Ultrasound diagnosis of pelvic endometriosis

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Abstract

Purpose: Endometriosis remains a challenging condition for clinicians, research scientists, and patients alike. Routine clinical examination is insufficient to diagnose and evaluate the extent of pelvic endometriosis which can be assessed by means of imaging techniques, including transvaginal sonography (TVS), transrectal sonography (TRS), rectal endoscopic sonography (RES), and magnetic resonance imaging (MRI). Our purpose was to analyze the different imaging techniques and their efficacy for the ultrasound diagnosis of pelvic endometriosis.

Materials and methods: This review examined 85 studies on the ultrasound diagnosis of endometriosis published between 2005 and 2010. The structure of the review is based first on the anatomical location of the endometriosis lesion, and then on the study of the techniques used, including transvaginal sonography, transrectal sonography, rectal endoscopic sonography, and MRI.

Results: TVS is the first-line imaging technique for diagnosing pelvic endometriosis. Many studies have demonstrated that sensitivities and specificities of TVS for diagnosing endometriomas range from 75% to 91% and 88% to 99%, respectively, while for RES the percentages are 88% and 90%, respectively, for the diagnosis of intestinal endometriosis. TVS and RES can correctly diagnose posterior deep infiltrating endometriosis (DIE) with an accuracy of 86.4% and 74.1%, respectively.

Conclusions: The analysis of these results show that ultrasound is the first-line diagnostic technique for the diagnosis of pelvic endometriosis. RES can help to identify the presence and the degree of wall infiltration of bowel sites. However, in patients with a consistent clinical suspicion of deep endometriosis, MRI is a good “all in one” examination to diagnose and define the exact extent of DIE.

Keywords: Ultrasound endometriosis, Endometriosis diagnosis, Deep endometriosis, Uterosacral endometriosis, Posterior endometriosis, Bladder endometriosis

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Introduction

Endometriosis is defined by the presence of the ectopic endometrial glands and stroma outside the uterus. Pelvic endometriosis may involve the peritoneum and ovaries as well as all pelvic organs. Deep infiltrating endometriosis (DIE), which is often associated with peritoneal and ovarian lesions, may involve the uterosacral ligaments (USL), the pouch of Douglas (partial or complete obliteration), the vagina, the rectum, and occasionally the bladder. DIE constitutes a major concern for the gynecologist in view of the greater severity of symptoms associated with this form of the disease, and its therapeutic complexity (1). Endometriosis remains a challenging condition for clinicians, research scientists, and patients alike. Continuous growth of endometriotic tissue is dependent upon estrogen. Thus endometriosis is more prevalent in reproductive years with a peak of incidence between 30 and 45 years of age. The estimated prevalence of endometriosis ranges between 10% and even more than 50%, depending on the underlying problems of the women studied (2). The hallmarks of endometriosis are peritoneal endometrial implants, endometriomas (endometriotic cysts), deep infiltrating endometriosis, and adhesions. It is a cause of pelvic
pain, dysmenorrhea, dyspareunia, dyschezia, and urinary symptoms, and it is associated with infertility.

Routine clinical examination is insufficient to diagnose and evaluate the extent of deep pelvic endometriosis (3). Pelvic endometriosis can be assessed by means of several imaging techniques, including transvaginal sonography (TVS), transrectal sonography (TRS), rectal endoscopic sonography (RES), and magnetic resonance imaging (MRI). TVS is the first-line diagnostic technique, owing to its relatively high accuracy and accessibility. Although it is usually the recommended procedure for diagnosing ovarian and bladder endometriosis, few data are available on the value of TVS for the assessment of deep pelvic endometriosis. TVS is the method of choice for differentiating endometriomas from other ovarian cysts.

Few studies have confirmed the relevance of TRS for the diagnosis of deep pelvic endometriosis since it was first reported. RES has been recommended to identify rectovaginal and/or uterosacral involvement. A combination of RES and MRI imaging has been proposed to evaluate posterior pelvic endometriosis (3). Despite a strong correlation between symptoms and DIE, conducting a physical examination, even during menstruation, has a limited capacity to diagnose and quantify DIE. RES, TVS and MRI have been recommended in various papers as an integrated approach to diagnose and locate DIE (84). TRS and RES, particularly, have been recommended for the diagnosis of uterosacral, rectovaginal, septal and intestinal endometriosis (4, 35). These methods are important for establishing the locations of the lesions and for assessing their size, which may be useful information for determining the choice of surgical technique to be used when surgery is indicated.

In recent years, some studies have emphasized the use of RES for evaluating deep endometriosis, and have reported promising results in view of the broad availability and good tolerability of the diagnostic tool. The use of MRI for the diagnosis of endometriosis underwent a major milestone following the publication of a study carried out by Nishmura et al (1987), who demonstrated the value of this method in the diagnosis of ovarian endometriosis. Although this diagnostic tool has been shown to be effective for evaluating the ovary, TVS remains the diagnostic method of choice in these situations, generally reserving MRI as a tool for resolving cases in which there is some doubt. The purpose of this study was to analyze the role of imaging techniques and their efficacy for the ultrasound diagnosis of pelvic endometriosis.

**MATERIALS AND METHODS**

This review examines 85 studies on the ultrasound diagnosis of pelvic endometriosis published between 2005 and 2010. The search was carried out on Medline, Embase, and The Cochrane Library using as key words endometriosis, ultrasound endometriosis, endometriosis diagnosis, deep endometriosis, uterosacral endometriosis, posterior endometriosis, bladder endometriosis, 3D endometriosis. We excluded papers on adenomyosis, endometriosis of the abdominal wall, and extrapelvic endometriosis. The structure of the review is based first on analyzing the anatomical site of the endometriotic lesion, and then the techniques used, including transvaginal sonography, trS, rectal endoscopic sonography, and MRI. We made a distinction between endometriosis diagnosis of the posterior compartment and anterior compartments. We also culled a number of images and tables useful for the identification of the described lesions and results which we reproduce in this review. Finally, we analyzed the results of the studies examined.

