STEPWISE STANDARDIZED APPROACH TO THE BASIC ULTRASOUND EXAMINATION OF THE FEMALE PELVIS

14

INTRODUCTION

The stepwise standardized approach to the basic ultrasound examination of the female pelvis applies a structured and standardized method of ultrasound examination which is simple to learn and complies with existing guidelines for the performance of the gynecologic examination (1). This stepwise approach is comprised of five steps that are geared towards the identification of pelvic abnormalities and comprise the basic gynecologic ultrasound examination. The five steps are designed to assess the bladder, uterus and cervix, the cul-de-sac, the adnexae and surrounding structures. This chapter describes the sonographic approach that is employed for each of the five steps and uses images and video clips to illustrate each step. Evaluation of the female pelvis by ultrasound is best achieved by the transvaginal approach, using a transvaginal transducer. This chapter will focus on this approach. When the transvaginal approach is not feasible, the transrectal approach is preferred and is usually well tolerated. The presence of a large pelvic mass that expands outside of the range of the transvaginal transducer necessitates a complementary abdominal approach for comprehensive assessment.

STEP ONE: PREPARING AND INTRODUCING THE TRANSVAGINAL TRANSDUCER

The transvaginal transducer is an endocavitary transducer that is designed to fit into small spaces. It is shaped like a long cylinder with a handle and has a small footprint at its tip that transmits and receives sound waves from the end of the transducer (**Figure 14.1**). The frequency range of a transvaginal transducer is typically in the 5-12 MHZ and given this high resolution, effective imaging to a 7-10 cm range can generally be achieved. The transvaginal transducer is made of a probe, or a transducer head, a connecting cable and a connector, or a device that connects the transducer to the ultrasound machine (**Figure 14.2**). The transvaginal transducer has a marker, such as a notch, a dot or a light that is typically located on the dorsal aspect, next to the handle of the probe (**Figure 14.1**). The transducer marker helps to identify the transducer orientation. For more information on the transvaginal transducer and its function please review chapters 1 and 2.

Figure 14.1: Transvaginal ultrasound transducer: note its shape like a long cylinder with a handle (labeled) and has a small footprint (labeled) at its tip that transmits and receives sound waves. The image also shows the transducer marker (labeled).

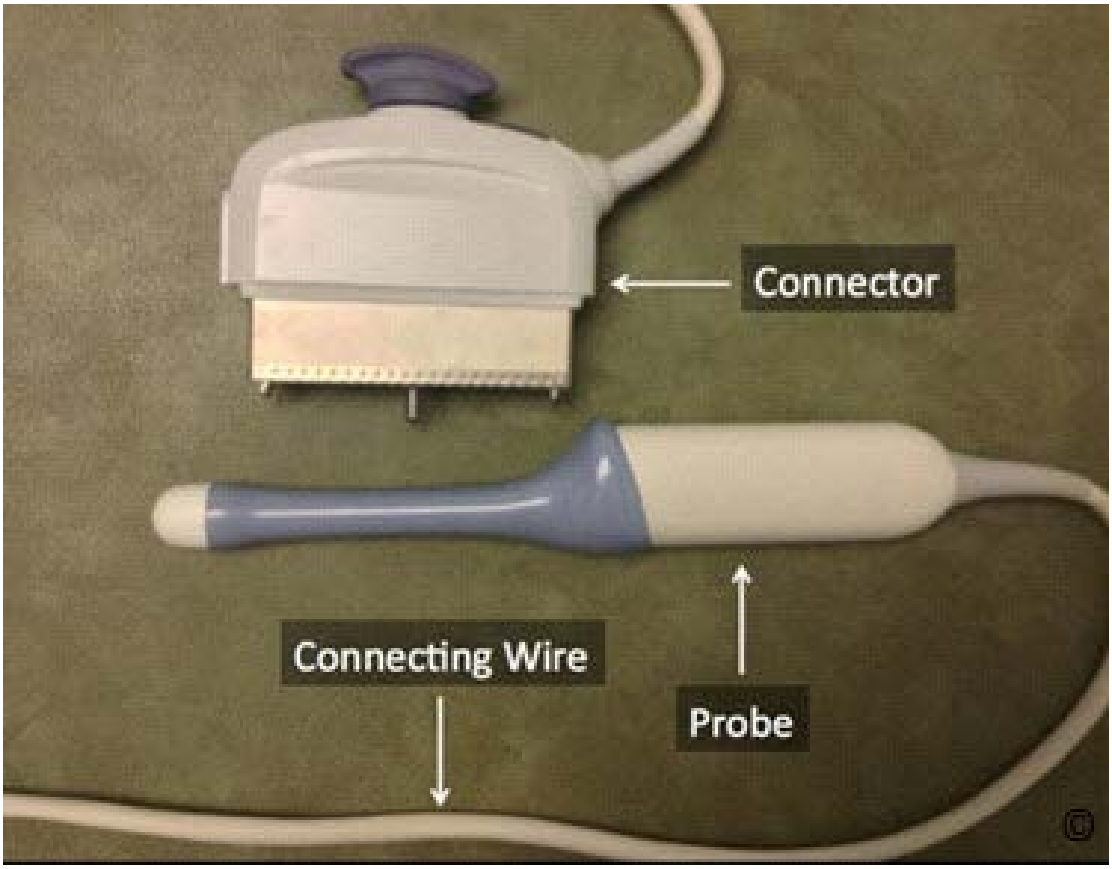

Figure 14.2: Transvaginal ultrasound transducer: Note its components that include the probe (see figure 14.1), a connecting wire (cable) and a connector (labeled). See text for details.

