RadioGraphics

Findings of Pelvic Endometriosis at Transvaginal US, MR Imaging, and Laparoscopy[1]

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ONLINE-ONLY CME

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LEARNING OBJECTIVES

After completing this journal-based CME activity, participants will be able to:

- Describe the different roles of transvaginal US and pelvic MR imaging in the investigation of endometriosis.
- Define optimal protocols for evaluating endometriosis with transvaginal US and MR imaging.
- Recognize transvaginal US and MR imaging features that are indicative of endometriosis and correlate them with laparoscopic findings.

TEACHING POINTS

See last page

Endometriosis is a common multifocal gynecologic disease that manifests during the reproductive years, often causing chronic pelvic pain and infertility. It may occur as invasive peritoneal fibrotic nodules and adhesions or as ovarian cysts with hemorrhagic content. Although findings at physical examination may be suggestive, imaging is necessary for definitive diagnosis, patient counseling, and treatment planning. The imaging techniques that are most useful for preoperative disease mapping are transvaginal ultrasonography (US) after bowel preparation, and magnetic resonance (MR) imaging. Initial transvaginal US is a reliable technique for detecting rectosigmoid endometriotic lesions. MR imaging is indicated as a complementary examination in complex cases of endometriosis with extensive adhesions and ureteral involvement. Peritoneal endometriotic implants are typically hypoechoic on transvaginal US images and demonstrate low signal intensity on T2-weighted MR images. Endometriotic implants most commonly are found in retrocervical and rectosigmoid sites, followed by the vagina, bladder, and ureters. Cysts with low-level internal echoes and echogenic peripheral foci at transvaginal US are suggestive of endometriomas. MR imaging has high specificity for identifying endometriomas, which are characterized by high signal intensity on T1-weighted images and low signal intensity on T2-weighted images. Correlation of the radiologic imaging features of endometriotic lesions with their laparoscopic appearances may help improve individual proficiency in the radiologic diagnosis of endometriosis. Supplemental material available at *http://radiographics.rsna.org/lookup/suppl/doi:10.1148/rg.314105193/-/DC1*.

Abbreviation: 3D = three-dimensional

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Introduction

Teaching Point

Endometriosis is a chronic gynecologic disorder that is characterized by the growth of endometrial tissue outside the uterine cavity, primarily as implants in the pelvic peritoneum and ovaries (1). Deeply infiltrating endometriosis, which is manifested as invasive tissue that infiltrates adjacent structures at a depth of more than 5 mm from the peritoneal surface, is associated with fibrosis and muscular hyperplasia. Ovarian lesions are characterized by cysts with hemorrhagic content. Endometriosis affects approximately 10% of women of reproductive age. It is found in 20%–50% of women with infertility and nearly 90% of women with chronic pelvic pain (2,3). Women who have a first-degree relative with the disease reportedly have a risk for endometriosis that is 10 times that of women without such a relation (4,5). There is also a strong concordance in monozygotic twins (3,6).

The pathogenesis of endometriosis is complex and has not yet been fully elucidated. Several pathogenic processes have been hypothesized, including implantation of endometrial glands and stroma on the peritoneum from retrograde menstruation, hematogenous and lymphatic dissemination, celomic metaplasia, stem cell migration from bone marrow, epigenetic factors, and polygenic-multifactorial inheritance (1,6–8). Chronic inflammatory insults caused by the augmented number of activated macrophages and peritoneal cytokines may lead to pain and infertility. Pain arises through several mechanisms, such as an increased density of peritoneal nerve fibers in patients with deeply infiltrating endometriosis (9). Secondary dysmenorrhea, deep dyspareunia, sacral backache with menses, perimenstrual diarrhea, cramping and dyschezia, dysuria, and hematuria are the most common and relevant clinical manifestations. Endometriosis-related pain may not correlate with the disease stage but may be associated with the lesion infiltration depth (10,11).

A definitive diagnosis of endometriosis is based on histologic confirmation of surgically resected lesions containing endometrial glands and stroma with various amounts of inflammation and fibrosis (12). A presumptive diagnosis of deeply infiltrating endometriosis may be developed on the basis of imaging with transvaginal ultrasonography (US), transrectal US, rectal endoscopic US, or magnetic resonance (MR) imaging, all of which have been used for this purpose (13–21). Physical examination is often inadequate because of the multiplicity of lesions, most of which are inaccessible to digital pelvic examination. For many years, laparotomy and laparoscopy were the only means of access to pelvic endometriotic lesions (10).

Transvaginal US and MR imaging provide comprehensive depiction of deeply infiltrating endometriotic lesions in pelvic and subperitoneal areas that are not easily accessible laparoscopically. These advantages have refined our understanding of the sites and pathologic features of deeply infiltrating endometriosis and knowledge of the pelvic anatomy. Collaboration between radiologists and gynecologists has enabled the achievement of high levels of diagnostic accuracy (22,23). Transvaginal US performed after bowel preparation should be the first-line imaging examination when the presence of endometriosis is suspected. This method is as accurate as transrectal US for diagnosing intestinal lesions and identifying the bowel layers affected, and it yields better results than MR imaging for the assessment of deeply infiltrating endometrial implants in other locations, especially small (<1.5-cm-diameter) lesions of the uterosacral ligament and bladder (18,22–26).

Teaching Point

MR imaging is an excellent method for identifying the old hemorrhagic content that characterizes endometriomas (27) and for mapping multiple deeply infiltrating endometrial implants, given its large field of view, multiplanar capabilities, and outstanding contrast resolution (14,17). Extensive pelvic adhesions and ureteral involvement are two important indications for MR imaging (14,28–30).

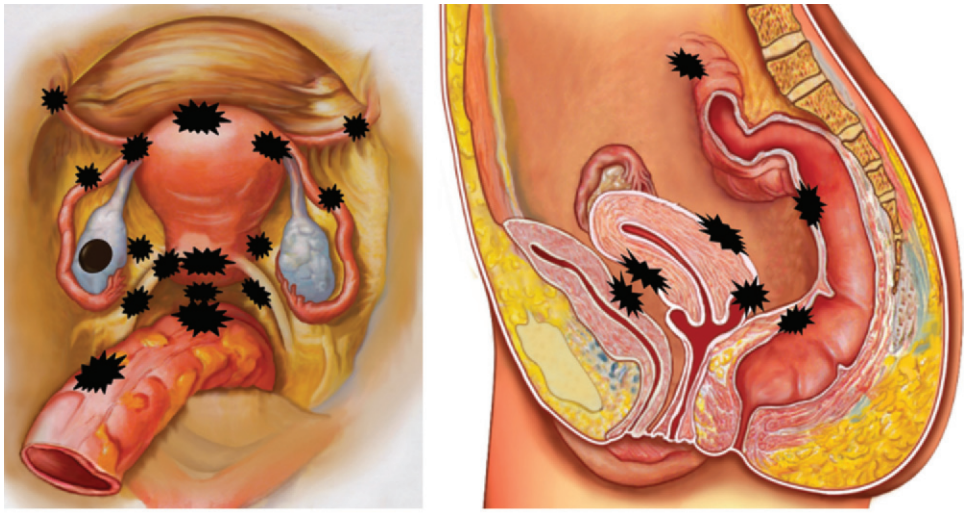
Teaching Point

The article describes the imaging protocol (transvaginal US after bowel preparation, followed by pelvic MR imaging) used at the authors' institutions to evaluate patients in whom the presence of endometriosis is suspected, and reviews the typical imaging appearances of deeply infiltrating endometriosis at transvaginal US, MR imaging, and laparoscopy.

Transvaginal US after Bowel Preparation

Procedure and Patient Preparation

At the authors' institutions, the transvaginal US examination is performed by using a US machine with a 5–9-MHz frequency transducer (Voluson 730 Expert; GE Healthcare, Milwaukee, Wis) after bowel preparation. Each examination is performed and interpreted in real time by the radiologist. Bowel preparation is used to eliminate fecal content and gas in the rectosigmoid colon. It includes a mild laxative administered in two oral doses (at 8:00 AM and 2:00 PM) the day before the scheduled transvaginal US examination, a low-residue diet for 24 hours before the examination, and an



a. b.

Figure 1. Drawings of the female pelvic anatomy in the axial **(a)** and sagittal **(b)** planes show the locations of multiple endometriotic lesions. The round black lesion in the right ovary in **a** represents an endometrioma. The lesions with irregular margins are indicative of deeply infiltrating endometriosis.

enema (120 mL of sodium diphosphate) administered approximately 1 hour before the examination. The decision about whether bowel cleansing will be performed by the patient at home or at the radiologic service depends on the patient's preference and logistical conditions. The duration of the US examination is 25–35 minutes.

The imaging algorithm includes evaluation of the uterus; ovaries; and pelvic peritoneum covering the bladder, uterus, Douglas pouch, retrocervical region, and rectosigmoid colon. The bladder wall, anterior uterine serosa, uterine insertion of the round ligaments, rectovaginal septum, and posterior vaginal fornix are also evaluated. The rectosigmoid colon is evaluated from the anal verge to the sigmoid–descending colon transition by rotating the transducer in the axial and sagittal planes while moving it up and down. The descending colon, appendix, and ileocecal transition are routinely assessed with transabdominal US performed by using a linear-array transducer after transvaginal US, because these structures may be inaccessible transvaginally. Diagnostic performance with the use of transabdominal US for detecting endometriotic lesions in the descending colon is similar to that with the use of transvaginal US for detecting lesions in the rectosigmoid colon. However, the presence of gas and fecal residues in the ileocecal segment may impair the accuracy of abdominal US findings.

With respect to intestinal lesions, the examination must include a determination of which layers of the bowel wall are affected. Characteristics of a normal intestinal wall depicted from the outer to the inner layer at transvaginal US include a thin hyperechoic line that represents the serosa; two hypoechoic strips separated by a thin hyperechoic line, which represent the muscularis propria; a hyperechoic line that represents the submucosa; a hypoechoic line representing the muscularis mucosa; and a hyperechoic linear interface between the bowel lumen and the mucosa. Other important points to be considered are the portion of the circumference that is affected and the distance from the inferior margin of the lesion to the anal verge. The latter can be estimated by measuring the distance between the peritoneal reflection, which is 7–9 cm from the anal verge, and the bowel lesion. To estimate the percentage of the intestinal circumference affected, an axial view is required on which the bowel can be separated into quadrants. In patients with bladder and intestinal lesions, a volumetric acquisition may be performed and a three-dimensional (3D) US image reconstructed to allow better evaluation of the lesion shape and provide the surgeon a spatially more comprehensive coronal view.

The introduction of 60 mL of US coupling gel into the upper third of the vagina provides distention of the posterior fornix and facilitates the identification of nodules and thickening of the posterior vaginal wall.

Pelvic adhesions can be evaluated by gently moving the transducer back and forth against the cervix during abdominal palpation to assess whether the uterus, ovaries, and bowel loops slide freely over each other (Video 1).

The data collected at US are described in detail in the radiology report, and anatomic drawings in the axial and sagittal planes are used to document the locations of endometriotic lesions for the attending gynecologist and surgeon (Fig 1).

MR Imaging Protocol for Evaluation of Pelvic Endometriosis

Plane and Pulse Sequence	Contrast Material Used?	TR/TE (msec)	ETL	FOV (cm)	Section Thickness, Spacing (mm)	Matrix	NSA	Saturation Pulse	
								Orientation	Technique
3D localizer	No	…	…	40	7, 2	256 × 128	One	…	…
Axial T2W FSE	No	3475/140	32	28	5, 0	384 × 256	Three	A, S, I	…
Sagittal T2W FSE	No	3650/140	33	24	5, 1	320 × 256	Four	A, S, I	…
Coronal T2W FSE	No	3575/140	37	24	5, 1	256 × 256	Four	A, S, I	…
Axial in-phase fast GRE	No	210/150–200	…	28	5, 0	256 × 192	One	…	…
Axial unenhanced fast GRE	Yes	200/150–200	…	28	5, 0	256 × 192	One	…	Fat
Sagittal dynamic LAVA	Yes	Minimum	…	30	4, 0	320 × 160	One	…	Fat special
Axial delayed phase LAVA	Yes	175/Minimum full	…	28	5, 0	256 × 192	One	…	Fat

Note.—For all imaging sequences except the 3D localizer, the frequency encoding direction is anteroposterior and bandwidth is 41.67 MHz. A = anterior, ETL = echo train length, FOV = field of view, FSE = fast spin echo, GRE = gradient echo, I = inferior, NSA = number of signals acquired, S = superior, TE = echo time, TR = repetition time, T2W = T2-weighted.

Limitations of Transvaginal US

The main limitation of transvaginal US is the restricted field of view. It is difficult to visualize lesions located outside the pelvis. Other common conditions that may impair lesion visualization are large ovarian cysts, subserosal leiomyomas, and acute retroflexion of the uterus. In addition, severe pelvic adhesions and other distortions of the pelvic anatomy may limit transvaginal US evaluation of the pelvic region.

Pelvic MR Imaging Technique

Procedure and Patient Preparation

Pelvic MR imaging is performed by using a 1.5-T MR imaging system (Signa; GE Healthcare, Milwaukee, Wis) with an eight-channel cardiac coil. In preparation for imaging, the patient must fast for at least 4 hours and refrain from voiding for 1 hour before the examination to correct the angle of uterine anteversion and displace the small bowel cephalad. Bowel cleansing is routinely performed by the patient with two doses of an oral laxative (5 mg bisacodyl per dose), one at 8:00 AM and the other at 2:00 PM the day before imaging. The patient also is instructed to follow a low-residue dietary regimen on the day before and the day of the MR imaging examination. Just before MR imaging, 10 mg butylescopolamine (Buscopan; Boehringer Ingelheim, Ingelheim, Germany) is injected intravenously to reduce bowel peristalsis, and 60 mL of gel is infused into the vagina to distend the fornix. The average duration of the MR image acquisition is 25 minutes; however, with an additional 20 minutes required for image interpretation, the MR imaging examination takes about 45 minutes—10 minutes more than transvaginal US.

For a number of reasons, we do not perform rectal distention with gel or saline solution. First, rectal distention may cause patient discomfort, and it increases bowel peristalsis, which may cause blurring of bowel segments on MR images. Second, the nondistended colon above the rectum may become spastic, creating an offset between the two segments that might obscure multifocal lesions or lesions in the upper part of the colon. Third, bowel wall retraction, a valuable sign of the presence of an endometriotic lesion, is likely to disappear when the rectum is distended. These observations agree with those reported by Hottat et al (31).

Our standard MR imaging protocol includes the acquisition of axial, sagittal, and coronal T2-weighted fast spin-echo images and axial T1-weighted gradient-echo images in and out of

phase and with fat suppression. Dynamic sagittal and delayed phase axial images are acquired with a LAVA (*l*iver *a*cquisition with *v*olume *a*cceleration) sequence (GE Healthcare) 50 seconds after the intravenous injection of a gadolinium-based contrast material. The MR imaging parameters are outlined in more detail in the Table.

In patients who have large (≥2-cm-diameter) paracervical lesions that extend to the inferior sacral plexus and pelvic floor or obviously involve the ureters, MR urography also is performed. For urographic imaging, we apply a coronal 3D volumetric T1-weighted time-of-flight fast spoiled gradient-echo sequence (section thickness, 3 mm; matrix, 320 × 192; bandwidth, 62.5 MHz; acquisition time, 21 seconds; field of view, 46 cm) immediately after the contrast-enhanced dynamic acquisitions and an additional intravenous injection of 20 mg furosemide.

