Multidetector computerized tomography enteroclysis vs. rectal water contrast transvaginal ultrasonography in determining the presence and extent of bowel endometriosis

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ABSTRACT

Objectives *To compare the accuracy of multidetector computerized tomography enteroclysis (MDCT-e) and rectal water contrast transvaginal ultrasonography (RWC-TVS) in determining the presence and extent of bowel endometriosis.*

Methods *This prospective study included 96 patients of reproductive age with suspicion of bowel endometriosis. Patients underwent MDCT-e and RWC-TVS before operative laparoscopy. Findings of MDCT-e and RWC-TVS were compared with histological results. The severity of pain experienced during MDCT-e and RWC-TVS was measured by a 10-cm visual analog scale.*

Results *Fifty-one patients had bowel endometriotic nodules at surgery. Sensitivity, specificity, positive predictive value, negative predictive value and accuracy for the diagnosis of rectosigmoid endometriosis were 95.8% (46/48), 100.0% (48/48), 100.0% (46/46), 96.0% (48/50) and 97.9% (94/96) for MDCT-e and 93.8% (45/48), 97.9% (47/48), 97.8% (45/46), 94.0% (47/50) and 95.8% (92/96) for RWC-TVS. MDCT-e was associated with more intense pain than was RWC-TVS.*

Conclusions *MDCT-e and RWC-TVS have similar accuracy in the diagnosis of rectosigmoid endometriosis, but patients tolerate RWC-TVS better than they do MDCT-e. Copyright © 2011 ISUOG. Published by John Wiley & Sons, Ltd.*

INTRODUCTION

Bowel endometriosis affects between 4 and 37% of patients with endometriosis[1]. Intestinal endometriotic lesions may have variable size. Small endometriotic nodules located on the serosal surface of the bowel rarely cause symptoms and, therefore, do not require treatment[2]. Larger endometriotic nodules infiltrate the bowel wall and may cause various gastrointestinal complaints such as dyschezia, diarrhea, constipation, abdominal bloating and intestinal cramping[1,3]. These symptoms may mimic irritable bowel syndrome (both in the form of diarrhea-predominant and constipation-predominant irritable bowel syndrome)[4,5]. Over the last 10 years, several studies have shown that surgical excision of bowel endometriotic nodules by either nodulectomy or segmental bowel resection significantly improves pain, intestinal symptoms and quality of life[6–11].

Symptoms caused by bowel endometriosis are non-specific[12], often resulting in misdiagnosis or delay in diagnosis. Physical examination may suggest the presence of rectovaginal endometriosis; however, it has poor accuracy in diagnosing rectosigmoid nodules[13,14].

A preoperative diagnosis of the presence and extent of bowel endometriosis is necessary to determine whether surgery is required and to plan the surgical procedure with the colorectal surgeon. Knowing before surgery the size and number of intestinal endometriotic nodules, the depth of infiltration of the nodules in the intestinal wall and the degree of stenosis of the bowel lumen allows determining whether surgery is required and may allow

ORIGINAL PAPER

the surgeons to choose between nodulectomy (partial or full thickness) and bowel segmental resection[1]. Until recently there has been no universally accepted criterion for choosing one or other of the two techniques; therefore, when surgery is required personal experience and opinion often influence the decision to perform bowel segmental resection or nodulectomy[15,16]. However, some surgeons choose bowel resection only in cases of either a single lesion > 3 cm in diameter, a single lesion infiltrating at least 50% of the circumference of the intestinal wall or three or more lesions infiltrating the muscular layer[2,17].

In addition, determining before surgery the extent of bowel endometriosis (and therefore the type of surgical treatment needed) allows the surgeon to inform the patient about the potential benefits and complications of the surgical procedure that will be performed. In fact, postoperative complications and evolution of digestive symptoms after surgery may differ between patients undergoing nodulectomy and those undergoing segmental resection, with a higher incidence of bladder-voiding dysfunction and postoperative constipation in patients undergoing the latter procedure[18,19].

It is well known that transvaginal ultrasonography (TVS) is the imaging method of choice for diagnosing ovarian endometriomas[20,21] and it has also been used for the diagnosis of deep endometriosis[22]. The objective of the current prospective study was to compare the accuracy of multidetector computerized tomography enteroclysis (MDCT-e) and rectal water contrast transvaginal ultrasonography (RWC-TVS) in determining the presence and extent of bowel endometriosis.

METHODS

Study population

Subjects were recruited for the study from patients referred to our endometriosis center between January 2008 and November 2009. Inclusion criteria for the study were: suspicion of deep pelvic endometriosis (on the basis of gynecological symptoms and vaginal examination); presence of gastrointestinal symptoms that might be caused by bowel endometriosis; reproductive age; and desire to undergo complete surgical excision of the endometriosis. Exclusion criteria were: previous bilateral ovariectomy; previous barium radiological examination or other examination for the diagnosis of bowel endometriosis; previous bowel surgery (except appendectomy); previous episodes suggestive of intolerance to iodinated contrast medium; renal or hepatic failure; and psychiatric disorders.

The presence of dysmenorrhea, deep dyspareunia, chronic pelvic pain and dyschezia was investigated and the intensity of their symptoms was assessed in all patients on a 10-cm visual analog scale (VAS), on which the left extremity represented absence of pain and the right extremity indicated maximum intensity of pain. The presence of the following gastrointestinal symptoms was assessed: diarrhea-predominant irritable bowel

syndrome; constipation-predominant irritable bowel syndrome; intestinal cramping; abdominal bloating; passage of mucus in the stools; and rectal bleeding. A symptom analog scale questionnaire – in which 1 indicates the absence of the symptom and 10 indicates the highest severity of the symptom – was used to estimate the severity of each of these symptoms, as previously described[23].

MDCT-e and RWC-TVS were independently and blindly performed by different investigators. The radiologists (E.B. and G.A.R.) and the ultrasonographers (S.F. and M.V.M.) were blinded to the clinical data and knew only that the presence of intestinal endometriosis was suspected. All patients underwent laparoscopy within 1 month from the completion of the diagnostic investigations.

Intestinal endometriosis was defined as the disease infiltrating at least the muscularis propria, as previously suggested by other authors[24,25] and by us[1]. Endometriotic foci located on the bowel serosa were considered peritoneal and not bowel endometriosis.

The findings of MDCT-e and RWC-TVS were compared with histological results, which were considered the gold standard. In particular, the study determined the accuracy of the imaging techniques in: assessing the presence of bowel endometriosis; estimating the size of rectosigmoid endometriotic nodules; estimating the number of intestinal endometriotic nodules with diameter > 1 cm per patient; and determining the presence of peritoneal endometriosis infiltrating only the intestinal serosa.

The study was approved by the local institutional review board and all patients participating in the study signed a written consent form.