It is optimal to perform the transvaginal ultrasound on a gynecologic examination table. This table is equipped with 2 footrests, which allows the patient to assume the lithotomy position for convenient transvaginal scanning. The gynecologic examination table also has a retractable leg support, which makes the transabdominal sonographic examination more comfortable (**Figure 3.2** in Chapter 3). If a gynecologic examination table is not available, an elevation below the woman's pelvis will enable the downward tilt of the transvaginal transducer handle (**Figure 3.3** in Chapter 3).

Step One: Technical Aspects: Preparing and Introducing the Transvaginal Transducer

The woman's demographic data, her last menstrual period and other important pertinent observations should be recorded before the transvaginal ultrasound examination is initiated. When preparing a transvaginal transducer for use in an ultrasound examination of the pelvis, gel should be placed in a protective cover, such as a condom or the digit of a surgical rubber glove, and the transducer should be inserted in the protective cover in order to prevent microbial contamination. It is easier to place the gel in the condom rather than on the tip of the transducer, however if you are using the digit of a glove, placing the gel on the tip of the transducer will minimize air entrapment. The condoms or gloves must be clean but need not be sterile. Gel is also applied to the outside of the protective cover, at the transducer tip, to facilitate transmission of ultrasound waves given that sound waves do not transmit well in air. Before starting the preparation, it is recommended to inquire about the woman's allergy to latex in order to avoid its exposure. In the presence of latex allergy, latex free condoms/gloves should be employed.

The woman's bladder should be emptied. The operator performing the transvaginal ultrasound examination should wear a glove and hold the transducer is such a way to secure the protective cover in place (**Figure 14.3**). The woman should be informed that the transvaginal transducer is about to be inserted in her vaginal canal. The transvaginal transducer is then inserted into the lower vaginal canal under direct vision, with the transducer marker at the 12 o'clock position (**Figure 14.4**). The transducer should be advanced gently into the vaginal canal while maintaining this orientation. The authors recommend that the transvaginal transducer is pointed slightly downward towards the rectum while it is being gently advanced into the vaginal canal in order to minimize discomfort generated from the sensitive urethral region. The operator should advance the transvaginal transducer into the vaginal canal under real-time ultrasound and not in the freeze mode. This allows for the identification on the ultrasound monitor of the cervix or the vaginal fornix. Once the apex of the vagina is reached and seen on the ultrasound monitor, the transducer should be withdrawn slightly to reduce pressure on the cervix and the uterine isthmus and minimize distortion of uterine orientation. This maneuver of minimizing pressure on the vaginal apex with the transvaginal transducer will also minimize woman's discomfort. The small footprint region of the transvaginal transducer needs to remain in contact with the vaginal

mucosa in order to transmit and receive ultrasound waves. In a symptomatic woman, the transducer can be used to probe (transducer palpation) any pelvic organ seen on the monitor and thus try to elicit the symptom (pain) that the woman may have, by using the contralateral hand to apply gentle pressure from the abdomen, in similar fashion to the bimanual vaginal examination. This maneuver may localize the source of the woman's symptom. **Table 14.1** lists the various ways that the transducer can be manipulated during the transvaginal ultrasound examination.

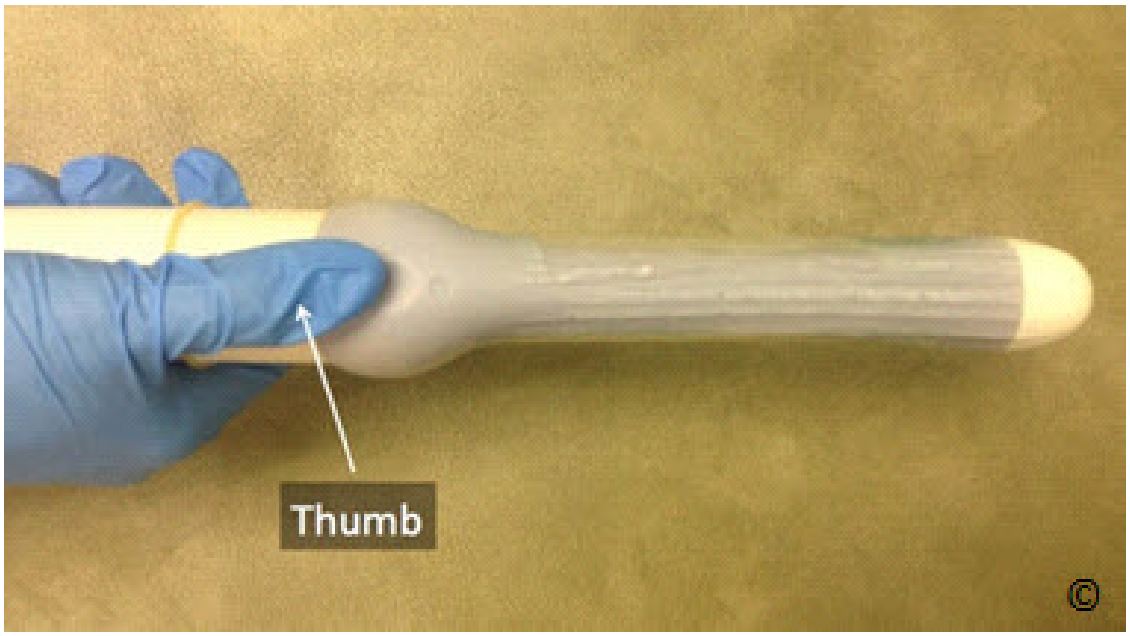

Figure 14.3: Note the preferred way to hold the transvaginal transducer during the ultrasound examination. The probe should rest in the palm of the operators scanning hand protected by a glove with the thumb on the transducer's marker, securing the protective cover in place.

