Diagnostic accuracy of physical examination, transvaginal sonography, rectal endoscopic sonography, and magnetic resonance imaging to diagnose deep infiltrating endometriosis

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Objective: To compare the value of physical examination, transvaginal sonography (TVS), rectal endoscopic sonography (RES), and magnetic resonance imaging (MRI) for the assessment of different locations of deep infiltrating endometriosis (DIE).
Design: Retrospective longitudinal study.
Setting: Tertiary university gynecology unit.
Patient(s): Ninety-two consecutive patients with clinical evidence of pelvic endometriosis.
Intervention(s): Physical examination, TVS, RES, and MRI, performed preoperatively.
Main Outcome Measure(s): Descriptive statistics, calculation of likelihood ratios (LR^+ and LR^-) of physical examination, TVS, RES, and MRI for DIE in specific locations confirmed by surgery/histology.
Result(s): The sensitivity and LR^+ and LR^- values of physical examination, TVS, RES, and MRI were, respectively, 73.5%, 3.3, and 0.34, 78.3%, 2.34, and 0.32, 48.2%, 0.86, and 1.16, and 84.4%, 7.59, and 0.18 for uterosacral ligament endometriosis; 50%, 3.88, and 0.57, 46.7%, 9.64, and 0.56, 6.7%, -, and 0.93, and 80%, 5.51, and 0.23 for vaginal endometriosis; and 46%, 1.67, and 0.75, 93.6%, -, and 0.06, 88.9%, 12.89, and 0.12, and 87.3%, 12.66, and 0.14 for intestinal endometriosis.
Conclusion(s): The MRI performs similarly to TVS and RES for the diagnosis of intestinal endometriosis but has higher sensitivity and likelihood ratios for uterosacral ligament and vaginal endometriosis. (Fertil Steril® 2008;■:■–■. ©2008 by American Society for Reproductive Medicine.)

Key Words: Endometriosis, deep infiltrating endometriosis, ultrasonography, magnetic resonance imaging, comparative studies, laparoscopy

Deep infiltrating endometriosis (DIE) is defined by the presence of endometrial implants, fibrosis, and muscular hyperplasia below the peritoneum. Deep endometriosis involves, in descending order of frequency, the uterosacral ligaments (USL), the rectosigmoid colon, the vagina, and the bladder (1). The exact incidence of DIE is unknown, but this disorder seems to be increasingly diagnosed (2). Despite a correlation between symptoms and various locations of DIE (3, 4), physical examination has limited value for assessing the extent of DIE (5, 6).

Rectal endoscopic sonography (RES), magnetic resonance imaging (MRI), and transvaginal sonography (TVS) have been recommended for diagnosing and locating DIE (7–14). Despite several reports suggesting that RES is highly accurate for diagnosing DIE, Delpy et al. reported poor accuracy for specific locations of DIE, except for intestinal endometriosis (7, 9, 15–17). The MRI is the best noninvasive technique for assessing DIE (8, 13, 18). Chapron et al. suggested that RES was more accurate than MRI for evaluating rectosigmoid endometriosis (15). Recently, we showed that RES and MRI had similar accuracy for diagnosing intestinal endometriosis but found that RES had limited value compared with MRI for other DIE locations. Few data are available on the value of TVS for detecting DIE (11, 12, 17). In a preliminary study, we found that TVS and RES had similar accuracy for diagnosing intestinal endometriosis (11).

The aims of this study were to compare the value of physical examination, TVS, RES, and MRI for the diagnosis of different locations of DIE.

MATERIALS AND METHODS

This longitudinal study involved 92 consecutive women referred with clinical evidence of pelvic endometriosis between April 2000 and May 2005. The women ranged in age from 20–51 years (median, 31.8 years). Their characteristics,

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clinical signs, and previous history of medical or surgical treatments are given in Table 1. All the women underwent physical examination, TVS, RES, and MRI before surgery. Different physicians interpreted all the techniques independently and blindly. The readers were informed of the women's clinical history and symptoms but were blinded to the results of physical and previous imaging examinations. The study was approved by the Ethics Committee of the Collège National des Gynécologues et Obstétriciens Français.

TABLE 1

Characteristics of patients with pelvic endometriosis.

Characteristic	No. of patients (%)
Infertility	21/92 (22.8%)
Previous surgery for endometriosis	31/92 (33.7%)
Nulliparous	56/92 (60.8%)
Noncyclic chronic pelvic pain	26/92 (28.3%)
Dysmenorrhea	79/92 (85.9%)
Deep dyspareunia	63/92 (68.5%)
Painful defecation	32/92 (34.8%)
Dysuria	3/92 (3.2%)
Asthenia	14/92 (15.3%)

Note: Most of the patients had associated symptoms.

Bazot. TVS, RES, and MRI for surgery in deep endometriosis. Fertil Steril 2008.

Physical Examination

Deep infiltrating endometriosis was diagnosed when [1] lesions were visualized on the posterior vaginal fornix, [2] infiltration or a nodule was detected on vaginal examination, involving the vagina, torus uterinus, uterosacral ligaments, or pouch of Douglas, and [3] infiltration or a mass was detected on rectal digital examination, involving the rectosigmoid colon. All the physical examinations were performed by the same highly experienced gynecologist (E.D.).

