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## Ultrasonography / Échographie Imaging the Endometrium: A Pictorial Essay

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### Abstract

Female gynaecologic conditions arising from the endometrium are common and depend on a woman's age, her menstrual history, and the use of medications such as hormone replacement and tamoxifen. Both benign and malignant conditions affect the endometrium. Benign conditions must be distinguished from malignant and premalignant conditions. The most commonly used imaging modality for evaluating the endometrium is pelvic ultrasound with transabdominal and transvaginal techniques. Additional imaging methods include hysterosonography and magnetic resonance imaging. This pictorial essay will review the normal and abnormal appearance of the endometrium and diagnostic algorithms to evaluate abnormal vaginal bleeding and abnormal endometrial thickness.

### Résumé

Les affections gynécologiques d'origine endométriale sont courantes. Leur nature varie selon l'âge et les antécédents menstruels de la femme, et selon qu'elle a pris ou non des médicaments comme ceux administrés dans le cadre d'une hormonothérapie substitutive ou d'un traitement par tamoxifène. Les affections qui touchent l'endomètre peuvent être bénignes ou malignes. Il convient donc de bien distinguer les affections bénignes des affections malignes et précancéreuses. L'échographie du bassin (avec recours à des techniques transabdominales et transvaginales) est la modalité d'imagerie la plus souvent utilisée pour évaluer l'endomètre. D'autres méthodes d'imagerie peuvent également être employées, notamment l'hystéro-échographie et l'imagerie par résonance magnétique. Dans cet essai illustré, nous examinerons les caractéristiques visuelles normales et anormales de l'endomètre et les algorithmes de diagnostic servant à évaluer les saignements vaginaux anormaux et l'épaississement anormal de l'endomètre.

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*Key Words:* Endometrium; Hysterosonogram, endometrial cancer; Endometrial hyperplasia; Endometrial polyp; Retained products of conception

Female gynaecologic conditions arising from the endometrium are common and depend on a women's age, her menstrual history, and the use of medications such as hormone replacement and tamoxifen. Both benign and malignant conditions affect the endometrium. Benign conditions must be differentiated from malignant and premalignant conditions. The most commonly used imaging modality for evaluating the endometrium is pelvic ultrasound (US) with transabdominal and transvaginal techniques. Additional imaging methods include hysterosonography and magnetic resonance imaging (MRI). This pictorial essay will review the normal and abnormal appearance of the endometrium

and diagnostic algorithms to evaluate abnormal vaginal bleeding and abnormal endometrial thickness.

### Normal Endometrium

Ultrasound is the first-line imaging test to evaluate the endometrium. The normal endometrium is composed of 2 layers and the combined thickness of the 2 layers depends on where a woman is in her menstrual cycle (Figures 1-3) [1]. The best way to measure the endometrial thickness is on a midsagittal transvaginal image. Immediately following menses, the endometrium is a thin echogenic line measuring 1-4 mm (Figure 1). In the first half of the menstrual cycle, the endometrium is in the proliferative phase and measures 4-8 mm. At the time of ovulation, the central functional layer of endometrium is relatively hypoechoic, giving a trilaminar appearance with 3 echogenic lines formed by the 2 basal layers of hyperechoic endometrium and the collapsed

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Figure 1. A 39-year-old premenopausal woman with normal endometrium immediately following menses. Transvaginal sagittal ultrasound shows endometrium as a thin echogenic line that measures 3 mm (normal 1–4 mm; calipers).

endometrial cavity (Figure 2). In the latter half of the menstrual cycle after ovulation, the endometrium is in the secretory phase and is uniformly echogenic measuring up to 14 mm due to cells rich in glycogen and mucus (Figure 3) [1,2]. Menopause is defined as the absence of menses for greater than 12 months and typically occurs in women over 50 years of age [3]. The normal endometrium in a postmenopausal woman measures less than 5 mm (Figure 4A).

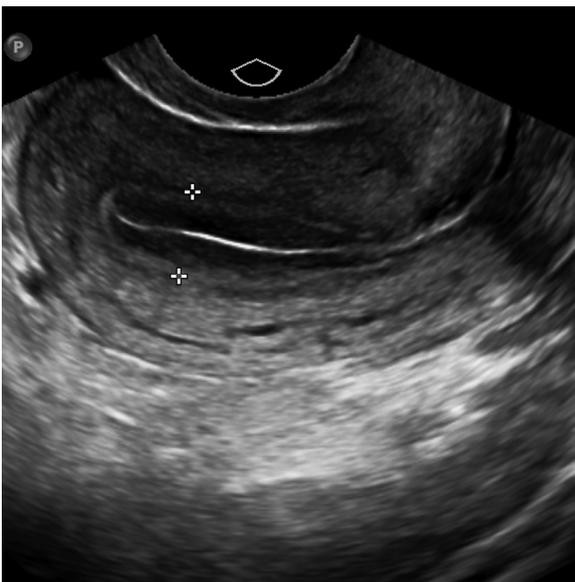


Figure 2. A 19-year-old female with normal endometrium in periovulatory phase. Transvaginal sagittal ultrasound shows endometrium measures 9 mm (calipers; typically 4–8 mm in the first half of the menstrual cycle). There is a trilaminar appearance. Central functional layer of endometrium is relatively hypoechoic.