Multidetector computerized tomography enteroclysis technique

MDCT-e was performed as previously described[26,27]. Patients were prepared by use of a low-residue diet for 3 days before the examination, and a laxative isosmolar nonabsorbable solution (Isocolan, Bracco, Milan, Italy) was administered orally (dose proportional to the patient's weight) on the day before the examination. Retrograde colonic distension was performed by introducing about 2000 mL of water (at 37°C). During the procedure pharmacological inhibition of peristaltic waves was obtained by intravenous injection of hyoscine butylbromide (Buscopan; Boehringer Ingelheim, Florence, Italy). Patients were examined with a 16-row MDCT scanner (LightSpeed, GE Medical Systems, Waukesha, WI, USA). The scan parameters were: 16×0.625 mm collimation, rotation time 0.6 s, tube voltage 120 kV; maximum mA peak was 370 mA. Patients were scanned in the supine position; a volumetric acquisition was performed from the dome of the diaphragm to the pubic symphysis, in portal phase (40 s after the arterial peak) after the injection of the intravenous contrast medium (iopamidol; Iopamiro, Bracco, Milan, Italy). The injection rate was

set at 2.5 mL/s with an automatic power injector. Bolus-tracking software (Smart-Prep, GE Medical Systems) was used to maximize the quality of MDCT images. The estimated radiation exposure during this scanning protocol – which was between 12 and 14 mGy in all cases – was evaluated by the computerized tomography dose index, which was automatically calculated by the scanner.

Multiplanar reconstructions were performed in all cases. The MDCT-e criterion to diagnose bowel endometriosis was the presence of solid nodules with positive enhancement, contiguous or penetrating the thickened intestinal wall (Figure 1). Involvement of the serosa was characterized by the presence of a nodule with an irregular profile adjacent to the bowel loop; in these cases, a hypodense layer (which separates the serosa from the lesion) was observed. Full thickness infiltration of the muscularis was diagnosed when the endometriotic lesion reached the bowel mucosa. In some patients, a pathological multilayered appearance of the bowel wall was observed in case of endometriotic infiltration. The submucosa may sometimes appear as a hypodense layer located between the muscularis and the mucosa (Figure 2).

Rectal water contrast transvaginal ultrasonography technique

Two physicians (S.F. and M.V.M.) performed all the examinations according to a standardized procedure, as previously described[28,29]. Three days before the examination patients were put on a low-fiber diet (daily fiber intake less than 10 g), as described elsewhere[30]. They had a rectal enema (120 mL of sodium diphosphate) within a few hours before the procedure to eliminate any fecal residue present in the rectosigmoid colon. Each
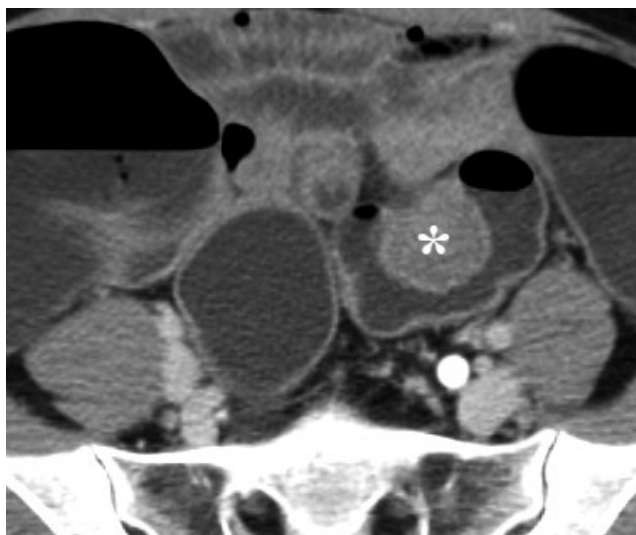

Figure 1 Axial multidetector computerized tomography enteroclysis image showing a nodule infiltrating the intestinal wall from the serosa towards the mucosa, while the mucosa (thin layer toward the lumen) is not infiltrated. Histology confirmed the absence of mucosal infiltration. The asterisk indicates an endometriotic nodule infiltrating the sigmoid colon.

Figure 2 Multidetector computerized tomography enteroclysis of a sigmoid endometriotic nodule (arrow) in a coronal reconstruction, showing the hypodense submucosa and the well-enhanced mucosa that separates the nodule from the lumen (arrowheads), which is not infiltrated. Histology confirmed that the infiltration reached the submucosa and that the mucosa was healthy.

examination was interpreted in real time and documented with images saved as Tif files.

The examinations were performed using a Siemens Sonoline Antares ultrasound machine (Siemens Medical, Erlangen, Germany) and a Voluson i ultrasound machine (GE Healthcare Ultrasound, Milwaukee, WI, USA) connected to transvaginal transducers. After the transducer had been introduced into the vagina, an assistant inserted a 6-mm (18 Ch) flexible catheter through the anal os into the rectal lumen up to a 20-cm distance from the anus. A gel infused with lidocaine (Luan, Molteni & C., Scandicci, Italy) was used to facilitate passage of the catheter. A 50-mL syringe was connected to the catheter and warm sterile saline solution was injected inside the rectum and the sigmoid under ultrasonographic control. The amount of saline solution needed to show the rectosigmoid ranged between 100 and 350 mL, depending on the distensibility of the intestinal wall. One hundred milliliters of saline solution were continuously and slowly infused at the beginning of the procedure; the rest of the solution was infused when requested by the ultrasonographer. During ultrasonography, when saline solution was not being infused, backflow through the catheter was prevented by placing a Klemmer forceps on the catheter. There was no significant leakage of saline solution into the space between the catheter and the anus. Images were obtained before, during and after saline injection.

Bowel endometriosis appears ultrasonographically as a nodular, solid, hypoechoic lesion, adjacent to and/or penetrating the intestinal wall. Hyperechoic foci may sometimes be present within the lesion. Intestinal distension allows defining the limits of the intestinal nodules and in particular the various layers of the

rectal wall in order to estimate the depth of infiltration. The intestinal serosa is hyperechoic; the two layers of the muscularis propria appear as hypoechoic strips separated by a fine hyperechoic line; the submucosa is hyperechoic; the muscularis mucosa is hypoechoic and the interface between the lumen and the mucosal layer is hyperechoic (Figure 3)[25]. Rectal endometriotic infiltration is demonstrated by the fact that the hypoechoic nodule penetrates the intestinal wall and, in general, it thickens the muscularis mucosa (Figures 4 and 5).

Tolerability of the examinations

Immediately after each examination patients were asked to rate the discomfort encountered during MDCT-e and RWC-TVS by means of a 10-cm VAS, a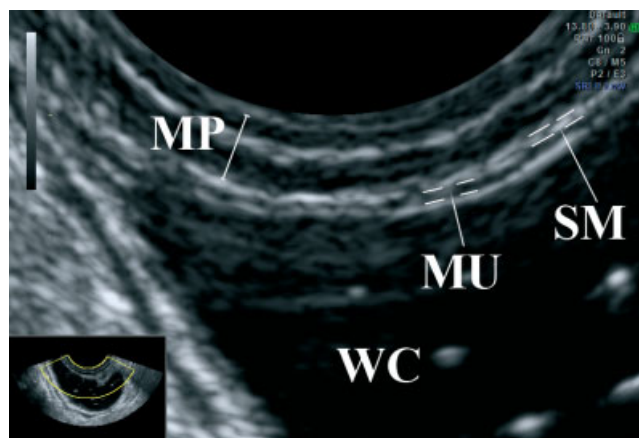s mentioned above; mild pain was defined as a VAS score of < 2, moderate pain as a VAS score ≥ 2 and ≤ 5 and severe pain as a VAS score > 5.

