Accuracy of magnetic resonance imaging and rectal endoscopic sonography for the prediction of location of deep pelvic endometriosis

Marc Bazot1,5, Carole Bornier1, Gil Dubernard2, Gilles Roseau4, Annie Cortez3 and Emile Darai2

1Services de Radiologie, 2Gynécologie-Obstétrique, 3Anatomo-pathologie, Hôpital Tenon, Paris, APHP, France and 4Centre chirurgical Trocadéro, département d’endoscopie digestive, Paris, France

5To whom correspondence should be addressed at: Service de Radiologie, Hôpital Tenon, 4 rue de la Chine, 75020 Paris, APHP, France. Tel: +33 1 56 01 64 53; Fax: +33 1 56 01 64 02; E-mail: marc.bazot@tnn.aphp.fr

BACKGROUND: We compared the accuracy of magnetic resonance imaging (MRI) and rectal endoscopic sonography (RES) for the diagnosis of deep pelvic endometriosis (DPE), with respect to surgical and histological findings.

METHODS: Longitudinal study of 88 consecutive patients referred for surgical management of DPE, who underwent both MRI and RES pre operatively. The diagnostic criteria were identical for MRI and RES and were based on visualization of hypointense/hypoechoic areas in specific locations. DPE was diagnosed when at least one site was involved. We calculated the sensitivity, specificity, predictive values, accuracy and 95% confidence interval of MRI and RES for DPE. RESULTS: DPE and endometriomas were present in 97.7 and 39.7% of women, respectively. The sensitivity, specificity and positive and negative predictive values of MRI and RES, respectively, were 84.8 and 45.6%, 88.8 and 40%, 98.5 and 87.8% and 40 and 8.5% for uterosacral endometriosis; 77.7 and 7.4%, 70% and 100, 85.3 and 100% and 89.7 and 70.9% for vaginal endometriosis and 88.3 and 90%, 92.8 and 89.3%, 96.4 and 94.7% and 78.8 and 80.6% for colorectal endometriosis. CONCLUSIONS: MRI is more accurate than RES for the diagnosis of uterosacral and vaginal endometriosis, whereas the two methods are similarly accurate for colorectal endometriosis.

Key words: endometriosis/magnetic resonance imaging/rectal endoscopic sonography/ultrasonography/uterosacral ligaments

Introduction

Deep pelvic endometriosis (DPE) is defined as the presence of endometrial implants, fibrosis and muscular hyperplasia below the peritoneum. DPE involves, in descending order of frequency, the uterosacral ligaments, the rectosigmoid colon, the vagina and the bladder (Jenkins et al., 1986). The exact incidence of DPE is unknown, but DPE is diagnosed in about one in five women with pelvic endometriosis.

Despite a strong correlation between symptoms and DPE (Fauconnier et al., 2002; Chapron et al., 2003a), physical examination, even during menstruation, has a limited capacity to diagnose and quantify DPE (Konicckx and Martin, 1994; Chapron et al., 2002a). Transrectal or rectal endoscopic sonography (RES), transvaginal sonography (TVS) and magnetic resonance imaging (MRI) have been all recommended to diagnose and locate DPE (Chapron et al., 1998; Kinkel et al., 1999; Roseau et al., 2000; Bazot et al., 2001, 2003, 2004a; Bazot and Darai, 2005).

Transrectal sonography (TRS) and RES have been recommended for the diagnosis of uterosacral, rectovaginal septal and intestinal endometriosis (Ohba et al., 1996; Chapron et al., 1998, 2004 Fedele et al., 1998; Roseau et al., 2000; Delpy et al., 2005). RES with a high-frequency probe is more widely used than TRS because it provides an overview of the rectosigmoid colon (Chapron et al., 1998, 2004; Roseau et al., 2000; Delpy et al., 2005). However, Delpy et al. (2005) reported that RES was poorly accurate for evaluating the various locations of DPE, with the exception of intestinal endometriosis.