Figure 3. A 39-year-old premenopausal woman with normal endometrium in the secretory phase. Transvaginal sagittal ultrasound shows endometrium measures 15 mm (calipers; typically up to 14 mm). Endometrium is echogenic due to mucus and glycogen in the endometrial cells.

When there is fluid in the endometrial canal, the 2 layers of endometrium are measured separately and added together (Figure 5) [1]. Some postmenopausal women are on hormone replacement and receive estrogen and progesterone that induces cyclical bleeding. It is important to measure their endometrium 4–5 days after the start of menses when it should measure less than 5 mm [1,4].

### Endometrial Hyperplasia, Polyps, and Cancer

Abnormal vaginal bleeding may occur in premenopausal and postmenopausal women. In premenopausal women, the most common causes are hormonal disturbances, fibroids, or adenomyosis. In postmenopausal women, causes include an atrophic endometrium, endometrial hyperplasia, endometrial cancer, endometrial polyps, and submucosal fibroids [5]. The most common cause of postmenopausal bleeding is an atrophic endometrium that is diagnosed when the endometrium measures less than 5 mm [1,6] (Figure 4A). Occasionally, an atrophic endometrium may contain cystic areas due to cystic dilatation of glands that may increase the thickness of the endometrium (Figure 4B) [7]. Endometrial hyperplasia is a premalignant condition. Both endometrial hyperplasia and cancer are due to unopposed estrogen that may be due to endogenous or exogenous sources, tamoxifen, obesity, chronic hypertension, or diabetes [8]. In a woman with postmenopausal bleeding, the endometrium is abnormal if it measures 5 mm or greater and this warrants endometrial biopsy (Figure 6) [1,4]. In asymptomatic postmenopausal women without vaginal bleeding, the endometrium is abnormal if it measures 9 mm or greater, and this warrants endometrial biopsy [9]. Endometrial cancer is the most common gynaecologic cancer and 90% of cases occur in

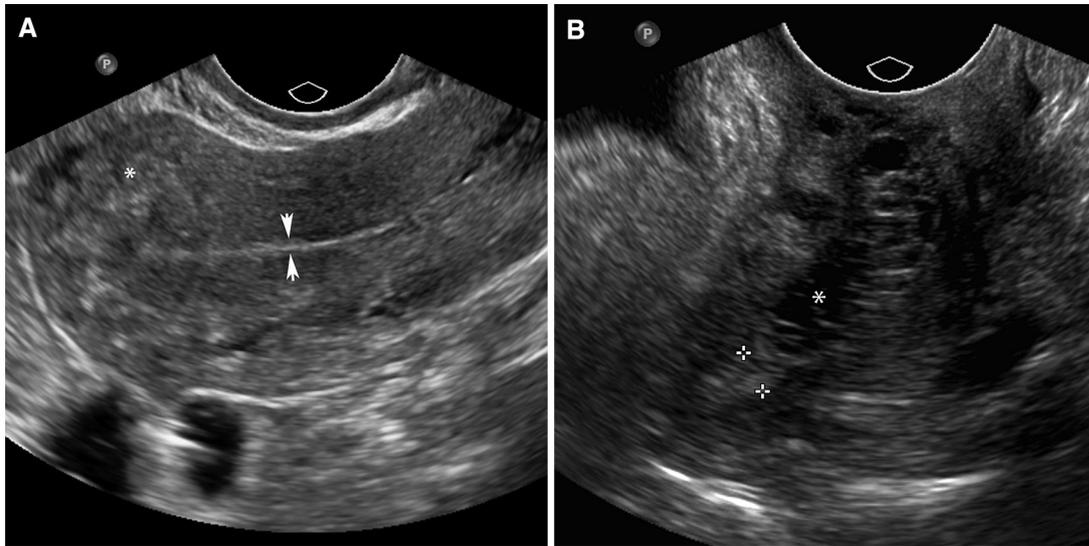


Figure 4. (A) A 51-year-old woman with postmenopausal bleeding. Transvaginal sagittal ultrasound (US) shows atrophic endometrium that measures 2 mm (arrowheads; typically less than 5 mm). The myometrium is heterogeneously echogenic in the fundus due to calcified arcuate arteries (asterisk). (B) A 91-year-old female with postmenopausal bleeding. Transvaginal sagittal US shows multiple cysts in the endometrium in the body and lower uterine segment (asterisk) where the endometrium measures 8 mm. At the fundus, the endometrium measures 4.5 mm (calipers). Because of vaginal bleeding, patient had endometrial biopsy that revealed benign cells. This is an example of endometrial cystic atrophy.

women over 50 years of age [10]. However, some premenopausal women are at increased risk, and they include women over 35 years of age with morbid obesity, chronic hypertension, chronic diabetes, or long-term tamoxifen therapy. These at-risk patients warrant endometrial biopsy when there is abnormal vaginal bleeding not due to pregnancy and not responsive to hormone therapy and the endometrium measures 16 mm or greater [6,8]. Ultrasound

signs that are more specific for endometrial cancer are a heterogeneous endometrium with colour flow or an indistinct endometrial-myometrial interface (Figure 7) [1]. Cystic areas may be observed in cases of atrophic endometrium, hyperplasia, polyps, or cancer and the presence of cysts in the endometrium is nonspecific [7].