**TOPOGRAPHY OF LESIONS**

The most common location of endometriosis is the ovary, also defined as endometrioma. Peritoneal lesions can be superficial or deep (exceeding a depth of 5 mm) and cause formation of adhesions and invasion of adjacent organs. The anatomical classification of deep infiltrating endometriosis proposed by Chapron et al in a 2003 study divides such lesions into two groups, defined by location in the anterior or posterior compartment (30, 44). The invasion of the bladder wall, and particularly of the detrusor muscle, defines bladder endometriosis, which is also classified as “anterior endometriosis.” Posterior endometriosis, on the other hand, includes a variety of anatomic locations: the most frequent one corresponds to endometriosis of the USL and the upper portion of the posterior cervix described by anatomists as the “torus uterinus” (Tab. I). The torus uterinus is anatomically defined as a small, transverse thickening that binds the insertion of both USL at the posterior uterus and is therefore treated together with lesion of the USL. Vaginal endometriosis belongs to posterior endometriosis and is located either in the upper portion of the posterior vaginal wall, the rectovaginal pouch, or the posterior vaginal fornix. Ureteral
endometriosis and bowel endometriosis (with invasion of the muscularis propria) are less frequent locations of posterior endometriosis. Frequency and associated symptoms of these locations of deep endometriosis are listed in Table I. Identification of specific locations of deep endometriosis is important especially in the management of rectal or urinary locations because it will lead to a correct multidisciplinary surgical approach (2, 34).

ULTRASOUND TECHNIQUES

Transvaginal sonography

Transvaginal sonography is performed with a wide-band 3.5 to 9 MHz transducer. Color Doppler examination uses a pulse repetitive frequency of 1000 to 1500 Hz, a wall filter of 50 Hz, and a high-priority color setup. Each examination should be interpreted in real-time. The transducer is positioned in the posterior cul-de-sac of the vagina and then slowly withdrawn through the vagina to visualize the posterior subperitoneal space, anatomically defined by the presence of a small transverse thickening joining the original insertion of the USL to the posterior wall of the uterus, the USL, and the posterior fornix of the vagina. The bowel wall and rectovaginal septum are examined by moving the probe up and down several times from the anal canal to the posterior fornix of the vagina. Rotation of the probe is essential to detect posterior endometriotic lesions. The transducer is then positioned in the anterior cul-de-sac of the vagina to examine the vesico-uterine septum and bladder (3).

As Guerriero et al suggest, when the B-mode is inconclusive for the presence of an echogenic portion in a round-shaped homogeneous hypoechoic “tissue” of low-level echoes, power Doppler imaging can be performed to exclude corpus luteum cysts (23).

Rectal endoscopic sonography (RES)

RES at 7.5 and 12 MHz is performed after a simple rectal enema. The transducer is positioned in the sigmoid and then slowly withdrawn through the sigmoid and rectum. Evaluation of the bowel wall and adjacent areas is carried out by moving the probe up and down several times before and after instilling water into the intestinal lumen. Involvement of USL, vagina, and colon/rectum is analyzed. Normal intestinal wall usually appears as a five-layer structure: the fourth hypoechoic layer corresponds to the muscularis propria. The surrounding areas are also scanned, with particular attention paid to the ovaries, cervix and body of the uterus, pouch of Douglas, USL areas and torus uterinum

<table>
<thead>
<tr>
<th>Anatomical location</th>
<th>Frequency</th>
<th>Clinical symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Torus uterinus and uterosacral ligament</td>
<td>69.2%</td>
<td>Deep dysparenuia</td>
</tr>
<tr>
<td>Vagina</td>
<td>14.5%</td>
<td>Painful defecation</td>
</tr>
<tr>
<td>Gastrointestinal symptoms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bowel</td>
<td>9.9%</td>
<td>Noncyclic pain</td>
</tr>
<tr>
<td>Gastrointestinal symptoms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bladder</td>
<td>6.4%</td>
<td>Lower urinary symptoms</td>
</tr>
<tr>
<td>Rectovaginal pouch adhesion</td>
<td>–</td>
<td>Severe dysmenorrhea</td>
</tr>
</tbody>
</table>

*Extracted from 241 patients with 344 pathologically proven lesions of deep endometriosis. Rectovaginal pouch adhesions are frequently associated with endometriosis but are not classified as deeply infiltrating lesions. *Modified from Kinkel et al, 2006 (2)
(16). Deep pelvic endometriosis is defined by the presence of a hypoechoic nodule or mass, with or without regular contours. In the rectum and/or sigmoid colon, involvement of the muscularis propria, which is hypoechoic and thin, is distinguished from the hyperechoic submucosa and mucosa. The largest diameter of the lesions, their location from the anus margins, and infiltration of adjacent pelvic organs must be recorded (3, 38).

**Trasvaginal 3D ultrasonography**

TVS 3D is performed using 3D scan with a wide-band 5 to 9 MHz volume transducer. The examination does not require any bowel preparation. The region of interest (ROI) is identified in 3D sonography using a B-mode scan and a transvaginal volume transducer; the investigator opens the volume box that determines the limits of the volumetric scan region. During the volumetric scan the transducer carries out a series of parallel scans of varying speed focusing on the ROI. The anatomical ROI is finally visualized on the monitor as a graphic containing the three orthogonal planes. During the volumetric scans the investigator adopts some expedients such as positioning the probe near the anatomical ROI and reducing or eliminating the patient’s movements (6, 68).

