITATIONS, REASONS FOR CAUTION: This is an observational study. It is not known if the small lesions of this study contributed to the symptoms or were progressive, stable or regressive. This study analyzed lesions in the bowel segment proximal to the primary large bowel lesion, but not in the distal segment as that would have required a change in standard of care surgical technique. This study protocol did not include shaving or disk resection or patients in whom no lesions were visualized. The use of additional techniques for recognition, such as hand-assisted laparoscopy or rectal probes, was not investigated.

WIDER IMPLICATIONS OF THE FINDINGS: This study confirms that some nonvisualized satellite lesions as small as 2 mm are palpable and that an increased length of resection can be used to remove lesions recognized by palpation and to avoid lesions at and beyond the stapler site. This may decrease recurrent surgery in 1–16% of the women undergoing surgery for bowel endometriosis. Knowledge of the occurrence of these small lesions may also be particularly useful in plans for repeat surgery or for women with clinically significant

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bowel symptoms and no visible lesions at laparoscopy. Moreover, small lesions are considered to be important as there is no current technique to determine whether a large primary lesion, smaller lesions, an associated adjacent tissue reaction or a combination of those cause symptoms.

STUDY FUNDING/COMPETING INTEREST(S): This CIRENDO cohort was supported by the G4 Group (the University Hospitals of Rouen, Lille, Amiens and Caen) and the ROUENDOMETRIOSE association. No specific funding was received for the study. H.R. reports receiving personal fees from Plasma Surgical Inc., Ethicon Endosurgery, Olympus and Nordic Pharma for presentations related to his experience with endometriosis surgery. D.C.M. reports being given access to Lumenis Surgical CO_2 Lasers' lab at a meeting. None of the other authors have conflicts of interest to disclose.

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Introduction

Endometriosis, the extrauterine presence of endometriotic glands and stroma, can present with advanced findings such as bowel nodules associated with gastrointestinal symptoms. In most women, laparoscopic shaving, disk resection or segmental resection of bowel nodules can result in low rates of recurrent surgery. In addition, limiting the degree of surgery can limit major complications (Abrao *et al.*, 2015; Roman *et al.*, 2016, 2018; Vercellini *et al.*, 2020). However, recurrence has been as high as 6.7–35.7% in subpopulations with positive margins (Nirgianakis *et al.*, 2014; Roman *et al.*, 2016).

Palpation at laparotomy is used to recognize endometriotic bowel lesions as small as 5 mm (Weed and Ray, 1987). Also, up to 20 bowel nodules not recognized at laparoscopy have been palpated and removed at laparotomy (Martin, 1991). Furthermore, retroperitoneal, rectovaginal nodules of up to 4 cm have required palpation for recognition (Moore *et al.*, 1988). Some large rectovaginal nodules were prospectively missed on barium enema, at laparoscopy and at laparotomy (Martin, 1999). Also, lesions of 0.1 mm to 1 cm as far as 5.4 cm from the primary lesion have been missed at surgery (Badescu *et al.*, 2016). It is noted that pathologists can recognize lesions smaller than surgeons or MRI (Martin, 1988; Rousset *et al.*, 2014; Badescu *et al.*, 2016).

The size of the lesions that are associated with pain is variable. When small and large lesions of the bowel coexist, it cannot generally be determined which, if either or both, cause pain and other symptoms. Furthermore, tenderness may extend to up to 27 mm from an endometriotic lesion in normal-appearing tissue (Demco, 1998). Palpation, anticipating that lesions as small as 2 mm can be recognized, has the potential of decreasing positive margins, residual endometriosis and recurrence. Palpation and other techniques, such as using a rectal probe to stretch the bowel and hand-assisted laparoscopy, may also be useful. Compounding surgical decisions is the recognition that endometriotic lesions can be regressive, stable or progressive (Evers, 2013). This complexity increases the level of preoperative discussions needed to clarify the patient's goals and respect their autonomy (Gillon, 2003).

This study aimed to assess the prevalence of nonvisualized palpable satellite endometriotic bowel nodules in women undergoing laparoscopic-assisted segmental bowel resection; to compare the intraoperative findings, surgical procedures and immediate postoperative complications between women with and without nonvisualized palpable satellite lesions; and to discuss the clinical importance.

Materials and methods

Setting

This single-arm, observational study of patients managed by laparoscopic-assisted segmental resection of the sigmoid, rectum or ileum was conducted from 15 January 2019 to 11 March 2020 at the Endometriosis Center, Tivoli-Ducos Clinic, Bordeaux, France. The University Hospital of Rouen Ethics Committee for Research approved this study (protocol E2019-05). All patients were included in the North-West Interregional Female Cohort for Patients with Endometriosis (CIRENDO, ClinicalTrials.gov Identifier: NCT02294825) study supported by the G4 Group (the University Hospitals of Rouen, Lille, Amiens and Caen) and the ROUENDOMETRIOSE Association, and coordinated by the corresponding author (H.R.). In the present study, we only enrolled patients scheduled for laparoscopic segmental resection of the sigmoid, rectum or ileum with suprapubic incision for placement of the proximal second stapler and removal of the specimen in the course of routine clinical care. There were no additional inclusion or exclusion criteria specific to this study. As the prevalence of nonvisualized palpable satellite endometriotic bowel nodules was not known, a 1-year sampling was planned and extended to 14 months to include 50 patients.

