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Transvaginal Scanning of the Endometrium

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Abstract: Transvaginal sonography (TVS) can accurately depict the anteroposterior, width, and long axis of the endometrium. This article describes and illustrates normal and abnormal endometria as depicted by TVS. **Indexing Words:** Endometrium · Transvaginal sonography

The recent development and clinical application of transvaginal transducers/probes has greatly enhanced the sonographic imaging of the endometrium over that obtained with conventional transabdominal scanning.[1] The major factors that have contributed to this enhancement include a shorter probe-to-target distance, which allows the use of higher frequency transducers, and the use of multielement phased linear arrays, which give more tightly focused beams with higher line densities than that attainable with conventional real-time probes.

After a discussion of the sonographic features of normal endometrium, this review will discuss and illustrate the clinical applications of this improved sonographic depiction of the endometrium by transvaginal scanning. These include

1. Sonographic detection of decidual changes in early intrauterine and ectopic pregnancy.
2. Adjunctive evaluation of some benign endometrial disorders such as endometritis or hyperplasia after detection by dilatation and curettage (D&C).
3. Sonographic detection of the extent of myometrial invasion (involvement) by endometrial carcinoma and malignant trophoblastic disease.
4. Evaluation of poor endometrial development.

Some of the material in this review has been excerpted from other papers we have prepared on this topic.[2] The material also complements that first reported by the clinical investigators at Western Pennsylvania Hospital.[1]

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INSTRUMENTATION

There are a variety of configurations of transvaginal transducer/probes, which vary according to the number and configuration of transducer elements, overall size and shape of the probe as well as the transducer frequency and beam focusing characteristics that are utilized. In general, transvaginal transducer/probes that afford the highest line density within a sector field-of-view of 85° to 120° are preferable. The transducer portion of the probe can have a variety of configurations including a mechanical sector single element transducer with an oscillating element, an electronically phased-array multielement transducer, a curved linear multi-element transducer, or rotating wheel configuration. In general, the curved linear multielement transducers afford the best line density and overall field-of-view for imaging of the endometrium. The frequency of the transducers of these probes ranges from 5MHz to 10 MHz and their focal field should be adjustable by the operator. The field of view of some rotating wheel mechanical sector transvaginal probes can be steered by adjusting the thumb wheel in the shaft of the probe. This affords an extended field of view without significant manipulation of the probe within the vagina.

SCANNING TECHNIQUE

With transvaginal scanning, one can image the endometrium in several different scanning planes (Figure 1).* The most useful and reproducible ones include

1. sagittal or long-axis views.

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2. semicoronal.
3. semiaxial views.

First, the endometrium should be imaged in its long axis by gently angled (anterior for anteflexed or posterior for retroflexed uterus) sagittal scans through the uterus with the probe head in the region of the uterine cervix. Second, the endometrium can be imaged in its short axis in a semicoronal or semiaxial plane by turning the probe approximately 90°. The fundus is imaged by directing the probe in various degrees of anterior or posterior inclinations as it is held next to the cervical lips. Imaging of the endometrium can be empirically optimized by observing the image when the probe is either inserted or withdrawn from the vaginal fornices.

In the long axis, one can appreciate the different interfaces arising from the endometrium itself beginning with the interface at the endocervical canal. This is highly contrasted in the periovulatory period when the cervical mucus has a high fluid content and is relatively anechoic compared with when the cervical mucus is thicker in the secretory phase resulting in a more echogenic texture.

After adequate images in the long axis are obtained, the probe can be turned 90° to image the uterus in a semicoronal or semiaxial plane (Figure 1B). In this plane, one can usually delineate the invagination of endometrium into the area of the tubal ostia. Imaging of the endometrium in this plane can be optimized by varying the position of the probe within the vagina. For example, the probe can be withdrawn and angled sharply anteriorly for very anteflexed uteri.

Once the endometrium is adequately imaged in its long and short axis, images of the cervix can be obtained after the probe is withdarwn into the mid-vagina. Cervical mucus within the endocervical canal has a different appearance to the endometrium throughout most of the cycle. It usually appears as a thin, mildly echogenic interface, except during ovulation, when the cervical mucus is anechoic due to its more fluid consistency.

NORMAL ENDOMETRIUM

Because of the relatively small size of the vagina in prepubertal girls, it is, in general, inadvisable to perform transvaginal sonography on girls prior to menarche. The same caution applies to postmenopausal women over 60 years of age whose vaginas may be atrophic or women who have vaginal adhesions secondary to the previous surgery for whom the examination may be painful. One should also be aware of whether or not the procedure might injure an intact or partially intact hymen since a transvaginal sonogram could induce unnecessary bleeding and/or pain.

After menarche, the endometrium undergoes cyclic changes in its thickness and texture, which can be related to the relative amounts of serum estrogen and progesterone (Figure 2). During the menstrual phase, the endometrium appears as an echogenic interrupted layer of 1 mm to 4 mm in total anterior/posterior width. A hypoechoic outer layer can be identified surrounding the endometrium corresponding to the inner layer of myometrium. This hypoechoic appearance of the inner myometrium may be related to the more compact configuration of the myometrial cells in this area or the relatively greater proportion of the connective tissue and smooth muscle of the intermediate and external layers of myometrium when compared to the inner layer. One millimeter to two millimeter vessels can be seen in the external myometrium, representing a venous plexus in the outer portion of the myometrium.[3] In older women, calcification may occur secondary to cystic medial necrosis within the arcuate arteries that course along the outer myometrium. These calcifications appear as punctate echogenicities.

During the proliferative phase, the endometrium thickens between 4 mm and 8 mm, and has a isoechoic or slightly hyperechoic texture relative to the outer myometrium (Figure 2A). In the late proliferative or peri-ovulatory phase of endometrial development, a multilayered endometrium can be seen (Figure 2B).[4] The inner hypoechoic area probably represents edema in the compact layer of the endometrium. As imaged in a semiaxial or semicoronal plane, the endometrium has the configuration of a theta (θ) with respect to the hypoechoic areas. In the secretory phase, the endometrium achieves a width of between 8 mm and 16 mm, and is echogenic, probably related to increased mucus and glycogen within the glands as well as the increased number of interfaces created by tortuous glands present in the secretory phase (Figure 2C). The endometrium typically achieves its greatest thickness in the midsecretory phase of a spontaneous cycle measuring up to 14 mm in width.