Limitations of Pelvic MR Imaging

Although MR imaging provides excellent multiplanar visualization, some conditions can reduce the quality of MR images and the sensitivity of the modality. One of the most important of these conditions is bowel peristalsis, especially in patients undergoing MR imaging to determine whether deeply infiltrating endometriosis of the intestine is present. Peristalsis blurs the bowel contours and adjacent organs and may simulate bowel thickening or mask small lesions. An empty bladder allows the small bowel to obtrude on the vesicouterine pouch or the uterine fundus, and small bowel peristalsis may lead to motion-related artifact on MR images. Even after bowel preparation, fecal residues and gas may impede visualization of deeply infiltrating endometriotic lesions. In patients with obstipation, fecal residues may persist even in the sigmoid colon. A redundant sigmoid colon, a common condition, contributes to these difficulties. Inability to introduce gel into the vagina of a patient may contribute to the failure to detect small lesions on the posterior vaginal wall. Large endometriotic ovarian cysts, subserosal leiomyomas (especially those located in the retrocervical region), and acute retroflexion of the uterus are other common conditions that may impair visualization of endometriosis at MR imaging just as they do at transvaginal US.

Imaging Features of Endometriosis

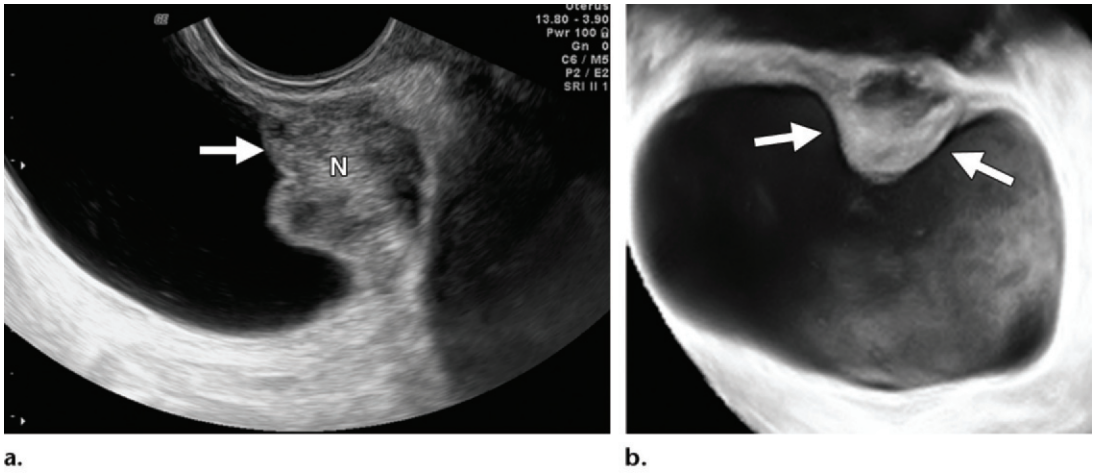
The detection of endometriosis at imaging is a challenge, and pelvic mapping of deeply infiltrating endometriotic lesions is of immeasurable value for planning patient care. Proper evaluation requires knowledge of the pelvic anatomy and the tissue characteristics of deeply infiltrating endometriotic lesions. These lesions are described as consisting of muscular hyperplasia surrounding foci of endometrial tissue. Their imaging features reflect the predominant smooth muscle proliferation and the fibrotic component (32), which often produce the appearance of a solid tumorlike mass with associated fibrosis extending more than 5 mm from the peritoneal surface into adjacent structures (8). On US images, the lesions in deeply infiltrating endometriosis are mostly hypoechoic in comparison with the myometrium. On MR images, they have signal intensity similar to that of smooth muscle, with low signal intensity on T2-weighted images, intermediate signal intensity on T1-weighted images, and minimal enhancement after the intravenous injection of contrast material. Cystic areas may be present, with or without hemorrhagic content. (Hemorrhagic content is easily identified at MR imaging because of the high sensitivity of the method for depicting blood.)

Teaching Point

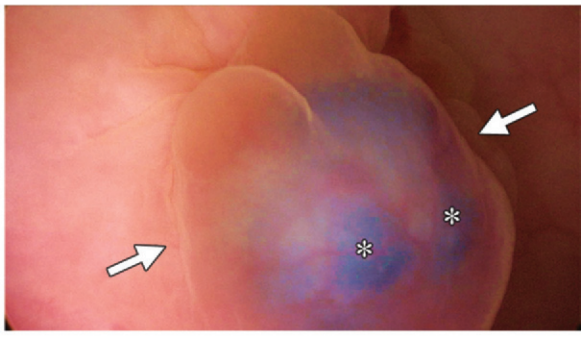
Endometriosis is characterized by multifocality (22,33). The anatomic structures most often involved are the uterosacral ligament, rectosigmoid colon, vagina, and bladder, in order of decreasing frequency. Although deeply infiltrating endometriosis is histologically benign, it may follow a malignant clinical course, metastasizing through lymphatic and vascular channels and invading nearby structures (34). The treatment of choice for endometriosis is laparoscopic resection of all endometriotic tissue (35). Inadequate surgical experience or technique or a less than accurate imaging evaluation may lead to the incomplete excision of lesions, with a poorer outcome. The surgeon plans surgical strategy and assembles a multidisciplinary team to perform the procedure on the basis of patient-specific information and imaging features. Complications of rectal, vaginal, and ureteral resection occur, albeit infrequently, and can worsen the patient's quality of life. Other important goals of disease mapping are to allow a comprehensive discussion with the patient about the treatment strategy and evaluation of the postoperative outcome. Evaluation includes transvaginal US after bowel preparation, performed within 3 months after the surgical procedure.

The imaging evaluation of endometriosis should be guided by the statistical frequency of involvement of various pelvic anatomic sites by deeply infiltrating endometriotic lesions.

Figure 2. Bladder endometriosis in a 28-year-old woman. **(a)** Sagittal transvaginal US image shows a hypoechoic nodule *(N)* attached to the bladder wall and hypoechoic endometrial tissue infiltrating the detrusor muscle (arrow). **(b)** Three-dimensional transvaginal US image shows projection of the nodule (arrows) into the bladder lumen. **(c)** Magnified cystoscopic view of the same lesion (arrows) shows bluish spots (*) that represent tiny hemorrhagic foci.



a. b.



c.

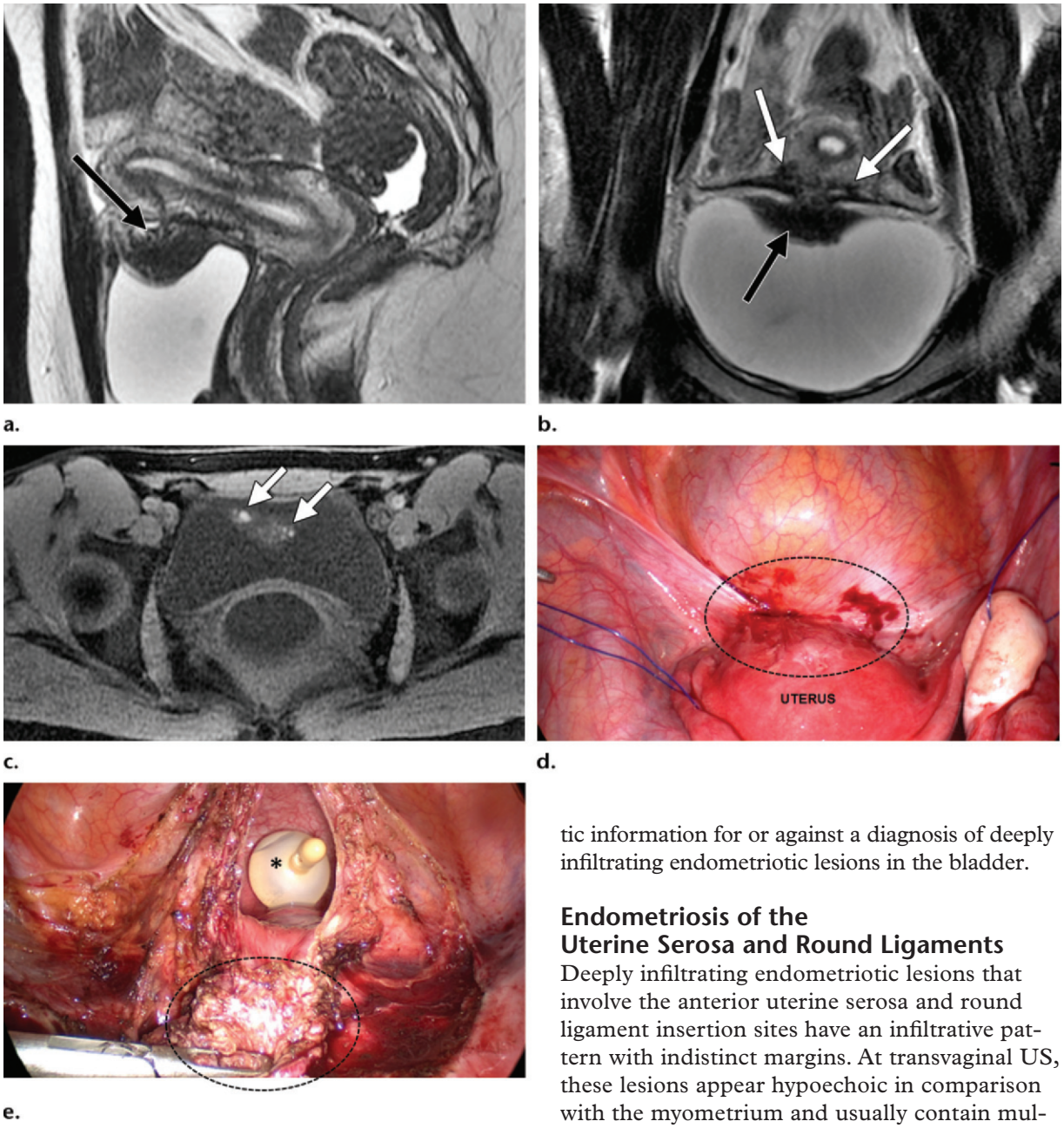
Bladder Endometriosis

Endometriosis of the urinary tract occurs in approximately 20% of cases, and the bladder is the organ most frequently involved. Most cases are asymptomatic, but women with bladder involvement may experience dysuria, urgency, and gross hematuria during menses. Bladder endometriosis is defined by full-thickness infiltration of the bladder detrusor and appears as a mural mass projecting into the bladder lumen (36). The bladder mucosa is usually intact. Small nodules of the vesicouterine fold are not considered indicative of bladder endometriosis. The endometrial implants are typically embedded in fibromuscular tissue and are not easily palpated at physical examination (8).

The most accurate imaging technique for diagnosing bladder endometriosis is transvaginal US, which allows the determination of lesion size and depth of extension into the detrusor (24). Transvaginal US typically depicts an endometriotic implant in the bladder as a solid hypoechoic nodule with regular or irregular contours that adheres to the posterior aspect of the bladder dome, frequently at the midline (Fig 2). The internal appearance of the lesions varies, depending on the presence and size of cystic areas within them. On MR images, the lesions generally appear isointense to myometrium on T1-weighted images, hypointense on T2-weighted images, and minimally enhanced after the injection of a gadolinium-based contrast material. Hyperintense spots representing hemorrhagic content also may be seen on T1-weighted images (Fig 3). At transvaginal US, the presence of a minimal amount of urine in the bladder is sufficient for a dynamic assessment of the posterior vesical wall. However, minimal filling of the bladder at MR imaging may impair the visualization of small lesions in the bladder dome because of the corrugated aspect of the bladder wall in that location. Intestinal loops in the vesicouterine pouch may produce artifacts due to peristaltic motion, which has a much greater effect on MR images than on transvaginal US images. The differential diagnosis of endometriotic lesions in the bladder includes a urachal remnant and epithelial and mesenchymal tumors (24,37).

At laparoscopy, the visible part of an endometriotic bladder lesion is like the tip of an iceberg; only a small part of the nodular lesion is visible

Figure 3. Bladder endometriosis in a 30-year-old woman with dysuria. **(a, b)** Sagittal **(a)** and coronal **(b)** T2-weighted MR images show a well-defined low-signal-intensity bladder wall nodule (black arrow) projecting into the lumen. Thickening of the anterior uterine serosa (white arrows in **b**) is also seen. **(c)** Axial T1-weighted MR image depicts hemorrhagic foci (arrows) within the bladder lesion. **(d)** Laparoscopic view shows retraction and distortion in the anterior compartment of the pelvis because of adhesions between the anterior uterine serosa and the vesicouterine peritoneum (dashed oval). **(e)** Laparoscopic view obtained after resection shows the site of the nodule in the bladder wall (dashed oval). A catheter balloon (*) can be seen through the opened bladder dome.

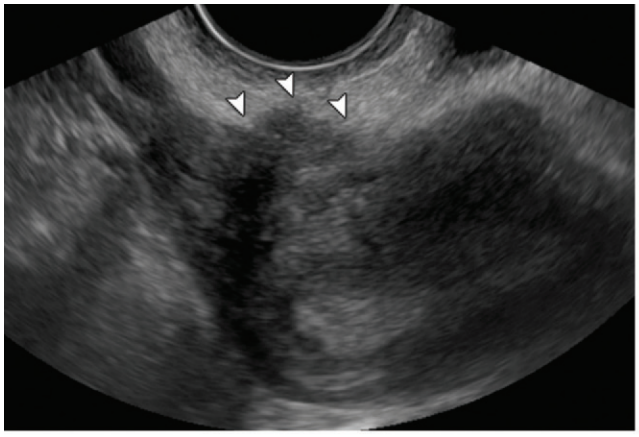


at the peritoneal surface, and the extent of lesion infiltration into the bladder layers cannot be assessed. Lesion palpation with a surgical probe reveals an irregular, ill-defined, firm nodule. Cystoscopic evaluation may provide additional diagnostic information for or against a diagnosis of deeply infiltrating endometriotic lesions in the bladder.

Endometriosis of the Uterine Serosa and Round Ligaments

Deeply infiltrating endometriotic lesions that involve the anterior uterine serosa and round ligament insertion sites have an infiltrative pattern with indistinct margins. At transvaginal US, these lesions appear hypoechoic in comparison with the myometrium and usually contain multiple bright foci or small cystic areas (Fig 4). At MR imaging, the lesions demonstrate low signal intensity on T2-weighted images, with small cystic areas (Fig 5). Extensive lesions may resemble adenomyosis (Fig 6). The differential diagnosis

Figures 4, 5. **(4)** Endometriosis of the anterior pelvic compartment in a 32-year-old woman. **(a)** Sagittal oblique transvaginal US image shows a hypoechoic endometriotic lesion (arrowheads) with irregular and ill-defined margins that has infiltrated the peritoneum near the insertion of the left round ligament. **(b)** Laparoscopic view depicts vesicouterine peritoneal infiltration (arrows) near the left round ligament *(LRL)*. **(5)** Endometriosis of the anterior pelvic compartment in a 34-year-old woman. **(a–c)** Coronal **(a)**, sagittal **(b)**, and axial **(c)** T2-weighted MR images show thickening and heterogeneous low signal intensity of the round ligaments at their insertion sites near the uterus. Small cystic foci with higher signal intensity (white arrows) are seen in the ligaments. The posterior bladder wall appears normal (black arrow in **a** and **b**). **(d)** Laparoscopic view shows distortion of the pelvic anatomy, with adhesion and retraction of the round ligaments (arrows). A small mesothelial cyst is attached to the posterior uterine wall (*) and rectosigmoid colon.



