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IN-DEPTH REVIEW

Imaging diagnosis of endometriosis

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ABSTRACT

Endometrosis is a common gynecologic disease that affects women of reproductive age and commonly causes pelvic pain and infertility. The most common types are superficial peritoneal implants, ovarian endometriotic cysts (endometriomas), and deep-infiltrating subperitoneal lesions. Diagnosis is often delayed, and up to 65% of women are initially misdiagnosed. Imaging methods play a pivotal role in patient counseling and clinical management of the disease, and have been replacing diagnostic laparoscopy in specialized centers worldwide. Comprehensive imaging mapping is required for adequate surgical planning and to assist fertility doctors in determining the appropriate treatment options. Transvaginal ultrasound (TVU) is the first-line imaging modality and is a widely available tool that enables accurate diagnosis of endometriosis when a dedicated protocol is used. TVU is the best imaging method to investigate multiple bowel lesions and small peritoneal implants. Magnetic resonance imaging (MRI) is an excellent multiplanar method for evaluating the pelvic cavity and extrapelvic sites in endometriosis. It is the method of choice to differentiate ovarian cysts and investigate endometriosis affecting the ureters, pelvic nerves, pelvic floor, and diaphragm. This In-Depth Review describes the imaging protocol and findings of TVU and MRI to investigate endometriosis.

Keywords: *Endometriosis. Endometrioma. Deep endometriosis. Magnetic resonance imaging. Transvaginal sonography. Imaging protocol.*

INTRODUCTION

Endometriosis is a chronic and progressive gynecological disease characterized by the presence of endometrium-like tissue outside the uterus and is associated with fibrosis and inflammatory reactions[1]. The establishment and growth of endometriotic lesions depends on estradiol stimulation, followed by an increase in prostaglandin production, resulting in a feed-forward mechanism of prostaglandin-mediated estradiol production[2]. It is mostly found in women of reproductive age, affecting up to 10% of the female population and 60% of patients with infertility[3,4].

Clinically, endometriosis can exhibit different phenotypes, varying from being asymptomatic to manifesting with excruciating pelvic pain; the most intriguing characteristic is the lack of correlation between advanced stages and the associated level of pain[5,6].

Multifocal pelvic endometriosis is the most common presentation, and three types of lesions may be observed: superficial implants on the peritonial surface, ovarian cysts (endometriomas), and deep-infiltrating lesions beneath the peritoneal surface and into the muscularis propria of the hollow viscera[7]. Although histologically benign, deep lesions can exhibit malignant behavior not only in terms of the depth of infiltration in a localized area, but also metastasize to regional lymph nodes. Endometriosis has been extensively defined as a pelvic disease; however, recent research has

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demonstrated multiple effects throughout the body, affecting cardiovascular, neurological, and metabolic systems, as well as immune function[2].

Diagnosis of endometriosis remains clinically challenging, and despite the high prevalence of the disease, it can take between 4 to 12 years between the onset of symptoms and a reliable diagnosis[8]. According to the new guidelines of the European Society of Human Reproduction and Embriology, laparoscopy is no longer the diagnostic gold standard and has been replaced by imaging methods, such as transvaginal ultrasound (TVU) and magnetic resonance imaging (MRI)[9]. TVU is the first-line imaging modality when endometriosis is suspected, and when performed by an expert in the field, it can provide accurate mapping of the affected sites[10]. It yields better performance for multible bowel lesions and small peritoneal implants[11,12]. MRI is an excellent imaging method for the diagnosis of ovarian endometriomas and multiple deeply infiltrating implants. Ureteral, diaphragmatic, and pelvic floor infiltrations are also important indications for MRI[13].

The impact of non-invasive diagnosis and staging of endometriosis based on imaging methods is tremendous and extends beyond preoperative evaluation. It plays a pivotal role in clinical counseling and treatment planning throughout a woman's life, from adolescence to menopause[9]. This In-Depth Review describes the imaging protocol used to investigate endometriosis using TVU and MRI, discusses its advantages and limitations, and reviews the most common imaging findings of endometriosis using both methods.

Transvaginal ultrasound (TVU)

TVU is the first-line imaging modality to investigate patients with suspected endometriosis[10]. It is widely available, cost-effective, and achieves excellent results when performed by an experienced radiologist. For studies assessing ovarian endometriomas, TVU has demonstrated high sensitivity (95%) and specificity (96%). For deep infiltrative endometriosis (DIE), studies are heterogeneous, reporting an overall sensitivity and specificity of 79% and 94%, respectively[14–16]. TVU performed after bowel preparation is a powerful tool to evaluate pelvic endometriosis enabling detection of the disease with high accuracy. It also allows a comprehensive roadmap detailing all the structures affected and the degree of infiltration to be obtained, which is crucial for appropriate clinical counseling and multidisciplinary surgical planning.

Patient preparation and imaging technique

Although routine TVU does not require specific preparation, an endometriosis search using ultrasound (US) can be optimized when simple bowel preparation is performed[17]. Advantages of such protocol include better detection of multiple bowel lesions, and identification of the layers and the circumference of the affected bowel. In addition, bowel cleaning improves the overall view of the pelvic cavity and pelvic organs by eliminating or minimizing artifacts such as gas and bowel content[18]. Bowel preparation is performed the day before and on the day of the examination (Table 1). The adverse effects are minimal and may include abdominal cramps and mild hypotension.

Mild bladder filling is another important issue in anterior compartment evaluation. Patients are instructed to empty bladder imediately before the procedure and drink aproximately 300 mL of water just before the exam. The latter is useful for ureteral evaluations. In addition to bowel and bladder preparations, patient positioning requires special attention. The pelvis should be elevated to facilitate free angulation of the probe into the posterior compartment, thereby enhancing the diagnostic capability while minimizing patient discomfort. The application of 60 mL of US gel to the upper third of the vagina is optional and can facilitate the search for DIE lesions in the posterior vaginal fornix. At the author's institution, TVU is performed after bowel preparation and interpreted in real time by the radiologist using a US equipment with a 5–9 MHz frequency transducer (Voluson E8, GE Healthcare, Milwaukee, WI USA).

The imaging algorithm should be standardized and should include evaluation of the anterior, medium, and posterior compartments of the pelvis[19,20]. The bladder wall, vesicouterine peritoneum, anterior uterine wall, and round ligaments were evaluated in the anterior compartment. The ovaries, fallopian tubes, ovarian fossa, broad ligaments, parametrium, and ureters were assessed in the middle compartment. In the posterior compartment, evaluation of the retrocervical space plays a pivotal role in the diagnosis of endometriosis because of a high prevalence of the disease in the uterosacral ligaments. The retrovaginal space, vagina, rectosigmoid colon, pararectal fossa, posterior uterine wall, and rectovaginal septum were also examined.