Endometrial volumes can be estimated by measurement of the long axis, anterioposterior, and transverse dimensions of the endometrium (Figures 2A, 2B, and 2C). The location at which the endometrium invaginates into the region of the tubal ostia can be used as a landmark for

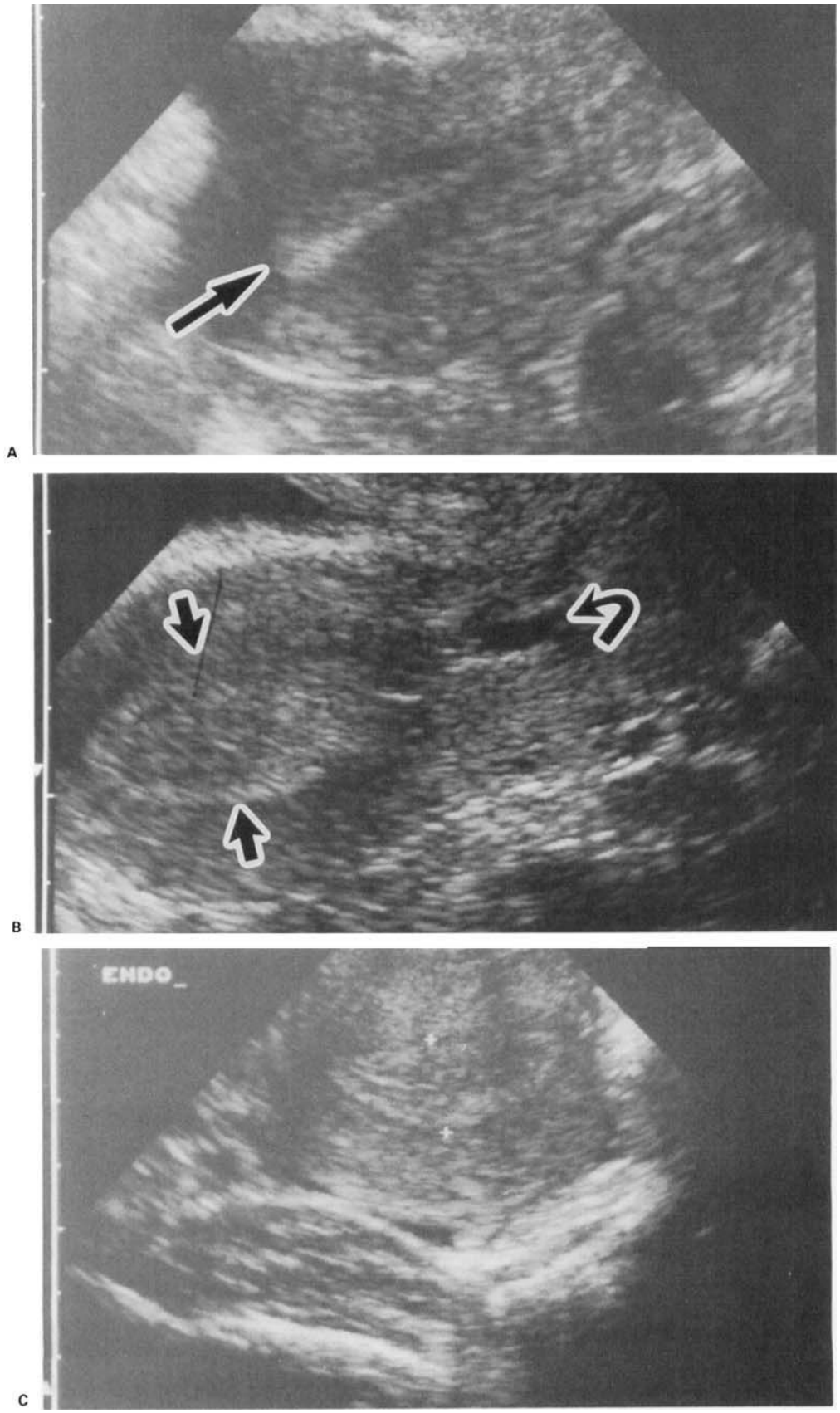

FIGURE 1. Scanning planes utilized for imaging the endometrium with TVS. **(A)** Long axis. Mildly echogenic endometrium in the early secretory phase (arrow). **(B)** Semicoronal plane (long axis). The transverse width of the endometrium (between straight arrows) is indicated. The cervical mucus within the endocervical canal has a high fluid content (curved arrow). **(C)** Semicoronal plane (short axis). By advancing the probe and angling it anteriorly, the endometrium (between plusses) is seen in its short axis.

