The diabetic pregnancy: An ultrasonographic perspective

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Abstract

The incidence of congenital foetal anomalies and perinatal mortality in diabetic pregnancy is much higher than that in the normal pregnancy. The purpose of this review is to evaluate the role of ultrasound in the management of pregnancy complicated by diabetes. The ultrasound has been found to be very useful for foetal surveillance, assessment of diabetes related foetal complications, image guided interventions and in the obstetric management of the pregnancies complicated by diabetes.

Keywords: Color Doppler, Diabetes, Fetal, Pregnancy, Ultrasound.

Introduction

Incidence of perinatal morbidity and mortality is 3-4 times higher in pregnancy complicated by diabetes, as compared to the general obstetric population. High maternal blood glucose level and concomitant foetal hyperinsulinaemia are the key factors in the pathophysiology of diabetes related perinatal complications.[1] The important perinatal complications are high perinatal mortality, inborn malformations (CNS and CVS), abnormal foetal growth (growth retardation or macrosomia), birth injury (shoulder dystocia), metabolic complications (acidosis) and resultant increase in neonatal intensive care unit (NICU) admissions.[1,2] The ultrasonography (USG) plays an important role in early detection of congenital malformations and safer pregnancy termination. In foetuses with reduced foetal growth (intrauterine growth retardation or small for gestational age foetuses), USG helps in foetal weight estimation and colour Doppler allows optimal foetal surveillance for timely delivery.[3] The role of USG to detect effective foetal weight in LGA (large for gestational age) foetuses is not reliable. However, measurement of the insulin-sensitive foetal fat layer or foetal abdominal circumference by ultrasound correlates well with the foetal hyperinsulinaemia and risk for macrosomia.[4,5] Foetal ultrasound may also be useful for determining the need for early pharmacological therapy to control maternal hyperglycaemia in gestational diabetes mellitus (GDM).[6]

Sonographic Evaluation of Congenital Malformations

The rate of occurrence of congenital malformations among the newborn babies of diabetic mothers is approximately 6-10%.[7] The congenital anomalies account for 40-50% of perinatal death among these infants.[8] With ultrasonography performed at 11-14 weeks of gestational age and a subsequent scan at 20-22 weeks, majority of congenital malformations, especially in diabetic pregnancies, can be identified by an expert sonographer; however it is difficult to identify imperforate anus and isolated cleft palate. The newer imaging modalities such as tissue harmonic imaging and targeted foetal echocardiography provide improved image quality than routine USG and hence provide better diagnostic accuracy.[8,9]

Congenital heart disease is the most common (almost 50%) congenital anomaly in diabetic pregnancies; transposition of the great vessels (TGV), coarctation of aorta (COA) and ventricular septal defect (VSD) being the commonest. The incidence being 27/1000 in diabetic mothers compared to 8/1000 in non-diabetic mothers. Less commonly hypertrophic cardiomyopathy with disproportionate septal thickening, causing transient subaortic stenosis and left ventricular outflow obstruction may be seen. The transient septal hypertrophy does not impair cardiac function and natural resolution takes place in 6-12 months of age. Severe cases of hypertrophic cardiomyopathy may produce systolic and diastolic dysfunction leading to congestive heart failure, which may be evident as early as 12 weeks of gestation.[9] Albert et al. found that foetal echocardiography has a higher detection rate for cardiac anomalies when compared to four-chamber view USG alone (92% vs. 33%).[7] However, in centers where foetal echocardiography facility is not available, first trimester HbA1c and nuchal translucency screening could be considered to select women for foetal echocardiography. Foetuses with congenital cardiac anomalies (of diabetic as well as non-diabetic

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mothers) may show first trimester nuchal translucency thickness >3.5mm measured by USG, and HbA1c level >6.9%.[7-9]

The incidence of neural tube defect (NTD) in diabetic pregnancy is approximately 20/1000 compared with 2/1000 in general population. Anencephaly (1/200) and caudal regression syndrome (1/200 to 1/500) are the most frequent NTD anomalies in foetuses of diabetic mothers. Anencephaly can be easily diagnosed by transabdominal USG characterized by absent bony calvarium and prominent bulging eyes. Caudal regression syndrome (CRS) is symmetric agenesis (of differing degree/extent) of lumbo-sacro-coccygeal spine. Other musculoskeletal abnormalities may be associated with CRS. Accurate diagnosis of CRS requires a thorough examination of spine and intactness of the overlying skin by transvaginal ultrasound. Characteristic imaging findings are abrupt discontinuity of the spine at thoracic/lumbar/sacral level with abnormal femora that are fixed in a typical "V" position (hip joints being externally rotated). Microcephaly and absent pituitary gland are other CNS anomalies associated with diabetic pregnancy.[8-10]

Imperforate anus, small bowel atresia and small left colon syndrome are the commonest gastrointestinal congenital anomalies seen in diabetic pregnancy. Antenatal USG has no role in diagnosing these conditions.[8,9]

Sonographic Estimation of Foetal Development and Growth

Foetuses of diabetic mothers usually show altered growth pattern, either small or large for gestational age (SGA or LGA), thereby necessitating an antenatal sonography.

