Transvaginal US of Endometriosis: Looking Beyond the Endometrioma with a Dedicated Protocol

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Abbreviations: DIE = deep infiltrating endometriosis, IDEA = International Deep Endometriosis Analysis, POD = pouch of Douglas, RVS = rectovaginal septum, TVS = transvaginal sonography, USL = uterosacral ligament

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SA-CME LEARNING OBJECTIVES

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

- List the four components of a US examination that is optimized for evaluation of pelvic endometriosis.
- Identify the anatomic locations and TVS findings of the various manifestations of endometriosis.
- Discuss the value of US in the management of endometriosis, including the unique features of US, performed as an extension of the physical examination, that enable acquisition of information that is not easily addressed with other imaging modalities.

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Transvaginal sonography (TVS) is a valuable primary imaging tool for the initial evaluation and management of endometriosis, a complex multifocal disease process with a varied spectrum of clinical and morphologic features that can substantially affect quality of life. The high accuracy of TVS for the detailed mapping of disease extent, an essential process for guiding treatment strategies, is well documented. The dynamic nature of US provides added value, revealing information that is not easily addressed with other imaging modalities. As recognized by the International Deep Endometriosis Analysis Consensus Group, a dedicated standardized protocol that is used by experienced and knowledgeable operators is necessary for a complete evaluation. The four components of a dedicated TVS protocol for evaluation of pelvic endometriosis are *(a)* evaluation of the uterus and adnexa, *(b)* dedicated search for deep infiltrating endometriosis, *(c)* assessment of the sliding sign, and *(d)* detection of sonographic soft markers. These components are described, and the multiple locations and US findings of endometriosis within the pelvis are reviewed, with emphasis on the unique features of US as an extension of the physical examination. In addition to enabling evaluation of the static findings of adenomyosis, endometrioma, hydrosalpinx, hematosalpinx, and hypoechoic nodules of deep infiltrating endometriosis, dynamic TVS enables assessment of pouch of Douglas obliteration, organ mobility, and site-specific tenderness, as well as tenderness-guided imaging. The benefits of implementing a dedicated TVS protocol in terms of improved patient care are also discussed.

Online supplemental material is available for this article.

Introduction

Endometriosis is a complex inflammatory disease process that can result in substantial life-altering morbidity, and early and accurate diagnosis of this disease can prove to be difficult (1–4). Endometriosis refers to the presence of endometrial glands and stroma outside the uterus, with resultant reactionary inflammation and fibrosis. Although the exact mechanism underlying endometriosis

TEACHING POINTS

- The accuracy and reliability of TVS in the evaluation of endometriosis have been well documented. However, given the complexity of this disease process, use of a dedicated TVS protocol with experienced and knowledgeable operators is necessary.
- The standardized systematic approach developed by the IDEA Consensus Group involves four key components of a dedicated TVS endometriosis protocol. These four components, which address the various locations and manifestations of endometriosis, are *(a)* evaluation of the uterus and adnexa, *(b)* dedicated search for DIE, *(c)* assessment of the sliding sign, and *(d)* detection of sonographic soft markers.
- At US, DIE appears as hypoechoic linear or round nodules with smooth or irregular borders and no to minimal internal vascularity at color Doppler US.
- The sliding sign maneuver is a dynamic real-time assessment of the POD for obliteration; it is performed by evaluating the motion of the uterus in relation to the bowel.
- Sonographic soft markers are subjective findings detected at US that indicate the presence of pelvic disease. These markers include site-specific tenderness and decreased ovarian and/or uterine mobility.

is not known, a favored theory is direct extension of cells into the peritoneal cavity caused by retrograde menstruation. Additional theories include lymphatic, vascular, iatrogenic, and other mechanisms of transplantation, as well as metaplastic transformation of coelomic cells lining the pelvic peritoneum (1,3). The ectopic endometrial glands can be present in multiple locations and can have multiple morphologic manifestations. The ectopic endometrial cells are hormonally responsive, resulting in cell proliferation, glandular activity, hemorrhage, and symptoms that can be cyclical.

Endometriosis occurs in 3%–15% of females of reproductive age (1,3,5–7). The exact prevalence is difficult to determine, as the clinical manifestations are variable, from no symptoms to severe pain and life-altering dysfunction. The prevalence is higher in symptomatic women: up to 50% in patients who are infertile and nearly 50%–90% in those with chronic pelvic pain (1,5,8). Common symptoms include dysmenorrhea, dyspareunia, irregular bleeding, chronic pelvic pain, and infertility, with additional less common symptoms depending on the location of disease.

Although clinical examination findings may include tenderness, a nodule (or nodules), or a mass (or masses), these findings may be normal and are often inadequate owing to the multiplicity and location of disease. In addition, the varied clinical and morphologic features do not always correlate (3,8). These nonspecific pelvic findings can lead to a difficult, delayed, or missed diagnosis and necessitate the use of imaging as a diagnostic tool, with US typically being the first modality of choice, given that it is easily accessible and inexpensive. Imaging evaluation is also essential for triaging patients for the different endometriosis treatment options.

Transvaginal sonography (TVS) is the primary tool for imaging endometriosis (5,9–11). The accuracy and reliability of TVS in the evaluation of endometriosis have been well documented. However, given the complexity of this disease process, use of a dedicated TVS protocol with experienced and knowledgeable operators is necessary (12–15). Use of an optimized dedicated TVS protocol addresses the multiple locations and manifestations and varied imaging appearances of endometriosis and thus enables detailed mapping of the disease extent, an essential component of patient care decisions (2,11,12,16).

Because US is operator dependent, with imagers routinely seeing only what they know to look for and where they know to look, the use of inadequate protocols results in inconsistencies in detection and decreased sensitivity with TVS. The importance of using a dedicated standardized protocol was recognized by the International Deep Endometriosis Analysis (IDEA) Consensus Group, a panel of experts convened to standardize US assessment of endometriosis (6). The panel recognized that the routine pelvic US protocol is not sufficient, as it is focused mainly on static imaging of the ovary and uterus.

To more accurately map the spectrum of disease, the operator needs to look beyond the endometrioma at the many additional manifestations of endometriosis, which TVS is well suited to reliably depict. In addition to the static imaging findings of adenomyosis, endometrioma, hydrosalpinx, hematosalpinx, and hypoechoic nodules of deep infiltrating endometriosis (DIE), there are unique dynamic features of US that can serve as extensions of the physical examination. The added benefits of these features enable the use of TVS techniques for acquisition of additional integral information that cannot be dynamically addressed by using alternate imaging modalities, including data obtained at assessment of pouch of Douglas (POD) and vesicouterine obliteration, with use of the sliding sign; organ mobility; and site-specific tenderness. Another benefit of TVS is that it enables tenderness-guided imaging.

The standardized systematic approach developed by the IDEA Consensus Group involves four key components of a dedicated TVS endometriosis protocol (6). These four components, which address the various locations and manifes-

Dedicated TVS Protocol for Endometriosis Developed by the IDEA Consensus Group

Evaluated Component(s)	Objective
Uterus and adnexa	Evaluation for evidence of endometriosis: Are there findings of adenomyosis? Is there an ovarian endometrioma? Is a hydrosalpinx or hematosalpinx present?
DIE	Search anterior and posterior compartments for nodules: Anterior uterine serosa to anterior pelvic wall Posterior uterine serosa to presacral space Are there any hypoechoic nodules?
Sliding sign	Dynamic assessment for vesicouterine and rectouterine pouch obliteration: Does the bladder move relative to the uterus? Does the cervix move relative to the rectum? Does the uterus move relative to the bowel?
Soft markers	Subjective findings at dynamic imaging: Is there site-specific tenderness? Are the organs mobile?

Source.—Reference 6.

tations of endometriosis, are *(a)* evaluation of the uterus and adnexa, *(b)* dedicated search for DIE, *(c)* assessment of the sliding sign, and *(d)* detection of sonographic soft markers (Table).

In this article, we describe and illustrate our application of the dedicated TVS approach developed by the IDEA Consensus Group and, within this context, review the varied clinical and TVS manifestations of pelvic endometriosis. These manifestations are organized according to the four fundamental TVS protocol components. The limitations and clinical benefits of TVS also are discussed. (The original slide presentation for this article from the RSNA Annual Meeting is available online.)

Four Components of the TVS Protocol for Endometriosis: Overview

The four components of the dedicated TVS protocol provide an assessment model for evaluation of pelvic endometriosis based on the pathophysiologic features of this complex disease (3). The first component involves evaluation of the uterus for adenomyosis and assessment of the ovary for an endometrioma, the pathognomonic manifestation of endometriosis. However, endometriosis can develop throughout the peritoneum as superficial or deep endometriosis. With superficial endometriosis, deposits of endometrial tissue are attached to the peritoneal surface without invasion of the underlying organ or retroperitoneum. In contrast, *DIE* is defined as a greater than 5-mm extension into the peritoneum, with organ invasion or retroperitoneal involvement (2,17).

The second component is a systematic search for DIE based on the anatomic location, with the most common sites located in the pelvis and included in the TVS field of view (18). The endometrial deposits incite local reactive inflammation and fibrosis that can result in the formation of adhesions, which, in turn, results in additional US findings. These findings are addressed by the third and fourth components (3,19). The third component is assessment for adhesive disease with use of the sliding sign in the POD and vesicouterine pouch. The fourth component involves evaluation of organ immobility, a US soft marker for pelvic disease related to adhesions. In addition, to provide additional evidence of disease, areas of site-specific tenderness are located during this protocol component. Pelvic adhesive disease is also assessed during the first protocol component; this includes inspection of the adnexa for morphologic manifestations such as hydrosalpinx.

Based on our experience, we propose that the four described components should be considered a framework of thought rather than discrete steps, because the components typically overlap during an examination. Since they are designed specifically for assessment of the various manifestations of endometriosis, all four components must be performed. A worksheet outlining the components and possible findings can be a helpful guide during real-time examination and aid in the documentation of the various findings (Appendix E1).