In some cases, the endometrium cannot be evaluated with ultrasound that may be due to fibroids, the position of the uterus or endometrial cancer [4]. These patients benefit from

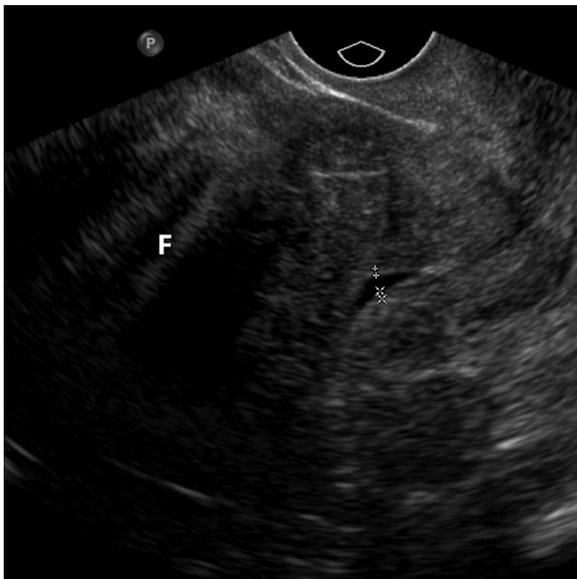


Figure 5. A 54-year-old postmenopausal woman with history of fibroids. Transvaginal sagittal ultrasound shows a small amount of fluid in the endometrial canal. The 2 layers of echogenic endometrium are added together to give an endometrial thickness of 4 mm that is normal (calipers). There is a shadowing fibroid at the uterine fundus that is difficult to measure with ultrasound (F).

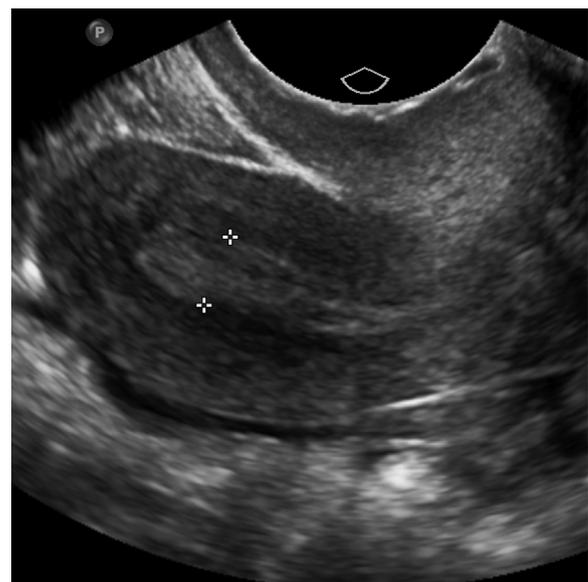


Figure 6. A 66-year-old woman with postmenopausal bleeding. Transvaginal sagittal ultrasound shows thickened heterogeneous endometrium measuring 6 mm (calipers; abnormal 5 mm or greater). There was mild colour flow (not shown). Endometrial biopsy revealed a benign polyp.

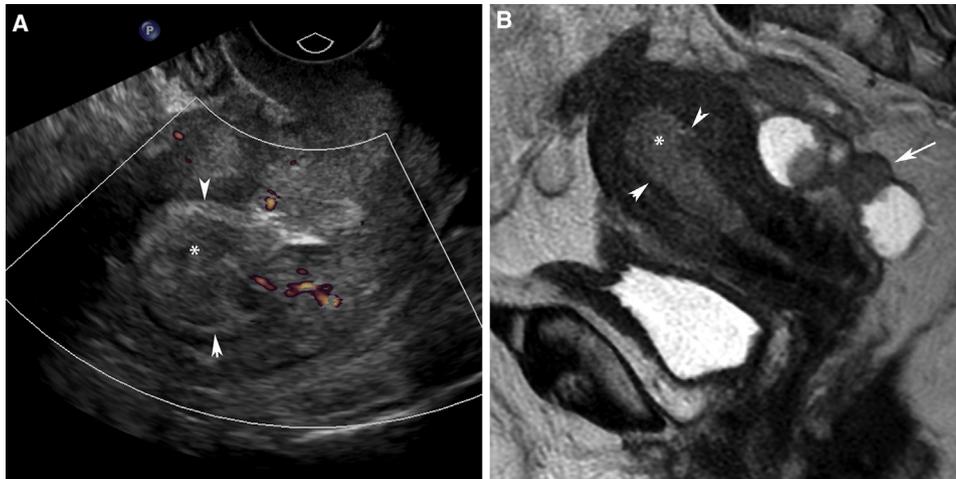


Figure 7. An 87-year-old woman with postmenopausal bleeding. (A) Transvaginal sagittal ultrasound shows a heterogeneous mass (asterisk) thickening the endometrial cavity that measures 24 mm (arrowheads). Mass demonstrates colour flow. Endometrial biopsy revealed endometrioid adenocarcinoma. (B) Sagittal T2 magnetic resonance imaging demonstrates the thickened endometrium that is lower signal intensity on T2 than normal due to the cancer (asterisk). There is no evidence of myometrial invasion and the low T2 signal intensity junctional zone is intact (arrowheads). The endometrial cancer is stage IA. Incidental note is made of complex solid and cystic enlargement of an ovary concerning for an ovarian neoplasm (arrow). This figure is available in colour online at <http://carjonline.org/>.

