

INTRODUCTION

The main objective of a third trimester obstetrical ultrasound examination is to provide accurate diagnostic information in order to optimize antenatal care and improve outcome for the mother and the fetus. The primary objective of a third trimester ultrasound examination is typically focused on fetal growth, position of the placenta, and the assessment of amniotic fluid.

It is generally accepted that ultrasound examination performed beyond the 28th week of gestation is considered in the third trimester and the assessment of fetal growth is commonly initiated at or around 28 - 32 weeks in at-risk pregnancies. It is important to note that despite the fact that a pregnancy may have had a prior second trimester ultrasound examination that determined normal fetal anatomy, it is the opinion of the authors that with any ultrasound examination that is performed in pregnancy, a re-evaluation of fetal anatomy is recommended, as many fetal malformations may not appear until later in gestation and some abnormalities may have been missed on prior ultrasound examinations. **Table 6.1** lists the component of the third trimester ultrasound examination. Pregnancy dating in the third trimester (> 28 weeks) is less accurate than earlier in gestation. If the first ultrasound in the pregnancy is performed in the third trimester, a discrepancy of gestational dating of more than 21 days should reassign the Expected Date of Delivery (EDD). Careful consideration should be given however for pregnancy management based upon a third trimester ultrasound given the possibility of associated fetal growth abnormality.

Determining the location of the placenta, assessment of the adnexae and amniotic fluid volume and basic fetal anatomy are discussed in details in respective chapters in the book. Furthermore, chapter 10 describes a six-steps standardized approach to the performance of the basic ultrasound examination. In this chapter we report in details on ultrasound assessment of fetal weight and discuss the role of spectral Doppler in the growth-restricted fetus.

TABLE 6.1

Components of the Third Trimester Ultrasound Examination

- Cardiac activity
- Fetal size (biometry and estimation of fetal weight)
- Fetal presentation and lie
- Fetal anatomy
- Placental localization
- Amniotic fluid assessment
- Evaluation of adnexae

ASSESSMENT OF FETAL WEIGHT

Pregnancy dating should not be performed in the third trimester given the inaccuracy of ultrasound in that gestational window, as the range is as wide as plus or minus 3 weeks. When faced with a pregnancy with unknown menstrual dates, presenting for an ultrasound in the third trimester, ultrasound dating in this scenario should be used for clinical management and if pregnancy induction is desired, consideration for documentation of fetal lung maturity should be performed.

Estimating fetal weight requires assessment of multiple biometric parameters, which typically include measuring the Biparietal Diameter (BPD), Head Circumference (HC), Abdominal Circumference (AC) and Femur Length (FL), and deriving the actual weight via a mathematical formula. Several formulas are currently available, but the one that is commonly preselected in the software of most ultrasound equipment is that developed by Hadlock et al (1). On-going studies will generate, in the near future, fetal weight formulas that are more contemporary. Details on the accurate measurement of the BPD, HC, AC and FL are described in chapter 5. Estimating fetal weight is more critical in the third trimester as it becomes important to detect fetal growth restriction or macrosomia. However, it should be considered that the assessment of fetal weight by ultrasound is more precise, the closer the fetal weight is to the mean. As the fetal weight falls outside the two standard deviations from the mean, the error in the ultrasound measurement increases. At both ends of the Gaussian curve (towards growth restriction and macrosomia), the fetal weight estimation becomes less precise and the measurement error commonly exceeds 10%. **Table 6.2** lists some important points related to estimating fetal weight by ultrasound.

TABLE 6.2

Ultrasound Estimation of Fetal Weight; Relevant Points

- BPD and HC are more precise biometric markers of gestational age than AC & FL.
- Transverse cerebellar diameter is the single biometric variable least affected by growth restriction and thus may be used in growth-restricted fetuses in which pregnancy dating is not established (2) (**Figure 6.1**).
- AC is the most accurate and sensitive predictor of fetal weight. It is typically the first biometric marker to be affected by growth abnormalities.
- AC is a difficult biometric marker to measure with the fetal spine at 6 or 12 o'clock.