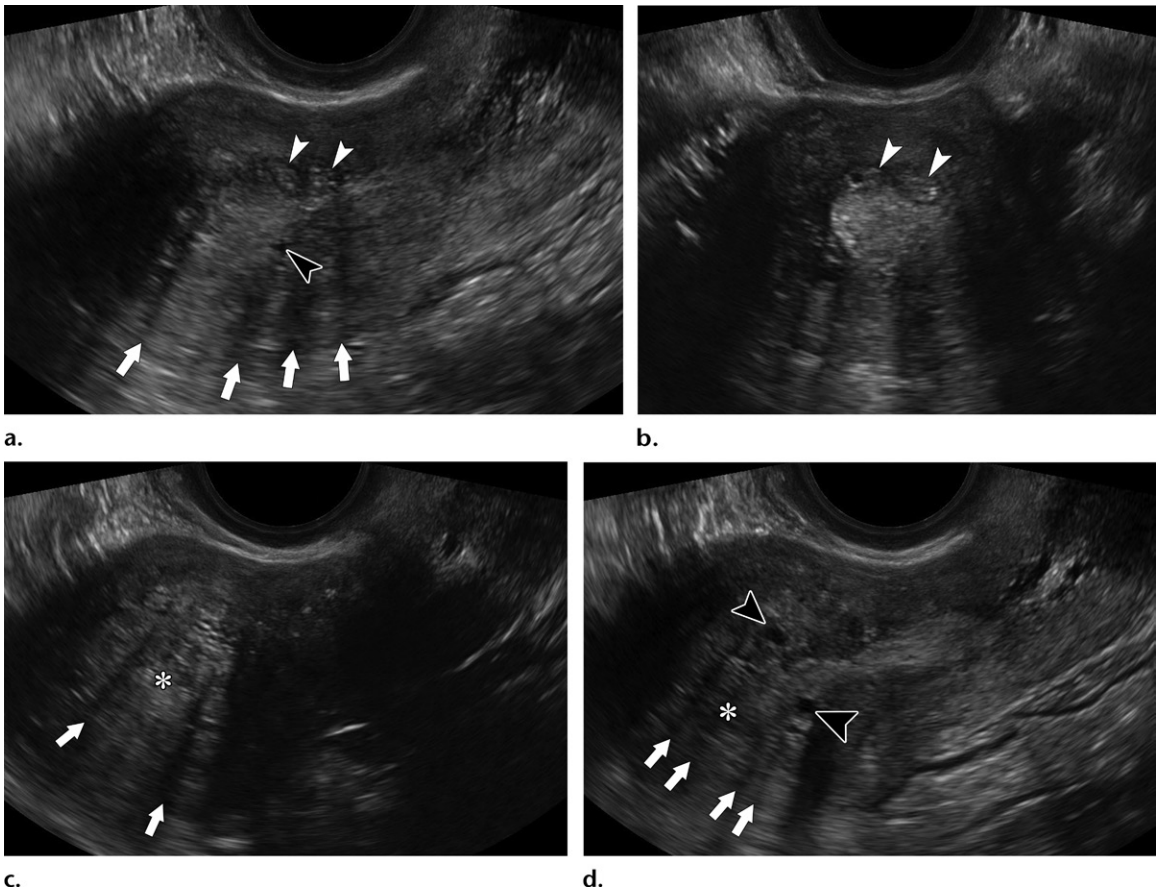


Figure 1. Adenomyosis in a 54-year-old woman with abnormal uterine bleeding and irregular periods; endometriosis was seen at laparoscopy. Sagittal (**a**, **c**, **d**) and transverse (**b**) gray-scale TVS images show echogenic nodules with hypoechoic rims (white arrowheads in **a** and **b**), myometrial cysts (black arrowheads in **a** and **d**), venetian blind shadowing (arrows in **a**, **c**, and **d**), and a heterogeneous myometrium with an ill-defined endometrial-myometrial junction (∗ in **c** and **d**).

Component 1: Evaluation of the Uterus and Adnexa

Component 1 involves a thorough evaluation of the uterus and adnexa. This includes, in addition to the routine pelvic TVS examination of the uterus and ovaries, special attention to the extraovarian manifestations of endometriosis within the adnexa, such as tubal disease and adhesions.

Uterus.—The uterus is imaged in the sagittal and axial planes, with careful attention given to the myometrium for changes related to adenomyosis, which can contribute to the patient's pain. There is an association between adenomyosis and endometriosis, and the presence of adenomyosis has been shown to correlate with more severe symptoms and a higher stage of disease (20–22). Adenomyosis is reported to have a mean prevalence of 20%–30% and a higher prevalence, of about 50%, in patients with DIE (21,23). When symptoms are present, they most commonly include menorrhagia and dysmenorrhea (23).

Adenomyosis refers to the presence of ectopic endometrial cells within the myometrium that incite a hyperplastic reaction, which, in turn, can result in multiple sonographic appearances (Fig 1), as recently reported by Cunningham et al (23). The ectopic endometrial cells are seen as hyperechoic nodules or linear striations within the myometrium that extend out from or close to the endometrium. These ectopic glands can undergo hormone-induced cystic change, which manifests as myometrial cysts. There is resultant pseudo-widening and poor definition of the endometrium as it interdigitates into the myometrium. The adjacent myometrium undergoes hyperplasia, which manifests as a hypoechoic rim around the echogenic nodule.

The myometrium may also become focally or diffusely heterogeneous, with poor definition of the borders and a relative absence of mass effect. In the areas of heterogeneous involvement, there can be a striated, venetian blind appearance. The sensitivity and specificity of TVS for detection of adenomyosis are reported to be 75%–88% and 67%–93%, respectively (21).

When evaluating the uterus, a specific search for DIE should also be performed by evaluating the organ for endometriosis deposits on the peritoneal reflection covering the anterior and posterior regions of the uterine serosa. These

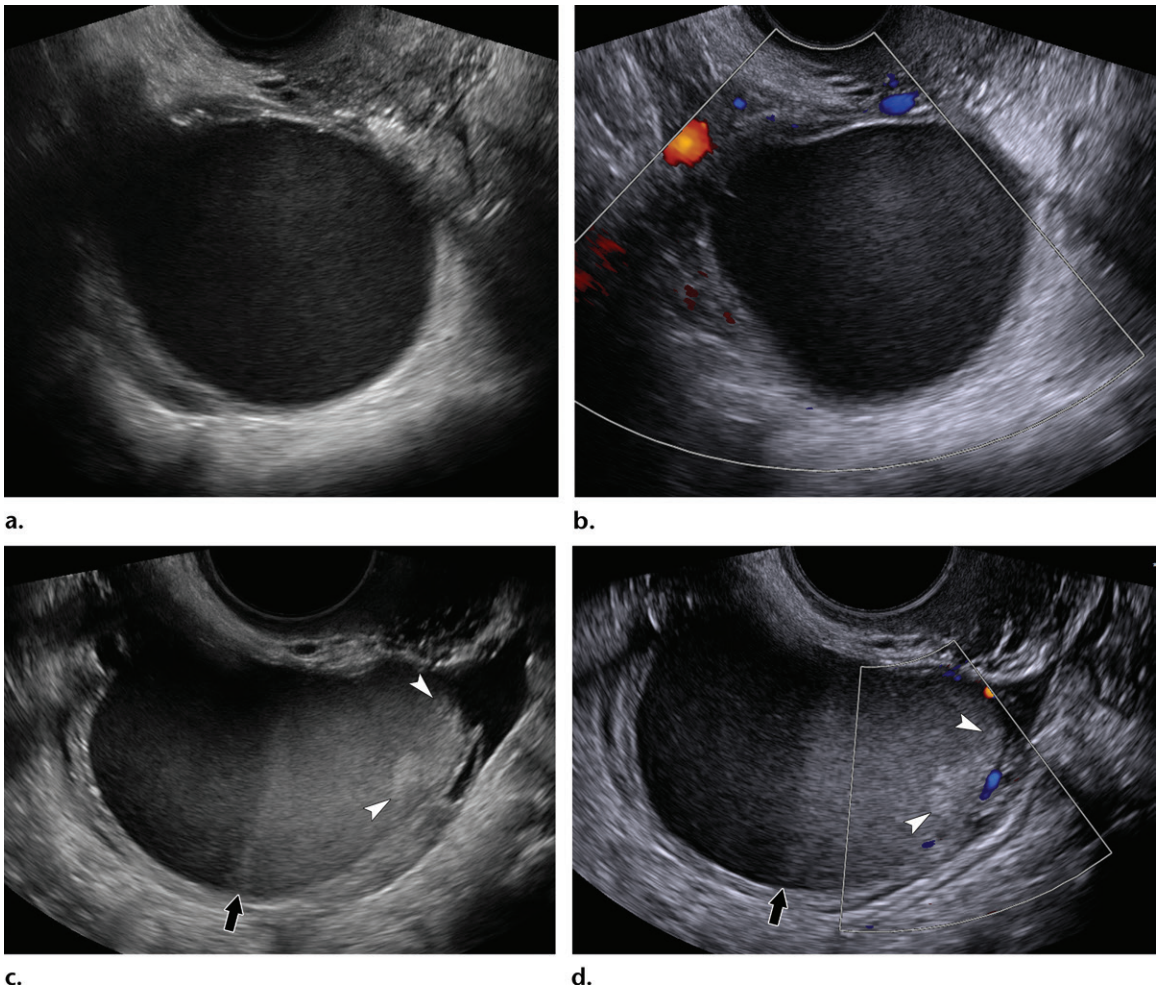


Figure 2. Typical and atypical ovarian endometriomas in two patients. **(a, b)** Transverse gray-scale **(a)** and color Doppler **(b)** TVS images in a 25-year-old woman with pelvic pain and a history of prior left oophorectomy performed secondary to endometriosis show the classic appearance of an ovarian endometrioma: a unilocular cyst containing homogeneous low-level echoes and no internal vascularity at color Doppler US. **(c, d)** Sagittal gray-scale **(c)** and color Doppler **(d)** TVS images in a 28-year-old woman with long-standing right lower quadrant pain and a laparoscopically confirmed endometrioma show a fluid-fluid level (arrow), with dependent hyperechoic material and an avascular nodule (arrowheads) within the endometrioma.

deposits invade inwardly and can have an appearance similar to that of adenomyosis described above; however, these deposits represent DIE.

The key to correct interpretation of DIE involving the uterine serosa is identification of findings that are peripheral, with extension from the peritoneum inward, rather than outward from the endometrium. Accordingly, the normal interface between the endometrium and the myometrium is preserved, and the inner myometrium is not thickened (23). This phenotype of DIE is typically ill defined and infiltrative rather than nodular, although involvement at the insertion of the round ligaments can be nodular and mimic a subserosal leiomyoma (24). Posterior serosal DIE can result in retractile retroflexion of the uterine fundus.

Ovary.—The ovary is one of the most frequent sites of endometriosis, with up to 67% involvement reported at laparoscopic studies in which both superficial ovarian endometriosis and endometriomas were included (4,25,26). The ovary is evaluated for an endometrioma, which is present in about one-third of patients with endometriosis (27). An endometrioma is considered to be an indicator of additional pelvic endometriosis, as it is rarely isolated but frequently associated with other findings (9,27–29).

An endometrioma is also considered a marker for severity of disease (9,28,29). Up to 50% of patients with DIE have an associated endometrioma, and these patients have a higher incidence of multifocal DIE with increased severity and adhesion formation (28). As such, the presence of an endometrioma amplifies the importance of the second protocol component, the search for DIE, particularly in intestinal, vaginal, and ureteral locations (28). In patients with an endometrioma, a main reason for incomplete surgery is the lack of preoperative identification

of the associated DIE (27). When patients with an ovarian endometrioma are symptomatic, they often have symptoms that are common to endometriosis: pelvic pain, dysmenorrhea, dyspareunia, and infertility.

