US of the Nongravid Cervix with Multimodality Imaging Correlation: Normal Appearance, Pathologic Conditions, and Diagnostic Pitfalls

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Abbreviations: \( \beta \)-hCG = beta subunit of human chorionic gonadotropin

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The adult uterine cervix may exhibit a wide variety of pathologic conditions that include benign entities (e.g., cervicitis, hyperplasia, nabothian cysts, cervical polyps, leiomyomas, endometriosis, and congenital abnormalities) as well as malignant lesions, particularly cervical carcinoma. In addition, lesions that arise in the uterine body may secondarily involve the cervix, such as endometrial carcinoma and prolapsed intracavitary masses. Many of these conditions can be identified and characterized at ultrasonography (US), which is considered the first-line imaging examination for the female pelvis. However, examination of the cervix is often cursory during pelvic US, such that cervical disease may be overlooked or misdiagnosed. Transabdominal US of the cervix may not afford sufficient spatial resolution to depict cervical disease in many patients; therefore, endovaginal US is considered the optimal technique. Use of supplemental imaging techniques, particularly the application of transducer pressure on the cervix, may be helpful. This review describes the normal appearance of the cervix at US, the appearance of cervical lesions and conditions that mimic abnormalities at US, and optimal US techniques for evaluation of the cervix. This information will help radiologists detect and diagnose cervical abnormalities more confidently at pelvic US.

SA-CME LEARNING OBJECTIVES

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

- Describe normal cervical anatomy, including the normal appearance of the cervix at US and MR imaging.
- Identify the appearance of common, less common, and rare benign and malignant cervical abnormalities at US.
- Discuss common pitfalls and limitations of US for evaluation of the cervix.

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Introduction

Although imaging of the cervix is a required component of every pelvic ultrasonographic (US) examination, the attention of the examining sonographer is typically focused on the body of the uterus, endometrium, and adnexa, often resulting in only a cursory examination of the cervix. This may lead to failure to diagnose clinically important abnormalities arising in the cervix in symptomatic patients. In addition, lack of familiarity with the range of normal appearances and common benign asymptomatic conditions of the cervix can lead to diagnostic errors, resulting in a recommendation for unnecessary additional imaging or interventions. In this article, we review the normal US appearance of the cervix, describe techniques that can be used for optimal US evaluation, and discuss a wide range of cervical abnormalities and associated potential pitfalls. Correlation with magnetic resonance (MR) imaging findings is also provided for many of the depicted abnormalities. Familiarity with this information should aid radiologists in detection and diagnosis of cervical abnormalities at US.
TEACHING POINTS

■ If an abnormality involving the cervix is identified at US, the use of transducer pressure can be extremely beneficial to determine if a lesion is located in the endocervical canal, particularly if the lesion is a pedunculated intracavitary myoma or pedunculated polyp. The application of transducer pressure on the cervix may show lesion mobility if a lesion is intracavitary, whereas lesions arising from the cervical stroma will be fixed in position despite transducer pressure.

■ At US, the cervix in patients with acute cervicitis of any cause often shows a diffusely heterogeneous echotexture of the cervical mucosa and stroma, but the key finding is markedly increased vascularity. Therefore, use of color Doppler US is recommended in cases of suspected cervicitis. Although hypervascularity may raise concern for cervical carcinoma, the lack of a discrete mass may serve as a feature that distinguishes this inflammatory condition from malignancy. However, because of the nonspecific nature of this appearance, determining the underlying cause requires a thorough history and, likely, microbiologic and/or histologic correlation.

■ It is important to visualize the origin of an endocervical polyp to differentiate it from a lesion arising in the uterine body that extends into the endocervical canal, particularly a prolapsed intracavitary leiomyoma or endometrial polyp (the latter of which is a histologic entity distinct from an endocervical polyp). This distinction is important because management of prolapsed uterine or endometrial lesions may be more complicated because of the higher attachment and more extensive blood supply.

■ Varying degrees of cystic, fatty, and calcific degeneration in a leiomyoma may lead to a more heterogeneous internal imaging appearance, but a smooth outer contour, preserved mucosa, and negative Papanicolaou (Pap) test are important differentiating features from cervical carcinoma.

■ Cervical carcinoma can lead to stenosis and obstruction of the cervical canal, with resulting hydrometra, hematometra, or pyometra. Because of the variable location of the transformation zone with advancing age, tumors tend to be exophytic in younger patients and endophytic in older patients.

Normal Anatomy and Imaging Appearance

Representing the lower cylindrical portion of the uterus, the normal cervix measures 2.5–3 cm in length and 2.5 cm in width in women (Fig 1) (1–3). Unlike the uterine myometrium, which is composed of approximately 65%–70% smooth muscle tissue (4), the cervical stroma is primarily collagenous tissue and is only approximately 15% smooth muscle (5). The cervix is considered to be composed of two portions, an upper or supra-vaginal portion and a lower portion that protrudes into the upper vaginal canal and is termed the ectocervix (6,7). The ectocervix is palpable during gynecologic pelvic examination, and its surface and opening into the vaginal canal (the external os) are readily visible at speculum examination, whereas the supravaginal cervix cannot be assessed with these techniques (6). The superior aspect of the vagina encircles the ectocervix and extends slightly higher posteriorly and laterally than anteriorly, forming the vaginal recesses or fornices (7). The junction of the supravaginal cervix with the uterine body is referred to as the isthmus, and often there is a slight external tapering of the outer contour of the uterus at this level. The canal at the isthmus narrows, measuring 1–12 mm in width over a length of 1 cm (Fig 1). This corresponds to the location of the internal cervical os, which is the opening of the endocervical canal that connects with the endometrial cavity (1).

The endocervical canal is centrally located in the cervix, connecting the uterine cavity with the vagina. The canal is fusiform, measures up to 8 mm in width, and tapers at both the internal and external cervical os (7). The endocervical mucosa within the supravaginal cervical canal is characterized by villi lined with a single layer of mucus-secreting columnar epithelial cells separated by crypts extending 3–10 mm into the stroma of the cervix. These crypts are commonly referred to as the endocervical glands (8). The mucosa is arranged into longitudinal ridges with interdigitating branching folds known as the plicae palmatae. Although sometimes visible at US and MR imaging, the plicae palmatae are best visualized on a hysterosalpingogram, and their appearance ranges from closely spaced and thin with numerous folds to thicker and sparse with widely separated folds (Fig 1) (1). The mucosa in the most superior aspect of the endocervical canal may undergo cyclical menstrual changes, although to a lesser degree than does the endometrium (3).

