Diagnosis of deep endometriosis: clinical examination, ultrasonography, magnetic resonance imaging, and other techniques

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The aim of the present review was to evaluate the contribution of clinical examination and imaging techniques, mainly transvaginal sonography and magnetic resonance imaging (MRI) to diagnose deep infiltrating (DE) locations using prisma statement recommendations. Clinical examination has a relative low sensitivity and specificity to diagnose DE. Independently of DE locations, for all transvaginal sonography techniques a pooled sensitivity and specificity of 79% and 94% are observed approaching criteria for a triage test. Whatever the protocol and MRI devices, the pooled sensitivity and specificity for pelvic endometriosis diagnosis were 94% and 77%, respectively. For rectosigmoid endometriosis, pooled sensitivity and specificity of MRI were 92% and 96%, respectively fulfilling criteria of replacement test. In conclusion, advances in imaging techniques offer high sensitivity and specificity to diagnose DE with at least triage value and for rectosigmoid endometriosis replacement value imposing a revision of the concept of laparoscopy as the gold standard. (Fertil Steril® 2017;108:886–94. ©2017 by American Society for Reproductive Medicine.)

Key Words: Endometriosis, deep endometriosis, clinical examination, transvaginal sonography, MR imaging

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Pelvic endometriosis is defined as the presence of endometrial tissue outside the endometrium and myometrium (1). Overall it is estimated to affect around 10% of women of reproductive age, increasing to 35%–50% in symptomatic patients (2, 3). Three main entities of pelvis endometriosis have been identified: peritoneal, ovarian or deep endometriosis (DE) (4).

DE is thought to affect 20% of women with pelvic endometriosis and is a source of pain and infertility (5, 6). However, while the three forms are often associated, in contrast to peritoneal and ovarian endometriosis, no clear consensus exists on the definition of DE. Based on the relation between the depth of infiltration and intensity of pain, it has been arbitrarily defined as endometriosis infiltrating the peritoneum by > 5 mm (7). The same authors have recently suggested that DE should be pathologically defined as adenomyosis externa (8). However, in accordance with a recent Cochrane metaanalysis, DE is defined in the present review as a fibrous/muscular infiltration of organs and anatomical structures containing endometrial tissue below the peritoneum, regardless the depth of infiltration (9).

Independently of the issue of DE definition, symptomatic patients with or without suggestive clinical examination, require additional routine investigations mainly comprising transvaginal sonography (TVS) and MR imaging (MRI), to determine therapeutic strategy. The goals of this review are to analyze the accuracy of clinical examination and imaging techniques to assess DE locations, to evaluate whether imaging techniques may replace the gold standard of diagnostic laparoscopy for some locations of DE, and finally, to determine

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whether imaging DE mapping could have implications on surgical management.

CLINICAL EXAMINATION

The first step in diagnosing DE is to establish the patient's clinical history with particular emphasis on symptoms (dysmenorrhea, dyspareunia, dysuria, dyschezia, and chronic pelvic pain) as well as, age, height, weight, ethnic origin, gravidity, parity, previous surgery for endometriosis, family history of endometriosis, previous non-surgical treatment for endometriosis, and infertility. However, several authors have underlined the poor relationship between symptoms exhibited by patients and the severity of the lesions rendering clinical diagnosis difficult (10–12). Moreover, it is thought that 2% to 50% of women could have asymptomatic endometriosis (10–12).

The second step is based on physical examination including a systematic analysis of the posterior vaginal fornix with a speculum to look for retraction and dark nodules. Digital examinations should be performed of the vagina to assess the characteristics of the uterus and adnexa, of the vesico-uterine pouch to detect bladder invasion, and of the retrocervical area to detect infiltration of the torus uterinum, uterosacral ligaments (USLs), pouch of Douglas (POD), vagina, and rectovaginal septum (RVS). Rectal digital examination can help in assessing the involvement of the rectum, parametrium and visceral pelvic fascia.

In the particular setting of DE, few data are available to evaluate the accuracy of physical examination. One retrospective study found that routine clinical examination detected DE in only 36% of 140 women with DE, and the authors suggest the accuracy of physical examination improves during menstruation (13). To detect rectosigmoid and retrocervical DE without differentiating between the different specific DE locations, Abrao et al. (14) reported that digital vaginal examination had a sensitivity of 72% and 68%, a specificity of 54% and 46%, a positive predictive value (PPV) of 63% and 45%, and negative predictive value (NPV) of 64% and 69%, respectively.