Endometrioma refers to the cyst that forms when ectopic endometrial glands and stroma in the ovary bleed. The cyst has a fibrous capsule and contains aged blood products. These cysts may be bilateral in up to 50% of patients (3,5). Characteristic US features of an endometrioma include a unilocular cyst with internal homogeneous low-level echoes, a perceptible wall with or without bright reflectors, and no solid component or internal vascularity at color Doppler US (Fig 2a, 2b) (4,21,30). If the cyst is locular, there is a minimal number (<5) of locules (21). In a study by Guerriero et al (31), almost 50% of the endometriomas did not demonstrate typical features, and these atypical endometriomas were more often found in postmenopausal women. Atypical US features include a fluid-fluid level and an avascular internal nodule or papillary projection (Fig 2c, 2d). Notably, decidualization of an endometrioma during pregnancy can mimic malignancy with solid vascularized components (32).

The size in three orthogonal planes and appearance of each endometrioma should be reported. The sensitivity and specificity of TVS for the detection of an endometrioma have been reported to range from 62% to 73% and from 67% to 93%, respectively (21).

In addition to assessment for endometrioma, evaluation of the ovarian margins should be performed. Superficial endometriosis and adhesions may appear as ill definition of the ovary with blurring of the ovarian margins (33). The presence of adhesions between an endometrioma and the peritoneum strongly correlates with endometriosis of the ovarian fossa peritoneum (34).

Adnexa.—The adnexa are also assessed for extraovarian morphologic evidence of pelvic adhesive disease such as hydrosalpinx and peritoneal inclusion cysts. Although nonspecific, pelvic adhesive disease is an important sequela of endometriosis that can result in chronic pelvic pain, infertility, and other symptoms that lead to a decreased quality of life (3).

Fallopian tube abnormalities have been reported in approximately 30% of women with endometriosis (35,36). Serosal and subserosal deposits typically result in peritubal adhesions that cause fluid distention and hydrosalpinx. Less commonly, the endometriosis can be intraluminal. A hydrosalpinx appears as a cystic tubular structure, with the salpingeal folds typically visible along the cyst edge, creating a cogwheel appearance on transverse views (Fig 3a, 3b). When the fallopian tube is distended with blood—that is, a hematosalpinx—low-level internal echoes that may display layering are visualized (Fig 3c). Although nonspecific, a hematosalpinx can be considered an indicator of endometriosis and sometimes may be an isolated finding (35,36).

A peritoneal inclusion cyst forms when adhesions trap fluid around the ovary and prohibit the peritoneum's normal reabsorption of the fluid (37). Key findings of a peritoneal inclusion cyst include a shape that typically conforms to the peritoneum and an eccentric position of the ovary within the cyst (Fig 3d). These findings of pelvic adhesive disease increase diagnostic suspicion for endometriosis in patients who are clinically suspected of having endometriosis.

Component 2: Search for DIE

DIE-related Anatomy.—The second component of a dedicated TVS protocol consists of a systematic search for DIE and precise mapping of the disease according to anatomic location (6,12,18). This search first requires a conceptual division of the pelvis into anterior and posterior compartments. In the sagittal plane, an imaginary line through the endometrial cavity and vagina divides the pelvis into anterior and posterior compartments. Familiarity with the anatomic landmarks in each compartment and with the subdivisions of these compartments facilitates a thorough systematic search and promotes the use of standardized reporting terminology. Historically, there has been a lack of uniformity in the description and classification of disease locations, and this has limited the coherence of research conclusions. Herein, we review the US classification of the anatomic locations of DIE, as defined by the IDEA Consensus Group (6) to promote uniform reporting.

The anterior compartment of the pelvis extends from the anterior uterine serosa to the anterior pelvic wall (Fig 4). The anterior compartment is viewed by placing the probe in the anterior vaginal fornix. It contains the bladder, ureters, uterovesical region, and anterior uterine serosa. The primary anatomic location to search for within the anterior compartment is the bladder, which can be divided into four sections: The trigone contains the orifices of the ureters and urethra and is within 3 cm of the urethral orifice. The base is extraperitoneal and anterior to the vagina and cervix, below the peritoneal reflection. The dome is intra-abdominal and covered by the peritoneal reflection. The extra-abdominal section is anterior and not covered with peritoneum.

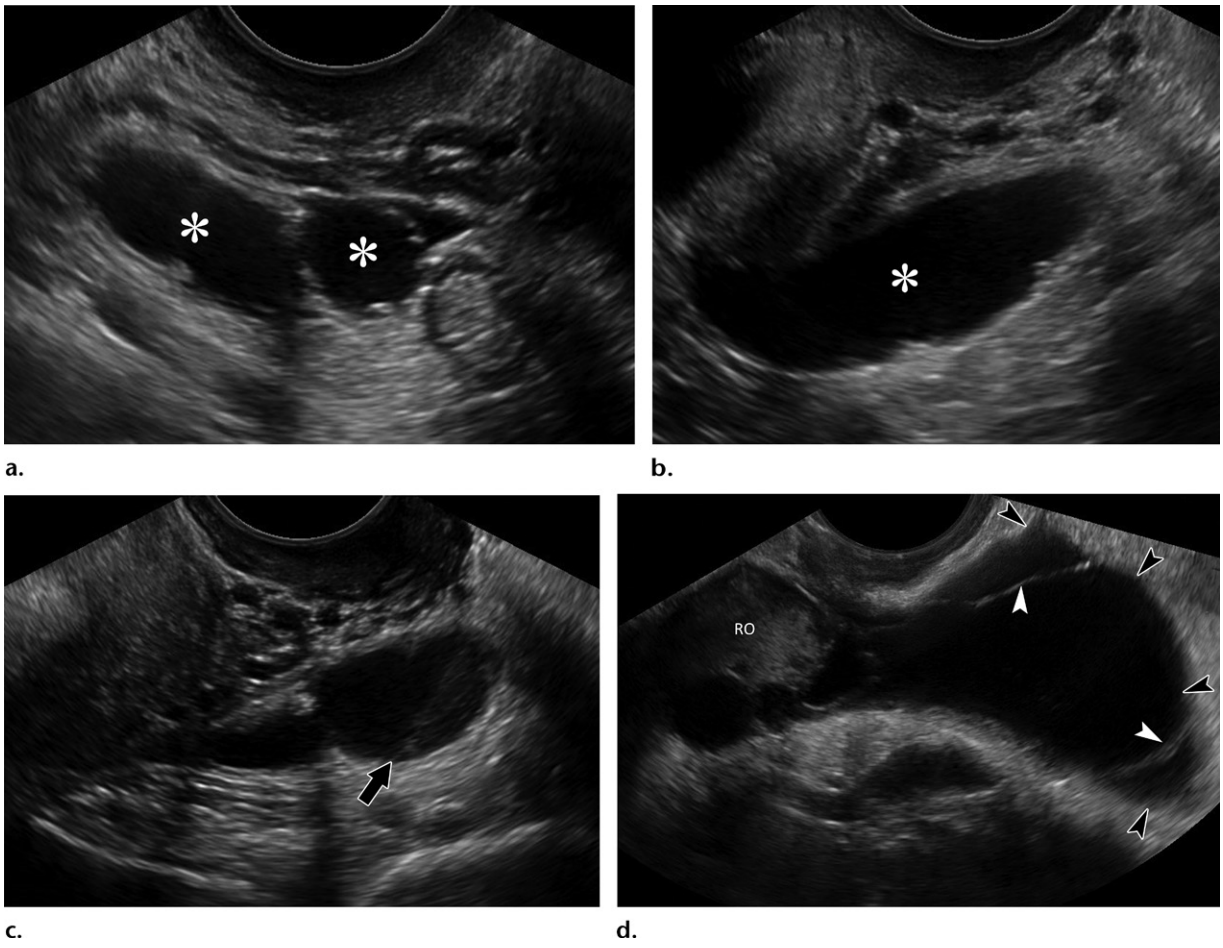


Figure 3. Pelvic adhesive disease in two patients with endometriosis. **(a–c)** Transverse **(a)** and sagittal **(b)** gray-scale TVS images of the right fallopian tube in a 32-year-old woman with severe lower quadrant pain, in whom endometriosis was seen at subsequent laparoscopy, show a right hydrosalpinx (*), with the salpingeal folds demonstrating the cogwheel appearance. Sagittal gray-scale TVS image **(c)** of the left adnexa shows a left hematosalpinx containing an echogenic fluid-fluid level (arrow). **(d)** Transverse gray-scale TVS image of the right adnexa in a 43-year-old woman with right pelvic pain and a history of endometriosis shows a large peritoneal inclusion cyst surrounding the right ovary *(RO)* and conforming to the shape of the peritoneum (black arrowheads). The ovary is located eccentrically within loculated fluid that is trapped between adhesions (white arrowheads).

To improve the detection of bladder endometriosis, the TVS examination should be performed with mild to moderate urine distention of the bladder. Care should be taken to avoid overdistending the bladder, which could decrease visibility of the bladder dome. The ureters should be identified at the ureterovesical junction, and the distal ureteral segment should be examined to as far retrograde as possible. In our experience, imaging the bladder at the end of the examination or having the patient drink water immediately before the examination facilitates greater distention and visibility of the bladder and distal ureters (5).

The posterior compartment extends from the posterior uterine serosa to the presacral space (Fig 5). The probe is placed in the posterior vaginal fornix to view the posterior compartment, with continued observation as the probe is inserted or withdrawn. The posterior compartment is the most common location for DIE and includes three key anatomic locations: the uterosacral ligaments (USLs), bowel, and rectovaginal area. The paired USLs are retrocervical, as they extend from the posterolateral portion of the cervix, encircle the rectum, and insert onto the sacral vertebrae. The USLs divide the upper rectum from the lower rectum.

According to the IDEA Consensus Group (6), the bowel can be divided into four descriptive segments. The lower anterior rectum is below the level of the peritoneal reflection and thus cannot be seen at standard laparoscopy. The upper anterior rectum is above the level of the peritoneal reflection and below the uterine fundus. The rectosigmoid junction is at the level of the uterine fundus. Last, the anterior sigmoid is above the level of the uterine fundus.