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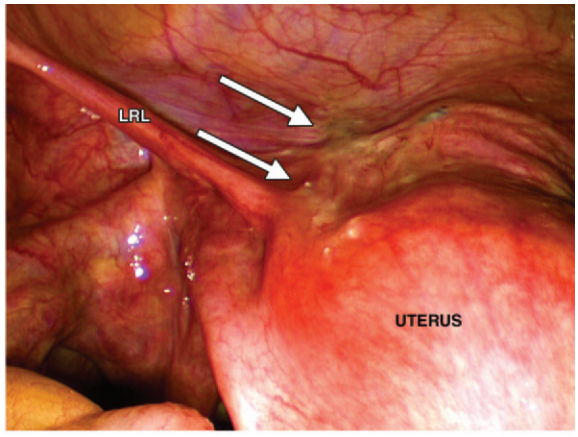

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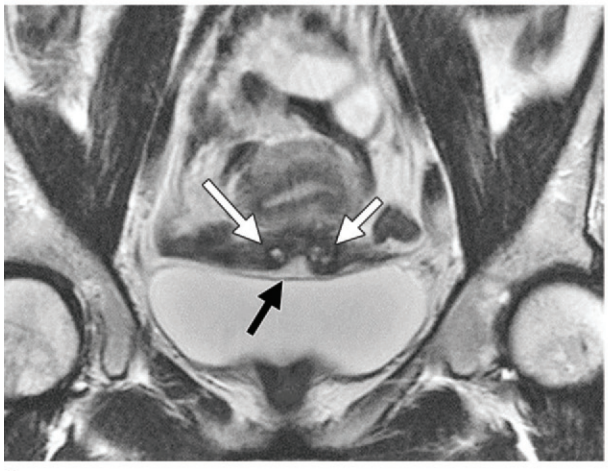

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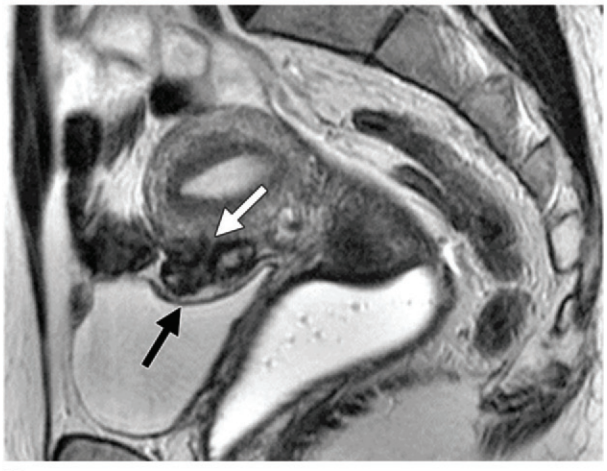

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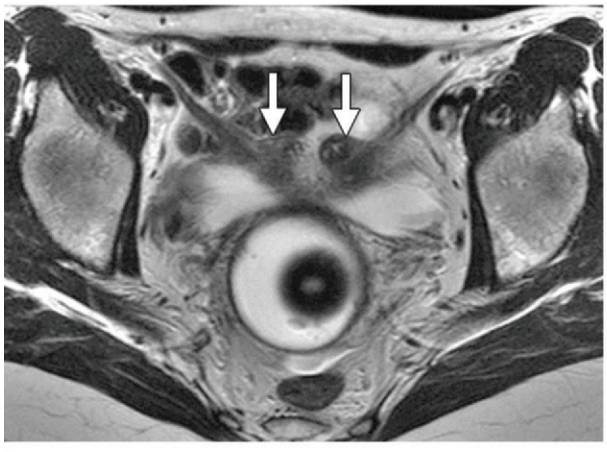

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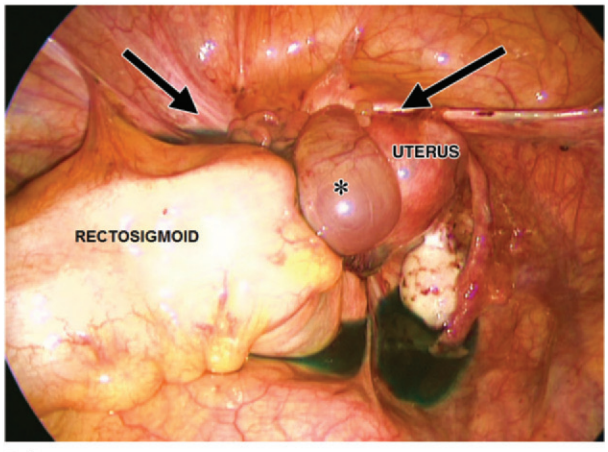
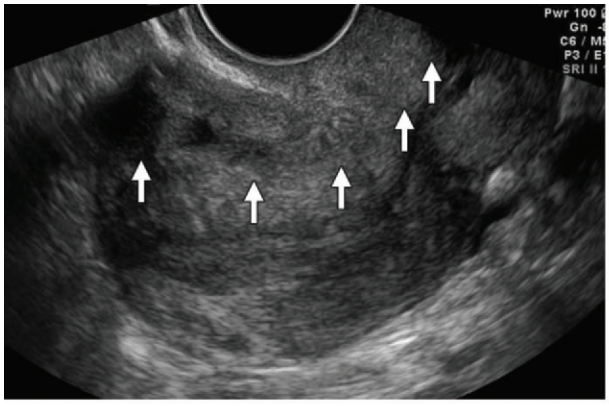


5d.

Figure 6. Extensive endometriosis in the anterior pelvic compartment in a 30-year-old woman. **(a)** Sagittal transvaginal US image shows a region of heterogeneous hypoechogenicity with ill-defined margins (arrows), a finding indicative of endometrial infiltration of the peritoneum in the vesicouterine pouch. **(b, c)** Sagittal **(b)** and coronal **(c)** T2-weighted MR images show extensive infiltration of the anterior uterine serosa and myometrium (area inside the dashed line) and posterior displacement of the uterus. A circumscribed low-signal-intensity nodule (arrow in **c**) is seen in the bladder dome, near the midline. **(d)** Axial T1-weighted MR image depicts hemorrhagic content in a right endometrioma (*) and in small cystic foci (arrows) within the anterior region of endometriotic tissue. **(e)** Laparoscopic view depicts endometriotic implants (arrows) in the anterior pelvic compartment, with associated firm adhesions to the anterior abdominal wall.



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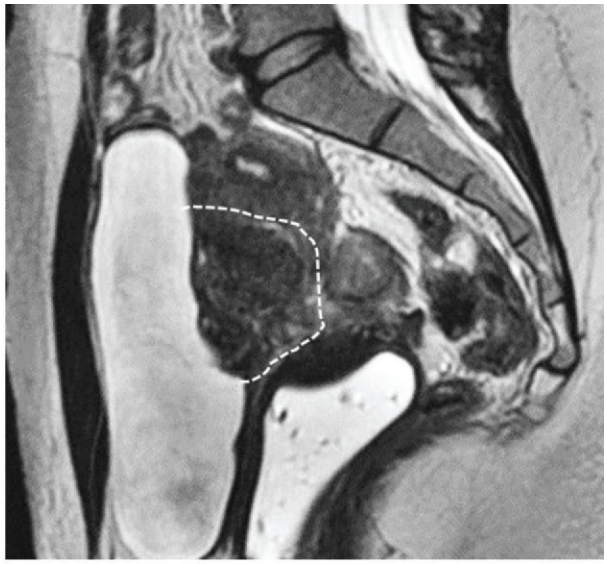

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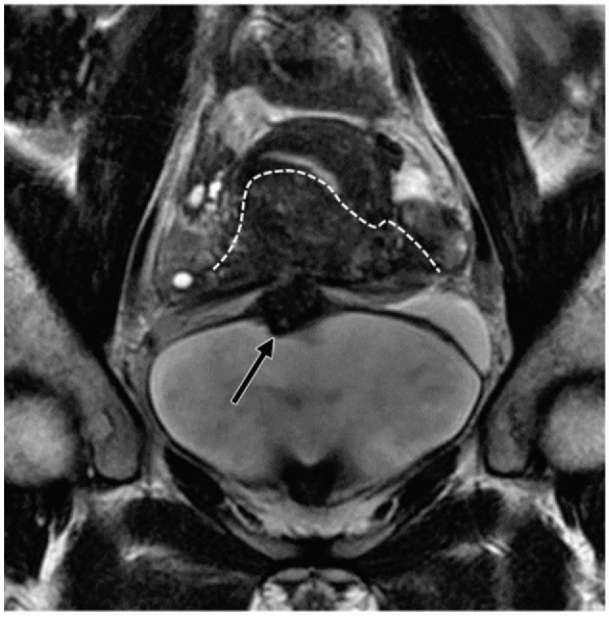

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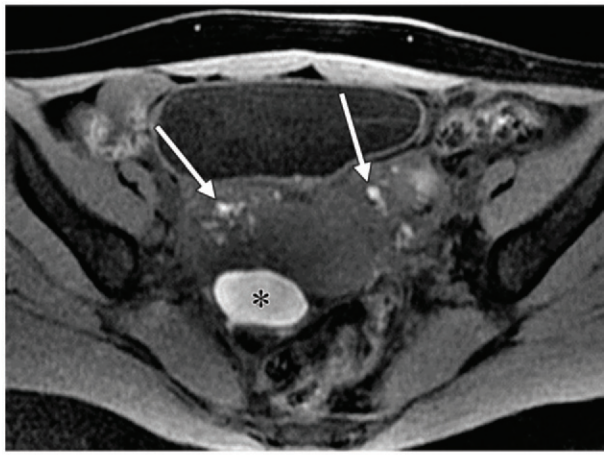

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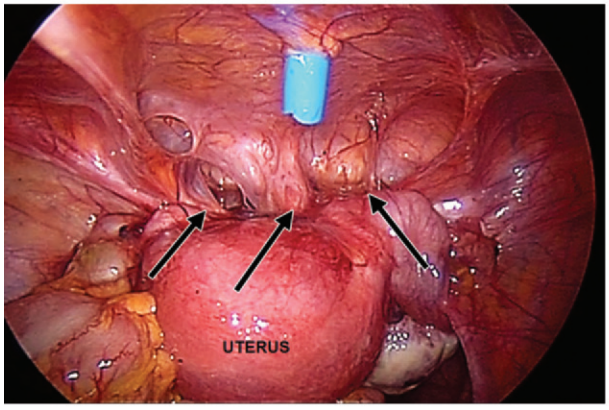
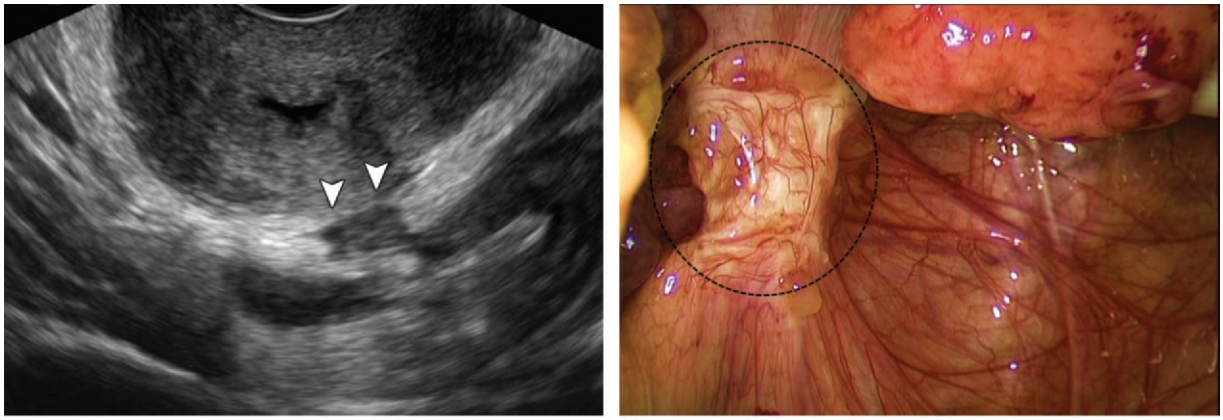


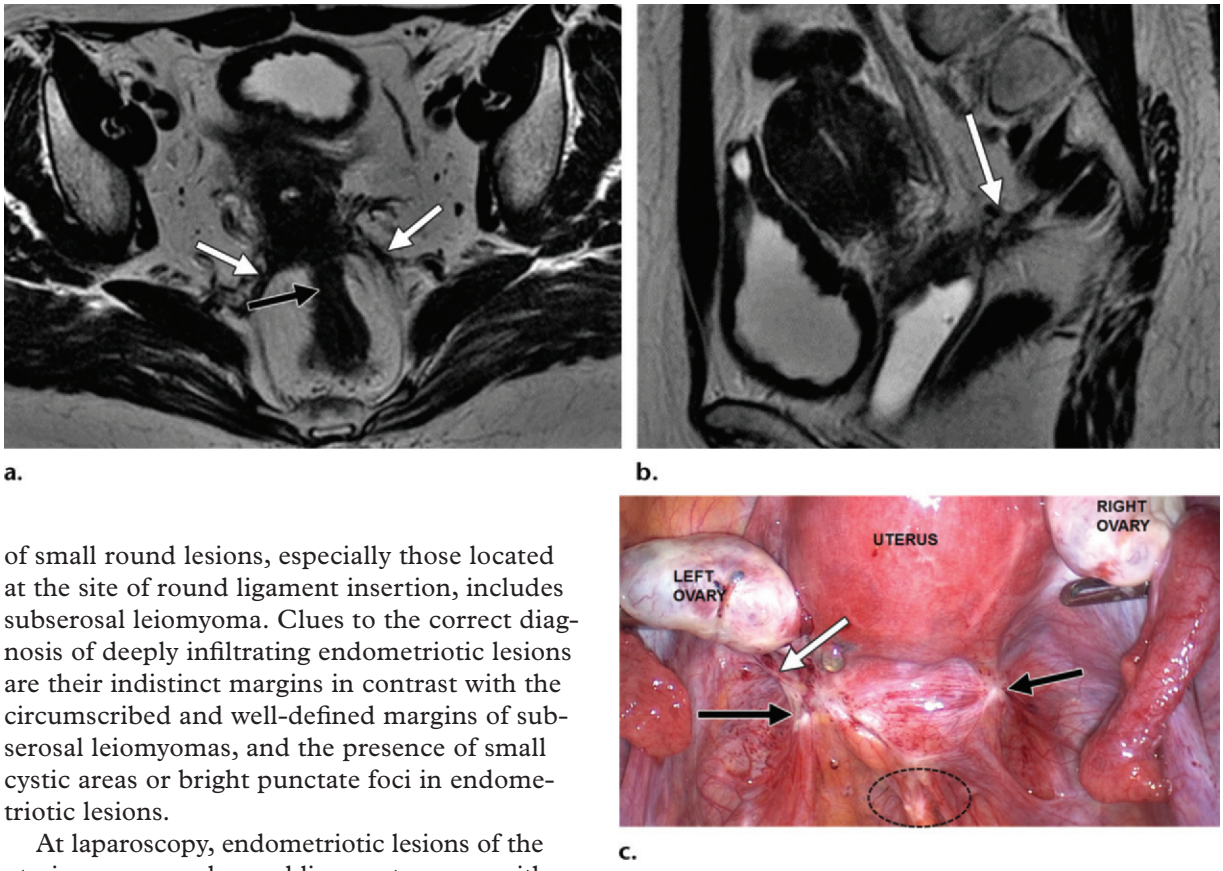
e.

Figure 7. Retrocervical endometriosis in a 26-year-old woman. **(a)** Axial transvaginal US image shows a small hypoechoic nodule (arrowheads) near the insertion of the left uterosacral ligament. **(b)** Laparoscopic view depicts focal infiltration and retraction of the left uterosacral ligament (dashed oval).



a. b.