Transvaginal Sonography

The TVS was performed with an Ultramark HDI 5000 unit (ATL, Bothell, WA) or a Siemens Elegra (Siemens, Erlangen, The Netherlands), using a wide-band 5- to 9-MHz transducer and a standardized protocol (12). No bowel preparation was used. Each examination was interpreted in real-time with a standardized protocol by the same radiologist (M.B.) with 15 years of experience in gynecologic imaging at the outset of the study.

The diagnosis of DIE was based on morphological criteria that varied according to the anatomical location and included abnormal hypoechoic linear thickening and nodules/masses with or without regular contours. Deep infiltrating endometriosis was diagnosed when at least one structure (uterosacral ligament(s), vagina, rectovaginal septum, rectosigmoid colon, or bladder) was involved. All endometriotic locations were diagnosed using published criteria (11, 12). The uterosacral ligaments were considered to be involved when they were visible and bore a nodule (regular or with stellate margins) or showed hypoechoic linear thickening with regular or irregular margins. The vagina was considered to be involved when the posterior vaginal fornix was thickened, with or without a round cystic anechoic area. The rectovaginal septum was considered to be involved when a nodule or mass was found below the horizontal plane passing through the lower border of the posterior lip of the cervix (under the peritoneum). The rectum/sigmoid colon was considered to be involved when an irregular hypoechoic mass was found, with or without hypoechoic or hyperechoic foci, penetrating into the intestinal wall. In this case, the normal hypoechoic aspect of the rectum/sigmoid colon muscularis propria, which is hypoechoic and thin (<3 mm) was replaced by the abnormal tissular mass. Lesions located on the sigmoid colon or at the rectosigmoid junction effaced the normal adipose tissue plane lying between the uterus and the rectum/sigmoid colon. Bladder involvement was diagnosed when a hypoechoic nodule or a cystic lesion was found within the bladder wall.

Associated lesions, such as ovarian endometriosis and uterine adenomyosis, were diagnosed using published criteria (10, 19, 20).

Rectal Endoscopic Sonography

After a simple rectal enema, RES was performed with an Olympus GF UM 20 Echo endoscope (SCOP Medicine Olympus, Rungis, France) with a diameter of 11.4 mm, operating at 7.5 and 12 MHz, following a standardized protocol (12). Each examination was interpreted in real-time by the same gastroenterologist (G.R.) with 5 years' experience in endometriosis at the outset of the study. Deep infiltrating endometriosis was defined by the presence of a hypoechoic nodule or mass, with or without regular contours. Involvement of the USLs, the vagina, the rectovaginal septum, and the rectosigmoid colon was analyzed. The RES cannot be used to assess bladder endometriosis, but the infiltration of adjacent pelvic organs was assessed. For the rectum or sigmoid colon, involvement of the muscularis propria (hypoechoic and thin) by endometriotic tissue was used for the diagnosis of intestinal endometriosis.

Magnetic Resonance Imaging

The patients had bowel preparation, fasted for at least 3 hours, and received 10 mg of tiemonium methylsulfate (Organon, Livron, France), an antispasmodic drug, at the outset of the examination to reduce bowel peristalsis. The MRIs were acquired on a 1.5-T device. The protocol included sagittal and axial fast spin-echo T_2-weighted images and gradient echo T_1 images with and without fat suppression, before and after injection of gadolinium. All sequences were acquired with anterior and posterior saturation bands

placed anteriorly and posteriorly to eliminate the high signal of subcutaneous fat. Additional sequences were acquired, especially for suspected rectal involvement. The performance of the different sequences was not compared. Each examination was interpreted according to a standardized protocol, retrospectively by one radiologist (C.L.) with two years' experience in gynecologic imaging at the outset of the study.

The diagnosis of DIE was based on the combined presence of signal abnormalities (13) (e.g., hyperintense foci on T_1-weighted or fat-suppression T_1-weighted MRIs, corresponding to hemorrhagic foci or small hyperintense cavities on T_2-weighted images, or areas corresponding to fibrosis, with a signal close to that of pelvic muscle on T_1- and T_2-weighted images, with or without foci or cavities, and with or without contrast enhancement after gadolinium injection) and morphologic abnormalities. These features were evaluated at each site of posterior or anterior DIE in accordance with previous reports (8, 13). All endometriotic locations were diagnosed using published criteria (8, 13). Uterosacral ligament endometriosis was diagnosed when the ligament bore a nodule (regular or with stellate margins) or showed fibrotic thickening compared with the contralateral USL, with regular or irregular margins. Uterosacral ligaments are well defined during surgery and corresponding to locations at the upper and posterolateral limits of the pubosacrogenital ligaments (21). The unilateral/bilateral nature of the involvement, and involvement of the torus uterinus (arciform abnormality) was noted. Vaginal endometriosis was defined by obliteration of the hypointense signal of the posterior vaginal wall on T_2-weighted images, with thickening or a mass (containing or not containing foci) behind the posterior wall of the cervix. Rectovaginal septum was defined by a nodule or a mass passing through the lower border of the posterior lip of the cervix (under the peritoneum). Rectosigmoid colon endometriosis was defined by the disappearance of the fat tissue plane lying between the uterus and the rectum/sigmoid colon, and its replacement by a tissue mass, and by the disappearance of the hypointense signal of the anterior wall of the rectum/sigmoid colon on T_2-weighted images, with contrast enhancement on T_1-weighted images.

Associated lesions, such as ovarian endometriosis and uterine adenomyosis, were diagnosed using published criteria (10, 22–24).