Figure 14.4: This image shows the orientation of the transvaginal transducer during insertion into the lower vaginal canal. The transducer marker (labeled) is kept at the 12 o'clock position during gentle insertion under direct vision and in real-time ultrasound mode. A mannequin is used for this demonstration.

TABLE 14.1	Manipulation of the Transducer During the Transvaginal Ultrasound Examination

1) Tilting (angling) the shaft of the transducer in an inferior to superior, or left to right orientation
2) Advancing or retracting the transducer in the vaginal canal
3) Rotating the transducer around its longitudinal axis

STEP TWO: THE SAGITTAL PLANE OF THE UTERUS

The midsagittal plane of the uterus is the first plane imaged when the transvaginal transducer is introduced with the marker at the 12 o'clock position (**Figure 14.4**). In this plane, you can see the upper vaginal canal, the bladder, the cervix, the isthmus, the fundal region of the uterus and the cul-de-sac (**Figure 14.5**). The display on the monitor for the sagittal plane of the uterus shows the bladder on the upper left side of the screen with the external cervical os pointing toward the right side of the screen (**Figure 14.5**). If the uterus is anteverted or anteroflexed, the uterine fundus appears on the same side of the urinary bladder. If the uterus is retroverted or retroflexed, the uterine fundus points toward the opposite side of the bladder. There is currently no international consensus on the display of organs in the transvaginal ultrasound examination. In the United States and other countries around the world, the image is displayed as shown in **Figure 14.5**. Some colleagues display the transvaginal ultrasound image with the tip of the ultrasound transducer at the bottom of the image (**Figure 14.6**). Irrespective of the display, the ultrasound examiners should familiarize themselves with pelvic anatomy. Chapter 11 presents more details on uterine orientation in the pelvis.

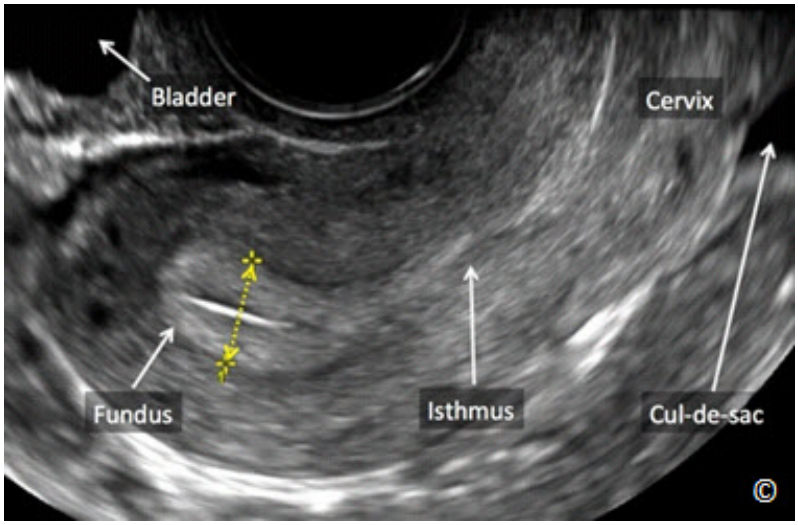

Figure 14.5: Transvaginal ultrasound of the midsagittal plane of an anteroflexed uterus showing the bladder in the left upper image, the fundus close to the bladder, the isthmus and the cervix in the right upper image. In this image, the endometrial thickness is measured (yellow double arrow and calipers). The cul-de-sac is also labeled and shows pelvic fluid.

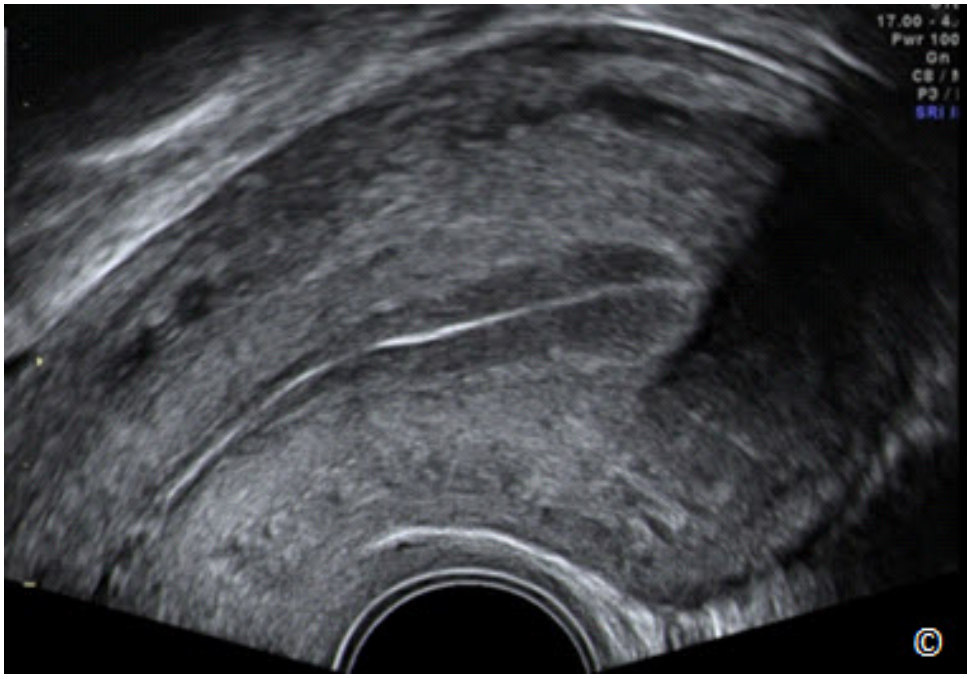

Figure 14.6: Transvaginal ultrasound of the sagittal plane of the uterus displayed with the tip of the transducer at the bottom of the image. See text for details. Image is courtesy of Dr. Bernard Benoit.