In our experience, even when the examination is performed by an expert, the sensitivity, positive (PLR) and negative (NLR) likelihood ratios are 73.5%, 3.3 and 0.34 for uterosacral ligament endometriosis, 50%, 3.88, and 0.57 for vaginal endometriosis, and 46%, 1.67, and 0.75 for intestinal endometriosis, illustrating the limits of physical examination (15). Moreover, clinical examination is further complicated by the high prevalence of myofascial trigger points in the pelvic floor in women with DE, a source of severe pain limiting the evaluation of DE locations (16).

ULTRASOUND

A recent international consensus highlighted the need for a reliable diagnostic system of triage to evaluate the location and the extent of DE (17). In this setting TVS emerges as the first-line imaging technique due to its availability and relatively low cost. In addition to the sonographic description of DE lesions, the operator should explore the peritoneum for superficial implants, the uterus for adenomyosis, and the ovaries for endometriomas. A transabdominal scan of the kidneys should also be systematic to detect hydronephrosis. This detection is important, as diagnosis of ureteral involvement in pelvic area is often difficult using imaging techniques. Moreover, hydronephrosis can be asymptomatic and can compromise the kidney function requiring surgical management with at least ureteral stent.

Standardized, consensual terminology describing TVS appearance and anatomical locations is essential in the diagnosis of DE (17). Lesions appear as hypo- or isoechoic solid nodules, which may vary in size and have smooth or irregular contours, or as hypoechoic thickening of the wall of bowel, vagina, and bladder (18, 19).

The distribution of DE nodules should be evaluated in the whole pelvic cavity including the anterior, posterior, and subperitoneal lateral compartments. In accordance with previous studies, DE lesions are most frequently located in the posterior compartment, involving the torus, USLs, vagina, RVS, POD, and rectosigmoid colon (6, 20). Less frequently, anterior DE locations are present involving the vesico-uterine pouch, bladder, and round ligaments. Finally, rarely described by TVS, lateral compartment involvement includes the parametrium, ureter, visceral fascia, and lateral pelvic wall. The accuracy of sonography should be analyzed according to the DE locations and the specific sonographic techniques used.

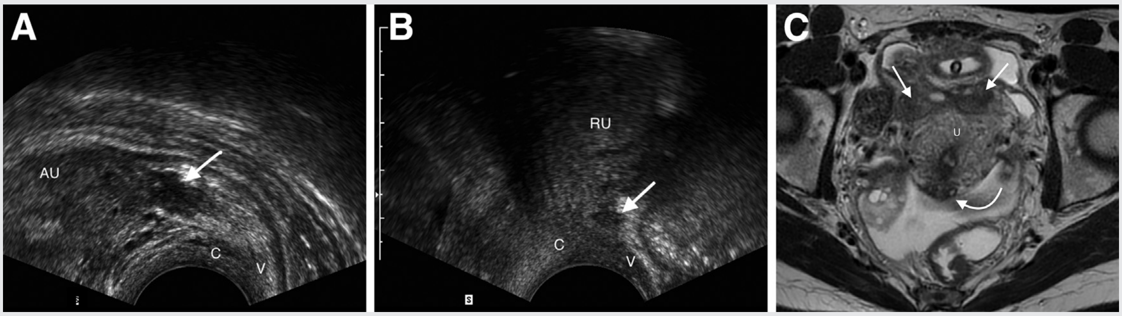
Guerriero et al. (21) performed a preliminary comparison between 'tenderness-guided' TVS and 3D-TVS to detect pelvic endometriosis independently of location, and reported that 'tenderness-guided' TVS was less accurate. Sonovaginography (SVG) is the combination of TVS with the introduction of a gel or saline solution into the vagina creating an acoustic window between the transvaginal probe and the surrounding structures of the vagina (22). Dessole et al. (22), comparing SVG to TVS, showed that SVG had higher sensitivity and specificity. Finally, independently of the DE location, Nisenblat et al. reported a pooled sensitivity and specificity for all TVS techniques (TVS, 3D-TVS, and SVG) of 79% and 94%, which approach the criteria for a triage test (9).

TVS Evaluation of the Posterior Pelvic Compartment

The torus uterinum is not clearly defined and has rarely been mentioned in previous TVS reports due to difficulties in evaluating the posterior wall of the uterus, particularly for retroversed and retroflexed uteri (23). In some cases, a nodular hypoechoic thickening located just behind the cervix above the posterior vaginal fornix may be suggestive of a diagnosis of DE (Fig. 1) (23).