Surgical and Pathologic Findings (reference standard)

Laparoscopy and laparotomy were performed in 79 (85.9%) and 13 (14.1%) cases, respectively. All locations of endometriosis were recorded on the surgical reports. Histologic criteria used for the diagnosis of pelvic endometriosis included the presence of ectopic endometrial tissue (ectopic glands together with stroma) (25).

Deep infiltrating endometriosis was diagnosed in the following circumstances:

1. When endometrial tissue (glands and stroma) was found on histologic examination of at least one resected subperitoneal lesion (26).
2. Deep infiltrating endometriosis was directly visualized during laparoscopy or laparotomy but only fibrosis and smooth muscle cells were found on biopsy or the lesion was not biopsied (27). In this latter case, subperitoneal endometriosis was diagnosed if another histologically proven site of endometriosis was found (21).
3. Complete cul-de-sac obliteration secondary to endometriosis was observed but could not necessarily be surgically cleared (frozen pelvis). Like Reich et al. (28), we considered that deep retrocervical endometriosis was present below the peritoneum in such cases.

Infiltration of the muscularis propria, submucosa, or mucosa of the rectosigmoid colon was recorded.

As recommended by Chapron et al. (29), a deep endometriotic location was considered isolated (bladder, uterosacral ligaments, vagina, rectovaginal septum, or intestine) when it was not associated with any of the other possible locations of DIE.

Statistical Analysis

For each of the five possible locations of DIE (USL, vagina, rectovaginal septum, intestine, and bladder), the performance of the different diagnostic methods was evaluated by comparing the group of women with DIE in a given location with the group of women without that location.

The sensitivity, specificity, positive and negative predictive values, accuracy, and likelihood ratios (95% confidence intervals [CI]) of physical examination, TVS, RES, and MRI were determined for each site of endometriotic involvement.

Parametric and nonparametric continuous variables were compared using Student's *t*-test, and categorical variables were compared using the χ^2 test, Fisher's exact test, the MacNemar test, or the *Z* statistic as appropriate. *P* values $< .05$ were considered statistically significant.

RESULTS

Surgical and Pathologic Findings

All but two of the patients had DIE proven by histology. Two patients with clinical and surgical signs of uterosacral endometriosis did not fulfill all histologic criteria for DIE but one woman had a histologically confirmed endometrioma. Deep infiltrating endometriosis was posterior and anterior in, respectively, 90 (97.8%) and 3 (3.3%) of the 92 women. Both the posterior and anterior compartments were involved in these latter three women (3.3%). Deep retrocervical endometriosis (frozen pelvis) was noted in 17 patients (18.5%). Deep infiltrating endometriosis was associated with endometriomas in 36/92 cases (39.1%). The distribution of the different sites of DIE is reported in Table 2.

TABLE 2

Locations of deep infiltrating endometriosis diagnosed at surgery and confirmed at histologic examination (n = 92 patients).

Subperitoneal locations	Diagnosis at surgery	Surgical specimens	Confirmation at histology	Isolated locations
Posterior compartment	90 (97.8%)	81 (88%)	81 (88%)	—
Uterosacral ligaments	85 (92.4%)	72 (78.3%)	72 (78.3%)	17 (18.5%)
Vagina	30 (32.6%)	19 (20.6%)	19 (20.6%)	1 (1.1%)
Rectovaginal septum	11 (11.9%)	11 (11.9%)	11 (11.9%)	0
Intestine	66 (71.4%)	56 (60.9%)	54 (58.7%)	4 (4.3%)
Sigmoid colon	6 (6.5%)	5 (5.4%)	5 (5.4%)	2 (2.2%)
Rectosigmoid junction	46 (50%)	39 (42.4%)	37 (40.2%)	1 (1%)
Rectum	14 (15.2%)	12 (13%)	12 (13%)	0
Anterior compartment bladder	3 (3.3%)	3 (3.3%)	3 (3.3%)	0

Bazot. TVS, RES, and MRI for surgery in deep endometriosis. Fertil Steril 2008.

Among 56 women who underwent colorectal resection (60.8%), histologic examination confirmed endometriotic involvement of the muscularis propria, submucosa, and mucosa in, respectively, 54 (96.4%), 20 (35.7%), and 2 (3.6%) cases.

Isolated DIE of the vagina, intestine, and uterosacral ligaments was detected in 1/92 (1.1%), 4/92 (4.3%), and 17/92 (18.5%) patients, respectively.

Physical Findings

Deep infiltrating endometriosis was diagnosed at physical examination in 75 of the 92 (81.5%) women. Uterosacral endometriosis was detected in 63/92 (68.5%) women (bilateral, 32; unilateral, 20; and indeterminate, 11). Rectosigmoid colon endometriosis was detected in 37/92 (40.2%) women. Vaginal and rectovaginal septum endometriosis was detected in 23/92 (25%) and 5/92 (5.4%), respectively.

The sensitivity, specificity, positive and negative predictive values, and accuracy of physical examination for the diagnosis of the different locations of DIE are given in Table 3.

Transvaginal Sonography Findings

The TVS yielded a diagnosis of DIE in 79 (85.7%) of the 92 patients (Table 4). All 11 false-negative results concerned women with uterosacral ligament endometriosis, which was either isolated (n = 7) or associated with vaginal endometriosis (n = 2), colorectal endometriosis (n = 1), or frozen pelvis (n = 1).

