

Ultrasound of the Diabetic Patient During Pregnancy

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Diabetes Mellitus is defined in Stedman's Medical Dictionary as a metabolic disease in which carbohydrate utilization is reduced and that of lipid and protein is enhanced. It is caused by insulin deficiency and is characterized in more severe cases by glycosuria, water and electrolyte loss, ketoacidosis and coma.¹¹ Diabetic women may be insulin dependent or develop diabetes during pregnancy (gestational diabetes). Pregnant women are often evaluated with sonography as excessive fetal growth, intrauterine growth restriction and congenital anomalies have long been recognized as complications of this medical disease.

INSULIN DEPENDENT DIABETES MELLITUS (IDDM)

Most major studies have documented an increase in major congenital malformations in infants of insulin dependent diabetic mothers. In the Diabetes in Early Pregnancy Study in the United States, the incidence of major anomalies were 2.1 % in 389 control women and 9.0 % in 279 IDDM women.¹⁰ It has also been reported that there is a significantly higher incidence of major anomalies in the offspring of diabetic women with elevated first trimester HbA_{1c} values.¹ The HbA_{1c} value reflects an integration of ambient blood glucose levels over a period of 4-6 weeks before its measurement.¹⁴ For this reason, this test has been especially useful in evaluating the degree of diabetic control in the critical early weeks of pregnancy. These studies and others suggest a cause and effect relationship between altered glucose metabolism and congenital anomalies, however a target site of action is unknown. While pregnant, a woman should have HbA_{1c} levels checked every 4-6 weeks to document the degree of glycemic control.¹⁴

The insult that causes congenital malformations in IDDM impacts on most organ systems and must act before 7 weeks gestation.⁷ For this reason many anomalies affecting various organ systems can be detected sonographically. (See Chart) Therefore, diagnostic testing and fetal surveillance is of utmost importance. In order to adequately evaluate for the majority of anomalies and growth disturbances which may be visualized sonographically, ultrasounds should be obtained over all gestational ages. These ultrasounds will assist in establishing dates, detecting structural fetal anomalies, and estimating fetal weight.

Congenital Malformations in Infants of Diabetic Mothers

- Cardiovascular
 - Transposition of the great vessels
 - VSD
 - ASD
 - Hypoplastic left heart
 - Coarctation of the aorta
- Central Nervous System
 - Anencephaly
 - Encephalocele
 - Meningomyelocele
 - Holoprosencephaly
 - Microcephaly
- Skeletal
 - Caudal regression syndrome
- Genitourinary
 - Renal agenesis
 - Polycystic kidneys
 - Double ureter
- Gastrointestinal
 - Tracheoesophageal fistula
 - Bowel atresia
 - Imperforate Anus

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Ultrasound Scanning Protocol

First Trimester Scan performed transvaginally to confirm or establish dates, R/O ectopic pregnancy and look for anomalies.

Chorionic villus sampling to test for chromosomal abnormalities.

13 - 14 Weeks To R/O anencephaly.

14 - 20 Weeks Amniocentesis offered to patients with recognized indication.

18 - 20 Weeks Targeted ultrasound to R/O most structural anomalies.

20 - 24 Weeks Fetal echocardiogram

Growth Scans (Every 4 - 6 Wks)	Intrauterine Growth Restriction (pregnancies complicated with vasculopathy) Macrosomia (women sub-optimally controlled)
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35 - 40 Weeks Biophysical Profile to evaluate chronic and acute fetal problems.

37 - 38 Weeks Amniocentesis for lung maturity to optimize delivery timing.

GESTATIONAL DIABETES (GDM)

Gestational Diabetes Mellitus is defined as carbohydrate intolerance of variable severity with onset or first recognition during the present pregnancy. This definition applies irrespective of whether or not insulin is used for treatment or the condition persists after pregnancy. It does not exclude the possibility that glucose intolerance may have antedated the pregnancy.

