ULTRASOUND IN THE SECOND TRIMESTER

5

INTRODUCTION

The main objective of a second trimester ultrasound examination is to accurately date the pregnancy, evaluate fetal anatomy, and assess placental location and the adnexae. Second trimester components of the basic ultrasound examination are listed in **Table 5.1** and may vary based upon the level of support provided by the local health care system and national guidelines.

TABLE 5.1	Components of the Basic Second Trimester Ultrasound Examination
	- Fetal presentation and position - Cardiac activity - Fetal number (and chorionicity if multiple pregnancy) - Fetal age/size (biometry) - Amniotic fluid assessment - Placental appearance and location - Basic fetal anatomy - Assessment of the adnexae

TIMING OF THE SECOND TRIMESTER ULTRASOUND EXAMINATION

It is generally accepted that the "second trimester/mid-trimester" refers to the period of 14-28 weeks of gestation, but for the sake of this chapter, we are referring to the second trimester as an ultrasound performed within the gestational period of 18 – 22 weeks. In countries where access to ultrasound clinics is difficult or limited, this time period can be extended to 16-25 weeks of gestation, with same caveats. At 16 weeks, the basic anatomy survey is more challenging than later in gestation, especially when portable ultrasound equipment is used and/or in obese women. On the other hand, dating a pregnancy at 25 weeks or greater, in the absence of a previous ultrasound, is much less precise than earlier in gestation.

Who should perform the ultrasound examination?

The operator performing the ultrasound examination differs according to local rules and traditions. In some countries, sonographers do the ultrasound examination and doctors review them; in other countries, doctors primarily do the ultrasound examinations. In certain locations, midwives perform the basic ultrasound examinations, whereas the doctors perform the targeted ultrasound examinations. This last approach is most applicable to low-resource (outreach) countries, due to shortage of medical personnel. Based upon our experience in low-resource settings, where sonographers are typically not available and healthcare workers are in short demand, midwives, when trained appropriately in didactic and hands-on supervised courses with competency evaluation, can achieve a basic ultrasound skill that allows for limited ultrasound examinations. Irrespective of the model in place, it is critical to ensure that operators performing the ultrasound examinations are skilled and trained in the performance of these examinations.

In several countries, guidelines for the performance of the basic ultrasound examination and the qualifications of the healthcare workers to perform such examinations are established. Readers who wish to review these guidelines and qualifications are referred to the American Institute of Ultrasound in Medicine (www.AIUM.org) and the International Society of Ultrasound in Obstetrics and Gynecology (www.ISUOG.org) websites.

Preparation for the ultrasound examination

Before the ultrasound examination is initiated the operator should have a good understanding of the physical principles of ultrasound, the basic operations of the ultrasound equipment and basic technical skills for the performance of the ultrasound examination, details of which are provided in Chapters 1, 2 and 3. **Table 5.2** provides an itemized list that needs to be checked before the initiation of any obstetric mid-trimester ultrasound examination.

Table 5.2	Itemized List to be Checked Before Initiation of the Second Trimester Ultrasound
	- Ensure that the woman’s position on the ultrasound bed is comfortable - Choose the obstetric setting on ultrasound machine - Enter the woman’s name and other identifiers - Enter the woman’s last menstrual period - Place gel on the abdomen - Adjust the gain settings - Adjust the depth and focal ranges - Use the correct orientation of the transducer when scanning

When performing an obstetric ultrasound examination in low-resource settings, the second trimester ultrasound examination can be simplified to six standardized steps, which are geared towards the identification of findings that have a direct impact on the wellbeing of the mother and fetus. These six steps are designed to assess fetal presentation and lie, the presence of fetal cardiac activity, the number of fetuses within the uterus, the adequacy of the amniotic fluid, the localization of the placenta and pregnancy dating. The technical aspects of five of these six steps are described and illustrated in Chapter 10. We will hereby describe the sixth step, which involves the biometric measurement of the fetus, including the biparietal diameter, the head circumference, the abdominal circumference and the femur length.

Fetal Biometry

Fetal biometry refers to *fetal age* and corresponds to the length of gestation (dating) while *size* refers to the fetal weight and will be discussed later. Caution! A pregnancy should not be re-dated if a prior appropriate ultrasound examination established pregnancy dates. Re-dating on the basis of 2nd trimester biometry should only be performed if the woman has not undergone any other earlier ultrasound in pregnancy in which dating was established. Although ultrasound dating in pregnancy is accurate in the second trimester, it is less precise than in the first trimester of pregnancy, when pregnancy is dated by crown-rump length measurement. We recommend the following parameters for pregnancy dating in the second trimester:

- For pregnancies between 14 0/7 weeks and 15 6/7 weeks gestation, a discrepancy of more than 7 days should result in a change in the Expected Date of Delivery (EDD).
- For pregnancies between 16 0/7 weeks and 21 6/7 weeks gestation, a discrepancy of more than 10 days should result in a change in the EDD.
- For pregnancies between 22 0/7 weeks and 27 6/7 weeks gestation, a discrepancy of more than 14 days should result in a change in the EDD.

Four fetal biometric measurements are required for dating and/or for estimating fetal weight including the Biparietal Diameter (BPD), the Head Circumference (HC), the Abdominal Circumference (AC) and the Femur Length (FL). In the following sections, measurement of each of these 4 biometric parameters is explained in details.

Biparietal Diameter

The Biparietal Diameter (BPD) (**Figures 5.1** and **5.2**) should be measured in a cross-sectional view of the fetal head at the level of the thalami. Sonographic landmarks identifying the correct BPD plane are listed in **Table 5.3** and the procedure to measure the BPD is shown in **Table 5.4**.

On occasions, especially in the third trimester when the fetal head is engaged, the BPD can be measured from a coronal plane of the head, if this is the only imaging option available.

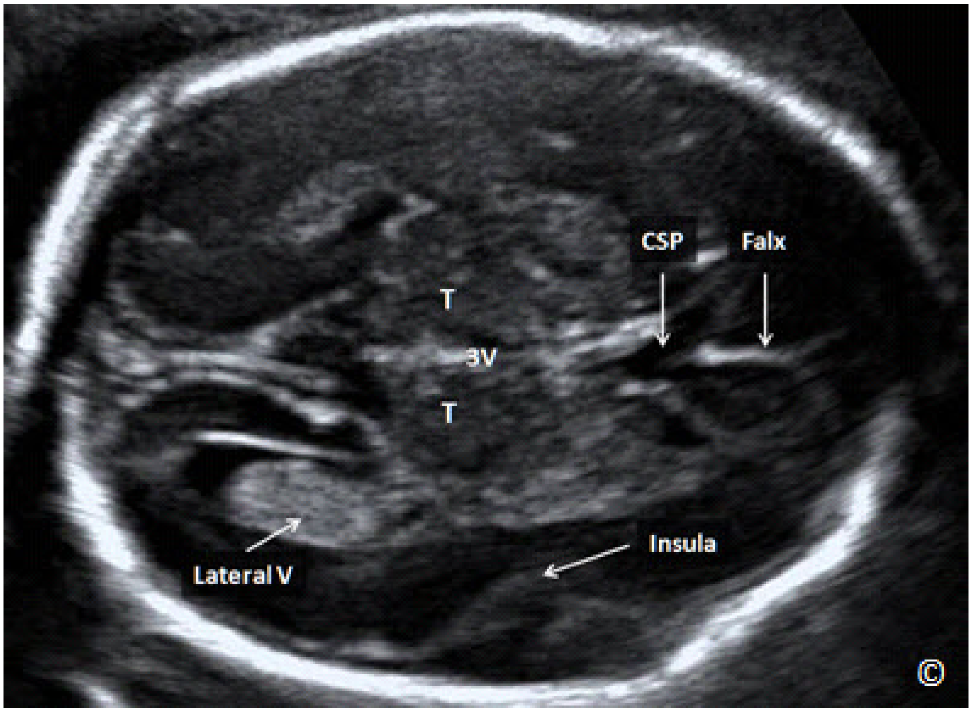

Figure 5.1: A transverse plane of the fetal head at the level of the biparietal diameter (BPD). In this plane, you should see the cavum septae pellucidi (CSP), the falx (labeled), the thalami (T), 3rd ventricle (3V) and the insula (labeled). A portion of the lateral ventricle is also seen (labeled).

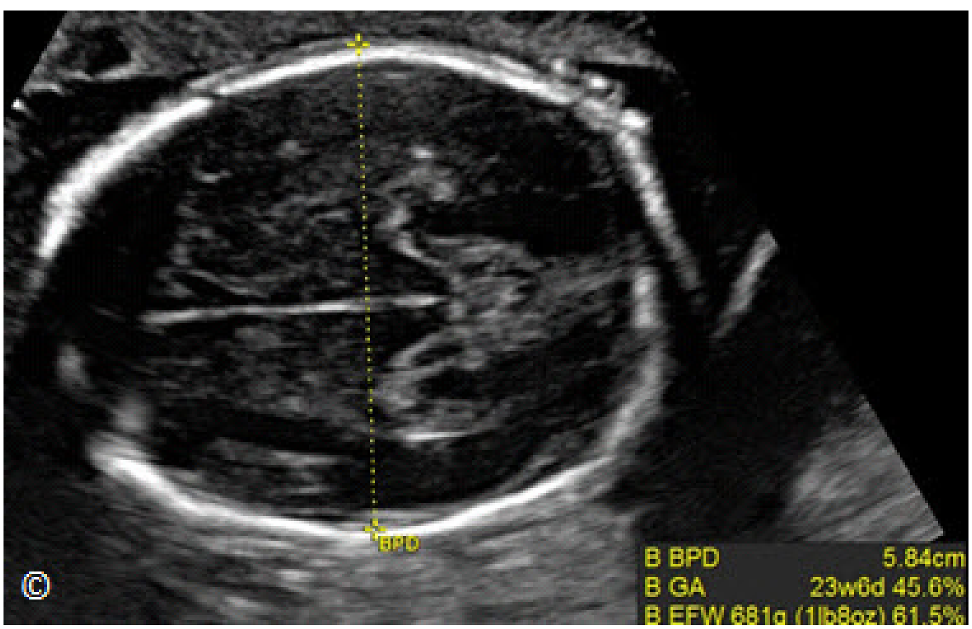

Figure 5.2: Transverse plane of the fetal head at the level of the biparietal diameter (BPD) showing correct caliper placement. Note that the upper and lower calipers are traditionally placed on the outer and inner edge(s) of the cranium respectively (GA = gestational age and EFW = estimated fetal weight).

Table 5.3	Sonographic Landmarks for the Measurement of the Biparietal Diameter Plane (BPD). See Figure 5.1
	- Midline Falx - Thalami - Symmetrical appearance of both cerebral hemispheres - No cerebellum visualized - Cavum Septae Pellucidi - Insula

Table 5.4	Procedure for the Measurement of the Biparietal Diameter (BPD). See Figure 5.2
	- Activate the biometry software (calculate knob) on the console of the ultrasound equipment - Select the BPD option, a caliper will appear on the monitor - Position the caliper on the outer edge of the proximal parietal bone, roughly at the level of the thalami, where the head is wider, and set it - Position the second caliper, symmetrically, on the inner edge of the distal parietal bone, in such a way that the line between the two calipers is at 90° with the midline falx, and set it. - Ensure that the BPD measurement is the widest possible and is perpendicular to the midline falx.

Head Circumference

The Head Circumference (HC) is measured in the trans-thalamic view, which is the same plane as that for the BPD measurement (**Figure 5.1** and **5.2**). There are three options for the measurement of the HC on most ultrasound equipment; the ellipse method (**Figure 5.3**), the 2-diameter method and the trace method. The ellipse method allows the operator to expand an ellipse over the cranium, typically by initially fixing the BPD and occipito-frontal diameters (OFD). The 2-diameter method utilizes the 2 diameters (BPD and OFD) and calculates the HC from an ellipsoid formula. The tracing method simply traces the cranium as seen on the display monitor. Of the three methods that can be selected on most ultrasound equipment, the ellipse method is preferred as it has the least inherent error (**Figure 5.3**). The authors recommend that you perform the HC measurement following the BPD measurement. This approach allows the operator to utilize the calipers placed for BPD measurement, which expedites the process. It is of note that when the HC is being measured, the lower caliper from the BPD diameter should be moved to the outer bony parietal edge (**Figure 5.4**). **Table 5.5** lists the steps for the measurement of the HC.

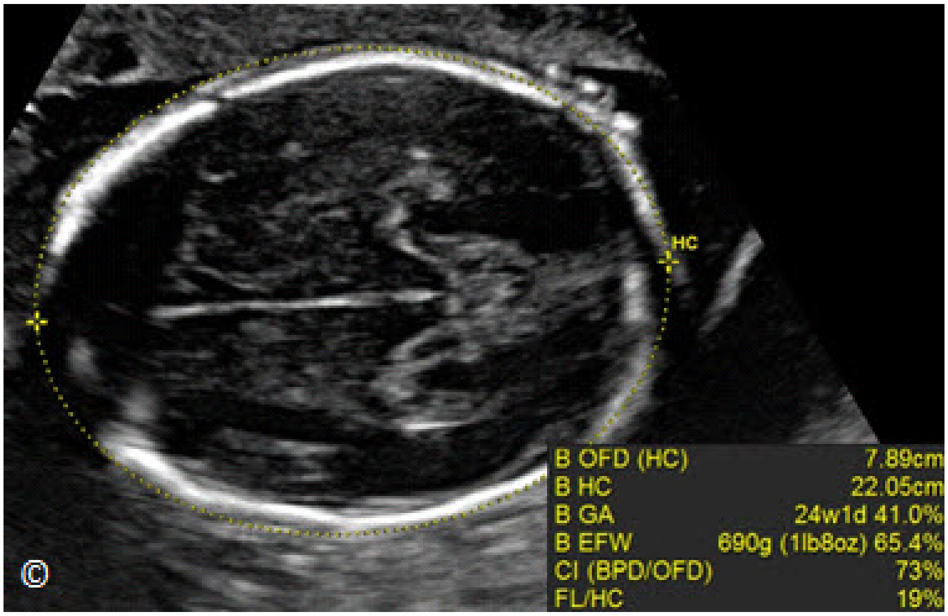

Figure 5.3: Transverse plane of the fetal head at the biparietal diameter (BPD) level. The head circumference (HC) is measured using the ellipse method. Note that the ellipse is tracing the outer edge of the fetal cranium. (OFD= occipito-frontal diameter, GA=gestational age, EFW=estimated fetal weight, CI=cephalic index and FL = femur length).