Figure 8. Bilateral retrocervical deeply infiltrating endometriosis in a 35-year-old woman with dyspareunia and pelvic pain. **(a)** Axial T2-weighted MR image shows bilateral regions of uterosacral ligament thickening with low signal intensity and irregular margins (white arrows). The rectum is retracted toward the retrocervical region (black arrow). **(b)** Sagittal T2-weighted MR image depicts left uterosacral ligament thickening with posterolateral extension of endometriosis to the pelvic wall (arrow). **(c)** Laparoscopic view demonstrates bilateral involvement of the uterosacral ligament with retractile lesions (black arrows), thick adhesions between the left ovary and the ipsilateral uterosacral ligament (white arrow), and another endometriotic lesion in the Douglas pouch (dashed oval).



a. b. c.

of small round lesions, especially those located at the site of round ligament insertion, includes subserosal leiomyoma. Clues to the correct diagnosis of deeply infiltrating endometriotic lesions are their indistinct margins in contrast with the circumscribed and well-defined margins of subserosal leiomyomas, and the presence of small cystic areas or bright punctate foci in endometriotic lesions.

At laparoscopy, endometriotic lesions of the uterine serosa and round ligaments appear either as small areas of tissue distortion with red hemorrhagic spots or as large masses associated with firm adhesions between the anterior pelvic wall and uterine serosa. The larger lesions may simulate neoplasms.

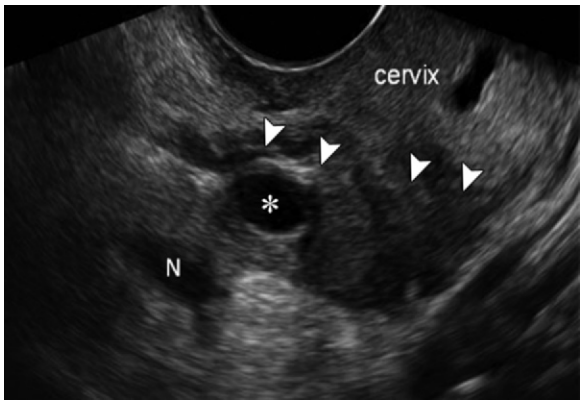
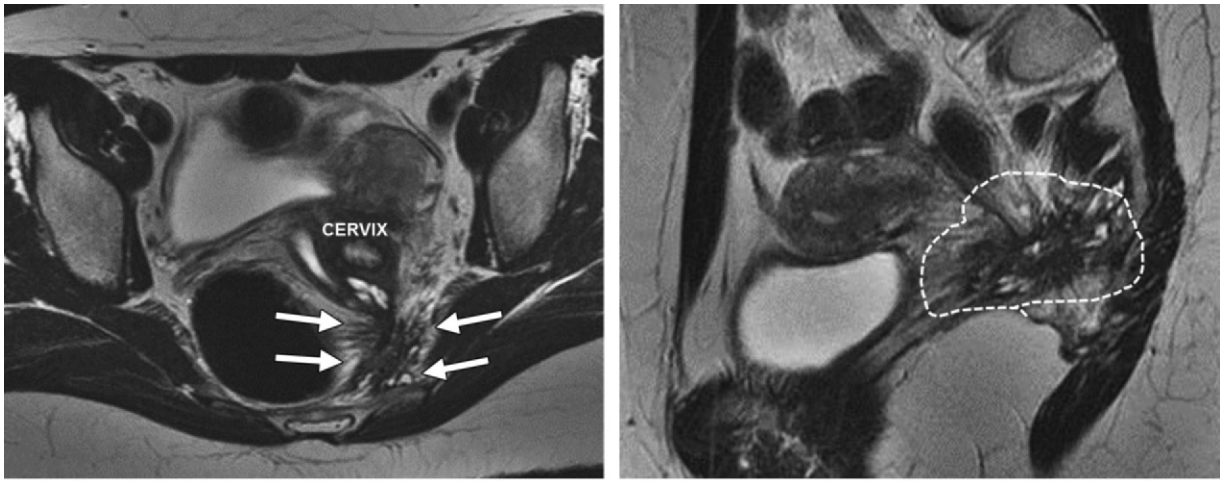


Figure 9. Retrocervical endometriosis in a 32-year-old woman. Axial oblique transvaginal US image shows a large lesion (arrowheads) with both solid and cystic components involving the right uterosacral ligament. The lesion contains a large round cyst (*). Another hypoechoic nodule *(N)* is seen attached to the anterior rectal wall.

Figure 10. Retrocervical endometriosis in a 34-year-old woman with back pain. **(a)** Axial T2-weighted MR image shows a stellate low-signal-intensity endometriotic lesion containing small cystic areas in the left uterosacral ligament. The lesion extends to the sacral region (arrows). **(b)** Sagittal T2-weighted MR image depicts the same lesion (area inside the dashed line).

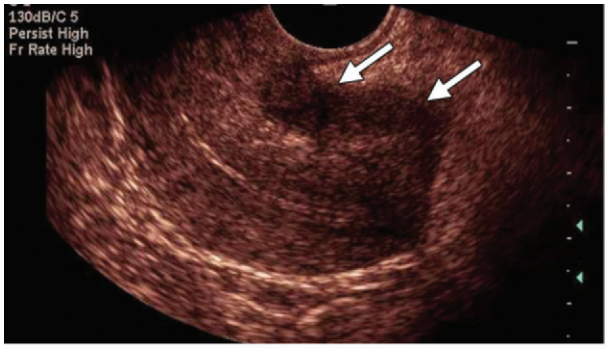


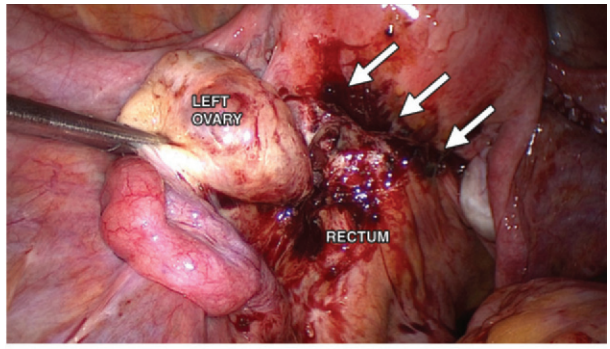
a. b.

Endometriosis of the Retrocervical Region

The retrocervical region is commonly affected by deeply infiltrating endometriosis, and involvement of this region usually causes severe and painful symptoms (33). Association with vaginal and intestinal lesions is frequent; in more extensive disease, adhesions among pelvic structures may result in a frozen pelvis. Although a thickened uterosacral ligament or nodules in the posterior cul-de-sac can be palpated in most patients, physical examination is insufficient for diagnosing and evaluating the extent of disease (10).

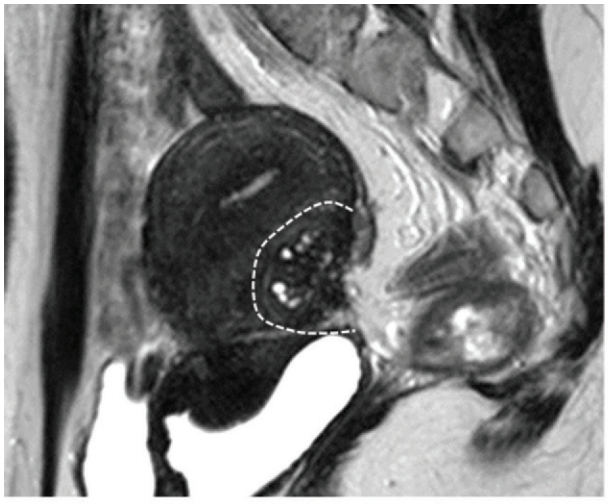
Lesions of the uterosacral ligament may be unilateral or bilateral. Morphologic abnormalities that may occur include asymmetry between the two ligaments, diffuse or localized thickening, and a nodule with a regular or stellate margin near the site of cervical uterosacral ligament insertion. At transvaginal US, these lesions appear hypoechoic (Fig 7). On T2-weighted MR images, they demonstrate low signal intensity similar to that of pelvic smooth muscle (Fig 8). Uterosacral ligament nodules commonly display a mixed echotexture due to anechoic or hypoechoic cystic areas within them at transvaginal US (Fig 9). Similarly, at MR imaging the cystic cavities can appear as simple fluid, with high signal intensity on T2-weighted images and low signal intensity on T1-weighted images (Fig 10). They also may show high signal intensity on T1-weighted fat-saturated images because of their hemorrhagic content.

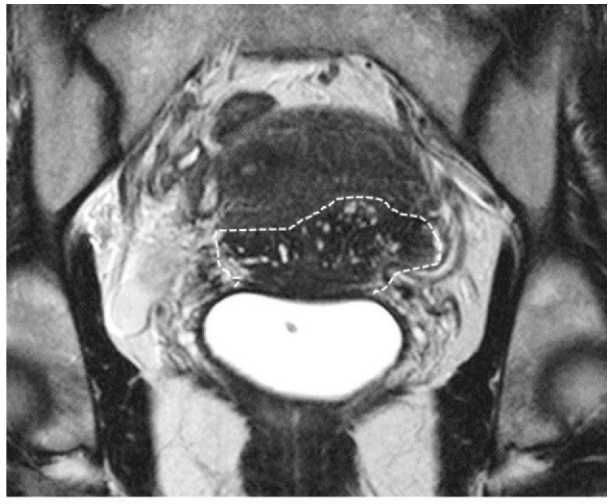




a. b.

Figure 11. Extensive endometriosis of the posterior pelvic compartment in a 27-year-old woman. **(a)** Sagittal transvaginal US image shows a hypoechoic lesion (arrows) with ill-defined margins covering and infiltrating the posterior uterine wall, from the fundus to the retrocervical region. **(b)** Laparoscopic view shows endometriotic tissue that has infiltrated the posterior uterine wall (arrows) and adheres to the anterior rectal wall. The left ovary is medially located and involved in the adhesive process.





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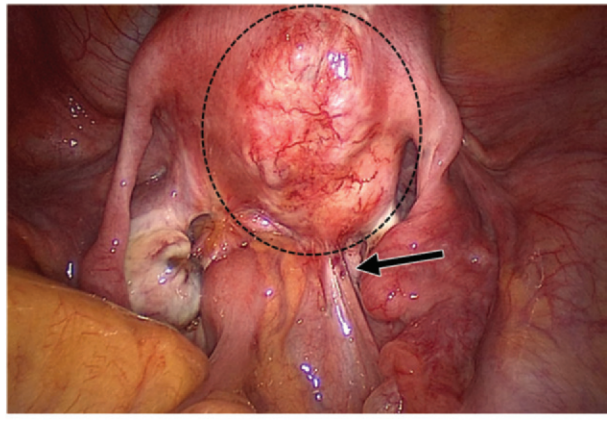


c.

Figure 12. Retrocervical endometriosis in a 31-year-old woman with infertility. **(a, b)** Sagittal **(a)** and coronal **(b)** T2-weighted MR images show an endometriotic lesion (area inside the dashed line) containing multiple tiny cystic foci. The lesion has infiltrated the posterior uterine serosa and myometrium and is causing uterine retractile retroflexion. **(c)** Laparoscopic view shows the endometriotic lesion (dashed oval) with associated rectal wall retraction (arrow).

Another appearance of retrocervical lesions is that of infiltrative tissue with indistinct margins that covers the posterior uterine serosa, usually from the uterine fundus to the retrocervical region, frequently with associated uterine retractile retroflexion. The infiltrative tissue is characteristically hypoechoic at transvaginal US and shows marked low signal intensity on T2-weighted MR images (Figs 11, 12). This pattern also usually includes multiple bright internal foci or small cystic areas. In patients with retroflexion of the uterus, evaluation of the cervical uterosacral ligament insertion may be particularly difficult at MR imaging. The differential diagnosis of retrocervical lesions includes peritoneal metastases, most commonly from gastrointestinal and ovarian malignancies (38). Findings of ascites and a tumor

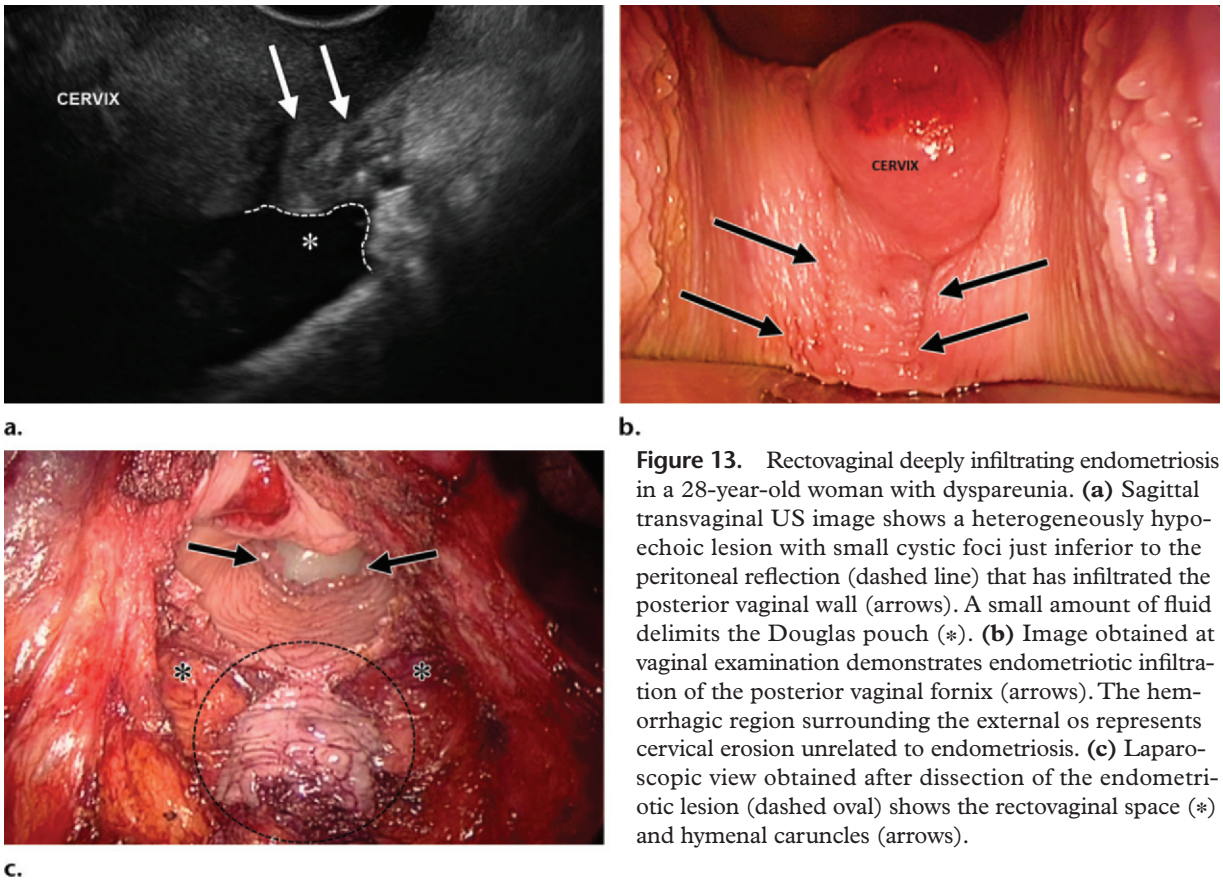


Figure 13. Rectovaginal deeply infiltrating endometriosis in a 28-year-old woman with dyspareunia. **(a)** Sagittal transvaginal US image shows a heterogeneously hypoechoic lesion with small cystic foci just inferior to the peritoneal reflection (dashed line) that has infiltrated the posterior vaginal wall (arrows). A small amount of fluid delimits the Douglas pouch (*). **(b)** Image obtained at vaginal examination demonstrates endometriotic infiltration of the posterior vaginal fornix (arrows). The hemorrhagic region surrounding the external os represents cervical erosion unrelated to endometriosis. **(c)** Laparoscopic view obtained after dissection of the endometriotic lesion (dashed oval) shows the rectovaginal space (*) and hymenal caruncles (arrows).

mass elsewhere in the abdominal cavity aid in diagnosing metastatic malignancies.