Patient data were prospectively recorded and included medical history, clinical symptoms, clinical and diagnostic imaging findings, surgical procedures and postoperative outcomes.

Patient selection

All women referred to our center for deep infiltrating endometriosis were clinically examined by a surgeon experienced in endometriosis and underwent a diagnostic MRI of the pelvis to determine the size of the lesion and help plan the surgical approach.

Procedures/interventions

Patients were informed about and gave written consented for the procedure. The type of procedure to be performed was determined, in cooperation with the patient, by one of two gynecologic surgeons (H.R. and B.M.) based on the patient's symptoms, expectations and the size, height and number of bowel nodules revealed by imaging techniques. All patients received a preoperative residue-free diet and bowel preparation on the day before surgery. Preoperative and postoperative hormonal suppression with continuous combined oral contraceptive pills or progestins were routinely administered for 1 month

or longer in patients free of hormonal therapy side effects. In patients who did not want to conceive, we also recommended postoperative long-term hormonal suppression (combined oral contraceptives or oral progestin) to reduce the risk of recurrence.

Surgery was performed by two gynecologists (H.R. and B.M.) with colorectal surgeons (D.C.M., M.N. and E.M.) and was based on standard clinical care using a laparoscopic approach. Segmental resection is generally employed for nodules larger than 5 cm, for nodules responsible for severe stenosis of the lumen, or with multifocal endometriosis of the rectosigmoid in which the distance between two consecutive nodules is <5–7 cm. There were no modifications to the stapler's placement on the distal margin that would change the standard of care.

The procedure was performed laparoscopically with hand assistance to remove the specimen. The bowel surfaces were visually examined for satellite lesions. No laparoscopic palpation techniques were used. In patients with deep endometriosis infiltrating the rectum or the sigmoid colon, the specimen was sectioned distally from the lowest colorectal nodule using endoscopic 45 or 60 mm linear staplers, generally 1 cm below the macroscopic limit of the large nodule. The colon was then exteriorized through a 5 cm suprapubic incision. The specimen was carefully checked for small nodules by palpation, and the proximal section was carried out 1 cm above the limit of the most proximal macroscopic nodule or the most proximal small nodule identified by palpation (Fig. 1). The colorectal anastomosis was performed using a circular surgical stapler (either 28 or 31 mm diameter). A bubble test was used systematically to ensure the integrity of the stapled line. In patients with deep endometriosis nodules of the ileum, we laparoscopically released the right colon over the right colonic angle to enable exteriorization of the right colon and ileum through the suprapubic incision. The last 40–50 cm of the ileum, cecum, appendix and right colon were checked for small nodules by palpation.

Sectioning of the ileum or proximal colon was done at least 1 cm proximally and distally from the most proximal and distal primary or satellite nodule (Fig. 1). When the colon was free of palpable endometriotic nodules, and the distance from the most distal nodule of the ileum and the ileocolonic junction was longer than 7–8 cm, we carried out a segmental resection of the ileum with end-to-end anastomosis using two semicircular 4/0 resorbable running sutures by hand. When the ileum's most distal nodule was closer to the ileocolonic junction or the deep endometriosis involved the cecum, we carried out an ileocolonic resection followed by ileocolonic side-to-side anastomosis using 80-mm endoscopic staplers. The length of the specimen removed, the presence and number of nonvisualized palpable small satellite nodules, and the distance to visualized macroscopic nodules were recorded. The endometriosis severity was classified using the revised American Society for Reproductive Medicine (rASRM) scoring systems (ASRM, 1997).