Figure 3 Rectal water contrast transvaginal ultrasonographic image showing normal rectal wall; the various layers can be recognized easily: muscularis propria (MP), submucosa (SM) and mucosa (MU). The rectum is dilated by saline solution (WC).

Figure 4 Rectal water contrast transvaginal ultrasonographic image showing a rectal endometriotic nodule thickening the muscularis mucosa (asterisk). The rectal lumen is distended by saline solution (WC).
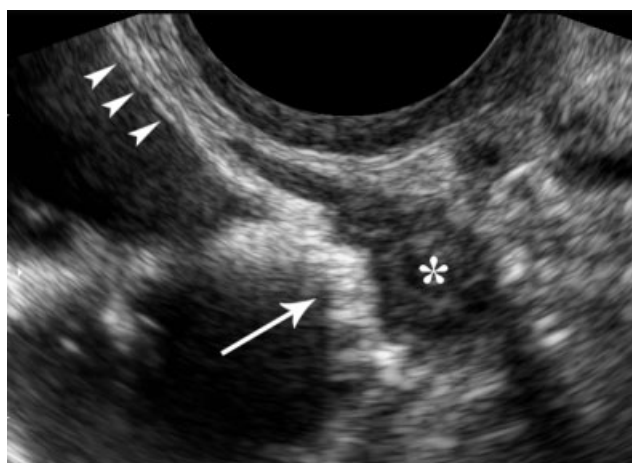

Figure 5 Rectal water contrast transvaginal ultrasonographic image showing a rectal endometriotic nodule (asterisk) with largest longitudinal diameter of 2.4 cm infiltrating the intestinal submucosa. The various layers of the intestinal wall can be observed in the healthy rectum (arrowheads) but they cannot be identified where the endometriotic nodule infiltrates the rectum (arrow).

Surgical technique and histological evaluation

Before laparoscopy the surgeons examined the reports and the images of both MDCT-e and RWC-TVS. Although the surgeons considered the imaging findings, the final decision on the type of surgical procedure (nodulectomy or bowel resection) was based on laparoscopic findings. All surgical procedures were performed laparoscopically by a team of gynecological and colorectal surgeons with extensive experience in the treatment of pelvic and bowel endometriosis. In all cases, after adequate adhesiolysis, the sigmoid colon and rectum were systematically examined to verify the presence of endometriotic lesions. Bowel endometriotic lesions were removed by intestinal resection in cases of a single lesion > 3 cm in diameter, a single lesion infiltrating at least 50% of the circumference of the intestinal wall or three or more lesions infiltrating the muscular layer[2]. In all other cases of bowel endometriosis partial- or full-thickness disk resection was performed. Nodulectomy was performed as previously described[1,17]. Briefly, the serosa around the nodule was cut, leaving ≥ 1 cm of macroscopically normal tissue. After the first incision the nodule was removed following the 'cleavage plane' until the surgeons were satisfied with the completeness of nodulectomy. Intestinal lesions infiltrating only the serosal layer of the bowel wall were excised by shaving. All visible lesions suspected to be endometriotic (except those on the diaphragm) were excised and sent for histological examination in agreement with our clinical protocol.

The same pathologist histologically evaluated all specimens excised at surgery. The pathologist measured the diameter of the intestinal endometriotic nodules immediately after surgery before the specimens were fixed in 4% formaldehyde for 12 h and then embedded in paraffin. The depth of infiltration of the endometriotic nodules in the bowel wall was determined in a

standardized fashion as previously described[2,17,26]. In cases of nodulectomy the specimens were macroscopically oriented along the intestinal wall (from the serosa towards the mucosa) and cut into macrosections of 2-mm thickness. From each macrosection tissue blocks of 1.5-cm length were obtained in variable numbers according to the size of the lesion, and from each tissue block a 5-μm section was obtained for microscopical evaluation. In cases of bowel resection the specimen was opened longitudinally through its entire length and 2-mm longitudinal bands of bowel wall, reaching the two resection margins and passing through all macroscopically visible lesions, were cut. These bands were sampled in tissue blocks and 5-μm sections were obtained for microscopic evaluation.

Statistical analysis

Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were determined for both MDCT-e and RWC-TVS. The diagnostic value of each test was also evaluated using positive likelihood ratio (LR+) and negative likelihood ratio (LR−)[31], which were calculated by using the CAT maker software (Oxford Centre for Evidenced-Based Medicine, Oxford, UK). McNemar's test with the Yates continuity correction was used to compare the accuracy of MDCT-e and RWC-TVS in the diagnosis of intestinal endometriosis (accuracy was calculated as (true positive + true negative)/(true positive + false positive + false negative + true negative)). McNemar's test was used to compare the number of patients in which the number of rectosigmoid nodules was correctly identified by MDCT-e and by RWC-TVS. The accuracy of the measurement of nodule size by imaging techniques was estimated by subtracting the size of the nodule as measured by the techniques from the size of the nodule as measured at histology. The Mann–Whitney test was used to compare the intensity of pain experienced by patients during MDCT-e and RWC-TVS, the chi-square test was used to compare the type of pain (mild, moderate or severe) and Spearman's rank correlation coefficient was used to determine whether there was a correlation between the intensity of pain experienced by patients during the two techniques. Data were archived using Excel 2007 (Microsoft, Redmond, WA, USA) and analyzed using Sigma Stat software version 3.5 (SPSS Science, Chicago, IL, USA). $P < 0.05$ was considered statistically significant.

RESULTS

Study population

Ninety-six patients were included in the study and all underwent surgery; Tables 1 and 2 show their demographic characteristics and symptoms. Surgery demonstrated that 51 patients (53.1%) had bowel endometriotic nodules (infiltrating at least the muscular layer of the bowel wall). In addition, nine patients had endometriotic lesions infiltrating the intestinal serosa. The remaining 36 patients had only pelvic endometriosis with no evidence of intestinal lesions. The largest intestinal endometriotic nodule was located on the sigmoid colon in 26 patients, on the rectum in 14 patients, at the rectosigmoid junction in eight patients, on the ileum in two patients and on the cecum in one patient (Figure 6). Endometriotic bowel nodules were excised by partial-thickness nodulectomy in three cases and by segmental bowel resection in 48 cases. The endometriotic lesions infiltrating only the intestinal serosa were located on the sigmoid colon in six cases, on the rectum in two cases and at the rectosigmoid junction in one case. The mean length of the resected bowel segment was 11.9 ± 4.6 cm. Histological examination confirmed the diagnosis of endometriosis in all the nodules excised at surgery; furthermore, it demonstrated that the deepest

Table 1 Characteristics of the study population ($n = 96$)

Characteristic	Value
Age (years)	33.4 ± 5.2
Body mass index (kg/m^2)	23.1 ± 2.6
Previous surgery for endometriosis	39 (40.6)
Number of previous surgical procedures for endometriosis*	1 (1–4)
Patients with previous live births	27 (28.1)
Number of previous live births†	1 (1–2)
Hormonal therapy at time of study	
None	62 (64.6)
Sequential oral contraceptive	18 (18.8)
Norethisterone acetate	7 (7.3)
Continuous oral contraceptive	3 (3.1)
Norethisterone acetate and letrozole	3 (3.1)
Gonadotropin-releasing hormone analog	3 (3.1)

*Data given as mean ± SD, *n* (%) or median range. Only patients who underwent previous surgery for endometriosis. †Only patients with previous live births.