The TVS yielded a diagnosis of uterosacral ligament, vaginal, rectovaginal, intestinal, and bladder endometriosis in, respectively, 68/92 (73.9%) (18 false-negative and 3 false-positive cases), 17/92 (8.5%) (16 false-negative and 3 false-positive cases), 1/92 (1.2%) (10 false-negative and 1 false-positive cases), 59/92 (64.1%) (4 false-negative cases), and 3/92 (3.2%) patients.

The TVS yielded a diagnosis of ovarian endometriosis in 43 patients (6.7%), and gave 2 false-negative and 8 false-positive results.

Rectal Endoscopic Sonography Findings

The RES yielded a diagnosis of DIE in 69 (75%) of the 92 patients (Table 5). All 21 false-negative results concerned

TABLE 3

Locations of deep infiltrating endometriosis: correlation of physical findings with surgical and pathologic findings.

PE	Sensitivity	Specificity	PPV	NPV	Accuracy
USLs	73.5% (61/83)	77.8% (7/9)	96.8% (61/63)	24% (7/29)	73.9% (68/92)
Vagina	50% (15/30)	87% (54/62)	65.2% (15/23)	78.3% (54/69)	75% (69/92)
RV septum	18.2% (2/11)	96.3% (78/81)	40% (2/5)	89.7% (78/87)	86.9% (80/92)
Intestine	46% (29/63)	72.4% (21/29)	78.4% (29/37)	38.2% (21/55)	54.4% (50/92)

Note: USLs = uterosacral ligaments; RV septum = rectovaginal septum; PPV = positive predictive value; NPV = negative predictive value; PE = physical examination.

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TABLE 4

Pelvic endometriosis: correlation of TVS results with surgical and pathologic findings.

TVS	Sensitivity	Specificity	PPV	NPV	Accuracy
USLs	78.3% (65/83)	66.7% (6/9)	95.6% (65/68)	25% (6/24)	77.2% (71/92)
Vagina	46.7% (14/30)	95% (59/62)	82.4% (14/17)	78.7% (59/75)	79.3% (73/92)
RV septum	9% (1/11)	98.7% (80/81)	50% (1/2)	88.9% (80/90)	88% (81/92)
Intestine	93.6% (59/63)	100% (29/29)	100% (59/59)	87.9% (29/33)	95.6% (88/92)

Note: USLs = uterosacral ligaments; RV septum = rectovaginal septum; PPV = positive predictive value; NPV = negative predictive value; TVS = transvaginal sonography.

Bazot. TVS, RES, and MRI for surgery in deep endometriosis. Fertil Steril 2008.

women with uterosacral ligament endometriosis that was either isolated (n = 11) or associated with vaginal (n = 8) or colorectal (n = 5) endometriosis.

The RES yielded a diagnosis of uterosacral ligament, vaginal, rectovaginal, and intestinal endometriosis in, respectively, 45/92 (48.9%) (43 false-negative and 5 false-positive cases), 2/92 (2.2%) (28 false-negative cases), 6/92 (6.5%) (9 false-negative and 4 false-positive cases), and 58/92 (63%) (6 false-negative and 2 false-positive cases) patients.

The RES yielded a diagnosis of ovarian endometriosis in 28 patients (30.4%), with 13 false-negative and 4 false-positive cases.

Magnetic Resonance Imaging Findings

The MRI yielded a diagnosis of DIE in 87 (94.6%) of the 92 patients (Table 6). All three false-negative results concerned women with uterosacral ligament endometriosis that was either isolated (n = 1) or associated with colorectal (n = 1) endometriosis or frozen pelvis (n = 1). Two false-positive results concerned women with MRI evidence of uterosacral ligament endometriosis that was not found at histology.

The MRI yielded a diagnosis of uterosacral ligament, vaginal, rectovaginal, intestinal, and bladder endometriosis in, respectively, 71/92 (77.2%) (13 false-negative and 1 false-positive cases), 33/92 (35.9%) (6 false-negative and 9 false-positive cases), 7/92 (7.6%) (5 false-negative and 1 false-positive cases), 57/92 (61.9%) (8 false-negative and 2 false-positive cases), and 3/92 (3.2%) patients.

The MRI yielded a diagnosis of ovarian endometriosis in 41 (44.6%) patients, with 3 false-negative and 7 false-positive cases.

Comparison of Physical Examination, TVS, RES, and MRI for the Diagnosis of Deep Infiltrating Endometriosis

With surgery and histology as the reference standard, physical examination, TVS, RES, and MRI correctly diagnosed DIE in, respectively, 75 (82.6%), 79 (85.9%), 67 (72.8%), and 87 (94.6%) of the 92 women (Table 7).

Physical examination, TVS, RES, and MRI correctly diagnosed uterosacral ligament endometriosis in, respectively, 61/83 (73.5%), 65/83 (78.3%), 40/83 (48.2%), and 70/83 (84.3%) women.

Physical examination, TVS, RES, and MRI correctly diagnosed rectosigmoid colon endometriosis in, respectively, 29/63 (46%), 59/63 (93.7%), 56/63 (88.9%), and 55/63 (87.3%) women.

Physical examination, TVS, RES, and MRI correctly diagnosed vaginal endometriosis in, respectively, 15/30 (50%), 14/30 (46.7%), 2/30 (6.7%), and 24/30 (80%) women.

TABLE 5

Locations of deep infiltrating endometriosis: correlation between rectal endoscopic sonography and surgical and pathologic findings.