It is noteworthy that when performing routine TVU, the probe is primarily located in the anterior vaginal fornix. To properly evaluate the posterior compartment,

Table 1. Preparation of the intestine for TVU

Previous day	Examination day
Oral laxative bisacodyl (2 tablets): 8 am and 2 pm	Maintenance of a low-residue diet
Low-residue diet all day	Administration of a rectal enema up to 1 hour before the examination

TVU: Transvaginal ultrasound.

the vaginal probe must be displaced posteriorly into the posterior vaginal fornix in association with downward angulation. The posterior location of the probe allows accurate assessment of the right and left uterosacral ligaments, the superior third of the vagina and the rectosigmoid colon, from the anal border to the descending-sigmoid colon transition. Supplemental Video 1 shows the dynamic assessment of the retrocervical space with TVU and demonstrates the normal aspect of the pelvic peritoneum, which is homogeneously hyperechoic. Supplemental Video 2 shows the dynamic assessment of the rectosigmoid colon using TVU after bowel preparation. The transducer is pressed against the posterior vaginal wall while following the bowel from the anal border to the descending – sigmoid colon transition.

As a dynamic method, the search for adhesions is mandatory during the TVU examination by applying the sliding sign maneuver in all three compartments. The maneuver comprises gentle pushing of the probe combined with abdominal palpation with the free hand. When the target structures do not slide freely against each other, the test is negative, with a high probability of adhesion and underlying DIE. In the anterior compartment, the test was used to determine if the posterior bladder wall was sliding against the anterior uterine wall; in the middle compartment if the ovaries were sliding easily against the pelvic side walls. In the posterior compartment, the test evaluates the mobility between the posterior uterine wall and the rectosigmoid colon. Site-specific tenderness and pain during the maneuvers can provide invaluable information during the examination, which can be a warning sign for DIE. Examiners should pay careful attention to painful areas, particularly in the posterior compartment of the pelvis[20,21]. The average duration of the exam is 20–30 minutes and depends on the complexity of each case.

Three-dimensional TVU (3D TVU) can be an additional tool to investigate endometriosis. The 3D reconstruction makes the retractile pattern of bowel and bladder lesions more evident[22]. Moreover, other tools such as volume contrast image (VCI) with thin slices improves spacial resolution and orientation by providing the observer with a range of different displays of the images in the three orthogonal planes[23].

Magnetic resonance imaging

MRI is a multiplanar imaging modality that allows excellent evaluation of multifocal DIE with a larger field of view than that of TVU, providing additional information regarding extrapelvic disease. It is particularly useful for characterization of ovarian cysts, ureteral and neural infiltration, pelvic floor extension and diaphragmatic disease[13,16]. MRI is more reproducible and multiple sequences acquired can be evaluated independently.

Patient preparation and imaging technique

Patient preparation is very important and includes (a) bowel cleansing, (b) a fasting period of at least 4 h, (c) medium bladder filling, (d) intravenous administration of an antiperistaltic agent (Buscopan: Boehringer Ingelheim, Germany), (e) vaginal distension with 60 mL of gel, and (f) infusion of 150 mL of saline solution into the rectum to obtain a mild distension of the rectosigmoid colon[24]. From the author's experience, bowel preparation and rectal distension are two indispensable tools to improve imaging. MRI was performed using a 1.5- or 3.0-T MRI imaging system (Signa, GE Healthcare, Miwaukee, WI, USA) and a high-resolution phased array coils (8–16 channels). The overall examination was completed in approximately 25–30 min and was well tolerated.

The imaging protocol included acquisition of axial, sagittal, and coronal T2-weighted fast-spin-echo images; axial T1-weighted gradient-echo images with fat suppression; and axial T1-weighted gradient-echo images in and out of phase. Post-contrast images are not mandatory for DIE evaluation but can be used in cases of complex ovarian or adnexial cysts, or when the possibility of malignant transformation must be ruled out[25]. Recently, we demonstrated that an abreviated protocol including a volumetric coronal T2-weighted fast-spin-echo sequence and axial T1-weighted gradient-echo sequence with fat suppression had similar performance for diagnosing multiple sites of DIE when compared with the full protocol[26].

Imaging interpretation and description should follow a standardized approach to enable accurate mapping

of the disease. The Society of Abdominal Radiology (SAR) Disease Focused Panel (DFP) on endometriosis recently published a consensus lexicon statement for reporting MRI findings[27]. Similar to the TVU recommendation, findings should be reported according to the compartments being analyzed (anterior, medium, and posterior). With a more comprehensive view compared to ultrasound (US), refined anatomical structures are included in each compartment, such as the entire path of the round ligaments, Retzius' space, and vesicovaginal space in the anterior compartment, the obturator fossa and parametrial ureteral path in the middle compartment, and the hypogastric plexus, presacral nerves, and lumbosacral plexus in the posterior compartment. Pelvic floor structures, sciatic nerves, and the abdominal wall can also be evaluated using MRI.

Imaging findings of endometriosis

The imaging findings of endometriosis reflect the histological components of the lesions characterized by the presence of endometrial-like tissue, smooth muscle proliferation, and fibrosis. Lesions can vary from small subperitoneal plaques to large nodules, with irregular margins and infiltrative patterns. On TVU, DIE lesions are predominantly hypoechoic compared with the myometrium[19]. On MRI, they present markedly low signal intensity on T2-weighted images, similar to the smooth muscle, intermediate signal intensity on T1-weighted images, and late contrast enhancement on post-contrast sequences. Cystic components are common, varying from small to large cavities with or without hemorrhagic content[28]. Bowel lesions demonstrate a marked hypoechoic pattern on TVS and a very low signal intensity on T2-weighted images, reflecting the predominance of stromal tissue and fibrosis.

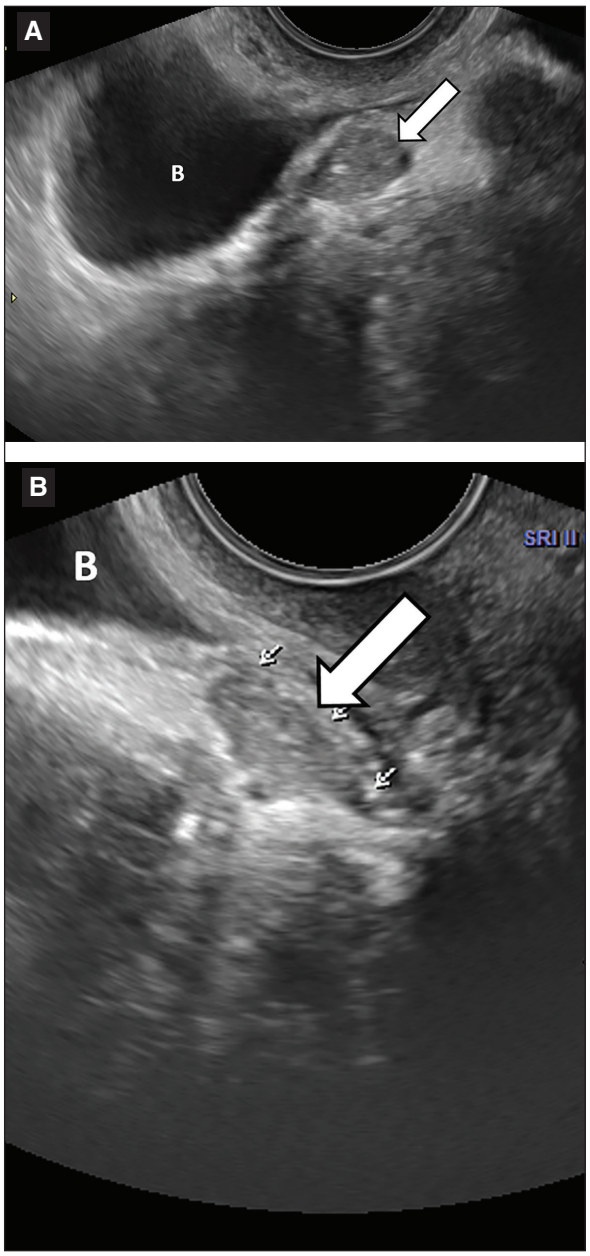

Figure 1. Bladder endometriosis in 32-year-old woman. **A:** axial oblique and **B:** sagittal TVU images demonstrating a hypoechoic nodule (arrows) containing small echogenic foci attached to the posterior bladder dome deeply infiltrating the detrusor muscle.