The midsagittal plane is also used to measure the uterine length from the fundus to the cervical external os and the depth of the uterus (anteroposterior dimension), which is a perpendicular diameter to the length, at the widest dimension (**Figure 14.7**). This midsagittal view also allows for the assessment and measurement of the endometrium. The endometrium is measured in an anteroposterior fashion at the widest location (**Figure 14.5**). When measuring endometrial thickness on ultrasound, it is critical to ensure that the uterus is in a mid-sagittal plane, the whole endometrial lining is seen from the fundal region to the endocervix, the image is clear and magnified and the thickest portion of the endometrium is measured (**Figure 14.5**).

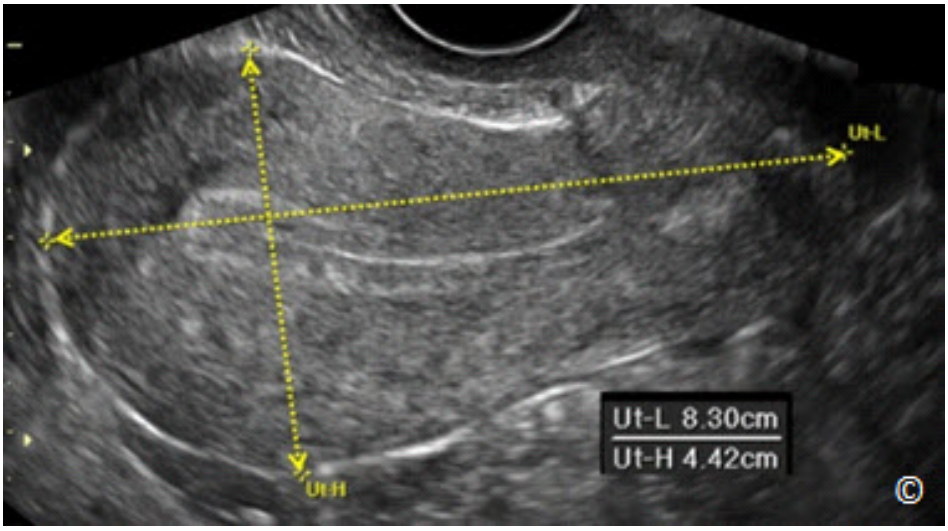

Figure 14.7: Transvaginal ultrasound of a midsagittal plane of the uterus showing measurements of uterine length (Ut-L) and height (Ut-H).

Step Two: Technical Aspects: Obtaining the Sagittal Plane of the Uterus

The sagittal or longitudinal plane of the uterus is obtained when the transvaginal ultrasound transducer is introduced into the upper vaginal canal with the marker at the 12 o'clock position. Slight manipulation of the transducer is sometimes required with an inferior–superior or right-left angling in order to get the midsagittal plane of the uterus as some uteri are slightly shifted to the right or left of the midline or rotated along the long axis of the body (2).

If the midsagittal plane appears to be significantly shifted to the right or the left of the midline, consideration should be given for evaluation of a unicornuate uterus with 3D ultrasonography (**Figure 11.20** in Chapter 11). Once the midsagittal plane of the uterus is identified, reduce the depth and sector width to ensure that the uterus is magnified for optimal visualization (**Figure 14.5** and **14.7**).

STEP THREE: THE TRANSVERSE PLANE OF THE UTERUS

The transverse or axial plane of the uterus demonstrates the width of the uterus and is a good plane to assess the myometrium (**Figure 14.8**). In this plane, the maximum width of the uterus is measured at the widest section (**Figure 14.8**). The endometrial lining should not be measured from this plane. This transverse plane of the uterus however is important in the evaluation of the endometrium at the fundal region, which helps in the identification of mullerian malformations. The presence of 2 endometrial echoes at the fundal region of the uterus, rather than a single one, suggests the presence of 2 endometrial cavities in the fundal region which may indicate the presence of a uterine septum, a bicornuate uterus or uterine didelphys (**Figure 14.9**). Differentiating between various types of mullerian anomalies requires a coronal plane of the uterus, which is obtained by 3D ultrasound or Magnetic Resonance Imaging (see chapter 11 for details).