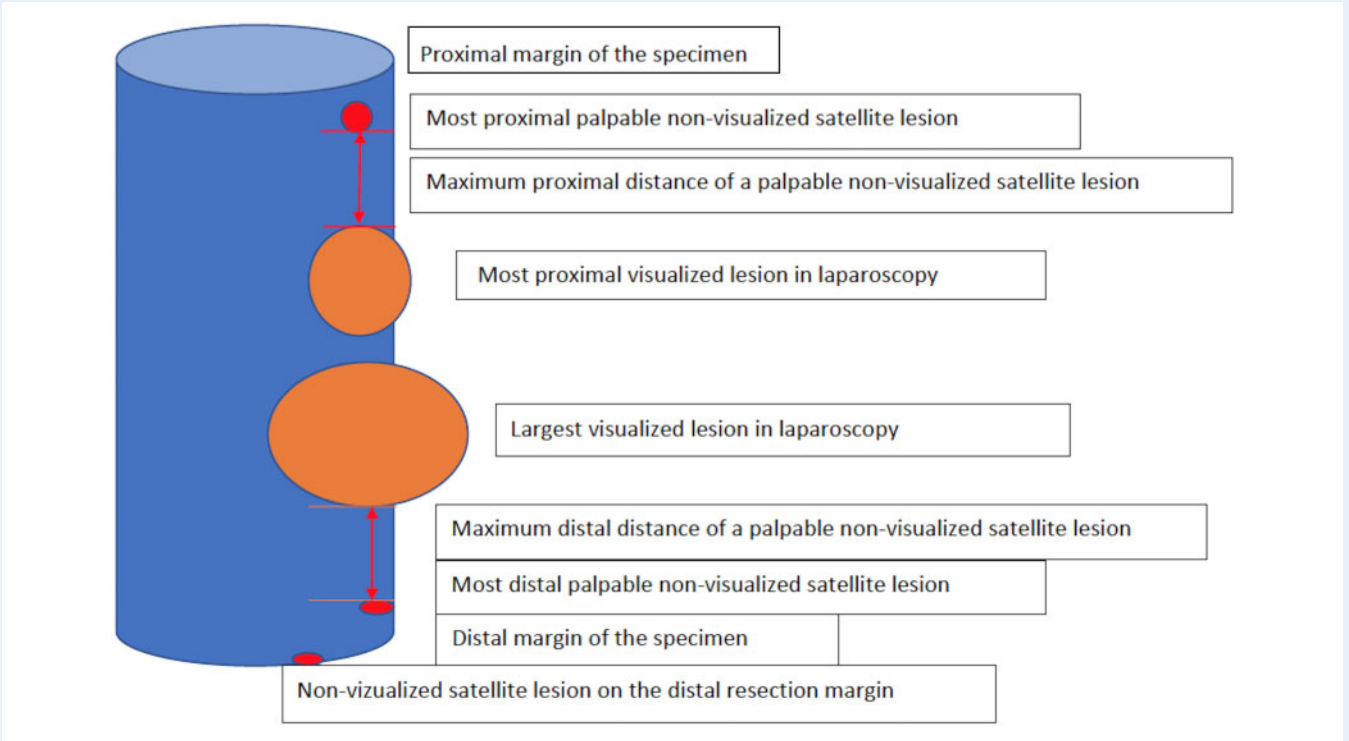

Figure 1. Schematic of rectosigmoid and ileal segments and measurements. The diagram illustrates an example of the length of the specimen removed, the presence and number of small nonvisualized palpable satellite nodules and the distance from the nonvisualized palpable satellite nodules to the macroscopic nodules during laparoscopy.

The specimens were processed routinely by pathology using hematoxylin and eosin staining. The histological definition of endometriosis was the presence of glands and stroma with or without hemorrhagic changes.

Statistical analysis

Statistical analysis was performed using Stata 11.0 Software (Stat Corporation, College Park, TX, USA). Qualitative variables were expressed in terms of frequency and percentage, and continuous variables were expressed as medians, quartiles and ranges. Fisher's exact test was used to compare categorical variables, and the Kruskal–Wallis test was used to compare continuous variables. *P*-values <0.05 were considered statistically significant.

Results

The demographic characteristics of the 51 patients who enrolled in this study are in Table I. The age range was 24–49 years. Group A (N = 38) had no nonvisualized palpable satellite lesions. Group B had nonvisualized palpable satellite nodules of the rectum, sigmoid and/or ileum (Figs 2 and 3). Pain on defecation was more common in Group B than in Group A (92.3% versus 58%, respectively; $P = 0.04$). No other characteristics were significantly different between the two groups.

The intraoperative findings, surgical procedures, and immediate postoperative complications are displayed in Table II. No intraoperative findings or immediate postoperative complications were significantly different between the two groups. The mean operating time was comparable between Group A and Group B (120 min versus 118 min, respectively).

Forty-nine (96.1%) of the 51 patients underwent segmental resection of the sigmoid or rectum, and 14 (27.5%) underwent segmental resection of the ileum. Twelve (23.5%) of the 14 patients who underwent ileal resection underwent both procedures. Eleven of the 49 patients (22.4%) with visible sigmoid or rectal lesions and 5 of the 14 patients (35.7%) with visualized ileal lesions also had nonvisualized palpable satellite lesions of the sigmoid or rectum or ilium, respectively; 3 patients (6.1%) had nonvisualized palpable satellite lesions of both the sigmoid or rectum and ilium. The two patients who had only ileal lesions had no nonvisualized palpable satellite lesions. Overall, 13 of 51 patients in our cohort (25.5%) had nonvisualized palpable satellite lesions. The range of nonvisualized lesion sizes was 2 mm to 1 cm in both the large and small bowel groups. Five (10%) with lesions of the large bowel and 4 (28.6%) of the 14 patients with lesions of the ileum had nonvisualized palpable satellite lesions at or beyond the planned stapler site. All the large lesions and none of the satellite lesions had been recognized preoperatively on MRI.