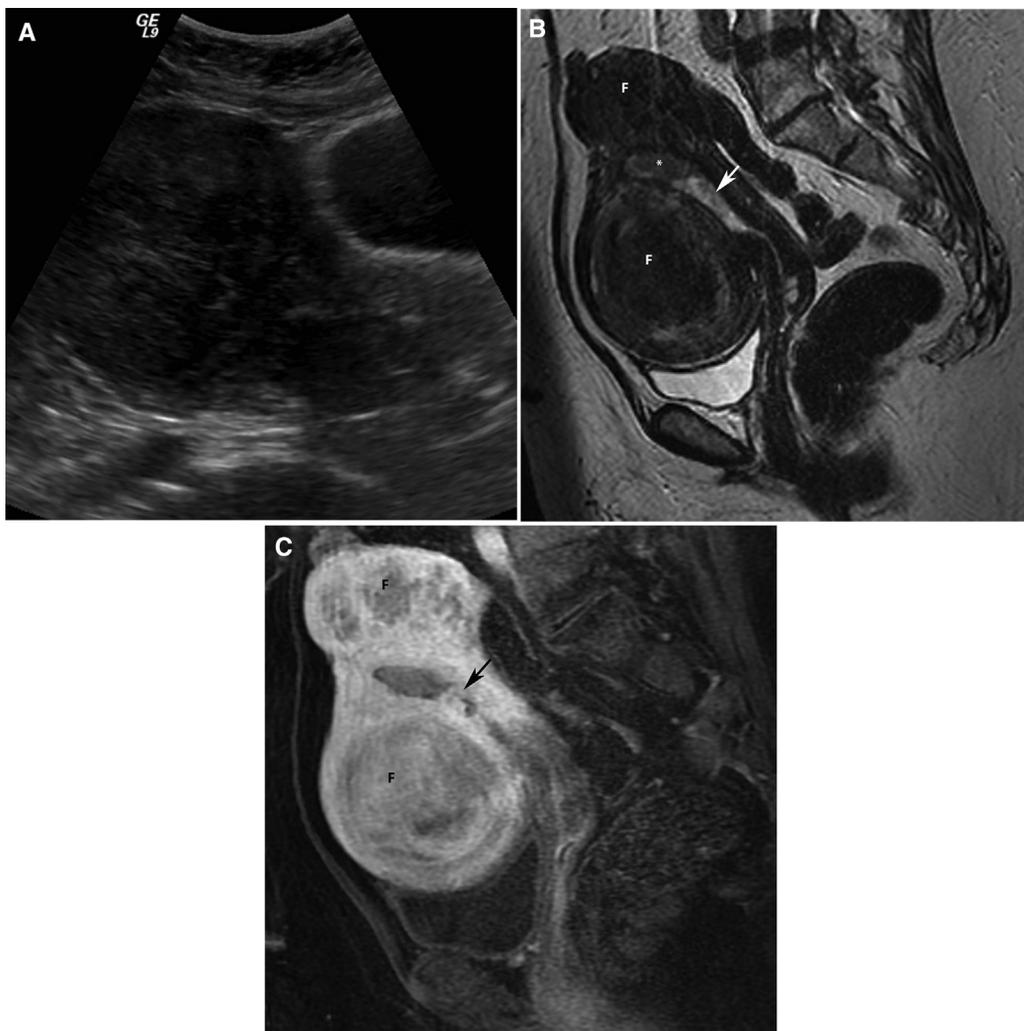


Figure 8. A 57-year-old woman with postmenopausal bleeding. (A) Transvaginal sagittal ultrasound shows enlargement of the uterus due to multiple fibroids. The endometrium cannot be evaluated. (B) Sagittal T2 magnetic resonance imaging (MRI) demonstrates thickening of the endometrium with heterogeneous areas of low T2 signal intensity (asterisk; white arrow) that represent abnormal endometrial tissue. (C) Sagittal gadolinium enhanced fat suppressed T1 MRI demonstrates enhancement of the abnormal endometrial tissue (black arrow). There is no myometrial invasion. Endometrial biopsy revealed endometrioid adenocarcinoma. In addition there are typical exophytic subserosal fibroids that are low signal intensity on T2 and enhance with contrast (F).