Differentiation of the area above and the area below the peritoneal reflection is important preoperatively, since DIE lesions below the reflection may not be easily assessed at laparoscopy and are at a greater surgical risk for associated

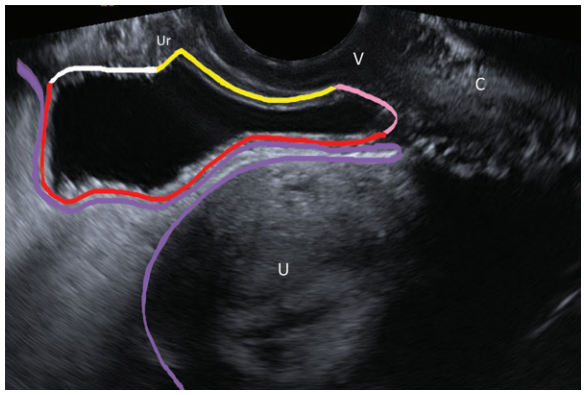
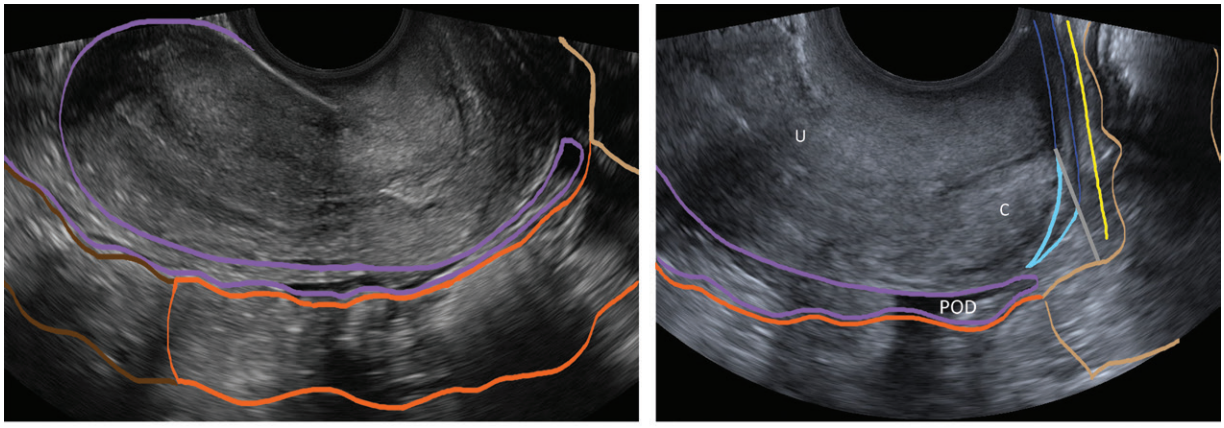


Figure 4. Anatomy of anterior pelvic compartment. Sagittal gray-scale TVS image shows structures that comprise the anterior pelvic compartment: bladder trigone (yellow line), bladder base (pink line), bladder dome (red line), extraperitoneal portion of the bladder (white line), and peritoneal reflection (purple line). *C* = cervix, *U* = uterus, *Ur* = urethra, *V* = vagina.



a. **b.**

Figure 5. Sagittal gray-scale TVS images show the anatomy of the posterior pelvic compartment. **(a)** The bowel includes the lower anterior rectum (tan outline), upper anterior rectum (orange outline), and rectosigmoid (brown outline). The peritoneal reflection also is outlined (in purple). **(b)** The rectovaginal area includes the vagina (dark blue outline), posterior vaginal fornix (cyan blue outline), rectovaginal septum (RVS) (yellow line), and lower anterior rectum (tan outline). The upper anterior rectum (orange outline), peritoneal reflection (purple outline), and axial line along the inferior border of the posterior lip of the cervix *(C)* (gray line) also are noted. *POD* = pouch of Douglas, *U* = uterus.

complications such as the development of rectovaginal fistulas (24). The rectovaginal area is extraperitoneal and contains the vagina, rectovaginal space, and anterior lower rectum. The rectovaginal space is the space between the anterior rectal wall and posterior vaginal wall, below the peritoneal reflection (5). If a small amount of fluid is present in the cul-de-sac, it enables delineation of the peritoneal reflection.

For the classification of DIE nodules, the rectovaginal space can be divided into two spaces by using an axial line along the inferior border of the posterior lip of the cervix. The RVS is the hyperechoic connective tissue within the rectovaginal space between the rectum and vagina and is delineated superiorly by the posterior lip of the cervix, as defined at TVS by the IDEA Consensus Group (6). With use of this sonographic definition, the RVS is considered to be involved when a DIE nodule is located below the posterior lip of the cervix in the rectovaginal space, and the posterior vaginal fornix is considered to be involved when a DIE nodule is located in the rectovaginal space above the posterior lip of the cervix. The posterior vaginal fornix is retrocervical. The posterior vaginal wall and fornix can be difficult to visualize sonographically, and in our experience, they are best seen during the initial insertion of the probe.

DIE Features.—DIE has been reported to be detected in 15%–30% of endometriosis cases (13). Although superficial endometriosis can be asymptomatic, DIE is strongly associated with more substantial symptoms, including severe pelvic pain, and often necessitates surgical treatment for which preoperative localization is essential (2,11,38). DIE typically involves fibromuscular structures; the most common anatomic locations of DIE are the USLs, vagina, bowel, and bladder (2,15,18,38). DIE frequently involves multiple locations, with some locations having a higher likelihood of multifocal disease (18).

Although surgery is the reference standard for diagnosing DIE, surgical findings can lead to an over- or underestimation of the degree of disease,

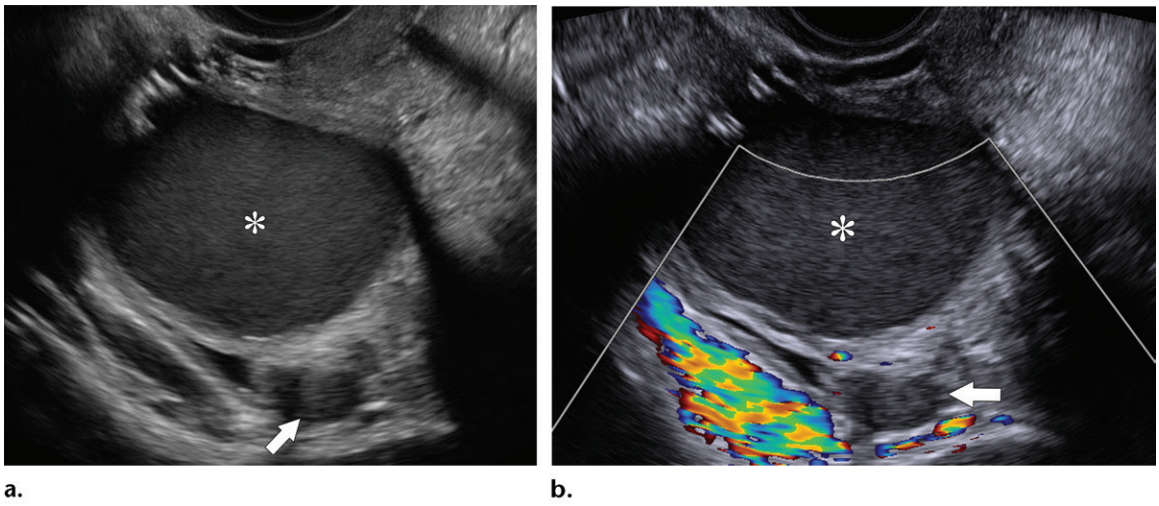


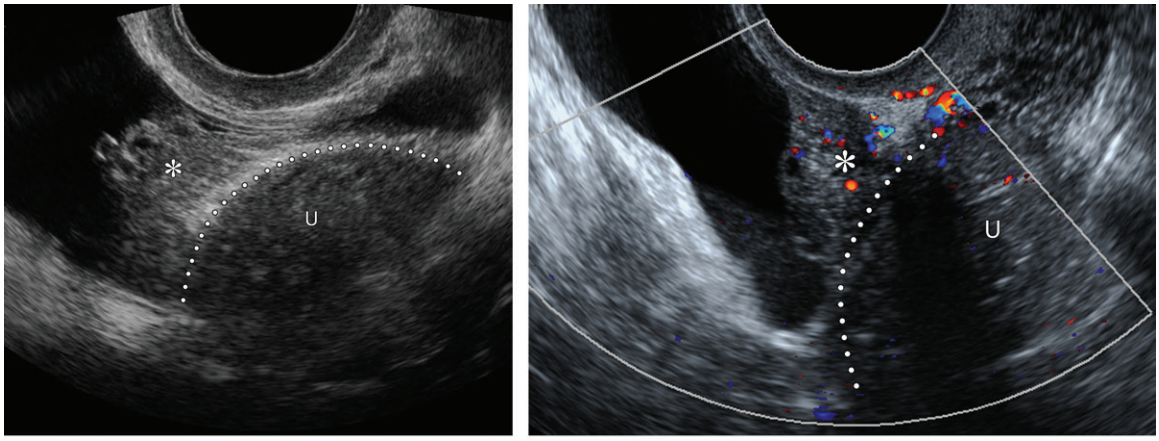
Figure 6. DIE nodule in a 28-year-old woman with irregular and postcoital vaginal bleeding who was confirmed to have extensive endometriosis at laparoscopy. **(a, b)** Transverse gray-scale **(a)** and color Doppler **(b)** TVS images show a well-circumscribed round avascular hypoechoic nodule (arrow) posterior to an ovarian endometrioma (*). **(c)** Sagittal gray-scale TVS image, with schematic depiction of the pelvic anatomy, shows the most common locations of DIE: the bladder (red star), bowel (orange star), vaginal fornix (cyan blue star), RVS (yellow star), and USLs (green star). *C* = cervix, *U* = uterus. The vagina (dark blue outline), upper anterior rectum (orange outline), lower anterior rectum (tan outline), peritoneal reflections (purple outlines), and bladder sections (white, pink, and red outlines) also are seen.

as lesions may be obscured owing to the location (11). In a prospective study by Exacoustos et al (12), preoperative systematic TVS performed by an experienced sonographer, as compared with surgery, was accurate in the detection of DIE, with accuracy ranging from 76% to 97%, depending on the location of the DIE. Results of additional studies (13–15,39) also have shown TVS to have high accuracy.

The US features of DIE are well documented (4,5,11,21). At US, DIE appears as hypoechoic linear or round nodules with smooth or irregular borders and no to minimal internal vascularity at color Doppler US (Fig 6a, 6b). The nodules can have internal cystic spaces caused by hemorrhage or bright internal reflectors. Involvement of the vagina or uterine serosa can be infiltrative rather than nodular (24). The nodules seen at imaging consist mainly of the muscle hyperplasia and fibrosis incited by the ectopic cells (2,5). The number, location, shape, and size of the nodules should be reported, with measurements obtained in three orthogonal planes provided. The degree of pain has been correlated with the depth of the lesion, which can be difficult to assess at laparoscopy (11,28,38). A thorough search includes careful systematic evaluation of the most common locations for DIE in the anterior and posterior compartments, with special attention given to the bladder in the anterior compartment and bowel, the rectovaginal area, and the USLs in the posterior compartment (Fig 6c).

Bladder.—The bladder is the most common location of urinary tract DIE. Of the various locations of urinary tract DIE, 85%–90% are in the bladder, with 9%, 4%, and 2% located in the ureter, kidney, and urethra, respectively (40,41). DIE of the urinary tract is identified in 0.3%–12.0% of women with endometriosis and in at least 14%–20% of women with DIE (40,42). Most patients with bladder DIE are symptomatic; common symptoms are urination frequency and urgency, dysuria, and hematuria (40,42). The severity of disease is greater in patients with urinary tract endometriosis, and urinary tract disease is frequently associated with the presence of additional DIE lesions (40,42).