The laparoscopic appearance of retrocervical deeply infiltrating endometriotic lesions is emblematic and easily recognized by the surgeon. The lesions are generally characterized by either irregular pale thickening or nodularity of the uterosacral ligament with irregular margins. In a blocked pelvis, the uterosacral ligament lesions are hidden by adhesions and distortion of pelvic anatomy.

Endometriosis of the Rectovaginal Space

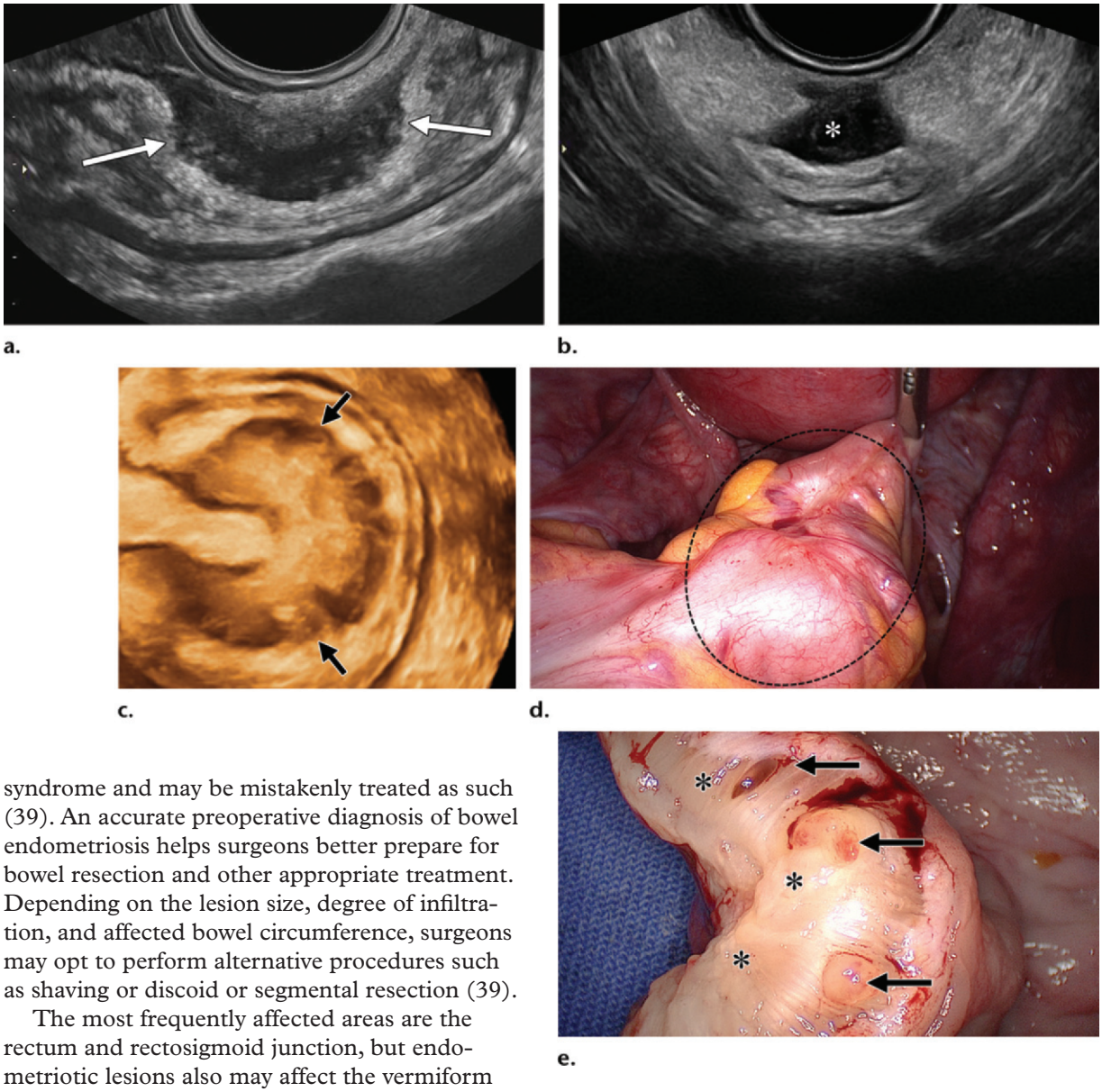
The rectovaginal space is the region situated between the posterior vaginal wall and the anterior rectal wall below the peritoneal reflection. The inferior two-thirds of this space, known as the rectovaginal septum, is rarely affected by deeply infiltrating endometriosis. Rectovaginal lesions are frequently extensions from retrocervical or posterior vaginal lesions. They occur as firm nodules that can be palpated at vaginal examination. The purplish nodular infiltrations are easily seen through the speculum, usually in the posterior vaginal wall, where they may cause retraction (8). At imaging, they have a hypoechoic appearance at transvaginal US and low signal intensity on T2-weighted MR images (Fig 13). It is crucial to determine whether lesions in this site have infiltrated the anterior rectal wall. A small amount of fluid in the posterior cul-de-sac facilitates the identification of the peritoneal reflection.

The laparoscopic appearance of these endometriotic lesions is similar to that of lesions in the bladder, which are also subperitoneal and therefore not readily accessible for endoscopic viewing. Careful instrumental palpation of the compromised area with incision of the posterior cul-de-sac peritoneum exposes the lesions.

Endometriosis of the Rectosigmoid Colon

Intestinal endometriosis occurs in 12%–37% of patients and is commonly associated with severe, deeply infiltrating endometriosis in multiple pelvic locations (uterosacral ligament, ovaries, vagina, bladder, and pelvic sidewall) (26,33). The classic symptoms are cyclic and include pain during defecation, bloating, and bowel cramping that are relieved by passing air or feces. Mild symptoms may be present during both the premenstrual and periovulatory periods. Cyclic rectal bleeding during menses is observed rarely. Because the symptoms are nonspecific, the condition is often misdiagnosed as irritable bowel

Figure 14. Intestinal endometriosis in a 36-year-old woman. **(a)** Sagittal transvaginal US image obtained after bowel preparation demonstrates a hypoechoic nodule (arrows) attached to the wall of the sigmoid colon and penetrating the muscularis propria interna. **(b)** Axial transvaginal US image shows a pyramid-shaped lesion (*) with its base adherent to the anterior rectal wall and its apex pointing toward the retrocervical region. **(c)** Three-dimensional image from transvaginal US demonstrates retraction of the bowel (arrows) because of fibrotic infiltration. **(d)** Laparoscopic image depicts a region of bowel wall distortion (dashed oval) with a central depression due to endometriotic infiltration and fibrotic reaction. Only the superficial aspect of the endometriotic lesion is seen. **(e)** Photograph of a gross specimen of resected bowel shows the endometriotic lesion (*), which contains several small peripheral cysts (arrows).

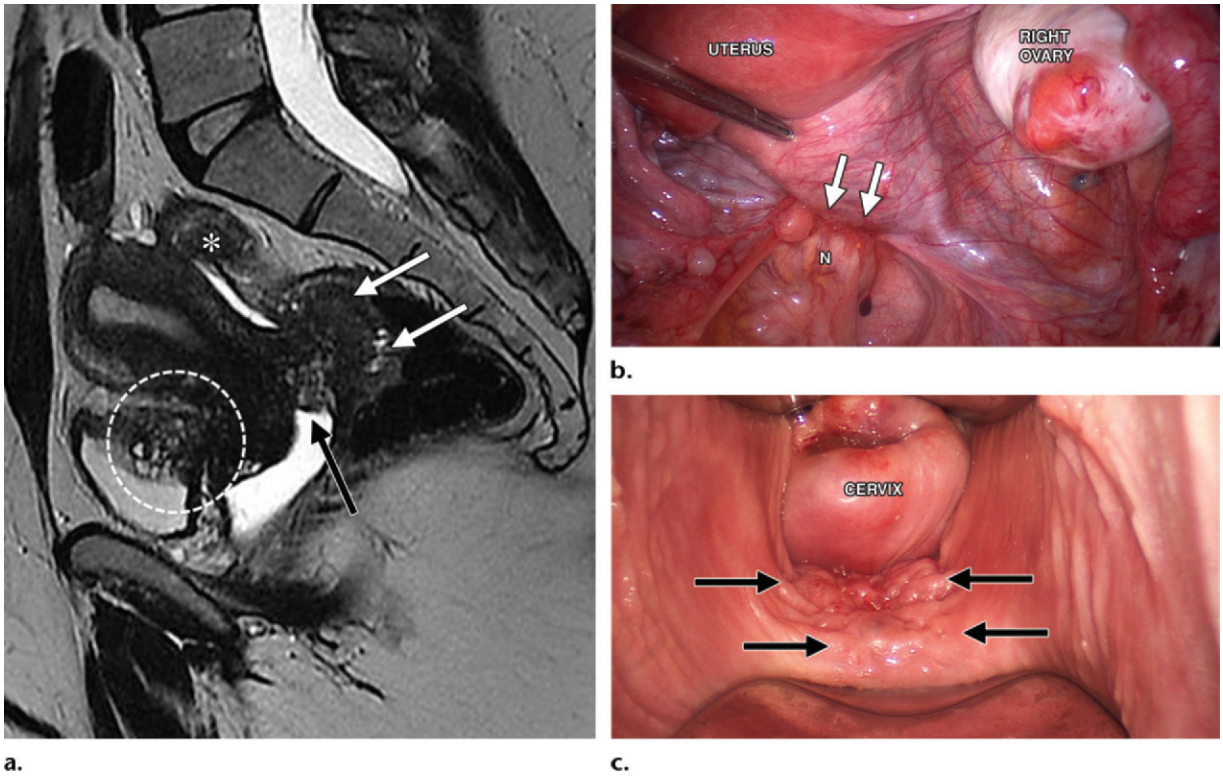


syndrome and may be mistakenly treated as such (39). An accurate preoperative diagnosis of bowel endometriosis helps surgeons better prepare for bowel resection and other appropriate treatment. Depending on the lesion size, degree of infiltration, and affected bowel circumference, surgeons may opt to perform alternative procedures such as shaving or discoid or segmental resection (39).

The most frequently affected areas are the rectum and rectosigmoid junction, but endometriotic lesions also may affect the vermiform appendix, ileum, cecum, and descending colon, in order of decreasing frequency (33). Intestinal lesions are not always isolated in a single area of the bowel. According to published data, rectal lesions are associated with a second intestinal lesion in 55% of cases (22). Similarly, rectosigmoid lesions are associated with deeply infiltrating ileocecal lesions (in the cecum, ileum, or both) in 28% of cases. The high frequency of second intestinal lesions in patients with a rectosigmoid lesion justifies a careful intestinal examination, since the number and location of intestinal lesions govern the surgical procedure (22).

The typical imaging appearance of intestinal endometriotic lesions is a solid, homogeneous nodule with irregular contours attached to the intestinal wall. Nodules demonstrate marked

Figure 15. Extensive deeply infiltrating endometriosis in a 32-year-old woman with infertility. **(a)** Sagittal T2-weighted MR image shows heterogeneous endometriotic nodules in the posterior bladder wall and vesicouterine peritoneum (dashed circle), anterior rectal wall (white arrows), vagina (black arrow), and sigmoid colon (*). **(b)** Laparoscopic image demonstrates adhesion of retrocervical lesions (arrows) to the rectal nodule *(N)*. **(c)** Image obtained at vaginal examination depicts endometriotic infiltration of the posterior vaginal fornix and rectovaginal space (arrows).



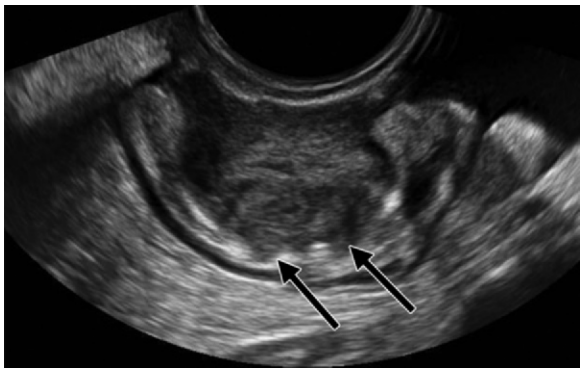


Figure 16. Intestinal endometriosis in a 40-year-old woman. Sagittal transvaginal US image obtained after bowel preparation shows a hypoechoic nodule attached to the sigmoid colon wall. Hypoechoic areas of discontinuity (arrows) in the normally hyperechoic submucosal layer of the bowel wall are indicative of endometriotic infiltration.

hypoechogenicity at transvaginal US after bowel preparation and low signal intensity at T2-weighted MR imaging (Figs 14, 15). On axial images showing rectal cross sections, the lesions generally are located between the 10-o'clock and 2-o'clock positions. They typically display a pyramidal shape, with the base of the pyramid adhering to the anterior rectal wall and the apex oriented toward the retrocervical region. The lesions are usually confined to the serosa or muscularis propria. If a lesion involves the submucosal layer, it demonstrates a striated aspect or areas of interruption in the hyperechoic intestinal layer at transvaginal US (Fig 16).

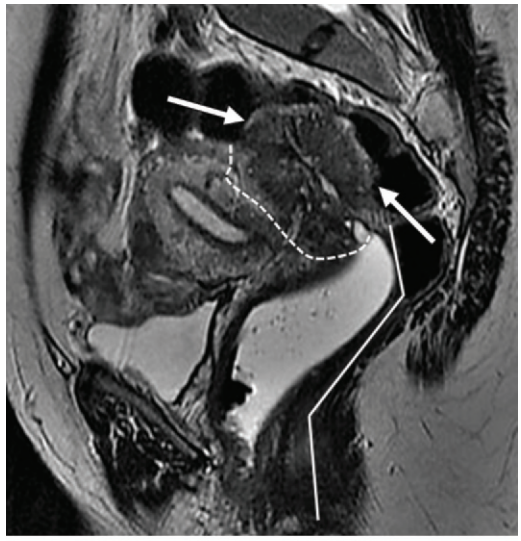
The distance between the inferior lesional margin and the anal border is important, because the risk of complications is greater with a gastrointestinal anastomosis in the lower rectum (<5 cm from the anal border) (25). This distance can be determined at transvaginal US or MR imaging. At transvaginal US, the peritoneal reflection is used as the primary point of reference, followed by the rectal curvatures in cases where location cannot be determined from the reflection, as described by Gonçalves et al (18). Because of the excellent

anatomic resolution provided by MR imaging, the distance measurement is most easily performed on MR images; however, the rectal curvatures then must be considered (Fig 17).

In the authors' experience, transvaginal US performed after bowel preparation is the best imaging modality for identifying intestinal lesions, determining which bowel wall layers are affected, and measuring the circumference of involved bowel. This method allows dynamic evaluation of the rectosigmoid colon from the anal verge to the descending colon and sigmoid transition with high spatial resolution and minimal patient discomfort. The proximity between the transducer and the targeted structure provides superior contrast resolution, which is important for visualizing small and laterally located lesions. Gonçalves et al used transvaginal US to detect at least two rectosigmoid lesions (23). Nodules in the descending colon and ileocecal region have exactly the same appearance as rectosigmoid nodules (Fig 18). MR imaging is not reliable for detecting deeply infiltrating endometriotic lesions, especially small nodules (<1.5 cm), in the sigmoid colon and ileocecal region (Fig 19). Gas and fecal contents, peristaltic artifacts, and even the redundant appearance of the bowel impair adequate assessment. In addition, a spastic colon on MR images may mimic deeply infiltrating endometriosis (Fig 20).