Several reports have suggested that MRI is the best noninvasive method for evaluating the different locations of pelvic endometriosis (Arrive et al., 1989; Togashi et al., 1991; Siegelman et al., 1994; Takahashi et al., 1994; Fedele et al., 1997; Outwater et al., 1998; Kinkel et al., 1999; Balleyguier et al., 2002; Bazot et al., 2004b). Recently, we found that MRI permitted accurate diagnosis of both anterior and
posterior DPE (Bazot et al., 2004b). Chapron et al. (2004) concluded that RES was more reliable than MRI for detecting intestinal endometriosis.

The aims of this study were to evaluate the accuracy of MRI and RES for the prediction of location of DPE, in a large series of women with surgical and histological documentation.

Materials and methods

This longitudinal study involved 88 consecutive women referred for surgical management of DPE between April 2000 and March 2005. All the women underwent both MRI and RES before surgery. The women ranged in age from 20 to 51 years (mean 32.1 years). Twenty-nine patients (32.9%) had a history of pelvic surgery. The principal clinical disorders were dysmenorrhoea (n = 70), dyspareunia (n = 55), dyschezia (n = 28), urinary disorders (n = 3) and infertility (n = 19).

All MRI and RES examinations were performed independently by different physicians and were interpreted in real time.

MRI technique and analysis

Patients fasted for at least 3 h before MRI and received an i.v. antispasmodic drug at the outset of the examination to decrease bowel peristalsis. MR images were acquired on a 1.5 T device. The protocol always included sagittal and axial fast spin-echo T2-weighted images and gradient echo T1 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 could be performed, especially for suspected rectal involvement. The performance of the different sequences was not compared.

The MR images were analysed in real time by different radiologists. Interobserver variability was not calculated. The radiologists were asked to determine whether DPE was present or absent. DPE was defined as the presence of implants of endometrial tissue in the subperitoneal space and in intraperitoneal structures (mainly the intestinal tract, and especially the sigmoid colon). Additional disorders such as ovarian endometriosis, the topography of the uterus (anteverted or retroverted) and associated uterine adenomyosis were diagnosed using published criteria (Nishimura et al., 1987; Togashi et al., 1988, 1991; Bazot et al., 2001).

The diagnosis of DPE was based on the combined presence of signal abnormalities (Bazot et al., 2004b) (e.g. hyperintense foci on T1-weighted and/or fat-suppression T1-weighted MR images, corresponding to haemorrhagic foci or small hyperintense cavities on T2-weighted images, or areas corresponding to fibrosis, with a signal close to that of pelvic muscle on T1- and T2-weighted images, with or without foci or cavities and with or without contrast enhancement after gadolinium injection) and morphological abnormalities. These features were evaluated at each site of posterior or anterior DPE. The abnormalities varied according to the anatomical location, as follows.

Posterior pelvic space

Uterosacral ligaments (USLs): involvement by endometriosis was recorded when the ligament bore a nodule (regular or with stellate margins) or showed fibrotic thickening compared to the contralateral USL, with regular or irregular margins (Figure 1). The unilateral/bilateral nature of the involvement, and involvement of the torus uterinus (arciform abnormality), was noted. When a USL was considered abnormal and was clearly distinguished from adjacent structures, its size was measured in its proximal portion, close to its insertion on the cervix, on the axial or sagittal view.

Vagina: obliteration of the hypointense signal of the posterior vaginal wall on T2-weighted images, with thickening or a mass (containing or not containing foci) behind the posterior wall of the cervix (Figure 2).

Rectovaginal septum: nodule or mass passing through the lower border of the posterior lip of the cervix (under the peritoneum) (Figure 3).

Rectum/sigmoid colon: disappearance of the fat tissue plane lying between the uterus and the rectum/sigmoid colon and its replacement by a tissue mass; disappearance of the hypointense signal of the anterior wall of the rectum/sigmoid colon on T2-weighted images and contrast enhancement on T1-weighted images (Figure 4). Abnormalities forming an obtuse angle with the wall of the rectum/sigmoid colon, the degree of extension and particularly the distance...
between the lower limit of the fibrotic mass and the rectal–anal junction were recorded.