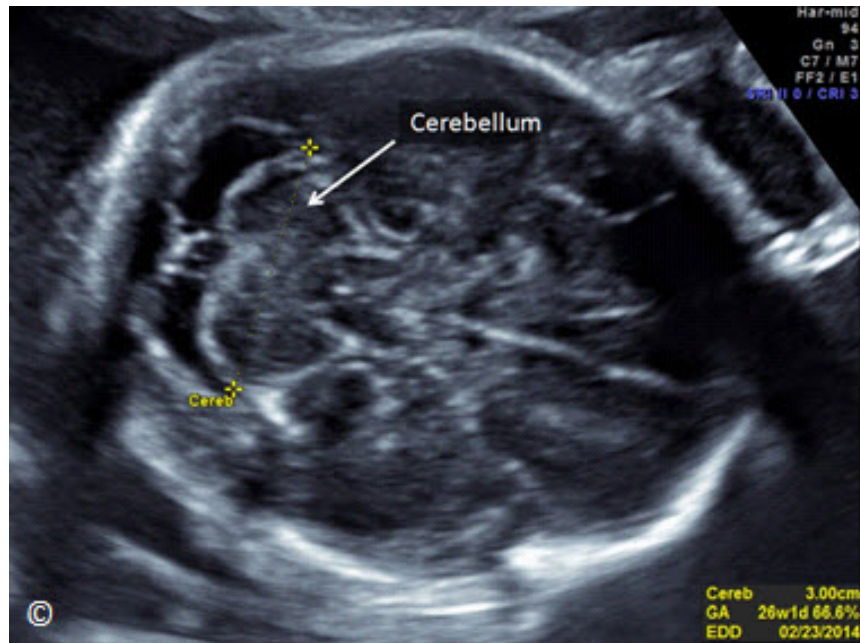


Figure 6.1: Transverse plane of the fetal head at the level of the posterior fossa showing the cerebellum. Measurement of transverse cerebellar diameter (shown) is least affected by fetal growth restriction.

INTRAUTERINE GROWTH RESTRICTION

Intrauterine growth restriction (IUGR) is defined by a sonographic estimated fetal weight below the 10th percentile for gestational age. It is a complex problem with various definitions, poor detection and limited preventive or treatment options. Evidence also link IUGR with impaired intellectual performance and diseases like hypertension and obesity in adulthood (3). It is important however to detect IUGR before birth as when IUGR is diagnosed prenatally and fetal surveillance is performed, pregnancy outcomes can be improved (4-6). IUGR has been classified as symmetrical or asymmetrical based upon whether the HC is affected or not. This classification differentiates early (symmetrical) versus late (asymmetrical) IUGR, with early IUGR being more commonly associated with chromosomal abnormalities or fetal infections. It is commonly agreed that the management is similar for both forms of IUGR and this distinction is no longer of real clinical value.

The first suspicion for the presence of IUGR may come from lagging fundal heights on prenatal visits. It is important to note that this screening method is effective when accurate fundal height measurements are obtained and when serial fundal height examinations are done (7). Once IUGR is diagnosed prenatally, a targeted ultrasound examination should be performed to exclude fetal malformations. Furthermore the assessment of amniotic fluid is an essential component of pregnancy evaluation and fetal surveillance. Fetal surveillance includes cardiotocography in the

form of non-stress testing and umbilical artery Doppler where available. Umbilical artery Doppler evaluation of IUGR has been shown to significantly reduce hospital admissions, duration of hospitalization, and perinatal mortality, without increasing the rate of unnecessary interventions (8). Doppler waveforms of the umbilical arteries can be obtained from any segment along the umbilical cord (**Figure 6.2**). In the same pregnancy, waveforms obtained near the placental end of the cord show more end-diastolic flow than waveforms obtained from the abdominal cord insertion (9). **Figure 6.3** shows umbilical artery Doppler waveforms obtained at the placental cord insertion. To optimize reproducibility, especially in multiple pregnancies, we recommend interrogating the umbilical artery at the abdominal cord insertion (**Figure 6.4**). The S/D ratio should be obtained in the absence of fetal breathing, and when the waveforms are uniform (**Figure 6.3** and **6.4**). Reversed end-diastolic velocity in the umbilical arterial circulation represents an advanced stage of placental compromise and has been associated with obliteration of more than 70% of arterioles in the placental tertiary villi (10, 11) (**Figure 6.5**). The presence of absent (**Figure 6.6**) or reversed end-diastolic flow in the umbilical artery is commonly associated with severe (birth weight below the 3rd percentile for gestational age) IUGR and oligohydramnios (12, 13). If Doppler surveillance is to be incorporated in clinical practice, the operators should undergo hands on training and should understand the physics of Doppler and the pathophysiology of placental insufficiency in fetal growth restriction.