In contrast to the endocervix, the mucosa of the ectocervix is composed of stratified squamous epithelium similar to the vaginal epithelium. The transformation zone is the region of the mucosa where the glandular tissue (columnar epithelium) is replaced by squamous epithelium (7). The location of this transformation zone, or squamocolumnar junction, varies with age. It is located in the ectocervix in 94% of women younger than 25 years but in only 2% of women older than 65 years (9). The transformation (or transition) zone is not discernible at imaging. The proximal migration of the transition zone results in decreased accessibility for tissue sampling as women age, which has important clinical implications because most carcinomas of the cervix arise in this transformation zone (9).

At US, the cervix appears ovoid or round on short-axis (labeled “coronal” endovaginal) views and cylindrical on long-axis (sagittal) views (Fig 1). The endocervical canal is best seen at sagittal imaging and usually appears as an echogenic line that represents the interface between the anterior and posterior mucosal layers. A small amount of fluid or mucus may be present in the canal, especially in the periovulatory period,
Figure 1. Normal US appearance of the cervix with multimodality imaging correlation. (a–c) In three different patients, sagittal (a, b) and coronal (c) gray-scale endovaginal US images show that the cervix appears cylindrical on the sagittal views and round or oval on the coronal view. The echogenic central line in a represents the interface between the two mucosal layers. The endocervical canal is lined by a glandular area (white arrows) that usually measures 2–4 mm in single-layer thickness and may contain a small amount of nearly anechoic fluid or mucus centrally. The glandular area ranges from hypoechoic (in a) to isoechoic or slightly hyperechoic (in b) relative to the cervical stroma. The regions of the internal cervical os (black arrow in a) and external cervical os (arrowhead in a) are also shown. In c, the plicae palmatae appear as serrations in the mucosa due to compact folds (see Movie 1 for another example). Cervical stroma is typically similar in echogenicity to myometrium and may demonstrate a narrow hypoechoic submucosal zone (arrowheads in b). (d, e) Sagittal (d) and axial (e) T2-weighted MR images in a different patient reveal a hyperintense inner zone (arrows in d) typically measuring 3–8 mm that corresponds to mucosa and secretions, a hypointense middle zone (arrowheads in e) due to the inner fibrous cervical stroma that is contiguous with the uterine junctional zone, and an outer intermediate-signal-intensity layer of fibromuscular tissue. The median longitudinal ridges of the plicae palmatae (arrows in e), ectocervix (seen below the line in d), and vaginal fornices (arrowheads in d) are also depicted. (f) Hysterosalpingogram in another patient shows the normal fusiform appearance of the endocervical canal, which tapers at the isthmus (arrow). Note also the plicae palmatae (arrowheads), which create a serrated appearance in the endocervical region.
appearing as a thin, centrally located anechoic or hypoechoic region (10). The normal cervical mucosa appears as an iso- to hyperechoic or hypoechoic layer (4,10) that usually measures 2–4 mm (mean, 3.3 mm) in thickness (2) and surrounds the canal. Occasionally, branching endocervical folds or mucosal serrations are visible at US, reflecting the presence of the plicae palmatae (Fig 1, Movie 1). Surrounding the glandular area, the fibromuscular stroma is typically similar in echogenicity to myometrium but may demonstrate a thin hypoechoic submucosal zone. At color Doppler US, little or no vascularization is typically seen in the cervix (11).

MR imaging is an excellent modality for visualizing the normal cervical anatomy and evaluating cervical lesions because of its superior soft-tissue contrast and wider anatomic coverage compared with those of US (12,13). In particular, MR imaging is used to characterize indeterminate US abnormalities (12,13) and to stage cervical carcinoma (14–17). On T2-weighted images, the cervix shows a distinctive trilaminar appearance (5), with an innermost hyperintense layer measuring 3–8 mm that corresponds to mucosa and secretions, a middle low-signal-intensity layer representing the inner cervical stroma that measures 3–8 mm, and an outermost intermediate-signal-intensity layer representing the outer cervical stroma that measures 2–8 mm (Fig 1) (5). The hypointense appearance of the inner cervical stroma on T2-weighted images has been suggested to reflect a greater number of fibroblasts and smooth muscle cells and less vascularized connective tissue compared with the outer stroma (5,18). The inner and outer cervical stromal layers typically appear contiguous with the uterine junctional zone and the outer myometrium, respectively (19). The zonal anatomy may also be visible on gadolinium-enhanced images because of differential enhancement of the cervical layers (18,19). The median longitudinal ridges of the plicae palmatae are visible at MR imaging in 47.5%–53.2% of women in their 20s through 40s but less commonly in older women (20). These ridges should not be mistaken for a cervical septum (21).

Computed tomography (CT) is not considered a first-line imaging modality to evaluate the cervix because of its inferior soft-tissue contrast and the exposure to ionizing radiation involved in its use. However, in patients with cervical carcinoma, CT may be used to evaluate for locally advanced disease, lymphadenopathy, distant metastases, and tumor recurrence, especially when MR imaging and positron emission tomography (PET)/CT are not available (22–24).

**Cervical US Technique**

Evaluation of the cervix typically is performed by using standard transabdominal and endovaginal techniques. The transabdominal approach provides a global overview of the anatomy but may not allow visualization of the cervix in 15%–55% of patients (3). The endovaginal approach usually results in more optimal visualization of the cervix because of the ability to place the transducer closer to the cervix and to use higher-frequency probes, both of which provide improved spatial resolution compared with the transabdominal approach. However, the endovaginal approach can be limited by a smaller field of view and less depth penetration and may not be feasible in some patients because of discomfort or prepubertal or virginal status (25,26).

In our protocol, gray-scale US of the cervix is performed with both long-axis (sagittal) and short-axis (labeled “coronal” endovaginal or “transverse” transabdominal) views (10). Transabdominal imaging allows the cervix to be imaged in a true axial plane; however, endovaginal imaging provides a short-axis view of the cervix that is closest to a coronal plane (10). To ensure that the entire cervix has been examined completely, the sonographer sweeps the US beam through the entire length of the cervix, from the internal os through the external os and upper vagina, and sweeps laterally through the cervix to include the parametrial and other adjacent pelvic tissues in the transabdominal and endovaginal examinations. This allows confident identification of the cervical borders, delineation of the extent of any masses or lesions (27), and characterization of pathologic processes from areas that secondarily may involve the cervix.

We also routinely perform color Doppler US of the cervix to evaluate for abnormal vascularity, which may permit detection of subtle lesions (11,28). Color Doppler US may also help define the vascular supply of a mass (Fig 2), a technique that has been reported to be helpful in detection and characterization of endometrial and uterine abnormalities (29–31). If necessary, spectral Doppler US can be added to confirm and further characterize vascularity identified at color Doppler US. Three-dimensional US imaging is used increasingly in US departments as part of a routine pelvic examination and may be especially helpful for evaluation of the cervix to delineate complex anatomic relationships, particularly abnormalities of the müllerian ducts.