B: bladder; TVU: transvaginal ultrasound.

ANTERIOR COMPARTMENT

Bladder

Bladder endometriosis is uncommon and is frequently preceded by DIE in the vesicouterine space and round ligaments. Clinically, patients can present with dysuria, urgency, hematuria, and suprapubic pain[29]. It is defined by full-thickness infiltration of the detrusor muscle by a solid nodule of endometriotic tissue, frequently located in the bladder dome and above the trigonal zone at the midline. On TVU, they are typically hypoechoic and heterogeneous owing to small cystic spaces and hyperechogenic foci (Figure 1). On MRI, they exhibit low signal intensity on T2-weighted images and are associated with hyperintense spots on T1-weighted images, with fat saturation representing hemorrhagic content (Figure 2). Post-contrast images demonstrated minimal enhancement of solid components. When located in the anterior bladder dome, the main differential diagnoses include a urachal remnant and mesenchymal tumors[28].

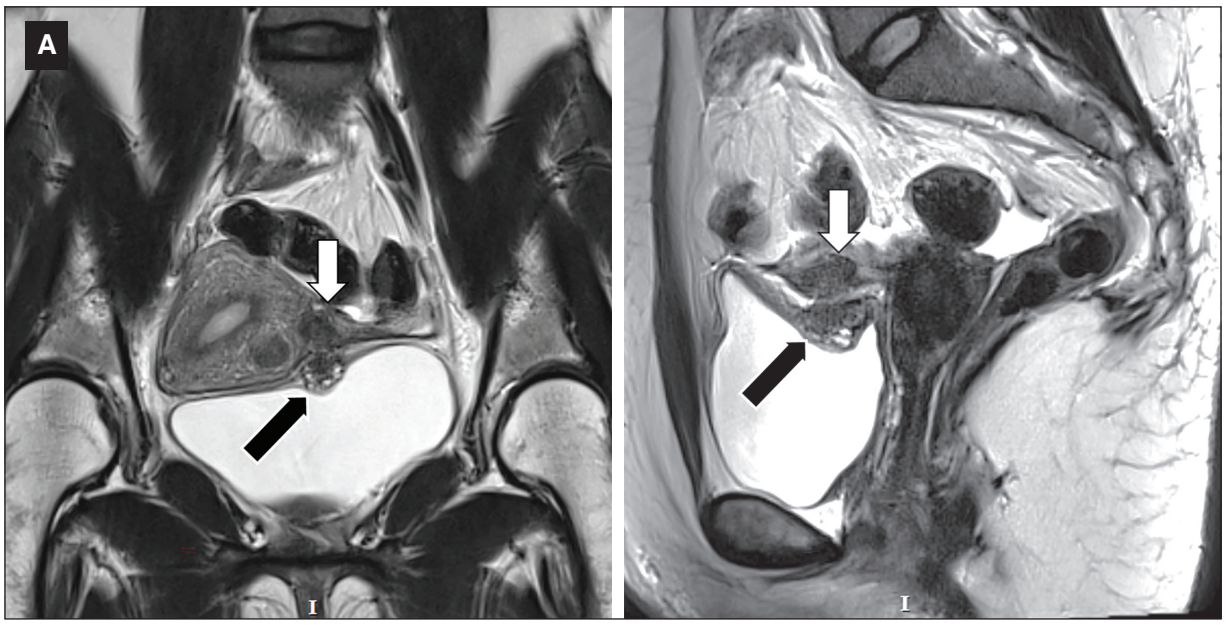

Figure 2. Bladder endometriosis in a 33-year-old woman with dysuria and chronic pelvic pain. **A:** coronal and **B:** sagittal T2-weighted MRI demonstrating a nodule with low signal intensity and small cystic areas (black arrows) attached to the posterior bladder wall, deeply infiltrating the detrusor muscle. A nodular thickening of the left round ligament is also seen (white arrows), adhered to the bladder nodule.
MRI: magnetic resonance imaging.

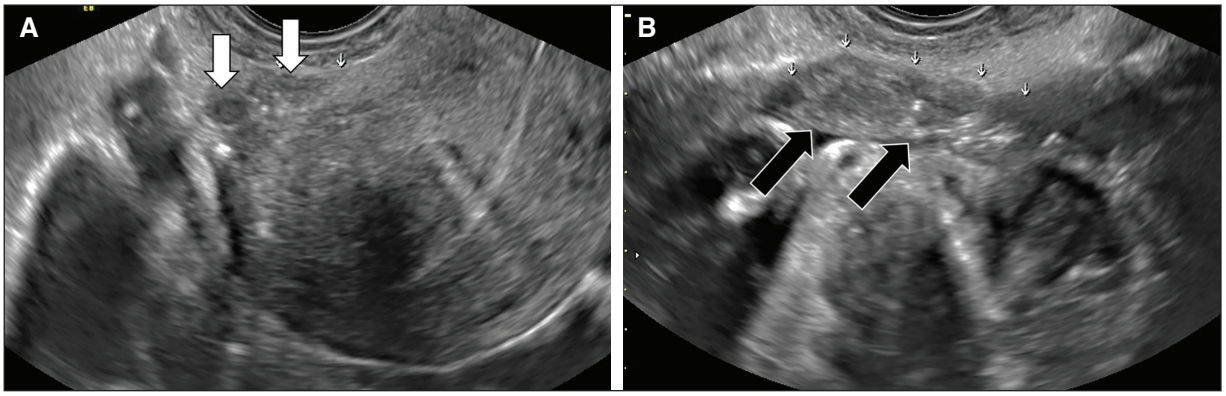

Figure 3. Endometriosis of the anterior compartment of the pelvis in a 28-year-old woman. **A:** sagittal TVU image showing heterogeneous hypoechoic tissue (white arrows), with ill-defined margins attached to the uterine wall. **B:** axial TVU image demonstrating a nodular thickening (black arrows) of the proximal third of the right round ligament.
TVU: transvaginal ultrasound.

TVU performs better than MRI in detecting small bladder lesions, usually <1.5 cm, especially because of the dynamic nature of the method, allowing detailed evaluation of the bladder wall[17]. The corrugated aspect of the bladder wall, when partially filled, may impair adequate assessment using MRI. Imaging plays a crucial role in bladder infiltration confirmation and staging, because the laparoscopic view is restricted to the peritoneal component of the lesions. In addition, it can provide reliable information regarding the involvement of the trigonal area and the distance to the uretovesical junction.