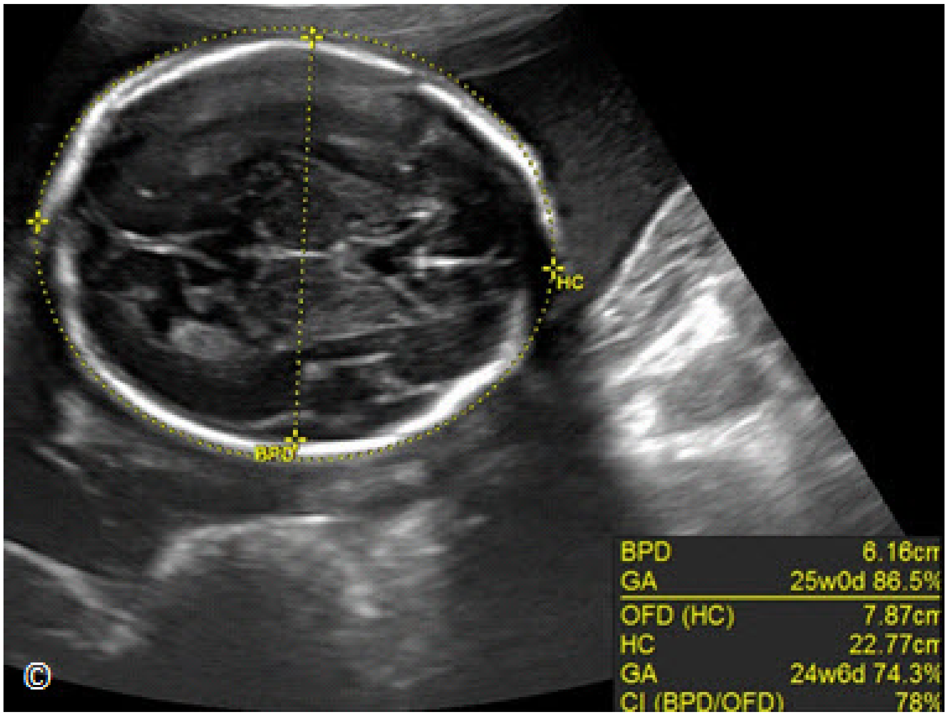

Figure 5.4: Transverse plane of the fetal head at the biparietal diameter (BPD) level. The head circumference (HC) is measured using the ellipse method. Note that the ellipse is tracing the outer edge of the fetal cranium, and the lower caliper for BPD measurement is placed at the inner edge of the parietal bone. (OFD= occipito-frontal diameter, GA=gestational age and CI=cephalic index).

TABLE 5.5	Procedures for the Measurement of the Head Circumference

- Activate the biometry software (Calculate knob) on the scanner console, select the HC and a caliper will appear on the screen
- Position the caliper on the outer edge of the proximal parietal bone, similar to the BPD measurement, and set it
- Position the second caliper, symmetrically, on the outer edge of the distal parietal bone, in such a way that the line between the two calipers is at 90° with the midline falx, and set it
- Open up the ellipse by rotating the trackball on the console sideways, until the ellipse is perfectly overlaid on the skull contour
- If the ellipse is not aligned with the ovoid of the fetal head, change the position of the two calipers, which act as hinges

Abdominal Circumference

The Abdominal Circumference (AC) is measured on a transverse section of the upper fetal abdomen. Sonographic landmarks identifying the correct plane for the AC measurement are listed in **Table 5.6** and **Figure 5.5**.

TABLE 5.6	Sonographic Landmarks for the Abdominal Circumference (AC)

- Circular cross section of the abdomen (as circular as possible)
- Spine seen on cross section
- Stomach bubble
- Intra-hepatic portion of the umbilical vein at the level of the portal sinus
- Large sections of fetal ribs seen on each side laterally
- Kidneys not be visualized in the image

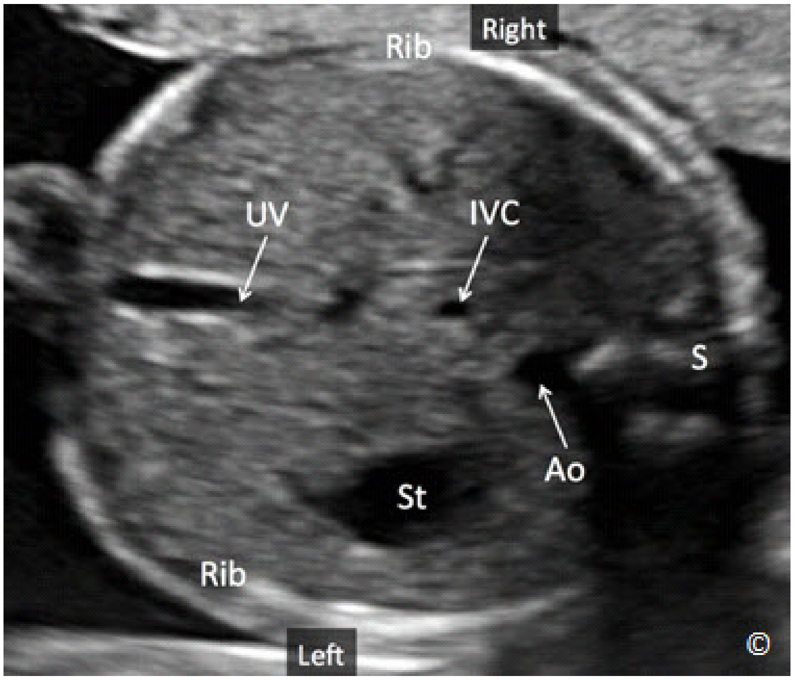

Figure 5.5: Transverse plane of the fetal abdomen at the anatomic level of the abdominal circumference. Note the anatomic landmarks that include the stomach bubble (St), the umbilical vein (UV), the descending aorta (Ao) and the inferior vena cava (IVC). The spine (S) is seen at 3 o'clock and one full rib (Rib) on each side.

Care should be taken to ensure that the cross-section of the abdomen is as circular as possible, in order to avoid errors in the measurement. This is easier in the 2nd than the 3rd trimester, when the fetal limbs or shadowing can indent the abdominal circumference (**Figure 5.6**). The AC is best measured with the fetal spine at 3 or 9 o'clock (**Figure 5.7 A and B**). Avoid measuring the AC if at all possible when the fetal spine is at 6 or 12 o'clock (**Figures 5.6 and 5.8 A and B**). The procedure to measure the AC is shown in **Table 5.7**.

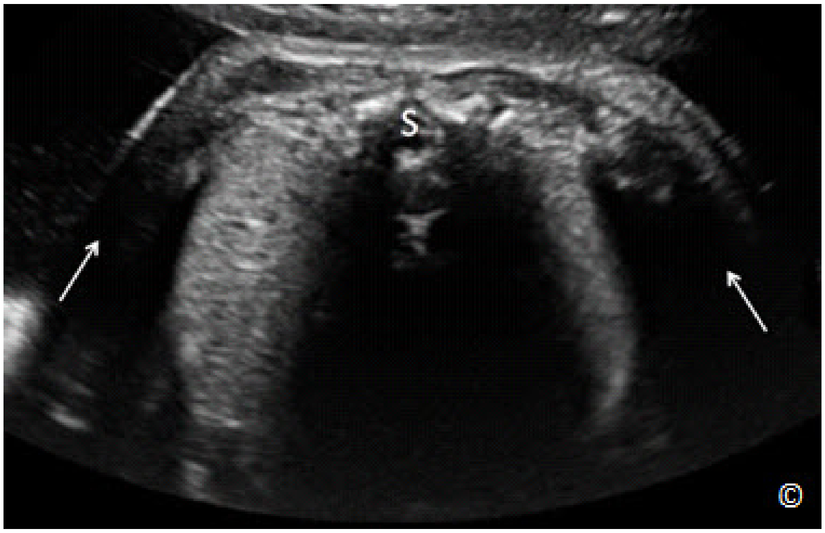

Figure 5.6: Transverse plane of the fetal abdomen at the level of the abdominal circumference (AC) in the third trimester of pregnancy. Note the shadowing (arrows) from upper extremity bones, obscuring the AC lateral borders. The spine (S) is at the 12 o'clock position, which makes optimal measurement of AC difficult.

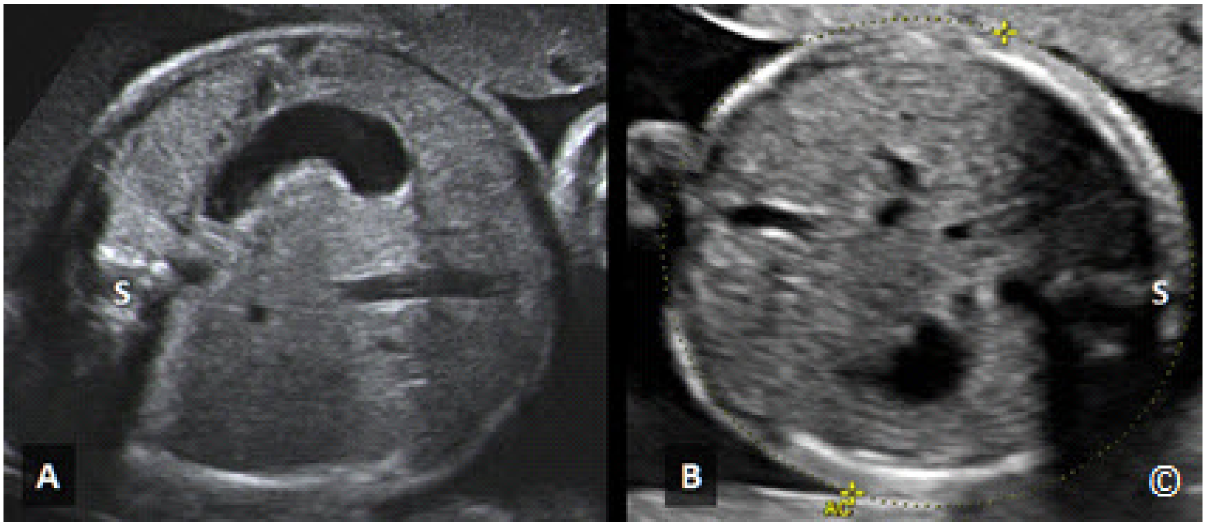

Figure 5.7 A and B: Transverse planes of the fetal abdomen at the level of the abdominal circumference (AC). The spine (S) is at the 9 o'clock position in A and at the 3 o'clock position in B. Spine positions at 9 or 3 o'clock are most optimal for AC measurement as it minimizes shadowing.

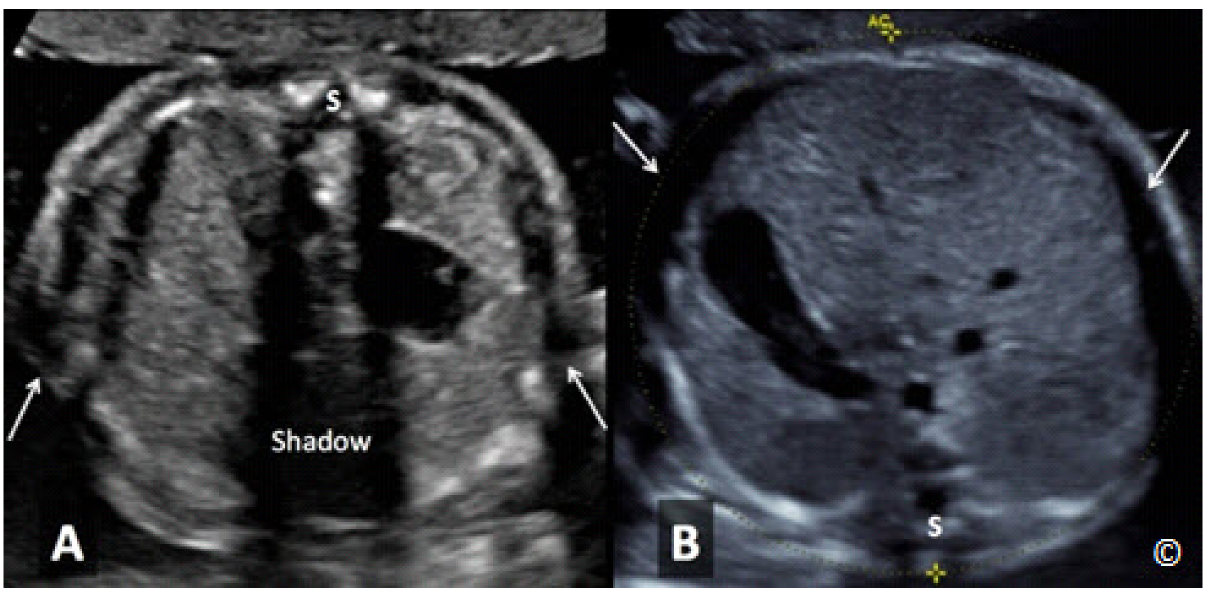

Figure 5.8 A and B: Transverse planes of the fetal abdomen at the level of the abdominal circumference (AC). The spine (S) is at the 12 o'clock position in A and at the 6 o'clock position in B. Spine position at 12 or 6 o'clock is the least optimal for AC measurement as it increases shadowing (A-labeled) and minimizes the ability to assess the lateral borders (arrows) (A and B) due to decrease in lateral resolution and rib shadowing.

TABLE 5.7	Procedures for the Measurement of the Abdominal Circumference (AC)

- Activate the biometry software on the scanner console (Calculate knob), select the AC and a caliper will appear on the screen
- Position the caliper on the outer surface of the skin line, on the proximal side of the fetal abdomen, roughly at the level of the rib end, and set it
- Position the second caliper, symmetrically, on the distal surface of the skin line, in such a way that the line between the two calipers is at 90° with the midline, and set it
- Open up the ellipse by rotating the trackball on the console sideways, until the ellipse is perfectly overlaid on the skin contour. Ensure to include the outer edge of the skin contour with the measurement
- If the ellipse is not aligned with the cutaneous outline of the abdomen, change the position of the two calipers, which act as hinges

Femur Length

In order to optimize the measurement of the Femur Length (FL), the whole femur diaphysis should be displayed on the screen, and the angle between the insonating beam and the shaft of the femur should be kept in the range of 45-90° in order to avoid underestimating the length of the femur due to ultrasound wave deflection (**Figure 5.9**). The longest visible diaphysis should be measured by placing each caliper at the end of the ossified diaphysis without including the distal femoral epiphysis, if visible (**Figure 5.10**). Femur measurement should exclude triangular spur artefacts that can falsely extend the diaphysis length (**Figure 5.10**).

