

INTRODUCTION

Ultrasound is an operator dependent imaging modality, and thus the quality of the ultrasound examination is dependent in large part on the skills of the operator. The technical aspects of the ultrasound examination in obstetrics and gynecology are not standardized, and the operators develop their own ultrasound skills and approach to the ultrasound examination based upon their own experience and habits. Understanding some basic principles and technical aspects of the ultrasound examination will undoubtedly improve the quality of the examination and reduce repetitive stress injuries. In this chapter, we present the technical aspects of the ultrasound examination with a focus on obstetrics. The approach to the performance of the transvaginal pelvic ultrasound examination is discussed in details in Chapters 11 and 14 and a standardized approach to the performance of the basic obstetric ultrasound examination is presented in chapter 10.

PREPARING THE PATIENT

The obstetric ultrasound examination is best performed with the patient on a comfortable scanning (ultrasound) table or stretcher with the patient's upper torso slightly inclined upward and the head supported by a soft pillow for comfort (**Figure 3.1**). If the ultrasound table does not incline, placing a pillow behind the patient's upper chest will improve comfort. Typically ultrasound tables have a retractable section beneath the legs with stirrups, which allow for the performance of a transvaginal ultrasound examination if needed (**Figure 3.2**). If a retractable portion and/or stirrups are not available, elevating the patient's buttocks with pillows or an inverted bedpan allows for the performance of the transvaginal ultrasound examination when needed (**Figure 3.3**). It is important to place the patient closer to the side of the table where the ultrasound machine is located (typically to the right side of the patient) as this will minimize reaching-over by the operator's arm, which improves ergonomics. Having a support pillow at the edge of the table where the operator's elbow rests will minimize tension on the operator's arm and shoulder and thus reduce the likelihood of repetitive stress injuries during the ultrasound examination (**Figure 3.4**). An alternate approach is to rest the operator's elbow on the patient's right thigh during the ultrasound examination (**Figure 3.5**).



Figure 3.1: The optimal position of the patient on the examination table. Note that the patient's upper torso is slightly inclined upward (arrow) for comfort.

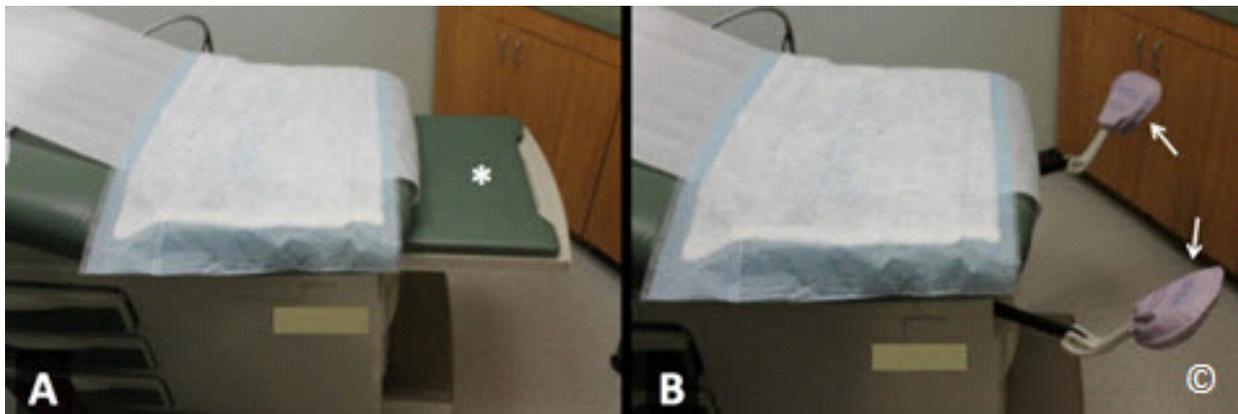


Figure 3.2: Ultrasound examination table showing a retractable section in A (asterisk), and the stirrups in B (arrows) that allow for the performance of a transvaginal ultrasound examination if needed.



Figure 3.3: A folded bed sheet is placed to elevate the patient's (mannequin in this figure) buttocks (arrows) for a transvaginal ultrasound examination if an ultrasound table's retractable portion and/or stirrups are not available.



Figure 3.4: Note the support pillow (labeled) at the edge of the table (asterisk) for support of the operator's elbow during ultrasound examination.



Figure 3.5: Note the ultrasound operator's elbow resting on the patient's thigh (arrows). This provides support and minimizes repetitive stress injuries.

Patients do not need to wear a special gown for the ultrasound examination but they should be provided with a towel (paper or linen) or a sheet to protect their clothes and for modesty (**Figure 3.6**). In some low-resource settings, patients may bring their own towels to the ultrasound examination. The ultrasound gel is water-based and typically does not stain, but it does wet clothes, which is unpleasant. Asking the patient to have a full bladder is generally not required anymore with modern ultrasound equipment. If the uterus is deep in the pelvis, in the first and early second trimester, and/or is obstructed by bowel gas, a transvaginal ultrasound should be performed when feasible for better visualization of gestational sac and adnexae.