**Transvaginal ultrasonography combined with water-contrast in the rectum**

Valenzano Menada et al in a prospective study in 2008 sought to determine whether adding water-contrast in the rectum during transvaginal ultrasonography (RCW-TVS) improves the diagnosis of rectal infiltration in women with rectovaginal endometriosis. On the day before surgery, each patient was asked to drink four doses of a granular powder (Selg 1000®; Promefarm, Milan, Italy) dissolved in 1000 mL of water per dose. A few hours before surgery, subject underwent RWC-TVS, using a 3.6 to 8.0 MHz multi-frequency transvaginal probe. A catheter (6 mm) was inserted into the rectal lumen up to a 20 cm distance from the anus and solution saline was injected inside the rectum under ultrasonographic control (7).

**Evaluation of posterior pelvis**

Posterior deep endometriosis is diagnosed if at least one structure (USL, recto-vaginal septum, ureter, ovary, recto- sigmoid colon) is involved. The diagnosis is based on morphological criteria that varies according to the anatomical location, and includes abnormal hypoechoic linear thickening and nodules/masses with or without regular contours (5). The *uterosacral ligaments* (USL) are considered to be involved when they are visible and bear a nodule (regular, or white stellate margins) or show hypoechoic linear thickening with regular or irregular margins. When the affected USL are clearly delineated from adjacent structures, the thickness is measured in the proximal part, near the insertion on the cervix (5).

Kenkel et al (2006), in a review, reported a series of 110 patients with histologically proved deep endometriosis infiltrating the USL, 77.3% (85 patients) of whom complained about severe, deep dyspareunia. Clinical examination was described as normal in 67% of patients with endometriosis of the USL, making further imaging studies necessary for diagnosis and treatment. In the same review, he reported that in a prospective study of 142 patients, TVS identified a hypoechoic nodule lateral to the upper third of the cervix in 64% (sensitivity) and excluded lesions of the USL adequately in 88% (specificity) (2, 33, 74).

Rectovaginal endometriosis involves the connective tissue between the anterior rectal wall and the vagina and it often infiltrates both. When endometriosis infiltrates the rectum, it may cause not only pain but also gastrointestinal symptoms including dyschezia, hematochezia, diarrhea, and constipation (17, 18). Surgical excision of rectovaginal endometriosis has been demonstrated to improve both pain and quality of life. However, the success rate depends on the complete excision of endometriosis, even when it infiltrates the bowel (7, 56, 58). Rectovaginal endometriosis is difficult to assess by clinical examination and infiltration of the rectal wall can only be suspected in 40% to 68% of the cases. Even during laparoscopy, generalist gynecologists may fail to diagnose rectovaginal endometriosis (19, 55). Therefore, imaging techniques are mandatory during the preoperative work-up. Determining before surgery whether bowel muscolaris is infiltrated by endometriosis allows the gynecologist to discuss the surgical approach (nodulectomy or bowel resection) with the colorectal surgeon. Furthermore, determining the presence and extension of rectal nodules allows the gynecologist to obtain informed consent from the patient. This consent is particularly relevant when rectal resection is required, because the risk of complications increases (2, 36, 37, 39, 40).

Several imaging methods have been used in the attempt
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to improve the non-invasive diagnosis of rectal infiltration in women with rectovaginal endometriosis, however TVS is the first-line procedure for the exploration of the pelvic cavity. Bazot et al showed that TVS reliably determines the presence and diameter of colorectal endometriotic lesions (3, 5, 27). Valenzano Menada et al, in a 2008 study including 35 women, showed that TVS combined with water-contrast in the rectum (RWC-TVS) is accurate in diagnosing rectal wall infiltration in women with rectovaginal endometriosis (7).

Rectovaginal endometriosis appears ultrasonographically as rounded or triangular hypoechoic masses, located anterior or lateral to the rectum, immediately adjacent or close to the rectal wall. Rectal endometriotic infiltration is defined by a rectovaginal hypoechoic mass that is adherent and/or penetrating into the intestinal wall, thickening the muscularis mucosa. Hypoechoic or hyperechoic foci are sometimes present (7).

Involvement of the vagina typically causes symptoms involving painful defecation during menstruation and dyspareunia. Diagnosis is usually clinical and identified at physical examination in 80% of cases. The sensitivity of ultrasound is reported to be as low as 29%. This difficulty is due to the configuration of transvaginal ultrasound probes with the receiver oriented toward the vaginal fornix. Orientation of the probe toward the posterior vaginal wall can be limited by the symphysis pubis and associated pain. Dessole et al have described an increase in the sensitivity of transvaginal ultrasound when a saline solution is instilled in the vagina, a procedure called sonovaginography.

As an alternative Guerriero et al in a 2007 study use a modified “tenderness guided” approach in the diagnosis of deep endometriosis of the cul-de-sac, retrocervical region, and rectovaginal septum to determine the accuracy of TVS, obtaining a specificity of 95% with a sensitivity of 90%. In their series, Guerriero et al performed TVUS in all patients. The modified tenderness-guided approach consisted of TVS combined with the introduction of 12 mL of ultrasound transmission gel (instead of the usual 4 mL) in the probe cover to create a stand-off to visualize the nearfield area. The posterior fornix was evaluated accurately with an up-and-down sliding movement of the probe. In addition, when the patient indicated that tenderness was evoked by the probe’s pressure, the sliding movement was stopped, and particular attention was paid to the painful site for detection of endometriosis lesions (8, 60). The vagina was considered to be involved when the posterior vaginal fornix was thickened, with or without a round cystic anechoic area (5).

Another site of deep endometriosis is the bowel (rectosigmoid colon, the appendix, the cecum, and the distal ileum) (Fig.1). The lesion invades serosa, subserosa, and muscularis propria, reacting with hypertrophia and fibrosis. Due to the normal appearance of the mucosa in most patients with bowel endometriosis, diagnosis by colonoscopy is often false negative. Various imaging techniques have been proposed to diagnose the bowel location of endometriosis.