The intraoperative surgical characteristics of patients with and without nonvisualized palpable satellite lesions are in Table III. The proximal limit to the most proximal visualized nodule in the sigmoid or rectum was significantly increased from a median of 10 mm in Group A to 20 mm in Group B ($P = 0.001$) among patients who underwent sigmoid or rectum resection. The proximal limit to the most proximal visualized nodule in the ileum was significantly increased from a median of 5 mm in Group A to 12.5 mm in Group B ($P = 0.04$) among patients who underwent ileal resection. No other characteristics were significantly different between the groups. The use of palpation added to the total length of rectosigmoid resected in this study: although that length was not measured directly, it was approximately the maximum distance from the large nodules to the most proximal nonvisualized palpable satellite nodules in the large bowel of 15 mm median (15–35 mm range). A similar increase was observed among patients who underwent ileal resection but involved both margins. This increase was no greater than the sum of each margin at 15–60 mm.

Table I Demographics of the 51 patients who enrolled in the study of endometriotic bowel satellites.

	Group A N = 38 (74.5%)	Group B N = 13 (25.5%)	*P*
Age (years)	33.5 (30; 37)	34 (31; 35)	0.79
BMI (kg/m^2)	22.7 (20; 24.4)	22 (20.3; 25.6)	0.85
Smoking	7 (18.4)	2 (15.4)	1
Past surgical history			
Abdominal surgery	31 (81.6)	10 (76.9)	1
Bowel resection	3 (7.9)	0	0.56
Open abdominal surgery	3 (7.9)	1 (7.7)	1
Endometriosis surgery	12 (31.6)	5 (38.5)	0.74
Nullipara	21 (55.3)	10 (76.9)	0.20
Infertility >12 months	17 (44.7)	9 (69.2)	0.20
Endometriosis-related pain			
Dysmenorrhea	33 (86.8)	12 (92.3)	1
Deep dyspareunia	26 (68.4)	10 (76.9)	0.73
Noncyclic pain	31 (81.6)	9 (69.2)	0.44
Digestive complaints			
Defecation pain	22 (58)	12 (92.3)	0.04
Cyclic constipation	20 (52.6)	9 (69.2)	0.75
Cyclic rectorrhagia	9 (23.7)	3 (23.1)	1
Cyclic diarrhea	24 (63.2)	7 (53.9)	0.74
Cyclic bloating	26 (68.4)	12 (92.3)	0.14
Digestive function assessment			
KESS constipation score*	13.5 (9.5; 18)	13.5 (9.5; 19)	0.93
GIQLI**	78.5 (66; 93)	75 (67; 84)	0.67
Wexner score for anal continence	1 (0; 5)	0 (0; 2.5)	0.17
Other baseline complaints			
Hydronephrosis	3 (7.9)	1 (7.7)	1
Digestive tract subocclusion/ occlusion	5 (13.2)	2 (15.4)	1
Kidney atrophy <10% residual activity on DMSA scintigraphy	1 (2.3)	0	1
Severe dysuria	2 (5.3)	0	1

Group A had no nonvisualized palpable satellite lesions. Group B had nonvisualized palpable satellite nodules of the rectum.
Data are reported as the Median (Quartile1; Quartile3). Fisher's exact test was used to compare categorical variables, and the Kruskal–Wallis test was used to compare continuous variables.
*KESS, Knowles Eccersley Scott Symptom; **GIQLI, Gastrointestinal Quality of Life index; DMSA, dimercaptosuccinic acid.

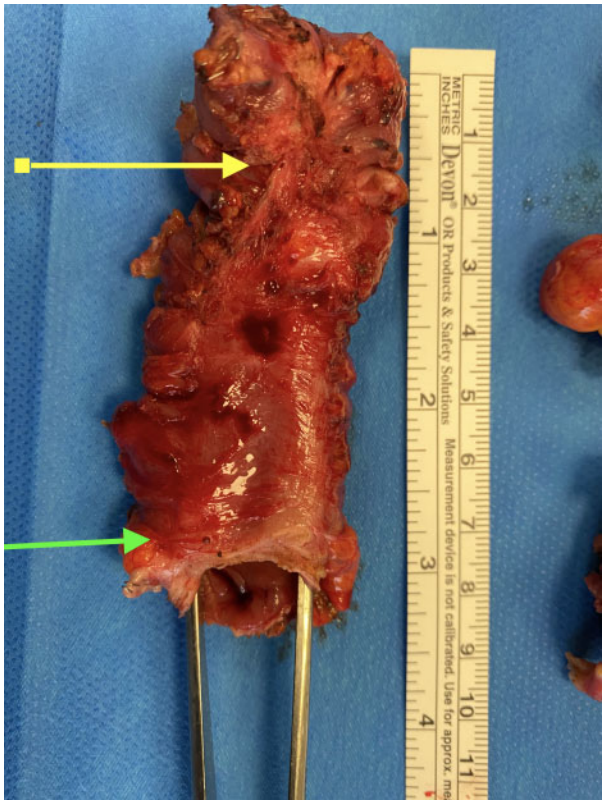

Figure 2. Colorectal section with main and satellite nodules. The excised specimen has the large visible nodule marked with a yellow arrow and the nonvisualized palpable satellite nodule marked with a green arrow.