Table 2 Symptoms of the study population ($n = 96$)

Symptom	n (%)*	Intensity (mean ± SD)†
Dysmenorrhea‡	72/80 (90.0)	7.4 ± 1.7
Deep dyspareunia§	49/89 (55.1)	5.7 ± 1.9
Chronic pelvic pain	61 (63.5)	5.8 ± 1.6
Dyschezia	39 (40.6)	4.9 ± 2.1
Infertility	32 (33.3)	N/A
Diarrhea-predominant IBS	28 (29.2)	7.4 ± 2.6
Constipation-predominant IBS	39 (40.6)	7.7 ± 1.5
Intestinal cramping	40 (41.7)	7.1 ± 2.0
Abdominal bloating	53 (55.2)	6.2 ± 2.6
Mucus in the stools	13 (13.5)	5.8 ± 1.6
Rectal bleeding	2 (2.1)	6.5 ± 1.2

*Sometimes there was more than one symptom for the same patient. †Intensity of pain symptoms assessed on a 10-cm visual analog scale; severity of gastrointestinal symptoms estimated by using a symptom analog scale questionnaire (1, absence of symptom; 10, highest severity of symptom). ‡Determined for the 80 menstruating patients who were not using continuous hormonal therapies. §Determined for the 89 sexually active patients included in the study. IBS, irritable bowel syndrome; N/A, not applicable.

Figure 6 Coronal multidetector computerized tomography enteroclysis image showing a cecal endometriotic nodule (arrow).

endometriotic nodule infiltrated the muscularis propria in 29 patients, the submucosa in 17 and the mucosa in five.

Accuracy of MDCT-e and RWC-TVS in the diagnosis of bowel endometriosis

MDCT-e identified 49 of 51 patients with bowel endometriosis (96.1%). In two patients endometriotic nodules infiltrating the muscularis propria of the rectum were not identified; both these nodules were excised by partial-thickness nodulectomy (largest diameter of the lesions, 16 and 14 mm). RWC-TVS identified 45 of 51 patients with intestinal endometriosis (88.2%). As expected, two ileal lesions and one cecal lesion were not identified. In addition, RWC-TVS did not identify two sigmoid nodules and one rectal nodule infiltrating the muscularis propria; two of these patients had large bilateral endometriotic ovarian cysts, which may have hampered the identification of intestinal nodules. There was one false positive on RWC-TVS – a rectovaginal endometriotic nodule that was judged to infiltrate the muscularis of the rectum. Surgery confirmed the presence of the rectovaginal nodule but did not reveal infiltration of the rectal muscularis. The sensitivity, specificity, PPV, NPV, LR+, LR− and accuracy of the two techniques in the diagnosis of intestinal endometriosis are listed in Table 3, while Figures 7 and 8 show comparative views of the same patient's lesions using the two techniques. McNemar's test demonstrated that the two techniques had similar accuracy in the diagnosis of bowel endometriosis ($P = 0.221$) and in the diagnosis of rectosigmoid endometriosis ($P = 1.000$). Histology demonstrated that endometriosis infiltrated the submucosa or mucosa of the rectosigmoid colon in 22 patients. MDCT-e correctly identified the depth of infiltration in 12 of these patients

Table 3 Diagnostic performance of multidetector computerized tomography enteroclysis (MDCT-e) and rectal water contrast transvaginal ultrasonography (RWC-TVS) in the diagnosis of bowel and rectosigmoid endometriosis

	MDCT-e	*RWC-TVS*
Bowel endometriosis*		
Sensitivity	49/51 (96.1)	45/51 (88.2)
Specificity	45/45 (100.0)	44/45 (97.8)
PPV	49/49 (100.0)	45/46 (97.8)
NPV	45/47 (95.7)	44/50 (88.0)
LR+	—†	39.71
LR−	0.04	0.12
Accuracy	94/96 (97.9)	89/96 (92.7)
Rectosigmoid endometriosis		
Sensitivity	46/48 (95.8)	45/48 (93.8)
Specificity	48/48 (100.0)	47/48 (97.9)
PPV	46/46 (100.0)	45/46 (97.8)
NPV	48/50 (96.0)	47/50 (94.0)
LR+	—†	45.00
LR−	0.04	0.06
Accuracy	94/96 (97.9)	92/96 (95.8)

Data given as *n* (%). *Bowel endometriosis defined as disease infiltrating at least the muscularis propria. †LR+ could not be calculated because there was no false positive. LR+, positive likelihood ratio; LR−, negative likelihood ratio; NPV, negative predictive value; PPV, positive predictive value.

(54.5%), while RWC-TVS correctly identified the depth of infiltration in nine of them (40.9%) ($P = 0.365$). All the other nodules that were seen to infiltrate the submucosa or mucosa at histology were judged to reach only the muscularis at MDCT-e and RWC-TVS. Both techniques had no cases of false-positive diagnosis of submucosal or mucosal infiltration.

Determination of the size and number of bowel endometriotic nodules

Both MDCT-e and RWC-TVS underestimated the size of the endometriotic nodules; however the underestimation was greater for RWC-TVS than for MDCT-e (Table 4). In addition, in both imaging techniques the underestimation was greater for nodules with diameter ≥ 30 mm.

Three patients had isolated intestinal nodules on the ileum and cecum that infiltrated the muscularis; these nodules were not considered in the following analysis because they could not be evaluated by RWC-TVS. With respect to the number of bowel endometriotic nodules in patients with rectosigmoid endometriosis ($n = 48$), a single nodule was present in 26 patients (54.2%), two nodules were present in 15 patients (31.3%), and three or more nodules were present in seven patients (14.6%). A total of 78 nodules were found at histology in the patients with rectosigmoid endometriosis, corresponding to a mean of 1.6 nodules per patient (median, 1 (range, 1–4) nodules).