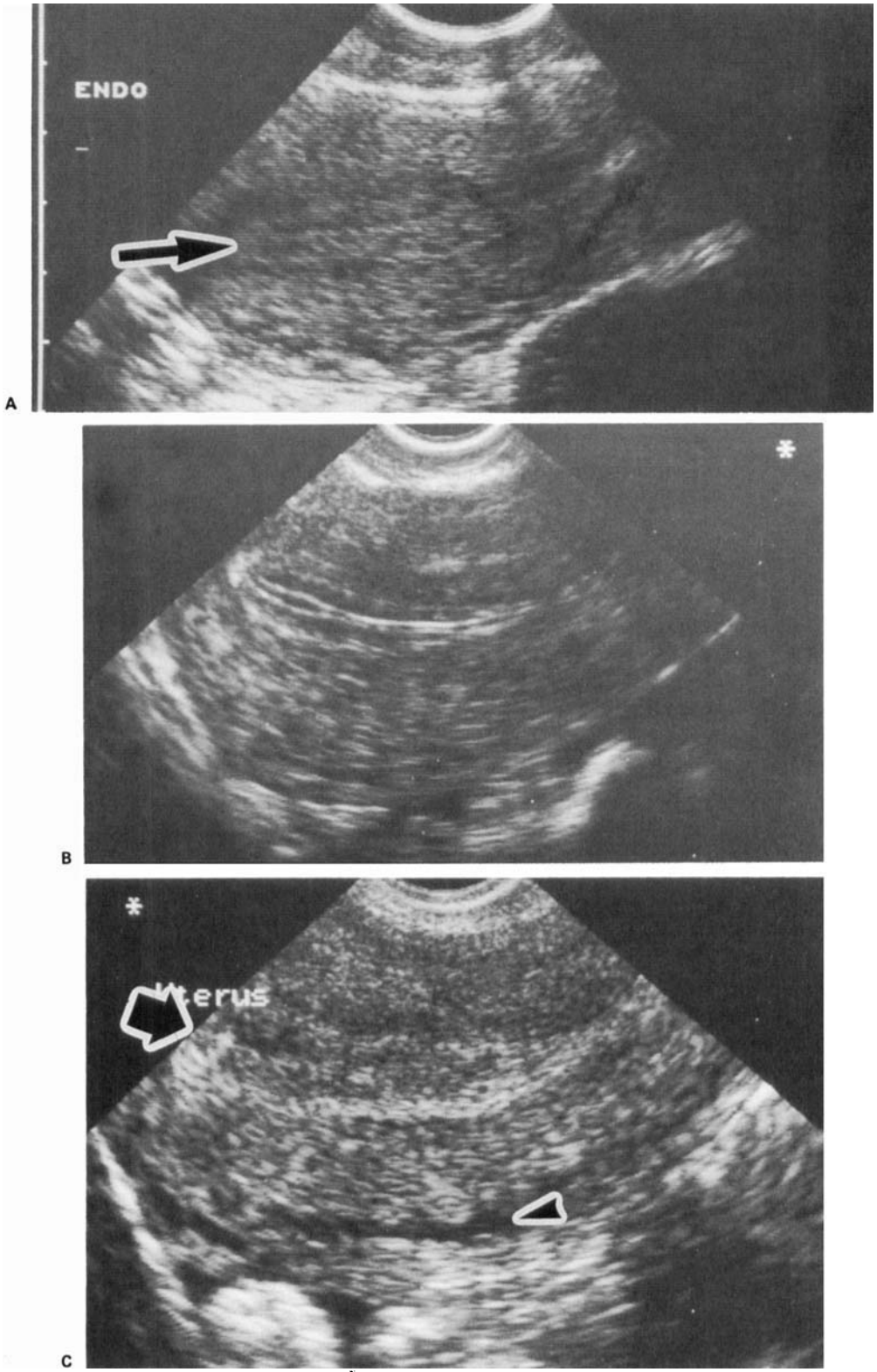

FIGURE 2. Normal cyclical changes of the endometrium. **(A)** Proliferative phase endometrium (arrow) appearing as isoechoic with the myometrium. **(B)** Late proliferative/early secretory phase endometrium showing multilayered endometrium in long axis. **(C)** Secretory phase endometrium (arrow) appearing as echogenic tissue compared to surrounding myometrium. The arcuate vessels are seen in the outer third of the myometrium (arrowhead).

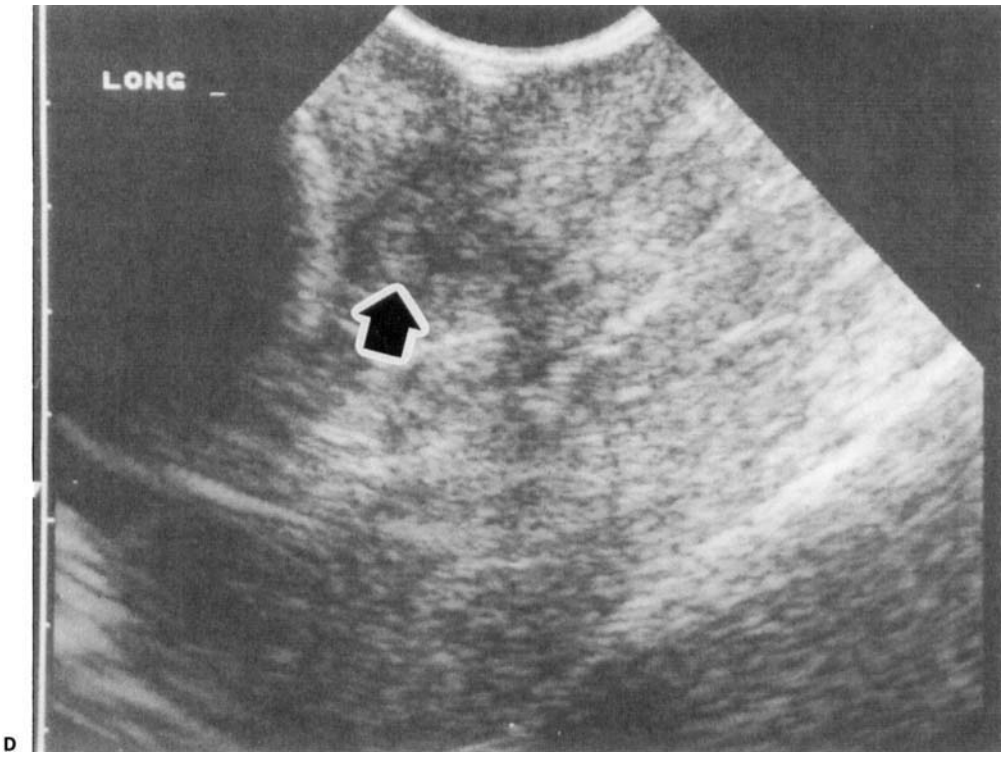

FIGURE 2. (D) Normal atrophic endometrium (arrow) in a postmenopausal woman.

measurement of the endometrium in the transverse plane. The endometrial volumes in our study of 10 normal women between 19 years and 39 years of age with spontaneous cycles demonstrate a statistically significant difference ($p > 0.02$) between proliferative (1.6 ± 0.4 mL) and secretory phase endometrium (3.6 ± 0.8 mL).

The endometrium in postmenopausal women should be thin (less than 10 mm) and is histologically atrophic (Figure 2D). Mucus trapped within the lumen may give the sonographic impression of a thickened endometrium. Postmenopausal women taking estrogen replacement may have relatively thick endometria, more than 12 mm in width, in response to the medication.[5] However, the actual range of normal thickness and texture for this group of patients has not been reported to date, and one has to rely on subjective assessments.

DECIDUAL CHANGES IN EARLY INTRAUTERINE PREGNANCY

Transvaginal sonography has had a major impact on the evaluation of patients with complicated early pregnancy. In particular, transvaginal sonography facilitates early detection of intrauterine pregnancy thereby virtually excluding the possibility of an ectopic pregnancy. The possibility of a heterotopic (ectopic and intrauterine) pregnancy should be suspected, however, in women on ovulation induction medication since multiple implantations of viable concepti can occur.

If pregnancy is achieved, the endometrium continues to be thick after the secretory phase of the conception cycle. The endometrium becomes more transonic due to its increased fluid content (Figure 3A). At 3 weeks to 4 weeks, menstrual age, the endometrium appears as a thickened interface not dissimilar to that seen in other endometrial disorders such as endometritis and endometrial hyperplasia.

After approximately 4 weeks, the chorionic sac can be delineated as an echogenic region with a hypoechoic center within the decidualized endometrium (Figure 3B). The decidua appears as an echogenic area surrounding the hypoechoic sac. Early in embryonic development, the hypoechoic gestational sac is seen within the echogenic chorionic mass.[6] With further differentiation of the choriodecidua, two layers of choriodecidua can be seen, representing the chorion frondosum/decidua capsularis surrounded by the decidua parietalis or vera and chorionic laeve.