Although normal USLs are usually not visible on ultrasound (18), they can sometimes appear as a thin regular lateral hyperechoic strand in the presence of pelvic fluid in the POD (23). A USL is considered to be involved by DE when a lateral, echoic, regular or irregular linear thickening is visible in the subperitoneal fat, mainly behind the upper part of vagina (Fig. 2) (17, 19, 23). Two recent meta-analyses of USL endometriosis have reported pooled sensitivities and specificities of 53%–64% and 93%–97%, respectively (9, 24). The contribution of rectal endoscopic sonography (RES) for USL endometriosis was only evaluated by one study and

FIGURE 1



Torus uterinum involvement by deep endometriosis on transvaginal sonography and magnetic resonance imaging. Transvaginal sonography shows an irregular hypoechoic nodule (*arrow*) above the cervix (C) and vagina (V) in two patients, (**A**) the first with an anteversed uterus (AU) and (**B**) the second with a retroflexed uterus (RU) corresponding to torus involvement by deep endometriosis (DE). (**C**) In a third patient, axial oblique 2D T2-weighted MR image shows a hypointense nodule located behind the lower part of the uterus (U) related to torus involvement by DE (*curved arrow*). Note the presence of bilateral round anterior nodule with low signal intensity corresponding to DE of both round ligaments (*arrows*).

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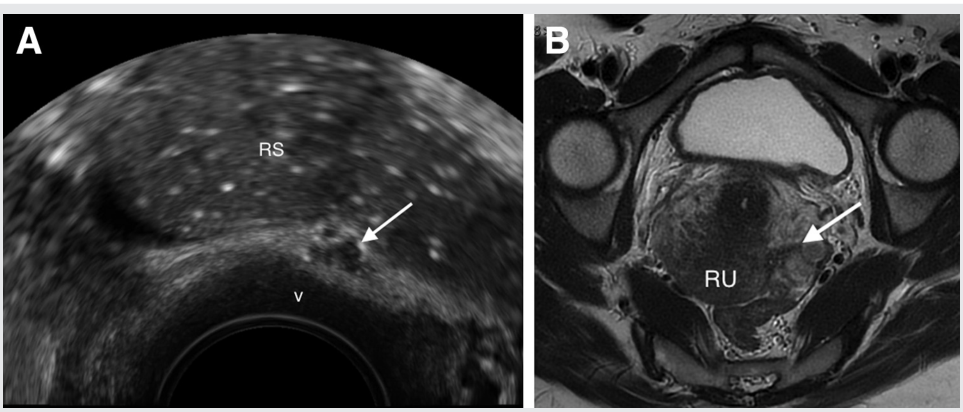
found a sensitivity and specificity of 48% and 44%, respectively (9, 15).

There is some inconsistency in the definition of RVS endometriosis in the literature (17). A recent consensus suggests that the RVS is involved when a nodule or mass is found below the horizontal plane passing through the lower border of the posterior lip of the cervix (under the peritoneum) (Fig. 3A and B) (17, 19). Overall then, major discrepancies exist between the pooled sensitivities and specificities provided by meta-analyses reporting values from 49% to 88% and 98% to 100%, respectively (9, 24). Moreover, comparing TVS to RES, Bazot et al. (15) observed a low sensitivity for both techniques while TVS had a higher specificity.

Mean normal vaginal thickness ranges from 3 mm to 5 mm and normal posterior and lateral vaginal fornixes are easily visible on TVS examination (23). Vaginal endometriosis is diagnosed when the posterior or a lateral vaginal fornix is thickened (>5 mm), with or without round cystic anechoic areas (Fig. 3A) (17, 19, 23). In a meta-analysis including 10 studies, the pooled sensitivity and specificity of TVS was 57% and 99%, respectively (25). Among the various TVS techniques, SVG provided the highest sensitivity and specificity reaching 91% and 89%, respectively (Fig. 3B) (26).

The bowel is considered involved when an irregular hypoechoic mass with or without hypoechoic or hyperechoic foci is found to have penetrated the intestinal wall; in this case the normal hypoechoic aspect of the bowel muscularis propria is replaced by an abnormal tissue mass (Fig. 4A) (19). Bowel DE can take the form of an isolated lesion or can be multifocal (multiple lesions affecting the same intestinal segment) and/or multicentric (multiple lesions affecting different intestinal segments) (27). The pooled sensitivity and specificity of TVS for rectosigmoid endometriosis are reported as 90% and 96%, respectively, with similar results being provided by RES (25). Recently, Guerriero et al., in a one-paired study,

FIGURE 2



Uterosacral ligament endometriosis on transvaginal sonography and magnetic resonance imaging. (**A**) Transvaginal sonography shows a small hypoechoic nodule (*arrow*) behind the vagina (V) and distant to the rectosigmoid colon (RS) corresponding to uterosacral ligament (USL) involvement by deep endometriosis (Fig. 2A). (**B**) In a different patient with retroversed uterus (RU), axial oblique 2D T2-weighted MR image (Fig. 2B) shows a linear irregular thickening of the left USL (*arrow*).