RES	Sensitivity	Specificity	PPV	NPV	Accuracy
USLs	48.2% (40/83)	44.4% (4/9)	88.9% (40/45)	8.5% (4/47)	47.8% (44/92)
Vagina	6.7% (2/30)	100% (62/62)	100% (2/2)	68.9% (62/90)	69.6% (64/92)
RV septum	18.2% (2/11)	95% (77/81)	33.3% (2/6)	89.5% (77/86)	85.9% (79/92)
Intestine	88.9% (56/63)	93.1% (27/29)	96.6% (56/58)	79.4% (27/34)	90.2% (83/92)

Note: USLs = uterosacral ligaments; RV septum = rectovaginal septum; PPV = positive predictive value; NPV = negative predictive value; RES = rectal endoscopic sonography.

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TABLE 6

Locations of deep infiltrating endometriosis: correlation between MRI and surgical and pathologic findings.

MRI	Sensitivity	Specificity	PPV	NPV	Accuracy
USLs	84.4% (70/83)	88.9% (8/9)	98.6% (70/71)	38% (8/21)	84.8% (78/92)
Vagina	80% (24/30)	85.5% (53/62)	72.7% (24/33)	89.8% (53/59)	83.7% (77/92)
RV septum	54.5% (6/11)	98.7% (80/81)	85.7% (6/7)	94.1% (80/85)	93.5% (86/92)
Intestine	87.3% (55/63)	93.1% (27/29)	96.5% (55/57)	77.1% (27/35)	89.1% (82/92)

Note: USLs = uterosacral ligaments; RV septum = rectovaginal septum; PPV = positive predictive value; NPV = negative predictive value; MRI = magnetic resonance imaging.

Bazot. TVS, RES, and MRI for surgery in deep endometriosis. Fertil Steril 2008.

Physical examination, TVS, RES, and MRI correctly diagnosed rectovaginal septum endometriosis in, respectively, 2/11 (18.2%), 1/11 (9%), 2/11 (18.2%), and 6/11 (54.5%) women.

DISCUSSION

This study of a large series of patients with clinical evidence of DIE shows that physical and ultrasonographic examination can miss some locations of DIE, and that MRI is the best imaging technique for mapping DIE.

Early diagnosis of pelvic endometriosis, and especially DIE, is a major challenge, as it can help to avoid mutilating surgery, improve quality of life, and enhance fertility (30–33). In previous studies the interval between symptom onset and the first medical consultation nearly reached 4 years, and that an additional 4 years was sometimes necessary to diagnose endometriosis, potentially explaining the high proportion of women who are diagnosed at an advanced stage (2). Symptoms of DIE include severe dysmenorrhea, deep dyspareunia, dyschezia, and dysuria; ovarian and peritoneal endometriosis do not appear to be associated with pelvic pain (34). The present study confirms that dysmenorrhea and deep dyspareunia are the most frequent symptoms of DIE. Fauconnier et al. (3) found a close relationship between specific symptoms and certain locations of DIE. Our results

TABLE 7

Comparison of the sensitivity, accuracy, LR^+, and LR^- of physical examination, TVS, RES, and MRI compared to surgical and pathologic findings.

	Test	PE	TVS	RES	MRI
USLs	Sensitivity	0.73 (0.63–0.82)	0.78 (0.69–0.87)	0.48 (0.37–0.59)	0.84 (0.77–0.92)
	Diagnostic accuracy	0.74 (0.64–0.82)	0.77 (0.69–0.86)	0.47 (0.36–0.56)	0.85 (0.77–0.92)
	LR^+	3.3 (0.95–11.1)	2.34 (0.93–5.96)	0.86 (0.45–1.06)	7.59 (1.19–48.3)
	LR^-	0.34 (0.22–0.58)	0.32 (0.18–0.60)	1.16 (0.73–3.91)	0.18 (0.10–0.31)
Vagina	Sensitivity	0.50 (0.32–0.68)	0.47 (0.29–0.65)	0.07 (0–0.16)	0.80 (0.66–0.94)
	Diagnostic accuracy	0.75 (0.66–0.84)	0.79 (0.71–0.88)	0.70 (0.60–0.79)	0.84 (0.76–0.91)
	LR^+	3.88 (1.85–8.11)	9.64 (3.00–31.0)	—	5.51 (2.94–10.3)
	LR^-	0.57 (0.40–0.83)	0.56 (0.40–0.70)	0.93	0.23 (0.11–0.48)
RV septum	Sensitivity	0.18 (0–0.41)	0.09 (0–0.26)	0.18 (0–0.41)	0.55 (0.16–0.75)
	Diagnostic accuracy	0.87 (0.80–0.94)	0.88 (0.81–0.95)	0.86 (0.79–0.93)	0.94 (0.87–0.98)
	LR^+	4.91 (0.92–26.2)	7.36 (0.50–109.5)	3.68 (0.76–17.8)	44.18 (4.73–286.8)
	LR^-	0.85 (0.64–1.13)	0.92 (0.76–1.11)	0.86 (0.65–1.14)	0.46 (0.32–0.95)
Intestine	Sensitivity	0.46 (0.34–0.58)	0.94 (0.88–1.00)	0.89 (0.83–0.98)	0.87 (0.79–0.96)
	Diagnostic accuracy	0.54 (0.44–0.65)	0.96 (0.91–1.00)	0.89 (0.86–0.97)	0.87 (0.83–0.95)
	LR^+	1.67 (0.87–3.19)	—	12.89 (3.54–51.8)	12.66 (3.31–48.37)
	LR^-	0.75 (0.54–1.03)	0.06	0.12 (0.05–0.22)	0.14 (0.07–0.26)

Note: PE = physical examination; TVS = transvaginal sonography; RES = rectal endoscopic sonography; MRI = magnetic resonance imaging; USLs = uterosacral ligaments; RV septum = rectovaginal septum; LR^+ = positive likelihood ratio; LR^- = negative likelihood ratio.