The differential diagnosis of intestinal lesions is not challenging, because unlike colon cancer, deeply infiltrating endometriosis starts at the serosal layer and rarely affects the mucosa. Advanced-stage endometriosis of the sigmoid colon may mimic a bowel-constricting neoplasm. Metastatic implants to the bowel, especially to the small intestinal loops, are another differential diagnosis (40).

Laparoscopic evaluation of an intestinal lesion reveals a parietal lesion surrounding a central depression that distorts the affected segment. The depth of infiltration of the intestinal wall cannot be assessed with endoscopy.



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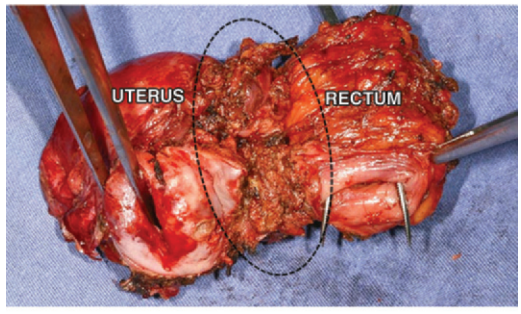
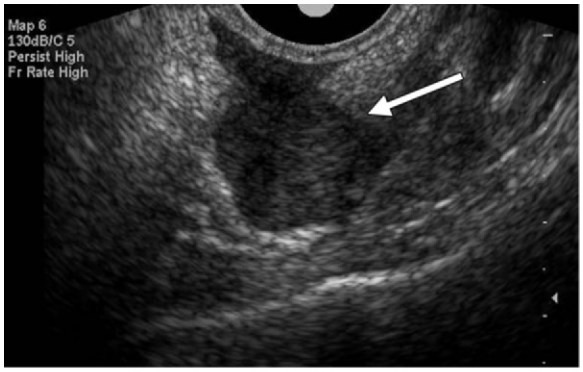


b.

Figure 17. Extensive deeply infiltrating endometriosis in the posterior pelvic compartment in a 34-year-old woman with pelvic pain and dyspareunia. **(a)** Sagittal T2-weighted MR image shows endometriotic infiltration (area inside the dashed line) of the posterior uterine serosa and vaginal fornix and the anterior rectal wall (arrows). The distance between the inferior margin of the nodule and the anal border can be estimated, but the rectal curvatures (solid line) must be considered. **(b)** Photograph of a gross specimen obtained at hysterectomy depicts endometriotic tissue (dashed oval) between the uterus and rectum.

Vaginal Endometriosis

Vaginal endometriosis may be an incidental finding in asymptomatic patients but is more often associated with dysmenorrhea and postcoital spotting. The condition is almost always associated with endometriosis in other pelvic locations (especially retrocervical and rectal lesions) and may appear as nodular or polypoid masses involving the posterior vaginal fornix (8). The accurate diagnosis of vaginal endometriosis is especially important because a specific surgical procedure is required for treatment and because the condition is associated with a risk for rectovaginal fistulation (33).



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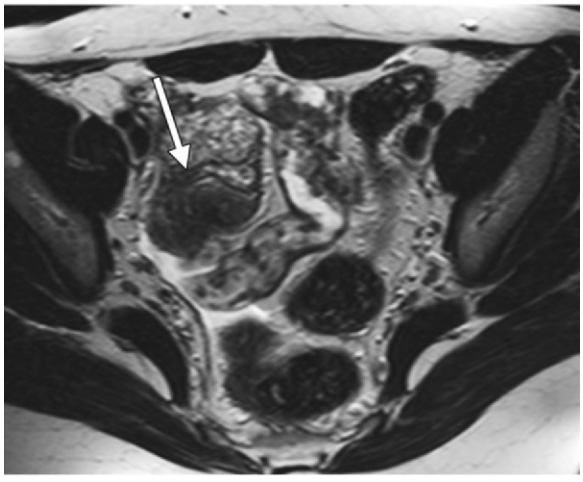


b.

Figure 18. Deeply infiltrating endometriosis of the cecum in a 28-year-old woman. **(a)** Transvaginal US image demonstrates a large hypoechoic nodule (arrow) attached to the bowel wall at the base of the cecum. **(b)** Axial T2-weighted MR image shows a low-signal-intensity nodular lesion (arrow) in the cecum.

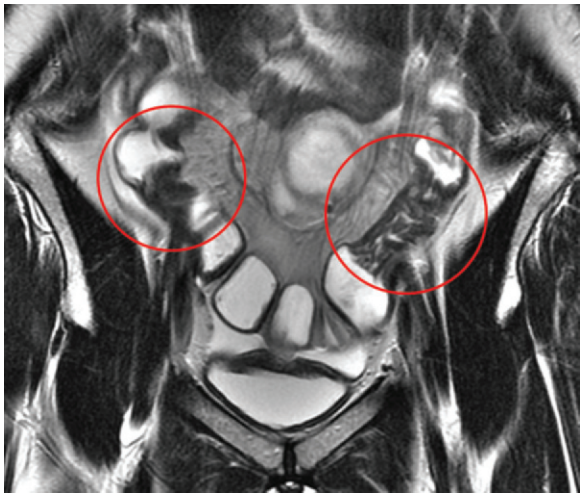
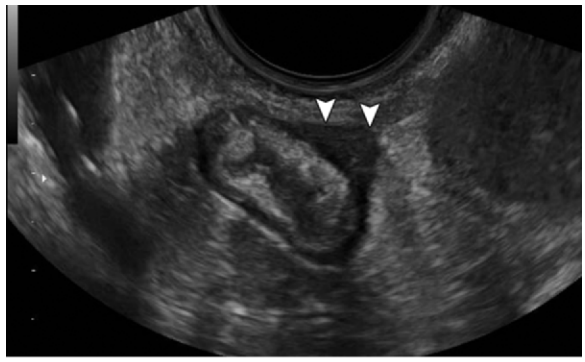


Figure 20. Coronal T2-weighted MR image obtained in a 25-year-old woman demonstrates two areas (red circles) that aroused the suspicion that intestinal endometriosis might be present. Transvaginal US showed no lesions. The MR imaging features may have been artifacts of peristalsis.



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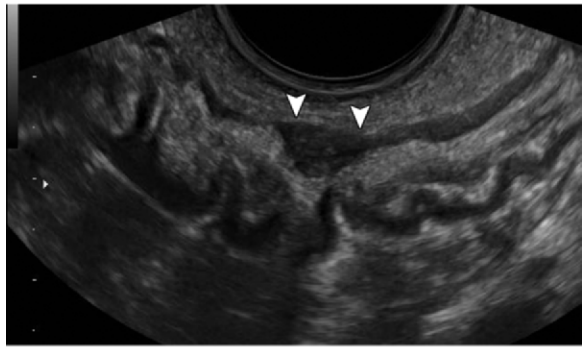

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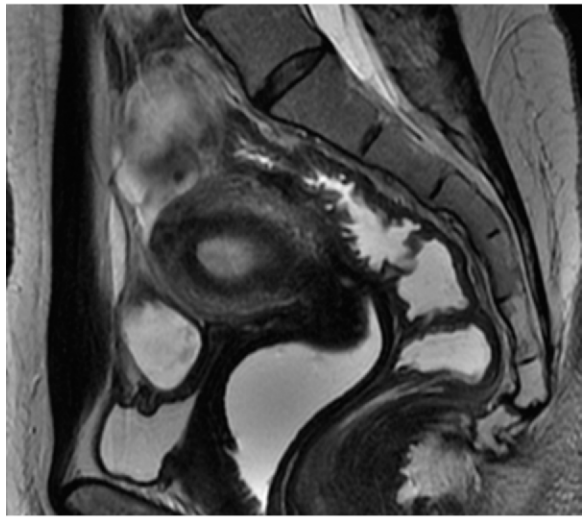
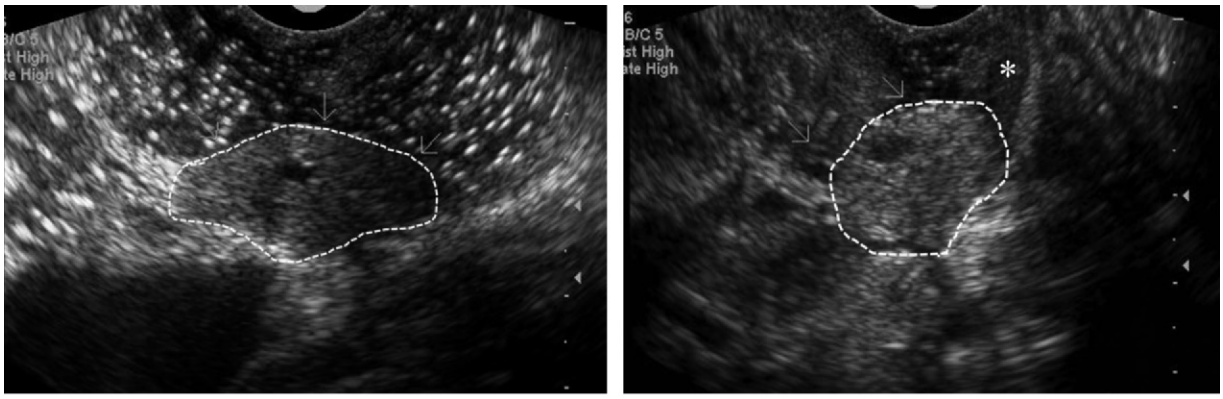


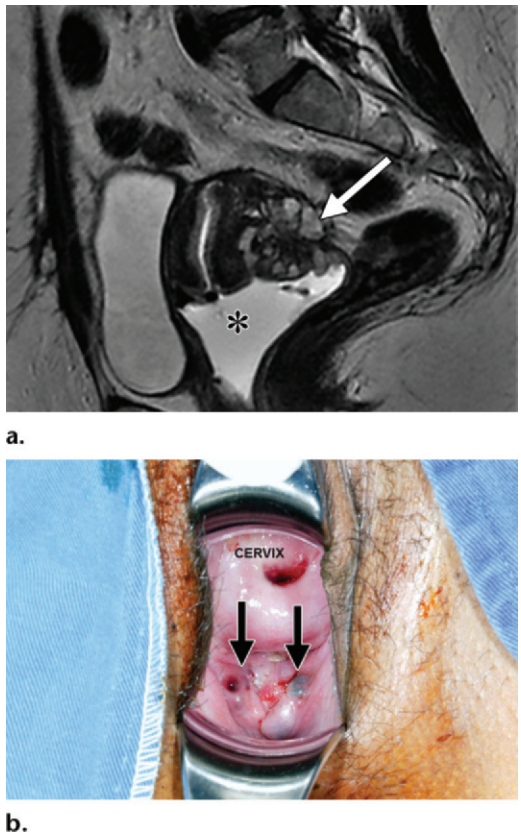
c.

Figure 19. Intestinal endometriosis in a 30-year-old asymptomatic woman. **(a, b)** Axial **(a)** and sagittal **(b)** transvaginal US images obtained after bowel preparation show a small (1.2-cm-diameter) hypoechoic nodule (arrowheads) attached to the wall of the sigmoid colon. **(c)** Sagittal T2-weighted MR image shows an apparently normal intestinal wall.



a. b.

Figure 21. Vaginal endometriosis in a 31-year-old woman with dyspareunia. **(a)** Transverse transvaginal US image shows a nodule (ovoid dashed line) that contains a small cystic area. The nodule is attached to the posterior vaginal wall and protrudes into the posterior fornix. The gel used for vaginal distention produces multiple hyperechoic foci, facilitating visualization of the nodule. **(b)** Sagittal transvaginal US image depicts the same nodule (ovoid dashed line). Normal vaginal wall (*) is seen inferior to the lesion.



a. b.

Figure 22. Vaginal endometriosis in a 37-year-old woman with pelvic pain and dyspareunia. **(a)** Sagittal T2-weighted MR image shows a large mixed (solid and cystic) endometriotic lesion (arrow) in the retrocervical region and posterior vaginal fornix. Distention of the vagina with gel (*) facilitates identification of the lesion. **(b)** Image from a vaginal examination shows that the endometriotic lesion occupies the posterior vaginal fornix (arrows).

The imaging appearance varies from thickening of the superior one-third of the posterior vaginal wall without a defined nodule to large polypoid masses that protrude into the posterior vaginal fornix. Insertion of vaginal gel before transvaginal US or MR imaging is useful for visualizing the posterior fornix and the interface between the posterior cervical lip and vaginal wall (Figs 21, 22). Vaginal endometriotic nodules are hypoechoic on transvaginal US images and demonstrate low signal intensity on T2-weighted MR images. They generally have a mixed internal appearance due to the presence of cystic areas. The acquisition of fat-saturated MR images aids in the identification of hemorrhagic spots in the posterior aspect of the fornix.

Ureteral Endometriosis

Ureteral endometriosis is uncommon but serious because of the lack of specific symptoms and the high risk for loss of renal function. Preoperative diagnosis is unlikely unless associated ureteral obstruction or hydronephrosis occurs. It is estimated that 47% of patients with ureteral

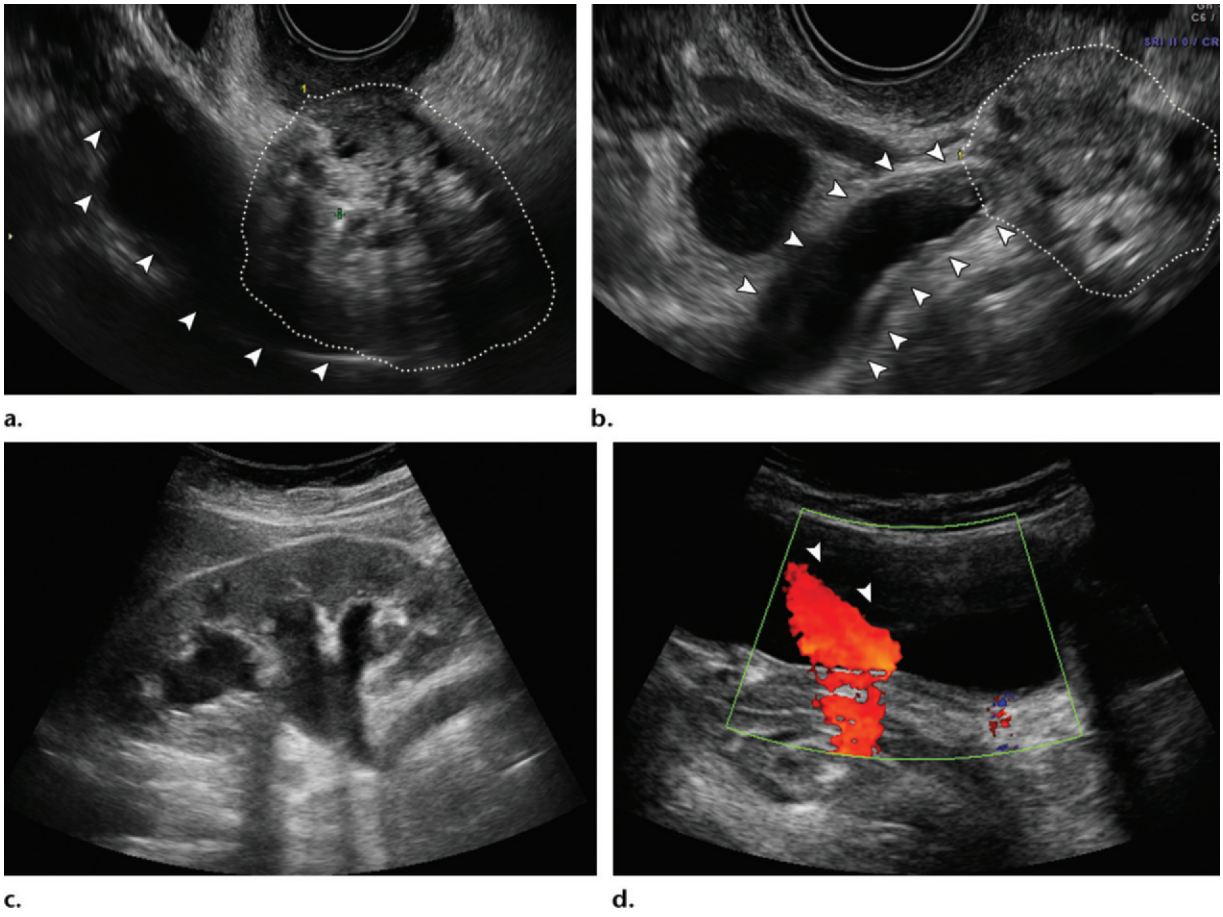


Figure 23. Paracervical endometriosis with ureteral stenosis in a 35-year-old woman with infertility. **(a, b)** Sagittal oblique transvaginal US images show a large heterogeneous paracervical mass (ovoid dotted line) representative of an endometriotic lesion that has surrounded the dilated left ureter (arrowheads). The lesion is best depicted in **a**, and the ureteral dilatation, in **b**. **(c)** Transabdominal US image of the left kidney demonstrates moderate hydronephrosis. **(d)** Transabdominal power Doppler US image shows a left ureteral jet (arrowheads).

endometriosis require nephrectomy at the time of diagnosis (41). Clinical manifestations are usually nonspecific, but dysmenorrhea and dyspareunia may predominate. Intrinsic and extrinsic ureteral involvement may occur. Extrinsic involvement is common (80% of cases) and is caused by progressive enclosure of the ureters by endometriotic tissue. Intrinsic ureteral endometriosis is histologically defined by infiltration of the muscularis of the ureteral wall. According to published data, the incidence of intrinsic ureteral involvement is underestimated (30). It is especially high among patients requiring radical ureteral surgery because of severe lesions.