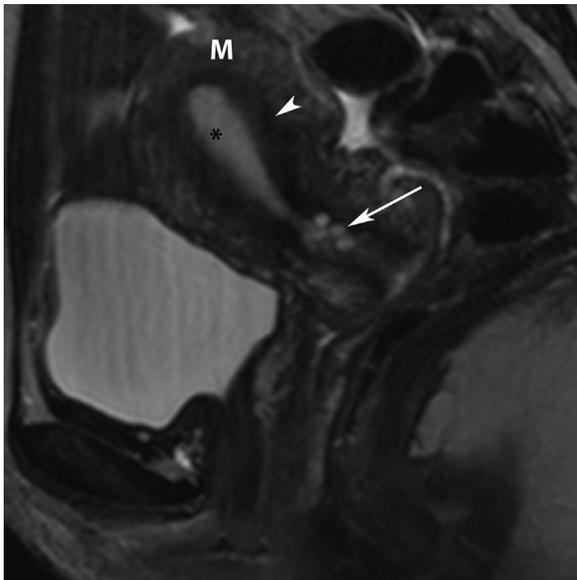


Figure 9. A 30-year-old premenopausal woman with breast cancer who had MRI to evaluate ovarian cysts. Sagittal T2 MRI demonstrates normal appearance of the uterus. The endometrium is T2 hyperintense (asterisk). It is surrounded by a low T2 signal intensity junctional zone that measures 8 mm or less (arrowhead). The surrounding myometrium is higher signal intensity than the junctional zone (M). Incidental note is made of nabothian cysts at the cervix (arrow).

further evaluation with MRI (Figure 8). Cases of endometrial cancer present with a thickened heterogeneous endometrium on T2 that enhances earlier than normal endometrium on dynamic gadolinium-enhanced images. There may be invasion of the central myometrium (Figures 7 and 8) [11]. The normal endometrium is hyperintense on T2 (Figure 9). At our institution, we perform pelvic MRI on a 3-T Siemens



Figure 10. A 68-year-old postmenopausal woman with invasive breast cancer on tamoxifen. Sagittal transvaginal ultrasound demonstrates polypoid thickening of the endometrium with cystic areas (asterisk). Endometrium measures up to 17 mm (calipers). Endometrial biopsy was negative for malignancy. She continues to have annual follow up surveillance. This figure is available in colour online at <http://carjonline.org/>.

Trio MR system (Erlangen, Germany). Imaging is performed as axial, sagittal, and coronal T2 and axial T1. Pre- and postgadolinium-enhanced imaging is performed in the sagittal plane as fat-suppressed T1 gradient echo (VIBE) with postgadolinium axial imaging. T2-weighted imaging is performed as a turbo spin echo sequence using a 24 cm field of view,  $320 \times 320$  matrix, 2 averages, 4 skip 0.6 mm (15% gap), repetition time (TR) 5000 ms, echo time (TE) 91 ms.

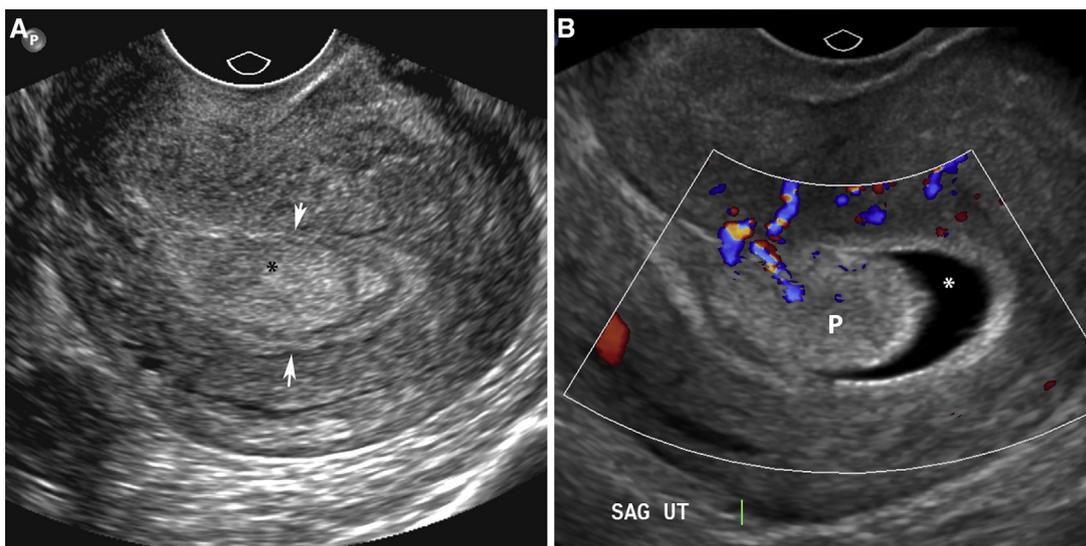


Figure 11. A 26-year-old premenopausal woman with pelvic pain. (A) Transvaginal sagittal ultrasound shows an echogenic mass in the endometrial cavity (asterisk). There is a hyperechoic rim around the echogenic mass that represents the normal endometrium known as the “hyperechoic line sign” (arrows). (B) Hysterosonogram was performed. Sterile saline distends the endometrial canal (asterisk). Fluid in the endometrial canal demonstrates the margins of the polyp (P) that measures  $1.2 \times 2.2 \times 3$  cm. Vascular stalk is shown with increased colour flow. Pulsed Doppler typically shows arterial flow in the vascular stalk (not shown). Patient had hysteroscopic polypectomy. Pathology revealed benign hyperplastic polyp without atypia. This figure is available in colour online at <http://carjonline.org/>.



Figure 12. A 28-year-old woman with recurrent pregnancy loss. Transvaginal sagittal hysterosonogram with saline distending the endometrial cavity demonstrates synechiae with multiple echogenic linear bands of fibrosis in the endometrial cavity (arrow). Patient was treated with diagnostic hysteroscopy and light curettage for lysis of adhesions.