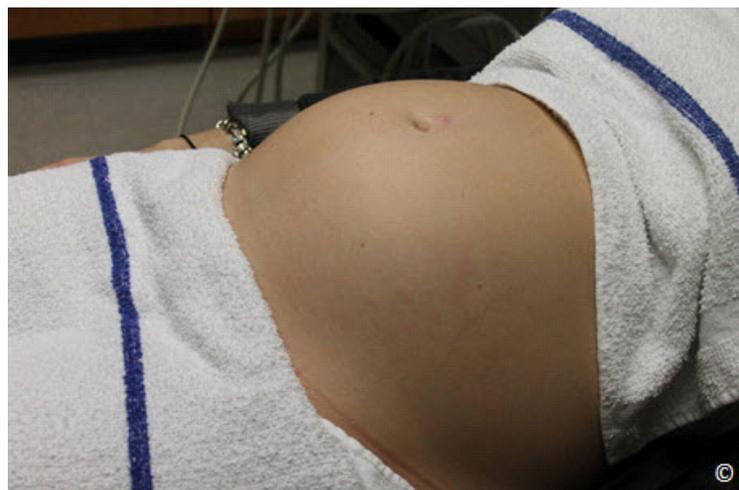


Figure 3.6: Patient preparation for an ultrasound examination. Note the placement of towels to protect the patient's clothes and for modesty.

APPLYING THE COUPLING AGENT

The coupling agent, either a gel or oil, eliminates the air interface between the transducer and the patient's skin (see chapter 1) . Gels are more convenient than oil, because the latter tends to stain and is more difficult to wipe off. But in low-resource countries where obtaining ultrasound gel is either expensive or impractical, regular cooking oil does an excellent job. When applying the gel, remember to use as little as possible, as scanning through a thick layer of gel tends to degrade the quality of the image by interposing numerous micro bubbles that are contained within the gel. All brands of gel are equally suited for sound transmission, but if you make lengthy examinations, try to select one that does not dry too fast. Other products that can degrade the ultrasound image include creams that the patient may have applied on her abdomen before the ultrasound examination. For instance, anti-stretchmark creams may contain chemicals that deteriorate sound transmission. Manufacturers market gel heaters for the purpose of easing patient discomfort, but an inexpensive baby bottle warmer will do as well.

POSITIONING THE OPERATOR/EQUIPMENT

There are 2 main operator positions for the performance of the obstetric ultrasound examination: standing or sitting. The standing position (**Figure 3.7**) minimizes pressure on the operator's shoulder and elbow and maintains the shoulder joint in an adducted position. Although this position minimizes repetitive stress injuries, it is somewhat uncomfortable for long examinations. The sitting position (**Figure 3.8**) allows for more comfort during the examination and is also a better station from which to manipulate the keyboard of the machine. In the sitting position, it is critical to ensure that the chair is high enough and the table is at a lower level in order to minimize reaching over with the transducer and to allow for minimal abduction of the operator's shoulder joint during scanning (**Figure 3.8**). When performing an ultrasound examination, face the screen as perpendicularly as possible in order to avoid perception and distortion artifacts, especially with newer ultrasound monitors. For example, a biparietal diameter can be difficult to measure when you look at the screen obliquely. Work in dim light to help avoid reflections on the screen.



Figure 3.7: The standing position minimizes pressure on the operator's shoulder and elbow and maintains the shoulder joint in an adducted position.



Figure 3.8: The sitting position allows for more comfort during the examination and is also a better station from which to manipulate the keys of the machine.

MINIMIZING REPETITIVE STRESS INJURIES

Repetitive stress injuries affecting the neck, shoulder, elbow and wrist are common in busy ultrasound practitioners. To avoid repetitive stress injuries pay attention to the following factors:

Posture

Position your ultrasound equipment and the patient such that the posture you hold is comfortable. Do not lean or bend over the patient and, avoid reaching over, especially in obese patients, during transabdominal (**Figure 3.9**) or transvaginal ultrasound examinations. Stand close to the patient and if not sitting, use the bed as a support to lean onto. If you are sitting, use a chair high enough, with a footrest. Position the patient close to the side of the table next to the ultrasound equipment which should be close enough to allow you to rest your “keyboard-hand” on the ultrasound console, instead of having to reach out each time. It is also important to place your non-scanning hand (typically left hand) on the freeze knob in order to freeze the image immediately when the desired target anatomy is viewed. Support your elbow of your scanning arm during the examination with a support pillow placed on the edge of the table or on the patient’s thigh as shown in **Figures 3.4 and 3.5**.

