**Clinical Opinion**

**Gynecology**

**Consider ultrasound first for imaging the female pelvis**

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Ultrasound technology has evolved dramatically in recent years and now includes applications such as 3-dimensional volume imaging, real-time evaluation of pelvic organs (simultaneous with the physical examination), and Doppler blood flow mapping without the need for contrast, which makes ultrasound imaging unique for imaging the female pelvis. Among the many cross-sectional imaging techniques, we should use the most informative, less invasive, and less expensive modality to avoid radiation when possible. Hence, ultrasound imaging should be the first imaging modality used in women with pelvic symptoms.

**Key words:** female pelvis, tenderness guided imaging, 3D ultrasound imaging

Evidence shows that ultrasound imaging is at least equally, if not more, effective for the target anatomic area.¹ This tenet applies particularly to obstetric and gynecologic patients for whom a skillfully performed and well-interpreted ultrasound image usually obviates the need to proceed to additional more costly and complex cross-sectional imaging techniques.¹⁻³

Yet still today, many women with pelvic pain, masses, or flank pain first undergo computed tomography (CT) scans and those with Müllerian duct anomalies typically have magnetic resonance images (MRIs).¹⁻⁵ Not uncommonly, CT or MRI of the pelvis often yield indeterminate and confusing findings that then require clarification by ultrasound imaging. The use of CT scans has tripled since 1993, and CT scans done in 2007 could result in as many as 29,000 future cancers in the United States, with the largest contribution to this risk arising from the CT of the pelvis and abdomen.⁶⁻⁷ For example, patients with suspected kidney stones frequently have a CT scan first, despite the associated radiation burden. A recent study compared initial evaluation of patients with nephrolithiasis by ultrasound imaging or by CT.⁴ This analysis showed no significant differences in subsequent complications, pain scores, return emergency visits, or hospitalizations. In addition, most of the patients who were evaluated first by ultrasound imaging ultimately did not need a CT scan, sparing radiation exposure.

This clinical opinion presents the current capabilities of ultrasound imaging as the first-line imaging technique for the nonpregnant female pelvis for most clinical scenarios. Ultrasound imaging has evolved very rapidly from the early days of “black dots on a white screen” to the current very sophisticated and high-resolution displays that use both 2-dimensional (2D) and 3-dimensional (3D) technology and blood flow mapping. The advent of the high-resolution endocavitary probes and the use of color Doppler imaging for blood flow mapping have further enhanced the diagnostic capabilities of this imaging modality. Several key technical advances have rendered ultrasound imaging an effective first-line (and often only) imaging modality for most gynecologic patients: (1) volume (3D/4-dimensional) imaging, (2) real-time transvaginal ultrasound imaging with sonographically enhanced physical examination,
and (3) Doppler techniques for blood flow evaluation.

**3D ultrasound imaging**

Currently available 3D/4-dimensional volume ultrasound imaging can produce images of the female pelvis of comparable quality and orientation to those of MRI and CT but without radiation and at relatively lower cost.  

Years ago, ultrasound examinations required filling a woman’s bladder and obtaining a series of 2D images one at a time, which rendered this approach very operator-dependent and limited to certain views that did not require reconstruction. Today, 3D volume ultrasound imaging allows the automated acquisition of an entire volume that, in turn, can generate hundreds of images and be used to reconstruct any view in any orientation. Furthermore, 3D ultrasound imaging is less expensive and less time-consuming than MRI. Bowel peristalsis does not affect ultrasound imaging as it does MRI, and many patients find this modality more comfortable than MRI. In contrast to MRI, patients with metal prostheses and pacemakers can undergo 3D ultrasound imaging that will yield similar images. Since the advent of volume imaging in ultrasound imaging, reconstructed views of the pelvis (such as the coronal view of the uterus) have greatly improved our ability to use ultrasound imaging to answer the vast majority of clinical questions in gynecology.

Three-dimensional volume sonography has now become an essential new tool in the ultrasound armamentarium that has proved just as effective as MRI for the demonstration of Mullerian duct anomalies, which include cervical duplications (Figure 1).  

Three-dimensional ultrasound imaging, like MRI, can produce an image of the uterine contour and the entire endometrial cavity simultaneously. Furthermore, 3D ultrasound imaging provides the ability to manipulate the volumes in any orientation for complete evaluation of the uterus, regardless of its orientation or rotation. Multiple studies have compared 3D ultrasound imaging with other imaging modalities and with operative findings, hence establishing the equivalency of 3D ultrasound imaging to MRI in diagnostic accuracy of Mullerian anomalies.  

Indeed, the accuracy of both 3D ultrasound imaging and MRI for the diagnosis of the specific type and extent of planning.

**FIGURE 1**

**Complete septate uterus using 3D volume imaging**

A, Three-dimensional ultrasound image shows the reconstructed coronal view of a septate uterus. Note the complete separation of the endometrial echo but with an intact flat serosal surface. B, Three-dimensional reconstructed view of the double cervix in the same patient. C, Three-dimensional ultrasound image shows the 3 orthogonal planes and the reconstructed view of the cervix. These images show how the different planes are accessed within the volume.

uterine malformations typically exceeds 90-95%.

Three-dimensional ultrasound imaging has emerged as the ideal imaging modality not only when examining patients with infertility but also for examining patients with pelvic pain associated with embedded intrauterine devices, fibroid tumors, adenomyosis, adnexal masses, torsion, endometriosis (Figures 2-5). Ultrasound volume imaging makes it possible to localize fibroid tumors, polyps, and hydrosalpinges with high precision, as well as other uterine abnormalities (Figures 3-6). We must educate the medical community to consider adopting 3D ultrasound imaging as the first assessment tool for specific gynecologic indications, such as the evaluation of the uterus for Mullerian anomalies or localization of intrauterine devices or other intracavitary lesions. In this setting, it is likely that fewer women would require a costly workup that involves multiple advanced imaging studies if 3D ultrasound images were performed first.