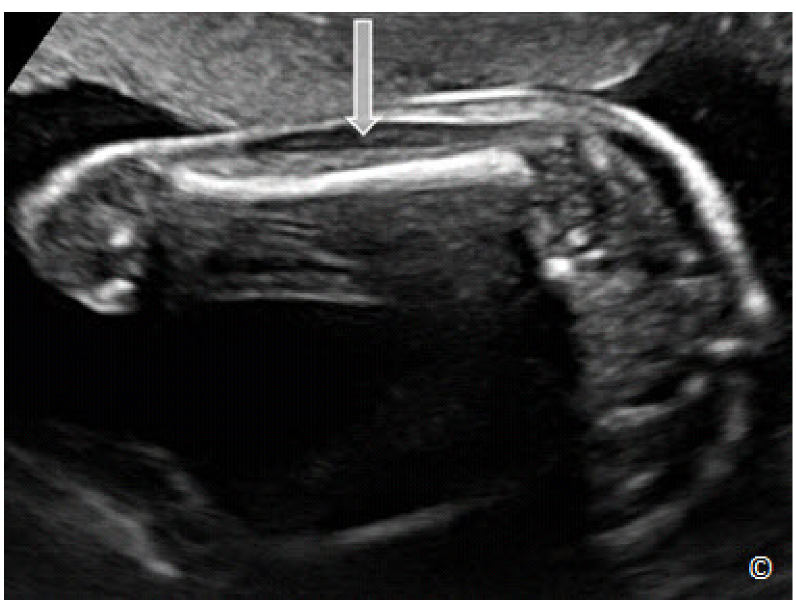

Figure 5.9: Optimal imaging of the femur for length measurement. Note that the whole femur diaphysis is seen and the angle between the insonating beam (arrow) and the shaft of the femur is almost 90 degrees.

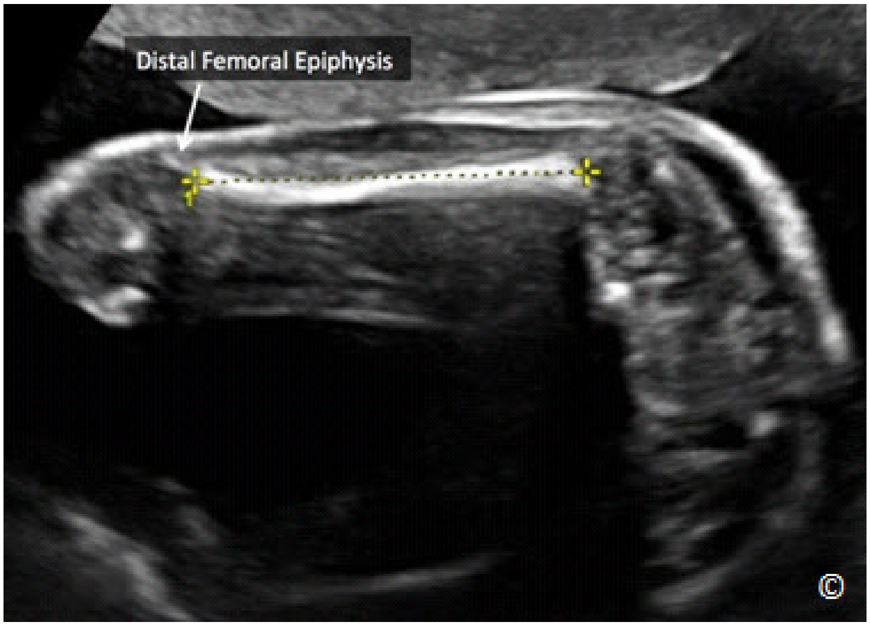

Figure 5.10: Femur length measurement. Note that the longest visible diaphysis is measured by placing each caliper at the end of the ossified diaphysis without including the distal femoral epiphysis (labeled).

It is important to note that imaging of the long axis of the femur can be more technically difficult than the BPD, HC and AC. Consideration should therefore be given to delay the introduction of the FL to the basic ultrasound examination, until more technical expertise is acquired by novice ultrasound operators. If this course is chosen, formula for EFW that does not utilize FL should be activated in the ultrasound equipment.

Estimating Fetal Weight

Once the four measurements described above have been calculated, the software of the ultrasound equipment derives the estimated fetal weight (EFW), using a mathematical formula. Hadlock et al is the formula that is most commonly used for EFW and was developed in the late 1980s (1). Calculating the EFW is more accurate in the second trimester than the third trimester but EFW is clearly of lesser clinical relevance in the second trimester. In the 3rd trimester, EFW is of crucial importance to detect fetal growth restriction or macrosomia. The estimation of macrosomia is not very accurate and the error can exceed 10% (2). Detailed discussion on estimation of fetal weight will be presented in the following chapter.

Basic Fetal Anatomy

Although fetal anatomy is part of the basic ultrasound examination as defined by national and international organizations (3, 4), in some low-resource (outreach) settings, the primary objective of the second trimester ultrasound is to identify high-risk pregnancies at increased risk for neonatal and maternal morbidity and mortality. To that end, review of basic fetal anatomy is typically not part of the basic ultrasound examination in that setting. Basic fetal anatomy is presented in this chapter for completeness sake and also as it is part of the basic ultrasound examination in the second and third trimester in many countries. Placental appearance, its location within the uterine cavity, amniotic fluid assessment and the adnexae are also part of the basic ultrasound examination. They are covered in separate chapters later in the book. **Table 5.8** shows a list of basic fetal anatomy for the second trimester ultrasound.

For more information on the practice guideline for the performance of the basic obstetric ultrasound examination, visit the American Institute of Ultrasound in Medicine (www.AIUM.org) and the International Society of Ultrasound in Obstetrics and Gynecology (www.ISUOG.org) websites (3, 4).

TABLE 5.8	List of Basic Fetal Anatomy in the Second Trimester of Pregnancy

- HEAD
    - Lateral cerebral ventricles, Choroid plexus, Midline falx, Cavum septae pellucidi, Cerebellum, Cistern magna; and Upper lip and philtrum.
- CHEST
    - Heart; Four-chamber view, Left ventricular outflow tract, Right ventricular outflow tract and Lung fields.
- ABDOMEN
    - Stomach (presence, size, and situs), Kidneys, Urinary bladder, Umbilical cord insertion into the fetal abdomen, and Umbilical cord vessel number.
- SKELETAL
    - Cervical, Thoracic, Lumbar, and Sacral spine.
- Extremities
    - Legs and Arms
- PLACENTA
- AMNIOTIC FLUID
- ADNEXAE

Head anatomy

Three axial sonographic planes are needed to assess the head anatomy: the plane at the level of the lateral ventricles (**Figure 5.11**), the plane at the level of the BPD (**Figure 5.2**), and the plane at the level of the posterior fossa (**Figure 5.12**).

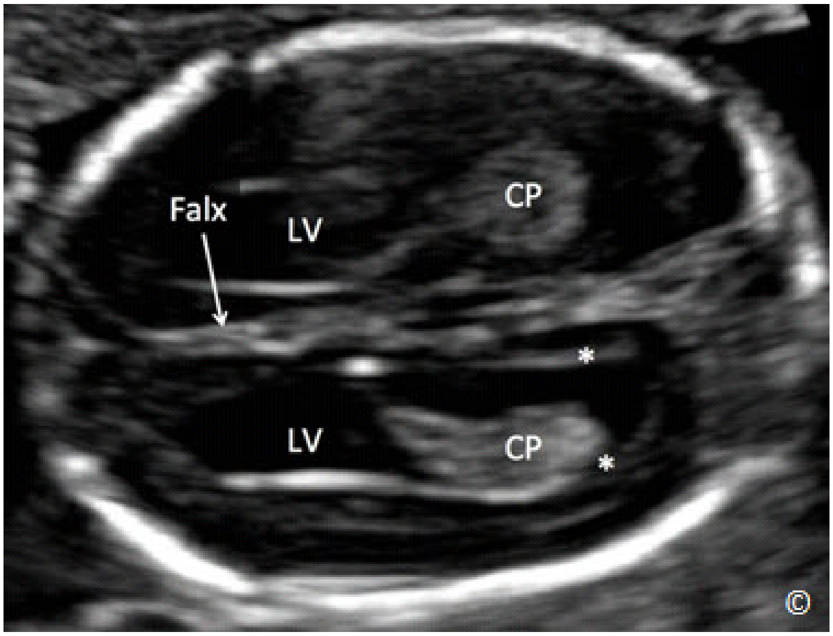

Figure 5.11: Transverse plane of the fetal head at the level of the lateral ventricles (LV). Sonographic landmarks for LV measurement include the LV, the cavum septae pellucidi and the midline falx (labeled). The LV is measured at the level of the atrium (asterisks). CP = Choroid Plexus.

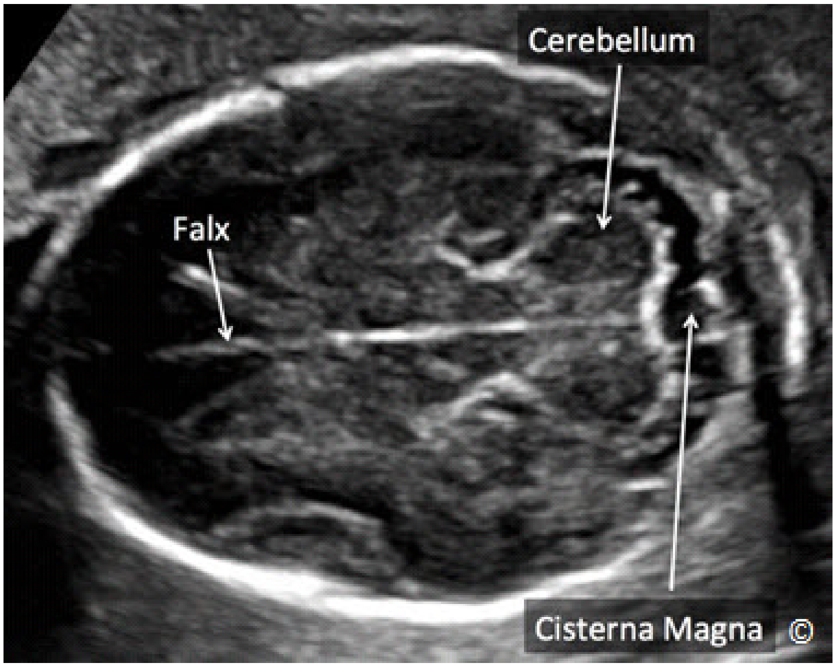

Figure 5.12: Transverse plane of the fetal head at the level of the posterior fossa. Sonographic landmarks include the cerebellum, cisterna magna and falx (labeled).

Plane at level of Lateral Ventricles

This represents an axial view of the fetal head, at the level of the lateral ventricles (**Figure 5.11**). Sonographic landmarks identifying the correct anatomic plane include the lateral ventricles, the cavum septae pellucidi and the midline falx (**Figure 5.11**). On this view, the width of the atrium of the distal lateral ventricle should be measured (**Figure 5.11**). Visualization of the proximal lateral ventricle is obscured by proximal parietal bone shadowing (**Figure 5.11**). The atrium of the lateral ventricle should be measured at the level shown in **Figure 5.11** and should be equal to or <10.0 mm. anytime in gestation. Ventriculomegaly is defined by a lateral ventricular measurement of greater than 10 mm and is the most common intracranial malformation (**Figure 5.13**) diagnosed prenatally. Ventriculomegaly is associated with many intracranial malformations and with fetal aneuploidy and its finding should therefore result in a targeted ultrasound examination of fetal anatomy and counselling for fetal aneuploidy testing. Holoprosencephaly, which results from failure of division of the prosencephalon during early embryogenesis into two lateral ventricles, can also be detected in this plane (**Figure 5.14 A and B**). Anencephaly (absence of brain tissue associated with absent calvarium) (**Figure 5.15 A and B**) and encephalocele (**Figure 5.16 A and B**), (localized defect of cranium – neural tube defect), can also be detected in this plane.

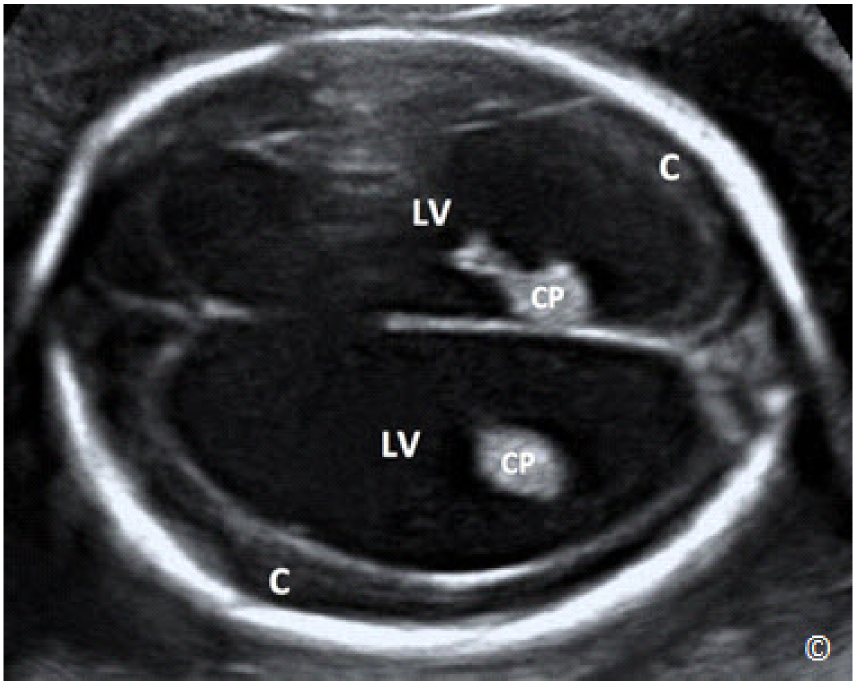

Figure 5.13: Transverse plane of the fetal head at the level of the lateral ventricles (LV) in a fetus with bilateral ventriculomegaly. Note the enlarged lateral ventricles (LV) and compressed cerebral cortex (C) and choroid plexus (CP).