**Anterior pelvic space**
Bladder involvement: nodule or mass usually located at the level of the vesicouterine pouch, forming an obtuse angle with the bladder wall; extension through the bladder wall involving the muscularis layer (obliteration of the hypointense signal of the wall on T2-weighted images), or protruding into the lumen with invasion of the mucosal layer (Figure 5).

**Rectal endoscopic sonography**
After a simple rectal enema, RES was performed with an Olympus GF UM 20 Echo endoscope (SCOP Medicine Olympus, 94150 Rungis, France) with a diameter of 11.4 mm, operating at 7.5 and 12 MHz. The procedure was performed under general anaesthesia in 40 women (45.5%) and with local or topical anaesthesia in 48 women (54.5%). The transducer was always positioned in the sigmoid and then slowly withdrawn through the sigmoid and rectum. Studies of the bowel wall and adjacent areas were carried out by moving the probe up and down several times before and after instilling water into the intestinal lumen. Involvement of the uterosacral ligaments, the vagina and the rectosigmoid colon was analysed.

DPE was defined by the presence of a hypoechoic nodule or mass, with or without regular contours. The largest diameter of the lesions, their location relative to the anal margins and infiltration of adjacent pelvic organs were assessed. In the rectum and/or sigmoid colon, involvement of the muscularis propria (hypoechoic and thin) was distinguished from the hyperechoic submucosa and mucosa (Figure 6). When possible, an attempt was made to evaluate the depth to which the deep endometriosis penetrated into the rectal wall (muscularis propria, submucosa or mucosa).

**Surgical and pathological findings**
The histological criteria used for the diagnosis of pelvic endometriosis included the presence of ectopic endometrial tissue (ectopic glands together with stroma) (Clement, 2002).

DPE was diagnosed in the following circumstances: (i) if endometrial tissue (glands and stroma) was found on histological examination of at least one resected subperitoneal lesion (Cornillie et al., 1990); (ii) DPE was directly visualized during laparoscopy or laparotomy but only fibrosis and smooth-muscle cells were found on biopsy, or the lesion was not biopsied (Adamson and Nelson, 1997). In this latter case, subperitoneal endometriosis was diagnosed if another histologically proven site of endometriosis was found. (iii) Complete cul-de-sac obliteration secondary to endometriosis was observed but could not necessarily be surgically cleared. Like Reich et al. (1991), we considered that deep retrocervical endometriosis was present below the peritoneum in such cases.

The largest diameter of the lesions was measured by palpation after colorectal resection. Infiltration of the muscularis propria, submucosa or mucosa of the rectosigmoid colon was analysed.

As recommended by Chapron et al. (2003), a deep endometriotic location was considered isolated (bladder or USLs or vagina or intestine) when it was not associated with any of the other deep pelvic endometriotic locations.
Statistical analysis

The sensitivity, specificity, positive and negative predictive values, accuracy and 95% confidence interval of MRI and RES were evaluated for each site of endometriotic involvement.

Parametric and non-parametric continuous variables were compared using Student’s t-test, and categorical variables were compared using the chi-square test, Fisher’s exact test, the Mac Nemar test or the Z-statistic as appropriate. P < 0.05 were considered statistically significant.

Results

Surgical and pathological findings

DPE was found at surgery plus biopsy and at surgery alone in 78/86 (90.7%) and 8/86 (9.3%) cases, respectively. DPE was associated with endometriomas in 35/88 cases (39.8%). Two patients with clinical and surgical signs of uterosacral endometriosis did not meet all the histological criteria for endometriosis and were thus considered disease-free, but one of these two women had a histologically confirmed endometrioma. The distribution of the different sites of DPE is reported in Table I.

DPE was posterior and anterior in 86 (97.7%) and 3 (3.4%), respectively, of the 88 women. Both the anterior and posterior compartments were involved in three women (3.4%).

Among women who underwent colorectal resection (61.4%), histological examination confirmed endometriotic involvement of the muscularis propria, submucosa and mucosa in 51 (94.4%), 19 (35.2%) and 2 (3.7%) cases, respectively.

Involvement of the muscularis propria, submucosa and mucosa was detected in 17 (62.5%), with seven and two false-negative and false-positive cases, respectively.