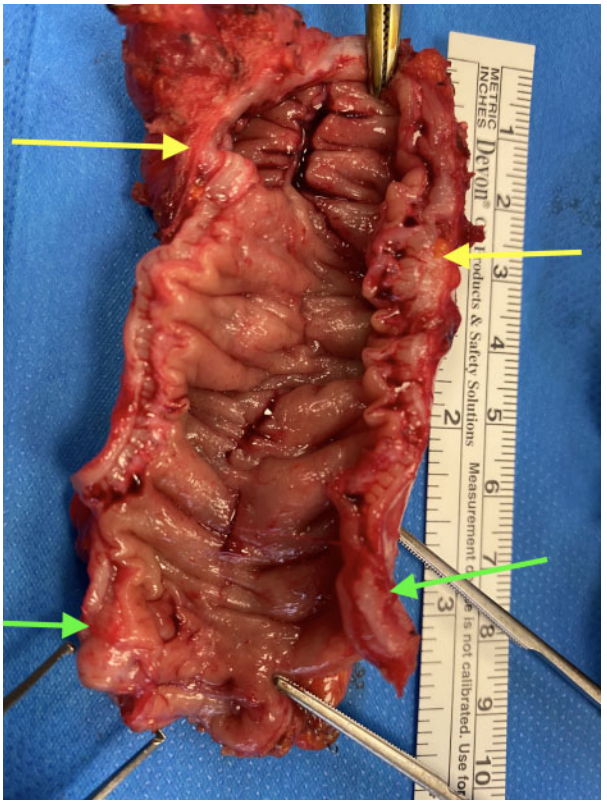

Figure 3. Open colorectal section with main and satellite nodules. After cutting the specimen, the larger nodule is marked with a yellow arrow, and the nonvisualized palpable satellite nodule marked with a green arrow. The larger nodule was 35 × 15 × 5 mm, and the nonvisualized palpable satellite nodule 5 × 5 × 5 mm.

Discussion

Main findings

We report an observational study in patients managed by laparoscopic-assisted segmental resection for deeply infiltrating endometriosis of the rectum, sigmoid or ileum in which the specimen was extracted through a suprapubic incision. During the extraperitoneal evisceration of the bowel, the surgeon could palpate the bowel and identified nonvisualized palpable satellite endometriotic nodules, ranging from 2 mm to 1 cm, infiltrating the bowel wall in 25.5% of patients, with 10% of patients with lesions of the large bowel and 28.6% patients with lesions of the ileum having nonvisualized palpable satellite lesions at or beyond the planned staple site. These nonvisualized palpable satellite nodules were within the muscularis and caused no recognized distortion of the serosal surfaces.

Strengths

There are several strengths to this study. Patients were enrolled in a prospective cohort and benefited from a detailed recording of data. All care was provided at a single tertiary care center. The surgery was performed by two experienced surgeons, who have cumulatively performed more than 1300 colorectal endometriosis procedures. In addition, data were recorded by a dedicated research technician, lending support to the accuracy and validity of our results. Finally, all procedures were standardized to facilitate extrapolation to other teams who employ the same surgical approaches.

Weaknesses

There are several limitations to the present study. First, a risk-benefit assessment will require a randomized prospective trial. Second, some residual lesions do not become symptomatic (Moen and Stokstad, 2002; Koninckx *et al.*, 2019). Third, the number of patients in our study is relatively small; therefore, additional studies are needed to determine the true proportion of nonvisualized palpable satellite endometriotic nodules. Fourth, distal colonic satellite lesions were not analyzed as there were no modifications to the standard of care placement of the distal stapler, as that would have required a change in the size of the incision. Fifth, this study was only on patients undergoing laparoscopic-assisted segmental resection; it does not identify lesions in patients who had shaving or disk resection or in whom no bowel lesions were identified on imaging or visualization at laparoscopy. Sixth, this study did not investigate the use of hand-assisted laparoscopy or

Table II Intraoperative findings, surgical procedures and immediate postoperative complications.