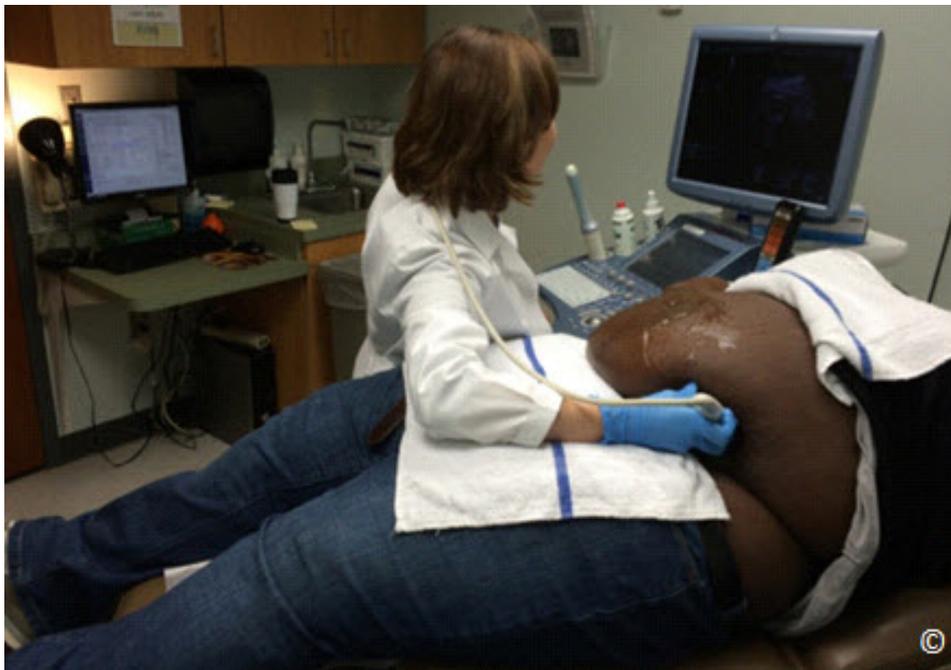


Figure 3.9: Reaching over the abdomen for an ultrasound examination in an obese woman. This should be avoided in order to minimize repetitive stress injury.

Ambient Light

Dim the ambient light so that there is no glare on the screen, yet enough light to find the keys on the keyboard easily. Dimming the ambient light is also important to allow you to optimize the ultrasound gain. In bright light, users tend to “over gain” the images and this “washes away” the subtle signals in the lighter part of the screen.

The Monitor

Position the monitor of the ultrasound equipment such that its display is at eye-level and perpendicular to your line of sight. Newer ultrasound equipment have flat panels for monitors, which are commonly on adjustable arms. It is usually simple to add a second monitor for the patient to view the examination. This will also avoid having the patient twist on the ultrasound table to look at the monitor on the ultrasound machine, as this may tense abdominal musculature and impair the examination. The second monitor may be connected either from a video port or a digital port.

HOLDING THE TRANSDUCER AND IMAGE ORIENTATION

Abdominal ultrasound transducers come in various shapes and sizes and are customized to specific study types and indications (see chapter 2 for details). In general, the curvilinear transducers are best adapted to obstetric scanning as they conform to the abdominal curvature in pregnancy (**Figure 3.10**). Larger transducers are harder to manipulate than smaller ones, but when they provide special functions such as 3D, our experience has been that users will tolerate the added bulk.



Figure 3.10: Curvilinear transducer being used in obstetrical scanning.

Figure 3.11 shows our preferred way of holding the transducer. The transducer should be held in the operator's scanning hand in a comfortable way and with minimal pressure on the wrist and phalangeal joints. It is important that the transducer rests (fills) the palm of the hand and the fingers hug the body of the transducer with minimal pressure (**Figure 3.11**). In this position, the thumb and fingers allow for the greatest precision of movements, such as sliding, rotating or angling, with minimal tension on the wrist. Note that the transducer is held very close to its footprint. Holding the transducer with the thumb and fingers at mid-body (**Figure 3.12**) forces the operator to use wrist motion, which increases the chance of repetitive stress injury and does not allow for fine transducer manipulation. Finally, holding the transducer near its cable end (**Figure 3.13**) is least effective as it requires elbow and shoulder motions and thus results in significant fatigue.



Figure 3.11: Our preferred way of holding a transducer. The transducer is held in the palm of the hand with minimal pressure on the wrist and phalangeal joints



Figure 3.12: Holding the transducer with the thumb and fingers at mid-body should be avoided, as it involves wrist motion for manipulation and thus may result in repetitive stress injury.



Figure 3.13: Holding the transducer with the thumb and fingers near its cable end is least effective as it involves elbow and shoulder motion for manipulation and thus may result in repetitive stress injury.

All transducers have a mark/notch that distinguishes one side from the other. In holding the transducer transversely, the mark on the transducer should be to the patient's right side (**Figure 3.14**) and if the transducer is held in a longitudinal orientation, the mark should be towards the uterine fundus (patient's head) (**Figure 3.15**). This orientation allows for the display of the right side of the patient's abdomen in transverse scanning and the upper part of the patient's abdomen in longitudinal scanning on the right side of the monitor (left side of the operator facing the monitor). Besides facilitating interpretation of your ultrasound images by others, there are advantages to sticking to these simple rules: The position of the fetus and placenta can be evaluated with a quick glance at the ultrasound images and spatial orientation is greatly facilitated.



Figure 3.14: When holding the transducer transversely, the mark on the transducer (labeled) should be to the patient's right side (labeled).



Figure 3.15: When holding the transducer longitudinally, the transducer mark (labeled) should be towards the uterine fundus (patient's head) (labeled).