As in vaginal endometriosis, isolated lesions in ureteral endometriosis are rare. Ureteral endometriotic lesions are nearly always associated with deeply infiltrating endometriotic lesions in other sites (eg, the uterosacral ligament, vagina, bladder, or intestine). The possibility of ureteral involvement must be considered in the presence of large paracervical lesions (≥ 2 cm in diameter). Renal US may depict hydronephrosis, but unless the ureters are dilated, it is difficult to visualize the ureteral pathways at transabdominal and transvaginal US. Ingestion of approximately 300 mL of water just before transvaginal US allows identification of the ureter and its peristaltic movement from the segment below the iliac vessels to the ureterovesical junction. Color or power Doppler US may demonstrate a jet indicative of unobstructed ureteral flow (Fig 23). However,

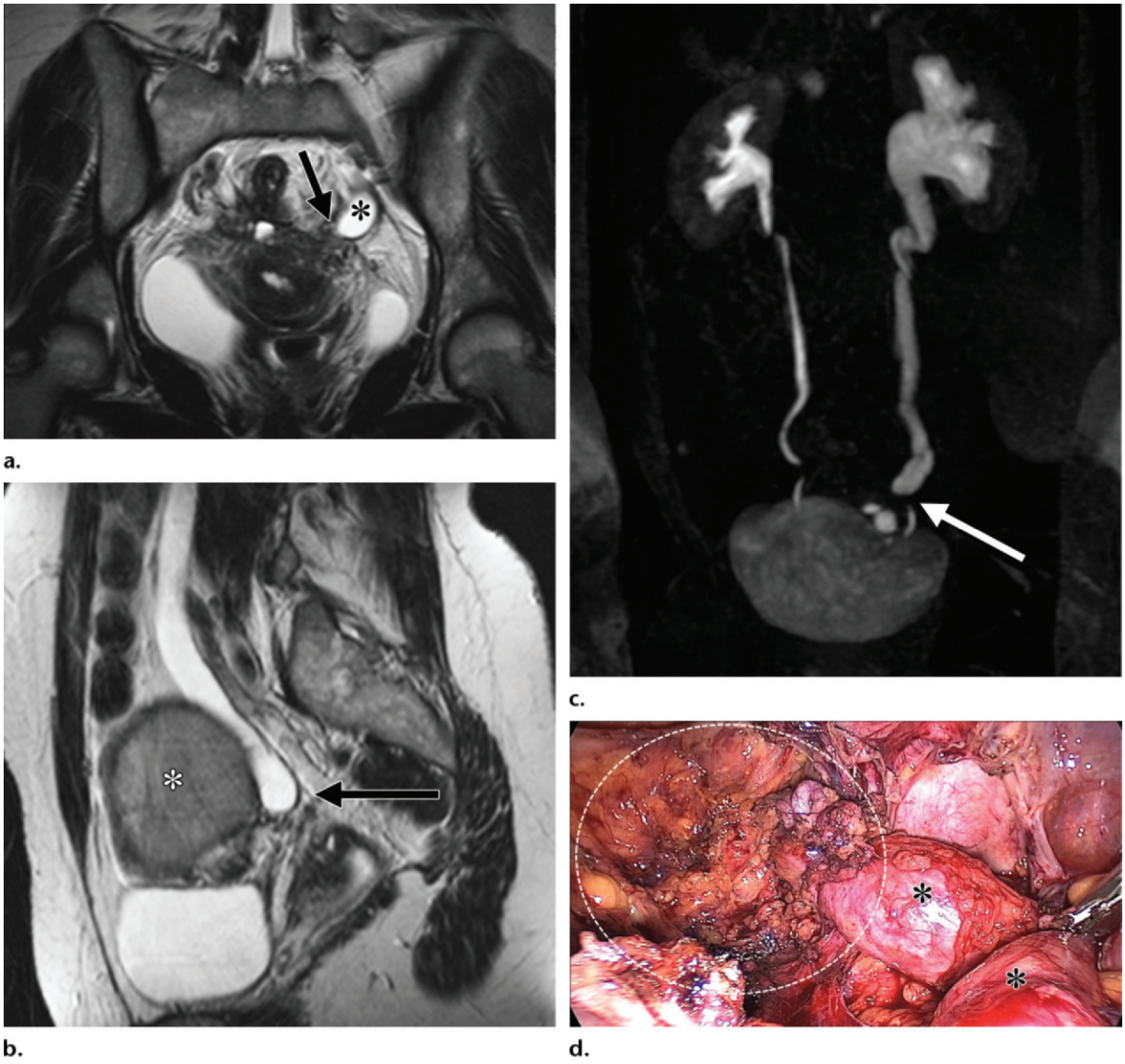
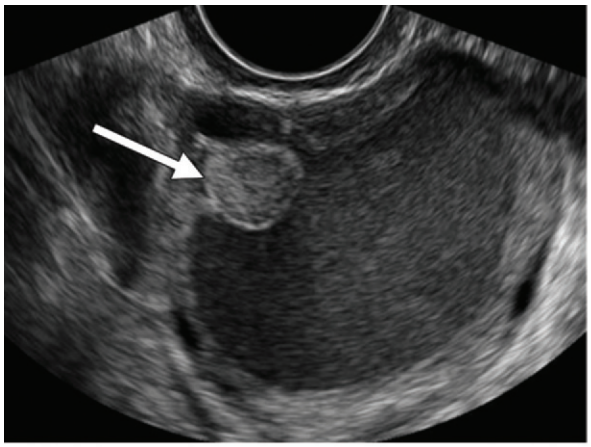


Figure 24. Paracervical endometriosis with ureteral stenosis in a 37-year-old woman with dysmenorrhea and infertility. **(a)** Coronal T2-weighted MR image demonstrates left paracervical thickening (arrow) that involves the ureter (*). **(b)** Sagittal T2-weighted MR image shows ureteral stenosis and dilatation near the lesion (arrow). There is also an endometrioma (*) in the left ovary. **(c)** MR urogram shows an asymmetric appearance of the ureters. The entirety of the left ureter above the point of obstruction (arrow) is dilated, whereas the distal segment has a diameter similar to that of the right ureter. **(d)** Laparoscopic image shows the endometriotic mass (dashed oval) and the dilated pelvic ureter (*).

the best imaging modality for ureteral evaluation is pelvic MR imaging, which allows a more comprehensive evaluation of the pelvic ureteral pathway than is possible with US. Pelvic MR imaging combined with MR urography allows a complete work-up in a single imaging evaluation (30,41). Ureteral endometriotic lesions appear as solid nodules with spiculated margins that envelop the ureter, causing mild to extensive dilatation (Fig 24). The lesions are hypoechoic on transvaginal US images and show low signal intensity on T2-weighted MR images. They may arise from the uterosacral ligament, broad ligaments, ovaries, or any peritoneal tissue along the ureteral pathway. The ureteral segment distal to the obstructive lesion has a normal diameter.



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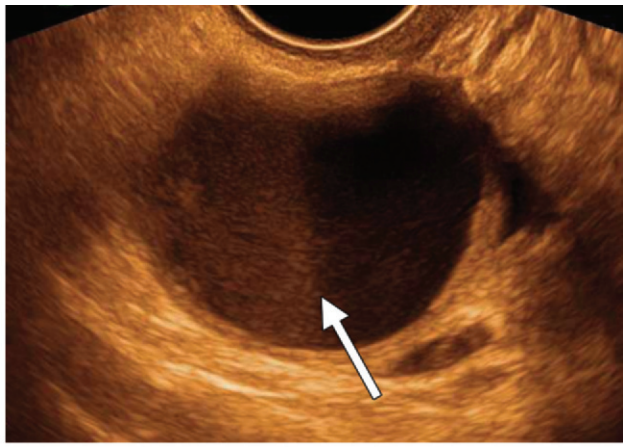

26.

Figures 25, 26. Endometriomas. **(25)** Transvaginal US image obtained in a 26-year-old woman with pelvic pain shows an endometrioma with a hyperechoic peripheral nodule (arrow) in the right ovary. **(26)** Transvaginal US image obtained in a 28-year-old woman shows an endometrioma with a fluid-fluid level (arrow) in the left ovary. The lighter area to the left of the arrow represents more recent hemorrhage, a finding made more recognizable by the sepia colorization.

The differential diagnosis of deeply infiltrating ureteral endometriosis includes ureteral obstruction by extension of cervical cancer. Correct diagnosis requires identification of the epicenter of the mass, which arises from the cervical mucosa toward the parametrial tissue in neoplastic disease and has associated intermediate signal intensity. In contrast, endometriotic lesions are associated with low signal intensity and retrocervical or paracervical locations. Laparoscopic identification and management of deeply infiltrating endometriosis of the ureter require an experienced laparoscopic surgeon. Meticulous exploration of the ureteral pathway and careful dissection are necessary to avoid complications and suboptimal resection. The lesions are characterized by fibrotic pale nodules with irregular margins and deep infiltration of periureteral connective tissue.

Ovarian Endometriosis

The ovaries are among the most common sites of endometriosis (20%–40% of cases). Ovarian endometriosis may manifest either as superficial fibrotic implants associated with fibrous adhesions or as chronic retention cysts with cyclic bleeding (endometriomas) (8). Endometriosis confined to the ovarian surface is underdiagnosed at imaging because of the microscopic size of the lesions.

Endometriomas are thick-walled cysts with a dark, dense content that represents degenerated blood products (Video 2). The cysts may be solitary or multiple, and they are bilateral in 50% of cases. Endometriomas may include peripheral nodules (blood clots) or fluid-fluid levels due to recent hemorrhages; in the latter, the nondependent portion represents the freshest bleeding. Even small endometriomas are vulnerable to perforation (27). A multilocular-appearing endometrioma may consist of multiple contiguous cysts. Endometriomas are a marker of severity of deeply infiltrating endometriosis (28). The risks for multifocal disease and intestinal involvement in patients with an endometrioma are two- to threefold the risks among patients with endometriosis but without an endometrioma. These observations highlight the importance of a careful search for severe, deeply infiltrating endometriotic lesions in patients with endometriotic cysts.

In the differential diagnosis of endometriomas, transvaginal US is highly sensitive (84%–100%) and specific (90%–100%) (42,43). Most endometriomas exhibit homogeneous, diffuse internal hypoechogenicity. Thin or thick septa, fluid-fluid levels, echogenic peripheral nodules, and bright foci within the cysts may be observed (Figs 25, 26). On color Doppler US images, the cysts appear hypovascular, without internal flow. Transvaginal US is also useful for preoperative evaluations of adhesions. Results of a recent study of women

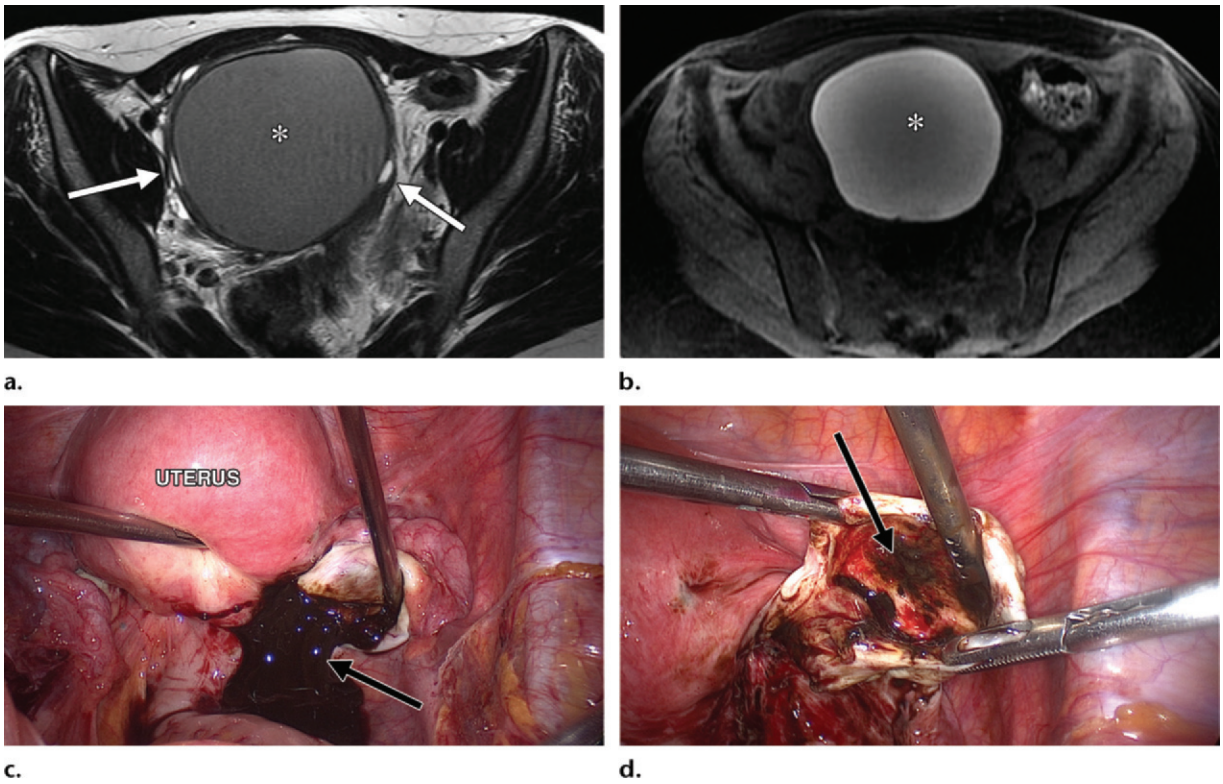

Figure 27. Large endometrioma in a 25-year-old woman with pelvic pain. **(a)** Axial T2-weighted MR image shows a large cyst (*) with peripheral follicles (arrows). **(b)** Axial T1-weighted MR image shows the shading sign (*) within the cyst, a central region of low signal intensity surrounded by peripheral high signal intensity representing older hemorrhage. **(c, d)** Laparoscopic images demonstrate the viscous chocolate-colored content (arrow) of the endometrioma.

who were believed to have an endometrioma indicated a high pretest probability of pelvic adhesions (96%) in those with fixation of at least one ovary to the uterus (44).