The dome is the most common location of DIE within the bladder (6,21,41). On TVS images, bladder DIE is visualized as hypoechoic focal nodular thickening of the bladder wall, sometimes with internal cystic spaces (Fig 7). The serosal



a. **b.**

Figure 7. Bladder DIE in a 47-year-old woman with chronic pelvic pain and infertility. Endometriosis was confirmed at cystoscopy. Transverse gray-scale **(a)** and sagittal color Doppler **(b)** TVS images show internal cystic change in an endometriosis nodule (*) that involves the dome of the bladder wall and projects into the lumen. There is mild internal vascularity within the nodule, which is near the uterine fundus (*U,* dotted line).

and muscle layers of the bladder are involved, but the mucosal layer is usually intact (5,21). Serosal involvement without muscle involvement is considered to be superficial disease (6). The detection of bladder DIE is strongly related to the lesion size, with smaller lesions missed at TVS (41). In the systematic review by Guerriero et al (39), the pooled sensitivity of TVS for bladder detection was 62%, and the specificity was 100%.

In contrast to the bladder, DIE involvement of the ureter is often clinically silent and can result in renal obstruction with subsequent renal failure (42). Ureteral involvement is more difficult to assess and requires a greater level of experience. Therefore, all examinations must include survey views of the kidneys to exclude occult hydronephrosis. Ureteral involvement is most often (in 75% of cases) due to extrinsic compression caused by the extension of a pelvic nodule encasing the ureter and involving the adventitia (21). Less often, there is intrinsic infiltration involving the mucosal and muscle layers (6,21). The distal ureter is the most commonly affected segment and should be assessed at TVS (21).

Findings of ureter involvement include a nodule along the course of the ureter, ureteral dilatation, and/or hydronephrosis. Large (>3 cm) RVS nodules are more likely to have ureteric involvement, and similarly, a larger USL nodule correlates with increased ureteral involvement (42,43). When ureteral endometriosis is identified, the distance between the lesion or stricture and the ureteric orifice along the ureteral path should be reported.

Bowel.—Overall, the intestines are involved in 5%–12% of women with endometriosis and in 10% of patients with DIE (18,38,44). The rectum and rectosigmoid junction account for 70%–93% of intestinal lesions and reflect a severe form of disease (11,21,44). Bowel DIE is commonly associated with other pelvic sites of involvement, with only 29% of bowel DIE cases reported to be isolated to the bowel (18). In addition, bowel DIE frequently involves multiple lesions within the bowel, with a second intestinal lesion seen in 55% of rectal DIE cases (5). Multiple sites are described as multifocal when they are in the same segment and as multicentric when they involve different segments (6). Symptoms include diarrhea, constipation, rectal bleeding, and pain with defecation.

Bowel DIE affects patient management substantially, and detection is essential. The endometrial glands and stroma invade, at minimum, the hypoechoic muscularis propria layer of the bowel wall and induce smooth muscle hyperplasia and fibrosis (45). Sonographic features include a thickened hypoechoic muscularis propria and hypoechoic nodules that may or may not contain internal hyperechoic foci. The nodule margins may be blurred. Although cystic changes are seen with bladder DIE, they are uncommon with bowel DIE (24). Typical reported shapes and morphologic features include a smooth round nodule; a nodule with a tapered extension, or "tail," which is called the "comet" sign; and a nodule with spikes and fanlike projections into the bowel—that is, the "Indian headdress" sign, which indicates involvement of the submucosa (Fig 8) (6,24,46).

As lesion depth cannot be assessed at laparoscopy, measurements in three orthogonal planes, including length, thickness, and transverse dimension, as well as a description of the nodule shape, should be reported. The distance from the anal

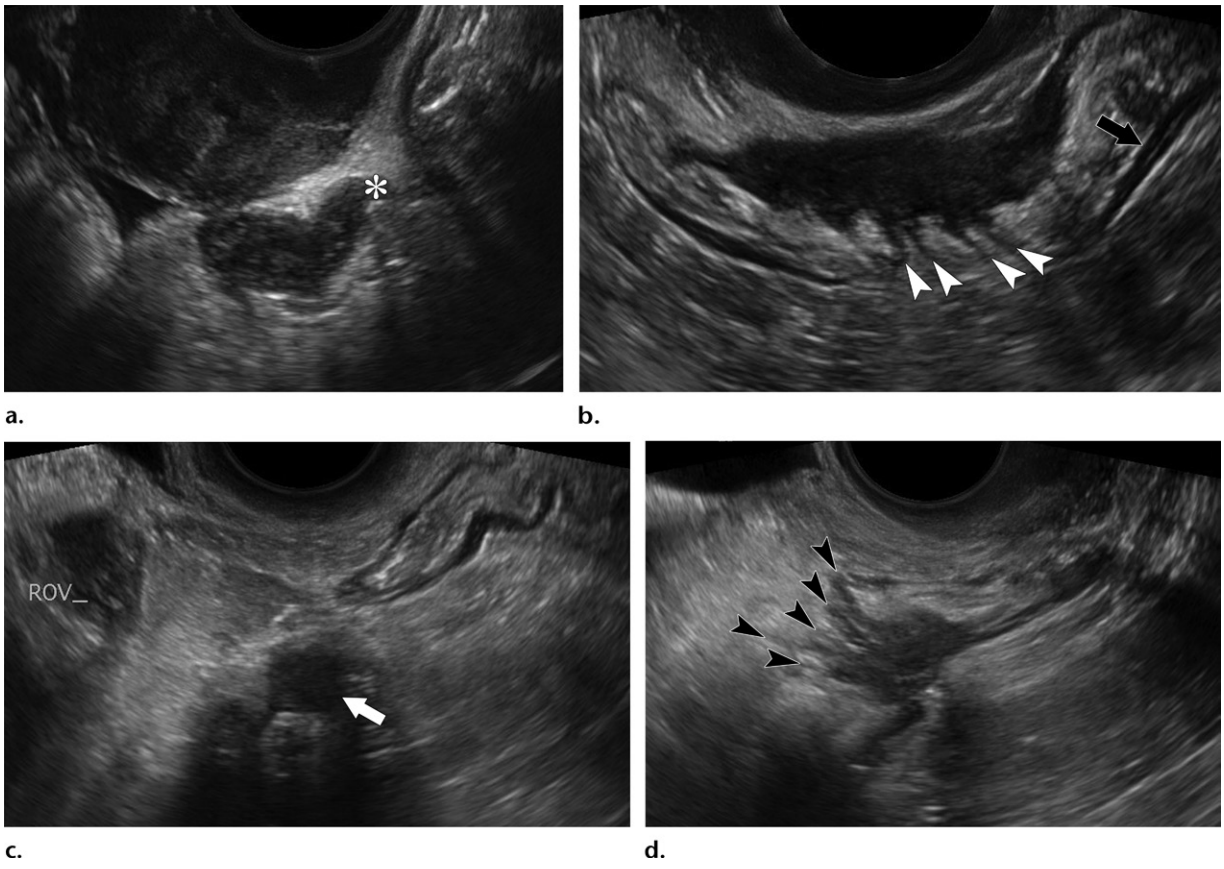


Figure 8. Variable appearances of bowel DIE in three women. **(a)** Sagittal gray-scale TVS image in a 35-year-old woman with irregular bleeding, increasing pelvic pain, and a history of endometriosis shows a hypoechoic nodule with a comet tail (*). **(b)** Sagittal gray-scale TVS image in a 37-year-old woman with worsening severe dysmenorrhea resulting in absence from work, diarrhea, and a vaginal endometriosis nodule seen at physical examination shows an asymmetric irregularly shaped nodule with serrated edges (arrowheads) on the luminal side of the anterior bowel wall, resembling an Indian headdress. The normal hypoechoic muscularis propria layer (arrow) is well seen in the posterior wall. **(c, d)** Transverse **(c)** and sagittal **(d)** gray-scale TVS images in a 46-year-old woman with chronic bilateral lower pelvic pain and cramping, a history of stage IV endometriosis, and multifocal multicentric bowel DIE at TVS show a round hypoechoic nodule (arrow in **c**) and a second hypoechoic nodule with retractions (arrowheads in **d**). *ROV* = right ovary.

verge also should be estimated and reported. In cases of multifocal DIE involvement, the entire length of the bowel segment, as well as the distance between individual nodules, should be measured (6). The bowel can become kinked, retracted, and/or narrowed owing to fibrosis; these findings are known to lead to overmeasurement of thickness and undermeasurement of length (6,47). The interface of folded intestinal loops can result in false-positive findings that decrease in frequency with greater operator knowledge and experience (24,48). Given the associated incidence of multifocal DIE, the detection of one nodule in the bowel should prompt an amplified search for other nodules, particularly after detection of a rectal nodule. The accuracy of TVS in the diagnosis of rectosigmoid bowel involvement is high, with overall pooled sensitivity and specificity values of 91% and 98%, respectively (14).

Rectovaginal Area.—Endometriosis involvement of the rectovaginal area reflects a severe stage of disease and is often associated with disease elsewhere (5,49). Given the extraperitoneal location of rectovaginal endometriosis, a proposed mechanism of development is metaplasia of müllerian duct remnants (2). It is recognized that TVS of this area has yielded lower accuracy and may require greater operator experience (6,15). In addition, the definitions and classifications of DIE in this area vary and overlap in the literature, contributing to the variance in the reported prevalences of DIE and accuracy of TVS (6,15,16).

Symptoms are common and include dysmenorrhea, dyspareunia, and postcoital bleeding. Rectovaginal lesions can be palpable clinically and visualized at speculum examination. However, the depth of extension cannot be assessed by using these methods. A key surgical distinction is that these lesions are below the peritoneal reflection and not visible at laparoscopy (21). The IDEA Consensus Group divides this area into two locations: the RVS and the vaginal fornix (6).