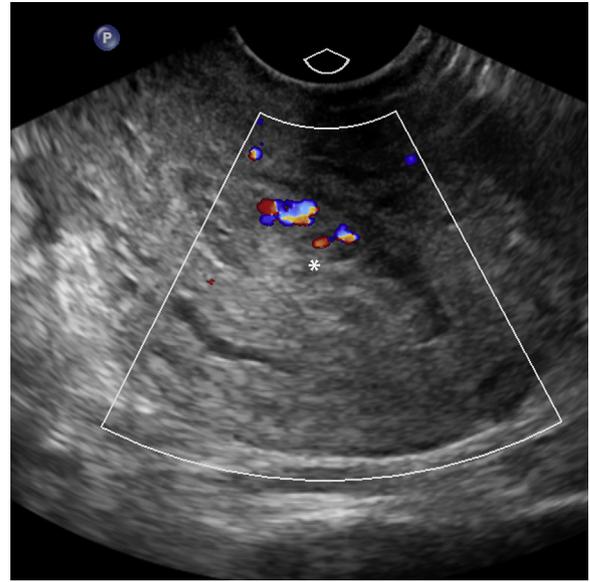


Figure 13. A 22-year-old woman who is 6 days postdilation and curettage for an 8 week pregnancy. She presents with pelvic pain and vaginal discharge with a positive serum beta human chorionic gonadotropin. Transvaginal ultrasound demonstrates retained products of conception with thickening of the endometrial cavity with a heterogeneous mass with colour flow (asterisk). Endometrium measures 18 mm. Patient was treated with repeat dilation and curettage and a course of antibiotics. This figure is available in colour online at <http://carjonline.org/>.

T1-weighted imaging is also performed as a turbo spin echo sequence with similar scan parameters with TR 800 ms, TE 11 ms. Fat-suppressed VIBE imaging is performed using 24 cm field of view,  $192 \times 144$  matrix, 1 average, 3 skip 0 mm, TR 3.76 ms, TE, 1.31 ms. As well, 1 mL gadoteridol per 10 pounds body weight is given by intravenous injection to a maximum dose of 20 mL with 3 postcontrast phases (immediate, early, and delayed venous phases).

Tamoxifen is given in some cases of early stage breast cancer to reduce recurrence and mortality. It is an estrogen antagonist in the breast but an estrogen agonist in the uterus where it induces endometrial proliferation with an increased incidence of hyperplasia, polyps, and endometrial cancer [8]. Cystic areas may be observed in the thickened endometrium and subendometrium [8]. Patients on tamoxifen with vaginal bleeding require biopsy when the endometrium measures 5 mm or greater. There is no consensus on how to manage asymptomatic patients on tamoxifen. Patients typically have annual screening pelvic US. A general guideline is to biopsy asymptomatic patients when the endometrium measures 9 mm or greater (Figure 10) [4].

Hysterosonography is performed to evaluate if endometrial pathology is focal or diffuse and to evaluate the endometrium in cases of a negative biopsy. Diffuse endometrial abnormalities such as a proliferative endometrium, hyperplasia and most cancers may be diagnosed with random endometrial biopsies [6,8]. Polyps, focal hyperplasia, and polypoid cancers may be missed at random biopsy. They can be diagnosed at hysterosonography and then be biopsied with hysteroscopic guidance (Figure 11) [6,8]. Hysterosonography should be performed 7-10 days after the start of the last menstrual cycle. It should not be

performed in women in the latter half of the menstrual cycle when the endometrium is thick and nodular [12]. Submucosal fibroids may be differentiated from polyps with hysterosonography as they are covered with normal endometrium [2,8].

Endometrial polyps are localized overgrowths of endometrial glands and stroma with a vascular core. They are most common in women who are at or near menopause [2,3]. The majority of polyps are asymptomatic [13]. In premenopausal women, endometrial polyps may cause intermenstrual bleeding or menorrhagia [2]. In postmenopausal women, they may cause postmenopausal bleeding. The prevalence of malignancy ranges from 0.8%-8% and is greater in women over 60 years of age with vaginal bleeding. In a study by Costa-Paiva et al [13], the prevalence rate of malignancy in endometrial polyps in patients with postmenopausal bleeding was 4.5% compared to 1.5% in asymptomatic women. Other risk factors for malignant or premalignant polyps include obesity, chronic hypertension, chronic diabetes, and size greater than 15 mm [13]. On ultrasound, polyps may be pedunculated or sessile and may be solitary or multiple. They are echogenic and typically have arterial flow in a vascular stalk due to a feeding artery [2]. Some polyps have cystic areas that may be due to dilated glands [3]. On transvaginal ultrasound, the endometrium may appear thickened with the “hyperechoic line sign” representing normal endometrium circumscribing the polyp (Figure 11) [14]. Polyps are evaluated well with hysterosonograms. Because the majority of endometrial polyps are