Bazot. TVS, RES, and MRI for surgery in deep endometriosis. Fertil Steril 2008.

confirm that deep dyspareunia is related to uterosacral ligament endometriosis. In contrast to previous studies, we found no significant relationship between noncyclic pain and intestinal endometriosis or between painful defecation and vaginal endometriosis (3). This apparent discrepancy underlines the value of using a standardized questionnaire to screen women with painful symptoms for endometriosis (34).

Physical examination is crucial for detecting DIE, although it is not very accurate for specific locations. Its accuracy appears to be higher during menstruation (6, 35). In this study, physical examination was performed irrespective of the menstrual cycle and diagnosed DIE in 81.5% of cases, a value higher than that reported elsewhere (6, 35, 36). This discrepancy could be partly explained by the high frequency of multiple and large deep endometriotic lesions in our patients. Multiple deep posterior endometriotic lesions and rectosigmoid colon endometriosis were observed in 81.5% and 69.9% of cases, respectively. Another likely factor was our team's extensive experience with endometriosis, underlining the importance of specialized centers. Despite our encouraging results, however, physical examination seems to have poor accuracy and unreliable likelihood ratios for all specific locations of DIE, and imaging techniques are therefore necessary (37). Full imaging of the pelvis is necessary for optimal planning of management for pelvic endometriosis. Although a recent report claimed that there were no reliable nonsurgical diagnostic tests for endometriosis, imaging techniques seem very useful for predicting specific locations of DIE (38).

We confirm that RES is inaccurate for USL endometriosis (11, 16). The TVS was a little less sensitive (78.3%) than MRI (84.4%) for the diagnosis of USL. Among the 18 false-negative TVS results, MRI was accurate in 12 cases. Dysmenorrhea or deep dyspareunia were always present, but physical examination was negative in more than one-third of patients. These data support the use of MRI for all symptomatic patients, even when physical examination and TVS are not contributive, although cost-effectiveness studies are needed. The "tenderness-guided" approach should be used systematically to increase the value of TVS for the diagnosis of USL (39). Intestinal endometriosis is one of the most severe forms of DIE. Accurate preoperative diagnosis of intestinal endometriosis is essential for informing women on the specific risks of surgery (e.g., colorectal resection). Previous studies have shown that TVS, RES, and MRI are all highly accurate for the detection of rectal endometriosis (8, 13, 15). In our study, MRI and ultrasonographic examinations (i.e., TVS and RES) provided positive likelihood ratios (LR^+) >10 and negative likelihood ratios (LR^-) <0.1, implying that these techniques are very helpful for ruling in and ruling out intestinal endometriosis, respectively. Various features of colorectal endometriosis can influence surgical management, such as the degree of rectal wall infiltration, the size of the rectal lesion, the distance from the anal margin, and the possible association with other endometriotic lesions. Despite better delineation of the intestinal layers, RES is not more accurate than TVS or MRI for detecting digestive layer involvement (11, 17, 40). As recently reported by Abrao et al. (36), mechanical cleansing of the lower bowel by means of a rectal enema 1 hour before TVS permits the identification of the different bowel layers. The value of digestive layer involvement for choosing the surgical technique has recently been challenged (41). Remorgida et al. (41) showed that segmental colorectal resection was the best surgical option for endometriosis, owing to the risk of persistent lesions in almost half the women who undergo full-thickness disc or superficial rectal resection. However, RES remains the best technique to evaluate the distance of rectal endometriosis from the anal margin. In accordance with previous studies, the rectosigmoid junction was the site of nearly two-thirds of cases of colorectal endometriosis (1, 42) and was easily analyzed whatever the imaging technique. Rectosigmoid endometriosis is almost always associated with torus uterinus or USL involvement. Hence, only the entire endometriotic lesion is measurable, and not the contribution of each specific anatomical location. In addition, adhesion between the anterior rectal wall and the posterior wall of the uterus is frequently responsible for partial or complete cul-de-sac of Douglas obliteration. Like Reich, we define cul-de-sac obliteration as the complete disappearance of this structure and the impossibility of distinguishing anatomical structures (28). This could explain the low incidence of posterior cul de sac obliteration observed in the present study.

In our series, vaginal and rectovaginal septum endometriosis was almost always associated with other pelvic endometriotic locations, and especially rectal endometriosis. The TVS and RES had lower sensitivities than MRI for vaginal and rectovaginal septum endometriosis. Opacification of the vagina (with saline solution or sonographic jelly) can increase the accuracy of TVS and MRI for rectovaginal endometriosis, but we did not use this technique (43, 44). The non use of sonovaginography during the initial phase of this study may explain the low frequency of vaginal involvement detected by imaging techniques. In addition, although nearly one-third of the patients had vaginal endometriosis at surgery, only two-thirds of cases were confirmed by histology, probably owing to the low frequency of endometrial glands within the specimens (45). Vaginal endometriosis is particularly important to diagnose, owing to the need for specific surgical procedures, such as protective colostomy, due to the risk of recto-vaginal fistulae (31).