At sonography, transabdominal, transrectal, and transvaginal approaches have been described. A comparative study between rectal endoscopic (transrectal) sonography and transvaginal ultrasound in 30 patients with clinical suspicion of posterior endometriosis indicated equivalent results, with a sensitivity of 84% and a specificity of 99% for transvaginal ultrasound. Diagnostic criteria at sonography for bowel endometriosis include a hypoechoic, irregular-shaped area corresponding to a layer of hypertrophic muscularis propria surrounded by a hyperechoic rim including mucosa, submucosa, and serosa. Nodular masses located within the outer rectal wall are relatively easy to identify by transvaginal US. Locations above the rectosigmoid junction might be beyond the field of view of a transvaginal approach and limited by the presence of air for the transabdominal approach (2). With TVS the rectum/sigmoid colon is considered to be involved when an irregular hypoechoic mass is found, with or without hypoechoic or hyperechoic foci, penetrating into the intestinal wall. In this case, the

Fig. 1 - Bowel endometriosis.
Ultrasound diagnosis of endometriosis

normal aspect of the rectum/sigmoid colon muscularis propria, which is hypoechoic and thin (<3 mm), is replaced by the abnormal tissue mass. No attempt is made to evaluate the depth of endometriotic infiltration within the rectal wall (i.e., submucosa or mucosa). Lesions located on the sigmoid colon or at the rectosigmoid junction replace the normal adipose tissue lying between the uterus and the rectum/sigmoid colon. In particular, rectosigmoid involvement is suspected when nodules are detected with the thin, band-like echoes departing from the center of the mass described as ‘Indian head dress’ (10).

RES defines bowel infiltrating endometriosis by the presence of a hypoechoic nodule or mass, with or without regular contours (5, 41) (Fig. 2).

In the rectum and/or sigmoid colon, involvement of the muscularis propria (hypoechoic and thin) is distinguished from that of the hyperechoic submucosa and mucosa. When possible, an attempt is made to evaluate the depth of infiltration by endometriosis within the rectal wall (i.e., submucosa or mucosa) (5). In addition to routine examination of the uterus and ovaries, the examination protocol includes the peritoneal surface that covers the vesicouterine pouch and the pouch of Douglas, the bowel (rectum, sigmoid colon, appendix, cecum and small intestine), the retrocervical area (uterosacral ligaments, torus uterinus, and posterior vaginal fornix), and rectovaginal septum. Patients are suspected of having deep retrocervical endometriosis when thick blocks of tissue, nodular formations, or irregular shaped, hypoechoic, retractable masses are found in this area, including lesions on the uterosacral ligament, pouch of Douglas, and/or vagina. Bowel involvement is established when a long, nodular, predominantly solid, hypoechoogenic lesion adhering to the wall of the intestinal loop is detected. The degree of infiltration varies, initiating at the serosal layer but sometimes penetrating as far as the mucosal layer (9, 63) (Tab. II).

Ultrasound is the method of choice to identify endometriomas. Several studies have described the ultrasound characteristics of endometriomas and attempted to define their typical ultrasound features. The ‘typical’ endometrioma is a unilocular cyst with homogeneous low-level echogenicity (ground glass echogenicity) of the cyst fluid (23, 69). Suren et al analyzed lesion size and unilocularity versus multilocularity in 122 histologically verified endometriomas. Unilocularity was found in 43% of endometriomas; 81% of the endometriomas ranged between 30 and 59 mm at their largest diameter. Patel et al studied sonographic criteria of 252 adnexal masses at ultrasound in 226 women. The positive predictive value of sonography to predict endometriosis is evaluated at 75% when criteria such as diffuse, low-level internal echoes and absent neoplastic features are used. The presence of hyperechoic foci alone on the surface of

![Fig. 2 - Bowel endometriosis identified with rectal endoscopic sonography (RES).](image)

<table>
<thead>
<tr>
<th>Study</th>
<th>No. Patients</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>PPv</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bazot et al.</td>
<td>34</td>
<td>100</td>
<td>91</td>
<td>83</td>
<td>100</td>
</tr>
<tr>
<td>Abrao et al.</td>
<td>32</td>
<td>100</td>
<td>67</td>
<td>67</td>
<td>100</td>
</tr>
<tr>
<td>Chapron et al.</td>
<td>81</td>
<td>97</td>
<td>89</td>
<td>87</td>
<td>98</td>
</tr>
<tr>
<td>Delpy et al.</td>
<td>30</td>
<td>92</td>
<td>66</td>
<td>64</td>
<td>92</td>
</tr>
</tbody>
</table>

*Modified from Abbas Bahr et al, 2006 (11)
Power and color Doppler supports diagnosis of endometriomas by showing a typical vascularization: regularly separated pericystic vessels with low to moderate vascular resistance. Differential diagnosis between teratomas and endometriomas appears important, as teratomas smaller than 6 cm tend to be treated with expectancy in premenopausal woman. Teratomas typically present an echogenic masses with acoustic shadowing due to hairballs or calcifications such as teeth or bone in the Rokitanski protuberance. Layered lines and dots, fat-fluid level, and isolated bright echogenic foci with acoustic shadowing are characteristic sonographic findings of dermoid cysts. Other differential diagnoses include functional cysts, such as corpus luteum or hemorrhagic follicular cysts, that will disappear or decrease in size at short-time follow-up. Ovarian fibromas demonstrate small vessels within a hypoechogenic attenuating mass at color Doppler examination, whereas tubo-ovarian abscesses present with fever and leucorrhea. Ovarian cancer can be difficult to exclude if wall irregularities are present; absence of color Doppler flow within the cyst helps to confirm the benign nature of the lesion (2, 81). Whenever sonographic features of ovarian masses are indeterminate, MRI is the imaging modality of choice to exclude malignancy (67).

Three-dimensional (3D) scans are useful because they clearly showed blood clots and the regular mural profile. The USL are considered to be involved when in 3D scans they appeared thickened or they showed a regular or irregular hypoechogenic nodule near their insertion on the cervix (77).