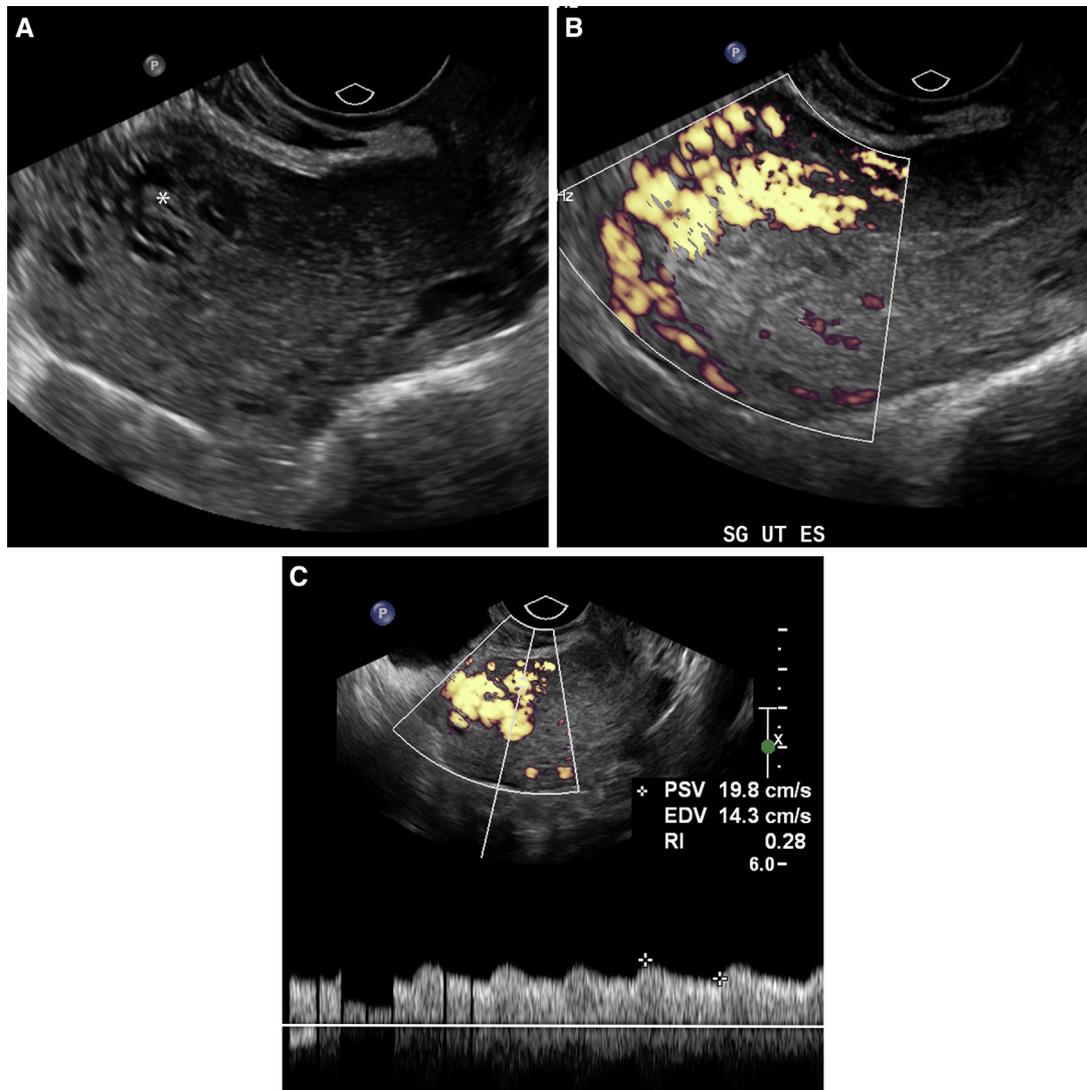


Figure 14. A 31-year-old woman who is 5 weeks status post D&C for anembryonic pregnancy. She had vaginal bleeding 1 week prior to presentation with a positive serum human chorionic gonadotropin (HCG) that was treated with repeat dilation and curettage and misoprostol. Her hematocrit fell from 29 to 20 in the emergency room on this admission when her serum HCG was negative. (A) Transvaginal sagittal ultrasound demonstrates heterogeneous anterior myometrium with multiple cyst-like spaces that represent abnormal vascular channels from a uterine arteriovenous fistula (asterisk). (B) Transvaginal sagittal ultrasound with power Doppler demonstrates endometrial thickness of less than 10 mm, and there is marked hypervascularity in tortuous vessels in the anterior myometrium. (C) Transvaginal ultrasound with pulsed Doppler demonstrates the peak systolic velocity is 19.8 cm/second and the resistive index (RI) is 0.28. This is a relatively slow flow uterine arteriovenous fistula and peak systolic velocities are typically higher. There were also prominent vessels in the left adnexa (not shown). She was treated with blood transfusions and recovered. EDV = end diastolic velocity; PSV = peak systolic velocity. This figure is available in colour online at <http://carjonline.org/>.

benign, small asymptomatic polyps in women without risk factors for malignancy may be managed conservatively with imaging surveillance. The treatment for symptomatic polyps is hysteroscopic excision [3,8].

### Endometrium and Fertility

Endometrial synechiae may cause infertility in young women. They represent adhesions and fibrosis in the endometrial canal that may be due to dilation and curettage (D&C), caesarean section, intrauterine device placement, or pelvic infections. Hysterosonography reveals thick fibrous strands without colour flow that may limit distension of the

endometrial cavity (Figure 12) [1,12]. The adhesions may be lysed surgically to improve fertility.