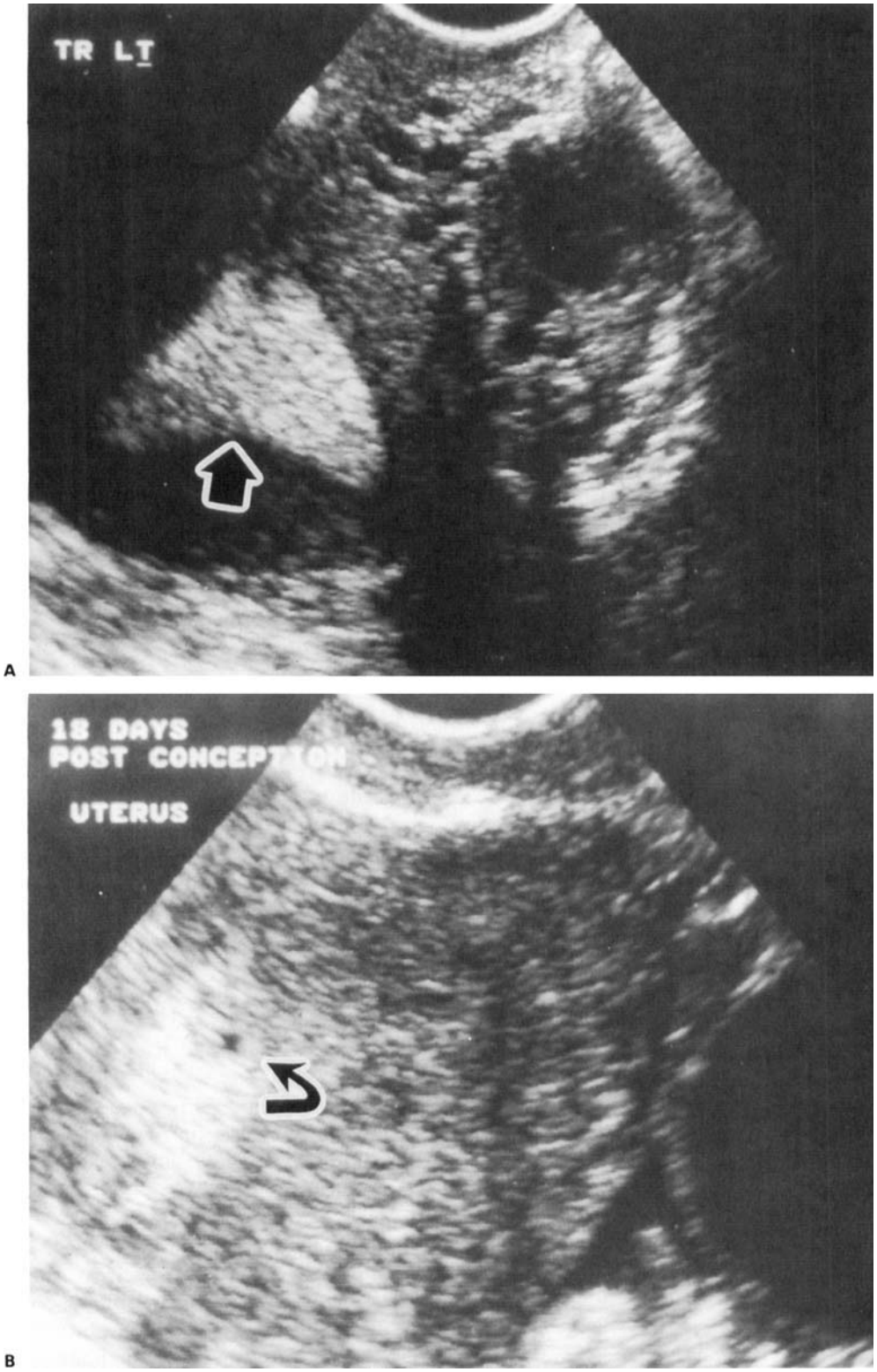

FIGURE 3. *Decidual changes.* **(A)** *Thickening of the endometrium (arrow) secondary to decidualization at 2 weeks 5 days after last menstrual period.* **(B)** Chorionic sac (curved arrow) identified at 18 days post-conception in successful in vitro fertilization (IVF cycle).

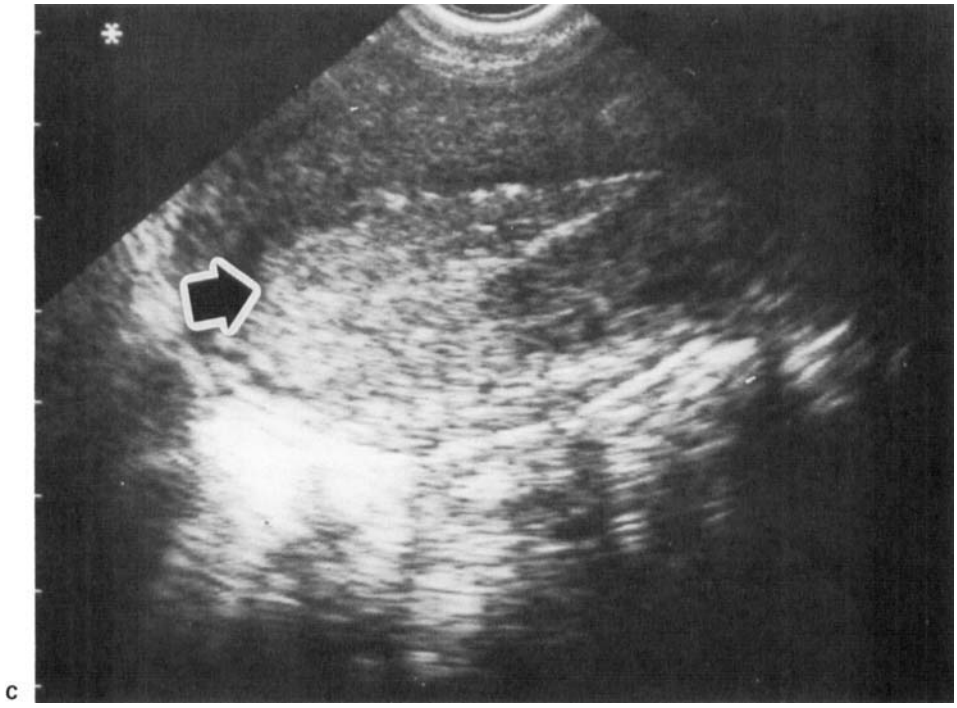

FIGURE 3. (C) Decidualized endometrium (arrow) in an unruptured ectopic pregnancy.

DECIDUAL CHANGES IN ECTOPIC PREGNANCY

Understanding the decidual changes that occur within the endometrium in intrauterine pregnancies is helpful in distinguishing that from the decidual reaction occurring in ectopic pregnancy. In ectopic pregnancy, the endometrium does undergo decidual changes without formation of chorionic villi. The typical appearance on TVS of decidualized endometrium is an echogenic linear interface similar to that seen in a secretory phase endometrium (Figure 3C). Rarely, the decidualized endometrium of an ectopic pregnancy contains intraluminal fluid, simulating the appearance of an abnormal gestational sac. The pseudogestational sac of an ectopic pregnancy can be confused with an early intrauterine pregnancy decidual reaction at 6 weeks to 8 weeks, menstrual age. Here, there has been decidualization of the endometrium, but due to poor luteal support, areas of hemorrhage and necrosis occur within the decidua. On transvaginal sonography, these appear as anechoic areas within the decidua as well as internally where there can be fluid collection within the lumen simulating a gestational sac. However, the pseudogestational sac associated with an ectopic pregnancy is rarely the size expected for a sac of an intrauterine pregnancy at a comparable menstrual age and the sac itself is irregular.[7]

BENIGN ENDOMETRIAL DISORDERS

Although it is not possible to definitely differentiate benign from malignant endometrial disorders based on their sonographic appearance with transvaginal sonography, many patients with endometrial disorders will present after histological evaluation of material obtained at dilatation and curettage. Most of these patients have dysfunctional uterine bleeding or a history of pelvic inflammatory disease. Thickened endometrium may also be discovered on a pelvic sonogram performed for an unrelated problem such as for evaluation of an adnexal mass.