Posterior vaginal fornix involvement is seen as a cystic or thickened area. Such abnormalities are seen also in the rectovaginal septum under a horizontal plane passing through the posterior lip of the cervix, under the peritoneum (6). Ghezzi et al in a prospective observational study analyzed the diagnostic and predictive value of ultrasound identification of kissing ovaries in the detection of endometriosis. The diagnosis of “kissing ovaries” was made when both ovaries were joined together behind the uterus in the cul-de-sac and were not separable by pushing the transvaginal probe and by moving the uterus transabdominally. The presence of definite endometriomas was not a prerequisite for the diagnosis of kissing ovaries. The detection of kissing ovaries at ultrasound is strongly associated with the presence of endometriosis and is a marker of the most severe form of this disease.

Evaluation of anterior pelvis

Endometriosis of the urinary tract is rare, occurring in approximately 1% of all patients with endometriosis and involves the bladder in 90% of these cases (14, 51). When endometriosis affects the bladder, its symptoms include suprapubic pain accompanied by cyclic polyuria (41%), dysuria (21%), and hematuria (19%). Repeated urinary infections may also occur. Ureteral endometriosis is generally characterized by nonspecific urinary symptoms, occasionally evolving insidiously to kidney failure. Ureter endometriosis is not associated with bladder disease; however, it is associated with advanced American Society for Reproductive Medicine (ASRM) stages and with retrocervical and rectum-sigmoid lesions. Only a few studies on a handful of cases have evaluated the role of TVS in the preoperative diagnosis of bladder endometriosis and they have reported conflicting results. TVS performed better than transabdominal ultrasound imaging (15, 42, 80).

When the bladder mass or lesion is documented by imaging techniques and/or cystoscopy, the differential diagnosis should include bladder carcinoma, angiomas, leiomyoma, cystopathies (amyloidosis, malakoplakia, glandular cystitis, and nephrogenic adenoma), and extravesical processes such as diverticulitis, with histologic study necessary in almost all cases (21, 61, 82).

In a retrospective analysis, Balleyguier et al (85) recruited 12 consecutive women with bladder endometriosis with recurrent pelvic pain and premenstrual cystalgia. They all underwent transabdominal ultrasound and TVS and MRI, with visibility and depth of infiltration of lesions noted. The researchers defined two types of endometriotic lesions infiltrating the bladder wall: superficial lesions located in the vesicouterine space, peritoneum, and bladder serosa without infiltration of the bladder muscularis; and deep lesions involving the muscularis. At TVS, deep infiltration of the muscularis was defined by a structure that deformed the intraluminal profile of the bladder. In this context, MRI appears to have an advantage over TVS for the diagnosis of deep endometriotic lesions associated with bladder lesions. The ultrasound examinations were performed in a standardized manner using an ultrasound machine equipped with a 5.0 to 8.0 MHz vaginal probe.

The transducer was positioned in the anterior vaginal fornix and tilted upwards to visualize the vesicouterine space.
and the bladder, in longitudinal and transverse sections. In these planes, the bladder wall can easily be visualized if a moderate amount of urine is present. When required, according to the examiner’s judgment, a transabdominal scan with a 3.5 to 5.0 MHz transducer was performed. Consensus regarding the diagnostic criteria suggestive of a bladder endometriotic nodule was reached before starting the study on the basis of the sonographic features described in the literature: the presence of a hypoechogenic or isoechochogenic nodule in the bladder wall, or a nodule with a heterogeneous echostructure containing numerous anechogenic (‘bubble-like’) areas.

Moreover, vascularization of the nodule was evaluated by means of power Doppler imaging, with a pulse repetition frequency of 500 Hz and a wall filter of 50 Hz, to detect low-velocity blood flow. The diagnosis of bladder endometriosis was confirmed at histopathology when endometrial glands and stroma were found infiltrating the bladder muscularis propria (15).

RESULTS

The studies analyzed between 2005-2010 showed the following results on sensitivity, specificity and accuracy of TVS. Transvaginal ultrasound is the first-line imaging technique for diagnosing pelvic endometriosis. Numerous studies have demonstrated that sensitivities and specificities of TVS for diagnosing endometriomas range from 75% to 91% and 88% to 99%, respectively (23).

In several studies published between 2005 and 2010, Bazot et al evaluated the sensibility, the specificity, and the positive and negative predictive power of TVS and RES for the diagnosis of USL, vaginal, recto-vaginal septum, intestinal and ovarian endometriosis (5, 48) (Tabs. III and IV).

In a multicenter study reported in 2010, Van Holsbeke et al analyzed 3511 patients included in the IOTA (International Tumors Ovarian Analysis), 713 (20%) of whom had endometriomas. Fifty-one per cent of the endometriomas were unilocular cysts with ground glass echogenicity of the cyst fluid. These characteristics were found less often among other benign tumors or malignancies, or among the small set of endometriomas (4%) found in postmenopausal patients. The most prominent differences in the ultrasound features of endometriomas and other tumors were in the tumor type and the echogenicity of the cyst fluid: 65% of the endometriomas were unilocular cysts versus 37% of the other benign tumors and 1% of the malignant tumors; 17% of the endometriomas had solid parts versus 40% of the other benign tumors and 93% of the malignant tumors; and 73% of the endometriomas had solid parts versus 40% of the other benign tumors and 6% of malignancies.