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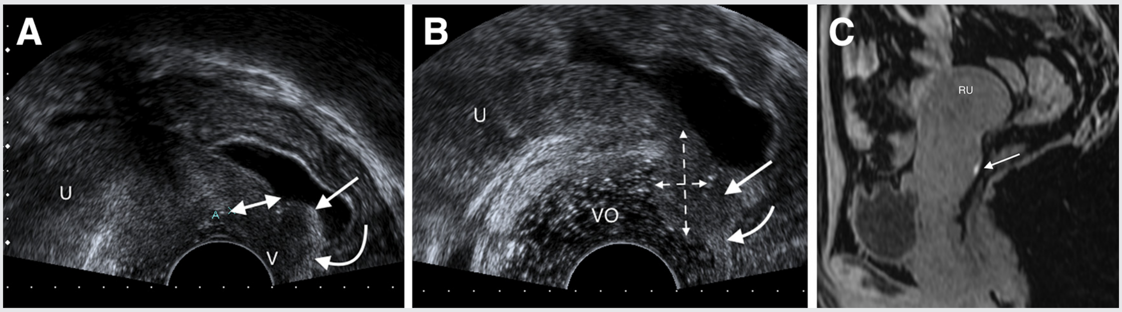
FIGURE 3



Vaginal and rectovaginal septum endometriosis on transvaginal sonography and magnetic resonance imaging. Transvaginal sonography (**A**) without and (**B**) with vaginal opacification (VO) by sonographic gel show an hypoechoic nodule (*arrow*) in the upper part of the hyperechoic rectovaginal septum (*curved arrow*) associated with a thickening of the vaginal wall (*double arrow*) easier to visualize with sonovaginography. (**C**) In the third patient with retroversed uterus (RU), sagittal 3DT1 MR image with fat suppression shows a thickening of the vaginal wall (*arrow*) containing high signal intensity spot on T1 typical of vaginal endometriosis.

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suggested that 2D-TVS was more sensitive but less specific than 3D-TVS (21).

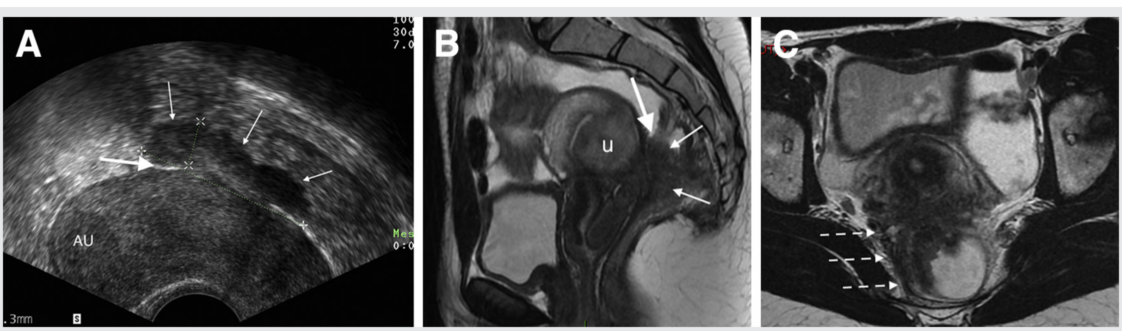
While obliteration of the POD does not correspond specifically to DE, it is frequently associated with severe DE, and especially with rectosigmoid colon endometriosis (Fig. 4A). In this setting, the TVS 'sliding sign' technique to detect POD obliteration in women with suspected endometriosis is highly relevant (28). Using this new technique, Reid et al. (29) found sensitivity, specificity, PLR, and NLR of 83.3%, 97.1%, 29.2, and 0.17, respectively. Meta-analyses report pooled sensitivities and specificities for POD obliteration of 52.3–83% and 91.7–97%, respectively (25, 30).

TVS Evaluation of the Anterior Pelvic Compartment

Anterior DE includes the involvement of the vesico-uterine fold, bladder and round ligaments that are often associated. The estimated prevalence of such locations is low, at 2% to 8.4% (19, 31, 32). In contrast to the posterior pelvic compartment, few data are available and the reports often fail to distinguish the various anterior DE locations (19, 25, 30, 33).