Hyperplasia of the endometrium is thought to occur secondary to the trophic influence of unopposed estrogen. The endometrium thickens and becomes pseudopolypoid in configuration. In mild cases, the polyps are microscopic but in more severe cases the polyps can measure up to 5 cm in size. In these patients, thickening of the endometrium over that expected for women of comparable age is usually detected on TVS (Figure 4A). In perimenopausal women, endometria of greater than 12 mm in thickness should be an indication for further evaluation, whereas in the postmenopausal patient, endometria over 8 mm should be considered abnormal. The sonographic findings must be interpreted in light of the patient's clinical presentation and laboratory findings.

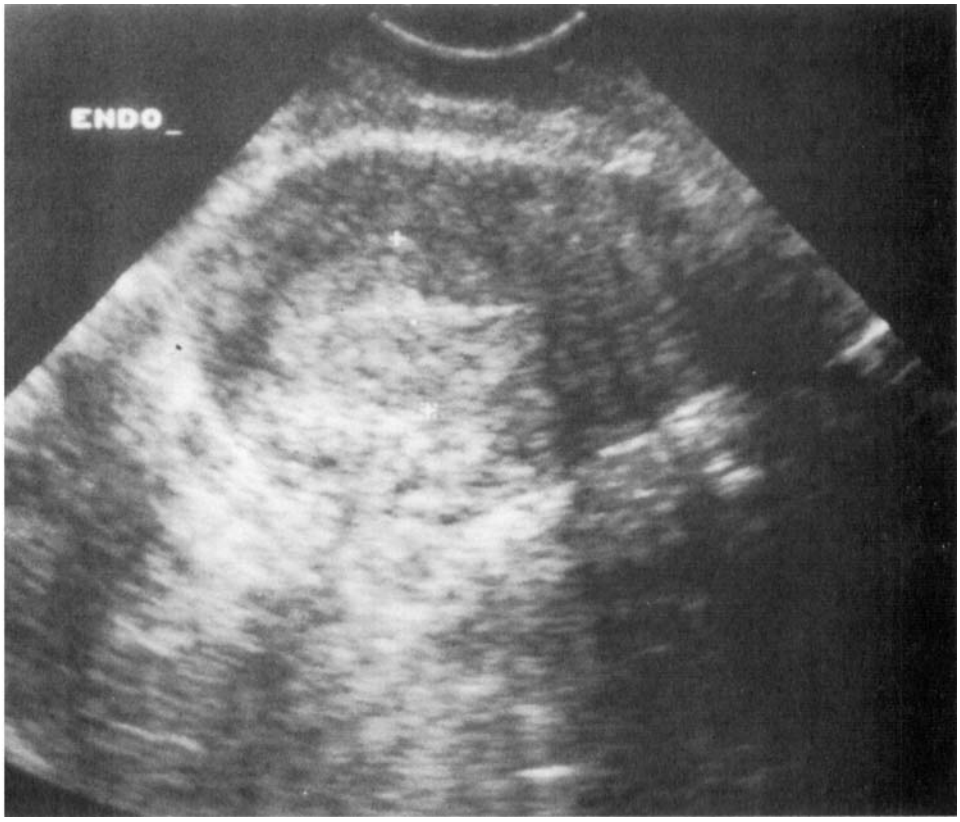

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FIGURE 4. Endometrial hyperplasia/carcinoma. **(A)** Hyperplastic endometrium (between plusses) with polyps.

Endometritis with or without intraluminal fluid can produce increased echogenicity and thickening of the endometrium (Figure 5A). In some cases, the hydropyosalpinx/tubo-ovarian abscess associated with pelvic inflammatory disease can be identified by transvaginal sonography as well.[1]

Occasionally, unclotted blood within the lumen is hypoechoic. Fluid can also be present within the endometrial lumen in a variety of disorders related to fluid overload or as a reflection of retained secretions related to cervical stenosis from cervical carcinoma and/or radiation-induced fibrosis with hematometrocolpos. Rarely, trapped collections of mucus can also create the sonographic impression of a thickened endometrium.

MALIGNANT ENDOMETRIAL DISORDERS

Sonography has an important role in management decisions concerning preoperative radiation therapy in patients with stage I adenocarcinoma of the endometrium.[8] In patients who demonstrate deep (over 50% of myometrium) invasion, preoperative radiation therapy may be administered with ovoids and tandem to reduce the likelihood of pelvic recurrence.[9] TVS seems to be accurate in determining whether invasion is deep or superficial (defined as less than 50% of myometrial width) (Figure 4B–G). Polypoid tumors may cause an apparent distension of the endometrial lumen and extrinsic thinning of the myometrium. However, the hypoechoic layer surrounding the endometrium is usually intact in these patients, indicating that the tumor is confined to the inner layers of myometrium. Tumors extending into myometrium can appear either hypoechoic or echoic. More differentiated tumors tend to be more echogenic than the less differentiated ones. The echogenicity is also probably related to the number of interfaces created by the infiltrating tumor and the myometrium.

MISCELLANEOUS CONDITIONS

Transvaginal sonography of the endometrium has an important role in determining the exact location of masses within the myometrium such as uterine fibroids. By detecting the displacement or distortion of the endometrium by myometrial masses, the relative size of the myometrial mass can be inferred.