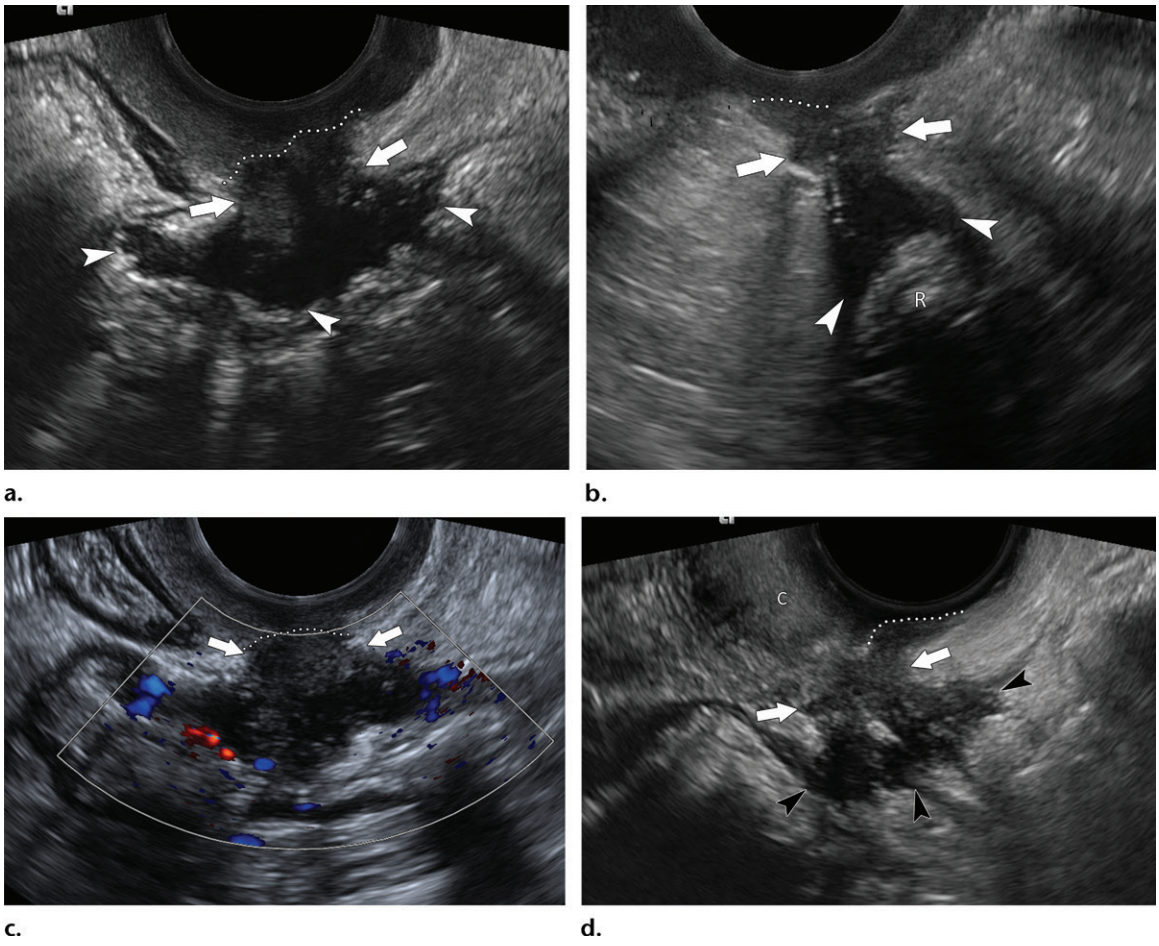
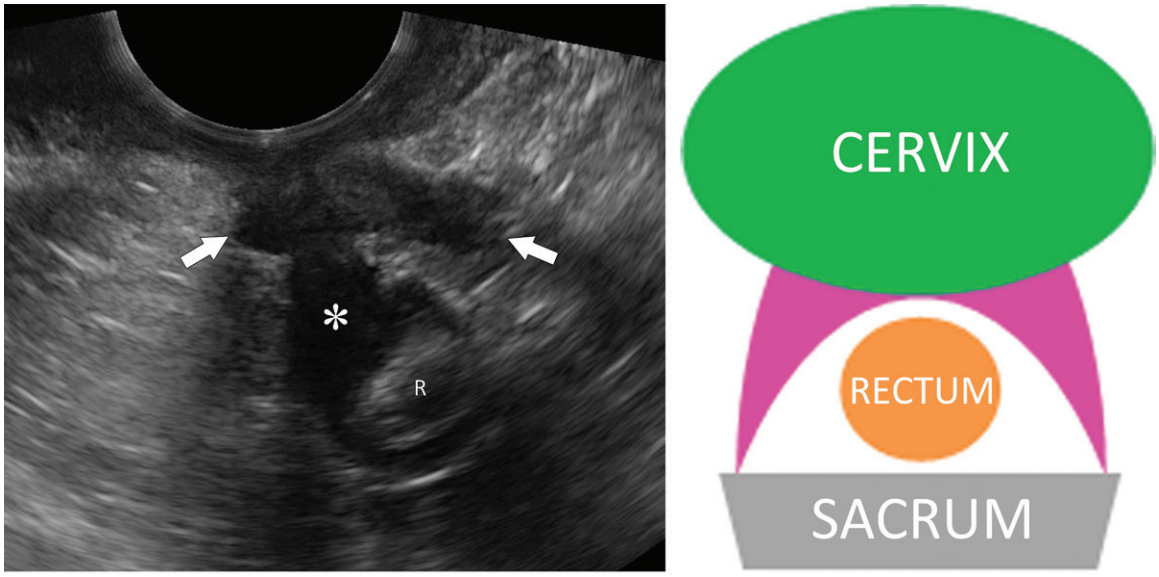


Figure 9. Rectovaginal DIE in two women. **(a–c)** Sagittal **(a)** and transverse **(b)** gray-scale, and color Doppler **(c)** TVS images in a 43-year-old woman with a history of severe endometriosis with nodules and adhesions, who presented with increasing pelvic pressure and dysuria several years after undergoing a hysterectomy and no vaginal lesions at speculum examination, show hypoechoic thickening of the lower anterior rectum *(R)* (arrowheads in **a** and **b**), with extension into the RVS (arrows) and posterior vaginal wall (dotted line). **(d)** Sagittal gray-scale TVS image in a 46-year-old woman with chronic bilateral lower pelvic pain and cramping, a history of stage IV endometriosis, and multifocal multicentric bowel DIE (same patient as in Figure 8c and 8d) shows an additional rectal nodule (arrowheads), with extension to the posterior vaginal fornix (arrows). The patient had focal tenderness in this area during TVS. *C* = cervix.

An RVS DIE nodule is located below the posterior lip of the cervix (6,16,21). The hyperechoic connective tissue in the septum is in contrast to the hypoechoic DIE nodules. Isolated involvement of the RVS is rare. Rather, involvement of the RVS is typically related to the adjacent bowel and/or vaginal disease. Bowel DIE involving the anterior lower rectum can extend anteriorly to involve the RVS, with additional extension to the vaginal wall possible (Fig 9a–9c). Likewise, RVS DIE can involve the posterior vaginal wall with or without posterior extension. The distance from the RVS nodule to the anal verge should be reported.

A nodule involving the vaginal fornix is located below the peritoneal reflection but above the posterior lip of the cervix.The normal vaginal wall is 3–5 mm in thickness (16). Involvement of the vaginal wall or posterior vaginal fornix can be nodular or diffusely thickened, with or without cystic change (6,16). A nodule of the posterior vaginal fornix that extends posteriorly and involves the anterior rectum can have the shape of an hourglass and is referred to as a diabolo-like or hourglass-shaped lesion. These lesions are immediately inferior to the peritoneal reflection and are typically large, with an average size of 3 cm (Fig 9d) (2,6).

Uterosacral Ligaments.—The USLs are the most common location of DIE (18,25,38). Sixty-nine percent of the DIE deposits detected at laparoscopy involve the USLs, and the majority of USL DIE deposits (up to 83%) are isolated (18). The USLs are involved in 28%–45% of women with endometriosis and in 66% of patients with DIE (18,25). Symptoms include dyspareunia in addition to dysmenorrhea, and chronic pelvic pain. A normal USL can be visualized when it is outlined by a small amount of free fluid (24,50). At TVS, a normal



a. b.

Figure 10. USL DIE. **(a)** Transverse gray-scale TVS image in a 43-year-old woman with a history of severe endometriosis with nodules and adhesions, who presented with increasing pelvic pressure and dysuria several years after undergoing a hysterectomy and no vaginal lesions at speculum examination (same patient as in Figure 9a–9c), shows irregular thickening of the USL (arrows), with adjacent rectal DIE (*). *R* = rectum. **(b)** Schematic drawing depicts the relationship of the USLs (pink area) with the pelvic anatomy.

USL is hyperechoic in contrast to the retrocervical hypoechoic nodular or linear thickening that occurs with DIE of the USL (Fig 10).

For best visualization of a thickened USL, the transducer is swept from right to left during imaging in the sagittal plane posterior and inferolateral to the cervix (6). When findings of DIE are detected at the midline, posterior to the cervix, there is presumed involvement of the torus uterinus, which is the junction of the right and left USLs (Fig 11). USL DIE can extend inferiorly to involve the vagina and to other surrounding structures such as the ureters and parametrium (6,21). The reported sensitivity and specificity of TVS for detection of USL DIE have been variable, with overall pooled sensitivity and specificity values of 53% and 93%, respectively, in the systematic review by Guerierro et al (39). Pooled sensitivity and specificity values of 71% and 93%, respectively, were reported in the Alborzi et al study (13). However, in a recent study (50) with experienced TVS operators, a sensitivity of 95%, specificity of 91%, and accuracy of 94% were reported.

Component 3: Assessment of the Sliding Sign

TVS enables dynamic real-time assessment of POD obliteration. Obliteration of the posterior cul-de-sac refers to the condition in which the rectosigmoid junction or anterior rectum is adherent to the cervix, and it may be accompanied by USL fusion (51). The detection of this severe form of endometriosis is important and critical for appropriate surgical planning.

POD obliteration can be predicted by performing a sliding sign assessment (6,52). Adding sliding sign assessment to TVS also increases accuracy in the detection of rectosigmoid and rectal DIE (44). POD obliteration is associated with a threefold increased risk of bowel involvement and can obscure DIE lesions at laparoscopy (51). The sliding sign maneuver is a dynamic real-time assessment of the POD for obliteration; it is performed by evaluating the motion of the uterus in relation to the bowel.

The sliding sign maneuver is performed in the sagittal plane with real-time assessment and cine clip recording. The sliding sign of the posterior compartment is used to evaluate the POD and consists of two parts. First, the operator gently presses against the cervix with the probe as the movement of the anterior rectum relative to the cervix and vagina is assessed. In the second part, the operator gently presses against the abdominal wall over the fundus of the uterus with his or her free hand while the probe is against the cervix as the movement of the bowel relative to the posterior uterine fundus is assessed. Preservation of the expected normal sliding of the structures relative to each other is considered a positive sliding sign.