Vesicouterine peritoneum and round ligaments

The vesicouterine space and proximal thirds of the round ligaments are the most common locations of DIE in the anterior compartment[19]. Lesions can vary from small plaques to large masses that obliterate the anterior cul-the-sac. They frequently display a mixed pattern due to cystic spaces and small hemorrhagic foci. On TVU, they are hypoechoic with anechoic or hypoechoic cystic spaces (representing thick content), and frequently exhibit small echogenic foci (Figure 3). TVU is the most

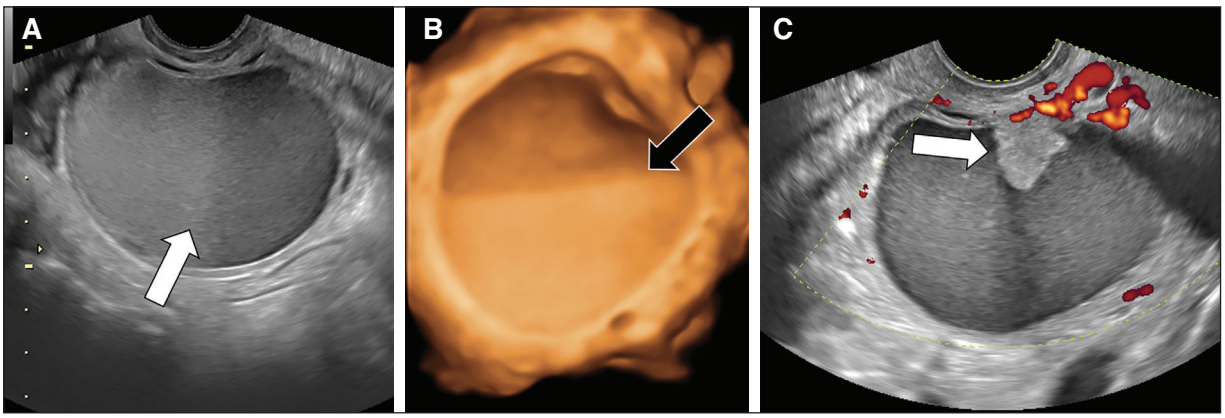

Figure 4. Ovarian endometrioma in a 25-year-old woman with dysmenorrhea **A:** TVU image shows an endometrioma with thick content, ground glass echogenicity and fluid-fluid level (arrow). **B:** three-dimensional image from TVU better demonstrating the fluid–fluid level within the cyst (arrow). **C:** TVU with power Doppler US image demonstrating a hyperechoic peripheral nodule (arrow) without internal flow.
TVU: transvaginal ultrasound; US: ultrasound.

appropriate choice for detecting tiny plaques attached to the anterior uterine wall and the round ligaments.

On MRI, they demonstrate low signal intensity on T2-weighted images, intermediate spinal intensity on T1-weighted images, and hemorrhagic content within the cystic spaces[28]. When present, adherence between these lesions and a bladder nodule is common and may be associated with obliteration of the anterior compartment. Differential diagnosis includes uterine leiomyoma, particularly when lesions have a nodular configuration instead of a plaque. Regular contours, nodular shape, and a lack of cystic components favor the possibility of leiomyoma.

Sometimes, these lesions can grow into the myometrium, deeply infiltrating the muscle in an imaging pattern that resembles adenomyosis. These patterns are considered markers for severe endometriosis, with an increased risk of bladder and intestinal lesions[30]. Complete resection of these lesions can result in uterine wall thinning, which increases the risk of uterine rupture during pregnancy[31].

MIDDLE COMPARTMENT

Ovaries

Ovarian endometriosis primarily manifests as chronic retention cysts with cyclical bleeding, called endometriomas. Although they have been frequently cited as one of the most common sites of endometriosis, prolonged use of oral contraceptives among young women has contributed to changes in the clinical scenario as they may prevent the development and growth of these cysts[17]. In contrast, the presence of an ovarian endometrioma is considered a marker of severe endometriosis with an increased risk of intestinal, ureteral, and vaginal lesions[32].

TVU demonstrates high sensitivity (84–100%) and specificity (90–100%) in the diagnosis of endometriomas, even for less experienced examiners. They present as uni- or multiloculated thick-walled cysts with hypoechogenic content. Echogenic mural nodules, bright internal foci, and fluid-fluid levels are commonly associated findings[33]. Color Doppler can be used to demonstrate the hypovascular pattern without internal flow and could help to identify nodular areas within the cysts (Figure 4). As part of the algorithm, the search for adhesions is mandatory when evaluating ovaries[17]. The maneuver consisted of gentle pushing of the probe combined with abdominal palpation with the free hand. When the ovaries are medially located and fixed (kissing ovaries), there is a high probability of underlying endometriosis[34].

MRI is the best imaging modality for diagnosing endometriomas and differentiating them from functional and other cysts, with high specificity (98%)[14]. They exhibited high signal intensity on T1-weighted images and low signal intensity on T2-weighted images (shading sign) (Figure 5). Shading can vary from a faint signal to a complete signal void, representing the old hemorrhagic content of the cysts (due to the high iron content). Similar to TVU, fluid levels, mural nodules, and thick septa were observed.

When reporting endometriomas, important issues should be addressed, such as (a) location within the ovary, peripheral or central, (b) maximum diameter, (c) laterality, (d) distance to the ureteral path, and (e) antral follicle count.

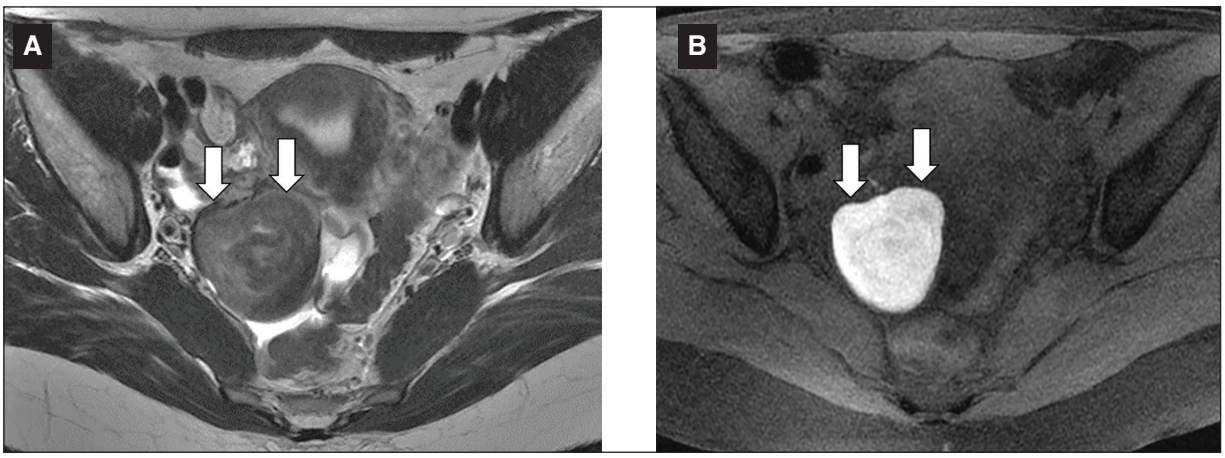

Figure 5. Endometrioma in a 29-year-old infertile woman. **A:** axial T2-weighted MRI demonstrating a cyst (arrows) with the shading sign representing old hemorrhagic content. **B:** axial T1-weighted fat-saturated MRI demonstrates hyperintense signal intensity (light bulb bright sign) characteristic of endometriomas (arrows).