Among women who underwent colorectal resection (5.8%), with five and one false-negative and false-positive cases, respectively.

Among women who underwent colorectal resection (6.8%), with seven and four false-negative and false-positive cases, respectively.

The sensitivity, specificity, positive and negative predictive values and accuracy of MR imaging for the diagnosis of the different locations of pelvic endometriosis are shown in Table II.

MRI yielded a diagnosis of USL endometriosis in 68 patients (77.3%), with 12 and 1 false-negative and false-positive cases, respectively.

MRI yielded a diagnosis of vaginal endometriosis in 30 patients (34%), with six and nine false-negative and false-positive cases, respectively.

MRI yielded a diagnosis of rectovaginal endometriosis in five patients (5.8%), with five and one false-negative and false-positive cases, respectively.

MRI yielded a diagnosis of intestinal endometriosis in 55 patients (62.5%), with seven and two false-negative and false-positive cases, respectively.

MRI yielded a diagnosis of bladder endometriosis in three patients (3.7%). The mean size of endometriotic lesions of the bladder was 28.1 mm (range 25–30 mm).

MRI yielded a diagnosis of ovarian endometriosis in 41 (46.6%) patients, with one and seven false-negative and false-positive cases, respectively.

RES findings

The sensitivity, specificity, positive and negative predictive values and accuracy of RES for the diagnosis of the different locations of pelvic endometriosis are given in Table III.

RES yielded a diagnosis of USL endometriosis in 41 patients (46.6%), with 43 and 5 false-negative and false-positive cases, respectively.

RES yielded a diagnosis of vaginal endometriosis in two patients (2.3%), with 25 false-negative cases and no false-positive case.

RES yielded a diagnosis of rectovaginal endometriosis in six patients (6.8%), with seven and four false-negative and false-positive cases, respectively.

Table I. Surgically and pathologically documented sites of deep pelvic endometriosis

<table>
<thead>
<tr>
<th>Deep pelvic locations</th>
<th>Surgery</th>
<th>Biopsy</th>
<th>Histology</th>
<th>Isolated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posterior USLs</td>
<td>86</td>
<td>78</td>
<td>76</td>
<td>83</td>
</tr>
<tr>
<td>Vagina</td>
<td>81</td>
<td>71</td>
<td>69</td>
<td>18</td>
</tr>
<tr>
<td>Rectovaginal septum</td>
<td>27</td>
<td>18</td>
<td>18</td>
<td>1</td>
</tr>
<tr>
<td>Intestines</td>
<td>60</td>
<td>54</td>
<td>51</td>
<td>3</td>
</tr>
<tr>
<td>Sigmoid colon</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Rectosigmoid junction</td>
<td>42</td>
<td>38</td>
<td>35</td>
<td>1</td>
</tr>
<tr>
<td>Rectum</td>
<td>12</td>
<td>11</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Anterior: bladder</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

USLs, uterosacral ligaments.

Isolated DPE of the bladder, vagina, intestines and USLs was detected in 1/88 (1.1%), 1/88 (1.1%), 3/88 (3.4%) and 18/88 (20.5%) patients, respectively.

Table II. Pelvic endometriosis: correlation of magnetic resonance imaging results with surgical and pathological findings

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity (95% CI)</th>
<th>Specificity (95% CI)</th>
<th>PPV (95% CI)</th>
<th>NPV (95% CI)</th>
<th>Accuracy (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>USLs</td>
<td>84.8% (67/79)</td>
<td>88.8% (8/9)</td>
<td>98.5% (67/68)</td>
<td>40% (12/30)</td>
<td>78.0% (75/88)</td>
</tr>
<tr>
<td>Vagina</td>
<td>77.7% (21/27)</td>
<td>85.5% (52/61)</td>
<td>70% (21/30)</td>
<td>89.7% (52/61)</td>
<td>84.2% (73/88)</td>
</tr>
<tr>
<td>RV septum</td>
<td>44.4% (4/9)</td>
<td>98.7% (78/79)</td>
<td>86% (4/5)</td>
<td>93.9% (78/83)</td>
<td>93.2% (82/88)</td>
</tr>
<tr>
<td>Intestines</td>
<td>88.3% (53/60)</td>
<td>92.8% (26/28)</td>
<td>96.4% (53/55)</td>
<td>78.8% (26/33)</td>
<td>89.8% (79/88)</td>
</tr>
<tr>
<td>Ovary</td>
<td>97.1% (34/35)</td>
<td>86.8% (46/53)</td>
<td>82.9% (34/41)</td>
<td>97.9% (46/47)</td>
<td>90.9% (80/88)</td>
</tr>
</tbody>
</table>