Sonographic imaging of the endometrium has

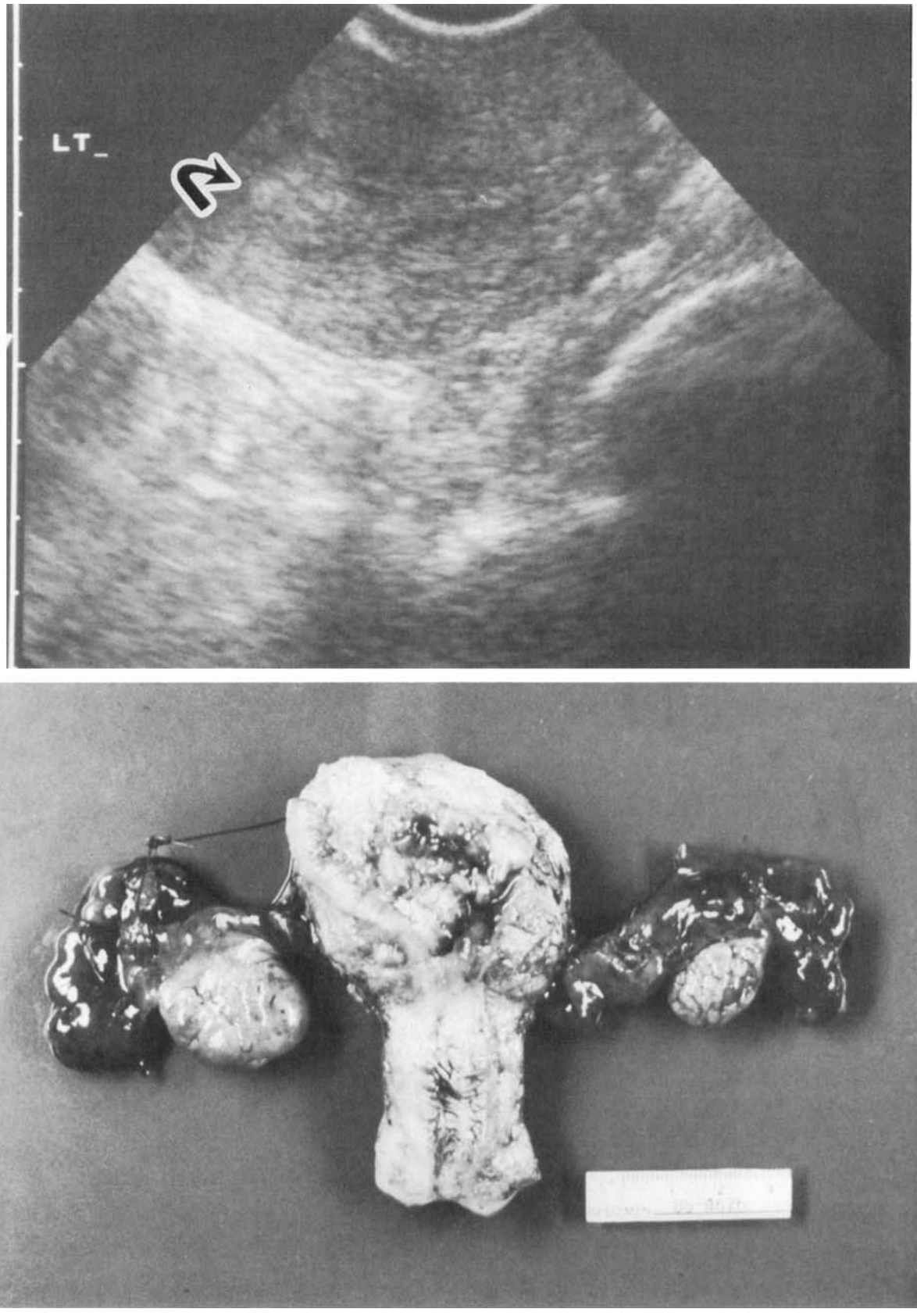


FIGURE 4. (B) Noninvasive polypoid tumor (curved arrow) expanding the endometrial lumen. **(C)** Sectioned specimen showing polypoid tumor within upper uterine lumen.

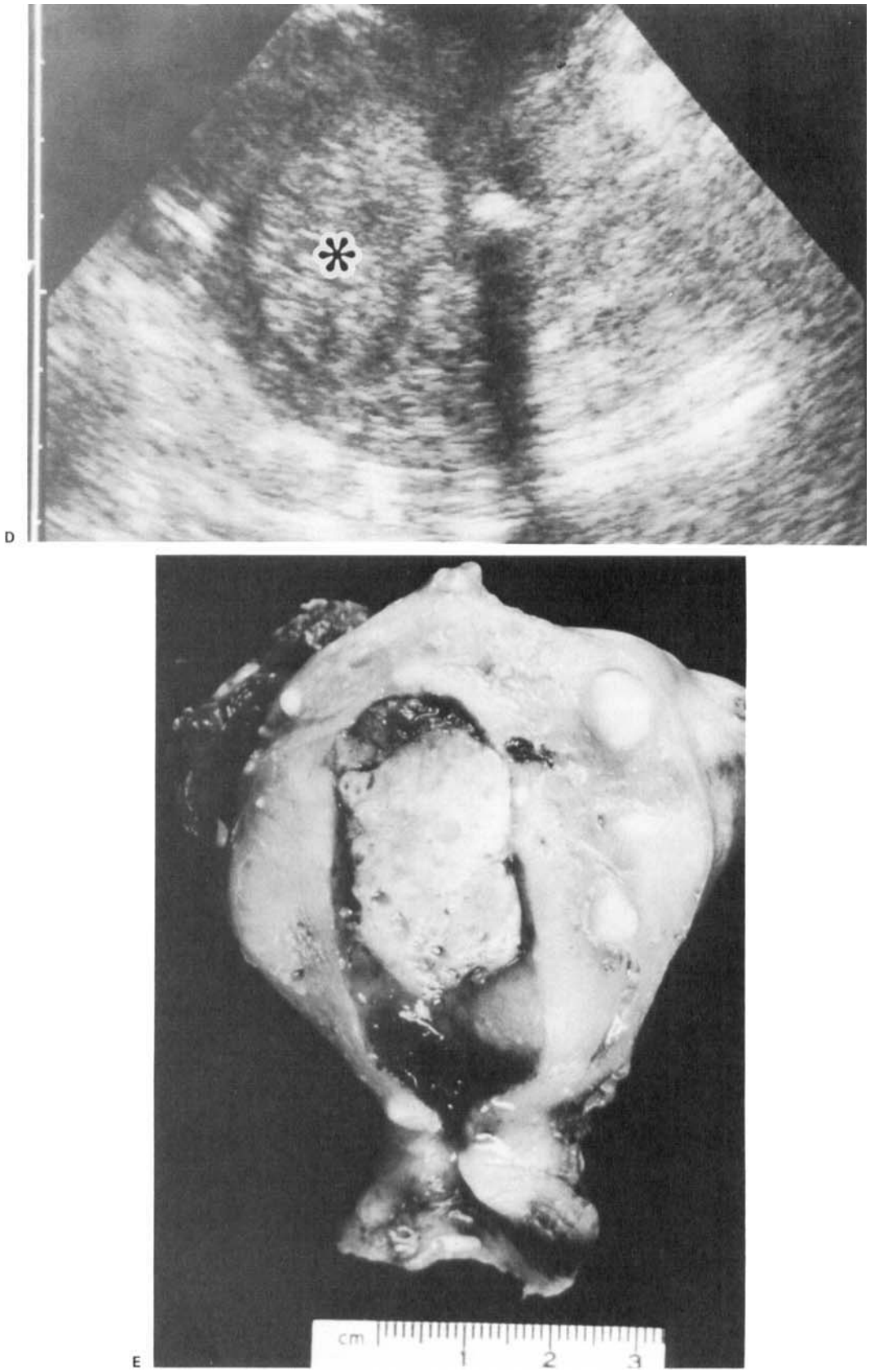
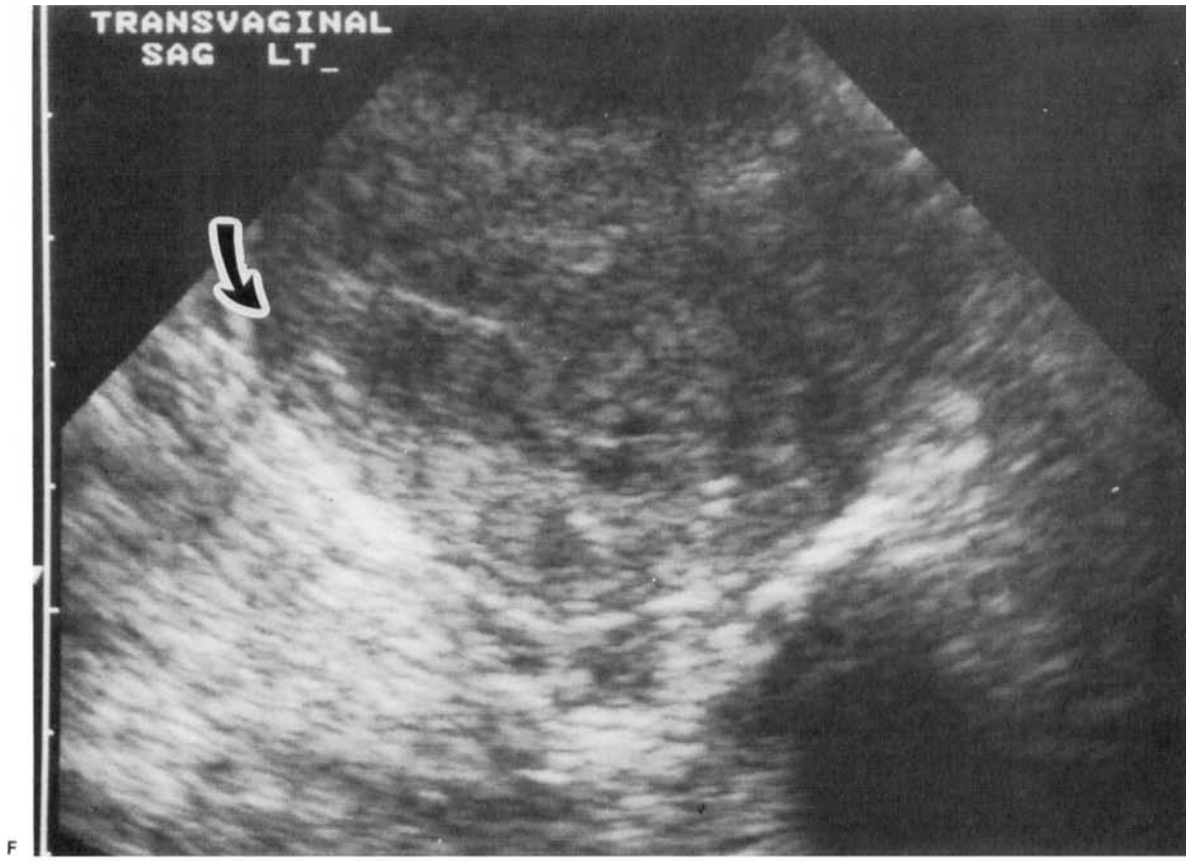