Bladder involvement is suggested when a hypo- or isoechoic nodule, either containing cystic lesions or not, is found within the bladder wall. The most frequently involved site is the bladder dome. Bladder involvement should be differentiated from superficial vesico-uterine endometriotic implants (<1 cm) in the vesico-uterine pouch without bladder wall involvement. A review of the literature for bladder endometriosis reveals a reported mean sensitivity of 55% and specificity of 93.5% (30). In the meta-analysis by Nisenblat (9), including two studies only, the sensitivity and specificity were 41% and 100%, respectively. In a series of 17 patients with bladder endometriosis, Millischer et al. (34) reported a sensitivity of 100% for TVS, similar to MRI and fusion imaging techniques.

FIGURE 4



Rectosigmoid colon endometriosis on transvaginal sonography and magnetic resonance imaging. (**A**) Transvaginal sonography shows a large irregular hypoechoic lesion in a patient with anteversed uterus (AU) corresponding to rectosigmoid colon endometriosis (*arrows*). In (**B**) another patient, sagittal and (**C**) axial, 2D T2-weighted MR image show a large hypointense lesion (arrows) immediately behind the uterus (U) related to rectosigmoid colon endometriosis. In all cases, note that the uterus and rectosigmoid are stuck together and responsible for complete pouch of Douglas obliteration (*large arrow*). In addition, note the presence of extensive right lateral involvement by DE with the parametrium, pelvic wall, and pelvic visceral fascia (*dotted arrows*).

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In contrast, Balleyguier et al., in a series of 12 women with bladder endometriosis, reported false-negative cases in one-third of the patients (33).

For vesico-uterine fold endometriosis, two series reported sensitivities and specificities of 16.7% and 33% and 99% and 100% (35, 36). These discrepant results could be partly explained by selection bias of inclusion among studies. In our experience, only cystic peritoneal implants are well detected whereas small thin peritoneal implants are usually missed on TVS examinations. The prevalence of round ligament endometriosis is estimated between 4.3% and 13.8% (37, 38). However, as only case reports are available, the diagnostic contribution of TVS cannot be evaluated.

TVS Evaluation of the Lateral Pelvic Compartment

The lateral pelvic compartment has not been clearly described on TVS. In our experience, this specific entity is represented by the pelvic ureter, parametrium, visceral fascia, and pelvic wall. Carfagna et al. (39) reported that the incidence of ureteral endometriosis was 6.5% in patients with DE with 46% of these patients displaying ureteral dilatation. Lima et al. (40) suggested that ureteral endometriosis should be suspected in the presence of USL nodules exceeding 1.7 cm suggesting a concomitant parametrial involvement. Pateman et al. (41) reported a sensitivity of 92%, a specificity of 100% and a negative LR of 0.08. No data are available evaluating the relevance of TVS for parametrial and visceral pelvic fascia.

MR IMAGING

The European Society of Urogenital Radiology (ESUR) provides recommendations about the optimal MRI protocol and criteria for the diagnosis of pelvic endometriosis (Tables 1 and 2) (42). In patients with previous equivocal TVS, MRI is recommended as a second-line technique in the preoperative workup of DE (Grade A) (42). DE is defined as implants or tissue masses that appear as hypointense areas and/or hyperintense foci on T1- or T2-weighted MR images in the following locations: the torus uterinum, USLs, vagina, RVS, rectosigmoid, POD, parametrium, bladder, and round ligaments (31, 42, 43).

In the meta-analysis of Nisenblat et al., the pooled sensitivity and specificity for DE diagnosis regardless of their locations was 94% and 77%, respectively, whatever protocol or device (1.5T or 3.0T) was used (9). In a preliminary study comparing 2D- and 3D-MRI, Bazot et al. (44) showed that both techniques provide a similar accuracy to diagnose specific DE locations with 3D-MRI saving time albeit resulting in a lower overall image quality.

TABLE 1

Optimal magnetic resonance imaging protocol in the diagnosis of pelvic endometriosis.

MRI protocol	Recommendation (grade)
Technical requirements	
Device: 1.5 or 3.0 T	No recommendation
Phased-array coil	Standard (C)
Timing of MRI examination	No recommendation
Fasting	Standard (B)
Moderately full bladder	Standard (C)
Bowel enema	"Best practice" (GPP)
Supine position	Standard (B)
Abdominal strapping	Standard (C)
Anti-peristaltic agent	Standard (C)
Vaginal opacification (gel)	Option (GPP)
Rectal opacification (water, gel)	Option (GPP)
MR sequences	
2DT2-weighted MRI (sagittal, axial, Oblique)	Standard (B)
3DT2-weighted MRI	Option (C)
T1-weighted MRI without/with fat-suppression	Standard (B)
Dixon technique (alternative to T1W)	Standard (C)
Intravenous contrast-enhanced MRI	No recommendation
Diffusion weighted MRI	No recommendation
Susceptibility-weighted MRI	No recommendation
Half-Fourier acquisition single shot turbo spin echo	Standard (C)

Note: GPP = good practice point; MRI = magnetic resonance imaging; T1W = T1-weighted.