MRI: magnetic resonance imaging.

Ovarian fossa

The peritonium of the ovarian fossa is a common site of DIE, especially when there is an endometrioma in the periphery of the ovary. Lesions manifest as plaques or nodules with ill-defined margins attached to the ovarian capsule; they appear hypoechoic on TVU, with low signal intensity on T2-weighted MRI images. The distance between the ureteral path and the endometriotic tissue is crucial for surgical planning and should be provided[17].

Ureters

Ureteral endometriosis is uncommon and frequently presents as extrinsic involvement of the distal ureters by direct extension of a large paracervical lesion (80% of cases)[35]. Intrinsic endometriosis, when the muscularis of the ureter is infiltrated, is rare and is responsible for the silent loss of renal function[36].

The comprehensive TVU protocol should include evaluation of both ureters. In our experience, it is better when performed at the end of the examination, when renal excretion of the ingested water is ongoing[17]. Supplemental Video 3 shows the dynamic assessment of the left ureteral path with TVU and demonstrates ureteral peristalsis, distal ureter, and ureterovesical junction. US allows evaluation of the ureter from the segment below the iliac vessels to the ureterovesical junction. Renal evaluation using a convex transducer through the abdominal wall can be useful in detecting hydronephrosis.

MRI is considered the best imaging method for ureteral and pelvic evaluation as a one-stop shot procedure, combining MR-Urography with the conventional pelvic protocol[28]. Lesions appear as solid nodules with irregular contours that enclose the ureteral path, are hypoechoic on TVU, and have low signal intensity on T2-weighted images. The ureters can be partially or completely involved by the endometriotic tissue, which is later associated with upstream dilatation.

POSTERIOR COMPARTMENT

Retrocervical and rectovaginal space

The retrocervical space is the most common location of DIE, and is the site at which endometriosis usually begins[5]. In decreasing order of frequency, the most common locations are the proximal third of the uterosacral ligaments and torus uterinus, rectovaginal space, posterior vaginal wall, and rectosigmoid colon. The relevant clinical manifestations include chronic pelvic pain, dysmenorrhea, and deep dyspareunia. Physical examination can show a thickened uterosacral ligament or nodularity in the posterior cul-the-sac; however, in most cases, this is insufficient for adequate diagnosis and staging of the multiple sites affected[37].

Retrocervical lesions can vary from small subperitoneal plaques to large nodules with irregular contours (Figure 6). They can be uni- or bilateral, display a mixed texture due to cystic areas, and show an inferior extension to the rectovaginal space, below the peritoneal reflection, and into the posterior vaginal fornix[28]. Supplemental Video 4 shows the dynamic assessment of the retrocervical space with TVU and demonstrates a

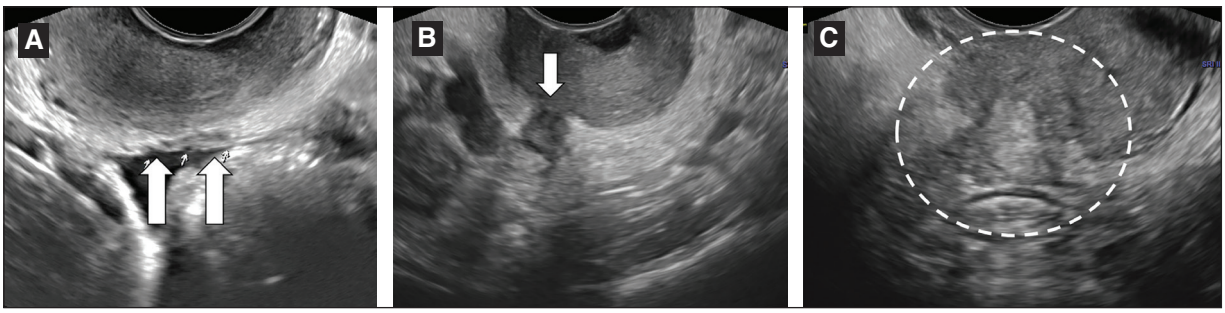

Figure 6. Different examples of retrocervical endometriosis. **A:** axial TVU after bowel preparation of a 33-year-old woman with deep dyspareunia demonstrating hypoechoic subperitoneal plaque affecting the retrocervical space (arrows). **B:** axial oblique TVU after bowel preparation in a 36-year-old infertile woman reveals a hypoechoic nodule compromising the ligament insertion (arrow). **C:** axial oblique TVU after bowel preparation of a 38-year-old woman with dysmenorrhea and deep dyspareunia, demonstrating a hypoechoic nodule with irregular margins located in the right insertion of the USL (dotted circle).

TVU: transvaginal ultrasound. USL: uterosacral ligament.

hypoechoic nodule in the proximal third of the right uterosacral ligament. Another common presentation is lateral extension of the parametrium. A comprehensive description of these lesions is mandatory, including the two largest dimensions of a nodule and the thickness of an abnormal uterosacral ligament in the oblique axial plane. In large retrocervical nodules, proximity to the hypogastric plexus and ureteral path should be addressed, as well as extension to the pelvic floor and presacral nerves[20].

In TVU, they are fundamentally hypoechoic and may contain small cystic areas and punctate hyperechoic foci. On MRI, they show a low signal intensity on T2-weighted images. Cystic areas can contain simple fluid or hemorrhagic content with a high signal intensity on T1-weighted fat-saturated images. Another possible pattern of presentation is when the endometriotic tissue deeply infiltrates the posterior uterine wall from the outside-in, which is frequently associated with uterine retractile retroflexion. It is considered a marker for severe endometriosis with an increased risk of intestinal and vaginal lesions and severe adhesions[38].

Vagina

Isolated vaginal lesions are rare. Vaginal endometriosis is almost always an inferior extension of a retrocervical lesion, with the posterior vaginal wall being the most affected area. They show a mixed pattern owing to the presence of rich glandular components that frequently contain hemorrhagic content[28]. Large nodules can protrude into the posterior fornix as polypoid masses. Deep dyspareunia is the most common clinical presentation.

On TVU, careful examination of the posterior vaginal wall may reveal asymmetric homogeneous or heterogeneous thickening and extension to the retrocervical tissue. MRI is highly specific for vaginal endometriosis, particularly when hemorrhagic cysts are present. Vaginal distension with US gel is useful for displaying fornix obliteration of asymmetric thickening of the vaginal wall (Figure 7).