	Group A N = 38 (74.5%)	Group B N = 13 (25.5%)	P
Operative time (min)	120 (90; 160)	118 (100; 140)	0.86
Intraoperative findings			
Deep endometriosis nodule location			
Left USL	1 (2.6)	2 (15.4)	
Right USL	3 (7.9)	1 (7.7)	1
Rectovaginal space	5 (13.2)	2 (15.4)	0.20
Both USL and rectovaginal space	30 (78.9)	10 (76.9)	0.12
rASRM score	67 (46; 110)	50 (42; 86)	0.37
Endometriomas of the right ovary			0.34
No	22 (57.9)	11 (84.6)	
<1 cm	3 (7.9)	1 (7.7)	
1–3 cm	6 (15.8)	1 (7.7)	
>3 cm	7 (18.4)	0	
Endometriomas of the left ovary			0.95
No	21 (55.3)	6 (46.2)	
<1 cm	3 (7.9)	1 (7.7)	
1–3 cm	8 (21.1)	4 (30.8)	
>3 cm	6 (15.8)	2 (15.4)	
Douglas obliteration			0.54
No	4 (10.5)	2 (15.4)	
Partial	7 (18.4)	4 (30.8)	
Complete	27 (71.1)	26 (53.9)	
Digestive tract infiltration			
Sigmoid colon	23 (60.5)	11 (84.6)	0.17
Rectum	37 (97.4)	11 (84.6)	0.16
Ileum	10 (26.3)	5 (38.5)	0.49
Appendix	10 (26.3)	4 (30.8)	0.73
Vaginal infiltration			1
No	24 (63.2)	9 (69.2)	
<1 cm	1 (2.6)	0	
1–3 cm	2 (5.2)	0	
>3 cm	11 (29)	4 (30.8)	
Bladder infiltration	2 (5.2)	3 (23.1)	0.10
Adenomyosis	25 (658)	8 (61.5)	1
Diaphragmatic location	5 (13.2)	2 (15.4)	1
Number of nodules involving the digestive tract			0.30
1	9 (23.7)	1 (7.7)	
2	12 (31.6)	3 (23.1)	
3	12 (31.6)	4 (30.8)	
4	2 (5.3)	3 (23.1)	
5	1 (2.6)	1 (7.7)	
6	1 (2.6)	1 (7.7)	
7	1 (2.6)	0	
Digestive tract surgical procedures			
Procedures on the rectosigmoid*			
Rectal shaving	2 (5.3)	1 (7.7)	1
Rectal disk excision	5 (13.2)	2 (15.4)	1
Segmental resection	37 (97.4)	13 (100)	1
Diverting stoma			0.45
No ileostomy	38 (97.4)	12 (92.3)	
Ileostomy	1 (2.6)	1 (7.7)	
Ileocolic resection	4 (10.5)	5 (38.5)	0.04
Resection of the cecum	2 (5.3)	0	1
Segmental resection of the ileum	4 (10.5)	0	0.56
Isolated appendectomy	7 (18.4)	0	0.17
Other surgical procedures			
Hysterectomy			0.49
No	32 (84.2)	13 (100)	
Total hysterectomy	1 (2.6)	0	
Total hysterectomy with extended colpectomy	5 (13.2)	0	
Excision of the parametrium	4 (10.5)	0	0.56
Including dissection/excision of endometriosis lesions on the sacral roots/sciatic nerve	1 (2.6)	0	1
Surgical procedures on urinary tract			
Bladder resection	1 (2.6)	0	1
Ureterolysis for ureter stenosis	4 (10.5)	1 (7.7)	1
Intraoperative JJ stent insertion	2 (5.3)	1 (7.7)	1
Intraoperative complications			
Ureteral transection	1 (2.6)	0	1
Second segmental resection needed for rectorrhagia originating from the stapled line	0	1 (7.7)	0.26
Immediate postoperative complications	7 (18.4)	2 (15.4)	1
Digestive tract fistula	1 (2.3)	1 (7.7)	1
Pelvic abscess requiring a second surgery	1 (2.3)	1 (7.7)	1
Pelvic abscess managed by antibiotics	15 (39.5)	1 (6.2)	0.42
Dysuria requiring self-catheterization after postoperative Day 7	2 (5.3)	0	1
Second segmental resection needed for rectorrhagia originating from the stapled line	1 (2.6)	0	1

Data are reported as either the Median (Quartile1; Quartile3) or N (%). Fisher's exact test was used to compare categorical variables, and the Kruskal–Wallis test was used to compare continuous variables.

*Rectal disk excision was conducted in conjunction with segmental resection of the sigmoid colon in 4 (10.5%) cases in Group A and 2 (15.4%) cases in Group B.

USL, uterosacral ligament; rASRM, revised American Society for Reproductive Medicine.

Table III Bowel nodules seen and not seen during laparoscopy.

	Group A N = 38 (74.5%) Median (Q1; Q3)	Group B N = 13(25.5%) Median (Q1; Q3) (min–max)	P
Rectosigmoid segmental resection	36 (94.7)	13 (100)	1
Length (mm)	85 (70; 100)(60-170)	90 (80; 110) (60–200)	0.27
Number of nodules seen in laparoscopy	2 (1; 3)(1-5)	2 (1; 2) (1–4)	0.95
Distal limit from the most distal nodule seen in laparoscopy (mm)	10 (5; 10)(5-20)	10 (10; 10) (5–10)	0.84
Proximal limit to the most proximal nodule seen in laparoscopy (mm)	10 (10; 12.5)(5-30)	20 (15; 45) (5–50)	0.001*
Nodules not seen in laparoscopy but identified by palpation	–	11 (84.6%)	
Number of nodules not seen in laparoscopy	–	1 (1; 1)	
Size of the largest nodule (mm)	–	5 (5; 6) (3–10)	
Size of the smallest nodule, if >1 nodule (mm)	–	3.5 (2; 5) (2–5)	
Maximum distance from the proximal limit of the most proximal visualized nodule to the most proximal nodule not seen in laparoscopy (mm)		15 (15; 35) (3–45)	
Segmental resection of the ileum	9 (23.7)	5 (38.5)	0.31
Associated cecum resection	4 (10.5)	5 (38.5)	0.10
Length of the ileum (mm)	100 (60; 150)(20-300)	60 (40; 220) (40–300)	0.84
Number of nodules of the ileum seen in laparoscopy	2 (1; 3)(1-4)	1 (1; 1) (0–7)	0.28
Proximal limit to the most proximal nodule seen in laparoscopy (mm)	5 (5; 10)(2-30)	12.5 (10; 27.5) (10–40)	0.04**
Distal limit from the most distal nodule seen in laparoscopy (mm) (N = 1)		10	
Nodules not seen in laparoscopy but identified by palpation	–	5 (38.5)	
Number of nodules not seen in laparoscopy		1 (1; 3) (1–5)	
Size of the largest nodule (mm)		5 (5; 5) (3–10)	
Maximum distance from the proximal limit of the most proximal visualized nodule to the most proximal nodule not seen in laparoscopy (mm)		25 (20; 60) (15–60)	
Maximum distance from the distal limit of the most distal visualized nodule to the most distal nodule not seen in laparoscopy (mm) (N = 1)		15	