A negative sliding sign is the abnormal absence of sliding of the two interfaces. The negative sign has been shown to be highly accurate (in 93%–97% of cases) in the prediction of

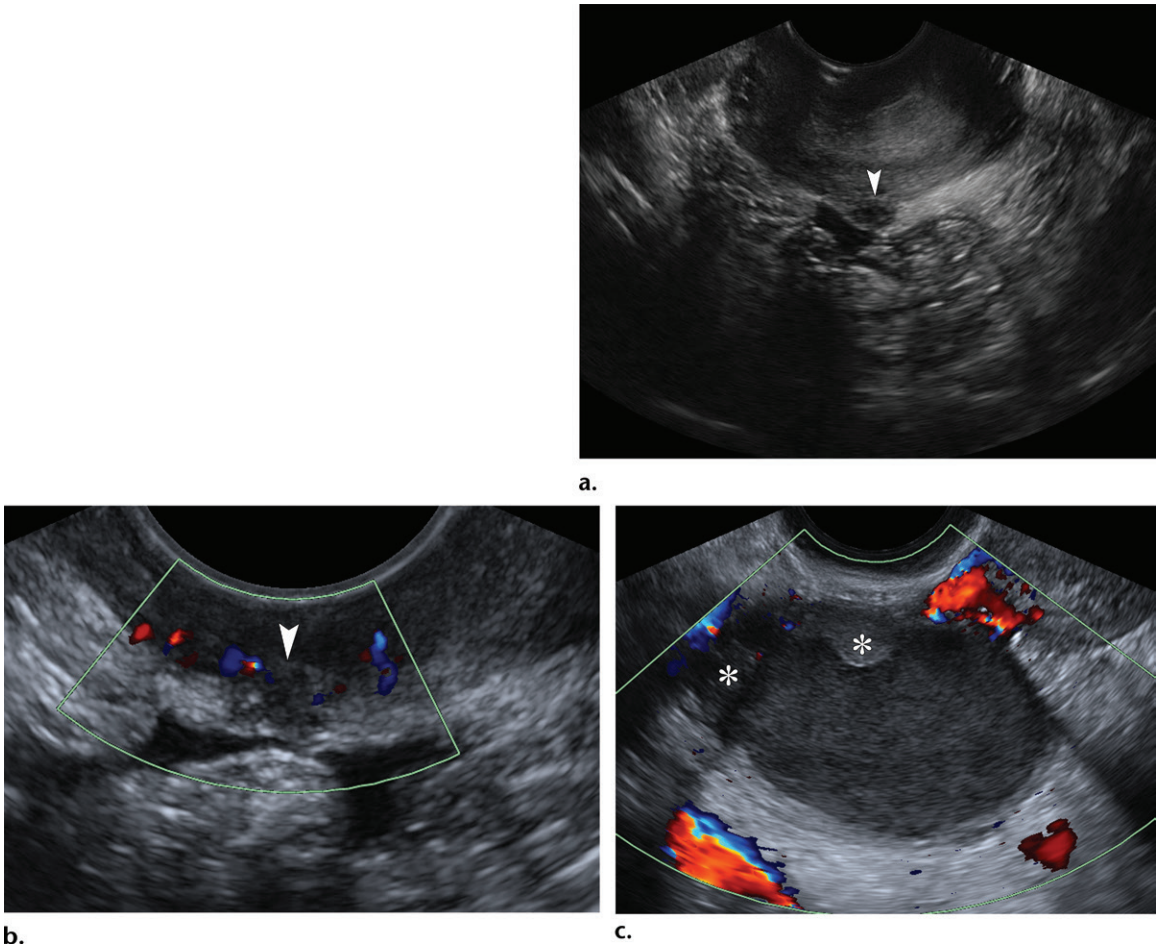


Figure 11. USL DIE in a 28-year-old woman with worsening pelvic pain, an endometrioma discovered at US, and a palpable retrocervical nodule at digital rectal examination. **(a, b)** Transverse gray-scale **(a)** and magnified color Doppler **(b)** TVS images show a round hypoechoic minimally vascular nodule at the torus uterinus (arrowhead), which is the junction of the right and left USLs. **(c)** Color Doppler US image of the right ovary shows an atypical endometrioma containing avascular echogenic mural nodules (*). An endometrioma and stage IV endometriosis were confirmed at laparoscopy.

POD obliteration, with a sensitivity of 83%–89% and a specificity of 92%–97% (12,52–54). A negative sliding sign reflects the presence of nonspecific pelvic adhesions, which prevent the uterus from moving separately from adjacent structures in the pelvis such as the rectosigmoid colon.

It is important to note that although a negative sliding sign is associated with increased bowel involvement, it is not specific for bowel DIE. The sliding sign can be negative in the absence of rectal DIE and positive in cases with rectal DIE (11,44). The sliding sign assessment is essentially a test for adhesions, which can be caused by superficial endometriosis, inflammation, or prior pelvic surgery. However, the most common cause of POD obliteration is rectal and rectosigmoid DIE (44). A negative sliding sign is predictive of rectal DIE, with a reported accuracy of 93%, and it should prompt an amplified search for bowel DIE in the posterior compartment (53).

In summary, a positive sliding sign occurs when the posterior wall of the cervix slides relative to the anterior wall of the rectum (Movie 1) and the uterine fundus slides relative to the bowel (Movie 2). A positive sign reflects a nonobliterated POD with high confidence, with the sliding sign having a high (93%) negative predictive value (52). The lack of sliding is considered a negative sliding sign (Movie 3) and is predictive of POD obliteration. The POD is considered to be obliterated sonographically when one or both of the two parts yield a negative sliding sign.

Pelvic adhesions can also cause a fixed retroverted uterus. In a retroverted uterus, the sliding sign is assessed differently, by applying probe pressure on the posterior uterine fundus to determine whether the anterior rectum slides relative to the retroflexed posterior uterine fundus and by applying transabdominal pressure on the uterus to see if the sigmoid moves freely relative to the anterior uterus (6).

A similarly performed assessment of the anterior compartment, with use of a gentle push with the probe, is used to evaluate for sliding of the posterior bladder relative to the anterior uterus. Although uterovesical obliteration is associated with anterior compartment endometriosis, it is nonspecific, as it has been reported in more than 30% of patients who have undergone a cesarean section (55). Nonetheless, this assessment remains important for presurgical evaluation, as most bladder nodules obliterate the vesicouterine space (41).

Component 4: Detection of US Soft Markers

Sonographic soft markers are subjective findings detected at US that indicate the presence of pelvic disease. These markers include site-specific tenderness and decreased ovarian and/or uterine mobility (8). Superficial endometriosis and adhesions are more likely to be present when sonographic soft markers are detected (6,8). In contrast to other imaging modalities, US offers the added benefit of enabling real-time scanning, during which the operator can obtain additional subjective information from the patient history, presence and location of pain during the examination, and performance of provocative maneuvers during the examination. Okaro et al (8) introduced the concept of subjective sonographic soft markers in a study that evaluated the presence of pelvic disease in women with chronic pelvic pain, approximately half of whom had endometriosis.

In contrast, TVS hard markers are objective findings of pelvic disease seen at static gray-scale US. These hard markers include findings of endometrioma, hydrosalpinx, hematosalpinx, and/or DIE nodules. Historically, standard pelvic US results have been considered negative if hard markers were absent. The addition of sonographic soft markers to the standard pelvic US examination increases the diagnostic value of TVS for pelvic disease, including endometriosis. In the Okaro et al study (8), 96 (80%) of 120 women with chronic pelvic pain were considered to have normal (ie, negative-result) examinations when only the absence of hard markers was considered. However, 51 (53%) of these 96 patients were considered to have abnormal (ie, positive-result) examinations when the presence of soft markers was included. The majority of these women, 73% (37 of 51) of those with soft markers only, were confirmed to have pelvic disease at laparoscopy.

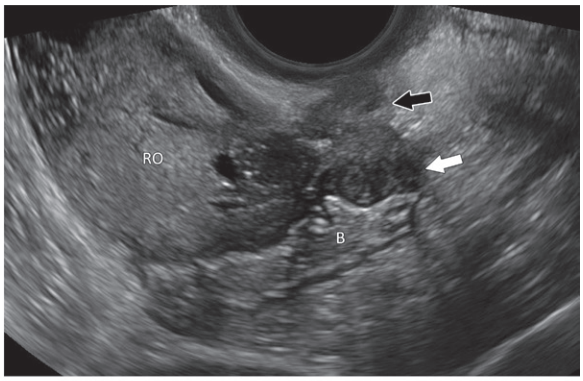
Site-specific tenderness is a sonographic soft marker. Patients are asked to report the sites of any pain during the examination. Focal areas of pain are associated with the presence of endometriosis (8,56). The degree of pain can be assessed with a verbal score of 1–10. In addition to noting the presence and location of site-specific tenderness, the sonographer should perform a dedicated evaluation of these sites, referred to as tenderness-guided US, which might lead to the detection of subtle endometriosis deposits or abnormalities that would not be appreciated otherwise (46). Guerriero et al (57) introduced the concept of tenderness-guided US and reported an increase in sensitivity and specificity for the detection of endometriosis in the rectovaginal area. However, in their study, they also created a "stand-off" between the probe and tissues by placing extra gel on the probe cover (11,57,58).

Another sonographic soft marker is ovarian mobility, whereby the ovary is deemed to be freely mobile, have reduced mobility, or have fixed mobility. Fixation implies that adhesions are present. Mobility is assessed by applying pressure on an internal tissue of interest with the probe or with the sonographer's free hand on the abdominal wall. Pressure is applied between the ovary and uterus to determine whether the ovary is fixed to the uterus or the pelvic sidewall. Similar to the process of performing a sliding sign assessment for POD obliteration, to establish whether the ovary is fixed to other structures as well, pressure is applied directly to the ovary (Fig 12, Movie 4).

Lack of ovarian mobility is associated with pelvic adhesive disease, even if the adhesions themselves are not visible sonographically (33). When visible, the adhesions may be seen as thin strands within physiologic pelvic fluid, or they may manifest as loculated fluid. They are considered a third soft marker by Okaro et al (8). The location of the ovaries should be documented, particularly if they are adherent to the sidewall, uterus, or each other. With severe adhesive disease, the ovaries can become fixed to each other within the cul-de-sac. In this case, they are referred to as "kissing" ovaries (Fig 13), which are associated with an increased incidence of bowel and fallopian tube endometriosis (6).

Limitations of TVS

Successful application of the described TVS protocol requires knowledgeable and experienced operators who, in turn, require education, training, and time. The threshold number of TVS examinations that should be performed to reach scanning proficiency in detecting bowel DIE and performing the sliding sign has been shown to be 40, at minimum, within a cohort of experienced sonographers (7,48). Operators who are more experienced in gynecologic TVS have outperformed less experienced operators in interpreting videos of the sliding sign (59). In the studies involving these comparisons, interpretation of the sliding sign at



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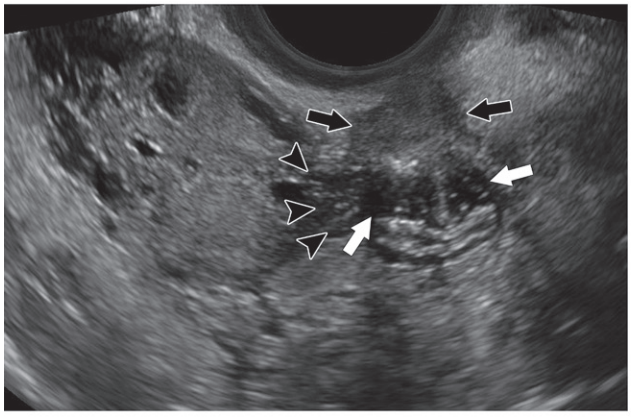

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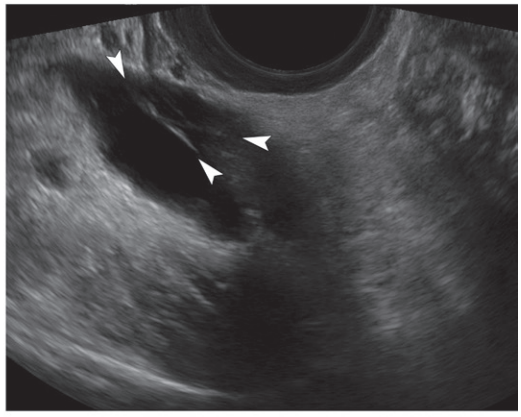

c.