The transducer cable should be supported in order to provide minimal pull (eliminate drag) during scanning. On many occasions, the cable can be supported in the transducer holder during scanning (**Figure 3.16**). Check that the cable is not too rigid, which may interfere with the ease of transducer manipulation. The transducer should be placed gently on the patient's abdomen with minimal pressure. Applying abdominal pressure with the transducer will not improve image quality and is uncomfortable for the patient and for the operator. Furthermore, transducer pressure on the abdomen may result in fetal bradycardia in some instances. The only instance where "digging" the transducer is justified is in late pregnancy, when the fetal head is low in the pelvis and evaluation of head anatomy and biometry is difficult.



Figure 3.16: In order to minimize pull on the transducer, the transducer cable should be supported as shown in this figure (labeled).

ULTRASOUND SCANNING TECHNIQUES

Understanding that ultrasound is an operator dependent imaging modality, there are some scanning techniques that can improve your image and maximize visualization of fetal anatomy and adnexal structures. We have selected here some scanning techniques that the authors use on a daily basis in their busy practice.

Select the appropriate ultrasound transducer and settings

It is important to start your ultrasound examination by selecting the appropriate ultrasound transducer and “presets” for the study. Transducers have various footprint sizes and Megahertz (MHz) ranges. Some are adapted for the first trimester and others for the third trimester when depth is critical. For more details on properties of transducers, see chapter 2. Furthermore, ultrasound machines have manufacturer-established presets that optimize resolution and frame rate for various types of study. It is important that you familiarize yourself with the presets and choose the right preset for the right study. It is advisable to have a session with the ultrasound company’s application specialist when a new ultrasound machine is bought in order to customize yourself with the manufacturer’s presets and the functionality of the equipment.

Apply minimal pressure on the abdomen

Learn to scan while applying minimal pressure on the patient’s abdomen. There are several advantages to this technique including minimizing the patient’s discomfort and reducing possibility of stress injury on the operator’s wrist and elbow. Furthermore, applying minimal pressure will allow for a film of amniotic fluid between the anterior uterine wall and the target organ, which enhances visualization (**Figures 3.17 A and B**). The only pressure that is needed is to allow full contact between the ultrasound transducer’s footprint and the patient’s skin.

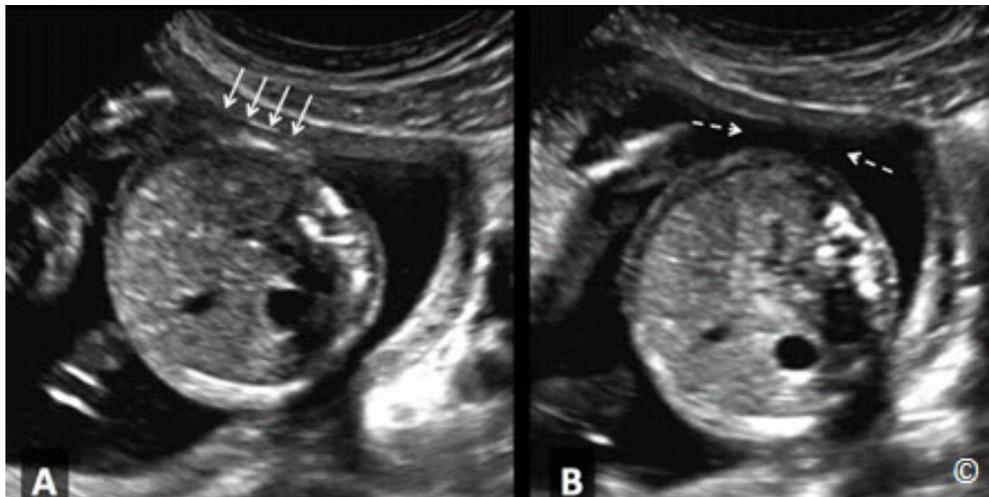


Figure 3.17 A and B: Transverse plane of the fetal abdomen in the second trimester of pregnancy. In A, increased pressure is applied on maternal abdomen resulting in compression of the fetal abdomen (arrows). Minimal optimal pressure is applied in B resulting in improved imaging with a film of amniotic fluid between the uterine wall and the fetal abdomen (broken arrows). Furthermore, minimal pressure results in no deformity of the abdominal perimeter, which improves abdominal circumference measurement (in B).

Reduce depth to a minimum

In order to optimize the performance of ultrasound, especially in obstetrics, it is important to minimize the amount of depth on your ultrasound screen (**Figures 3.18 A and B**). This will enhance resolution and frame rate. An image with greater depth requires more processing from the ultrasound equipment, which results in slower frame rate and reduced resolution.