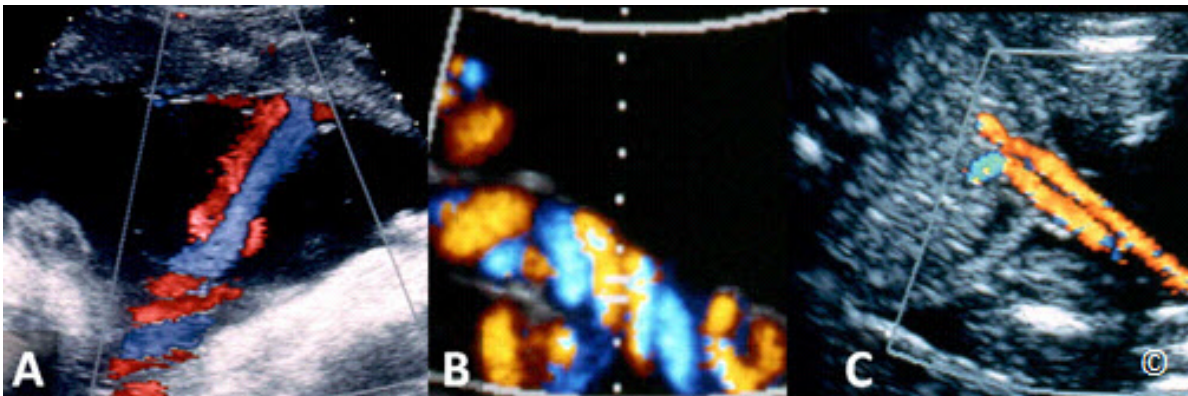


Figure 6.2: Color Doppler mode showing the umbilical cord at its placental insertion site (A), free loop in the amniotic cavity (B), and at the fetal abdominal insertion (C).

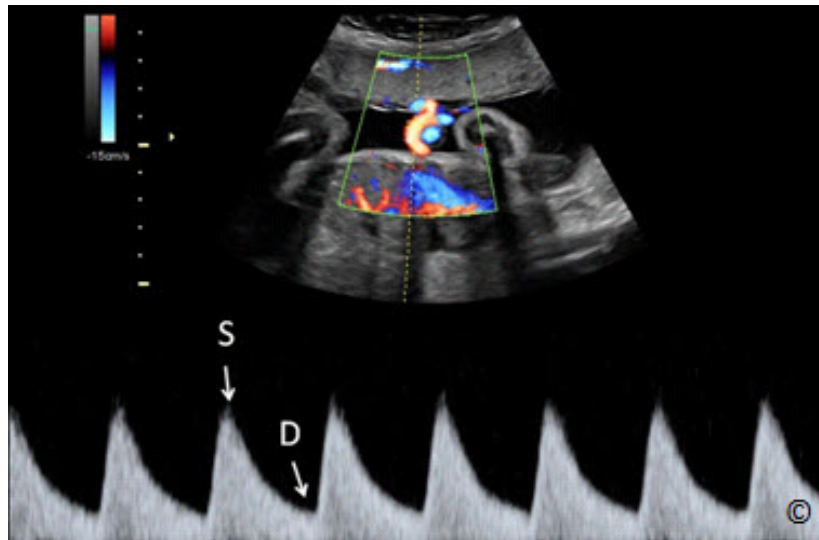


Figure 6.3: Spectral (Pulse) Doppler of the umbilical artery at the placental cord insertion. (S = Systole and D= Diastole). Note the uniformity of Doppler waveforms, implying absent fetal breathing.

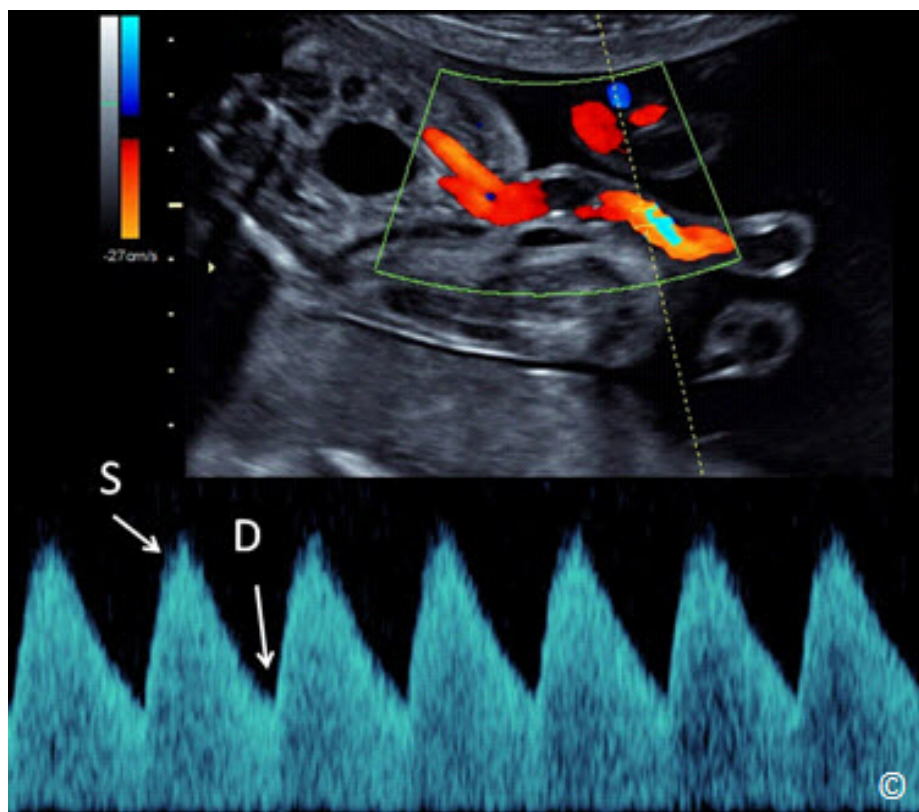


Figure 6.4: Spectral (Pulse) Doppler of the umbilical artery at the abdominal cord insertion. (S = Systole and D= Diastole).