RV septum, rectovaginal septum; PPV, positive predictive value; NPV, negative predictive value; CI, confidence interval.
RES yielded a diagnosis of intestinal endometriosis in 57 patients (64.8%), with six and three false-negative and false-positive cases, respectively.

RES yielded a diagnosis of ovarian endometriosis in 26 patients (29.5%), with 13 and 4 false-negative and false-positive cases, respectively.

**Comparison of MRI and RES for the diagnosis of posterior**

With histological findings as the reference standard, MRI and RES correctly diagnosed DPE in 84 and 64 women, respectively, and colorectal endometriosis in 53 and 54 women. The Mac Nemar test showed a significant difference in diagnostic accuracy between MRI and RES as regards DPE ($P < 0.05$), but not colorectal endometriosis.

There was one false-positive RES diagnosis of DPE (uterosacral endometriosis). When the results of the two methods were combined, there remained seven false-negative diagnoses, all of uterosacral endometriosis. RES gave 21 false-negative diagnoses, of which 14 (66.7%) were correctly diagnosed by MRI. MRI gave 11 false-negative diagnoses, of which 4 (36.4%) were correctly diagnosed by RES.

Among the 54 cases of resected colorectal endometriosis, MRI and RES correctly diagnosed muscularis propria involvement in 50/51 (98%) and 46/51 cases (90.2%), respectively. RES correctly diagnosed submucosal and mucosa rectal infiltration in 3/19 (15.8%) and 0/2 cases, respectively.

The largest macroscopic diameter of the endometriotic lesions ranged from 5 to 95 mm (mean 33.26 mm). The mean size ($\pm$ range) of the colorectal lesions, as assessed by MRI and RES, respectively, was 29.8 mm (range 5–60 mm) and 14.5 mm (range 10–35 mm). Relative to histological measurements, the size of colorectal endometriotic lesions was correctly assessed by MRI ($P < 0.05$) but not by RES.

**Discussion**

This longitudinal study shows that MRI is more accurate than RES for diagnosing the different sites of DPE, with the exception of intestinal endometriosis, for which MRI and RES had similar accuracy.

Correct evaluation of the location and extent of endometriotic involvement is important, so that patients can be given appropriate information on the potential risks of surgery. Although TVS is the main imaging technique used to evaluate pelvic endometriosis, there are few data on its accuracy for DPE (Bazot et al., 2004a; Bazot and Darai, 2005). Other imaging techniques such as TRS, RES and MRI have also been recommended (Fedele et al., 1997; Chapron et al., 1998; Kinkel et al., 1999; Roseau et al., 2000; Balleyguier et al., 2002; Bazot et al., 2004b; Delpy et al., 2005). Our findings support the results of a previous study showing that MRI is highly accurate for the diagnosis of both anterior and posterior DPE (Bazot et al., 2004b). In contrast, RES cannot explore anterior endometriotic locations. In addition, RES is not suitable for diagnosing endometrial ovarian cysts. Indeed, RES probes, operating from 7.5 to 12 MHz, permit adequate evaluation of proximal organs and anatomic structures. We therefore restricted our comparison of RES and MRI to the diagnosis of endometriosis involving the USLs, rectosigmoid colon, vagina and rectovaginal septum.