Rectosigmoid colon

Intestinal endometriosis is among the most aggressive of diseases and is present when the endometriotic tissue deeply infiltrates the bowel wall beyond the muscular layer from outside-in[39]. The mucosa is rarely affected. The rectosigmoid colon is the most affected site, followed by the appendix, ileum and cecum. Symptoms are nonspecific and can include abdominal distension, chronic constipation, diarrhea, and, rarely, hematochezia. Bowel endometriosis can be multifocal when multiple lesions are detected in the same segment or multicentric when different bowel segments are compromised[40].

TVU after bowel preparation is an excellent tool for investigating bowel endometriosis, allowing comprehensive evaluation of the rectosigmoid colon from the anal verge to the descending colon[18]. Other bowel loops, such as the ileocecal region and appendix, can be accurately evaluated using transvaginal and transabdominal approaches. The main advantage of US over MRI is the dynamic nature of the method, enabling careful examination of the bowel loops in both the axial and sagittal planes. Supplementary video 5 shows the dynamic assessment of the rectosigmoid colon by TVU after bowel preparation and shows two adjacent bowel lesions at the level of the peritoneal reflexion. Bimanual examination is mandatory during

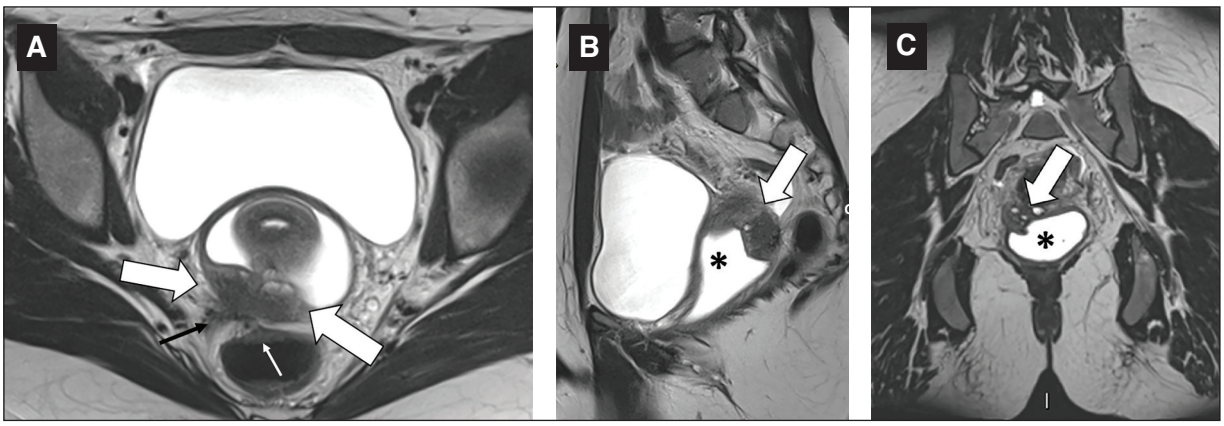

Figure 7. Endometriosis of the posterior compartment of the pelvis in a 41-year-old-woman with severe dyspareunia. **A:** axial T2-weighted MRI showing mixed thickening compromising the posterior vaginal wall associated with partial obliteration of the posterior vaginal fornix (white arrows). **B and C:** there is also thickening of the right uterosacral ligament insertion (thin black arrow) and anterior rectal wall (thin white arrow). Note that vaginal distension with US gel (asterisk) in sagittal and coronal T2-weighted MRI better demonstrates the vaginal lumen and the nodular vaginal thickening (arrows).

MRI: magnetic resonance imaging; US: ultrasound.

bowel inspection to stretch the bowel loops and avoid folds and peristaltic artifacts. The sliding sign maneuver is also crucial to identify obliteration in the pouch of Douglas and must be included in the algorithm[18].

MRI can also accurately detect bowel lesions, but this method is certainly more susceptible to artifacts. In our experience, the combination of bowel preparation, fasting, antiperistaltic agent, and saline distension of the rectosigmoid colon can improve the sensitivity of the method, particularly for small lesions (< 1.5 cm). Imaging should provide the size of the lesions in three dimensions: circumference of the bowel involved, affected bowel layers, distance to the anal border, and distance between different nodules. Surgical management differs among shaving (tiny to small nodules), discoid resection (nodules < 3 cm), and segmental resection (nodules > 3 cm).

Bowel lesions appeared as homogeneous hypoechoic nodules on TVU, with markedly low signal intensity on T2-weighted images, attached to the bowel wall, and deeply infiltrating the bowel from outside-in (Figures 8 and 9). They rarely contained cystic areas or invaded mucosal layers. When the submucosa is infiltrated, a striated aspect can be observed (Figure 10)[28].

Right iliac fossa

The right iliac fossa (cecum, ileum, and appendix) can be compromised by endometriosis in approximately 28% of cases in which rectosigmoid disease is present. Appendiceal endometriosis is uncommon and is an incidental finding in patients with multifocal DIE. It can be associated with mucocele or intussusception of the cecal base[28]. US is better than MRI in detecting small ileal nodules or subtle lesions affecting the tip of the appendix. The transabdominal approach with a linear transducer is recommended as an additional component of the TVU algorithm. Lesions demonstrate the same aspect as the rectosigmoid nodules, hypoechoic on TVU, and with low signal intensity on T2-weighted images (Figure 11). The main differential diagnosis for appendiceal endometriosis is carcinoid tumor, and histopathological analysis is required because the image cannot rule out malignancy[41].

Diaphragm

The diaphragm is the most common location of thoracic endometriosis and clinically manifests as catamenial shoulder pain and right-sided spontaneous pneumothorax. Approximately 91.7% affect the right chest, and up to 85% of the cases are associated with severe pelvic endometriosis. MRI is the method of choice for demonstrating plaques or nodules with high signal intensity on fat-suppressed T1-weighted sequences, representing hemorrhagic content[42].