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MRI Evaluation of the Posterior Pelvic Compartment

The pooled sensitivity and specificity of MRI for torus and USL endometriosis were 86% and 84%, respectively (Figs. 1 and 2) (25). In a prospective study, we demonstrated that MRI had a higher accuracy to diagnose USL than TVS and RES (15). Moreover, a similar high accuracy was found for both 2D- and 3D-MRI (44).

Only three studies have evaluated MRI for RVS endometriosis giving a pooled sensitivity and specificity of 81% and 86%, respectively (25). RES was less sensitive than TVS and MRI (15). In contrast, Abrao et al. (14) reported that TVS displayed a higher sensitivity than MRI. The pooled sensitivity and specificity of MRI for vaginal endometriosis was 77% and 97%, respectively (Fig. 3C) (25). 2D-MR imaging had a lower accuracy than 3D-MRI. In a comparative study, MRI provided a higher sensitivity than RES (15). The pooled sensitivity and specificity of MRI for rectosigmoid endometriosis were 92% and 96%, respectively (Fig. 4C) (25). Rousset et al. (45) found a higher accuracy of 3.0T MR enterography in the diagnosis of multifocal and multicentric bowel endometriosis located above the rectosigmoid junction. The pooled sensitivity and specificity of MRI for POD obliteration were 90% and 98%, respectively (Fig. 4C) (25). Bazot et al. (44) found a similar sensitivity and specificity of 71% and 100%, respectively, for 2D- and 3DT2-weighted MRI (44).

MRI Evaluation of the Anterior Pelvic Compartment

Some retrospective studies suggest that MRI is particularly relevant to diagnose bladder endometriosis with a sensitivity and specificity ranging from 88% and 100%, and 97.9% and 100%, respectively (31, 33, 34). However, a meta-analysis by

TABLE 2

Magnetic resonance imaging criteria: diagnosis of deep endometriosis by location.

Location	Definition
Torus uterinus	Presence of a mass or thickening in the upper mid-portion of the posterior cervix.
USL	Involvement by endometriosis present when ligament bears a nodule or shows fibrotic thickening compared to the contralateral USL, with regular or irregular margins. When bilateral involvement is associated with the torus uterinus it is termed an arciform abnormality
Vagina	Obliteration of the hypointense signal of the posterior vaginal wall/posterior vaginal fornix on T2W images, with thickening or a mass (containing or not containing foci of high T2W SI) behind the posterior wall of the cervix
Rectovaginal septum	Nodule or mass passing through the lower border of the posterior lip of the cervix (under the peritoneum)
Rectosigmoid	Disappearance of fat tissue plane lying between uterus and rectum/sigmoid colon, replacement by a tissue mass which form an obtuse angle with the wall of the rectosigmoid Disappearance of the hypointense signal of the anterior wall of the rectum/ sigmoid colon on T2W images
Pouch of Douglas	Partial or complete obliteration with presence or absence of suspended or lateralized fluid collection
Parametrium	Low-signal-intensity area on T2W MRI, with or without tiny high T2W SI spots in the paracervical or paravaginal region Unilateral (or bilateral) ureteral dilatation
Bladder	Nodule or mass usually located at level of vesicouterine pouch, forming an obtuse angle with the bladder wall Extension through bladder wall involving muscular layer (obliteration of hypointense signal of wall on T2W), or protruding into lumen with invasion of the mucosal layer
Round ligament	Involvement by endometriosis present when ligament shows fibrotic thickening (generally > 1 cm) compared to the contralateral round ligament, with regular or irregular margins and occasionally a nodular appearance.

Note: DE = deep endometriosis; SI = signal intensity; T1W = T1-weighted; T2W = T2-weighted; USL = uterosacral ligament.

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Medeiros et al. (46) found a lower pooled sensitivity of 64%. In the meta-analysis by Nisenblat (9) including only one study, the sensitivity and specificity were 41% and 100%, respectively. In a series of 17 patients with bladder endometriosis, Millischer et al. reported a sensitivity of 100% for MRI similar to TVS and fusion imaging techniques (34). For round ligament endometriosis, only anatomical and MR features have been described but without evaluating the relevance of MRI (47).

MRI Evaluation of the Lateral Pelvic Compartment

In accordance with Querleu and Morrow (48), the connective tissue surrounding the vascular uterine pedicle defines the parametrium. On MRI, the presence of low signal intensity on T2-weighted MRI, pelvic wall involvement and ureteral dilatation is suggestive of a diagnosis of parametrial endometriosis (43). In a preliminary study, we showed that MRI exhibited a sensitivity and specificity of 83.3% and 98.6% in a population of patients with a prevalence of parametrium involvement of 14.5% (43). No data are available evaluating the relevance of MRI for visceral pelvic fascia.