This study confirms that the USLs are the main site of DPE. Involvement of this site was isolated in 22% of our patients. Delpy et al. (2005) reported that RES had a sensitivity of 42% (8/19 cases) for USL endometriosis, a value similar to that found here. In contrast, Fedele et al. (1998) reported that TRS had a sensitivity of 80% (8/10) for USL involvement. This discrepancy may be partly explained by the high prevalence of multiple posterior DPE in our series, possibly contributing to an underestimation of this location. Preoperative diagnosis of USL endometriosis is particularly important for the surgeon, as removal of these lesions is associated with a high risk of bladder dysfunction (Volpi et al., 2004). Nerve-sparing surgery of the inferior hypogastric plexus has been recommended to avoid this complication; it is especially feasible in women with isolated USL endometriosis, whereas more extensive endometriotic lesions are not always compatible with this conservative surgery (Volpi et al., 2004).

Rectosigmoid endometriosis is one of the most severe forms of DPE. Colorectal resection is associated with a high risk of complications, but less extensive surgery can be associated with clinical recurrences requiring additional treatment (Fedele et al., 2004, 2005). Dubernard et al. (2006) have shown that colorectal resection is associated with a significant improvement in quality of life. Therefore, accurate preoperative diagnosis of intestinal endometriosis is essential to inform women on the specific risks of surgery (especially
de-novo digestive and urinary symptoms). In the current study, MRI and RES had similar accuracies for intestinal endometriosis with muscularis propria involvement. However, neither MRI nor RES correctly assessed the depth of penetration into the bowel wall. MRI also accurately showed the size of colorectal endometriotic lesions, contrary to RES. Further studies are required to determine the place of RES, alone or combined with MRI, in the pre-operative assessment of intestinal endometriosis, particularly in terms of cost-effectiveness and availability relative to MRI. In this specific setting, RES that require general anaesthesia in several patients may be used only to better define the lesion suspected by MRI.

One-third of our patients had vaginal endometriosis, almost always associated with other sites of DPE. Its diagnosis is particularly important, owing to the need for specific additional procedures and to the complications of surgical excision. Indeed, excision of vaginal endometriosis raises specific surgical issues, such as pelvic infection and rectovaginal fistulae, especially in women with associated rectosigmoid involvement. Concomitant vaginal and intestinal resection is required, carrying a risk of rectovaginal fistulae, which is the main complication of colorectal resection (Darai et al., 2005a). Protective colostomy is required to avoid this complication, imposing the need for a second operation; post-operative adhesions are also frequent, with possible repercussions for subsequent fertility (Darai et al., 2005b). We found that MRI had acceptable accuracy for the diagnosis of vaginal endometriosis, whereas RES failed to identify 25 of the 27 cases. One possible explanation for the low accuracy of RES is its inability to distinguish between rectal and vaginal endometriosis, as the ultrasound energy is absorbed by the first few millimetres of bowel involvement.

Rectovaginal septum involvement was relatively infrequent in this study (10.2%) and was always associated with other sites of DPE. Nisolle and Donnez (1997) suggested that rectovaginal septum endometriosis should be considered as an adenomyotic lesion corresponding to the reminiscence of embryonic residual septum endometriosis. However, our findings support the three-step development of pelvic endometriosis postulated by Koninckx et al. (1991, 1994) and recently confirmed by Chapron et al. (2002b). MRI and RES both had low sensitivity and high specificity for rectovaginal septum endometriosis, in keeping with previous reports (Bazot et al., 2003, 2004b).

Several limitations of our study must be considered. First, the prevalence of DPE was particularly high, creating a possible source of bias. As a matter of fact, the posterior probability of positive test (100%) was truly similar to pretest probability (98%, i.e. prevalence). Our findings cannot therefore be extrapolated to the general population of women with symptoms of DPE. To evaluate the overall presence of DPE, another study including patients with chronic pelvic pain, not only patients referred for surgical management of DPE, should be performed. Second, we were unable to refine the specific indications of RES, owing to the retrospective nature of our study. Finally, no attempt was made to evaluate the intra- and inter-observer variability of MRI and RES.

In conclusion, this study shows that MRI is more accurate than RES for the diagnosis of DPE and for determining the precise sites of involvement. In contrast, MRI and RES had similar accuracy for the diagnosis of intestinal endometriosis. Further studies are required to determine the precise place of RES in the pre-operative assessment of DPE.

References