MDCT-e identified 69 nodules in 48 women with rectosigmoid endometriosis; the median number of nodules per patient with intestinal endometriosis was 1 (range, 1–3). RWC-TVS identified 59 nodules in the study population (one false-positive nodule); the median number of
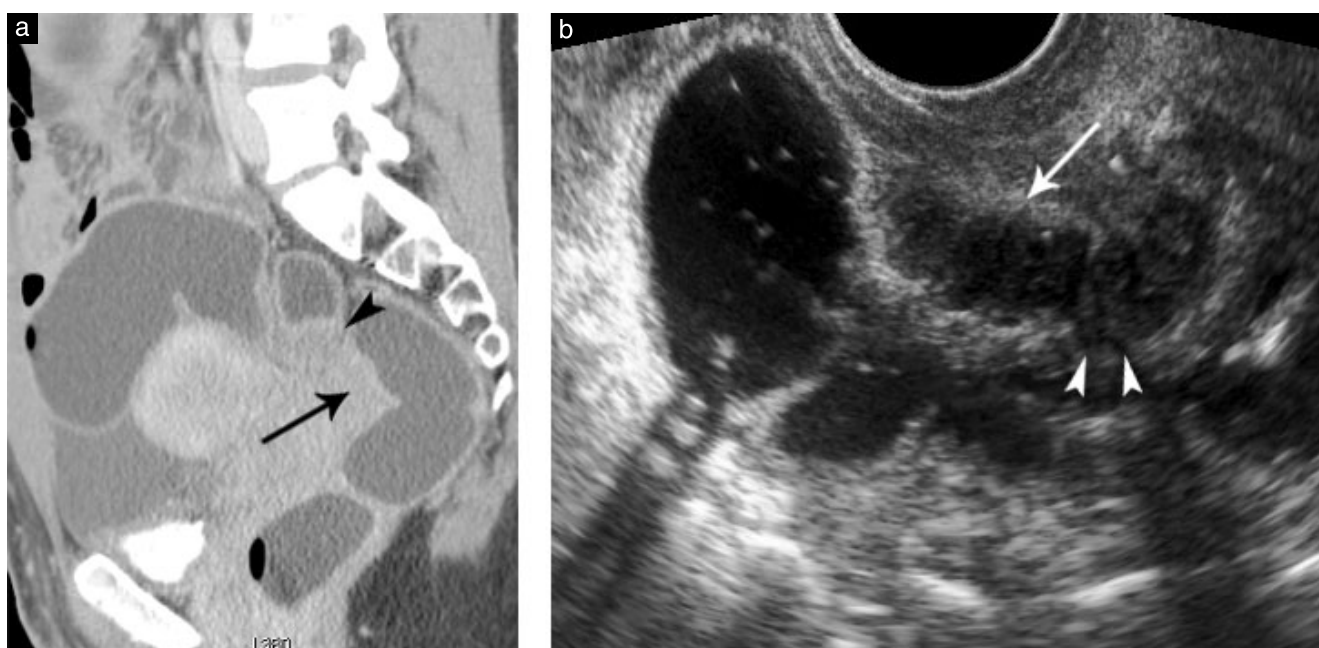
Figure 7 (a) Multidetector computerized tomography enteroclysis (MDCT-e) image and (b) rectal water contrast transvaginal ultrasonography (RWC-TVS) image showing a rectal endometriotic nodule (arrows) infiltrating the submucosal layer that was detected by both techniques. On MDCT-e the continuity of the submucosa (hypodense layer) is disrupted by the nodule (arrowhead). On RWC-TVS the nodule disrupts the continuity of the submucosa (hyperechoic layer, arrowheads).
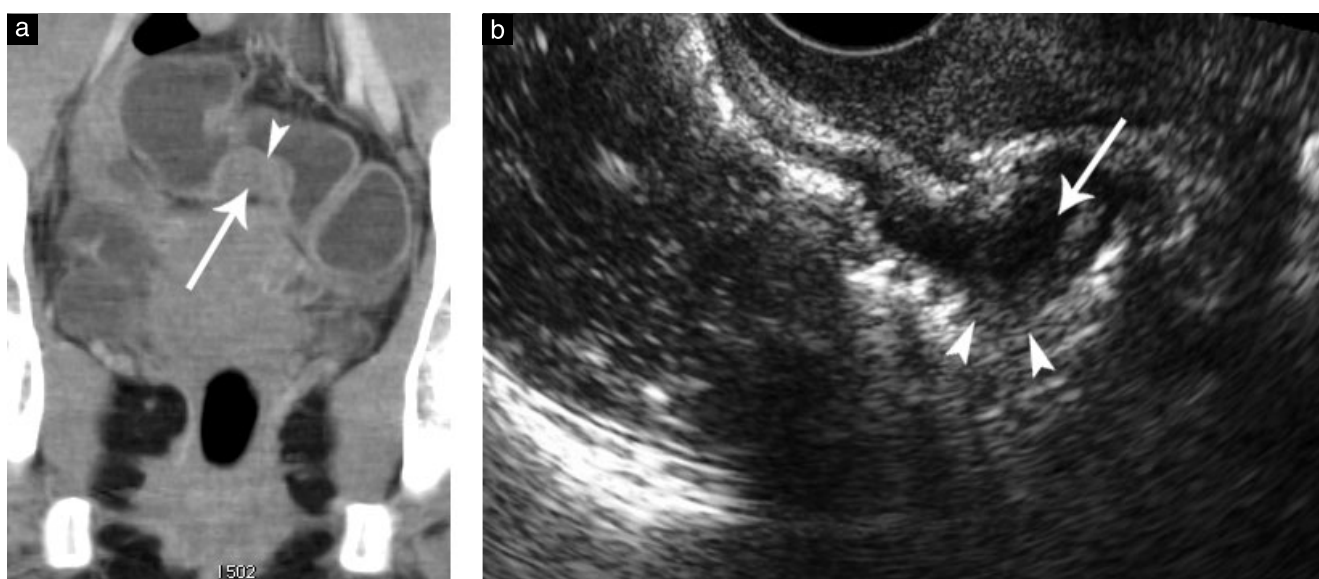

Figure 8 (a) Multidetector computerized tomography enteroclysis (MDCT-e) image and (b) rectal water contrast transvaginal ultrasonography (RWC-TVS) image showing an endometriotic nodule (arrows) infiltrating the muscularis and the submucosa of the rectosigmoid junction that was detected by both techniques. On both MDCT-e and RWC-TVS, the continuity of the submucosa is disrupted by the endometriotic nodule (arrowheads). Histological examination of the specimen excised at surgery confirmed that the intestinal mucosa was not infiltrated.

nodules per patient with intestinal endometriosis was 1 (range, 1–2). In patients with intestinal endometriosis all nodules identified by imaging techniques were confirmed by histology. MDCT-e correctly identified the number of rectosigmoid nodules per patient in 39 of these 48 patients (81.3%) and RWC-TVS correctly identified the number of rectosigmoid nodules per patient in 31 of them (64.6%). McNemar's test showed that there was no significant difference in the proportion of patients in

whom MDCT-e and RWC-TVS correctly identified the number of rectosigmoid nodules ($P = 0.080$).