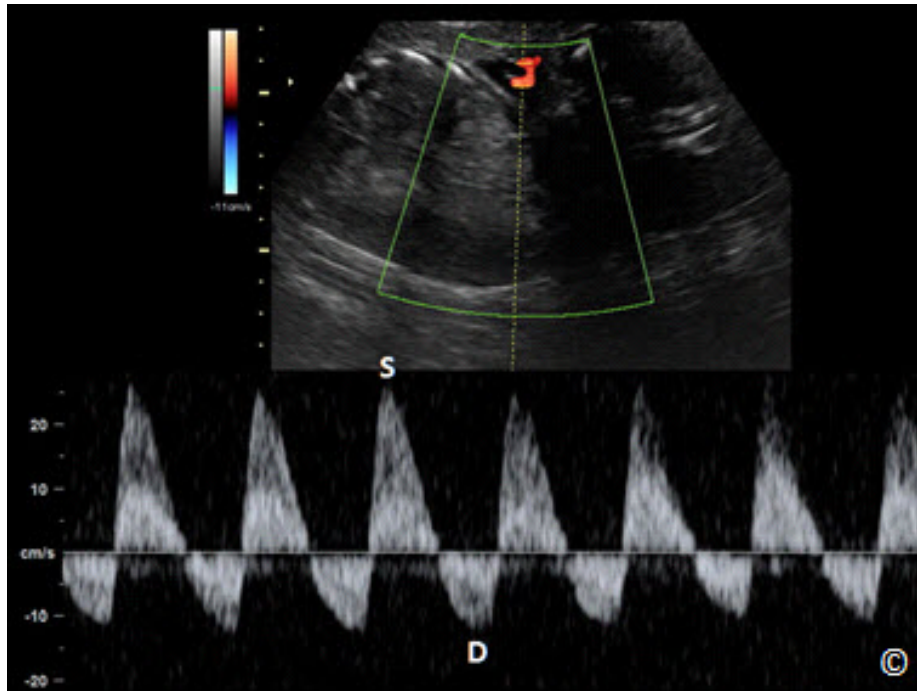


Figure 6.5: Spectral (Pulse) Doppler of the umbilical artery in a fetus with reversed end diastolic velocity (D). This pattern represents an advanced stage of fetal compromise (S = Systole).

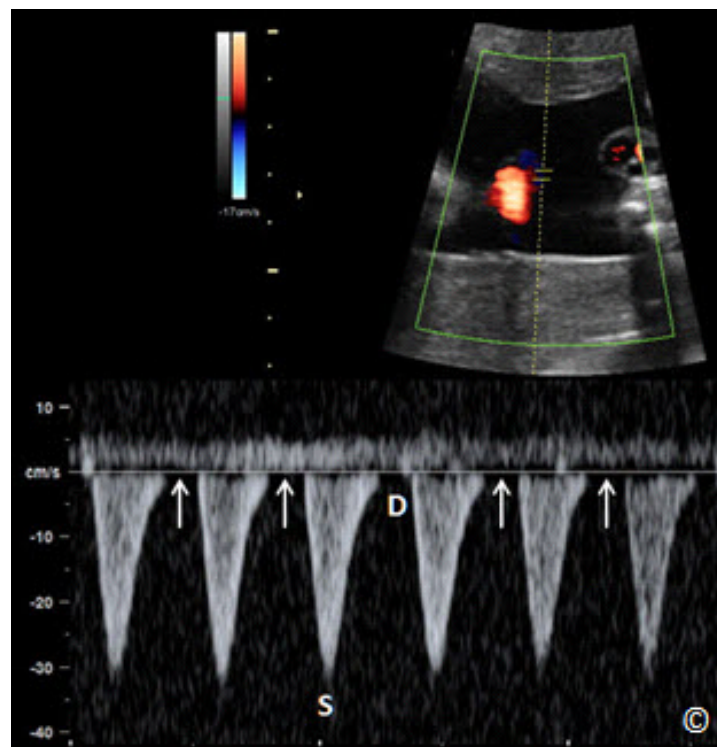


Figure 6.6: Spectral (Pulse) Doppler of the umbilical artery in a fetus with absent end diastolic velocity (arrows). (S = Systole and D = Diastole).