If an abnormality involving the cervix is identified at US, use of transducer pressure can be extremely beneficial to determine if a lesion is located in the endocervical canal, particularly a pedunculated intracavitary myoma or pedunculated
Figure 2. Use of color Doppler US and transducer pressure for detection and characterization of an endocervical mass in a 29-year-old woman with vaginal spotting. (a) Sagittal gray-scale endovaginal US image of the cervix shows a subtle mildly echogenic lesion (arrows) in the endocervical canal. (b) Sagittal color Doppler US image reveals color signal (arrows) extending from the anterior myometrium into the lesion. Identification of a vascular pedicle facilitated detection of a pedunculated mass, which proved to be an intracavitary polyp. In a sagittal gray-scale endovaginal US cine clip obtained with application of transducer pressure (Movie 2), a mobile lesion was seen that was separable from the cervical stroma, a finding that confirmed a pedunculated endocervical lesion.

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The application of transducer pressure on the cervix may show lesion mobility if a lesion is intracavitary, whereas lesions arising from the cervical stroma will be fixed in position despite transducer pressure (Fig 2, Movie 2).

In addition to these techniques, a transperineal approach can be used if endovaginal imaging is contraindicated (e.g., premenarche) and may provide superior imaging in up to 75% of patients compared with transabdominal examination (4). Saline-infused sonohysterography also can be used to aid in detection and characterization of intracavitary and endocervical lesions (33). Experimental US techniques for evaluation of the cervix include use of intracervical transducers (34) and elastography (35).

Benign Entities

Congenital Cervical Anomalies

A thorough evaluation of the cervix is necessary in patients with known or suspected uterine developmental abnormalities because the müllerian ducts give rise to the cervix as well as to the uterus and upper two-thirds of the vagina. US is an excellent modality for evaluation of müllerian anomalies, including anomalies of the cervix, particularly the presence of a septum, duplication, or agenesis. However, in complex cases, MR imaging may be indicated (36).

The most common uterine developmental abnormality, accounting for 34%-55% of cases, is a septate uterus (36,37), which results from incomplete resorption of the uterovaginal septum after fusion of the paired müllerian ducts. These septa can be partial or, less commonly, complete. A complete septum extends to the external cervical os and may extend into the upper vagina in as many as 25% of cases (36). In the case of a complete septum, the cervical canal is divided by a plane of tissue (Fig 3, Movie 3) that may appear hypoechoic if fibrous (38). Detection of the septum at US may be improved through use of color Doppler US and three-dimensional imaging (39).

There also may be a duplicated cervix, which usually occurs with uterus didelphys (40). Uterus didelphys is the consequence of complete non-fusion of the müllerian ducts, resulting in two complete cervices with separate endometrial canals and minimal (if any) fusion at the level of the cervix (36). Cervical duplication is not unique to uterus didelphys and can occur rarely with septate and bicornate uterine configurations (40). In cervical duplication, the two endocervical canals usually are divided by a thicker plane of tissue than is seen with a cervical septum (Fig 4) and may diverge inferiorly (40,41). However, it is often difficult to distinguish a duplicated cervix from a single cervix with a septum, even with use of optimal US technique (40).

Hypoplasia or agenesis of the uterus and cervix results from absent or severely arrested development of the müllerian ducts during gestation and is a relatively rare congenital anomaly that is a frequent cause of primary amenorrhea. Women with this anomaly, also called Mayer-Rokitansky-Küster-Hauser syndrome, typically have a blind-ending vagina, and the uterus is often completely absent. However, rudimentary uterine tissue may be present and sometimes contains functioning
Figure 3. Complete uterine septum in a 31-year-old woman with a history of pelvic pain. (a) Coronal gray-scale endovaginal US image through the cervix shows division of the endocervical canal by a thin plane of tissue (arrow). Note the associated posterior acoustic shadowing, which increases the conspicuity of the septum. (b) Coronal three-dimensional reformatted US image better depicts the full extent of the septum (arrow) and shows a flat uterine fundal contour (arrowheads), a finding consistent with a septate uterus and not a bicornuate uterus or other duplication anomaly of the uterus. The septum was also well depicted in a coronal US cine clip (Movie 3).

Figure 4. Uterus didelphys in a 24-year-old woman with a vaginal septum. Coronal gray-scale endovaginal US images of the uterus (a) and cervix (b) show two widely separated uterine horns (arrows in a) and two cervical canals († in b), findings indicative of uterus didelphys with cervical duplication. The tissue separating the endocervical canals is thicker than the septum seen in Figure 3 and is similar in echogenicity to cervical stroma, as expected for two fully formed cervices.

endometrium (Fig 5, Movie 4) (42,43). If functioning endometrial tissue is present, the presenting symptom may be postpubertal cyclic pain due to accumulation of hemorrhagic products in the rudimentary uterus. As with other müllerian duct anomalies, the ovaries are usually normal, which is an important differentiating feature from complete androgen insensitivity syndrome. Visualization of suspected müllerian duct anomalies should prompt evaluation of the kidneys because concurrent renal anomalies occur in 30%–50% of cases, most commonly renal agenesis, although renal ectopia, renal dysplasia, and collecting system duplication have been described (36,37,44,45).

Cervicitis
Cervicitis is the generic term used to describe cervical inflammation and may be acute or chronic. Noninfectious causes of cervicitis include trauma, pelvic radiation, chemical irritation, and, less likely, malignancy. However, most acute cervicitis is secondary to an infectious agent. The ectocervix, with epithelium closely resembling the vagina, is most susceptible to the microorganisms Trichomonas vaginalis, Candida albicans, and herpes simplex virus (especially type 2), as well as those more generically responsible for bacterial vaginosis (46,47). Neisseria gonorrhoeae and Chlamydia trachomatis have
a predilection for infecting the glandular epithelium of the endocervix (12). Patients usually present with purulent or mucopurulent cervical and vaginal discharge and may complain of pelvic pressure or discomfort (48).

There is very little published in the imaging literature about this relatively common condition, perhaps because patients with cervicitis are not commonly referred for imaging. In addition, similar to inflammation throughout the rest of the body, US findings of cervicitis can be subtle or even completely occult, especially if the condition is more chronic or if the patient is examined during or after effective antimicrobial treatment.

At US, the cervix in patients with acute cervicitis of any cause often shows a diffusely heterogeneous echotexture of the cervical mucosa and stroma, but the key finding is markedly increased vascularity (Figs 6, 7; Movies 5–7). Therefore, use of color Doppler US is recommended in cases of suspected cervicitis. Although hypervascularity may raise concern for cervical carcinoma, the lack of a discrete mass may serve as a differentiating feature of this inflammatory condition from malignancy. However, because of the nonspecific nature of this appearance, determination of the underlying cause requires a thorough patient history and likely microbiologic and/or histologic correlation.