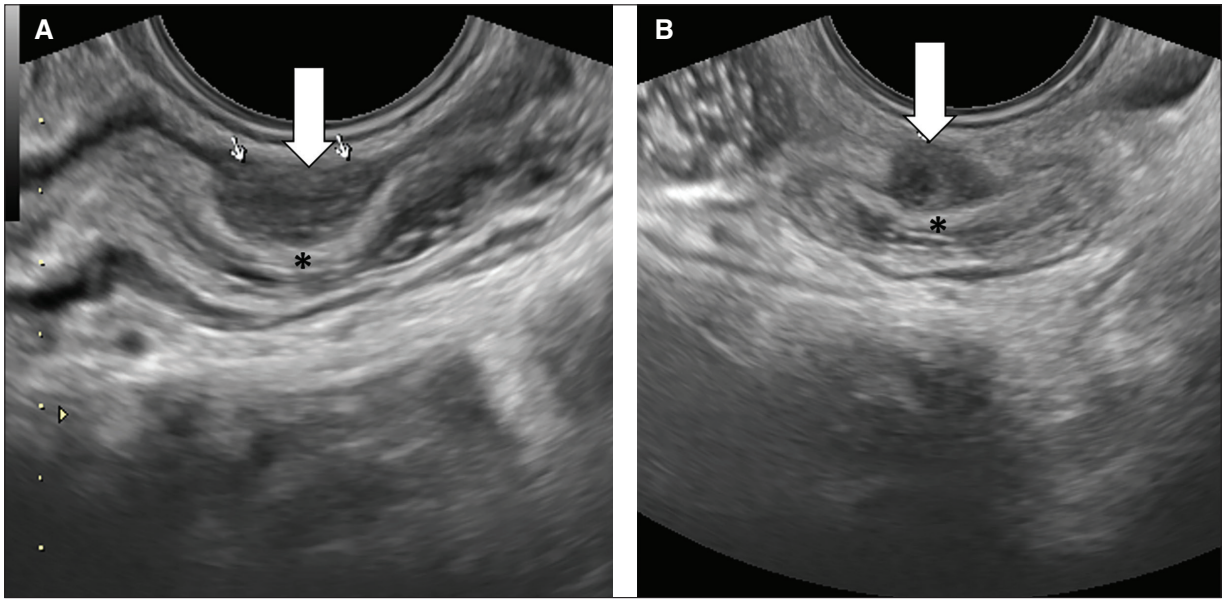

Figure 8. Intestinal endometriosis. **A:** sagittal and **B:** axial TVU after bowel preparation of a 31-year-old woman demonstrating a hypoechoic nodule attached to the bowel wall and deeply infiltrating the muscularis propria from outside-in (arrows). The submucosa (asterisk) is preserved.

TVU: transvaginal ultrasound.

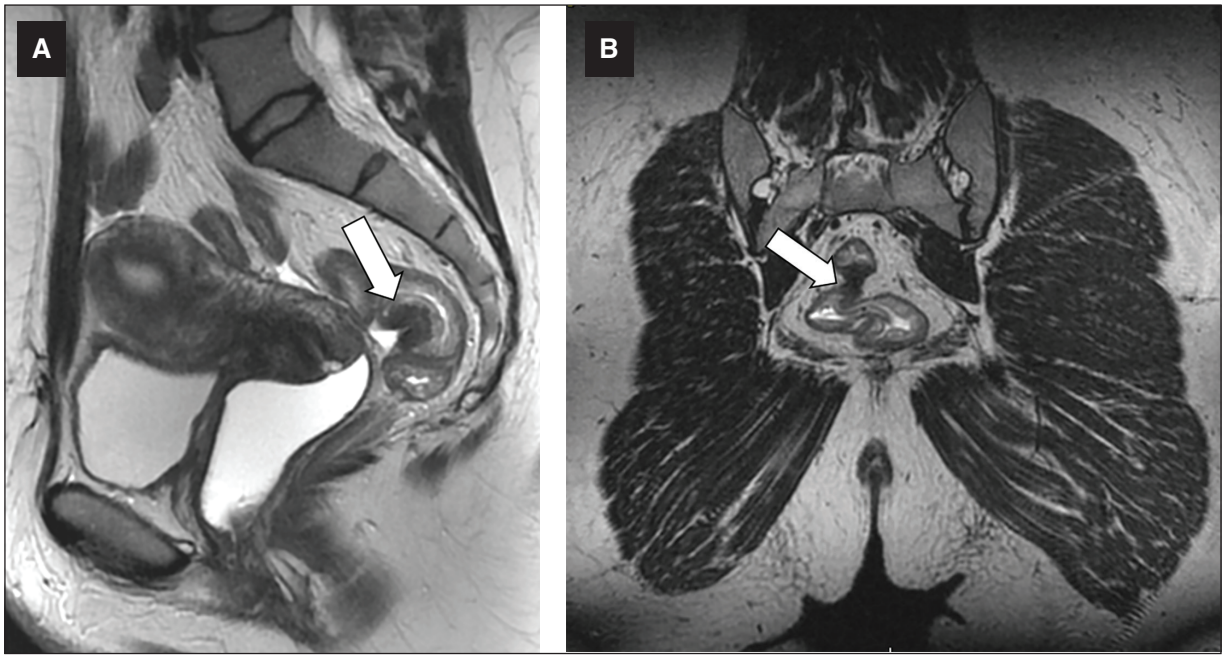

Figure 9. Rectal endometriosis in a 37-year-old woman with pelvic pain and dyschesia. **A:** sagittal. **B:** coronal. T2-weighted MRI demonstrating a nodule with low signal intensity attached to the anterior rectal wall and deeply infiltrating the muscularis propria from outside-in (arrows).

MRI: magnetic resonance imaging.

In our experience, transabdominal US evaluation using a convex transducer through the right subcostal area may demonstrate findings suggestive of endometriotic implants. The findings can range from heterogeneous hyperechoic plaques associated with cystic areas to multiple cystic areas with predominant anechoic content attached to the right diaphragmatic surface (Figure 12).

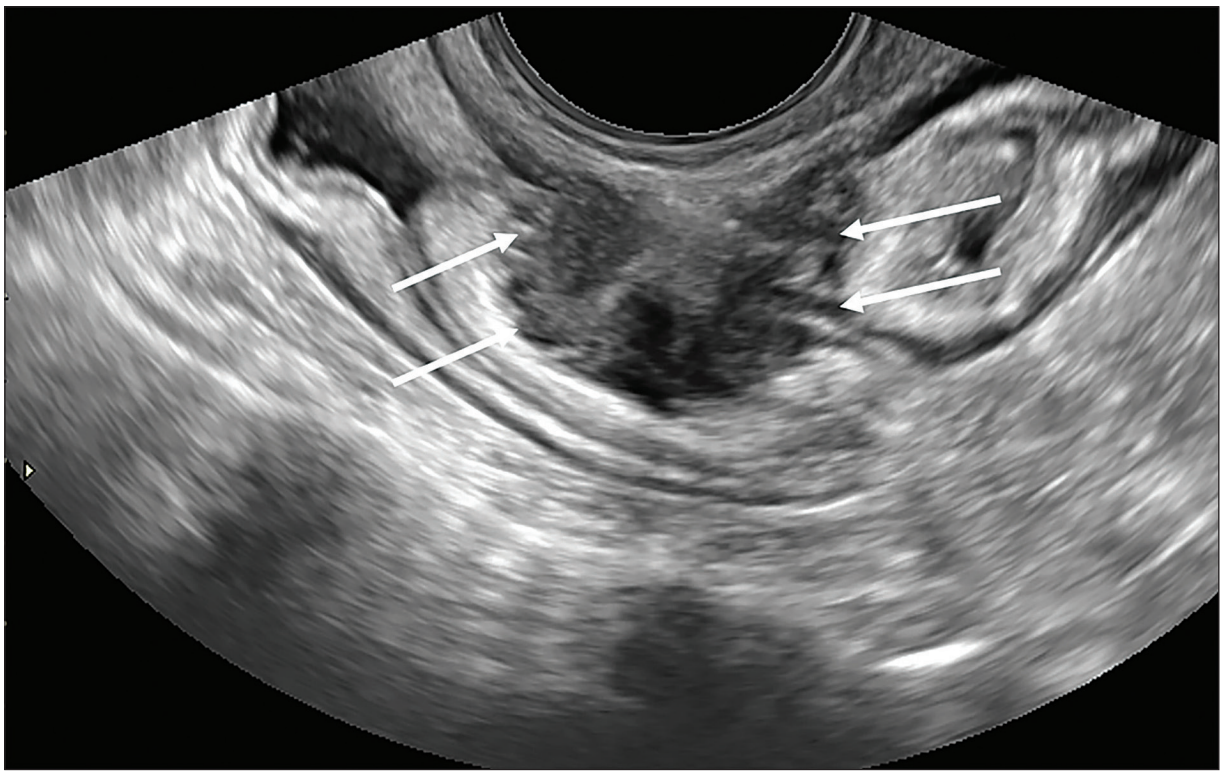

Figure 10. Sigmoid colon endometriosis in a 39-year-old woman. Sagittal TVU image after bowel preparation shows a hypoechoic nodule infiltrating the muscularis propria and the submucosa, the latter demonstrated by the striated pattern (arrows).
TVU: transvaginal ultrasound.