Several limitations of our study must be considered. First, the prevalence of DIE was particularly high, representing a possible source of bias, especially for descriptive statistical analysis (e.g., sensitivity). Likelihood ratios were therefore calculated to give more robust data. Second, the high incidence of multiple and severe DIE may explain the high rate of diagnosis by physical examination. These two limitations are related because the study was conducted in a specialized center. Third, we did not examine the intraobserver or interobserver variability of physical examination, TVS, MRI, and RES. Fourth, during the 5-year period study, only 92 women

with evidence of DIE underwent all three imaging techniques, representing a potential bias, especially with respect to the learning curve for each technique. However, no other large studies of patients examined with all these imaging techniques are available. Finally, additional studies are required to compare the cost-effectiveness of MRI and diagnostic laparoscopy for the assessment of DIE.

In conclusion, MRI provides a more reliable map of DIE than physical examination, TVS, or RES. In women with chronic pelvic pain suggestive of pelvic endometriosis, TVS should remain the first-line technique examination, although normal TVS findings do not rule out the diagnosis. Hence, MRI should be used to examine symptomatic women before surgery. The use of rectal endoscopic sonography should be restricted to cases in which a discrepancy is found between physical examination and first-line imaging techniques.

REFERENCES

1. Jenkins S, Olive DL, Haney AF. Endometriosis: pathogenetic implications of the anatomic distribution. Obstet Gynecol 1986;67:335–8.
2. Ballweg ML. Impact of endometriosis on women's health: comparative historical data show that the earlier the onset, the more severe the disease. Best Pract Res Clin Obstet Gynaecol 2004;18:201–18.
3. Fauconnier A, Chapron C, Dubuisson JB, Vieira M, Dousset B, Breart G. Relation between pain symptoms and the anatomic location of deep infiltrating endometriosis. Fertil Steril 2002;78:719–26.
4. Chapron C, Fauconnier A, Dubuisson JB, Barakat H, Vieira M, Breart G. Deep infiltrating endometriosis: relation between severity of dysmenorrhoea and extent of disease. Hum Reprod 2003;18:760–6.
5. Koninckx PR, Martin D. Treatment of deeply infiltrating endometriosis. Curr Opin Obstet Gynecol 1994;6:231–41.
6. Chapron C, Dubuisson JB, Pansini V, Vieira M, Fauconnier A, Barakat H, et al. Routine clinical examination is not sufficient for diagnosing and locating deeply infiltrating endometriosis. J Am Assoc Gynecol Laparosc 2002;9:115–9.
7. Chapron C, Dumontier I, Dousset B, Fritel X, Tardif D, Roseau G, et al. Results and role of rectal endoscopic ultrasonography for patients with deep pelvic endometriosis. Hum Reprod 1998;13:2266–70.
8. Kinkel K, Chapron C, Balleyguier C, Fritel X, Dubuisson JB, Moreau JF. Magnetic resonance imaging characteristics of deep endometriosis. Hum Reprod 1999;14:1080–6.
9. Roseau G, Dumontier I, Palazzo L, Chapron C, Dousset B, Chaussade S, et al. Rectosigmoid endometriosis: endoscopic ultrasound features and clinical implications. Endoscopy 2000;32:525–30.
10. Bazot M, Cortez A, Darai E, Rouger J, Chopier J, Antoine JM, et al. Ultrasonography compared with magnetic resonance imaging for the diagnosis of adenomyosis: correlation with histopathology. Hum Reprod 2001;16:2427–33.
11. Bazot M, Detchev R, Cortez A, Amouyal P, Uzan S, Darai E. Transvaginal sonography and rectal endoscopic sonography for the assessment of pelvic endometriosis: a preliminary comparison. Hum Reprod 2003;18:1686–92.
12. Bazot M, Thomassin I, Hourani R, Cortez A, Darai E. Diagnostic accuracy of transvaginal sonography for deep pelvic endometriosis. Ultrasound Obstet Gynecol 2004;24:180–5.
13. Bazot M, Darai E, Hourani R, Thomassin I, Cortez A, Uzan S, et al. Deep pelvic endometriosis: MR imaging for diagnosis and prediction of extension of disease. Radiology 2004;232:379–89.
14. Bazot M, Darai E. Sonography and MR imaging for the assessment of deep pelvic endometriosis. J Minim Invasive Gynecol 2005;12:178–85.
15. Chapron C, Vieira M, Chopin N, Balleyguier C, Barakat H, Dumontier I, et al. Accuracy of rectal endoscopic ultrasonography and magnetic resonance imaging in the diagnosis of rectal involvement for patients presenting with deeply infiltrating endometriosis. Ultrasound Obstet Gynecol 2004;24:175–9.
16. Delpy R, Barthet M, Gasmi M, Berdah S, Shojai R, Desjeux A, et al. Value of endorectal ultrasonography for diagnosing rectovaginal septal endometriosis infiltrating the rectum. Endoscopy 2005;37:357–61.
17. Bazot M, Malzy P, Cortez A, Roseau G, Amouyal P, Darai E. Accuracy of transvaginal sonography and rectal endoscopic sonography for the diagnosis of deep infiltrating endometriosis. Ultrasound Obstet Gynecol 2007;30:994–1001.
18. Balleyguier C, Chapron C, Dubuisson JB, Kinkel K, Fauconnier A, Vieira M, et al. Comparison of magnetic resonance imaging and transvaginal ultrasonography in diagnosing bladder endometriosis. J Am Assoc Gynecol Laparosc 2002;9:15–23.
19. Atri M, Reinhold C, Mehio AR, Chapman WB, Bret PM. Adenomyosis: US features with histologic correlation in an in-vitro study. Radiology 2000;215:783–90.
20. Bazot M, Darai E, Rouger J, Detchev R, Cortez A, Uzan S. Limitations of transvaginal sonography for the diagnosis of adenomyosis, with histopathological correlation. Ultrasound Obstet Gynecol 2002;20:605–11.
21. Touboul C, Fauconnier A, Zareski E, Bouhanna P, Daraï E. The lateral infraureteral parametrium: myth or reality? Am J Obstet Gynecol 2008;199:242.e1–6.
22. Nishimura K, Togashi K, Itoh K, Fujisawa I, Noma S, Kawamura Y, et al. Endometrial cysts of the ovary: MR imaging. Radiology 1987;162:315–8.
23. Togashi K, Nishimura K, Itoh K, Fujisawa I, Noma S, Kanaoka M, et al. Adenomyosis: diagnosis with MR imaging. Radiology 1988;166:111–4.
24. Togashi K, Nishimura K, Kimura I, Tsuda Y, Yamashita K, Shibata T, et al. Endometrial cysts: diagnosis with MR imaging. Radiology 1991;180:73–8.
25. Clement MD. Diseases of the peritoneum (including endometriosis). In: Kurman RJ, ed. Blaustein's pathology of the female genital tract. 5th ed. New York: Springer-Verlag, 2002:729–89.
26. Cornillie FJ, Oosterlynck D, Lauweryns JM, Koninckx PR. Deeply infiltrating pelvic endometriosis: histology and clinical significance. Fertil Steril 1990;53:978–83.
27. Adamson GD, Nelson HP. Surgical treatment of endometriosis. Obstet Gynecol Clin North Am 1997;24:375–409.
28. Reich H, McGlynn F, Salvat J. Laparoscopic treatment of cul-de-sac obliteration secondary to retrocervical deep fibrotic endometriosis. J Reprod Med 1991;36:516–22.
29. Chapron C, Dubuisson JB, Chopin N, Foulot H, Jacob S, Vieira M, et al. Deep pelvic endometriosis: management and proposal for a "surgical classification". Gynecol Obstet Fertil 2003;31:197–206.
30. Redwine DB, Wright JT. Laparoscopic treatment of complete obliteration of the cul-de-sac associated with endometriosis: long-term follow-up of en bloc resection. Fertil Steril 2001;76:358–65.
31. Darai E, Thomassin I, Barranger E, Detchev R, Cortez A, Houry S, et al. Feasibility and clinical outcome of laparoscopic colorectal resection for endometriosis. Am J Obstet Gynecol 2005;192:394–400.
32. Darai E, Marpeau O, Thomassin I, Dubernard G, Barranger E, Bazot M. Fertility after laparoscopic colorectal resection for endometriosis: preliminary results. Fertil Steril 2005;84:945–50.
33. Dubernard G, Piketty M, Rouzier R, Houry S, Bazot M, Darai E. Quality of life after laparoscopic colorectal resection for endometriosis. Hum Reprod 2006;21:1243–7.
34. Fauconnier A, Chapron C. Endometriosis and pelvic pain: epidemiological evidence of the relationship and implications. Hum Reprod Update 2005;11:595–606.
35. Koninckx PR, Meuleman C, Oosterlynck D, Cornillie FJ. Diagnosis of deep endometriosis by clinical examination during menstruation and plasma CA-125 concentration. Fertil Steril 1996;65:280–7.
36. Abrao MS, Goncalves 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;22:3092–7.