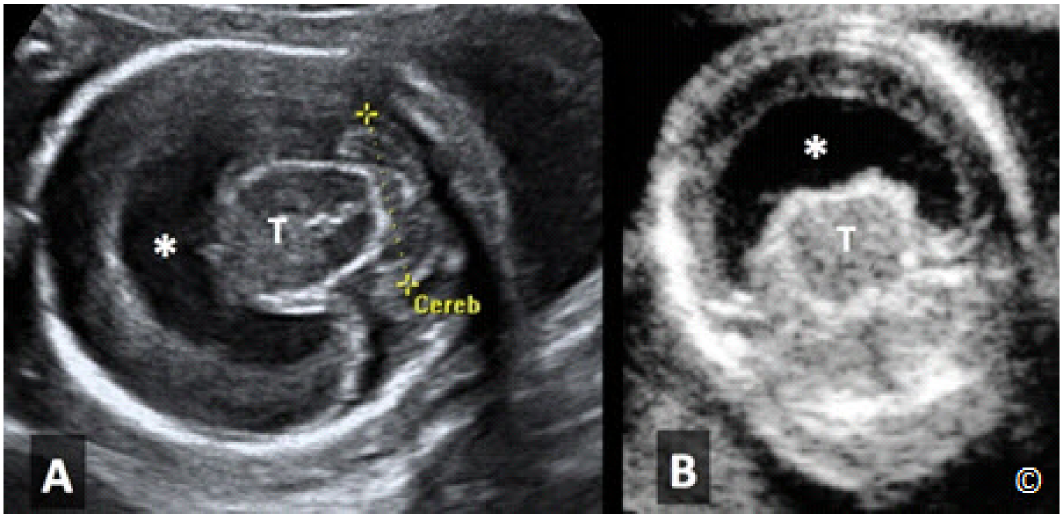

Figure 5.14 A and B: Holoprosencephaly in 2 fetuses shown in a transverse plane (A) and coronal plane (B) of the fetal head. A single ventricle is seen (asterisk) with fused thalami (T). Note a hypoplastic cerebellum (Cereb) in A (not typically a feature of holoprosencephaly).

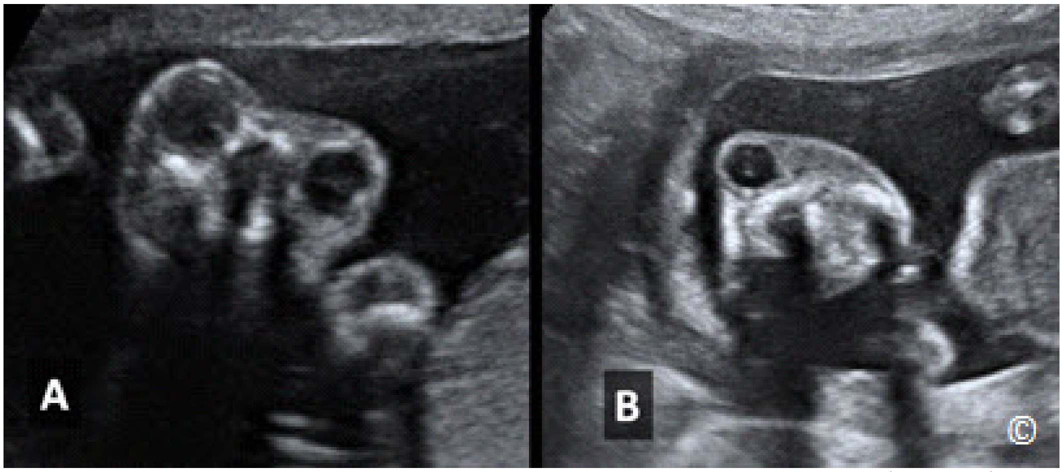

Figure 5.15 A and B: Imaging of the fetal head in 2 fetuses with anencephaly (A and B). Note the absence of fetal cranium and normal brain tissue.

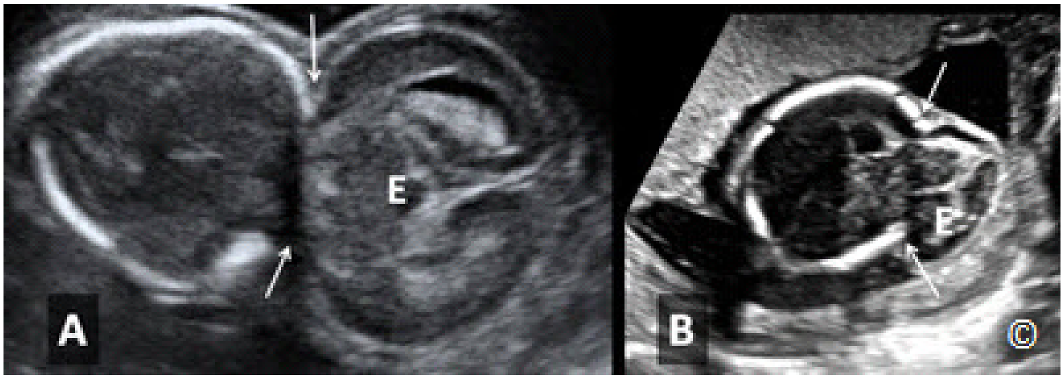

Figure 5.16 A and B: Transverse planes of the fetal head in 2 fetuses (A and B) with encephaloceles (E). Note the location of the cranial defect (arrows), in the occipital aspect of the cranium, which is the most common location for such defects. Brain tissue can be seen in both encephaloceles (E).

Plane at level of Posterior Fossa

The plane at the level of the posterior fossa, also known as the trans-cerebellar plane, is an axial (or slightly oblique) view at the level of the posterior fossa (**Figure 5.17**). In this plane you can see the cerebellum, the cisterna magna, and the 3rd and 4th ventricles (**Figure 5.17**). This plane is easily obtained by angling the ultrasound transducer posteriorly about 45 degrees from the BPD plane while avoiding shadowing from the cranial bone. The most common abnormalities detected in this view represent the Dandy-Walker malformation (**Figure 5.18**), cerebellar vermis dysgenesis (**Figure 5.19**) and the Chiari II malformation (**Figure 5.20**) (typical of spina bifida). Occasionally, posterior, small occipital encephaloceles may only become evident in this scanning plane. Spina bifida (with Chiari II malformation) (**Figure 5.20, 5.21 A and B**) requires neonatal surgery both to cover the spinal defect and to shunt the commonly associated obstructive ventriculomegaly.

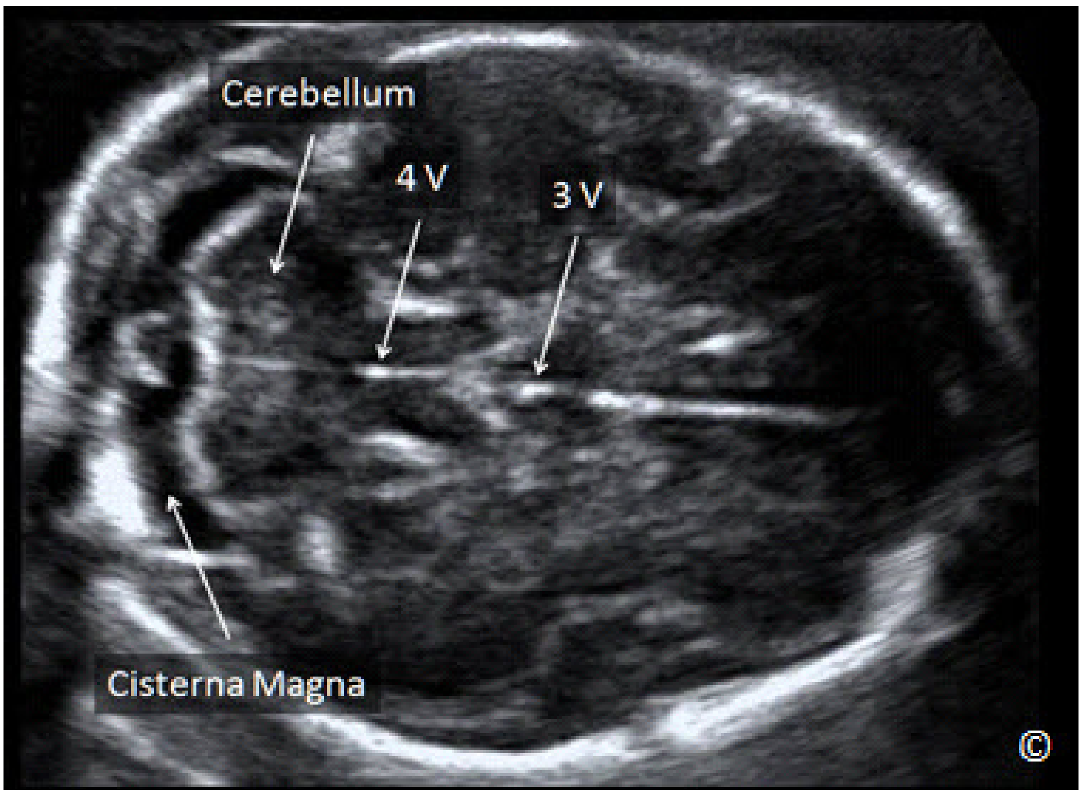

Figure 5.17: Transcerebellar plane of the fetal head (transverse – oblique). The posterior fossa contains the cerebellum and cisterna magna (labeled). The 4th and 3rd ventricles (4V and 3V) are seen in this plane.

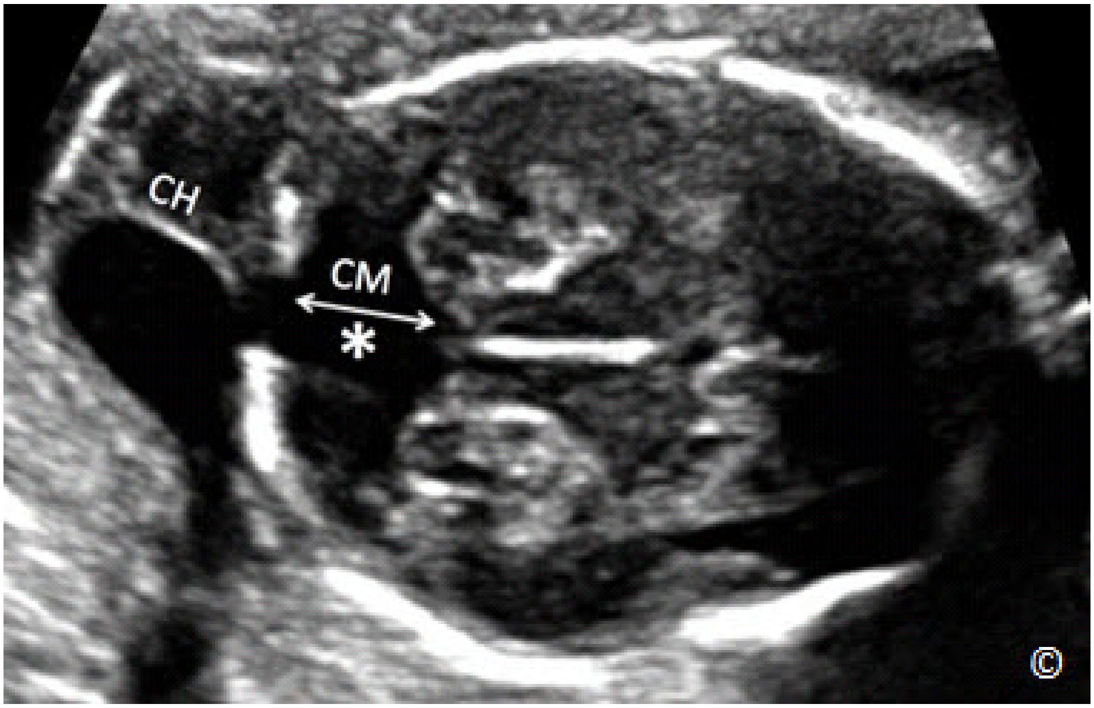

Figure 5.18: Transcerebellar plane of a fetus with Dandy Walker malformation (asterisk). Note the absence of the cerebellum and enlargement of cisterna magna (CM). Note the presence of a cystic hygroma (CH) in this fetus.

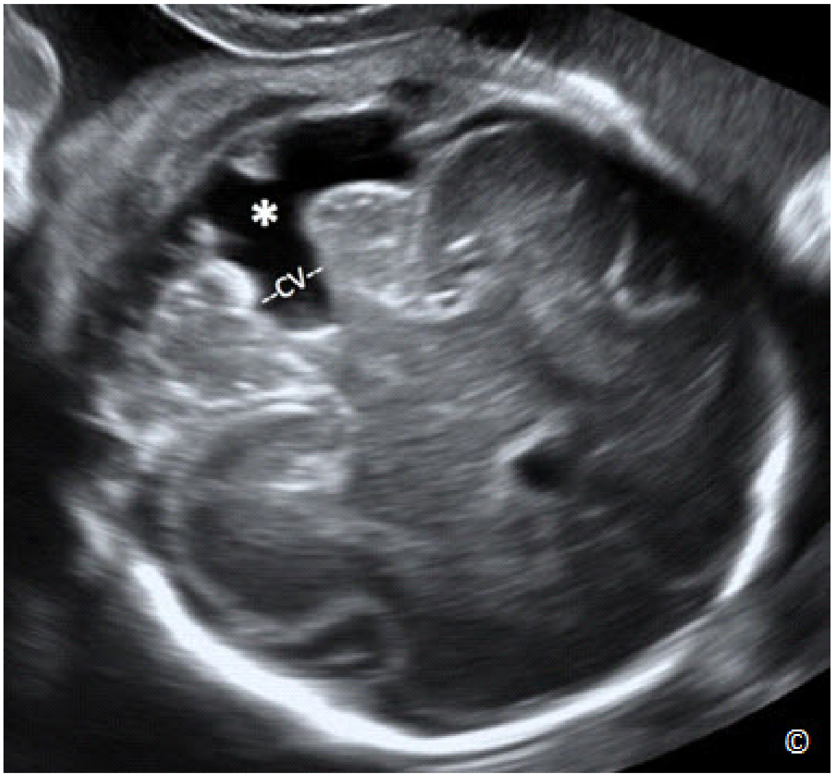

Figure 5.19: Transcerebellar plane of a fetus with cerebellar vermis dysgenesis (asterisk). Note the absence of the cerebellar vermis (CV) with enlargement of cisterna magna (asterisk).