MR imaging is widely accepted as the best imaging modality for diagnosing endometriomas. The high specificity of the method (98%) is attributed to the ability to detect aged hemorrhagic content (27). The shading sign, a common and unique feature of endometriomas, represents old blood products, which contain extremely high iron and protein concentrations. These hemorrhagic cysts typically show high signal intensity on T1-weighted images and low signal intensity on T2-weighted images (Fig 27). However, endometriomas also may show variable signal intensity on T2-weighted images (27). Shading varies from a faint signal to a complete signal void. Solid components, thick septa, and fluid-fluid levels may also be observed at MR imaging.

The differential diagnosis of endometrioma includes hemorrhagic corpus luteum cysts. The latter are usually unilocular, have a "reticulated" pattern on transvaginal US images, do not exhibit shading on T2-weighted images, show a peripheral halo of signal hyperintensity on T1-weighted images, and quickly resolve. Dermoid cysts may mimic endometriomas, but they can be differentiated by the presence of a chemical shift artifact and signal drop-out on fat-suppressed MR images (40). In women who have undergone treatments for assisted conception, another important differential diagnosis must be considered: multiple corpora lutea, which may be seen after induced ovulation. The isolated appearance of each corpus luteum cyst in such cases is similar to that of the functional corpus luteum, but the patient's medical history includes recent oocyte retrieval.

Summary

The article describes the imaging procedures and findings that are most useful for the diagnosis

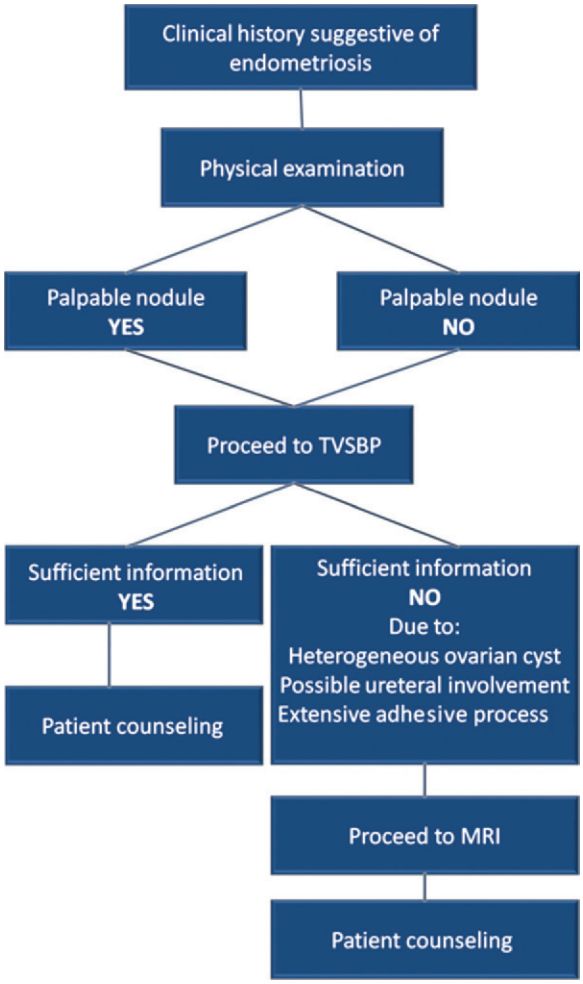

Figure 28. Flow chart depicts the algorithm for imaging evaluation of endometriosis. *MRI* = MR imaging, *TVSBP* = transvaginal US after bowel preparation.

of endometriosis. Peritoneal fibrotic nodules, ovarian cysts with old hemorrhagic content, and adhesions are the most representative findings of the disease. The imaging algorithm for patients in whom the presence of endometriosis is suspected should include transvaginal US as the first-line procedure (Fig 28). A detailed evaluation of the rectosigmoid colon to identify all the endometriotic lesions and determine which layers of the colon are affected is helpful for surgical planning. MR imaging also is useful for diagnosis in women with more complex patterns of disease, such as those with extensive pelvic adhesions and those in whom ureteral involvement is suspected. The information obtained with these imaging methods is of utmost relevance to treatment planning.

The correlation of imaging features with laparoscopic findings further expedites diagnosis and contributes to diagnostic accuracy.

References

1. Bulun SE. Endometriosis. N Engl J Med 2009;360(3):268–279.
2. Giudice LC, Kao LC. Endometriosis. Lancet 2004;364(9447):1789–1799.
3. Practice bulletin no. 114: management of endometriosis. Obstet Gynecol 2010;116(1):223–236.
4. Malinak LR, Buttram VC Jr, Elias S, Simpson JL. Heritage aspects of endometriosis. II. Clinical characteristics of familial endometriosis. Am J Obstet Gynecol 1980;137(3):332–337.
5. Matalliotakis IM, Arici A, Cakmak H, Goumenou AG, Koumantakis G, Mahutte NG. Familial aggregation of endometriosis in the Yale Series. Arch Gynecol Obstet 2008;278(6):507–511.
6. Bedaiwy MA, Falcone T, Mascha EJ, Casper RF. Genetic polymorphism in the fibrinolytic system and endometriosis. Obstet Gynecol 2006;108(1):162–168.
7. Sasson IE, Taylor HS. Stem cells and the pathogenesis of endometriosis. Ann NY Acad Sci 2008;1127:106–115.
8. Clement MD. Diseases of the peritoneum (including endometriosis). 5th ed. New York, NY: Springer-Verlag, 2002; 729–789.
9. Anaf V, Simon P, El Nakadi I, et al. Hyperalgesia, nerve infiltration and nerve growth factor expression in deep adenomyotic nodules, peritoneal and ovarian endometriosis. Hum Reprod 2002;17(7):1895–1900.
10. Chapron C, Dubuisson JB, Pansini V, et al. Routine clinical examination is not sufficient for diagnosing and locating deeply infiltrating endometriosis. J Am Assoc Gynecol Laparosc 2002;9(2):115–119.
11. Koninckx PR, Oosterlynck D, D'Hooghe T, Meuleman C. Deeply infiltrating endometriosis is a disease whereas mild endometriosis could be considered a non-disease. Ann NY Acad Sci 1994;734:333–341.
12. Clement PB. The pathology of endometriosis: a survey of the many faces of a common disease emphasizing diagnostic pitfalls and unusual and newly appreciated aspects. Adv Anat Pathol 2007;14(4):241–260.
13. Bazot M, Thomassin I, Hourani R, Cortez A, Darai E. Diagnostic accuracy of transvaginal sonography for deep pelvic endometriosis. Ultrasound Obstet Gynecol 2004;24(2):180–185.
14. Bazot M, Lafont C, Rouzier R, Roseau G, Thomassin-Naggara I, Daraï E. Diagnostic accuracy of physical examination, transvaginal sonography, rectal endoscopic sonography, and magnetic resonance imaging to diagnose deep infiltrating endometriosis. Fertil Steril 2009;92(6):1825–1833.

15. Bazot M, Darai E, Hourani R, et al. Deep pelvic endometriosis: MR imaging for diagnosis and prediction of extension of disease. Radiology 2004;232(2):379–389.
16. Abrão MS, Gonçalves MO, Dias JA Jr, Podgaec S, Chamié LP, Blasbalg R. Comparison between clinical examination, transvaginal sonography and magnetic resonance imaging for the diagnosis of deep endometriosis. Hum Reprod 2007;22(12):3092–3097.
17. Chamié LP, Blasbalg R, Gonçalves MO, Carvalho FM, Abrão MS, de Oliveira IS. Accuracy of magnetic resonance imaging for diagnosis and preoperative assessment of deeply infiltrating endometriosis. Int J Gynaecol Obstet 2009;106(3):198–201.
18. Gonçalves MO, Dias JA Jr, Podgaec S, Averbach M, Abrão MS. Transvaginal ultrasound for diagnosis of deeply infiltrating endometriosis. Int J Gynaecol Obstet 2009;104(2):156–160.
19. Kinkel K, Chapron C, Balleyguier C, Fritel X, Dubuisson JB, Moreau JF. Magnetic resonance imaging characteristics of deep endometriosis. Hum Reprod 1999;14(4):1080–1086.
20. Chapron C, Vieira M, Chopin N, et al. Accuracy of rectal endoscopic ultrasonography and magnetic resonance imaging in the diagnosis of rectal involvement for patients presenting with deeply infiltrating endometriosis. Ultrasound Obstet Gynecol 2004;24(2):175–179.
21. Delpy R, Barthet M, Gasmi M, et al. Value of endorectal ultrasonography for diagnosing rectovaginal septal endometriosis infiltrating the rectum. Endoscopy 2005;37(4):357–361.
22. Piketty M, Chopin N, Dousset B, et al. Preoperative work-up for patients with deeply infiltrating endometriosis: transvaginal ultrasonography must definitely be the first-line imaging examination. Hum Reprod 2009;24(3):602–607.
23. Gonçalves MO, Podgaec S, Dias JA Jr, Gonzalez M, Abrão MS. Transvaginal ultrasonography with bowel preparation is able to predict the number of lesions and rectosigmoid layers affected in cases of deep endometriosis, defining surgical strategy. Hum Reprod 2010;25(3):665–671.
24. Fedele L, Bianchi S, Raffaelli R, Portuese A. Pre-operative assessment of bladder endometriosis. Hum Reprod 1997;12(11):2519–2522.
25. Pereira RM, Zanatta A, de Mello Bianchi PH, Chamié LP, Gonçalves MO, Serafini PC. Transvaginal ultrasound after bowel preparation to assist surgical planning for bowel endometriosis resection. Int J Gynaecol Obstet 2009;104(2):161.
26. Chamié LP, Pereira RM, Zanatta A, Serafini PC. Transvaginal US after bowel preparation for deeply infiltrating endometriosis: protocol, imaging appearances, and laparoscopic correlation. RadioGraphics 2010;30(5):1235–1249.
27. Togashi K, Nishimura K, Kimura I, et al. Endometrial cysts: diagnosis with MR imaging. Radiology 1991;180(1):73–78.
28. Chapron C, Pietin-Vialle C, Borghese B, Davy C, Foulot H, Chopin N. Associated ovarian endometrioma is a marker for greater severity of deeply infiltrating endometriosis. Fertil Steril 2009;92(2):453–457.
29. Balleyguier C, Roupret M, Nguyen T, Kinkel K, Helenon O, Chapron C. Ureteral endometriosis: the role of magnetic resonance imaging. J Am Assoc Gynecol Laparosc 2004;11(4):530–536.
30. Chapron C, Chiodo I, Leconte M, et al. Severe ureteral endometriosis: the intrinsic type is not so rare after complete surgical exeresis of deep endometriotic lesions. Fertil Steril 2010;93(7):2115–2120.
31. Hottat N, Larrousse C, Anaf V, et al. Endometriosis: contribution of 3.0-T pelvic MR imaging in preoperative assessment—initial results. Radiology 2009;253(1):126–134.
32. Anaf V, Simon P, Fayt I, Noel J. Smooth muscles are frequent components of endometriotic lesions. Hum Reprod 2000;15(4):767–771.
33. Chapron C, Fauconnier A, Vieira M, et al. Anatomical distribution of deeply infiltrating endometriosis: surgical implications and proposition for a classification. Hum Reprod 2003;18(1):157–161.
34. Abrão MS, Podgaec S, Dias JA Jr, et al. Deeply infiltrating endometriosis affecting the rectum and lymph nodes. Fertil Steril 2006;86(3):543–547.
35. Redwine DB, Wright JT. Laparoscopic treatment of complete obliteration of the cul-de-sac associated with endometriosis: long-term follow-up of en bloc resection. Fertil Steril 2001;76(2):358–365.
36. Ferrero S, Bogliolo S, Valenzano Menada M, et al. Diagnosis and management of bladder endometriosis. J Endometriosis 2009;1(3-4):113–121.
37. Yu JS, Kim KW, Lee HJ, Lee YJ, Yoon CS, Kim MJ. Urachal remnant diseases: spectrum of CT and US findings. RadioGraphics 2001;21(2):451–461.
38. Levy AD, Shaw JC, Sobin LH. Secondary tumors and tumorlike lesions of the peritoneal cavity: imaging features with pathologic correlation. RadioGraphics 2009;29(2):347–373.
39. Pereira RM, Zanatta A, Serafini PC, Redwine D. The feasibility of laparoscopic bowel resection performed by a gynaecologist to treat endometriosis. Curr Opin Obstet Gynecol 2010;22(4):344–353.
40. Woodward PJ, Sohaey R, Mezzetti TP Jr. Endometriosis: radiologic-pathologic correlation. RadioGraphics 2001;21(1):193–216.
41. Seracchioli R, Mabrouk M, Manuzzi L, et al. Importance of retroperitoneal ureteric evaluation in cases of deep infiltrating endometriosis. J Minim Invasive Gynecol 2008;15(4):435–439.
42. Garcia-Velasco JA, Somigliana E. Management of endometriomas in women requiring IVF: to touch or not to touch. Hum Reprod 2009;24(3):496–501.
43. Savelli L. Transvaginal sonography for the assessment of ovarian and pelvic endometriosis: how deep is our understanding? Ultrasound Obstet Gynecol 2009;33(5):497–501.
44. Guerriero S, Ajossa S, Garau N, Alcazar JL, Mais V, Melis GB. Diagnosis of pelvic adhesions in patients with endometrioma: the role of transvaginal ultrasonography. Fertil Steril 2010;94(2):742–746.

Findings of Pelvic Endometriosis at Transvaginal US, MR Imaging, and Laparoscopy

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Page E78
Endometriosis is a chronic gynecologic disorder that is characterized by the growth of endometrial tissue outside the uterine cavity, primarily as implants in the pelvic peritoneum and ovaries (1).

Page E78
Transvaginal US performed after bowel preparation should be the first-line imaging examination when the presence of endometriosis is suspected. This method is as accurate as transrectal US for diagnosing intestinal lesions and identifying the bowel layers affected, and it yields better results than MR imaging for the assessment of deeply infiltrating endometrial implants in other locations, especially small (<1.5-cm-diameter) lesions of the uterosacral ligament and bladder (18,22–26).

Page E78
MR imaging is an excellent method for identifying the old hemorrhagic content that characterizes endometriomas (27) and for mapping multiple deeply infiltrating endometrial implants, given its large field of view, multiplanar capabilities, and outstanding contrast resolution (14,17). Extensive pelvic adhesions and ureteral involvement are two important indications for MR imaging (14,28–30).

Page E81
On US images, the lesions in deeply infiltrating endometriosis are mostly hypoechoic in comparison with the myometrium. On MR images, they have signal intensity similar to that of smooth muscle, with low signal intensity on T2-weighted images, intermediate signal intensity on T1-weighted images, and minimal enhancement after the intravenous injection of contrast material. Cystic areas may be present, with or without hemorrhagic content.

Page E92
In the authors' experience, transvaginal US performed after bowel preparation is the best imaging modality for identifying intestinal lesions, determining which bowel wall layers are affected, and measuring the circumference of involved bowel. This method allows dynamic evaluation of the rectosigmoid colon from the anal verge to the descending colon and sigmoid transition with high spatial resolution and minimal patient discomfort. The proximity between the transducer and the targeted structure provides superior contrast resolution, which is important for visualizing small and laterally located lesions.