37. Ripps BA, Martin DC. Correlation of focal pelvic tenderness with implant dimension and stage of endometriosis. J Reprod Med 1992;37:620–4.
38. Simoens S, Hummelshoj L, D'Hooghe T. Endometriosis: cost estimates and methodological perspective. Hum Reprod Update 2007;13:395–404.
39. 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.
40. Bazot M, Bornier C, Dubernard G, Roseau G, Cortez A, Darai E. Accuracy of magnetic resonance imaging and rectal endoscopic sonography for the prediction of location of deep pelvic endometriosis. Hum Reprod 2007;22:1457–63.
41. 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: 2317–20.
42. Chapron C, Chopin N, Borghese B, Foulot H, Dousset B, Vacher-Lavenu MC, et al. Deeply infiltrating endometriosis: pathogenetic implications of the anatomical distribution. Hum Reprod 2006.
43. Dessole S, Farina M, Rubattu G, Cosmi E, Ambrosini G, Nardelli GB. Sonovaginography is a new technique for assessing rectovaginal endometriosis. Fertil Steril 2003;79:1023–7.
44. Takeuchi H, Kuwatsuru R, Kitade M, Sakurai A, Kikuchi I, Shimanuki H, et al. A novel technique using magnetic resonance imaging jelly for evaluation of rectovaginal endometriosis. Fertil Steril 2005;83: 442–7.
45. Anaf V, Simon P, Fayt I, Noel J. Smooth muscles are frequent components of endometriotic lesions. Hum Reprod 2000;15:767–71.