Based on the decision-tree analysis, the optimal rule to

### TABLE III - EVALUATION OF PELVIC ENDO METRIOSIS BY TRANSVGAGINAL SONOGRAPHY IN COMPARISON TO SURGICAL AND HISTOLOGICAL FINDINGS IN 81 PATIENTS*

<table>
<thead>
<tr>
<th>Site</th>
<th>Sensitivity % (n)</th>
<th>Specificity % (n)</th>
<th>PPV % (n)</th>
<th>NPV % (n)</th>
<th>Accuracy % (n)</th>
<th>+LR</th>
<th>-LR</th>
</tr>
</thead>
<tbody>
<tr>
<td>USL</td>
<td>80.8 (59/73)</td>
<td>75.0 (6/8)</td>
<td>96.7 (59/61)</td>
<td>30.0 (6/20)</td>
<td>80.3 (65/81)</td>
<td>3.2</td>
<td>0.25</td>
</tr>
<tr>
<td>Vagina</td>
<td>50.0 (13/26)</td>
<td>96.4 (53/55)</td>
<td>86.7 (13/15)</td>
<td>80.3 (53/66)</td>
<td>81.5 (66/81)</td>
<td>1.1</td>
<td>0.52</td>
</tr>
<tr>
<td>RVS</td>
<td>11.1 (1/9)</td>
<td>100 (72/72)</td>
<td>100 (1/1)</td>
<td>90.0 (72/80)</td>
<td>90.1 (73/81)</td>
<td>0.2</td>
<td>0.89</td>
</tr>
<tr>
<td>Intestine</td>
<td>92.2 (50/54)</td>
<td>100 (27/27)</td>
<td>100 (50/50)</td>
<td>87.1 (27/31)</td>
<td>95.1 (77/81)</td>
<td>–</td>
<td>0.17</td>
</tr>
<tr>
<td>Ovary</td>
<td>94.3 (33/35)</td>
<td>84.8 (39/46)</td>
<td>82.5 (33/40)</td>
<td>95.1 (39/41)</td>
<td>88.9 (72/81)</td>
<td>5.9</td>
<td>1.4</td>
</tr>
</tbody>
</table>

+LR, positive likelihood ratio; -LR, negative likelihood ratio; NPV, negative predictive value; PPV, positive predictive value; RVS, rectovaginal septum; USL, uterosacral ligament. *Modified from Bazot et al, 2007 (5)
detect endometriomas was “an adnexal mass in a premenopausal patient with ground glass echogenicity of the cyst fluid, one to four locules and no papillations with detectable blood flow.” Based on clinical considerations, the following rule seems preferable: “premenopausal status, ground glass echogenicity of the cyst fluid, one to four locules and no solid parts” (24).

In a prospective observational multicenter study reported in 2010, Holland et al enrolled 211 women with clinically suspected or proven pelvic endometriosis who were booked for laparoscopy (26). The severity of endometriosis was assessed preoperatively using TVS and the findings were compared with the results obtained by laparoscopy using the ASRM classification.

In total, 201 women were included in the final analysis. Of these, no endometriosis was found at laparoscopy in 62/201 (30.8%; 95% CI, 24.8-37.5), whereas 33/201 patients (16.4%; 95% CI, 11.9-22.2) had minimal endometriosis, 31/201 (15.4%; 95% CI, 11.1–21.1) had mild endometriosis, 27/201 (13.4%; 95% CI, 9.4-18.8) had moderate endometriosis and 48/201 (23.9%; 95% CI, 18.5-30.2) had severe endometriosis (Tab.VI).

This study confirms that TVS is an accurate diagnostic method for pelvic endometriosis. There was a high level of agreement between TVS and laparoscopy in assessing the severity of disease. The accuracy of TVS in diagnosing moderate and severe pelvic endometriosis was 94% (26, 76).

TVS and RES correctly diagnosed posterior DIE in 70/81 (86.4%) and 60/81 (74.1%) patients, respectively (5). Guerrero et al with the new approach “Tenderness-guided” transvaginal ultrasonography, obtained a specificity of 95% with a sensitivity of 90%, a positive predictive value of 97%, and a negative predictive value of 86%. In their series transvaginal ultrasonography showed a specificity of 100% with a sensitivity of 100% for the diagnosis of ovarian endometriosis (8).

In a 2008 prospective study by Valenzano Menada et al, “transvaginal ultrasonography combined with water-contrast in the rectum” correctly identified the presence of rectovaginal endometriosis in 67 (out 69) women and the absence of rectovaginal nodules in 21 women. In two cases, small rectovaginal nodules (largest diameters 0.5 and 0.7 mm) were missed at RWC-TVS.

The sensibility, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of RWC-TVS in diagnosing rectovaginal endometriotic nodules are given in Table IV, however, it could not determine whether the mucosa was infiltrated. In patients with superficial lesions which did not reach the bowel muscularis, RWC-TVS did not reliably determine whether the bowel serosa was infiltrated. TVS and RWC-TVS correctly diagnosed

### TABLE IV - ACCURACY OF TVS AND RWC-TVS IN DETECTING THE PRESENCE OF RECTOVAGINAL ENDOMETRIOSIS*

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity %</th>
<th>Specificity %</th>
<th>PPV %</th>
<th>NPV %</th>
<th>Accuracy %</th>
<th>LR+</th>
<th>LR-</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diagnosis of rectovaginal endometriosis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TVS</td>
<td>92.8</td>
<td>90.5</td>
<td>97.0</td>
<td>79.2</td>
<td>92.2</td>
<td>9.74</td>
<td>0.08</td>
</tr>
<tr>
<td>RWC-TVS</td>
<td>97.1</td>
<td>100.0</td>
<td>100.0</td>
<td>91.3</td>
<td>97.8</td>
<td>_a</td>
<td>0.03</td>
</tr>
<tr>
<td><strong>Diagnosis of rectal infiltration</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TVS</td>
<td>56.5</td>
<td>92.5</td>
<td>72.2</td>
<td>86.1</td>
<td>83.3</td>
<td>7.57</td>
<td>0.47</td>
</tr>
<tr>
<td>RWC-TVS</td>
<td>95.7</td>
<td>100.0</td>
<td>100.0</td>
<td>98.5</td>
<td>98.9</td>
<td>_a</td>
<td>0.04</td>
</tr>
</tbody>
</table>

*LR+ could not be calculated because of the absence of false positive cases. *Modified from Valenzano Menada et al, 2008 (7)
Ultrasound diagnosis of endometriosis

the presence of rectovaginal endometriotic nodules in 83/90 (92.2%) and 88/90 (97.8%) patients, respectively (7, 53, 59).