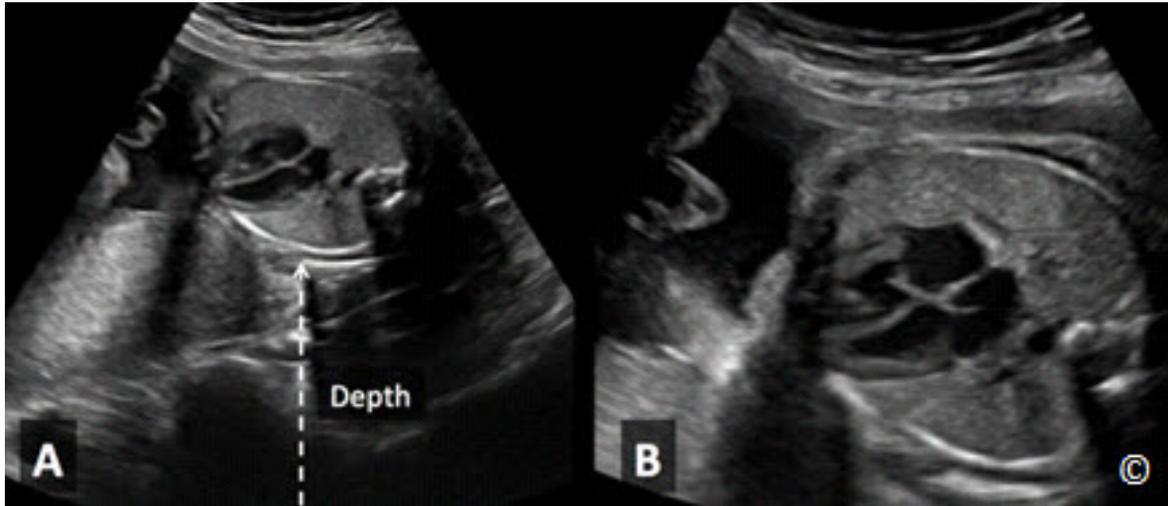


Figure 3.18 A and B: Ultrasound image of the four-chamber view in the second trimester of pregnancy. Note how small the fetal heart is in A, as the depth of the image is not adjusted (arrow). The depth is minimized in B (same fetus) resulting in image magnification. Minimizing depth also improves frame rate (not shown).

Minimize the sector width

Most ultrasound machines have the ability to adjust the sector width on the ultrasound screen. It is important to start your examination with a wide sector width (**Figure 3.19**) and once the target organ is under view, reduce the sector width as much as possible around the target organ (**Figure 3.20**).



Figure 3.19: Transverse view of the fetal head in the second trimester of pregnancy. This shows a wide sector width (arrow), which is the initial approach to image optimization. Once the target organ is under view, reduce the sector width (See **Figure 3.20**).



Figure 3.20: Transverse view of the fetal head of the same fetus shown in figure 3.19. Adequate sector width is applied (arrow). This maneuver optimizes imaging and increases frame rate.

Adjust focal zones

Focal zones should be adjusted to the level of the target organ at study (**Figure 3.21 A and B**). Using multiple focal zones tend to reduce frame rate and thus should be avoided in obstetrical scanning.

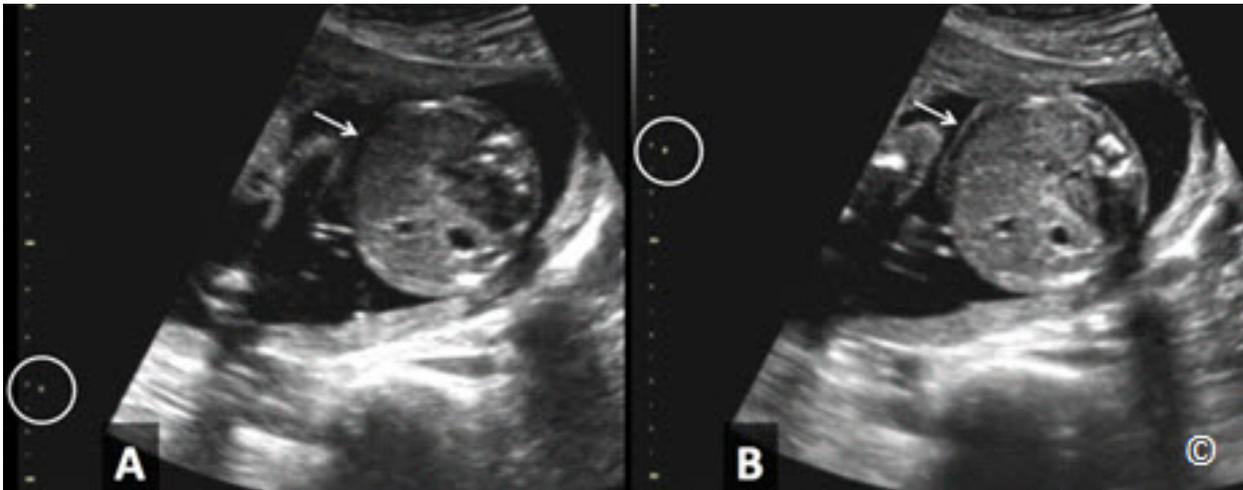


Figure 3.21 A and B: Ultrasound of the transverse plane of the fetal abdomen. In A, the focal zone is erroneously applied below the target organ (circle). Note the improved lateral resolution (arrows – compare A to B) of the target organ (abdomen) in B where the focal zone is accurately applied (circle).

Zoom area of interest

Once you have adjusted the depth, sector width, and focal zone, magnify the area of interest by selecting the “zoom” option on the ultrasound machine (**Figure 3.22 A and B**). This can be achieved by zooming the whole image, or selecting an area of interest from the image to magnify. It is important to learn to scan with this feature, which allows for the identification of details within target organs. This is especially critical when you are scanning the fetal heart given its complex anatomy and small size (**Figure 3.22-B**).