FIGURE 4. (D) Noninvasive polypoid tumor (asterisk) demonstrating an intact subendometrial halo. Within the myometrium is a small calcified intramural fibroid. **(E)** Sectioned specimen of Figure 4D showing exophytic tumor and multiple intramural fibroids.



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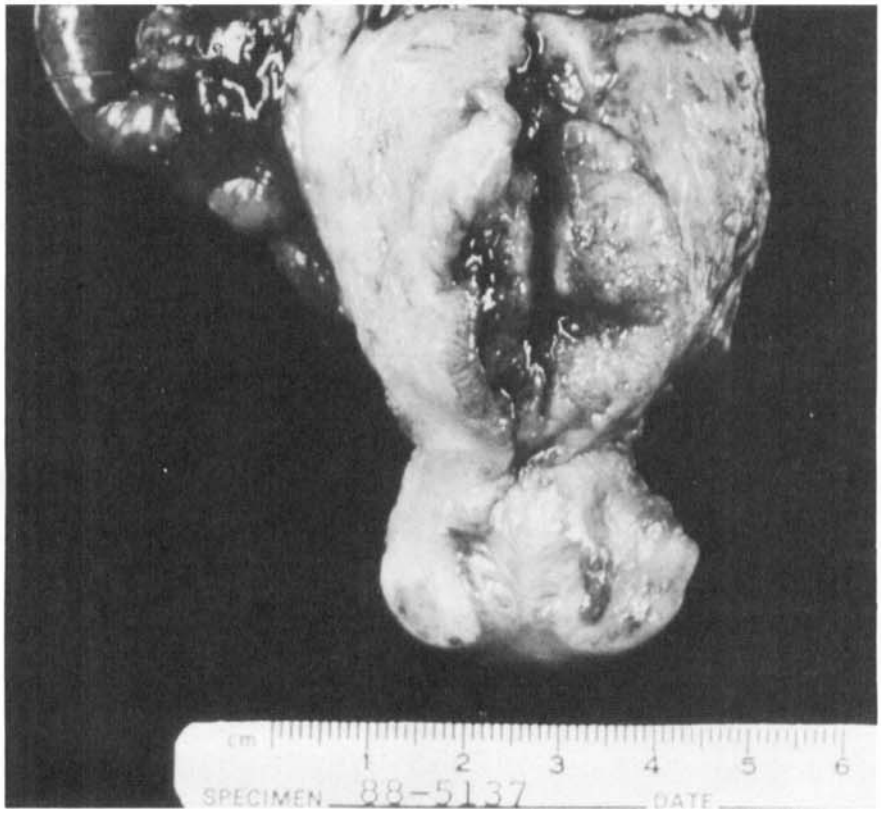

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FIGURE 4. (F) Invasive endometrial tumor as suggested by an irregular and thickened hypoechoic endometrium (arrow). **(G)** Sectioned specimen of Figure 4F showing invasive tumor.