Although the presence of small groups of bright dots in the endocervical canal (Fig 8) has been associated with chronic cervicitis, it is not a specific finding for this condition (2). Both endometrial and endocervical echogenic foci may be incidental findings that are reportedly associated with a history of prior uterine or cervical instrumentation (49). Furthermore, the clinical importance of pathologically diagnosed chronic cervicitis in asymptomatic women has been questioned. In particular, it has been suggested that the presence of inflammatory cells within the cervix may be physiologic, representing a mechanism for clearance of epithelial debris and coitally transmitted material (7,50).
Cervicitis in a 21-year-old woman with reported “bumps” in the genital region. (a) Sagittal gray-scale endovaginal US image shows subtle diffuse heterogeneity of the cervix with loss of definition of normal zonal anatomy. The finding was better depicted during a sagittal sweep through the cervix (Movie 5). (b) Sagittal color Doppler endovaginal US image more clearly shows the abnormality and depicts marked hypervascularity. The patient tested positive for *N gonorrhoeae, C trachomatis*, and herpes simplex virus. (c) Sagittal gray-scale transabdominal US image obtained during subsequent second-trimester US shows reconstitution of the normal cervical appearance (arrows). A = amniotic fluid, B = bladder. The patient continued to show no clinical evidence of carcinoma 6 years later. (7) Cervicitis in a 27-year-old woman with right lower quadrant pain and an intrauterine device. (a) Sagittal gray-scale endovaginal US image of the cervix shows a malpositioned intrauterine device (arrow) in the endocervical canal (see also Movie 6). The cervix appears heterogeneously hypoechoic (arrowheads) and was hypervascular (Movie 7), findings that raise concern for cervical carcinoma. (b) Sagittal contrast-enhanced CT image shows increased diffuse enhancement of the cervix, with no focal mass or disruption of normal cervical shape or contour. The intrauterine device (arrow) is partially seen. Other CT findings included a complex cystic lesion in the left ovary (arrowhead) and mesenteric inflammatory changes (not shown). These findings, in the setting of a malpositioned intrauterine device and a recent normal Pap test, strongly favor an infectious cause. Actinomycosis was diagnosed after resection of the adnexal mass.

**Cervical Stenosis**

Cervical stenosis is usually an acquired condition related to scarring of the endocervical canal from prior surgery, radiation therapy, or chronic infection or, less commonly, cervical carcinoma, or rarely it may be congenital (51). Although US cannot be used to directly measure the diameter of the region of luminal narrowing, stenosis can be inferred by persistent fluid in the endocervical canal (Fig 9) or uterine cavity. Although a small amount of fluid or mucus in the endocervical canal may be normal in women of menstruating age (10), a large amount of endocervical and endometrial fluid distending the canal, particularly if the fluid is complex, should prompt a careful search for potentially associated endometrial or cervical mass lesions because this finding may signal an underlying malignancy (52–54). If the fluid in the endocervical canal is complex, its heterogeneous echogenicity at US may mimic a solid lesion (Fig 9);
however, the absence of detectable flow at color Doppler US and the central location should suggest the correct diagnosis. In equivocal cases, MR imaging may be performed to confirm that the US finding represents complex fluid and not a mass (Fig 9).

**Endocervical Hyperplasia**

Diffuse hyperplasia of the epithelium of the endocervix is usually a nonspecific incidental finding, although it can be associated with a watery vaginal discharge. It is frequently seen in women who use oral progestational agents for contraception and in pregnant or postpartum patients (13). The endocervical mucosa may appear diffusely thickened, accentuating the interdigitating branching folds of the plicae palmae. The diffuse nature of this finding, with preservation of the overall form and structure of the endocervical canal, allows differentiation of endocervical hyperplasia from a focal cervical mass (Fig 10) (55).

**Nabothian Cysts**

Nabothian cysts are the most common benign masslike lesions of the cervix (Fig 11). Nabothian cysts are mucus-retention or epithelial-inclusion cysts that form because of obstruction of an endocervical gland by proliferating squamous epithelium (12). They are hypothesized to form secondary to chronic mild cervical inflammation and are most frequently seen in women in the reproductive years. The majority are less than 1 cm and are incidentally detected at imaging. They may enlarge and become symptomatic because of mass effect, but this happens infrequently (56,57). Nabothian cysts must be identified correctly because no treatment is required unless they are symptomatic. Although reported in only 20% of hysterectomy specimens (2) and in 12% of MR imaging examinations (58), nabothian cysts are considered a normal finding in multiparous women (8) and may be underreported in both the pathology and imaging literature, especially when they are small.
Figure 10. Endocervical hyperplasia in a 43-year-old woman with a history of pelvic pain. (a) Sagittal color Doppler endovaginal US image of the cervix shows conspicuity of the plicae palmatae (arrows), which are outlined by fluid in the endocervical canal. The appearance raised concern for a mixed cystic and solid cervical mass. (b, c) Sagittal T2-weighted (b) and axial T1-weighted (c) MR images obtained to characterize the cervical abnormality reveal fusiform expansion of the endocervical glandular region (arrows) associated with T1 shortening, an appearance suggestive of hyperplasia rather than a mass (55). Pathologic examination revealed laminar endocervical glandular hyperplasia, one of the pseudoneoplastic endocervical glandular lesions. In retrospect, the US abnormality seen in a conforms to the expected configuration of the endocervical canal, and the plicae palmatae are preserved and not effaced. Both findings, if correctly identified, would favor a diffuse process affecting the endocervical mucosa rather than a focal cervical mass. Most nabothian cysts appear as simple anechoic cysts in the cervix, without vascularity. However, they may vary in appearance because of proteinaceous or hemorrhagic content, clustering of adjacent cysts, and deep extension into the cervical stroma, sometimes enlarging the cervix (12,56). One type of nabothian cyst, the “tunnel cluster” variant, appears as a complex multicystic cervical mass that may mimic a rare cervical malignancy called minimal deviation adenocarcinoma, or adenoma malignum (8). Tunnel cluster–variant nabothian cysts are pseudoneoplastic glandular lesions of the cervix that occur in up to 8% of women, most frequently in multigravid women older than 30 years (59). They are characterized at histopathologic analysis by multicystic dilatation of the endocervical glands. Although confident differentiation of pseudoneoplastic lesions from malignancy is problematic at both imaging and pathologic examination (60), US features that raise concern for malignancy include a solid component and marked vascular flow in the lesion at color Doppler US (61). MR imaging also may be helpful in distinguishing adenoma malignum from benign multicystic lesions of the cervix (62–64). MR imaging features that are reported to be associated with malignancy include solid enhancing components, irregular margins, local invasion, and metastases (13,63–65). Clinical factors that raise concern for adenoma malignum include persistent watery discharge, a Pap test showing cytologic abnormality, gastric mucin in the vaginal discharge, or a history of Peutz-Jeghers syndrome (65).