Note that for many machines there are 2 forms of zoom. One is simply a button that is “rotate” right or left and makes the image bigger or small. The other zoom (often a box that you can position and size over and area) is a “write-zoom”, that reconfigures the machine to concentrate more data on that area. Familiarize yourself with both options if available on your ultrasound equipment.

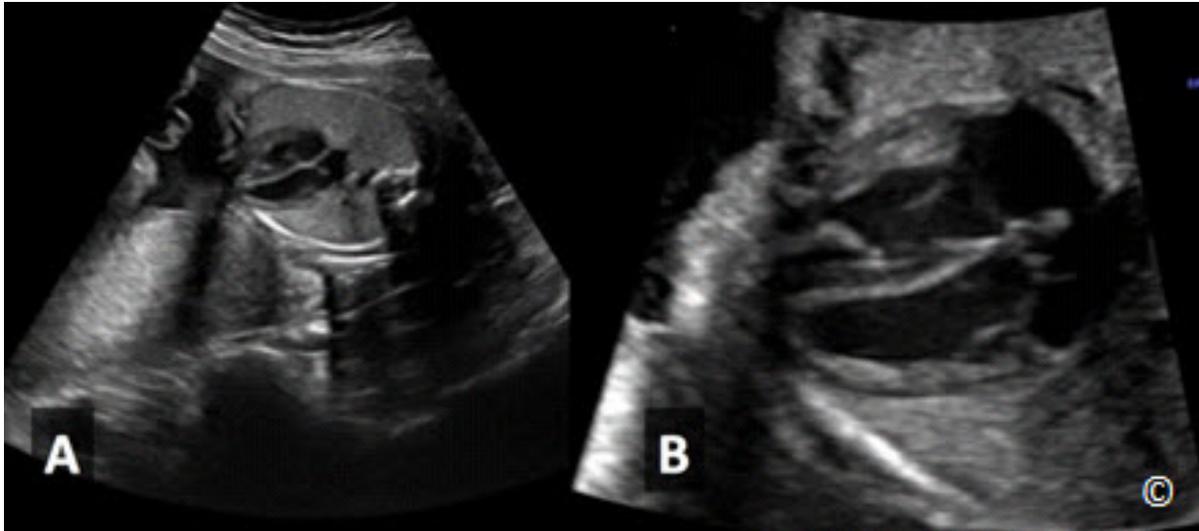


Figure 3.22 A and B: Four-chamber view of the fetal heart without (A) and with (B) magnification in the same fetus. The detailed anatomic features of the heart can be easily recognized in B when compared to A. Image magnification and zoom are important features in cardiac imaging.

Maintain the target anatomic area in the center of the screen

It is important to keep the area of interest in the center of your screen in order to minimize the effect of lateral resolution as the ultrasound resolution decreases significantly from the central area of the image towards each lateral side. Furthermore, this technique allows for the ultrasound beam to insonate the target area in a perpendicular orientation, which enhances visualization (**Figure 3.23 A and B**). The “slide technique”, which has not been previously described to our knowledge, allows you to move a target area from the lateral aspect of the image into the center without losing orientation. The slide technique involves sliding the transducer along its long axis as shown in **Clip 3.1 A**. This brings target anatomy from the lateral to the center of the screen while maintaining the same anatomic view and orientation of the target image. **Clip 3.1B** shows the corresponding ultrasound cine loop.

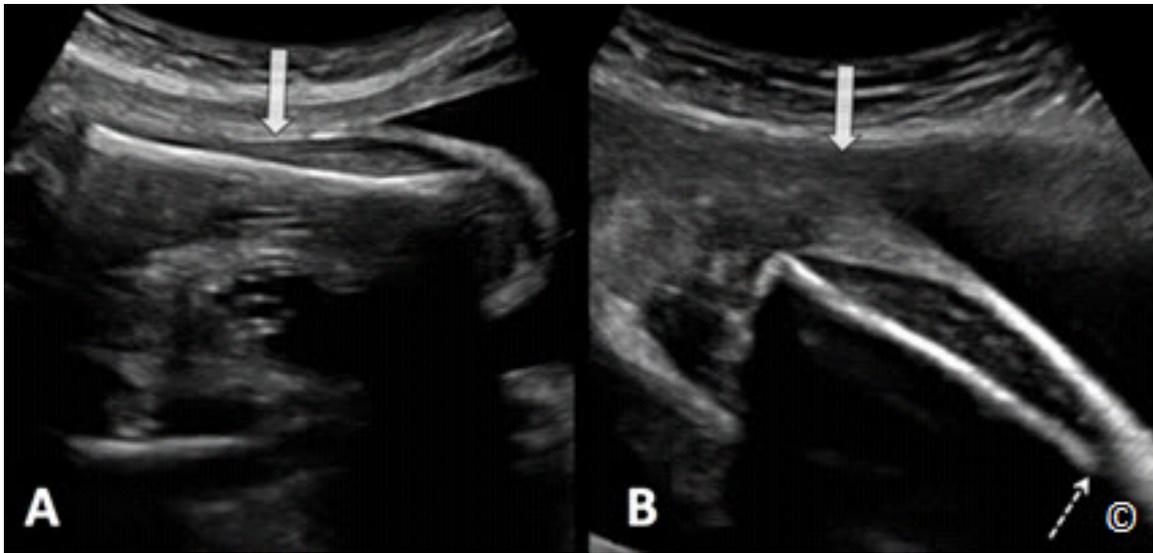


Figure 3.23 A and B: Ultrasound image of a femur in longitudinal view. In A, the femur is in the center of the image allowing for optimal imaging of its borders and thus measurements. In B, the distal portion of the femur is in the lateral aspect of the image resulting in reduced resolution (broken arrow). The solid arrow in A and B shows the direction of the ultrasound beam.