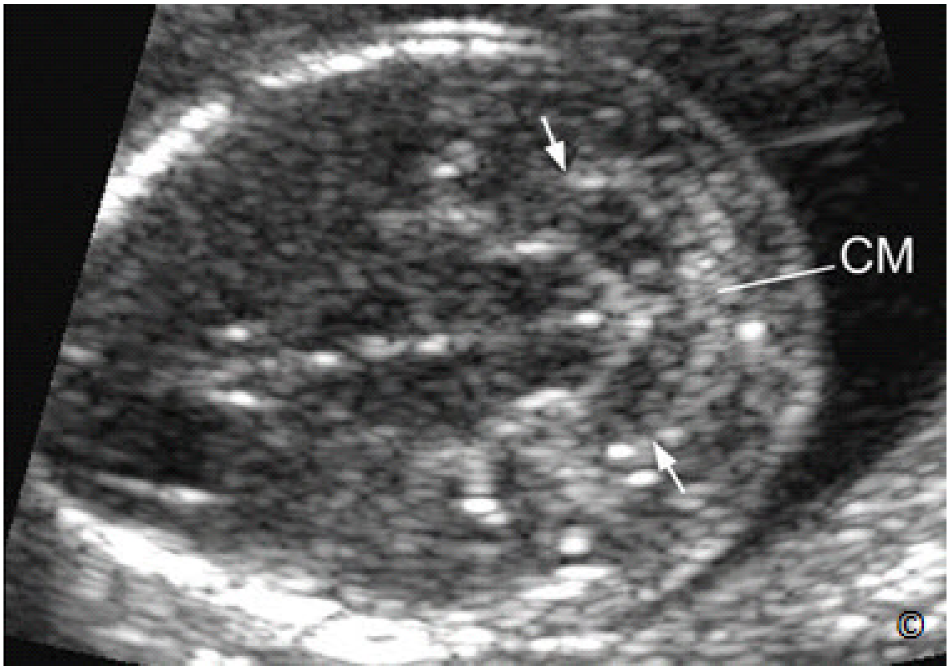

Figure 5.20: Transcerebellar plane of a fetus with spina bifida showing the posterior fossa changes (Chiari II). Note the obliteration of the cisterna magna (CM) and abnormal shape of the cerebellum (arrows).

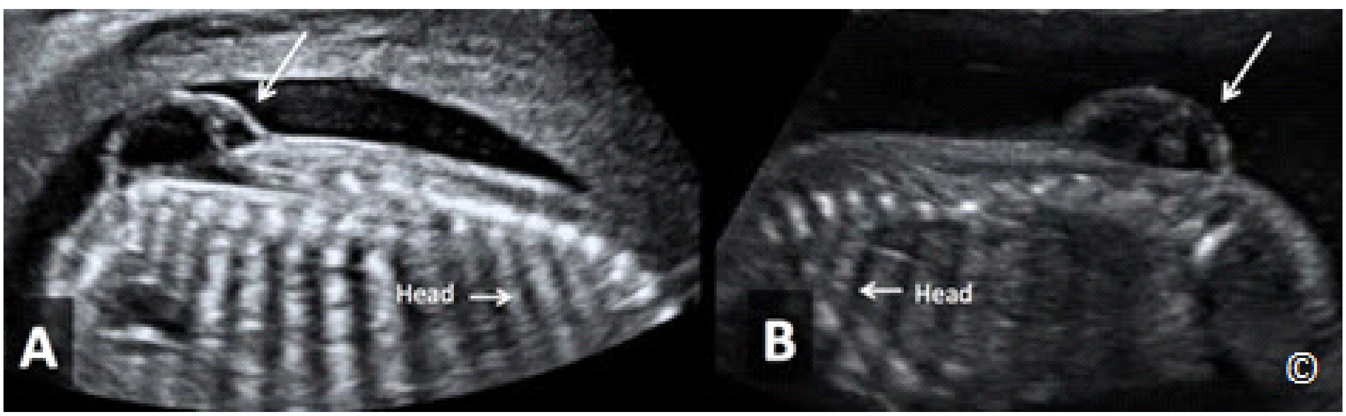

Figure 5.21 A and B: Longitudinal (Mid-sagittal) planes of the fetal spine in 2 fetuses (A and B) with spina bifida. Note the lumbo-sacral locations of the spinal defects (arrows).

Plane at level of Biparietal Diameter

The sonographic landmarks identifying the correct BPD plane have been previously described in this chapter (**Figure 5.2**) and include the midline falx, the cavum septae pellucidi and the thalami. Abnormalities detected in this plane include ventriculomegaly (**Figure 5.22 A and B**), holoprosencephaly (**Figure 5.14**), agenesis of the corpus callosum (**Figure 5.23**) and septo-optic dysplasia (**Figure 5.24**). Other rare intracranial abnormalities, such as tumors, can also be detected in this plane. Comprehensive evaluation of the fetal central nervous system requires multiple views of the fetal brain from its sagittal, coronal and axial (transverse) views and through the abdominal and transvaginal (when feasible) approach.

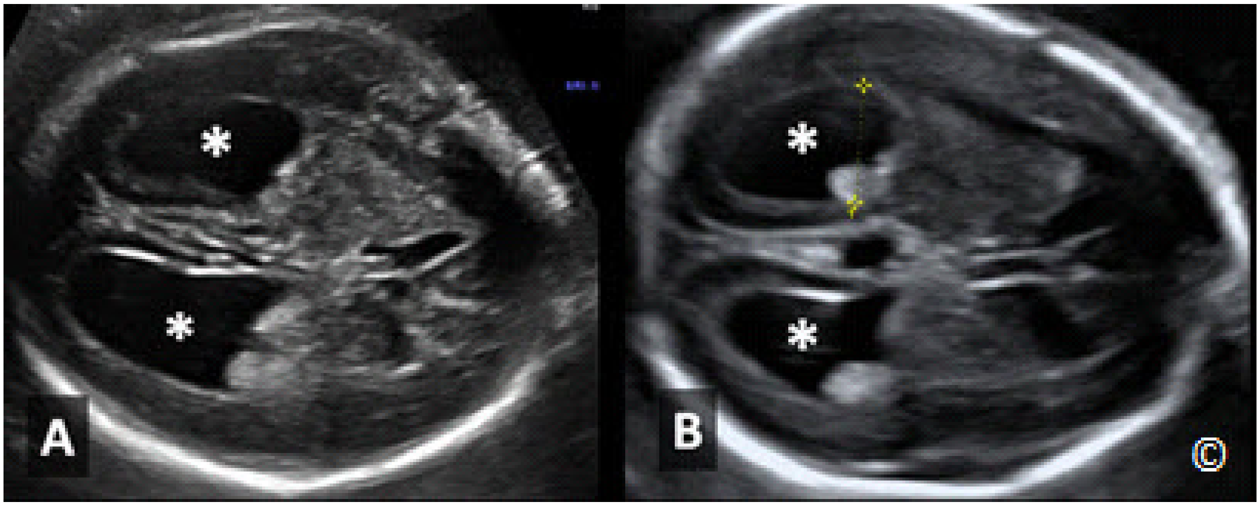

Figure 5.22 A and B: Transverse plane of the fetal head) in 2 fetuses with bilateral ventriculomegaly (asterisks). Note the enlarged lateral ventricles (asterisks).

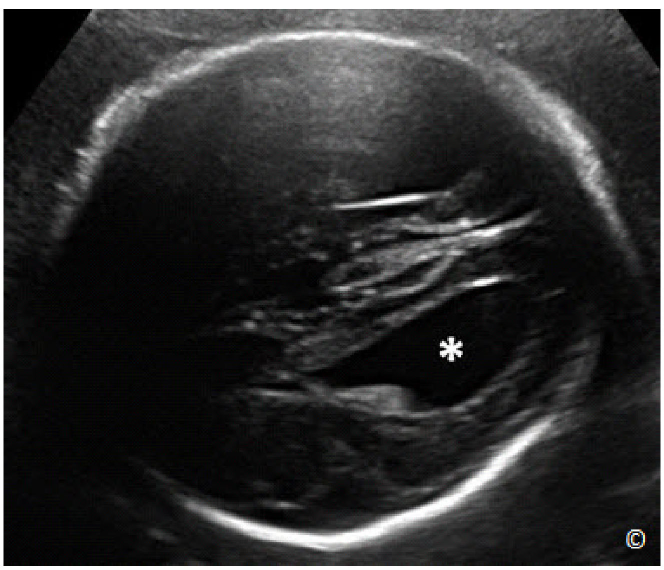

Figure 5.23: Transverse plane of the fetal head at the level of the lateral ventricles in a fetus with agenesis of the corpus callosum (ACC). Note the tear-shaped lateral ventricle (asterisk), a characteristic of ACC.

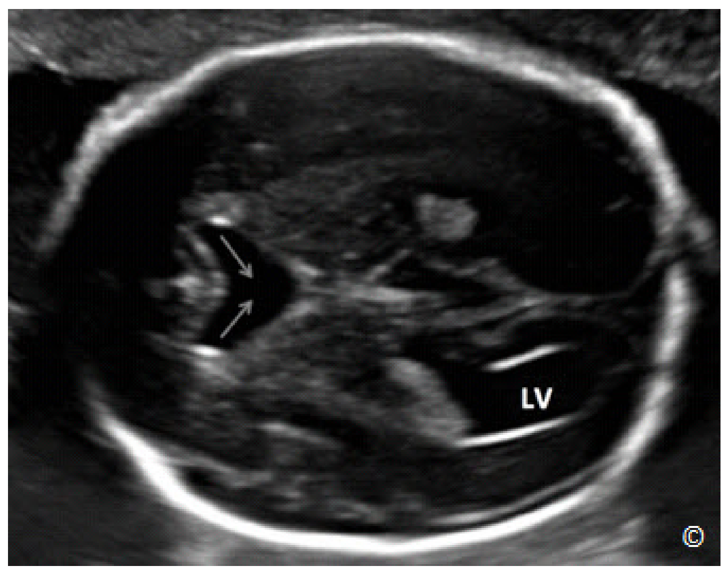

Figure 5.24: Transverse plane of the fetal head at the level of the BPD in a fetus with septo-optic dysplasia. Note the absence of cavum septae pellucidi and fusion of frontal horns of the lateral ventricles (arrows). LV= left ventricle.

Facial Anatomy

Basic sonographic anatomy of the face can be primarily achieved by the evaluation of the orbits and the upper lip and philtrum.

Plane at level of Fetal Face

The evaluation of the fetal face can be obtained by rotating the transducer 90 degrees from the BPD plane and sliding tangentially to view the two orbits and then the upper lip and philtrum. The bi-ocular plane is a tangential plane of the fetal head at the level of the orbits (**Figure 5.25**). The tangential view of the lips (**Figure 5.26**) allows for the detection of facial clefting (**Figure 5.27**). The mid-sagittal view of the facial profile (**Figure 5.28**) is important as it allows for evaluation of the fetal lower chin, is recognized by mothers and may play a role in maternal-fetal bonding.

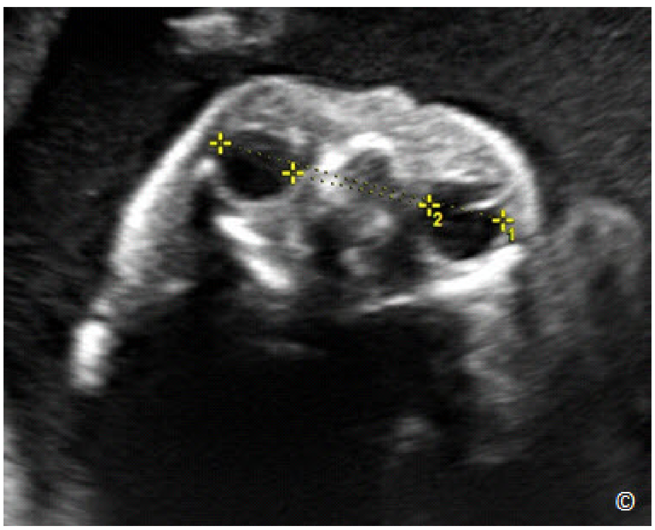

Figure 5.25: Tangential plane of the fetal head at the level of the orbits. Outer (1) and inner (2) ocular diameters can be measured in this plane.

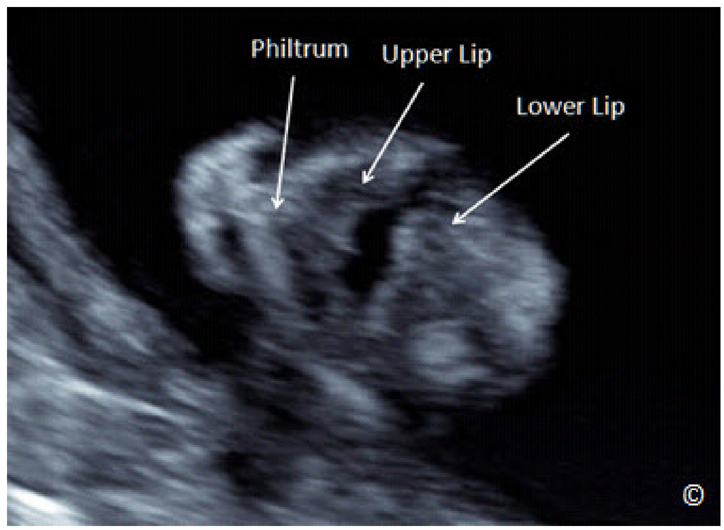

Figure 5.26: Tangential plane of the fetal face showing the soft tissue of the upper lip, philtrum and lower lip (labeled).

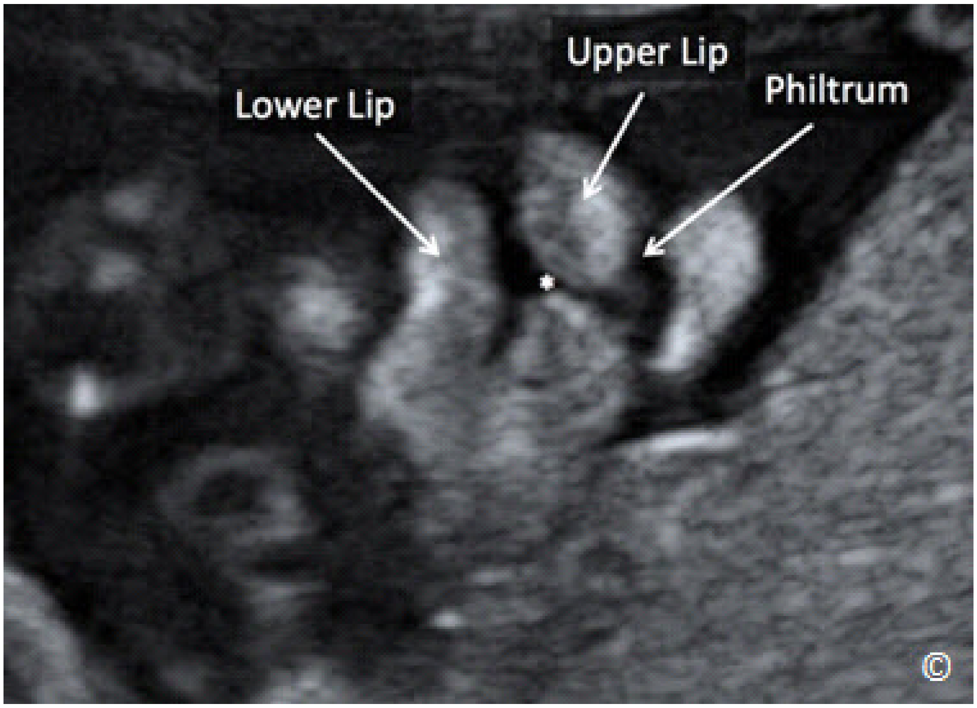

Figure 5.27: Tangential plane of the fetal face showing the soft tissues of the upper lip, philtrum and lower lip in a fetus with left cleft lip (asterisk).