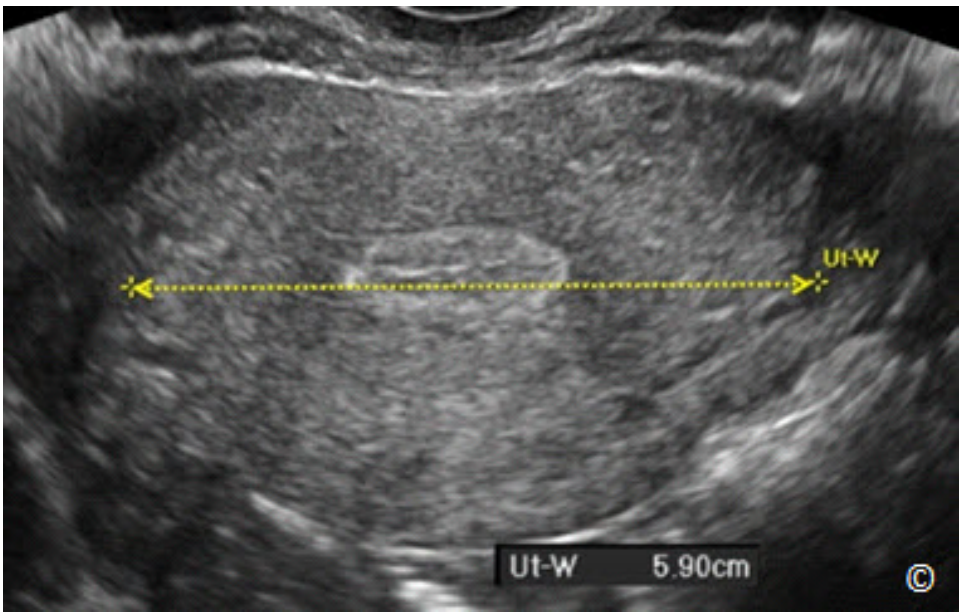

Figure 14.8: Transvaginal ultrasound of a transverse plane of the uterus at its widest dimension showing the measurement of uterine width (Ut-W).

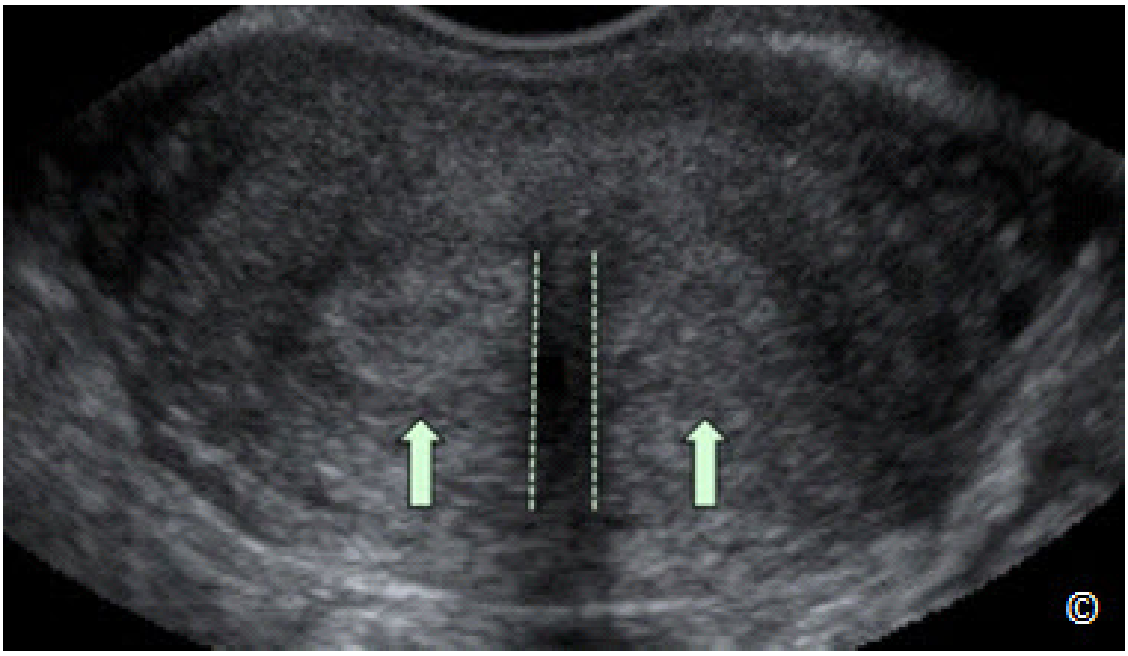

Figure 14.9: Transvaginal ultrasound of a transverse plane of the uterus showing 2 separate endometrial echoes (arrows). A coronal plane of the uterus, which can be obtained by 3D ultrasound or Magnetic Resonance Imaging, can determine the type of mullerian abnormality.

Step Three: Technical Aspects: Obtaining the Transverse Plane of the Uterus

The transverse plan of the uterus is obtained by rotating the transducer along its long axis 90 degrees counterclockwise from the midsagittal plane of the uterus. When the transverse plane is imaged, a superior-inferior movement (angling) of the tip of the transducer allows for the evaluation of the uterus in transverse view from the cervical/isthmic region into the fundus. As you perform this maneuver, freeze the screen at the widest segment, and use this plane for measurement. Although you can get the midsagittal plane of the uterus by either a clockwise or a counterclockwise rotation from the midsagittal plane, counterclockwise rotation will ensure that the transducer marker is on the patient's right side, which maintains appropriate orientation.

STEP FOUR: THE RIGHT AND LEFT ADNEXAE

Imaging of each adnexa includes an evaluation of the ovary, the fallopian tube and any other abnormality of surrounding structures. The normal fallopian tube is not easily seen on ultrasound. When the tube is filled with fluid, or thickened due to inflammation, it is then typically seen in a medial location to the ovary.

The normal ovary is relatively easy to detect in the reproductive years. The presence of ovarian follicles, or a corpus luteum, serves to differentiate the ovary from surrounding tissue in the

adnexa on ultrasound (**Figure 14.10**). The normal ovary in typically located lateral to the broad ligament and overlying the hypogastric vein (**Figure 14.10**). Bowel peristalsis helps to differentiate between moveable structures and the static ovary.