Endocervical Polyps

Endocervical polyps are the most common benign cervical growth, with a reported incidence of up to 4% in gynecologic patients (66). They occur most commonly in multiparous women in their 30s and 40s (66) and are a common cause of intermenstrual bleeding. Other presenting symptoms include metrorrhagia, menorrhagia, postmenopausal bleeding, contact bleeding, or vaginal discharge. They are believed to be a pathologic result of focal hyperplasia of the glandular epithelium and are
Figure 11. Nabothian cysts in different patients. (a) Sagittal gray-scale endovaginal US image of the cervix shows the typical appearance of nabothian cysts: multiple anechoic cystic structures in the endocervical mucosa, some of which extend into the stroma. (b) Coronal gray-scale endovaginal US image shows an echogenic nabothian cyst without shadowing (arrow), reflecting proteinaceous or crystalline content. (c) Coronal gray-scale endovaginal US image shows the multicystic appearance of the cervix due to conglomerated nabothian cysts, which sometimes mimics the appearance of a multicystic mass. (d, e) Sagittal gray-scale (d) and spectral Doppler (e) endovaginal US images show a complex hypoechoic mass (M) with no detectable internal vascularity, a finding thought to represent a hemorrhagic nabothian cyst. Note the adjacent small simple nabothian cysts (arrow in d). (f) Axial T1-weighted MR image in the same patient as in d and e shows a hyperintense lesion (arrow) in the cervix that corresponds to the US finding and is consistent with a hemorrhagic nabothian cyst.

often associated with endometrial hyperplasia, which suggests a possible link to estrogen exposure as a cause. In addition, as many as 25% of patients who have a cervical polyp have a coexisting endometrial polyp (67). Histologically, classic endocervical polyps are composed of a connective-tissue
Figure 12. Endocervical polyp in a 49-year-old woman with menorrhagia and anemia. (a) Sagittal gray-scale endovaginal US image shows a mixed echogenic mass outlined by fluid in the endocervical canal. Cursors show caliper placement for measurement of the mass. (b) Coronal color Doppler endovaginal US image shows a vessel extending from the posterior cervix into the mass. Arterial flow seen at spectral Doppler US (not shown) was consistent with a feeding artery. Pathologic examination revealed an endocervical polyp. The small amount of fluid in the endocervical canal at US outlined the polyp, allowing it to be detected easily and measured accurately. The fluid occurred naturally in this patient, but the same effect can be achieved with instillation of fluid into the endometrial and endocervical canal at saline-infused US.

Stalk with a columnar epithelium, frequently with squamous metaplasia. They usually are adenomatous, although five other histologic variants (cystic, fibrous, vascular, inflammatory, and fibromyomatous) are found less commonly (66,67). Malignancy or dysplasia can occur in 0.2%–1.5% of cases (67,68) and is most common in the perimenopausal age group (69).

At gray-scale US, endocervical polyps typically appear slightly hyperechoic compared with the normal mucosa and may be mobile at dynamic imaging with use of transducer pressure (2,32). Color and spectral Doppler US may reveal a vascular stalk (Fig 12) (28) arising from the endocervical mucosa and extending into the polyp, confirming the endocervical origin. It is important to visualize the origin of the endocervical polyp to differentiate it from a lesion arising in the uterine body and extending into the endocervical canal, particularly a prolapsed intracavitary leiomyoma or endometrial polyp (the latter of which is a histologic entity distinct from an endocervical polyp). This distinction is important because management of prolapsed uterine or endometrial lesions may be more complicated because of the higher attachment and more extensive blood supply (70). Visualization of the origin of an endocervical mass can sometimes be aided by hysterosonography (71) or MR imaging (72,73) if necessary. Endocervical polyps may undergo cystic change and may be confused with nabothian cysts if the vascular pedicle is not visualized and the sonographer does not realize that the lesion lies within the endocervical canal.

Leiomyomas

The cervical stroma is susceptible to formation of leiomyomas, and these lesions have similar imaging features to their uterine body counterparts on US and MR images. At US, cervical leiomyomas are typically solid, hypoechoic, and centered in the cervical stroma and may demonstrate refractory shadowing (Fig 13) (74). At MR imaging, they usually are isointense on T1-weighted images and hypointense on T2-weighted images, relative to the outer myometrium. Varying degrees of cystic, fatty, and calcific degeneration within a leiomyoma may lead to a more heterogeneous imaging appearance internally (75,76), but a smooth outer contour, preserved mucosa, and negative Pap test are important features for differentiation from cervical carcinoma. Although most cervical leiomyomas are asymptomatic, patient symptoms may mirror the symptoms of uterine leiomyomas, including abnormal uterine bleeding or pressure symptoms due to mass effect, especially when the mass is large (12). In pregnant patients, cervical leiomyomas may lead to shoulder dystocia during delivery and increased postpartum blood loss (77,78).

Because fewer than 10% of all uterine leiomyomas arise in the cervix, care must be taken to determine that a visualized leiomyoma in the cervical region is not a prolapsing leiomyoma from the uterine cavity (79,80). Visualization of a vascularized stalk arising from the endometrial canal and extending to the leiomyoma at color Doppler US indicates a uterine origin (Fig 14) (28,81). The analogous finding at MR imaging is a stalk connecting the apparent cervical mass
to the uterine cavity (“broccoli” sign) (72,73), which can establish the origin in patients with an indeterminate diagnosis at US. This distinction is especially important if targeted therapy or surgery is being considered. Cervical leiomyomas tend to be less responsive to treatment with arterial embolization than are uterine body leiomyomas (82).

Endometriosis
Endometriosis, a benign gynecologic disorder that affects approximately 10% of women of reproductive age, is defined by endometrial tissue outside the uterus (83). Cervical involvement is rare, occurring in 0.11%–2.4% of patients with endometriosis (84). Cervical endometriosis may be superficial (involving the inner cervix) or deep (involving the outer third of the cervix). The pathogenesis of cervical endometriosis is unclear, but it is hypothesized to be the result of traumatic disruption of the mucosa, permitting implantation of cast-off endometrial fragments (84,85). Superficial cervical endometriosis may be an incidentally detected histologic finding in asymptomatic women (84,86), but cervical endometriosis also may manifest as a cervical mass, with symptoms of pelvic pain or abnormal vaginal bleeding (87). A variety of mani-
Figure 15. Deeply infiltrating endometriosis involving the cervix in a 41-year-old woman with infertility. (a) Coronal gray-scale endovaginal US image of the cervix shows an ill-defined posterior hypoechoic mass (arrows). Without a history of endometriosis, the finding could be mistaken for a primary cervical lesion, such as a carcinoma. * = cervical canal. (b) Sagittal T2-weighted MR image shows deeply infiltrating endometriosis in the cul-de-sac involving the posterior uterus and cervix (arrows), which accounts for the US finding. A complex adnexal cystic lesion (E) was markedly hyperintense on T1-weighted MR images (not shown), in keeping with an endometrioma.

manifestations of cervical endometriosis have been reported at US, ranging from a complex cystic mass to a solid-appearing lesion with extension into the paracervical tissues, potentially producing a US appearance that is similar to that of other entities, including leiomyomas, polyps, and carcinoma (84,87,88). Clinical history and speculum examination may allow establishment of the correct diagnosis; however, sometimes cervical endometriosis is recognized only at histopathologic examination.