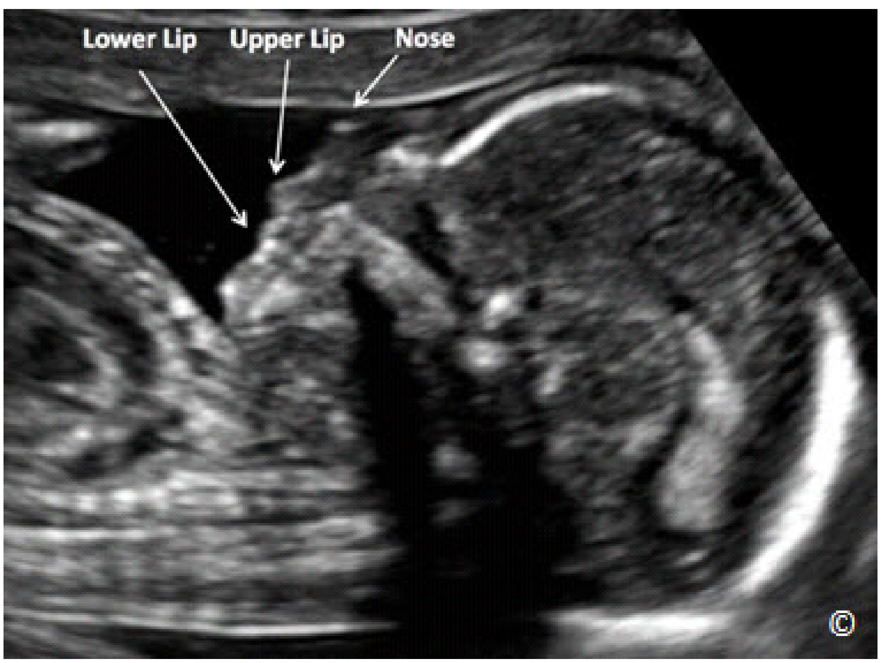

Figure 5.28: Midsagittal view of the fetal head and face. Note the recognizable fetal profile that includes the tip of the nose, the upper lip, and lower lip (labeled).

Chest Anatomy

The plane required to assess both the lungs and the heart is the 4-chamber view, which corresponds to an axial view of the chest at the level of the heart (**Figure 5.29**). **Table 5.9** lists the sonographic landmarks of the four-chamber view plane.

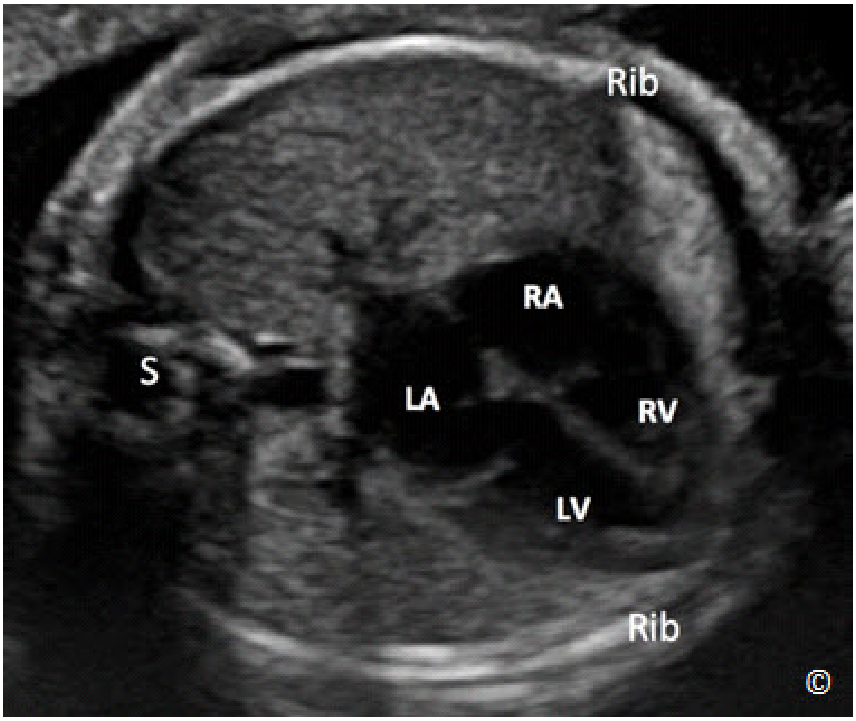

Figure 5.29: Axial (transverse) view of the fetal chest at the level of the four-chamber view. Note the presence of one full rib on each lateral border (Rib). S= spine, LA= left atrium, RA= right atrium, LV= left ventricle and RV= right ventricle.

TABLE 5.9	Sonographic Landmarks of the Four-Chamber View Plane
	- One full rib on each side of the chest - Four-chamber view - Heart occupies 1/3 of thoracic area - Heart rotated to left with cardiac axis at 45 +/-20^{o}

In this plane, the cardiac chamber that is the most posterior is the left atrium, whereas the cardiac chamber just below the sternum is the right ventricle (**Figure 5.29**). Major anomalies that can be identified in this view include cardiac and pulmonary malformations. Common congenital heart abnormalities that can be detected on the 4-chamber view include ventricular hypoplasia (right or left) (**Figure 5.30**), large septal defects (atrio-ventricular septal defect) and severe outflow tract obstructions (pulmonary valvular atresia or critical aortic stenosis). Most of these cardiac defects require neonatal cardiac surgery because of ductus-dependency. Atrio-ventricular septal defect does not represent a neonatal emergency, but is associated with Down syndrome in up to 60% of the cases. Most common chest lesions include: diaphragmatic hernia (**Figure 5.31**); cystic and hyperechoic lesions of the lung, such as Congenital Cystic Adenomatoid Malformation (C-CAM, cystic or solid type) (**Figure 5.32**); extra-lobar sequestration (**Figure 5.33**); and pleural effusions (**Figure 5.34**). Some of these lesions are benign and often regress spontaneously by the time of birth. Pleural effusions, if in the context of non-immune hydrops fetalis, can lead to fetal or neonatal demise. Diaphragmatic hernia needs early post-natal surgery, with survival rates of roughly 50 - 70% in tertiary centers.

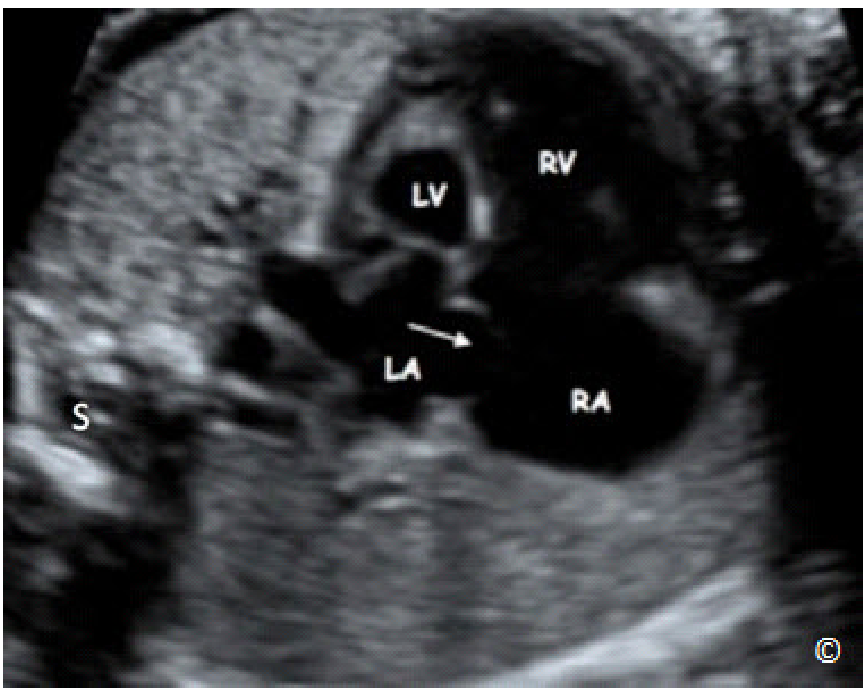

Figure 5.30: Four-chamber view plane of a fetus with hypoplastic left heart syndrome. Note the diminutive size of the left ventricle (LV). Arrow points to the foramen ovale that typically displays reverse flow in this condition. S = spine, LA= left atrium, RA= right atrium, and RV= right ventricle.

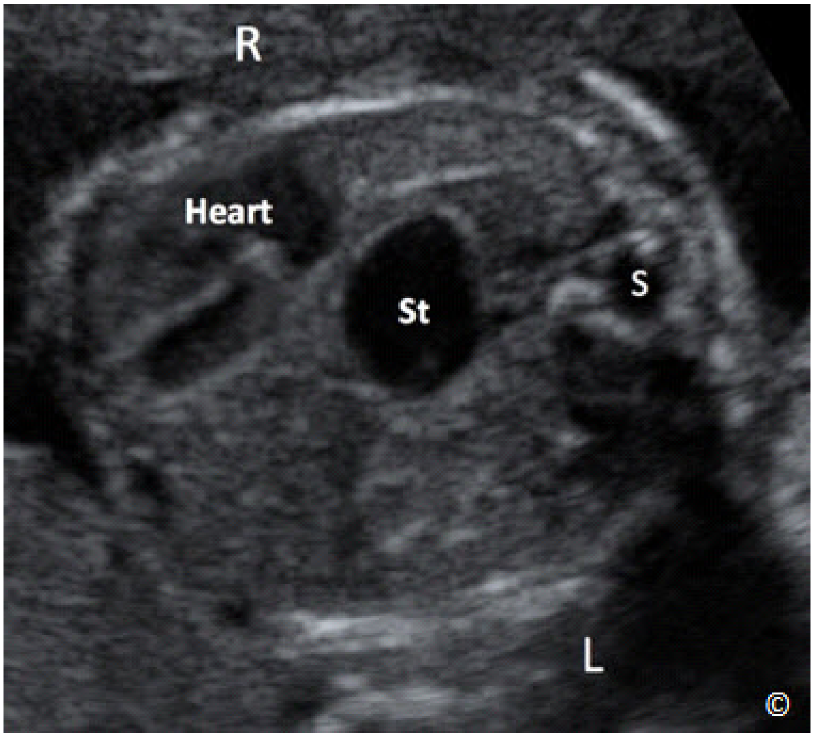

Figure 5.31: Transverse plane of the chest in a fetus with congenital diaphragmatic hernia. Note the upward displacement of the stomach (St) into the chest. The heart (labeled) is pushed into the right chest. S = spine, R=right, L=left.

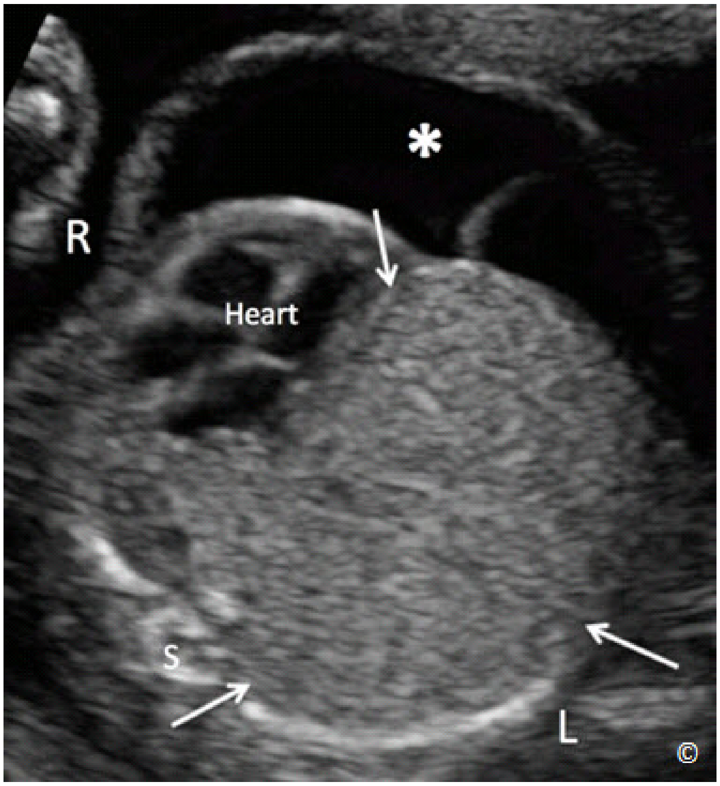

Figure 5.32: Transverse plane of the fetal chest at the level of the four-chamber view in a fetus with congenital cystic adenomatoid malformation of the left lung. Note the large echogenic lung mass (arrows) associated with fetal ascites (asterisk). The heart is shifted to the right chest. R = right, L = left and S = spine.