In a prospective study, Bergamini et al evaluated the accuracy of transrectal sonography (TRS) and a new technique called transvaginal sonography with water-contrast in the rectum (RWC-TVS) for the diagnosis of rectosigmoid endometriosis, and the accuracy of barium enema (BE) and RWC-TVS in the detection of intestinal stenosis due to endometriosis. They compared TRS and RWC-TVS performed before surgery with operative and pathologic findings in 61 consecutive patients who underwent laparoscopy or laparotomy for suspected rectosigmoid endometriosis. The accuracy of BE and RWC-TVS in the detection of intestinal stenosis was evaluated comparing the radiologic and ultrasonographic results with the macroscopic findings at surgery and pathology. RWC-TVS diagnosed rectosigmoid endometriosis with same accuracy of TRS and was as efficient as BE in the detection of a significant intestinal lumen stenosis. For the diagnosis of rectosigmoid endometriosis sensitivity, specificity, positive and negative predictive values of TRS and RWC-TVS were 88.2% and 96%, 80%, and 90%, 95.7%, and 98%, and 57.1% and 81.8%, respectively. For the detection of intestinal stenosis the sensitivity, specificity, positive and negative predictive values of BE and RWC-TVS were 93.7% and 87.5%, 94.2% and 91.4%, 88.2% and 82.3%, and 97% and 94.1%, respectively. Based on these results, RWC-TVS seems to offer potential advantages over the imaging techniques previously proposed to preoperatively assess deep infiltrating endometriosis (25).

In a prospective study of 2010, Goncalves et al demonstrated the importance of the ultrasound diagnosis for successful surgical treatment of deep bowel endometriosis (32). In their study they determined the capacity of transvaginal ultrasonography with bowel preparation (TVUS-BP) to predict the presence of one or more rectosigmoid nodules and the deepest bowel layer affected by the disease. In this study 194 patients with clinical and TVUS-BP-suspected deep endometriosis underwent videolaparoscopy.

In diagnosing bowel nodules and rectosigmoid lesions, TVUS-BP had a sensitivity of 97% and 81%, specificity 100% and 99%, PPV 100% and 93%, NPV 98% and 96%, respectively, thus confirming the importance of this technique for defining the most appropriate surgical strategy to be implemented (32, 62, 65, 70, 78).

In a study by Grasso et al, pelvic endometriosis was diagnosed at 3D TVUS in 23 of the 24 patients (23/24; 95.8%). Endometrial cysts were diagnosed with a sensitivity of 87.5% and a specificity of 100%. Deeply infiltrating pelvic cysts were identified with a sensitivity of 95.8% and a specificity of 100%.

TABLE V - EVALUATION OF PELVIC ENDOMETRIOSIS BY RECTAL ENDOSCOPIC SONOGRAPHY IN COMPARISON TO SURGICAL AND HISTOLOGICAL FINDINGS IN 81 PATIENTS*

<table>
<thead>
<tr>
<th>SITE</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>PPV</th>
<th>NPV</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>USL</td>
<td>46.6 (34/73)</td>
<td>50.0 (4/8)</td>
<td>89.5 (34/38)</td>
<td>9.3 (4/43)</td>
<td>46.9 (38/81)</td>
</tr>
<tr>
<td>Vagina</td>
<td>7.7 (2/26)</td>
<td>98.2 (54/55)</td>
<td>66.7 (2/3)</td>
<td>69.2 (54/78)</td>
<td>69.1 (56/81)</td>
</tr>
<tr>
<td>RVS</td>
<td>22.2 (2/9)</td>
<td>93.1 (67/72)</td>
<td>28.6 (2/7)</td>
<td>90.5 (67/74)</td>
<td>85.2 (69/81)</td>
</tr>
<tr>
<td>Intestine</td>
<td>88.9 (48/54)</td>
<td>92.6 (25/27)</td>
<td>96.0 (48/50)</td>
<td>80.6 (25/31)</td>
<td>90.1 (73/81)</td>
</tr>
<tr>
<td>Ovary</td>
<td>68.6 (24/35)</td>
<td>91.3 (42/46)</td>
<td>85.7 (24/28)</td>
<td>79.2 (42/53)</td>
<td>81.5 (66/81)</td>
</tr>
</tbody>
</table>

+LR, positive likelihood ratio; -LR, negative likelihood ratio; NPV, negative predictive value, PPV, positive predictive value; RVS, rectovaginal septum; USL, uterosacrwal ligament. *Modified from Bazot et al, (5)
endometriosis was diagnosed in 15 of the 19 patients with surgically proven dIE (15/19; 78.9%). There were two false positives in which the investigator made an incorrect diagnosis of USL infiltration.

Sensitivity and specificity of TVUS for uterosacral involvement were 50% and 94.7%, respectively. Sensitivity and specificity for posterior vaginal fornix infiltration were, respectively, 84% and 80%. Rectovaginal septum endometriosis and sigmoid colon endometriosis were diagnosed with a sensitivity of 76.9% and 33.3%, respectively. Specificity was 100% in both cases. For bladder endometriosis sensitivity was 25% and specificity 100% (6, 45). Preoperative TVS yielded a diagnosis of bladder endometriosis in 18/41 cases (43.9%), whereas in 23/41 (56.1%) the presence of the endometriotic nodule was missed. The sonographic characteristics of endometriotic nodules visualized at TVS are given in Table VII. No discrepancy was found between TVS and surgery as far as the location of the nodule was concerned. The sensitivity, specificity, positive and negative predictive values, and overall accuracy of TVS for the diagnosis of bladder endometriotic nodules were 44% (18/41), 100% (449/449), 100% (18/18), 95% (449/472) and 95% (467/490), respectively (15).