Cervical involvement may also occur as an extension of deeply infiltrating pelvic endometriosis into the posterior cervix. Deeply infiltrating endometriosis is defined by endometriotic implants more than 5 mm below the peritoneal surface (83). At US, posterior-compartment infiltrating endometriosis may appear as ill-defined hypoechoic tissue in the cul-de-sac with penetration of the posterior cervical and uterine serosa, potentially mimicking peritoneal carcinomatosis or an invasive cervical malignancy (Fig 15) (83). In equivocal cases, MR imaging may help to establish the correct diagnosis by showing the characteristic low T2 signal intensity (with or without T2 bright or hemorrhagic foci) of infiltrative endometriosis and by demonstrating other findings of endometriosis in the pelvis (83).

Cervical Carcinoma
The most common malignancy that originates in the cervix is carcinoma, which arises almost exclusively from the transformation zone where the squamous epithelium and columnar epithelium meet. Between 80% and 90% of carcinomas are squamous, and 5%–20% are adenocarcinomas (12).

Cervical carcinoma is the third most common gynecologic malignancy in the United States but is the leading gynecologic cancer worldwide (89). There are multiple known risk factors for development of cervical carcinoma, including history of multiple sexual partners, early age of first intercourse, multiparity, lower socioeconomic standing, cigarette smoking, immunosuppressed state, and use of oral contraceptives. In addition, there is a strong association with human papillomavirus, with serotypes 16, 18, 31, 33, and 56 accounting for more than 80% of all invasive cervical carcinomas (89). The increasing use of the human papillomavirus vaccine is predicted to decrease the incidence of cervical carcinoma significantly in coming years (90).

Patients with cervical carcinoma commonly present with abnormal vaginal bleeding, including both intermenstrual and postmenstrual symptoms. Cervical carcinoma can lead to stenosis and obstruction of the cervical canal, with resulting hydrometra, hematometra, or pyometra. Because of the variable location of the transformation zone with advancing age, tumors tend to be exophytic in younger patients and endophytic in older patients (15,91,92).

Staging
Because of the epidemiologic characteristics of cervical carcinoma, staging traditionally has been performed clinically by using the International
Figure 16. Cervical carcinoma in a 50-year-old perimenopausal woman with vaginal spotting. (a) Sagittal color Doppler endovaginal US image shows a vascular, solid, hypoechoic cervical mass (arrows show the cranio-caudal extent) effacing the normal cervical anatomy. The ill-defined and lobulated margins, diffuse vascularity, and lack of refractory shadowing help differentiate this mass from a leiomyoma (cf Fig 13). The irregular margins and distortion of the cervix were better shown in a cine clip (Movie 8). (b) Sagittal T2-weighted MR image shows a heterogeneous mass (arrow) involving the entire endocervical region and extending into the lower portion of the uterine body, with high- and intermediate-signal-intensity components. There is no full-thickness disruption of the T2-hypointense inner cervical stroma to indicate parametrial invasion. Histopathologic analysis revealed cervical adenocarcinoma. *= uterine leiomyoma.

Federation of Gynecology and Obstetrics (FIGO) system (14). Accurate staging is critical because risk stratification and treatment of clinically visible lesions varies depending on size of the tumor, presence and extent of local invasion, and presence of metastases (14,16). Surgical resection is an option for tumors that are confined to the uterus and upper two-thirds of the vagina (FIGO stage IIA or lower). Chemotherapy and radiation therapy are preferred for tumors that are considered locally advanced (stage IIB or higher) because of invasion of the parametrium (stage IIB), the lower third of the vagina (stage IIIA), pelvic side wall (stage IIIB), or bladder or rectum (stage IVA) (14). Chemotherapy and radiation therapy also are preferred for tumors with poor prognostic factors, including size larger than 4 cm (stage IIA2) and nodal involvement (93–95). In comparison, small tumors measuring less than 2 cm (stage IA2 or IB1) may be amenable to fertility-sparing surgery, particularly radical vaginal trachelectomy, if the remaining cervical length is estimated to be greater than 1 cm and there is no nodal involvement (16).

Despite the importance of correct staging, clinical staging is known to have limited accuracy, reportedly about 66%, which decreases from stage I (78%) to stage III (25%) (96). Therefore, with the new FIGO system, use of diagnostic imaging, including CT and MR imaging, is recommended but is not mandatory (14). MR imaging is the single best modality for evaluating local extent of tumor because of its excellent soft-tissue contrast (14,22,97), but PET/CT is superior for detection of nodal metastases (98), and CT is an option when PET/CT and MR imaging are not available (22–24). US is usually not used in staging.

Sonographic Appearance
Early tumors are difficult to detect at US because of their small size and similar echogenicity to that of normal cervical mucosa. However, in patients with invasive cervical carcinoma, up to 93% are visible at US (99). With increasing size, the tumor is likely to demonstrate altered echotexture, distortion of normal cervical morphology (Figs 16, 17; Movies 8, 9) (91,92), and lack of compressibility (27). In advanced cases, the normal cervix may be entirely replaced by tumor (Fig 16, Movie 8), and the key to detection is to identify effacement of the normal cervical architecture with or without distortion of the shape of the cervix or to identify features of local invasion (Fig 17). In addition, because as many as 95% of cervical carcinomas are hypervascular, color Doppler US may facilitate visualization and delineation of the tumor (11,99). Although a hypervascular cervical mass with irregular margins is suspicious for cervical carcinoma, ultimately histopathologic or cytologic examination is necessary for diagnosis.