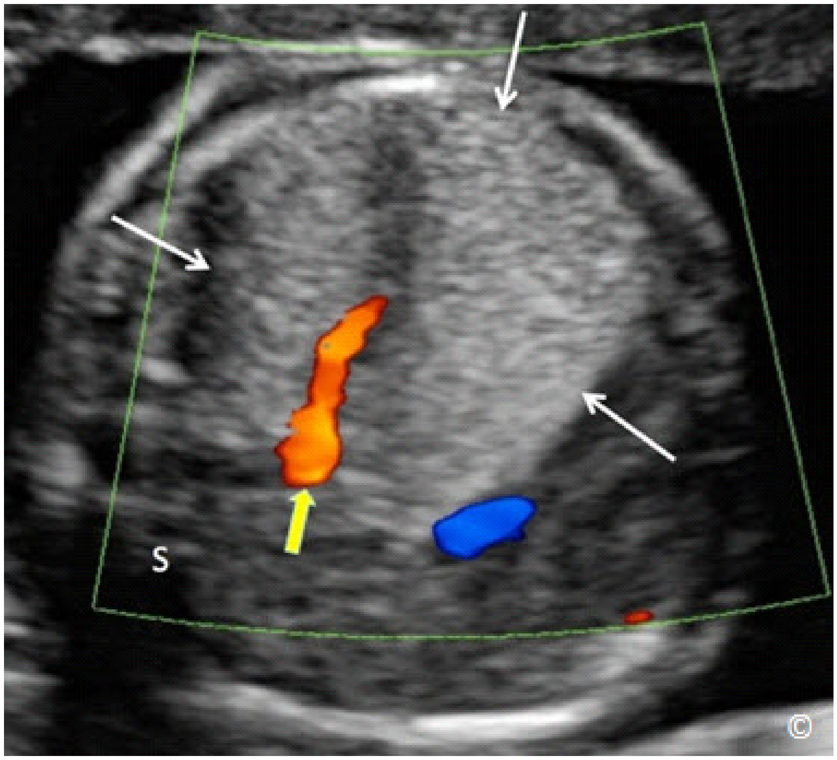

Figure 5.33: Transverse plane of the chest in 2D and color Doppler modes in a fetus with pulmonary sequestration (white arrows). Note the vascular supply (yellow arrow) that typically arises from the systemic circulation. S = spine

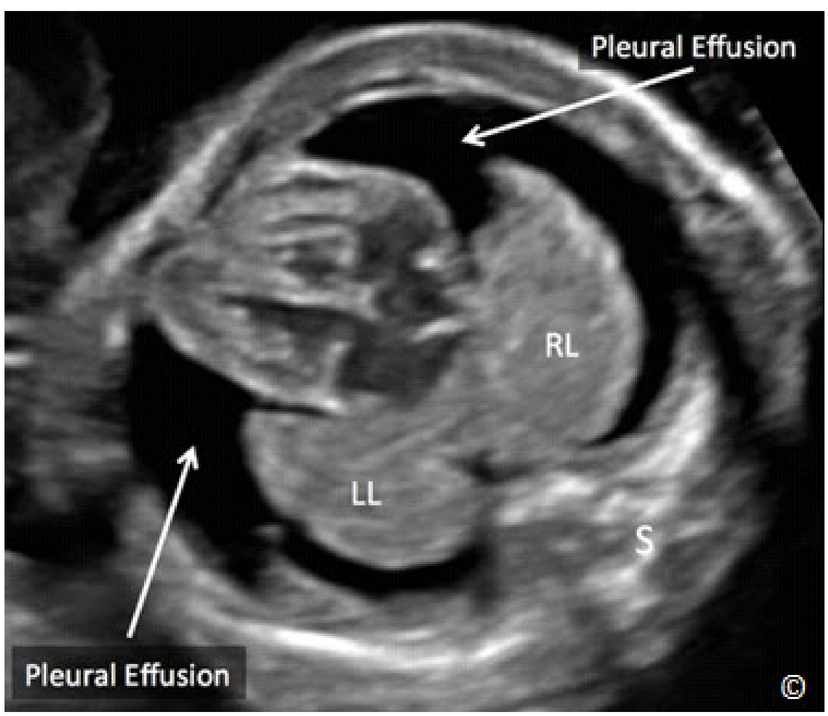

Figure 5.34: Transverse view of the fetal chest at 23 weeks' gestation showing bilateral pleural effusions (arrows). Pleural effusions regressed spontaneously and resolved in this fetus with follow-up ultrasound examinations. S = spine, RL = right lung, LL = left lung.

Abdominal Anatomy

The stomach is visualized on the transverse view in which the AC is measured. Persistent, non-visualization of the stomach is typically a sign of esophageal atresia, whereas double bubble is a sign of duodenal atresia (**Figure 5.35**). Wall abnormalities include exomphalos (omphalocele) (**Figure 5.36**) and gastroschisis (**Figure 5.37 A and B**). All these anomalies are usually non-life threatening, but require early neonatal surgery. Some major kidney anomalies are associated with significant decrease in amniotic fluid such as bilateral renal agenesis (**Figure 5.38 A and B**), infantile polycystic disease (**Figure 5.39 A - C**), and bladder outlet obstruction (**Figure 5.40 A and B**). Hydronephrosis, from reflux or pyelo-ureteral obstruction (**Figure 5.41**) is generally less severe.

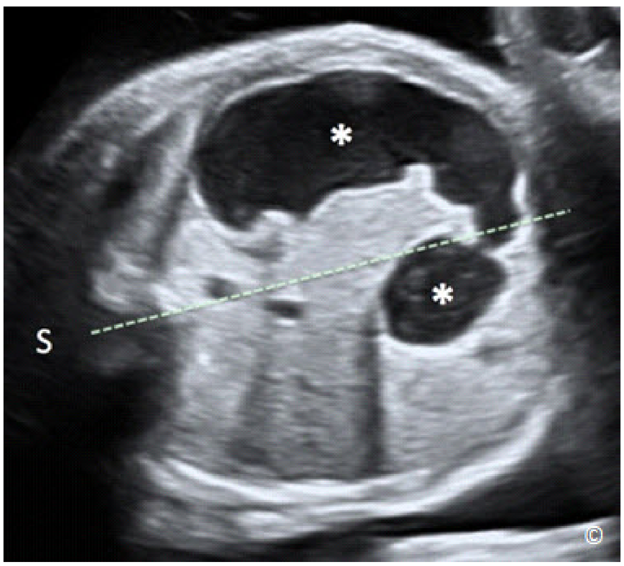

Figure 5.35: Transverse plane of the abdomen in a fetus with duodenal atresia. Note the enlarged stomach that crosses the midline (dashed line) and is shaped in a double bubble (asterisks). S = spine.

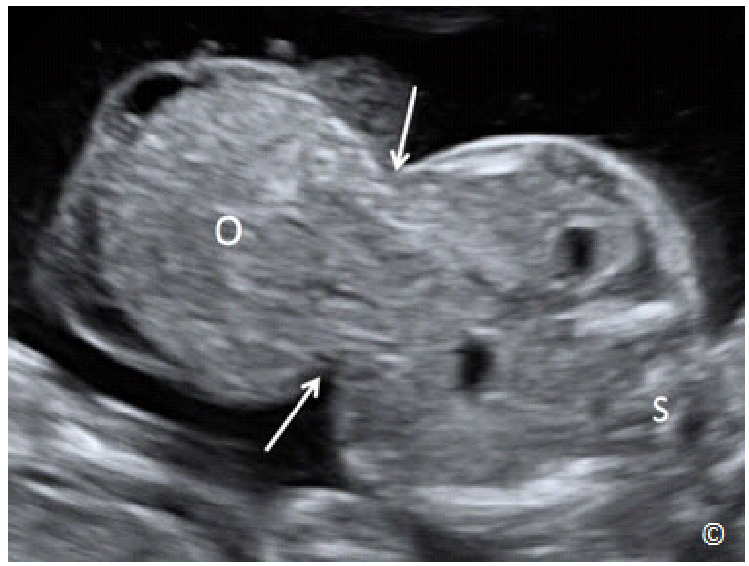

Figure 5.36: Transverse plane of the fetal abdomen in a fetus with an omphalocele (O). Note the central location of the defect in the abdomen (arrows). S = spine.

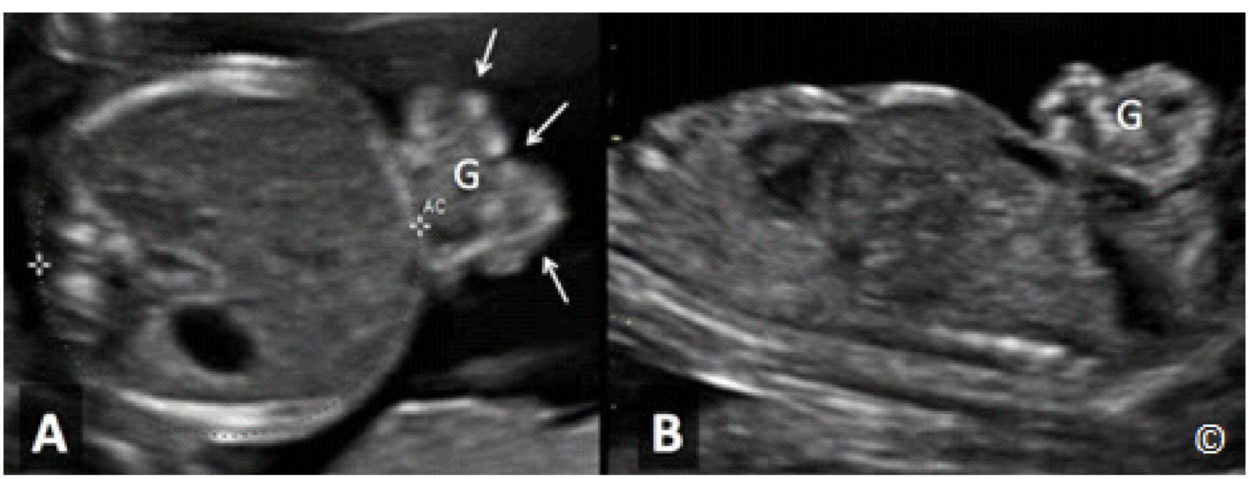

Figure 5.37 A and B: Transverse (A) and midsagittal (B) planes of a fetus with gastroschisis (G). Note the lack of a membrane cover of the gastroschisis (arrows). AC = Abdominal Circumference.

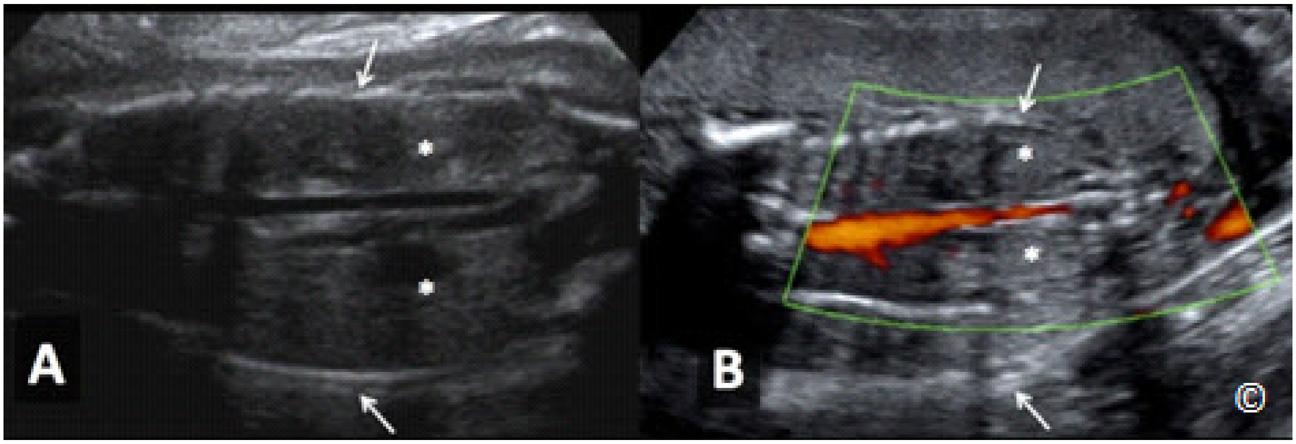

Figure 5.38 A and B: Coronal planes of the abdomen in 2D (A) and color Doppler (B) modes in a fetus with bilateral renal agenesis. Note the presence of anhydramnios (arrows) and absence of kidneys (asterisks) in the renal fossa. Note the absence of renal arteries on color Doppler (B).

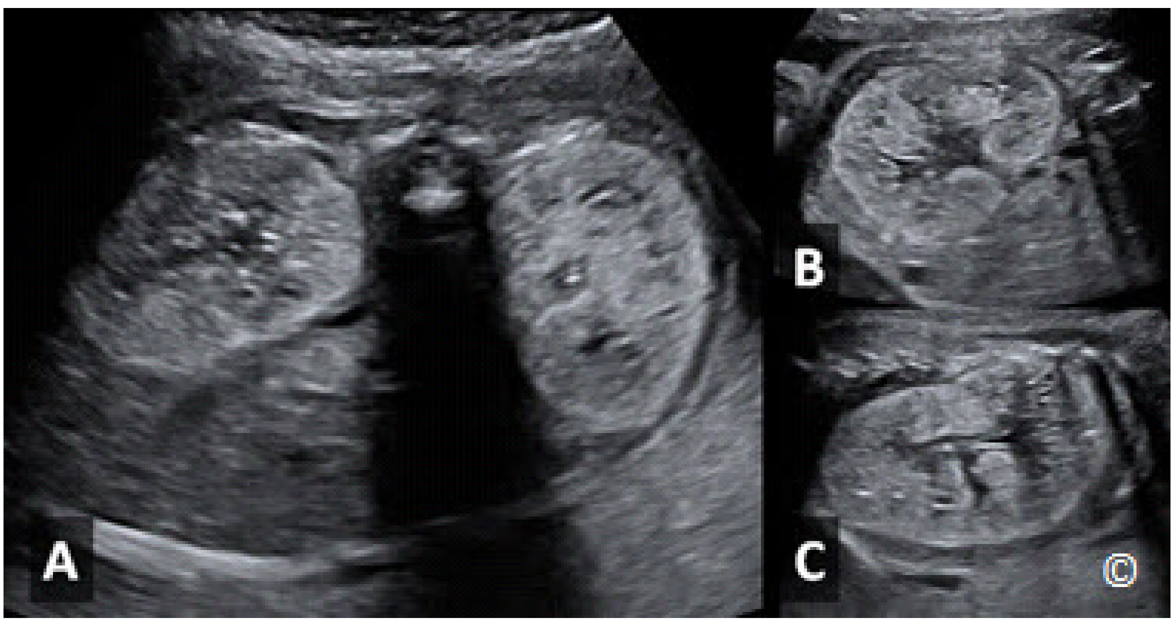

Figure 5.39 A, B, and C: Transverse (A) and longitudinal (B and C) views of the kidneys in a fetus with infantile polycystic kidney disease. Note the enlarged size of both kidneys and increase in echogenicity. There is also associated anhydramnios (not shown).