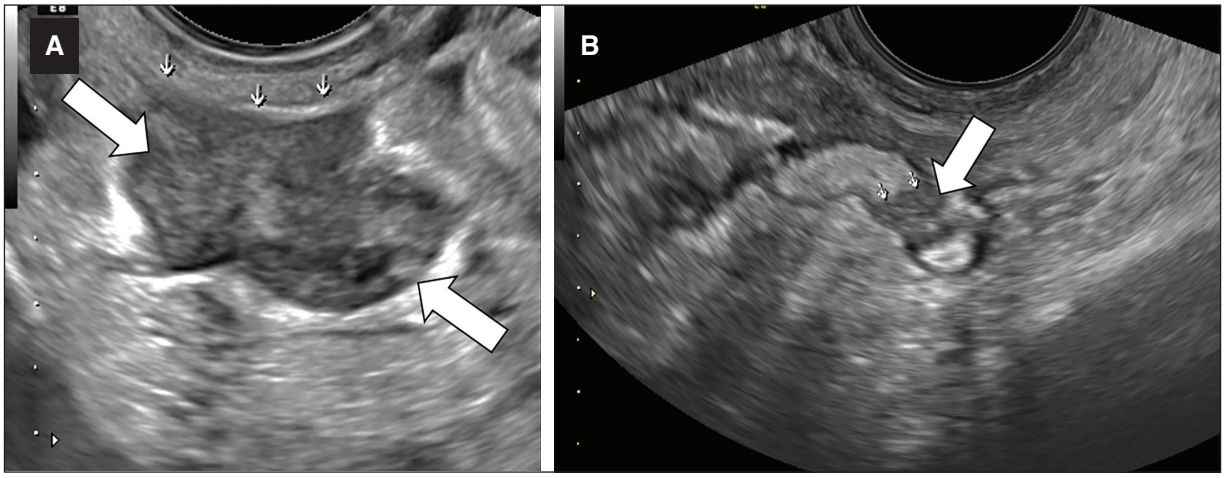

Figure 11. Endometriosis of the right iliac fossa in an asymptomatic 43-year-old woman. **A:** axial TVU image after bowel preparation demonstrating a large hypoechoic nodule deeply infiltrating the cecal base (arrows). **B:** sagittal TVU image after bowel preparation demonstrating a nodular hypoechoic thickening of the distal third of the appendix (arrow).
TVU: transvaginal ultrasound.

Structured report

Imaging diagnosis of endometriosis should include a standardized report to improve communication with referring physicians and patients, as well as to ensure uniform interpretation and documentation among radiologists. It must follow the appropriate anatomical terminology and updated lexicon for endometriosis reports, including all potential sites affected. Schematic drawings or sketches pointing to the exact location of DIE implants can add value to the report, providing a roadmap for surgeons during the procedure[43].

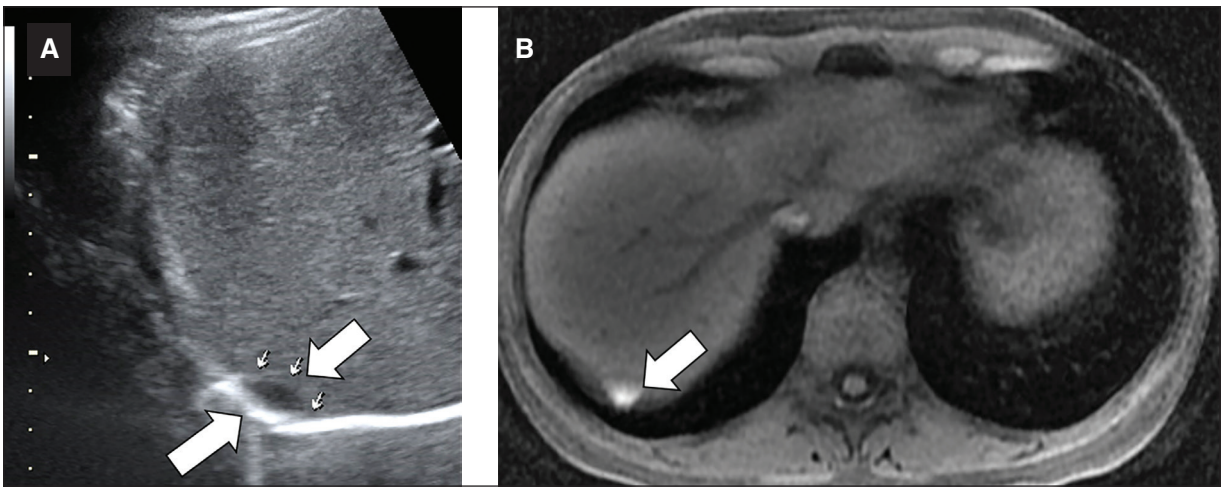

Figure 12. Diaphragmatic endometriosis in a 33-year-old-woman with catamenial right shoulder pain. **A:** abdominal US image demonstrates a hyperechoic plaque associated with cystic area (arrows) located between the diaphragm and hepatic surface. **B:** axial T1-weighted MRI with fat-saturation demonstrating hyperintense nodular foci located between the hepatic surface and the diaphragm representing hemorrhagic content (arrow).

MRI: magnetic resonance imaging; US: ultrasound.

CONCLUSION

The diagnosis of endometriosis remains a clinical challenge and may take up to 12 years until definitive detection. Imaging has altered the clinical scenario, replacing diagnostic laparoscopy and acting as an invaluable tool for patient counseling and surgical planning. A dedicated TVU protocol is the first-line imaging modality for diagnosis and staging of DIE. US is the most appropriate method for evaluating bowel endometriosis and small peritoneal implants. MRI is very useful for multiple-site evaluation and has an advantage for ovarian, ureter, diaphragm, pelvic floor, and pelvic nerve evaluation. Early diagnosis can avoid long-term sequelae, and accurate preoperative staging can optimize surgical management and complete eradication of DIE implants.

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Conflicts of interest

There are no conflicts of interest to declare.

Ethical disclosures

Protection of individuals. This study was conducted in compliance with the Declaration of Helsinki (1964) and its subsequent amendments.

Confidentiality of data. The author declare that no patient data are available in this article.

Right to privacy and informed consent. The author declares that there are no ethical responsibilities, since handling human beings' confidential information was not necessary.

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