Although US is not central to staging cervical carcinoma, local invasion may be detected at US by using endovaginal and endorectal imaging and dynamic maneuvers (27,99–101). Reported US features of local invasion include visualization of the mass beyond the anatomic borders of the
Figure 17. Locally advanced squamous cell carcinoma of the cervix in a 33-year-old woman with symptomatic anemia and a beta subunit of human chorionic gonadotropin (β-hCG) serum level of 33 IU/mL. The patient had regular menstrual cycles, with her last menstrual period 4 weeks before the US examination, and reported no intercourse in the previous 5 months. (a) Sagittal gray-scale endovaginal US image shows a cervical mass (M) with nodular invasion (arrow) of the bladder (arrowhead) (Movie 9). (b) Coronal color Doppler endovaginal US image shows a hypervascular mass with parametrial invasion (arrow) causing obstruction of the left ureter (arrowhead). The invasive features allow differentiation of the cervical mass from benign lesions such as cervicitis and leiomyomas. Lymphadenopathy was also visible at US (not shown). (c) Sagittal T2-weighted MR image shows replacement of the cervix and lower uterine segment with the tumor, which focally invades the bladder (arrow). Cervical carcinoma has been reported in the literature as an uncommon cause of elevated β-hCG serum levels (91,92).

cervix directly into the paracervical tissues and/or vaginal fornices and loss of mobility of the tumor relative to the rectum (27,99). Bladder invasion can be suspected when loss of bladder mobility relative to the tumor is noted with probe pressure (102) and is diagnosed when the tumor interrupts the bladder wall and/or appears as nodular protrusions in the bladder lumen (Fig 17, Movie 9) (103). If cervical carcinoma is suspected on the basis of US features, imaging of the retroperitoneum should be performed to evaluate for lymphadenopathy, hydroureter, and hydronephrosis.

Other Cervical Malignant Lesions
In addition to primary carcinoma of the cervix, cervical malignancy can occur secondary to direct extension from adjacent tumors (Fig 18), in particular, tumors of endometrial or myometrial origin (104) and, less commonly, those in other pelvic organs. Primary cervical lymphoma is rare, with lymphomatous involvement of the cervix more commonly resulting from secondary invasion than from a primary lesion (12). Other malignancies may rarely arise from the cervix, including melanoma, sarcoma, and neuroendocrine tumors, and require histopathologic examination to distinguish them from cervical carcinoma (12).

Imaging Pitfalls
Identification and characterization of cervical lesions requires meticulous US technique and knowledge of the normal imaging appearance of the cervix. The most common pitfalls encountered include failure to recognize the presence of a cervical lesion (Figs 19, 20), failure to appreciate the malignant potential of a lesion (Fig 20), misinterpretation of a pseudolesion as a pathologic condition (Fig 21) (105), and misidentification of the origin of a lesion (Fig 14).
Endometrial carcinoma invading the cervix in a 62-year-old woman with postmenopausal bleeding. (a) Sagittal color Doppler endovaginal US image shows an irregular, lobulated, hypoechoic, hypervascular mass (arrows) without refractory shadowing, with a similar appearance to cervical carcinoma. (b) Sagittal gray-scale endovaginal US image of the uterus shows that the tumor (arrows) is centered in the endometrial canal of the uterine body, favoring secondary involvement of the cervix by a primary uterine mass over primary cervical carcinoma with invasion of the uterus. (c) Sagittal T2-weighted MR image confirms a heterogeneous endometrial mass with extension into the endocervical canal (arrow) and protrusion into the upper vagina. Histopathologic examination revealed poorly differentiated endometrial carcinoma. Occasionally, the origin of a uterine mass may remain unclear despite histopathologic examination; MR imaging may allow identification of the origin of the malignancy (104). This distinction is important because treatment of endometrial carcinoma is different from that of cervical carcinoma.

It is not uncommon, in our experience, to encounter pelvic US studies in which few images of the cervix have been acquired. An important clue to cervical abnormality may be the failure to document a normal cervix despite the ability to achieve a US window that allows the probe to be swept through the entire uterus and cervix. Figure 19 illustrates an example in which failure to identify and image a normal cervix led to misinterpretation of a cervical mass as adenomyosis. However, failure to see the normal cervical anatomy in the expected location (near the US probe) should have been a clue to this pitfall. Figure 20 illustrates the pitfall of interpreting all solid uterine masses as likely to be benign, most commonly leiomyomas. It is important to consider the possibility of malignancy, especially in symptomatic postmenopausal patients, when lesions are first detected or manifest with atypical features. As in Figure 20, the presence of a large amount of endometrial fluid should raise concern for a mass lesion obstructing the endocervical canal and should prompt more thorough US of the cervix and lower endometrium for malignancy, including use of color Doppler US.

Similar to the endometrium, the endocervical mucosa may vary in thickness and appearance. Figure 21 depicts normal endocervical mucosa in a neonate under the influence of maternal estrogen, a finding that simulates the appearance of endocervical polyps. Plicae palmatae (Fig 1, Movie 1) should also be recognized as a non-pathologic finding. As discussed, nabothian cysts are commonly found in the cervix and generally
Figure 19. Squamous cell carcinoma of the cervix in a 45-year-old woman with vaginal bleeding, abdominal distention, and a serum β-hCG level of 249 IU/ml. (a) Sagittal gray-scale endovaginal US image of the midline pelvis shows a globular heterogeneous structure thought to represent a retroverted uterus, with heterogeneity of the echotexture related to adenomyosis. However, no images of a normal cervix were obtained. (b) Sagittal T2-weighted MR image obtained 10 days later because of persistent symptoms shows a cervical mass (arrows) with parametrial and uterine invasion and ascites (+) due to peritoneal carcinomatosis. The vagina (V) contains fluid and packing material. Metastatic lymphadenopathy and liver metastases were also seen (not shown). Biopsy revealed poorly differentiated squamous cell carcinoma. No products of conception were identified at dilation and curettage, which suggests that the tumor may have been the source of the β-hCG. In retrospect, the heterogeneous structure in a represents a markedly abnormal cervix replaced by tumor.

Figure 20. Squamous cell carcinoma in a 60-year-old woman with postmenopausal bleeding. (a) Sagittal gray-scale endovaginal US image of the pelvis shows a heterogeneous mass abutting the transducer, initially thought to represent a retroverted uterus with leiomyomas. However, identification of complex fluid distending the endometrial canal (arrows), a finding likely representing hematometra, and an irregular mass (outlined by cursors) led to concern for cervical carcinoma rather than leiomyomas. No normal cervix was depicted. (b) Sagittal T2-weighted MR image shows an obstructing cervical mass (arrows) with hematometra (+). Histopathologic analysis revealed squamous cell carcinoma. This case emphasizes the importance of visualizing the entire uterus in addition to identifying a normal cervix because hematometra may indicate a clinically important cervical abnormality.

are considered an incidental finding. Diagnosis of nabothian cysts at imaging is often straightforward; the radiologist should be familiar with the wide variety in appearances of this common finding to avoid unnecessary additional imaging and procedures.