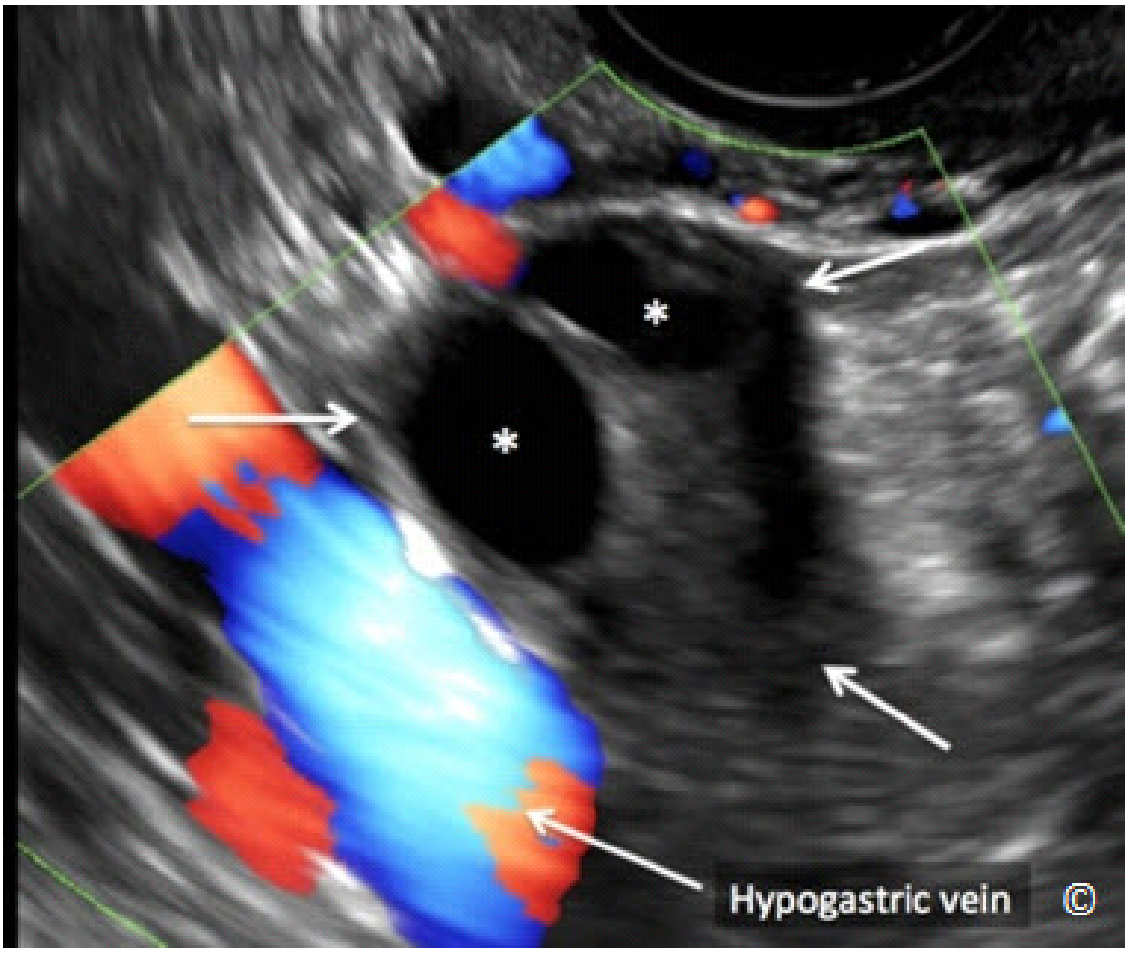

Figure 14.10: Transvaginal ultrasound of the ovary (arrows) in the adnexa overlying the hypogastric vein (labeled). Note that the ovarian tissue is slightly less echogenic than the surrounding tissue and can be noted by the presence of ovarian follicles (asterisks).

The size of the normal ovary varies slightly with the time of the menstrual cycle as well as the woman's age. The ovary should be measured on ultrasound in 3 dimensions; width, length and depth, on views obtained in 2 orthogonal planes (See **Figure 12.6**). The ovary appears ovoid (like a chicken egg) in shape and typically contains numerous follicles especially in the reproductive years. Refer to chapter 12 for more details on the ultrasound evaluation of the ovary.

Step Four: Technical Aspects: Imaging the Right and Left Ovary

The transverse plane of the uterus, at its widest dimension, typically displays the ovarian ligaments on the right and left side as thin hypoechoic curvy lines (**Figure 14.11**). To image the right ovary, start with the transverse plane at its widest dimension of the uterus and angle the transvaginal transducer towards the right iliac crest of the woman (handle of the probe almost touching the woman's left inner thigh) (**Figure 14.12**). Follow the right ovarian ligament as it commonly leads toward the right ovary (**Clip 12.1**). The right ovary will come into view overlying the right hypogastric vein (**Figure 14.10**). Repeat the same maneuver on the opposite side to image the left ovary. On occasions, the operator needs both hands, one to manipulate the transvaginal probe and the second to place it on the abdominal wall and facilitate the mobilization of the pelvic structures. **Figure 14.13** is an extended view of the transverse pelvis on transvaginal ultrasound showing the uterus, ovaries, tubo-ovarian ligaments and hypogastric vessels.