The middle cerebral artery has also been used in surveillance of the IUGR fetus, in combination with the umbilical artery. Under normal conditions, the middle cerebral artery shows a high impedance circulation with continuous forward flow present throughout the cardiac cycle (**Figure 6.7**) (14). The middle cerebral arteries, which carry more than 80% of the cerebral circulation, represent major branches of the circle of Willis and are the most accessible cerebral vessels for ultrasound imaging in the fetus (15). The middle cerebral artery can be imaged with color Doppler ultrasound in a transverse plane of the fetal head obtained at the base of the skull (**Figure 6.8**). In this transverse plane, the proximal and distal middle cerebral arteries are seen in their longitudinal view, with their course almost parallel to the ultrasound beam (**Figure 6.8**). In the presence of fetal hypoxemia, central redistribution of blood flow occurs, resulting in an increased blood flow to the brain, heart and adrenal glands, and a reduction in flow to the peripheral and placental circulations. This blood flow redistribution, known as the brain-sparing reflex, is reflected in a low pulsatility index (PI) in the middle cerebral artery (**Figure 6.9**) in IUGR hypoxemic fetuses and plays a major role in fetal adaptation to oxygen deprivation (14, 16). Middle cerebral artery Doppler has been found to identify a subset of IUGR fetuses at increased risk for cesarean delivery due to non-reassuring fetal heart rate patterns, and neonatal acidosis (17,18).

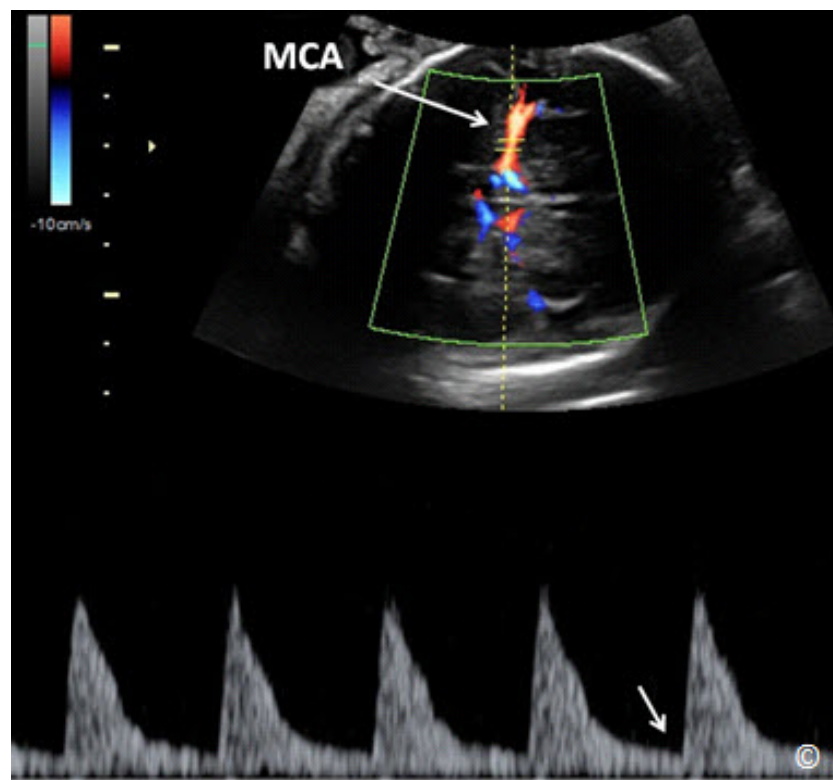


Figure 6.7: Spectral (Pulse) Doppler of the middle cerebral artery (MCA) in a normal fetus. Note that the MCA shows high impedance circulation with continuous forward flow during diastole (arrow).