We find the application of dynamic imaging techniques and use of color Doppler US particularly important in detection and determination of the origin of endocervical lesions. Identification of the origin of a lesion as either in the endometrial or endocervical cavity is important for patient treatment. It may be challenging to determine on the basis of static images if a lesion arises from the cervical stroma and impinges on the cervical canal or is located in the endocervical
canal. The ability to assess for mobility of a lesion when transducer pressure is applied to the cervix aids in diagnosis of an intracavitary lesion (Fig 2). Once a lesion is diagnosed as intracavitary, color Doppler US is performed to determine the origin of the lesion by helping identify the origin of its vascular pedicle (Figs 2, 12, 14).

Conclusion

Evaluation of the cervix at US is best accomplished endovaginally. Endovaginal US allows use of high-resolution probes that provide the spatial resolution necessary for detection of subtle lesions and allows the operator to evaluate the cervix from a variety of angles to obtain the optimal imaging plane. The operator should examine the entire cervix fully in both the coronal and sagittal planes. Several techniques in addition to standard gray-scale imaging, in particular the application of transducer pressure on the cervix to observe real-time motion of lesions and the use of color Doppler US, can aid the sonographer and radiologist in complex cases to detect and better characterize the origin of lesions seen in the cervix. Although US is of limited use for detection and staging of cervical carcinoma, careful imaging of the cervix may aid in detection of small tumors.

MR imaging allows excellent visualization of the cervix and provides superior soft-tissue contrast and wider anatomic coverage compared with those at US. Therefore, potential indications for MR imaging after cervical US include characterization of a cervical abnormality in cases where the diagnosis remains unclear, further delineation of a complex Müllerian anomaly, evaluation of the extent of pelvic endometriosis, and staging of cervical carcinoma. Of note, although the imaging appearance of a cervical mass can be diagnostic, histopathologic examination is still necessary in some cases, particularly when malignancy is suspected.

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The article entitled “US of the Nongravid Cervix with Multimodality Imaging Correlation” by Wildenberg et al (1) is a comprehensive review of US of the nongravid cervix, including normal and near-normal findings and benign, congenital, and malignant conditions. The text and static images are supplemented by helpful cine clips and correlation with other cross-sectional imaging results. The imaging examples are divided between benign conditions, including cysts, polyps, hyperplasia, inflammation, endometriosis, and leiomyomas, and malignant processes, including local and advanced cervical carcinoma, squamous cell carcinoma, and extension of endometrial carcinoma. In addition to the general descriptions and excellent imaging examples, the authors included a frank discussion of imaging pitfalls and how to negotiate them with use of color Doppler US, real-time compression, and other advanced imaging, particularly MR imaging.

Although pelvic US in the nonpregnant population is a common imaging examination, the cervix is frequently the forgotten component and is either incompletely imaged or not mentioned in the report. Pelvic US dictation templates typically do not include any particular measurements or specific description of the cervix. Many radiologists believe that the cervix falls into the clinical realm, and while this may be true for direct visualization of the exocervix and for screening for cervical carcinoma, US, and in particular endovaginal US, is the most common initial imaging modality used for evaluation of the cervix. Despite the frequent use of this procedure, most authors of texts on US include extensive discussion of the cervix in pregnancy with regard to diagnosis of cervical incompetency, cerclage position, placenta previa, vasa previa, and cervical ectopic pregnancy but mention findings of the nongravid cervix only in passing. The scientific literature has a similar bias toward pregnancy-related cervical issues. Practicing radiologists have few handy references when faced with a potential or definitive cervical abnormality. It is hoped that reference to the discussion and imaging examples in this article will help prevent overcalls of benign inconsequential findings, such as prominent or unusual nabothian cysts interpreted as masses, and undercalls of malignancy.

The advice given in the section on imaging pitfalls cannot be overly emphasized: Every pelvic US examination should include adequate evaluation of the cervix. If a normal cervix cannot be documented, a pathologic condition may be present, and further imaging is warranted. Both deep endometriosis and malignancy can cause considerable technical and interpretive difficulties. These two diagnoses may result in suboptimal imaging because of general pelvic distortion and bowel adhesions as well as pelvic pain and bleeding during the imaging process. Invasive deep endometriosis is a difficult diagnosis to make primarily with US, and because of its frequency and degree of major symptoms, improved detection with US is an important goal. Use of the US probe to elicit focal pain may help localize these hypoechoic implants. Directing attention to the retrocervical region by evaluating for the “sliding” sign can allow assessment for deep endometriosis that obliterates the pouch of Douglas. To evaluate for this sign,
the sonographer uses an endovaginal probe to exert gentle pressure against the cervix to assess the mobility of the anterior rectum against the posterior cervix. An examination with negative results for the sliding sign may be a good predictor of deep endometriosis that involves the rectosigmoid (2,3).

Although the authors portray the added value of MR imaging after confusing findings at pelvic US, routine endovaginal US of the cervix can be supplemented by several other US techniques that are not discussed or demonstrated in the article. The transperineal US technique originally was described as a method to evaluate the location of a posterior placenta with respect to the internal cervical os in the third trimester, when shadowing from the fetal head interfered with adequate visualization. Transperineal US is also an excellent method to evaluate the vagina and exocervix, as shown in Figure 1, which depicts a large cervical polyp protruding through the external os into the distal vagina. Endovaginal imaging during saline injection into the vagina is
another effective method to image an abnormality near the external os. Figure 2 shows an example of a patient with a large cervical polyp that extends into a saline-filled vagina. Saline infusion sonohysterography is an excellent technique to evaluate focal and diffuse endometrial abnormalities because the endometrial cavity usually is easy to distend. The cervix is considerably less distensible, but some dilatation with saline can be achieved by inflating the catheter balloon just within the cervix. This technique was used to confirm a thin long endocervical polyp in the patient shown in Figure 3. Lastly, two- and three-dimensional reformatted images are helpful to evaluate the cervix and endometrium in the coronal plane, replicating one of the benefits of MR imaging. Figure 4 is a coronal reformatted US image of a patient with hematometra due to a cervical carcinoma.

Another related US technique that may have benefit in evaluation of the cervix is elastography. Initial investigations have included this technique to evaluate cervical stiffness during pregnancy (4) and assess the ability to prevent or induce labor (5,6). Elastography also may be useful in evaluation of the nongravid cervix for detection of cervical carcinoma (7) and differentiation of benign from malignant disease (8). This technique is not yet well validated or widely available but bears future surveillance for general use.

In summary, the article by Wildenberg et al is an excellent compendium of US of the nongravid cervix and includes static images and cine clips, correlative imaging findings, and sound advice on how to avoid a variety of pitfalls. The authors should be congratulated for expertly providing a needed reference for practicing radiologists who perform and interpret pelvic US.

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