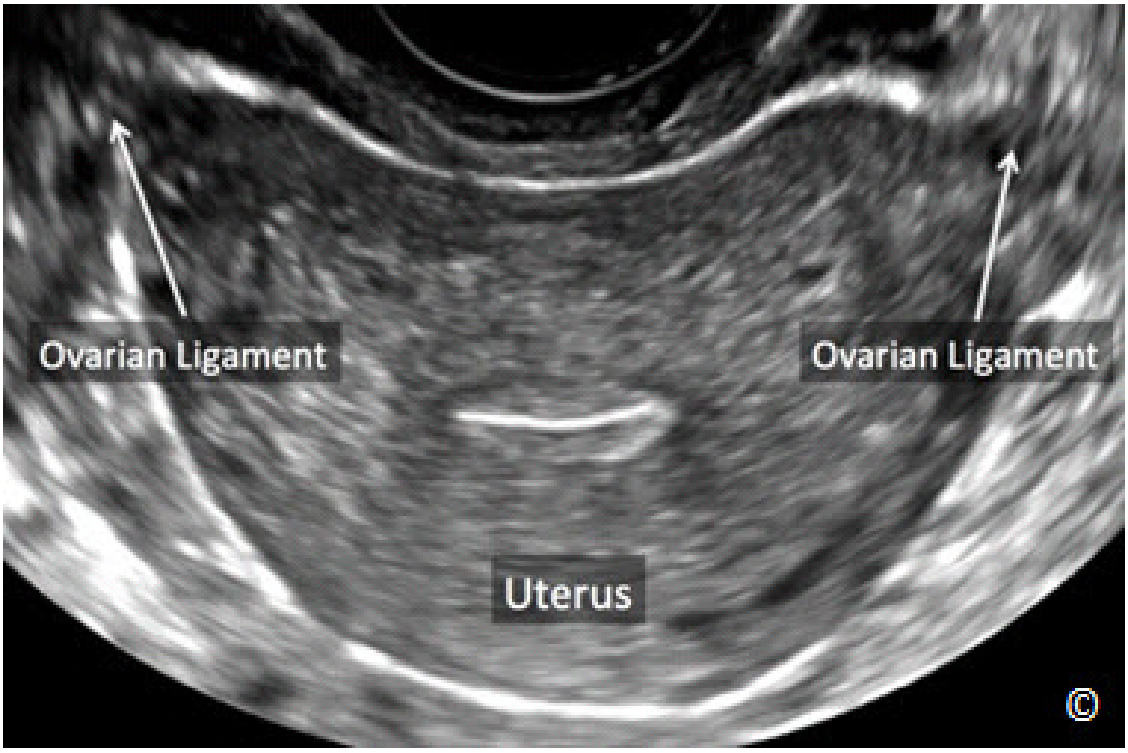

Figure 14.11: Transvaginal ultrasound of a transverse plane of the uterus (labeled) showing the ovarian ligaments (labeled) as thin hypoechoic curvy lines.

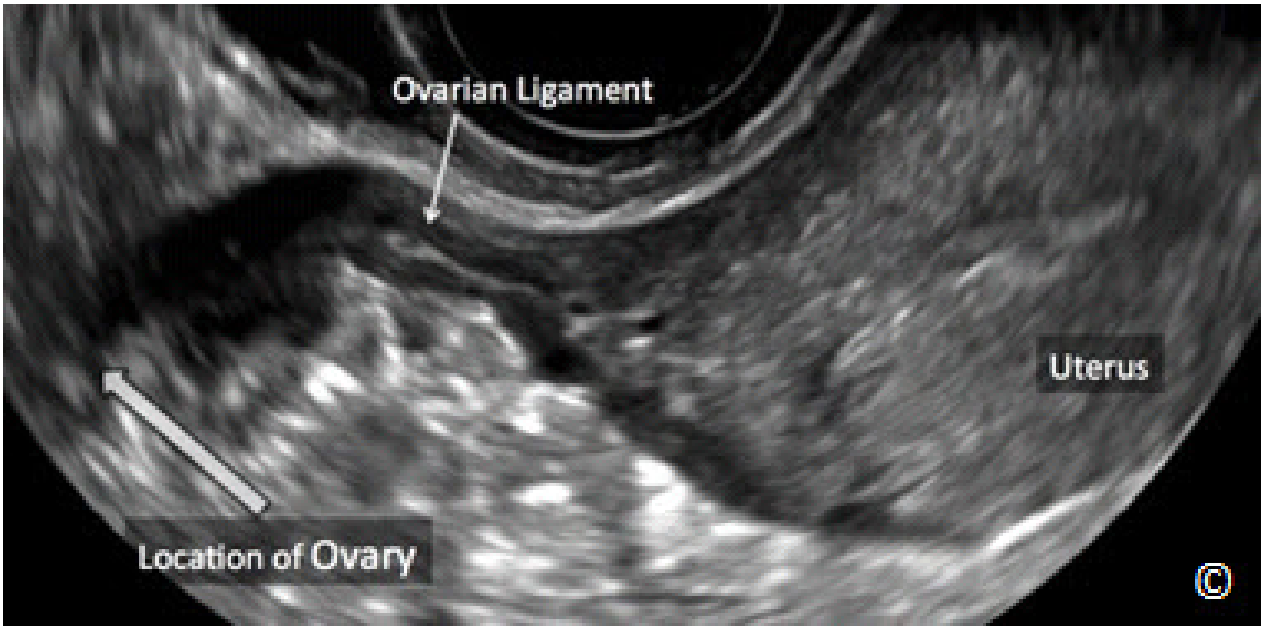

Figure 14.12: Transvaginal ultrasound of the same uterus as in figure 14.11 with the transducer angled to the adnexal region. By following the ovarian ligament (labeled), the ipsilateral ovary can be commonly seen.