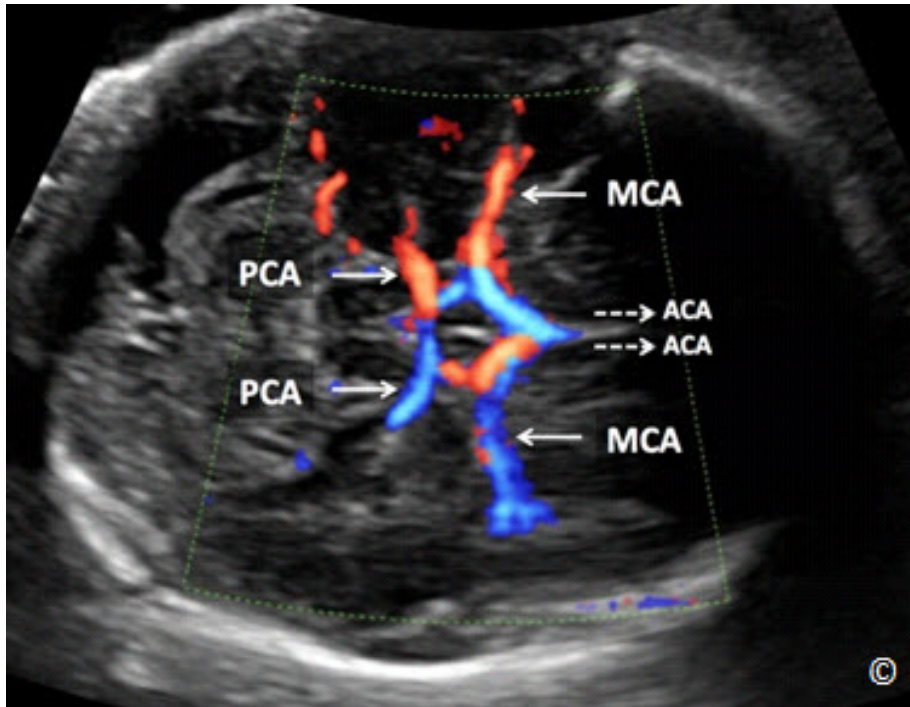


Figure 6.8: Transverse plane at the base of the fetal brain with color Doppler mode showing the circle of Willis. Note the course of the middle cerebral arteries (MCA) and posterior cerebral arteries (PCA). The anterior cerebral arteries (ACA) are not seen due to their course perpendicular to the ultrasound beam (dashed arrows).

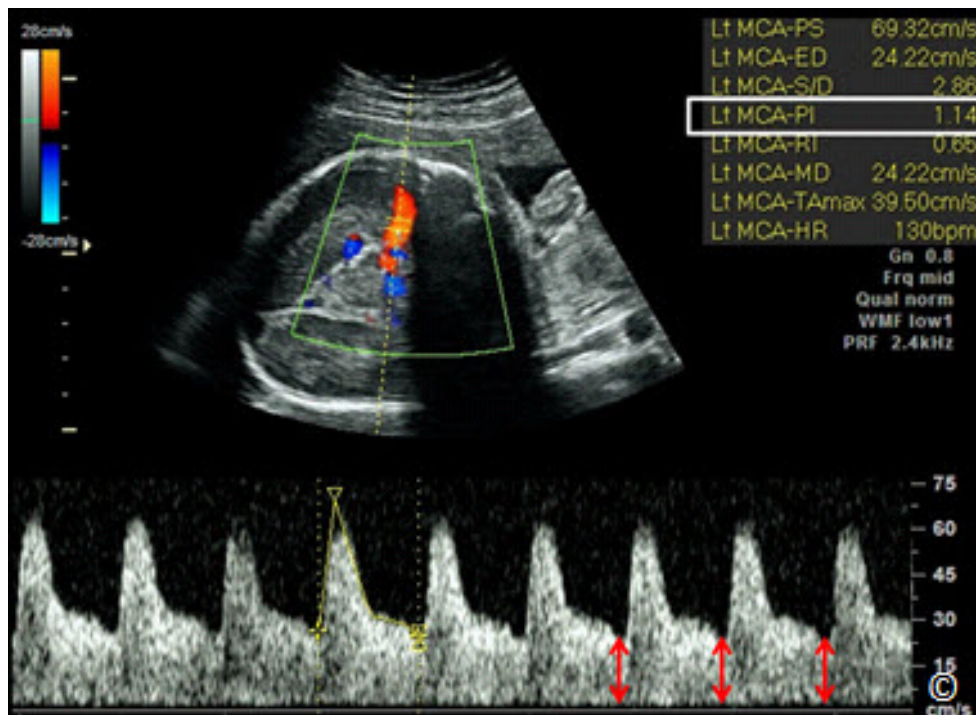


Figure 6.9: Spectral (Pulse) Doppler of the middle cerebral artery in a growth restricted fetus. Note the low impedance circulation (PI = 1.14) (white rectangle) with increased flow during diastole (red double arrows). This represents brain sparing.

FETAL MACROSOMIA

The term fetal macrosomia implies fetal obesity and has been traditionally defined by a fetal weight greater than 4000 or 4500 grams irrespective of gestational age (19). Large for gestational age is a term that is used for the neonatal period and is defined by a birth weight equal to or greater than the 90th percentile for a given gestational age (19). Although the risk of neonatal morbidity is increased at birth weights above the 4000 grams threshold, the neonatal risk is markedly increased above the 4500 grams threshold (20,21). It is for this reason that a threshold of 4500 grams is often used for defining fetal macrosomia.

The incidence of macrosomia can be as high as 10% of live births and a number of risk factors predispose for macrosomia; they are listed in **Table 6.3**.

| TABLE 6.3 | Predisposing Factors for Neonatal Macrosomia |
|-----------|--|
| | <ul style="list-style-type: none">- Pregestational or gestational diabetes- Prior history of macrosomia- Maternal obesity- Increased weight gain during pregnancy- Gestational age greater than 42 weeks- Increased maternal birth weight- Increased maternal height |

Macrosomia predisposes the mother and the newborn to significant complications including an increased risk for postpartum hemorrhage, birth canal lacerations and cesarean delivery. Fetal trauma includes an increased risk for shoulder dystocia, which may result in brachial plexus injury (Erb-Duchenne palsy).