Fisher's exact test was used to compare categorical variables, and the Kruskal–Wallis test was used to compare continuous variables.
*Identification of nonvisualized nodules increases the length of the segment by 1 cm (median value).
**Identification of nonvisualized nodules increases the length of the ileum by 1 cm (median value).

rectal probes for the identification of nonvisualized lesions; those techniques may be useful. Last, the level of the current use among surgeons of palpation for recognition of small lesions is unknown.

Clinical significance

The standard of care for symptomatic bowel endometriosis includes laparoscopy (Abrao *et al.*, 2015; Roman *et al.*, 2016; Vercellini *et al.*, 2020), laparotomy (Weed and Ray, 1987; Moore *et al.*, 1988; Martin, 1991; Bailey *et al.*, 1994; Roman and FRIENDS group (French coloRectal Infiltrating ENDometriosis Study group), 2017), segmental resection, disk resection, shaving and intentional incomplete resection. Intentional incomplete resection is used in circumstances such as inadequate preoperative preparations, preservation of the uterus and dissection to avoid endometriosis/adenomyosis in the posterior cervix where cervical incompetence and uterine rupture are concerns (Martin, 1988; Carmona *et al.*, 2009; Ziadeh *et al.*, 2020). Laparoscopy appears best for visualization while laparotomy is better for palpation (Weed and Ray, 1987; Moore *et al.*, 1988; Martin, 1991; Bailey *et al.*, 1994). In one multicenter study, different centers preferentially used laparotomy or laparoscopy (Roman and FRIENDS group (French coloRectal Infiltrating ENDometriosis Study group), 2017).

The clinical significance of nonvisualized palpable satellite bowel lesions as small as 2 mm at or beyond the planned stapler line in 10% patients with lesions of the large bowel and 28.6% of patients with lesions of the ileum and of similar small lesions reported in the literature needs clarification. Although the recurrence rates are low for all patients, at 1–16% after laparoscopic bowel resection for endometriosis, recurrence is higher at 38.5% and 7% of the 16% and 14.6% of women with histologically positive resection margins in Nirgianakis *et al.* (2014) and Roman *et al.* (2016), respectively. That suggests that some women with endometriosis severe enough to require resection may benefit from a decrease in positive margins. Furthermore, women having other laparoscopic procedures might benefit from increased recognition and removal of identifiable endometriotic nodules. Long-term follow-up is needed. Nirgianakis *et al.* (2014) reported postoperative recurrence as late as 90 months while Roman *et al.* (2016) reported a recurrence at 4.7 years. One author (D.C.M.) has discovered recurrences at 7–10 years after excision (unpublished data).

Surgical approach

Currently, laparoscopy and laparotomy are standard of care, with some centers in multicenter studies preferring one over the other (Martin, 1991; Bailey *et al.*, 1994; Roman and FRIENDS group (French coloRectal Infiltrating ENDometriosis Study group), 2017). A low reoperation rate for bowel lesions after laparoscopic resection argues against the need for palpation as an initial approach (Redwine and Hopton, 2018; Roman *et al.*, 2018). This is supported by the observation that there were no significant differences in postoperative digestive symptoms between patients randomized to either conservative rectal surgery or colorectal resection (Roman *et al.*, 2018). Also, in those women managed by shaving or disk excision, in whom some small nonvisualized palpable satellite nodules were likely to be overlooked, only one recurrence was recorded during a 5-year postoperative follow-up (Roman *et al.*, 2018). However, if the specimen is extracted through a small suprapubic incision, then palpation of the bowel and adding an additional 15 mm (range 15–35 mm) of large bowel and 40 mm (range 15–60 mm) of small bowel to remove of nonvisualized palpable satellite nodules appears prudent.

Although the risk of significant symptomatic recurrence in the bowel may be low (Redwine and Hopton, 2018; Roman *et al.*, 2018), the persistence of unrecognized endometriosis may, in theory, be responsible for the persistence or subsequent recurrence of gastrointestinal symptoms, pain and psychological distress, necessitating additional supportive, medical or surgical care (Martin and Ling, 1999; Roman *et al.*, 2016). If a physician is unaware of the possibility that small, unrecognized, but potentially recognizable satellites can be the cause, then they do not know that looking for these is an option and cannot inform the patient of that possibility. However, the presence of endometriosis in these women does not mean that they will become symptomatic (Moen and Stokstad, 2002). Patients may have regressive or stable rather than progressive disease; extensive surgery is not always indicated (Evers, 2013; Abrao *et al.*, 2015; Badescu *et al.*, 2018; Redwine and Hopton, 2018).