Diagnosis of infiltration of the intestinal serosa

Nine patients had superficial endometriotic lesions infiltrating only the bowel serosa. MDCT-e identified seven of these nodules (77.8%) (Figure 9); in one patient, MDCT-e suggested the presence of a serosal lesion that was not

Table 4 Difference between size of nodule estimated by imaging techniques and that measured on histopathology in patients with a single intestinal nodule

	Largest diameter on histology (mm, mean ± SD)	MDCT-e		RWC-TVS	
		Mean difference (mm (95% CI))*	Limits of agreement (mm)†	Mean difference (mm (95% CI))*	Limits of agreement (mm)†
All nodules (n = 26)	29.0 ± 8.9	1.7 (0.7 to 2.7)	−3.0 to 6.3	4.5 (3.2 to 5.8)	−1.8 to 10.8
Nodules with diameter < 30 mm (n = 12)	21.3 ± 4.9	0.5 (−0.7 to 1.6)	−3.4 to 4.3	2.5 (1.0 to 4.0)	−2.4 to 7.4
Nodules with diameter ≥ 30 mm (n = 14)	35.6 ± 5.4	2.9 (1.7 to 4.2)	−1.2 to 7.1	6.0 (4.6 to 7.5)	0.6 to 11.6

*Mean difference calculated by subtracting size of nodule measured by imaging technique from size of nodule measured on histology. †Limits of agreement calculated as mean difference ± 2 SDs of the difference. MDCT-e, multidetector computerized tomography enteroclysis; RWC-TVS, rectal water contrast transvaginal ultrasonography.

Figure 9 Coronal multidetector computerized tomography enteroclysis image showing a small nodule adjacent to the sigmoid colon (arrows). The infiltration was judged to be limited to the intestinal serosa (arrowhead) because the nodule had a small diameter and did not bulge towards the intestinal lumen, and the intestinal wall profile was preserved.

Figure 10 Rectal water contrast transvaginal ultrasonographic image showing an endometriotic nodule that was judged to infiltrate only the intestinal serosa (asterisk). The nodule is adherent to the uterus (U) and causes minimal distortion of the intestinal wall with no thickening of the muscularis mucosa.

confirmed at surgery. RWC-TVS identified seven serosal lesions (77.8%; Figure 10), but in one patient infiltration was estimated to reach the muscularis. In addition, in two patients RWC-TVS suggested the presence of serosal lesions that were not observed at surgery.

Tolerability of MDCT-e and RWC-TVS

During MDCT-e no patient experienced intolerance to iodinated contrast medium or adverse reactions to it. During both the examinations all patients tolerated intestinal distension and in no patient was it necessary to interrupt the procedure. However, the intensity of pain experienced during MDCT-e was significantly higher than the intensity of pain experienced during RWC-TVS (Table 5). A positive correlation was observed between the intensity of pain experienced by the patients during the two examinations (Spearman correlation coefficient = 0.575; $P < 0.01$).

DISCUSSION

Previous studies have suggested that TVS could reliably diagnose rectosigmoid endometriosis[1]. The sensitivity of TVS for detecting rectosigmoid endometriosis is between 91 and 98%, the specificity between 97 and 100%, the PPV between 97 and 100% and the NPV between 87 and 98%[13,14,25,32–35]. However, more expensive techniques are still used for the diagnosis of bowel endometriosis (such as magnetic resonance imaging (MRI) and MDCT-e), possibly because the accuracy of TVS depends on the experience of the ultrasonographer. Recently, RWC-TVS has been developed to facilitate identification of intestinal lesions in patients with rectovaginal endometriosis and to determine the depth of infiltration of endometriosis in the intestinal wall[28,29].

This study demonstrates that RWC-TVS is as accurate as MDCT-e for the diagnosis of rectosigmoid endometriosis (defined as nodules infiltrating at least the muscularis propria). Both MDCT-e and RWC-TVS underestimated

Table 5 Intensity of pain experienced by 96 patients during multidetector computerized tomography enteroclysis (MDCT-e) and rectal water contrast transvaginal ultrasonography (RWC-TVS) as measured on a 10-cm visual analog scale (VAS)

Intensity of pain	MDCT-e	RWC-TVS	P
Overall intensity of pain (mean ± SD)	5.2 ± 2.1	4.1 ± 2.0	< 0.001
Categorical intensity of pain (*n* (%))			< 0.001
Mild pain (VAS score < 2)	4 (4.2)	14 (14.6)	—
Moderate pain (VAS score ≥ 2 and ≤ 5)	45 (46.9)	57 (59.4)	—
Severe pain (VAS score > 5)	47 (49.0)	25 (26.0)	—

the size of bowel endometriotic nodules, but underestimation was greater for RWC-TVS than for MDCT-e, particularly when the nodules had largest diameter ≥ 30 mm (Table 4). This finding may be explained by the fact that when performing imaging techniques, particularly RWC-TVS, it might be difficult to choose the plane in which the irregular endometriotic nodule has the largest diameter. However, the difference between the estimated size of the nodule and the largest diameter as measured on histopathology was quite small and, in most cases, it seems unlikely that this difference would affect the choice of nodulectomy or bowel resection as treatment. Importantly, patients tolerated RWC-TVS better than they did MDCT-e. These findings are in line with those of previous studies demonstrating the accuracy of TVS in the diagnosis of rectosigmoid endometriosis[13,14,25,32–35] and comparing TVS with other techniques such as MRI[13,14] and rectal endoscopic ultrasonography[14,32,33].

We are aware that the choice of the two imaging techniques evaluated in this study may be criticized. MDCT-e was chosen as gold standard for the diagnosis of endometriosis for several reasons. Although this technique is not universally used in the diagnosis of bowel endometriosis and has some important limitations (such as the use of iodinated contrast medium and ionizing radiation), its sensitivity, specificity and accuracy are > 95%[23,36]. Furthermore, MDCT-e is more accurate than other techniques (such as MRI) in the diagnosis of cecal and ileal endometriosis[27] and in identifying endometriotic nodules with extensive fibrosis and limited endometrial tissue[37]. Finally, MDCT-e was chosen for comparison with RWC-TVS because both these techniques are based on the retrograde distension of the intestinal lumen with contrast medium.

The potential benefit of introducing aqueous contrast medium into the rectum during TVS has been questioned[38]. RWC-TVS was used in the current study because, in a previous investigation, we could not reproduce the findings of other authors reporting good accuracy of TVS in determining the presence of bowel endometriosis and in estimating the depth of infiltration of the lesions in the intestinal wall[29]. TVS is an operator-dependent procedure and it is possible that the differences observed in the accuracy of this technique are determined by the experience of the ultrasonographer carrying out the procedure. However, adding intestinal aqueous contrast to TVS may facilitate the identification of rectosigmoid lesions[29]. Other techniques have been proposed for improving the

accuracy of TVS in the detection of deep endometriosis, such as sonovaginography (injection of saline solution into the vagina)[39] or the use of large quantities of ultrasound transmission gel (12 mL) in the probe cover ('tenderness-guided' TVS)[40]. Up to now, no study has established whether any one of these ultrasonographic techniques is superior to the others in the diagnosis of deep endometriosis.