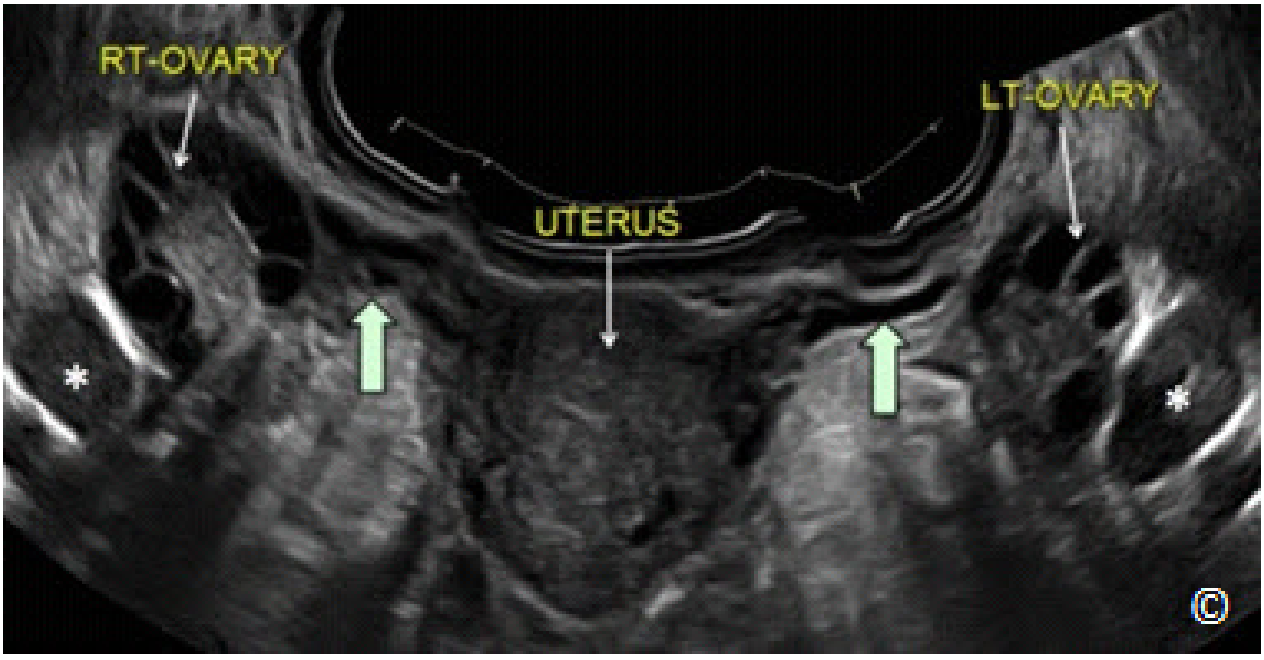

Figure 14.13: Transvaginal ultrasound in extended transverse view of the pelvis showing the uterus (labeled), right and left ovaries (labeled), ovarian ligaments (blue arrows) and the right and left hypogastric veins (asterisks).

Once one ovary is identified on transvaginal ultrasound, identifying the contralateral ovary can be commonly achieved by fanning the probe to the opposite side of the pelvis at equidistance from the mid-transverse plane of the uterus. Normal ovaries tend to be positioned in the same anatomic location, on either side of the uterus.

The ovaries may not be identifiable in some women. This occurs most frequently prior to puberty, after menopause, or in the presence of large uterine fibroids, which shadow the adnexal regions. Also, it is common occurrence that the left ovary is shadowed by the colo-rectal content. In this case, pelvic pressure by the contralateral hand towards the left iliac fossa may help in locating the ovary. Along the same line, if a patient has undergone hysterectomy, the ovaries are typically more difficult to image by ultrasound because the bowel fill the space left by the removal of the uterus, and make ultrasound imaging less optimal. In women who had prior vaginal hysterectomy, the ovaries are commonly located around the vaginal cuff, and in women who had laparoscopic hysterectomy; the ovaries are commonly located next to the lateral pelvic walls. On rare occasions, filling the bladder may help to localize the ovaries in these conditions.

STEP FIVE - WITHDRAWAL OF THE TRANSVAGINAL TRANSDUCER

Once the ultrasound examination is completed, the transvaginal transducer can be gently withdrawn from the vaginal canal. It is recommended that the operator holds the transducer is such a way to secure the protective cover in place as the transducer is being withdrawn from the vaginal canal (**Figure 14.4**). This maneuver will minimize dislodging the protective cover and exposing the patient to the bare transducer. The protective cover can be removed after the transducer is outside of the vaginal canal and disposed off in appropriate containers.

Protocols for ultrasound transducer cleaning should be adhered to in order to reduce the spread of infectious agents. The transvaginal transducer should be wiped clean between patients and disinfection should be performed according to national or manufacturer guidelines (3). It is safer to wipe the transducer in the freeze mode in order to protect the array within.

Documentation of the ultrasound examination and description of ultrasound abnormalities in the pelvis are discussed in details in separate chapters.

References:

1) AIUM practice guidelines for the performance of pelvic ultrasound examinations, revised 2009. http://www.aium.org/resources/guidelines/pelvic.pdf.

2) Sakhel K, Sinkovskaya E, Horton S, Beydoun H, Chauhan SP, Abuhamad AZ. Orientation of the uterine fundus in reference to the longitudinal axis of the body: a 3-dimensional sonographic study. J Ultrasound Med. 2014 Feb; 33(2):323-8.
3) AIUM Official Statement: Guidelines for Cleaning and Preparing Endocavitary Ultrasound Transducers Between Patients, approved 2003. http://www.aium.org/officialStatements/27