Detection of Gestational Diabetes

The 2nd International Workshop conference on Gestational Diabetes Mellitus recommended that all pregnant women be screened for gestational diabetes, with a 50g oral glucose load followed by a glucose determination 1 hour later.⁴ This test is generally performed at 24 - 28 weeks gestation. The sensitivity of this screening technique is approximately 80%. Women whose plasma glucose level equals or exceeds 140 mg/dl should be evaluated with a 3-hour Glucose Tolerance Test (GTT). One can expect approximately 15% of women with an abnormal screening value to have a abnormal 3-hour GTT.⁶

Approximately 22% of infants born to women with gestational diabetes are macrosomic.³

Macrosomia may be defined one of two ways: as a birth weight in excess of 4,000 grams or using population specific growth curves, infants with a birth weight above the 90%. Macrosomia in these infants is characterized by specific organomegaly with increases in fat and muscle mass specifically in the fetal trunk and shoulders. Brain growth is usually not altered therefore the head circumference is usually normal. As excess fetal size is strongly associated with shoulder dystocia during a vaginal delivery, macrosomia is relevant information for the clinician

Detection of Gestational Diabetes Upper Limit of Normal

Screening Test	Plasma (mg/dl)
50g- 1 hour	140
*Oral GTT	
Fasting	105
1-hour	190
2-hour	165
3-hour	145
* Diagnosis of gestational diabetes is made when any two values are met or exceeded.	

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Diagnostic ultrasound is an excellent modality to evaluate macrosomia and many ultrasound parameters can be used to detect it. The abdominal circumference measurement is probably the most reliable sonographic parameter for the detection of macrosomia in the third trimester. Landon et al found

accelerated abdominal circumference growth, in 97 diabetic women who had at least 3 ultrasound studies in the third trimester of pregnancy.⁵ Abdominal growth of 12mm or more per week detected large for gestational age (LGA) fetuses with 84% sensitivity and 85% specificity. Jazayeri et al reported that an AC measurement of 35cm or more predicted 93% of macrosomic infants.⁹ Recently, sonographic measurements of the subcutaneous tissue thickness of the fetal abdomen was performed, evaluating 113 normal sized fetuses and 20 macrosomic fetuses.¹² The mean soft tissue thickness of the normal weighted fetus was 7.0mm versus 12.4mm for the LGA fetus.

A prospective study of fetal humeral soft tissue thickness measurements in pregnancy complicated by GDM, was performed to determine whether this parameter could predict fetal size.² The fetal humeral soft tissue thickness (STT) was defined as the linear distance from the edge of the humerus to the skin surface. The measurement was obtained on a transverse view of the proximal humeral diaphysis. Sonograms performed during the third trimester in 93 women with GDM and 198 non diabetic pregnancies revealed accelerated growth beginning at 31 weeks gestation. The facial cheek to cheek diameter (CCD) measurement was introduced in 1993 to evaluate fetal growth disturbances.¹³ This linear measurement was obtained on a coronal view of the face at the level of the nostrils and lips. For 87 LGA fetuses, the mean cheek to cheek diameters were significantly larger than for AGA fetuses.

While one may believe that estimated fetal weight (EFW), would be a sensitive parameter to detect LGA infants, its not as sensitive as the AC or the humeral STT. Estimation of fetal weight appears simple, yet it involves the skilled measurement of several fetal structures which can include the BPD, AC, and FL. At term, estimated fetal weights may not be reliable and can error greater than 10%. Tamura et al have reported their results using Shepard's (BPD/AC) formula in studying 147 diabetic women during the last two weeks of the third trimester.³ They reported 77% sensitivity and 77% specificity for detecting infants with birth weights exceeding the 90%.

In a recently published article by Humphries et al, prediction of birth weight was significantly more accurate when sonographers rather than maternal-fetal medicine specialists performed the ultrasound examination.¹⁶ Significantly higher percentage of predictions were within 10% of the birthweight when obtained by sonographers (70%) than physicians (54%). While both groups had similar accuracy in detecting macrosomic fetuses, registered sonographers were significantly more likely to detect IUGR. In a pregestational diabetic woman whose pregnancy is complicated by vasculopathy and/or hypertension, Doppler velocimetry of the uterine arteries and the umbilical artery may be beneficial for antepartum fetal surveillance.¹⁵

In conclusion, Diabetes mellitus is a serious medical condition. However, the discovery of insulin in 1921 was a significant advancement for the treatment of pregnancies complicated by diabetes mellitus.⁷ Fetal and neonatal mortality have been reduced from approximately 65% before the discovery of insulin to 2 to 5% at the present time.⁷ With careful regulation of maternal glucose levels and optimal care, the perinatal mortality rate excluding major congenital anomalies is equivalent to that observed in normal pregnancies.

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