TVS should be considered the first-line investigation in patients with deep endometriosis, and allows the diagnosis of intestinal lesions[25,34]. Other investigations such as RWC-TVS, MDCT-e, MRI, rectal endoscopic ultrasonography and double-contrast barium enema may be used to determine the characteristics of intestinal endometriosis, such as the size and number of nodules, the depth of infiltration of the nodules in the intestinal wall and the degree of stenosis of the bowel lumen. RWC-TVS has several advantages over the other techniques. It is less expensive than MDCT-e and MRI and the equipment required to perform the procedure is commonly available to gynecologists, who are usually involved in the management of patients with endometriosis. Furthermore, RWC-TVS has other advantages over MDCT-e – i.e. it does not require iodinated contrast medium and ionizing radiation and it is less painful for the patient. Finally, a recent study has shown that RWC-TVS allows estimation of the degree of stenosis of the intestinal lumen caused by endometriosis[41]; unfortunately, this parameter was not examined in the current study – the major limitation of our investigation. Theoretically, RWC-TVS may also allow determination of the extent of the disease along the longitudinal intestinal axis. Obviously, RWC-TVS cannot determine the presence of intestinal nodules located proximally to the sigmoid because these lesions are beyond the field of TVS. A recent study demonstrated that endometriotic lesions of the ileum and/or cecum are observed in 28% of patients with rectosigmoid endometriosis[35]; in the current series, three out of 51 patients with bowel endometriosis (5.9%) had lesions located only on the ileum and cecum. These lesions of the right bowel may remain undiagnosed if the diagnostic investigation is restricted to the rectosigmoid colon.

A limitation of the current study is that MDCT-e and RWC-TVS did not estimate the percentage of the circumference of the intestinal wall infiltrated by endometriosis, a criterion used to choose between nodulectomy and bowel resection[2,17]. Therefore, patients scheduled for nodulectomy on the basis of MDCT-e

and RWC-TVS findings should be informed that bowel resection might be required for the complete excision of intestinal endometriosis. Future studies should examine whether MDCT-e and RWC-TVS can reliably estimate what percentage of intestinal circumference is infiltrated by endometriosis.

MDCT-e may still have a role in the diagnostic work-up of patients with suspected bowel endometriosis. When TVS or RWC-TVS demonstrates large intestinal nodules infiltrating the bowel muscularis, bowel resection can probably be performed without further investigation unless the surgeon wants to exclude intestinal lesions located proximally to the sigmoid. In contrast, when ultrasonography demonstrates a single bowel nodule that may be excised by nodulectomy, MDCT-e should be used to exclude the presence of other intestinal nodules and, thus, to adequately plan the surgical procedure with the colorectal surgeon and the patient.

In conclusion, this study has shown that RWC-TVS is a reliable technique for determining the presence and extent of rectosigmoid endometriosis and that it has an accuracy similar to that of MDCT-e. However, RWC-TVS may sometimes underestimate the presence of multiple bowel nodules. RWC-TVS can be performed easily in an ambulatory setting and it is well tolerated by patients.

REFERENCES

1. Remorgida V, Ferrero S, Fulcheri E, Ragni N, Martin DC. Bowel endometriosis: presentation, diagnosis, and treatment. *Obstet Gynecol Surv* 2007; **62**: 461–470.
2. Remorgida V, Ragni N, Ferrero S, Anserini P, Torelli P, Fulcheri E. The involvement of the interstitial Cajal cells and the enteric nervous system in bowel endometriosis. *Hum Reprod* 2005; **20**: 264–271.
3. Seracchioli R, Mabrouk M, Guerrini M, Manuzzi L, Savelli L, Frascà C, Venturoli S. Dyschezia and posterior deep infiltrating endometriosis: analysis of 360 cases. *J Minim Invasive Gynecol* 2008; **15**: 695–699.
4. Ferrero S, Abbamonte LH, Valentino R, Ragni N. Abdominal pain, bloating, and urgency. *Obstet Gynecol* 2005; **106**: 195.
5. Ferrero S, Camerini G, Ragni N, Remorgida V. Endometriosis and irritable bowel syndrome: co-morbidity or misdiagnosis? *BJOG* 2009; **116**: 129. Comment on: *BJOG* 2008; **115**: 1392–1396; author reply 129–130.
6. Thomassin I, Bazot M, Detchev R, Barranger E, Cortez A, Darai E. Symptoms before and after surgical removal of colorectal endometriosis that are assessed by magnetic resonance imaging and rectal endoscopic sonography. *Am J Obstet Gynecol* 2004; **190**: 1264–1271.
7. Dubernard G, Piketty M, Rouzier R, Houry S, Bazot M, Darai E. Quality of life after laparoscopic colorectal resection for endometriosis. *Hum Reprod* 2006; **21**: 1243–1247.
8. Seracchioli R, Poggioli G, Pierangeli F, Manuzzi L, Gualerzi B, Savelli L, Remorgida V, Mabrouk M, Venturoli S. Surgical outcome and long-term follow up after laparoscopic rectosigmoid resection in women with deep infiltrating endometriosis. *BJOG* 2007; **114**: 889–895.
9. Minelli L, Fanfani F, Fagotti A, Ruffo G, Ceccaroni M, Mereu L, Landi S, Pomini P, Scambia G. Laparoscopic colorectal resection for bowel endometriosis: feasibility, complications, and clinical outcome. *Arch Surg* 2009; **144**: 234–239.
10. Darai E, Thomassin I, Barranger E, Detchev R, Cortez A, Houry S, Bazot M. Feasibility and clinical outcome of laparoscopic colorectal resection for endometriosis. *Am J Obstet Gynecol* 2005; **192**: 394–400.
11. Ferrero S, Camerini G, Menada MV, Biscaldi E, Ragni N, Remorgida V. Uterine adenomyosis in persistence of dysmenorrhea after surgical excision of pelvic endometriosis and colorectal resection. *J Reprod Med* 2009; **54**: 366–372.
12. Maroun P, Cooper MJ, Reid GD, Keirse MJ. Relevance of gastrointestinal symptoms in endometriosis. *Aust N Z J Obstet Gynaecol* 2009; **49**: 411–414.
13. Abrao MS, Gonçalves MO, Dias JA Jr, Podgaec S, Chamie LP, Blasbalg R. Comparison between clinical examination, transvaginal sonography and magnetic resonance imaging for the diagnosis of deep endometriosis. *Hum Reprod* 2007; **22**: 3092–3097.
14. Bazot M, Lafont C, Rouzier R, Roseau G, Thomassin-Naggara I, Daraï E. Diagnostic accuracy of physical examination, transvaginal sonography, rectal endoscopic sonography, and magnetic resonance imaging to diagnose deep infiltrating endometriosis. *Fertil Steril* 2009; **92**: 1825–1833.
15. Donnez J, Squifflet J. Complications, pregnancy and recurrence in a prospective series of 500 patients operated on by the shaving technique for deep rectovaginal endometriotic nodules. *Hum Reprod* 2010; **25**: 1949–1958.
16. Daraï E, Dubernard G, Coutant C, Frey C, Rouzier R, Ballester M. Randomized trial of laparoscopically assisted versus open colorectal resection for endometriosis: morbidity, symptoms, quality of life, and fertility. *Ann Surg* 2010; **251**: 1018–1023.
17. Remorgida V, Ragni N, Ferrero S, Anserini P, Torelli P, Fulcheri E. How complete is full thickness disc resection of bowel endometriotic lesions? A prospective surgical and histological study. *Hum Reprod* 2005; **20**: 2317–2320.
18. Ferrero S, Ragni N, Remorgida V. Post-operative digestive symptoms after colorectal resection for endometriosis. *Hum Reprod* 2006; **21**: 1941–1942.
19. Roman H, Loisel C, Resch B, Tuech JJ, Hochain P, Leroi AM, Marpeau L. Delayed functional outcomes associated with surgical management of deep rectovaginal endometriosis with rectal involvement: giving patients an informed choice. *Hum Reprod* 2010; **25**: 890–899.
20. Mais V, Guerriero S, Ajossa S, Angiolucci M, Paoletti AM, Melis GB. The efficiency of transvaginal ultrasonography in the diagnosis of endometrioma. *Fertil Steril* 1993; **60**: 776–780.
21. Guerriero S, Mais V, Ajossa S, Melis GB. Predictive value of color Doppler for ovarian endometrioma. *Fertil Steril* 1995; **63**: 1136–1137.
22. Bazot M, Malzy P, Cortez A, Roseau G, Amouyal P, Daraï E. Accuracy of transvaginal sonography and rectal endoscopic sonography in the diagnosis of deep infiltrating endometriosis. *Ultrasound Obstet Gynecol* 2007; **30**: 994–1001.
23. Ferrero S, Camerini G, Ragni N, Venturini PL, Biscaldi E, Remorgida V. Norethisterone acetate in the treatment of colorectal endometriosis: a pilot study. *Hum Reprod* 2010; **25**: 94–100.
24. Chapron C, Fauconnier A, Vieira M, Barakat H, Dousset B, Pansini V, Vacher-Lavenu MC, Dubuisson JB. Anatomical distribution of deeply infiltrating endometriosis: surgical implications and proposition for a classification. *Hum Reprod* 2003; **18**: 157–161.
25. Goncalves MO, Podgaec S, Dias JA Jr, Gonzalez M, Abrao MS. Transvaginal ultrasonography with bowel preparation is able to predict the number of lesions and rectosigmoid layers affected in cases of deep endometriosis, defining surgical strategy. *Hum Reprod* 2010; **25**: 665–671.
26. Biscaldi E, Ferrero S, Fulcheri E, Ragni N, Remorgida V, Rollandi GA. Multislice CT enteroclysis in the diagnosis of bowel endometriosis. *Eur Radiol* 2007; **17**: 211–219.
27. Biscaldi E, Ferrero S, Remorgida V, Rollandi GA. Bowel endometriosis: CT-enteroclysis. *Abdom Imaging* 2007; **32**: 441–450.
28. Menada MV, Remorgida V, Abbamonte LH, Fulcheri E, Ragni N, Ferrero S. Transvaginal ultrasonography combined with water-contrast in the rectum in the diagnosis of rectovaginal