Retained products of conception (RPOC) may occur in women following spontaneous or therapeutic abortion or in the post-partum period (first 6 weeks post delivery). Clinically, women will have vaginal bleeding or a discharge and a positive human chorionic gonadotropin. On ultrasound, the most specific sign for RPOC is an endometrial mass that may or may not demonstrate vascularity with colour flow. In at-risk women, the diagnosis may be made if the endometrium measures 10 mm or greater even without a focal mass or colour flow with a sensitivity of over 80% (Figure 13) [15,16]. Conversely, the diagnosis of RPOC may be ruled out if the endometrium

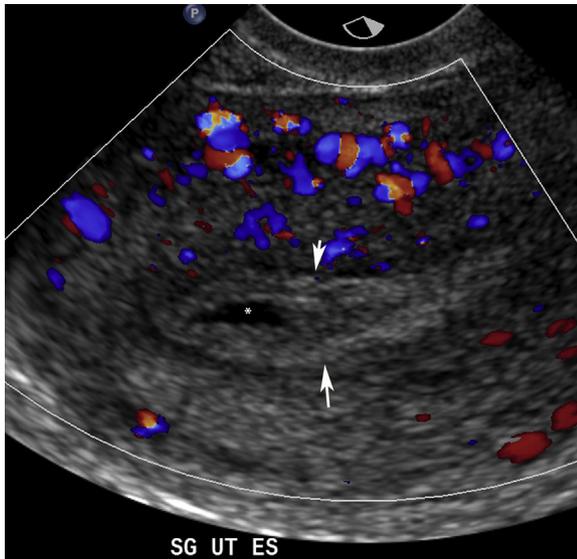


Figure 15. A 22-year-old woman with pelvic pain and fever. She was found to have a tubo-ovarian abscess on computed tomography. Transvaginal pelvic ultrasound demonstrates thickening of the endometrium (arrows) with fluid and debris in the endometrial cavity (asterisk) in keeping with endometritis. Tests were positive for *Chlamydia trachomatis* and she was treated with antibiotics. In some cases of endometritis, there is gas in the endometrial cavity characterized by dirty shadowing. This figure is available in colour online at <http://carjonline.org/>.

measures less than 10 mm without vascularity with a negative predictive value of 63%–80% [15,16]. The treatment options for RPOC are conservative management, prostaglandin E1 analogs and dilatation and curettage (D&C) [16]. Another cause for vaginal bleeding in women following D&C is a post-procedure arteriovenous malformation (AVM) (Figure 14). On greyscale US, uterine AVMs demonstrate heterogeneous echogenicity in the myometrium with cyst-like spaces creating a “spongy texture” due to hypoechoic tubular areas representing abnormal vascular channels. On spectral Doppler, they demonstrate marked hypervascularity with high-velocity, low-resistance arterial flow and abundant venous flow. The peak systolic velocities are typically in the 35–97 cm/second range but may be higher and the resistive index is in the 0.3–0.52 range (mean, 0.42) [17]. Spectral analysis of the normal uterine arteries reveals flows ranging from 9–44 cm/seconds and resistive indices ranging from 0.59–0.86 (mean, 0.73) [18]. There are also prominent parametrial vessels. Small AVMs may resolve spontaneously without intervention. However, when patients present with menorrhagia and anemia, angioembolization may be required. It is important to make the diagnosis of AVM because D&C can lead to serious hemorrhage [2,18]. Another cause for hypervascularity in the myometrium in the post-partum period unrelated to D&C is enhanced myometrial vascularity from subinvolution of the placental implantation site. Like AVM’s, subinvolution of the placental implantation site may cause vaginal bleeding that may resolve on its own or require embolization particularly when very high velocity flow is detected [16]. Uterine arteriovenous malformations may also be seen with gestational

trophoblastic disease and in cases where the beta human chorionic gonadotropin is positive, it is important to consider placental site trophoblastic tumour that is a rare condition that may occur 4–36 months following pregnancy [18,19].

Endometritis may be due to sexually transmitted diseases associated with pelvic inflammatory disease or may occur secondary to RPOC. Women typically have a vaginal discharge and may have pelvic pain and fever. On US, the endometrium is thick and heterogeneous with fluid and debris in the endometrial canal [1,2]. Gas may be present characterized by echogenic foci with dirty shadowing (Figure 15).

## Conclusion

Endometrial conditions are common in women of all age groups and radiologists play an important role in the diagnostic work-up of these patients. In women with abnormal vaginal bleeding, ultrasound is the first-line imaging modality and dictates when a woman needs endometrial biopsy to differentiate benign from malignant or premalignant conditions. When the endometrium is not well evaluated with US, hysterosonography or MRI is performed. Some women with endometrial conditions are asymptomatic and radiologists are the first to detect an abnormality on a study performed for another indication. Women in the postpartum period may have vaginal bleeding due to retained products of conception that must be differentiated from a uterine AVM to avoid catastrophic hemorrhage from D&C. RPOC must also be differentiated from enhanced myometrial vascularity from subinvolution of the placental implantation site. Hysterosonography may diagnose endometrial causes of infertility such as endometrial synechiae.

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