ADDITIONAL IMAGING TECHNIQUES TO ASSESS DE LOCATIONS

Before surgical management of severe DE, mainly involving the rectosigmoid colon, parametrial, pelvic visceral fascia and ureter, various additional imaging techniques can be used to form a comprehensive mapping of DE locations. This approach is particularly useful to anticipate surgical difficulties and potential risk of complications. In this setting, it is not possible to define clear indications for these additional imaging techniques which depend on the surgeon's experience and the nature of the surgery.

The contribution of multislice computerized tomography (CT) enteroclysis in the evaluation of bowel endometriosis was initially studied by Biscaldi et al. (49) and gave a sensitivity and specificity of 98.7% and 100%, respectively. The same authors found a similar accuracy for both multidetector CT enema (MDCT-e) and MRI enema (MRI-e) (50). Belghiti et al. (27) reported a lower accuracy of CT scan enema for the diagnosis of multifocal and multicentric endometriotic lesions in a recent study comparing CT enema to 1.5T MRI.

Even if renal scintigraphy remains essential to evaluate kidneys; the addition of urographic phase during CT-colonography with contrast media (MDCT) could be useful for ureteral evaluation (51). Recently, Zannoni et al. (51), using MDCT and urographic phase (CTCU), found respective sensitivities and specificities of 60–70.2% on the right side and 57.1–76.9% on the left.

Several studies evaluating the relevance of double contrast barium enema (DCBE) in the evaluation of intestinal endometriosis in comparison to TRS, rectal water-contrast TVS, and MRI found a similar relative accuracy between all four techniques (52–54). Despite all these data, the role of these additional imaging techniques requires further investigation to evaluate their contribution in the diagnosis of DE, taking into account the radiation exposure in young patients.

DISCUSSION

The first issue when evaluating the contribution of imaging techniques in the diagnosis of DE is related to the definition of DE per se. As previously mentioned, the simple definition of DE as a fibrous infiltration of anatomical structures and organs by endometriosis without considering the depth of penetration, should be retained. This option is supported in clinical practice by the lack of clear measurement criteria provided by clinical evaluation, imaging studies, and histological analysis to diagnose the different deep endometriotic locations.

The histological diagnosis of endometriosis requires the presence of both endometrial cells and stroma. However, it has been demonstrated that the fibrotic component in DE is preponderant. Indeed, a previous study showed that the relative cross-sectional areas of endometriotic islands, smooth muscle and fibrotic components were 12.2%, 40.3%, and 47.5%, respectively (18). Therefore, the systematic use of criteria including both glandular endometrial cells and stroma exposes to an underestimation of DE diagnosis on histology and justify the requirement for multiple sectioning.

The second issue is the assessment of DE by clinical examination. As previously mentioned a high heterogeneity exists in the evaluation of clinical examination for the diagnosis of DE according to series mainly from specialized centers (14, 15). This could be explained by various factors including a clinical presentation varying from asymptomatic and unexplained infertility to chronic pain and severe dysmenorrhea and the impossibility to time the onset of the disease. In addition to the ignorance of suggestive symptoms of DE by both patients and practitioners, the considerable delay before diagnosing DE indirectly argues for the low relevance of clinical examination (55, 56).

Another issue is related to the European Society of Human Reproduction and Embryology (ESHRE) recommendations for the diagnosis of endometriosis (57). These guidelines affirm that the gold standard for diagnosing most forms of endometriosis in women presenting with suggestive symptoms, is visual laparoscopic inspection of the pelvis (57). However, laparoscopy is considerably less accurate than histology for the diagnosis of endometriosis as reported by Wykes et al. (sensitivity of 94% and a specificity of 79%) (58).

A recent Cochrane review used the values of Wykes et al. (25) to define a replacement test that could potentially avoid diagnostic laparoscopy for the diagnosis of pelvic endometriosis. In addition, triage tests were defined as follows: a test providing a sensitivity $\geq$95% and specificity $\geq$50% "rules out" the diagnosis with high accuracy if there is a negative test result (SnOUT test), and a test with sensitivity $\geq$50% and specificity $\geq$95% "rules in" the diagnosis with high accuracy if there is a positive result (SpIN test) (9, 25). Using these different criteria and in the light of current data showing the contribution of imaging techniques for the assessment of DE locations, the role of diagnostic laparoscopy should be reconsidered (59).