ULTRASOUND SCANNING TECHNIQUES FOR THE OBESE PREGNANT PATIENT

The prevalence of obesity continues to be on the rise, with the most recent estimates reporting obesity in about one-third of the adult population (1), and in more than one half of pregnant women in the United States (2). Obese women are at increased risk for complications during pregnancy, including gestational diabetes, hypertension, and cesarean delivery (3). In addition to maternal complications, obesity also poses risks to the fetus including an increased risk of prematurity, stillbirth, macrosomia, and a higher rate of congenital anomalies (4). Although sonographic screening during pregnancy is recommended for all women, it is particularly relevant in the obese population due to higher rates of structural abnormalities, specifically neural tube defects, heart defects, and abdominal wall defects (5).

Sonographic assessment of fetal anatomy in the obese population is challenging with multiple studies confirming that maternal obesity significantly reduces the likelihood of completion of the anatomic survey, and ultrasound screening is associated with lower detection rates of fetal anomalies (6-9). A recent fetal imaging consensus meeting in the United States, sponsored by multiple societies including the Eunice Kennedy Shriver National Institute of Child Health and Development (NICHD), made specific recommendations for the pregnant obese population, including a targeted ultrasound at 20-22 weeks gestation (approximately 2 weeks later than the usual time period for anatomy survey in the non-obese patients), and a follow up ultrasound exam in 2 to 4 weeks if fetal anatomy could not be completely assessed (10).

The main difficulty that arises when scanning obese pregnant women is the size of the panniculus, which not only significantly increases the distance between the transducer and the fetal target organs, but also scatters the ultrasound beam and thus degrades resolution (**Figure 3.24**). Several ultrasound-scanning techniques, which attempt to reduce the distance between the patient's skin and the fetus, can be utilized to help improve imaging in obese patients (11). The following is a list of techniques commonly used in ultrasound examinations of obese pregnant women:

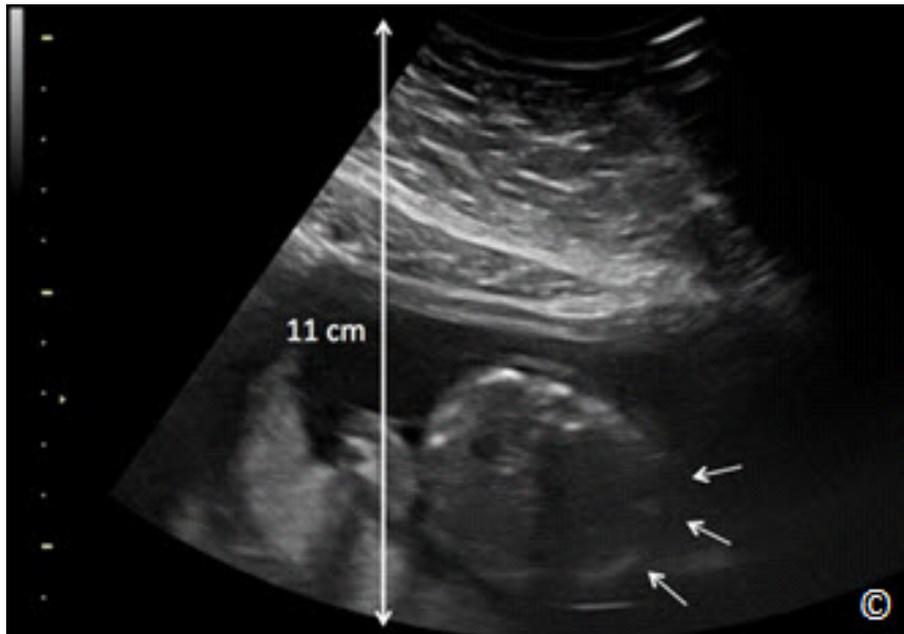


Figure 3.24: Ultrasound image of the fetal abdomen at a depth of 11 cm in an obese pregnant woman. Note the sub-optimal resolution of the right lateral fetal abdomen (small arrows).

Transvaginal ultrasound in early gestation

Ultrasound performed transvaginally between 13 and 15 weeks' gestation may prove to be the most optimal time for imaging of the fetus in obese women with high body-mass index (BMI). Several studies have shown the ability of the "early" ultrasound in documenting fetal anatomy in the general population (12-14) and this approach should be adapted to the obese pregnant women especially those with a high BMI. Further studies however are needed to confirm the feasibility of this approach in the obese population.