endometriosis infiltrating the bowel. *Fertil Steril* 2008; **89**: 699–700.

29. Valenzano Menada M, Remorgida V, Abbamonte LH, Nicoletti A, Ragni N, Ferrero S. Does transvaginal ultrasonography combined with water-contrast in the rectum aid in the diagnosis of rectovaginal endometriosis infiltrating the bowel? *Hum Reprod* 2008; **23**: 1069–1075.

30. Lijoi D, Ferrero S, Mistrangelo E, Casa ID, Crosa M, Remorgida V, Alessandri F. Bowel preparation before laparoscopic gynaecological surgery in benign conditions using a 1-week low fibre diet: a surgeon blind, randomized and controlled trial. *Arch Gynecol Obstet* 2009; **280**: 713–718.

31. Deeks JJ, Altman DG. Diagnostic tests 4: likelihood ratios. *BMJ* 2004; **329**: 168–169.

32. Bazot M, Detchev R, Cortez A, Amouyal P, Uzan S, Daraï E. Transvaginal sonography and rectal endoscopic sonography for the assessment of pelvic endometriosis: a preliminary comparison. *Hum Reprod* 2003; **18**: 1686–1692.

33. Bazot M, Malzy P, Cortez A, Roseau G, Amouyal P, Daraï E. Accuracy of transvaginal sonography and rectal endoscopic sonography in the diagnosis of deep infiltrating endometriosis. *Ultrasound Obstet Gynecol* 2007; **30**: 994–1001.

34. Hudelist G, Tuttlies F, Rauter G, Pucher S, Keckstein J. Can transvaginal sonography predict infiltration depth in patients with deep infiltrating endometriosis of the rectum? *Hum Reprod* 2009; **24**: 1012–1017.

35. Piketty M, Chopin N, Dousset B, Millischer-Bellaische AE, Roseau G, Leconte M, Borghese B, Chapron C. Preoperative work-up for patients with deeply infiltrating endometriosis: transvaginal ultrasonography must definitely be the first-line imaging examination. *Hum Reprod* 2009; **24**: 602–607.

36. Biscaldi E, Ferrero S, Remorgida V, Rollandi GA. MDCT enteroclysis-urography with split bolus technique provides information on ureteral involvement in patients with suspected bowel endometriosis. *AJR Am J Roentgenol* (in press).

37. Biscaldi E, Ferrero S, Remorgida V, Fulcheri E, Rollandi GA. Rectosigmoid endometriosis with unusual presentation at magnetic resonance imaging. *Fertil Steril* 2009; **91**: 278–280.

38. Abrao MS, Podgaec S, Dias JA Jr, Gonçalves MO. Diagnosis of rectovaginal endometriosis. *Hum Reprod* 2008; **23**: 2386. Comment on: *Hum Reprod* 2007; **22**: 3092–3097; author reply 2386–2387.

39. Dessole S, Farina M, Rubattu G, Cosmi E, Ambrosini G, Nardelli GB. Sonovaginography is a new technique for assessing rectovaginal endometriosis. *Fertil Steril* 2003; **79**: 1023–1027.

40. Guerriero S, Ajossa S, Gerada M, D'Aquila M, Piras B, Melis GB. "Tenderness-guided" transvaginal ultrasonography: a new method for the detection of deep endometriosis in patients with chronic pelvic pain. *Fertil Steril* 2007; **88**: 1293–1297.

41. Bergamini V, Ghezzi F, Scarperi S, Raffaelli R, Cromi A, Franchi M. Preoperative assessment of intestinal endometriosis: a comparison of transvaginal sonography with water-contrast in the rectum, transrectal sonography, and barium enema. *Abdom Imaging* 2010; **35**: 732–736.