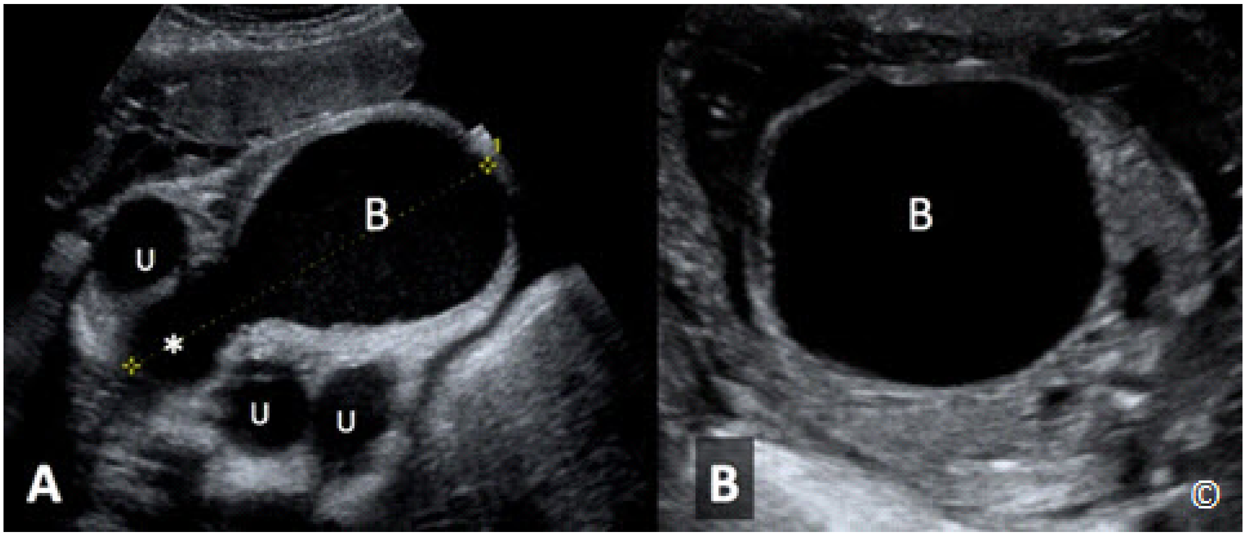

Figure 5.40 A and B: Transverse planes of the lower (A) and upper (B) pelvis in a fetus with posterior urethral valves. Note the distended bladder (B), dilated ureters, seen on cross section in A (U) and the characteristic keyhole appearance of the proximal urethra, seen in A (asterisk).

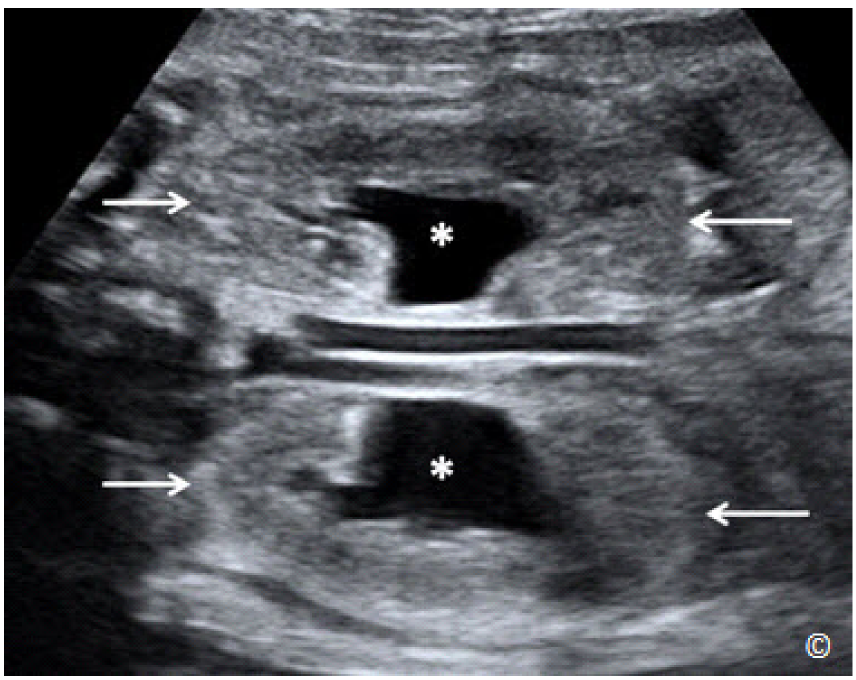

Figure 5.41: Coronal view of the abdomen in a fetus with bilateral uretero-pelvic obstruction. Note the dilated renal pelves (asterisks). The kidney borders are marked with arrows.

Skeletal Anatomy

The spine should be visualized and evaluated in sagittal, transverse or coronal planes, though the highest detection rate of spina bifida (**Figure 5.42 A - C**) is not reached through the direct assessment of the spine but through the recognition of the cranial signs ["*banana*" (**Figure 5.43**) and "*lemon*" (**Figure 5.44**) signs]. The long bones of the 4 limbs should be visualized as well, noting major abnormalities, such as severe shortening (micromelia) or bowing (**Figures 5.45 and 5.46**). An attempt to visualize both hands and feet should be made when feasible. Major abnormalities, such as transverse reduction defect, with absence of a hand or a foot, or aplasia radii can be diagnosed when such attempt is made. Of importance is also the assessment of fetal joint movement. Fixed joints in a fetus should suspect the presence of arthrogryposis.

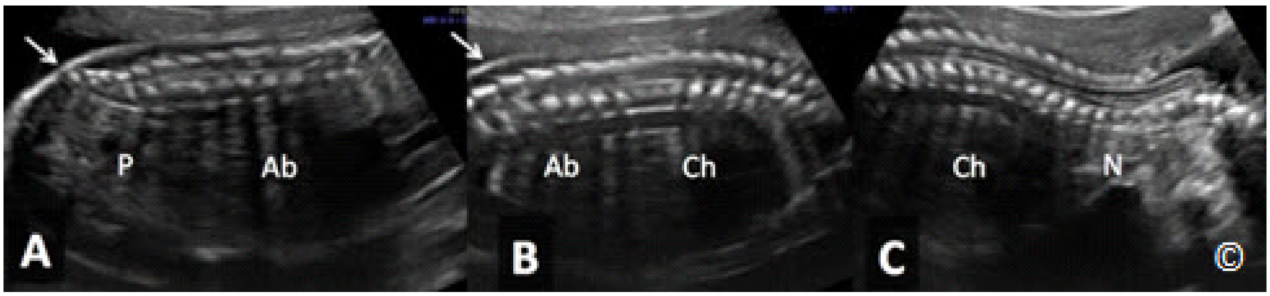

Figure 5.42 A, B, and C: Mid-sagittal planes of the fetal pelvis (P)(Figure A), abdomen (Ab)(Figure B), chest (Ch) and neck (N)(Figure C) showing longitudinal views of the spine. The intact overlying skin can be seen in planes A and B (arrows).

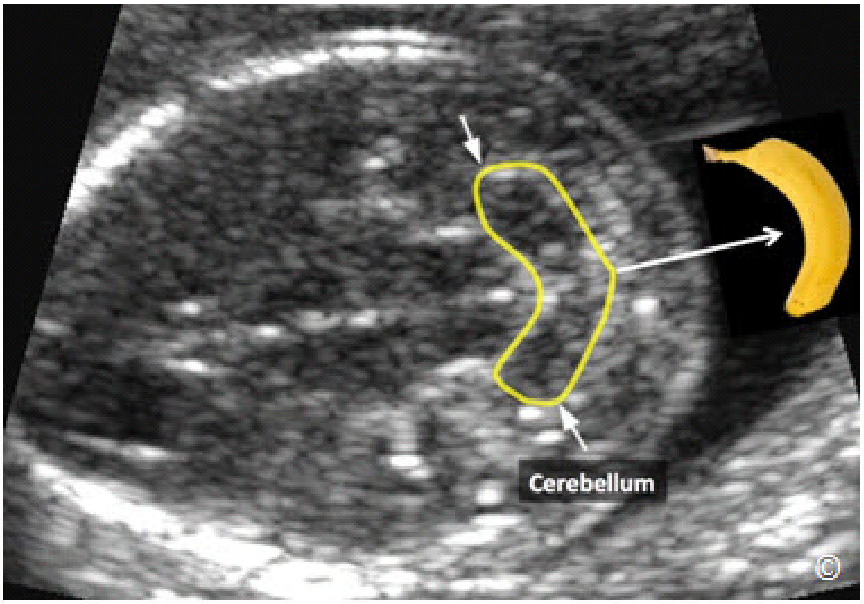

Figure 5.43: Transverse view of the fetal head at the level of the cerebellum (Transcerebellar) in a fetus with spinal neural tube defect. Note the "banana-shaped" cerebellum (arrows, yellow line), a central nervous system feature (Arnold Chiari) associated with open neural tube defect. See text for details.

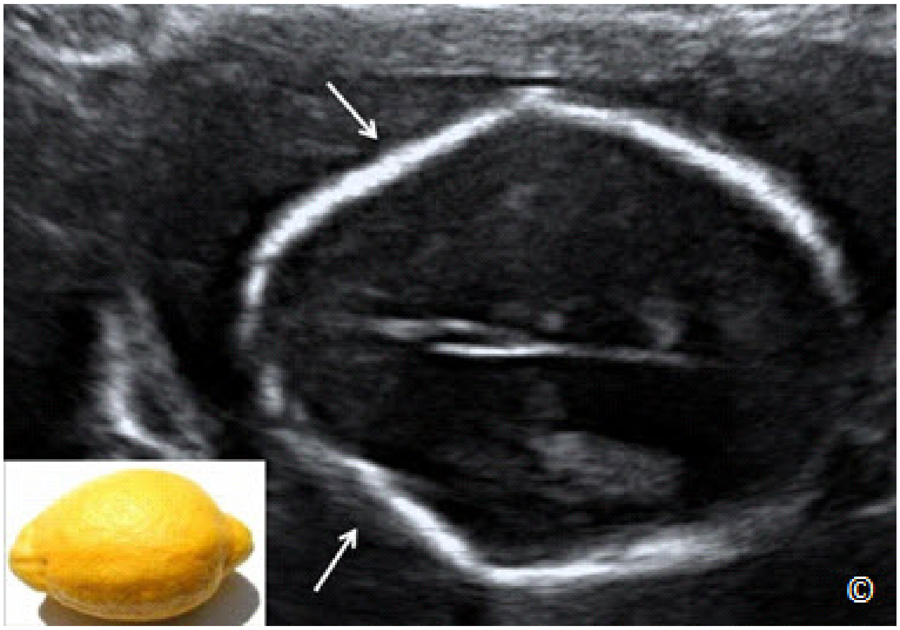

Figure 5.44: Transverse view of the fetal head at the level of the lateral ventricular plane in a fetus with spinal neural tube defect. Note the ”lemon-shaped” cranium (arrows), a feature (Arnold Chiari) associated with open neural tube defect. See text for details.

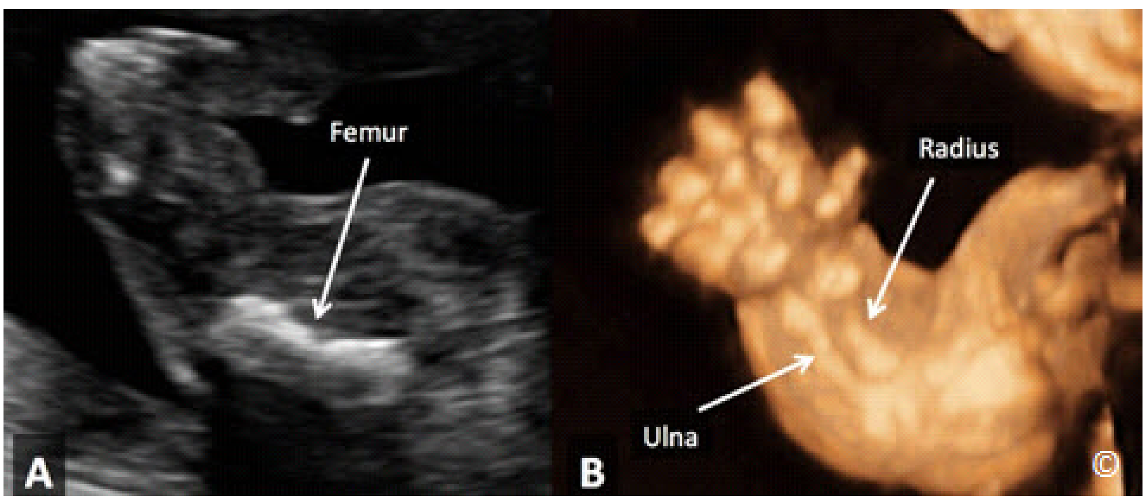

Figure 5.45: Longitudinal view of the femur in 2D mode (A), and the upper extremity in 3D ultrasound (B) of a fetus with lethal skeletal dysplasia. Note the severe shortening and bowing of the long bones.

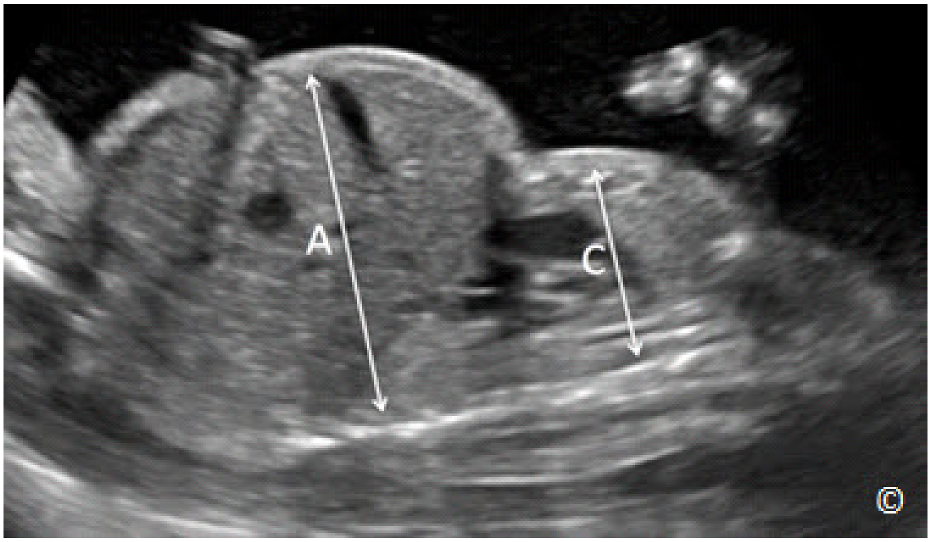

Figure 5.46: Midsagittal view of a fetus with lethal skeletal dysplasia (same as in figure 5-45). Note the small chest (C) in comparison to the abdomen (A).

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