The surgical management of bowel endometriosis involves consideration of the surgical approach and extent of surgery (Abrao *et al.*, 2015; Roman *et al.*, 2018; Vercellini *et al.*, 2020), the risk of low anterior resection syndrome (Riiskjaer *et al.*, 2016), the risk of bowel stenosis (Bertocchi *et al.*, 2019; Roman *et al.*, 2019; Braund *et al.*, 2020), the potential presence of laparoscopically nonvisualized palpable satellite lesions (Weed and Ray, 1987; Moore *et al.*, 1988; Martin, 1991), the potential presence of occult microscopic endometriosis (Badescu *et al.*, 2016, 2018; Roman *et al.*, 2016), surgical morbidities (Riiskjaer *et al.*, 2016; Abo *et al.*, 2018) and the expectations and informed choice of patients (Gillon, 2003). Some studies have concluded that segmental bowel resection may not be routinely justified in patients without a malignancy because the rate of significant postoperative complications can be notable even in the hands of experienced surgeons (Remorgida *et al.*, 2007; Roman *et al.*, 2010, 2018; Abrao *et al.*, 2015; Bertocchi *et al.*, 2019; Braund *et al.*, 2020; Vercellini *et al.*, 2020).

Imaging

One question is whether appropriate imaging can equal palpation of small lesions. In practice, imaging has limited sensitivity for identifying the small lesions examined in this study. Rousset *et al.* (2014), using MR enterography, found that the mean length of deep infiltrating endometriotic bowel lesions was 28 mm, and the minimal lesion size that could be identified was 10 mm. At present, MRI has limited use in recognizing many of the small lesions noted in this study.

Other concerns

In patients with persistent or recurrent symptoms suggesting bowel involvement, a second surgical procedure, such as laparotomy or hand-assisted laparoscopy for the palpation of large and small bowel as well as the mesentery, appendix and retroperitoneum, can reasonably be discussed with the goals of complete removal of recognized small nodules. Long-term follow-up of a large sample of women enrolled in a 2-arm study that compares removal versus observation of small nonvisualized palpable satellite nodules is necessary to determine whether the resection of both visualized and nonvisualized palpable satellite nodules results in better functional outcomes.

If palpation is determined to be needed for the adequate care of a significant number of patients, then this will be a concern at minimally invasive approaches. For routine laparoscopy, palpation with a probe or grasper provides tactile feedback, and the degree of force can be determined manually. The sensitivity of laparoscopic probes or graspers and rectal probes compared with manual palpation needs investigation. Hand-assisted laparoscopic robotic surgery may provide a more adequate assessment (Akin *et al.*, 2019).

Another technique used to visualize otherwise unrecognized lesions is the use of a rectal probe to stretch the bowel surface. A 29-mm rectal probe in the bowel can be used to elevate and stretch the bowel to help identify small nodules (Reich *et al.*, 1991; Arrington, 2020). Other techniques, such as hand-assisted laparoscopy for palpation through a small suprapubic incision during resection, require investigation. As palpation of the distal segment was not feasible in our protocol, a rectal probe or hand-assisted laparoscopy may have improved our recognition.

Conclusion

Although the clinical significance needs clarification, nonvisualized palpable satellite endometriotic bowel nodules as small as 2 mm can be recognized using palpation and resected. A focused awareness that 2-mm lesions are palpable can result in increased recognition in some bowel and retroperitoneal cases. Until markers can clarify which lesion or peripheral areas cause symptoms, the resection of all recognized lesions that are reasonable to resect appears prudent.

This increased recognition adds a new level of concern for the surgeons involved in the management of bowel endometriosis, as it suggests that some women with no visible lesions may have symptomatic bowel disease. The use of palpation may add to preoperative consent information for primary surgery and suggests that the use of laparotomy or other techniques for recognition is a consideration for repeat surgery, particularly if laparotomy was not used at the first surgery.

Further study is needed to confirm or expand these findings and determine if there is an association of small lesions with postoperative residual bowel symptoms or recurrent bowel surgery. Other techniques, such as a rectal probe to stretch the sigmoid to push lesions to the

surface and hand-assisted laparoscopy for palpation through a small suprapubic incision during laparoscopic resection, require investigation.

Data availability

The data underlying this article will be shared on reasonable request to the corresponding author.

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Authors' roles

All authors have made substantial contributions to the concept, design of the work, acquisition, analysis or interpretation of data; made substantial contributions to drafting or critically revising the work; and provided final approval and agreed to be accountable for all aspects of the work.

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Conflict of interest

H.R. reports receiving personal fees from Plasma Surgical Inc., Ethicon Endosurgery, Olympus and Nordic Pharma for presentations related to his experience with endometriosis surgery. D.C.M. reports being given access to Lumenis Surgical CO_2 Lasers' lab at a meeting. None of the other authors have conflicts of interest to disclose.

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