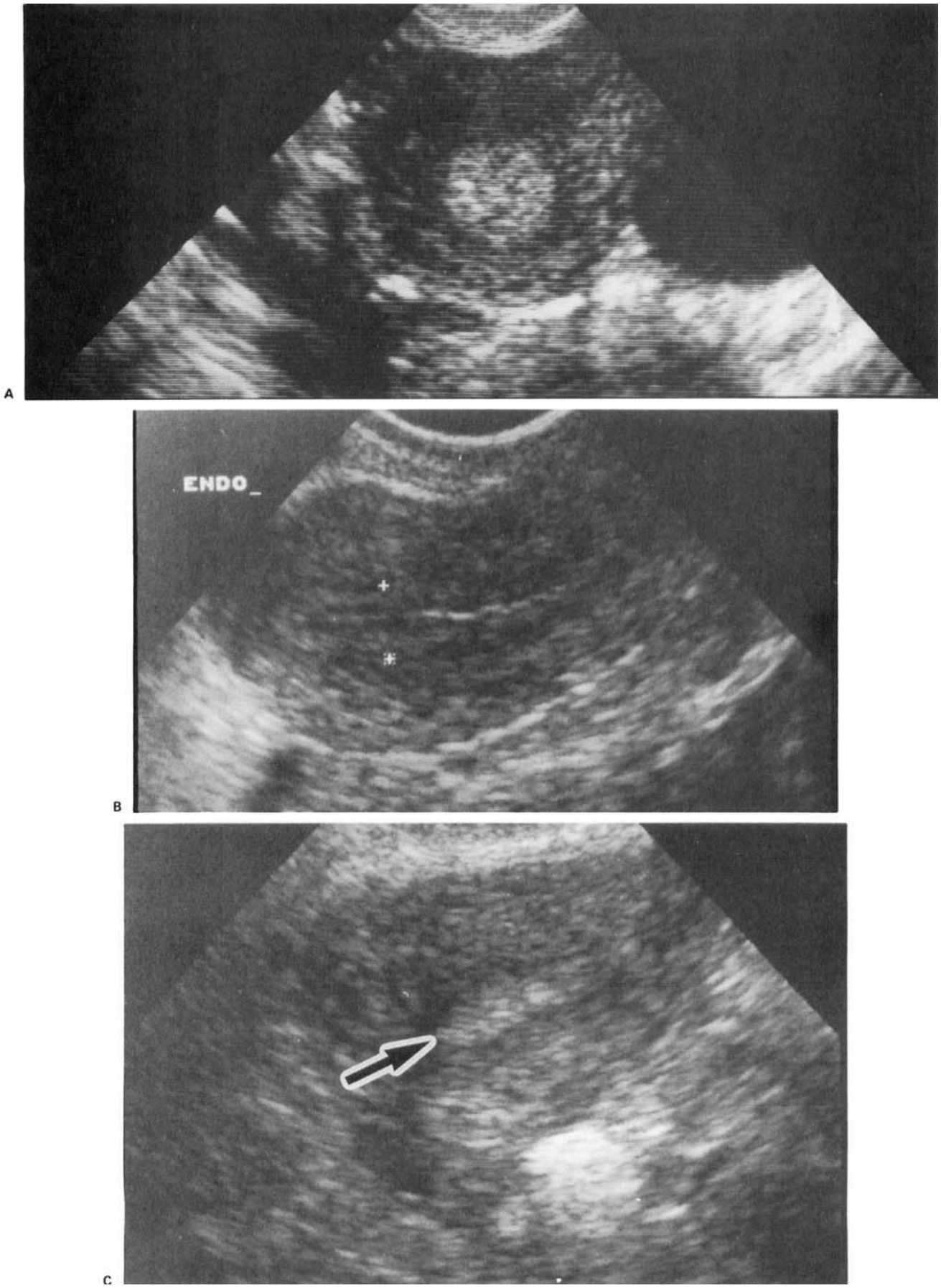

FIGURE 5. Miscellaneous conditions affecting the endometrium. **(A)** Endometritis appearing as a thickened endometrium seen in short axis (courtesy of Ellen Mendelson, MD). **(B)** Multilayered midcycle endometrium (between plusses) in a successful IVF conception cycle. **(C)** Thin midcycle endometrium (arrow) in a nonconception IVF cycle.

an important role in identifying the endometrial lumen in uteri that are malformed due to fusion disorders such as a bicornuate uterus. Although not as definitive as hysterosalpingography, one can detect the echogenic endometrium in the lumen of a malformed uterus with TVS. This technique also facilitates the introduction of catheters transcervically such as transuterine gamete intrafallopian tube transfer (GIFT) techniques.[10]

Recent studies with transvaginal sonography corroborates those done with transabdominal sonography, which indicate that the texture of the endometrium may have predictive value concerning the relative probability that a pregnancy will be achieved after ovulation induction.[11-13] When two 20-patient groups who underwent similar ovulation induction prior to in vitro fertilization and embryo transfer were analyzed, it was noted that patients who achieved pregnancy more frequently had a multilayered periovulatory endometrium than the group who did not conceive (74% vs. 26%) (6) (Figure 5B and C). Similarly, in the secretory phase, conception was found to be more likely when there was an echogenic and thick (over 13 mm) endometrium 11 days postovulation.[2] In luteal phase inadequacy, the secretory endometrium is not maintained once pregnancy is achieved. On sonography, the endometrium may be thinner and less echogenic than expected in these patients.

SUMMARY

This review has discussed and illustrated the numerous applications of transvaginal sonography in the sonographic evaluation of the endometrium. Its major applications are in early pregnancy evaluation and in evaluation of patients with endometrial carcinoma. As more clinical experience with this technique is gained, more extensive application of this technique will undoubtedly come about.

REFERENCES

1. Mendelson EB, Bohm-Velez M, Joseph N, Neiman HL: Endometrial abnormalities: Evaluation with transvaginal sonography. *AJR* 150:139–142, 1988.
2. Fleischer A, Gordon A, Entman S, et al: Transvaginal sonography of the endometrium, in *Principles and Practice of Ultrasonography in Obstetrics and Gynecology* (ed 4), Fleischer A, Romero R, Manning F, Jeanty P, James A (eds). Appleton and Lange, Norwalk, CT, 1989.
3. Farrer-Brown, Beilby JOW, Tarbit MH: The blood supply of the uterus. *J Obstet Gynaecol Br Commonwealth* 77(8):673–681, 1970.
4. Forrest TS, Elyaderani MK, Muilenburg MI, Bewtra C, Kable WT, Sullivan P: Cyclic endometrial changes: US assessment with histologic correlation. *Radiology* 167:223–237, 1988.
5. Salm R, Redruth, Cornwall: Mucin production of normal and abnormal endometrium. *Arch Pathol* 73:30–39, 1962.
6. de Crespigny L, Cooper D, McKenna M: Early detection of intrauterine pregnancy with ultrasound. *J Ultrasound Med* 7:7–10, 1988.
7. Nyberg DA, Filly RA, Laing FC, Mack LA, Zarutskie PW: Ectopic pregnancy: Diagnosis by sonography correlated with quantitative HCG levels. *J Ultrasound Med* 6:145–150, 1987.
8. Fleischer AC, Dudley BS, Entman SS, Baxter JW, Kalemeris GC, James AE: Myometrial invasion by endometrial carcinoma: Sonographic assessment. *Radiology* 162:307–310, 1987.
9. Calitchi E, Lobo P, Martin M, et al: The role of radiation therapy in the treatment of adenocarcinoma of the corpus uteri stage I: A ten year experience (1970–1979). *Acta Radiol Oncol* 23:461–466, 1984.
10. Jansen RPS, Anderson JC: Catheterization of the fallopian tubes from the vagina. *Lancet* 2:309–310, 1987.
11. Fleischer A, Herbert C, Wentz A: Transvaginal sonography of the endometrium in conception and nonconception IVF cycles. 1988, in preparation.
12. Rabinowitz R, Laufer N, Lewin A, Navot D, Bar I, Margalioth EJ, Schenker JJG: The value of ultrasonographic endometrial measurement in the prediction of pregnancy following *in vitro* fertilization. *Fertil Steril* 45(6):824–828, 1986.
13. Brandt TD, Levy EB, Grant TH, Marut E, Leland J: Endometrial echo and its significance in female infertility. *Radiology* 157:225–229, 1985.