Scanning underneath the panniculus

The operator can lift the panniculus with the left hand and scan underneath it with the right hand. This maneuver is tiring however and should not be employed for long scanning time. Alternatively, you can ask an assistant or the patient to hold the panniculus up, as this will reduce the patient's skin to fetus distance in most instances (**Figure 3.25**).



Figure 3.25: Scanning under the panniculus in an obese pregnant woman. In this figure, the patient is holding the panniculus up (arrow) during the examination.

Scanning above the panniculus

The ultrasound examination can be performed above the panniculus in the region of the mid-abdomen while pushing the panniculus down, which may shorten the distance between the skin surface and the fetus (**Figure 3.26**). This maneuver may be improved by filling the patient's bladder, which displaces the uterus cephalad.



Figure 3.26: Scanning above the panniculus in an obese pregnant patient. In this figure, an assistant is pushing the panniculus down (arrow) during the examination.

Using the umbilicus as an acoustic window

The umbilicus can be used as an acoustic window by filling it with ultrasound gel and scanning through it. Alternatively, the transvaginal probe can be used through the umbilicus given its small footprint (**Figure 3.27**). This may allow you to see fetal anatomy more clearly in some obese patients.



Figure 3.27: Scanning through the umbilicus using the transvaginal transducer in an obese pregnant patient. This technique may improve imaging in some obese patients.

Placing the patient in the Sims position

The Sims position involves a position in which the patient lies on the left side with the knee and thighs drawn upward toward the chest. The chest and abdomen are allowed to fall forward. This approach for scanning allows the panniculus to be displaced to the left side. The operator places the transducer on the mother's right flank, groin and right lateral quadrants of the abdomen where the adipose tissue is thin (**Figure 3.28**).



Figure 3.28: Scanning a pregnant obese woman in the Sims position. Note that the woman's panniculus is shifted to the left side. Insonating the uterus from the right lateral quadrant may improve imaging given the presence of less adipose tissue.

CLIP 3.1



CLIP 3.2



References:

- 1) Center for Disease Control and Prevention; Adult Obesity Facts – <http://www.cdc.gov/obesity/data/adult.html>
- 2) Flegal KM, Carroll MD, Kit BK, Ogden CL. Prevalence of obesity and trends in the distribution of BMI among US adults 1999-2010. *JAMA* 2012; 307: 491-7.
- 3) Cedergren MI. Maternal morbid obesity and the risk of adverse pregnancy outcome. *Obstet Gynecol* 2004; 103:219-24.
- 4) Stothard KJ, Tennant PW, Bell R, Rankin J. Maternal overweight and obesity and the risk of congenital anomalies: a systematic review and meta-analysis. *JAMA* 2009; 301: 636-50.
- 5) Watkins ML, Rasmussen SA, Honein MA, Botto LD, Moore CA. Maternal obesity and risk for birth defects. *Pediatrics* 2003; 111:1152-8.
- 6) Dashe JS, McIntire DD, Twickler, DM. Effect of maternal obesity on the ultrasound detection of anomalous fetuses. *American College of Obstetricians and Gynecologists* 2009; 113: 1001-8.
- 7) Dashe, JS, McIntire DD, Twickler DM. Maternal obesity limits the ultrasound evaluation of fetal anatomy 2009; 28: 1025-30.
- 8) Fuchs F, Houllier M, Voulgaropoulos A, Levailant JM, Colmant C, Bouyer J, Senat MV. Factors affecting feasibility and quality of second-trimester ultrasound scans in obese pregnant women. *Ultrasound Obstetric Gynecology* 2013; 41: 40-46.
- 9) Hershey D. Effect of maternal obesity on the ultrasound detection of anomalous fetuses, *Obstetric Gynecology* 2009; 114:694.
- 10) Reddy UM, Abuhamad AZ, Levine D, Saade GR. Fetal Imaging Executive Summary of a Joint Eunice Kennedy Shriver National Institute of Child Health and Human Development, Society for Maternal-Fetal Medicine, American Institute of Ultrasound in Medicine, American College of Obstetricians and Gynecologists, American College of Radiology, Society for Pediatric Radiology, and Society of Radiologists in Ultrasound Fetal Imaging Workshop. *J Ultrasound Med* 2014; 33:745–757.
- 11) Paladini D. Sonography in obese and overweight pregnant women: clinical, medicolegal and technical issues. *Ultrasound Obstetric Gynecology* 2009; 33: 720–729
- 12) Rossi AC, Prefumo F. Accuracy of ultrasonography at 11-14 weeks of gestation for detection of fetal structural anomalies: a systematic review. *Obstet Gynecol.* 2013 Dec; 122(6):1160-7.
- 13) Souka AP, Pilalis A, Kavalakis Y, Kosmas Y, Antsaklis P, Antsaklis A. Assessment of fetal anatomy at the 11-14-week ultrasound examination. *Ultrasound Obstet Gynecol.* 2004 Dec; 24(7):730-4.
- 14) Whitlow BJ, Economides DL. The optimal gestational age to examine fetal anatomy and measure nuchal translucency in the first trimester. *Ultrasound Obstet Gynecol.* 1998 Apr; 11(4):258-61.