Ultrasound has been shown to be inaccurate in predicting macrosomia (22,23). Using the Hadlock's formula to predict fetal weight, a mean absolute error of 13% for infants greater than 4,500 g is noted, compared with 8% for non-macrosomic infants (24). Among women without diabetes, ultrasound biometry used to detect macrosomia has a sensitivity of 22-44%, a specificity of 99%, a positive predictive value of 30-44%, and a negative predictive value of 97-99% (25,26). With birth weight exceeding 4,500 g, only 50% of fetuses weigh within 10% of the ultrasound-derived estimated weight (27), suggesting that the usefulness of ultrasonography for obtaining estimated weights is limited. These limitations are neither operator-dependent nor equipment-dependent (27). One study comparing ultrasound-estimated fetal weight, Leopold maneuvers-estimated weight, and maternal perception of fetal weight in post-term parous women found no statistical differences between the three groups (28).

On ultrasound examination, the macrosomic fetus will show an increased subcutaneous fat layer that is mostly evident in the abdominal circumference plane (**Figure 6.10**). The abdominal circumference is the most sensitive biometric marker of fetal macrosomia and the first to show such growth abnormality.

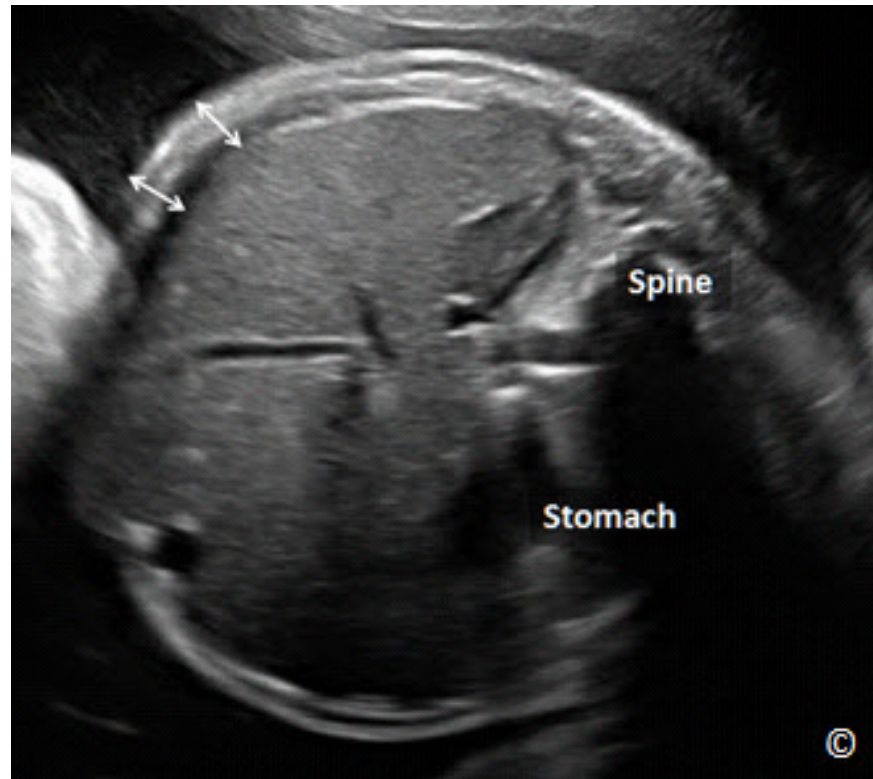


Figure 6.10: Transverse plane of the fetal abdomen at the level of the abdominal circumference in a macrosomic fetus. Note the increased subcutaneous fat (double arrows).

References:

- 1) Hadlock FP, Harrist RB, Carpenter RJ, Deter RL, Park SK. Sonographic estimation of fetal weight. The value of femur length in addition to head and abdomen measurements. *Radiology*. 1984 Feb;150(2):535-40
- 2) Chavez MR, Ananth CV, Smulian JC, Yeo L, Oyelese Y, Vintzileos AM. Fetal transcerebellar diameter measurement with particular emphasis in the third trimester: a reliable predictor of gestational age. *Am J Obstet Gynecol*. 2004 Sep;191(3):979-84
- 3) Demicheva E, Crispi F. Long-Term Follow-Up of Intrauterine Growth Restriction: Cardiovascular Disorders. *Fetal Diagn Ther*. 2013 Aug 14. [Epub ahead of print]