Figure 12. TVS soft markers for endometriosis in a 37-year-old woman with a history of severe stage IV endometriosis, dyspareunia, and increasing chronic right lower quadrant pain. **(a, b)** Transverse gray-scale TVS images obtained at a site of focal tenderness show a hypoechoic bowel DIE nodule (white arrows) that contains several tiny internal hyperechoic foci. The nodule is adjacent to the right ovary *(RO),* with extension along and thickening of the USL (black arrows). The thin strands reflect adhesions and endometriotic changes between the ovary and involved bowel *(B)* (arrowheads in **b**). The ovary could not be separated from the bowel at compression and was better appreciated at cine clip imaging (Movie 4). **(c)** Sagittal gray-scale TVS image of the right adnexa shows pelvic adhesions (arrowheads) within loculated fluid, adjacent to the ovary.

the uterine fundus proved to be more difficult, and it may require more training. In our clinical practice, having a second person available to help perform this maneuver has been beneficial. The downward pressure on the uterine fundus is easier and possibly more effective and reliable when it is applied by a person who has both hands free.

Operator experience also decreases false-positive findings, as mimics of disease, such as pseudothickening of the bowel wall by folds, can be more readily recognized (48). Given the detailed advanced techniques in the protocol, the additional time required to perform the examination is a consideration. In our experience, after initial training, a scheduled examination time of 45 minutes is appropriate for an operator.

Even with experienced sonographers, technical limitations exist. Patient factors such as prior surgeries, body habitus, vaginismus, low pain threshold, and chronic pain may affect the quality and feasibility of the examination. The performance of dynamic maneuvers may be limited in patients who cannot tolerate full inser-

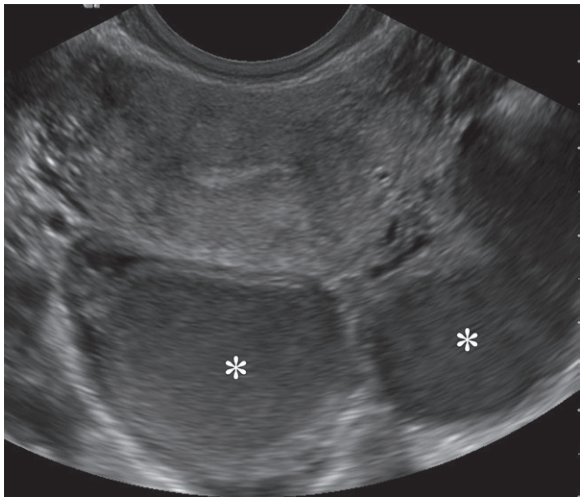

Figure 13. Kissing ovaries in a 25-year-old woman with pelvic pain and a history of endometriosis, who was found to have bilateral endometriomas (*). Transverse gray-scale TVS image of the pelvic cul-de-sac shows adherent ovaries secondary to pelvic adhesive disease. The ovaries were inseparable during compression maneuvers.

tion of the transvaginal probe, probe movement, or probe pressure. Severely distorted anatomy due to adhesions, positioning of the uterus, or disease such as large leiomyomas may affect visualization at TVS. In addition, because there is a limited field of view with TVS, this modality cannot be used to assess for remote sites of involvement and rarer atypical sites of abdominal, high pelvic, pelvic floor, diaphragm, or chest involvement (60).

Adding components to the TVS protocol would facilitate improved imaging and/or imaging of other sites. Bowel preparation before the examination has been shown to enable better assessment of intestinal layer involvement and improved visualization of the lesions, given the lack of artifact from gas and bowel contents (24). Transabdominal US of the appendix, terminal ileum, and cecum also could be attempted after bowel preparation (24,60). Transabdominal imaging of the abdominal wall is useful for detecting suspected deposits, most commonly at the site of scarring from a prior cesarean section (60). It also enables the evaluation of rare inguinal endometriosis when it is suspected clinically (60).

Occasionally, the appendix can be visualized in the pelvis on TVS images, and it should be assessed if it is visible. Performing sonovaginography, with the insertion of gel into the vaginal fornix, can improve visualization of the vaginal area (61). These and other additional maneuvers add complexity to the examination; this factor needs to be weighed against the added benefit. The adding of components can be considered on a case-by-case basis, depending on the clinical factors and initial TVS findings.

The accuracy of TVS for the detection of endometriosis in the pelvis is location dependent (12,13). Although high accuracy for the detection of bowel DIE has been demonstrated, the pooled accuracy for the detection of non-bowel DIE has been only fair in systematic reviews (9,14,39). Although bowel DIE may be inherently more reliably detected, some of this variance reflects the use of nonstandardized definitions and lesion classifications, while some of the variance reflects differences in operator experience and technique.

Location-based variance has also been demonstrated in studies in which the accuracy of MRI was assessed (13). The variable detection between sites and modalities suggests that one modality may be more beneficial in certain locations. One setting in which MRI is potentially more beneficial is in the assessment of ureteral involvement. The ureteral segment most commonly involved is the distal ureter 3–4 cm above the ureterovesical junction, a location that may not be easily visualized at US but would be more consistently visualized with MRI (3,62). MRI also enables evaluation for multiple ureteric lesions (5). The use of MRI is indicated in cases of suspected ureteric involvement, such as those in which a large USL or RVS DIE lesion is detected at initial TVS or hydronephrosis is present (42,43). Similarly, since 28% of patients with rectal and/or sigmoid DIE have associated ileocecal disease, evaluation of the ileocecal region with MR enterography or US following bowel preparation could be considered when rectal DIE is detected at TVS (10,24,60).

In general, when assessing the accuracy of TVS in the detection of DIE and in comparison with the accuracy of MRI, results are highly variable. An adequate comparison is difficult owing to variability in the techniques used, patient populations, lesion definitions, lesion size, and operator experience (13). MRI has its own set of limitations, contributing to false-negative and false-positive examinations (5). Also, it is more expensive to perform and less readily available, and like TVS, it requires a specific protocol and is experience dependent.

Overall, the accuracy of TVS in the detection of DIE is similar to that of MRI (11,13). However, TVS has additional diagnostic and clinical value owing to its capability for dynamic imaging. Therefore, TVS is the first-line imaging modality for patients suspected of having endometriosis, with additional imaging performed on the basis of the clinical and TVS findings (5,9–11). MRI has a second-line examination role and is of particular benefit to patients suspected of having urinary, high pelvic, diaphragmatic, or pelvic nerve involvement; extensive pelvic adhesions; atypical endometriomas; or other conditions that limit or physically prohibit transvaginal interrogation.

Clinical Benefits

The site-specific diagnosis and disease localization achieved with the described dedicated TVS examination yield key information that is necessary for patient counseling, appropriate disease management, triage, and thus improved patient care. Endometriosis can be managed with surgical and/or medical treatment, and currently, there is an increasing trend toward the use of medication for hormone control to avoid or delay surgery (6). Navigating these treatment options requires precise attention to the clinical history and the clinical and imaging findings.

In patients in whom surgery is indicated, the goal is complete resection. Dedicated TVS is beneficial for preoperative planning, including determining the surgical approach, complexity of the surgery, and need for subspecialists (2,5,12). The results of a recent study by Tompsett et al (63) showed that with the use of a

US-based staging system, US findings correlate with disease stage and can be used to predict the complexity of laparoscopic surgery. In turn, as recommended by the World Endometriosis Society, patients with higher disease stage can be triaged to centers of expertise to facilitate complete resection of disease with decreased complications, operating room time, and need for repeat surgeries (6,64). The preoperative mapping of disease location with use of static and dynamic TVS, and knowledge of the location and degree of pain are valuable for directing the surgeon to areas that may have been missed otherwise.

In addition to providing guidance in surgical treatment, sonographic soft markers potentially add value in the triaging of patients for laparoscopic diagnosis and medical management. Although laparoscopy is the reference standard for diagnosis, it has risks and is operator dependent. Also, minimal disease or atypical lesions can be hard to diagnosis at laparoscopy, and inadequate sampling can lead to negative histologic results and, in turn, a missed or delayed diagnosis (8,11,12,65). Moreover, among patients with chronic pelvic pain, the cause cannot be determined in 40% of them who undergo laparoscopy (8).

Including an evaluation for soft markers in the TVS protocol potentially decreases the need for diagnostic laparoscopy (8,11,38). Patients can be assigned to low- and high-level categories of suspicion according to the compilation of findings. In the Okaro et al study (8), the patients whose scans were false negative for soft markers had endometriosis, but most of these cases were those of low-level disease that could be treated with medication. A false-negative scan is one that depicts no soft markers when disease is detected at laparoscopy. As such, the data suggest that the disease in patients who have negative TVS findings without hard or soft markers can be managed without surgery (8). Similarly, a negative sliding sign, indicating POD obliteration, can aid in triaging patients to the high-level suspicion category (53). Future research is needed to assess and validate the patient care outcomes that result from use of this standardized TVS protocol for endometriosis in terms of counseling, triage, surgical planning, and tailored management of endometriosis (9).

Conclusion

TVS of the pelvis is the primary imaging modality for evaluation of patients suspected of having endometriosis. However, use of a dedicated protocol is necessary. TVS enables accurate assessment of the location, extent, and severity of pelvic endometriosis. This assessment is essential for guiding medical and surgical management–related decisions. The unique dynamic and real-time features of TVS enable acquisition of information that is not easily addressed with other imaging modalities and improve the value of this examination for diagnosis and management guidance.

The standardized TVS protocol developed by the IDEA Consensus Group includes four components designed to guide detection of the various manifestations of endometriosis. However, increased accuracy requires experienced operators who are well versed in how to look, where to look, and what to look for. This ability requires increased awareness and education regarding these advanced US techniques. On the basis of our experience, using the described TVS protocol after acquiring dedicated education and training can lead to increased detection of endometriosis. With the implementation of a standardized systematic search, imagers will be equipped to look beyond the endometrioma and detect the various manifestations of endometriosis in these patients and, in turn, provide enhanced information for optimized patient care.

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