The last issue that we raise in this paper is how to decide which combination of non-invasive tests should be used to assess the diagnosis of DE in comparison to diagnostic laparoscopy. Recently, Nisenblat et al. suggested that none of the combinations using symptoms, clinical data, serum biomarkers and TVS findings reached the replacement value thus supporting laparoscopy as the gold standard for the diagnosis of pelvic endometriosis (25). However, these authors did not include a combination of TVS and MRI. Moreover, in a prospective series using the STAndards for the Reporting of Diagnostic accuracy (STARD) criteria, Saba et al. reported that the accuracy of TVS and MRI alone for the diagnosis of rectosigmoid endometriosis were similar (73%) and the accuracy of the combined techniques was 95% thus reaching the value of a replacement test (60). Although previous studies have demonstrated a high inter- and intra-observer agreement for TVS and MRI in the diagnosis of DE, no data are available to evaluate these agreements with both techniques on the same population (21,61–63).

As demonstrated for most DE locations, and particularly in the rectosigmoid colon, TVS and MRI exhibited at least similar sensitivities and specificities to laparoscopy supporting their use as a replacement option. Moreover, the concept of diagnostic laparoscopy should also be discussed taking into account surgical risks. For other DE locations for which imaging techniques do not reach a replacement but only a triage value, the association of DE with endometriomas could contribute to reaching the replacement value (64). Finally, there is some consensus that both TVS and MRI reach the replacement value for endometriomas (9, 46).

From a clinical point of view, both TVS and MRI reach at least the value of a triage test for DE and the value of a replacement test for rectosigmoid colon endometriosis (i.e., allowing medical treatment without additional invasive investigations). For the surgical management of DE, a comprehensive mapping of pelvic endometriosis including DE and associated adenomyosis is required (65). Indeed, a recent study underlined the high frequency of associated adenomyosis to endometriosis, particularly DE lesions (66). In a longitudinal prospective study, Holland et al. (36) evaluated the severity of pelvic endometriosis according to the American Society for Reproductive Medicine (ASRM) classification on preoperative TVS and found a good correlation between TVS and laparoscopic findings with a kappa coefficient of 0.786. However, it is important to note that the ASRM classification does take into account specific DE locations. In a recent prospective multicenter study, Menakaya et al. (67) using an Ultrasound-Based Endometriosis Staging System (UBESS) noted a good correlation between the TVS staging with the laparoscopic complexity scoring system of the Royal College of Obstetricians and Gynecologists. Exacoutos et al. (65) confirmed the contribution of TVS for the mapping of DE but underlined its limit for vaginal endometriosis raising an issue for surgeons when concomitant vaginal and rectal resection is required.

Previous studies have demonstrated that the Enzian classification supplements the ASRM classification with regards to the description of DE (68). Recently, the World Endometriosis Society consensus on the classification of endometriosis stated that until better classification systems are developed, a classification toolbox including the Enzian scoring system may be used by surgeons (69). Moreover, comparing the MRI-Enzian and histopathological-Enzian scores, Di Paola et al. (70) found an excellent correlation, particularly for RVS, USL, and rectosigmoid locations but less so for bladder endometriosis. These authors concluded that MRI correlated with the Enzian score in the detection of DE allowing accurate preoperative staging. Furthermore, using a model for predicting operating time based on the Enzian classification, Haas et al. were able to plan resources more precisely for surgical management (71). Further studies are required to evaluate the contribution of the Enzian score in predicting surgical complexity and the risk of complication according to the Clavien-Dindo classification.

Some methodological limitations of the current review deserve to be mentioned. First, most of the results were derived from meta-analyses with a potential bias linked to the selection of papers included (9, 25, 46). Second, there is a potential overestimation of the relevance of different imaging techniques because the studies are mainly performed by specialized teams with a high degree of expertise (9, 25, 46). Third, a recent Cochrane meta-analysis (9) reported confusing data from transrectal sonography (TRS) and rectal endoscopic sonography (RES) studies. It is worth pointing out here that TRS (5 MHz frequency) provides a limited analysis of the rectosigmoid colon whereas RES (7.5–12 MHz) provides an overview of the whole sigmoid and rectosigmoid colon with higher spatial resolution.

Finally, a high heterogeneity in the evaluation of rectovaginal endometriosis was observed. This may partly arise from the initial description provided by Thomas Cullen in 1920 which included vaginal endometriosis in the term RVS (72).

In conclusion, in the light of recent advances in imaging techniques, both the definition of DE and the use of laparoscopy as the gold standard in the diagnosis of DE, deserve to be revised. Further efforts should be made to improve the knowledge of sonologists and radiologists on imaging criteria for early detection of this debilitating pathology.

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