- 4) American College of Obstetricians and Gynecologists. Intrauterine growth restriction. Washington (DC): ACOG; 2000. ACOG Practice Bulletin No. 12.
- 5) Bilardo CM, Wolf H, Stigter RH, Ville Y, Baez E, Visser GH, Hecher K. Relationship between monitoring parameters and perinatal outcome in severe, early intrauterine growth restriction. *Ultrasound Obstetric Gynecology* 2004; 23(2):119-25.
- 6) Baschat AA. Arterial and venous Doppler in the diagnosis and management of early onset fetal growth restriction. *Early Hum Dev* 2005; 81(11):877-87.
- 7) Cnattingius S, Axelsson O, Lindmark G. Symphysis-fundus measurements and intrauterine growth retardation. *Acta Obstet Gynecol Scand* 1984;63:335-40
- 8) Alfirovic Z, Neilson P. Doppler ultrasonography in high-risk pregnancies: systematic review with meta-analysis. *Am J Obstet Gynecol* 1995; 172:1379-87.
- 9) Trudinger BJ. Doppler ultrasonography and fetal well being. In: Reece EA, Hobbins JC, Mahoney M, Petrie RH, eds. *Medicine of the Fetus and Mother*. Philadelphia: JB Lipincott Co.; 1992.
- 10) Kingdom JC, Burrell SJ, Kaufmann P. Pathology and clinical implications of abnormal umbilical artery Doppler waveforms. *Ultrasound Obstet Gynecol* 1997; 9(4):271-286.
- 11) Morrow RJ, Adamson SL, Bull SB, Ritchie JW. Effect of placental embolization on the umbilical artery velocity waveform in fetal sheep. *Am J Obstet Gynecol* 1989; 161(4):1055-1060.
- 12) McIntire DD, Bloom SL, Casey BM, Leveno KJ. Birth weight in relation to morbidity and mortality among newborn infants. *N Engl J Med* 1999; 340(16):1234-8.
- 13) Copel JA, Reed KL. *Doppler ultrasound in Obstetrics and Gynecology*. First edition, New York, New York: Raven Press; 1995:187-198.
- 14) Mari G, Deter RL. Middle cerebral artery flow velocity waveforms in normal and small-for-gestational age fetuses. *Am J Obstet Gynecol* 1992; 166:1262-1270.
- 15) Veille JC, Hanson R, Tatum K. Longitudinal quantitation of middle cerebral artery blood flow in normal human fetuses. *Am J Obstet Gynecol* 1993; 169(6):1393-1398.
- 16) Berman RE, Less MH, Peterson EN, Delannoy CW. Distribution of the circulation in the normal and asphyxiated fetal primate. *Am J Obstet Gynecol* 1970; 108:956-969.
- 17) Severi FM, Bocchi C, Visentin A, Falco P, Cobellis L, et al. Uterine and fetal cerebral Doppler predict the outcome of third trimester small-for-gestational age fetuses with normal umbilical artery Doppler. *Ultrasound Obstet Gynecol* 2002;19:225-228.
- 18) Cruz-Martinez R, Figueras F, Hernandez-Andrade E, Oros D, Gratacos E. Fetal brain Doppler to predict cesarean delivery for nonreassuring fetal status in term small-for-gestational-age fetuses. *Obstet Gynecol* 2011; 117(3):618-26.
- 19) American College of Obstetricians and Gynecologists. Fetal macrosomia. Washington (DC): ACOG; 2000. ACOG Practice Bulletin No. 22.
- 20) McFarland LV, Raskin M, Daling JR, Benedetti TJ. Erb Duchenne's palsy: a consequence of fetal macrosomia and method of delivery. *Obstet Gynecol* 1986;68:784-788

- 21) Gross TL, Sokol RJ, Williams T, Thompson K. Shoulder dystocia: a fetal-physician risk. *Am J Obstet Gynecol* 1987;156:1408-1418
- 22) Rossavik IK, Joslin GL. Macrosomatia and ultrasonography: what is the problem? *South Med J* 1993; 86:1129-1132
- 23) Sandmire HF. Whither ultrasonic prediction of fetal macrosomia? *Obstet Gynecol* 1993;82:860-862
- 24) Alsulyman OM, Ouzounian IG, Kjos SL. The accuracy of intrapartum ultrasonographic fetal weight estimation in diabetic pregnancies. *Am J Obstet Gynecol* 1997; 177: 503-506
- 25) Smith GC, Smith MF, McNay MB, Fleming IE. The relation between fetal abdominal circumference and birth weight: findings in 3512 pregnancies. *Br J Obstet Gynaecol* 1997;104:186-190
- 26) O'Reilly-Green CP, Divon MY. Receiver operating characteristic curves of sonographic estimated fetal weight for prediction of macrosomia in prolonged pregnancies. *Ultrasound Obstet Gynecol* 1997;9:403-408
- 27) Benacerraf BR, Gelman R, Frigoletto FD Jr. Sonographically estimated fetal weights: accuracy and limitation. *Am J Obstet Gynecol* 1988;159:1118-1121
- 28) Chauhan SP, Sullivan CA, Lutton TD, et al: Parous patients' estimate of birth weight in postterm pregnancy. *J Perinatol* 15:192,1995