The real-time transvaginal ultrasound imaging

The advent of the transvaginal transducer is one of the most important innovations in pelvic imaging in recent decades. This advance allows the operator to place a high-frequency endocavitary ultrasound transducer in close proximity to target pelvic organs, thus improving image resolution and obviating the need for patients to have a full bladder before ultrasound examinations. Ultrasound imaging has the added advantage of real-time imaging, which allows for the probing of pelvic organs to elicit patient’s symptoms and thus correlate symptoms with specific pelvic anatomic locations. The practitioner therefore can gain crucial information about the degree and area of pain and mobility of organs in the pelvis and correlate the ultrasound findings with the physical examination. The ability to examine and image the patient at the same time offers considerable and too often neglected value, which is unique to ultrasound imaging as a cross-sectional imaging technique. Tenderness-guided ultrasound imaging has become the most effective way of the detection of implants of painful deep-penetrating endometriosis throughout the pelvis. Ultrasound imaging has proved to be accurate for the evaluation of deep infiltrating endometriosis and for patients with pain because of extensive pelvic adhesions (Figure 7). Not only can we identify abnormalities on the images, but also simultaneous gentle pushing can show whether organs slide
past each other, thus providing crucial information about the origin of a mass (adnexal mass vs broad ligament fibroid tumor) and the connections and adhesions between the organs. Real-time ultrasound imaging also permits the performance of sonohysterography, a procedure that involves placement of a small catheter through the cervix into the uterus and the injection of a small amount of saline solution. By distending the endometrial cavity, the clinician can evaluate the endometrium for polyps, submucosal fibroid tumors, synechiae, and uterine shape when necessary. Adjunctive to sonohysterography, the installation of microbubbles is useful for the determination of tubal patency and is critical to those patients with contrast allergies.

**3D Doppler interrogation**

To characterize pelvic masses, ultrasound imaging offers the advantage of combining morphologic and vascular imaging. The addition of Doppler gives invaluable information about the location and degree of blood flow in and around pelvic lesions without the need to inject contrast. Not only is the characteristic grey-scale image of pelvic abnormalities key in making a diagnosis, but also 3D Doppler ultrasound imaging can evaluate the mapping and density of blood flow and even provide a quantitative measure of the amount of blood flow in a lesion. Cancers characteristically have abundant and disorganized blood flow patterns, whereas benign lesions have limited blood flow, and cysts lack blood flow altogether (Figures 8 and 9). Color Doppler mapping often furnishes the

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**FIGURE 4**

*Adenomyosis demonstrated by 2D and 3D ultrasound imaging*

A, Two-dimensional longitudinal view of the uterus with extensive adenomyosis. Note the heterogeneity of the anterior myometrium and the irregular cystic areas that are consistent with dilated glands. A distinct endometrial echo is not seen. B, The 3-dimensional coronal view shows more clearly the very irregular and cystic junctional zone between the endometrium and myometrium, which is typical of severe adenomyosis.

**FIGURE 5**

*Coronal view of the uterus containing a fibroid and polyp*

Three-dimensional reconstructed coronal view of uterus shows a small polyp within the uterine cavity and a partially submucosal fibroid tumor at the fundus of the uterus (both shown by calipers). 1, 2, 3, and 4 are the normal caliper measurement numbers inserted by machine.

**FIGURE 6**

*2D and 3D inverse view of a hydrosalpinx*

A, Two-dimensional oblique view of a multiseptate adnexal fluid collection, suspected of being a hydrosalpinx. Numbers 1 and 2 are normal caliper measurement numbers inserted by machine. B, Three-dimensional inverse mode view of the same adnexal fluid collection definitively demonstrates a hydrosalpinx. With the use of the inverse mode, the cystic areas all become solid, and the solid areas disappear from the image; hence, a cast of the hydrosalpinx can be viewed even as it traverses multiple planes.
key to the evaluation of an adnexal mass and differentiates an endometrioma from an ovarian tumor or an ovarian fibroma. For example, the unique Doppler pattern of a hemorrhagic corpus luteum permits this definitive diagnosis as a cause of acute pelvic pain (Figure 9).

Comment

Unfortunately, not every ultrasound imaging practitioner has achieved comfort with high-resolution 3D ultrasound imaging, tenderness-guided transvaginal imaging, and pelvic Doppler imaging. It is unfortunate that ultrasound users have such a wide range of experience, such that not everyone uses the modality to its full potential. Inexperience should not justify ordering an MRI or CT scan. Ultrasound technology has advanced very quickly, and many practitioners still provide basic 2D ultrasound imaging without implementing the newer modalities that ultrasound imaging offers, which emphasizes the need for education and dissemination of this information. In this era of cost concerns, it is very important to recognize that ultrasound technology now offers multiple applications such as 3D volume imaging (similar to CT and MRI), real-time evaluation of pelvic organs along the physical examination, and Doppler blood flow mapping (without contrast). Collectively, these applications make ultrasound imaging a unique imaging modality that ideally is suited to evaluate the female pelvis. Consistent use of ultrasound imaging first in women with pelvic symptoms, especially with the
adjunct of 3D and Doppler if necessary, would likely render further imaging unnecessary and at the same time be cost-effective and safer.

REFERENCES