In a retrospective longitudinal study, Bazot compared physical examination, TVS, RES for the assessment of different locations of dIE. The sensitivity of physical examination, TVS, RES, and MRI were, respectively, 73.5%, 78.3%, 48.2%, 84.4%, for uterosacral ligament endometriosis; 50%, 46.7%, 6.7%, and 80%, for vaginal endometriosis; and 46%, 93.6%, 88.9%, and 87.3% for intestinal endometriosis (27, 32).

However, MRI is the best imaging technique for diagnosing deep pelvic endometriosis, as it offers an

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**TABLE VI - ACCURACY OF ULTRASOUND IN DIAGNOSING DIFFERENT STAGES OF PELVIC ENDOMETRIOSIS USING LAPAROSCOPY AS THE GOLD STANDARD***

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absent vs present</td>
<td>n (%; 95% CI)</td>
<td>n (%; 95% CI)</td>
</tr>
<tr>
<td>Absent to mild vs moderate to severe</td>
<td>n (%; 95% CI)</td>
<td>n (%; 95% CI)</td>
</tr>
<tr>
<td>Absent to moderate vs severe</td>
<td>n (%; 95% CI)</td>
<td>n (%; 95% CI)</td>
</tr>
</tbody>
</table>

**TABLE VII - TRANSVAGINAL SONOGRAPHIC CHARACTERISTICS OF ENDOMETRIOTIC NODULES***

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean ± SD or N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lesion diameter (mm)</td>
<td>20.22 ± 8.82</td>
</tr>
<tr>
<td>Hypoechoic</td>
<td>18/18 (100)</td>
</tr>
<tr>
<td>Location</td>
<td></td>
</tr>
<tr>
<td>Base</td>
<td>7/18 (38.9)</td>
</tr>
<tr>
<td>Dome</td>
<td>11/18 (61.1)</td>
</tr>
<tr>
<td>Morphology</td>
<td></td>
</tr>
<tr>
<td>Comma-shaped</td>
<td>12/18 (66.7)</td>
</tr>
<tr>
<td>Spherical</td>
<td>6/18 (33.3)</td>
</tr>
<tr>
<td>Presence of a bright rim</td>
<td>10/18 (55.6)</td>
</tr>
<tr>
<td>Obliteration of vesicouterine pouch</td>
<td>15/18 (83.3)</td>
</tr>
<tr>
<td>Pain on pressure with probe</td>
<td>18/18 (100)</td>
</tr>
</tbody>
</table>

*S Modified from Savelli et al, 2009 (15)
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overview of all potential locations and has a sensitivity of 90.2%, a specificity of 91.3%, and an accuracy of 90.8% (3, 72).

DISCUSSION

For the diagnosis of pelvic endometriosis it is necessary to collect an adequate clinical history, perform a physical examination, and use various techniques imaging besides transvaginal ultrasounds (TRS, RES and MRI have also been recommended). Transvaginal sonography is the first-line imaging method in patients with pelvic disorders and shows a high degree of accuracy in diagnosis of endometrial cysts. Correct evaluation of the location and extent of endometriotic lesion is important so that patients can be given appropriate information on the surgery and the potential risks. Accuracy depends on the location of the lesions and the experience of the sonographer. Bazot et al consider TVS the first-line imaging technique for suspected deep pelvic endometriosis but found that the limit of TVS is the distance from the probe and the presence of fecal material. Goncalves and Abrao (2009) conclude in their paper (1, 46) that one of the principal differentiating factors of this exam is that all patients must be submitted to bowel preparation with a simple rectal enema just one hour before the procedure.

For USL involvement (the main location of deep pelvic endometriosis), the reported sensitivity of sonography varies between 70.6% and 80%. This variability could be explained by differences in study populations, anatomic conditions, and associated lesions. Indeed, retroflexed uterus, subserous leiomyoma, and endometriotic ovarian cysts lying on the USL may hide the insertion and proximal part of these ligaments. Using transrectal sonography, researchers demonstrated that the thickness of the USL depended on the point of measurement. In addition to irregular features, these authors underlined that the thickness of the medial portion of the ligament was the most specific criterion for the diagnosis of endometriotic involvement. Using TVS or rectal endoscopic sonography, normal USL usually are not visible, and the mean thickness of USL with histologically proven involvement is less than 8.6 mm on TVS. Transvaginal sonography offers an adequate view of the rectal wall, and particularly the rectosigmoid junction located near the retrocervical area, which is the main site of colorectal involvement. The disappearance of the normally hypoechoic structure between the vagina and intestinal wall suggests the presence of bowel endometriosis. One study suggested that power Doppler was more efficient than conventional color Doppler and could help in evaluating the microvascular architecture in female pelvic disorders. Further studies are required to determine the usefulness of Doppler sonography in the assessment of deep pelvic endometriosis (3).

CONCLUSIONS

The analysis of these results showed that ultrasounds are the first-line diagnostic technique for the diagnosis of pelvic endometriosis. An accurate ultrasound study is essential for diagnosis, evaluation of extent, pre-surgery assessment, and for providing the patients with correct information. TVS is the most common and useful diagnostic tool for its immediacy and simplicity in diagnosing pelvic endometriosis of both the posterior and anterior compartments. RES can help to identify the presence and the degree of wall infiltration in bowel sites. However, in patients with a consistent clinical suspicion of deep endometriosis, MRI is also a good “all in one” exam to diagnose and define the exact extent of deeply infiltrating endometriosis (6).

More studies are necessary to understand the best multidisciplinary diagnostic approach especially when a deep infiltration of posterior pelvis is suspected and before deciding on a surgical procedure.

Conflict of interest: None of the authors has any conflict of interest to report.

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