The most precise estimation of foetal gestational age (±7days) in the first trimester is done by crown lump length (CRL). However, the finding of "early growth restriction" (diagnosed by measuring CRL) in diabetic pregnancies has no proven association with the development of congenital malformation in later stages of gestation.[9]

SGA foetuses are commonly seen in diabetic pregnancies having the vascular disease. This is related to the impairment of placental perfusion due to involvement of the placental villi as a part of diabetic vasculopathy. In this scenario, SGA foetuses have asymmetrical or disproportional growth retardation (normal-sized head but small body), typically starting at the beginning of the third trimester.[11] Pregnancies with severe pre-existing diabetes may produce genetic abnormalities and SGA foetuses with symmetric or proportionate growth retardation (small-sized head and body), detected usually by early second trimester. Symmetric growth retardation may be associated with impaired perfusion and /or poor placental development. In both the types of SGA foetuses, USG foetal biometric assessment is better than the clinically estimated foetal size/gestational age by palpation/measurement of the symphysis-fundal height. After 28 weeks of gestation (i.e., in third trimester), USG foetal growth assessment (to diagnose SGA foetuses) is done by measuring biparietal diameter (BPD), abdominal circumference (AC) and femur length (FL). Among these, AC is the most sensitive parameter to assess the foetal growth. Gray scale USG is more useful for keeping track of asymmetrical SGA foetuses. On the other hand, uterine and umbilical arterial Doppler examination (to evaluate the impaired blood supply of the placenta) is particularly beneficial for monitoring SGA foetuses with symmetrical growth. Moreover, USG guided aminiocentesis for genetic typing should be considered in diabetic mothers with symmetric SGA foetuses.[11,12]

Severe hyperglycaemia is characterized by acidaemia and hypoxaemia, but minor degrees of hyperglycaemia are associated with acidaemia in the absence of hypoxaemia. However, in the presence of mild foetal hypoxaemia, minor degrees of foetal hyperglycaemia may result in severe acidosis and even foetal death. Therefore, biweekly or more frequent Doppler studies of the utero-placental and foeto-placental vasculatures in diabetic pregnancies is recommended to assess the progressive impairment of placental perfusion, thereby predicting the point of foetal decompensation which necessitates the delivery.[12-14]

On color Doppler studies, the uterine artery reflects the utero-placental and the umbilical artery reflects the foeto-placental circulation. If perfusion is decreased (on foetal side or on placental side), the umbilical artery will show increased impedance to blood flow and decreased diastolic component on color Doppler spectral waveform. This reduced diastolic flow component in umbilical artery is reflected as increased values of the Doppler indices, viz., resistive index (RI), pulsatility index (PI) and systolic-diatolic ratio (SDR). Moreover, progressive reduction in the diastolic blood flow in the umbilical artery waveform (on spectral Doppler) suggests progressive impairment of foeto-placental perfusion. Initially foetus tries to compensate for the impaired placental circulation by redistributing the blood flow to vital organs like brain, kidney and heart. This phenomenon is referred as "brain sparing-

effect" and is characterized by increased PI in middle cerebral artery and decreased PI in descending aorta. In the worst scenario, when there is absent or reversed diastolic flow in the umbilical artery or loss of initial "brain sparing effect", the delivery should be considered at any foetal age.[15]

In diabetic pregnancies, the maternal hyperglycaemia causes foetal hyperglycaemia and hyperinsulinaemia. Foetal hyperinsulinaemia in turn causes macrosomia, either directly through its anabolic effect on nutrient uptake and utilization, or indirectly through stimulating insulin like growth factor. Nutritional status of the foetus best correlates with the abdominal circumference. Ultrasonography is not reliable for prediction of birth weight in LGA foetuses. However, measurement of foetal abdominal circumference that has more subcutaneous fat (insulin sensitive layer) is particularly useful in identifying macrosomia. The sensitivity and specificity for predicting a macrosomic infant (>4000g) in a diabetic mother, using AC >35cm, between 28 and 32 weeks of gestation, has been reported to be 76% and 74%.[17] Doppler examination is not helpful for evaluating LGA foetuses.

Sonography in recommending medical therapy in diabetic mothers

Foetal AC measurement by USG (between 28 and 32 weeks of gestation) determining the risk for foetal macrosomia, may guide the start of pharmacological treatment in diabetic mothers. It has been reported that diabetic mothers having foetal AC >75th percentile with plasma glucose level <105 mg/dl, when managed with insulin had lower chances of delivering an LGA foetus (13%), relative to those managed with diet alone (45%).[17]

Three-Dimensional Ultrasonography in Diabetic Pregnancy

The utility of three-dimensional (3D) USG is still being established. Several studies have tried to use 3D USG for foetal weight determination, but due to limited field of view it was difficult to view the entire foetus. However, it can measure the volume of different foetal parts like abdomen, thigh and upper arm, thereby helping in foetal weight estimation in the third trimester. In addition, foetal bone anomalies are better detected on 3D USG (as compared to 2D USG), and hence foetal skeletal dysplasias can be detected more accurately on 3D USG.[20] The work on assessment of congenital cardiac anomalies and heart diseases is under evaluation.

Limitations of Ultrasonography in Diabetic Pregnancy

It has been observed that the detection rate of congenital anomalies for diabetic women is significantly lower than that for general population. The most important factor is the poor image quality in diabetic mothers related to obesity, repeated insulin injections given over the lower abdomen and previous caesarean section (CS) scars. However, this problem could potentially be overcome by various techniques. Newer imaging modalities such as tissue harmonic imaging allow detection of higher frequency ultrasound waves and produces a higher resolution image in obese women. Use of transvaginal scan at 14-16 weeks of gestation negates the problem associated with non-uniformity of the abdomen as a result of scarring due to CS or insulin injection.[8]

Conclusion

Ultrasound is a cost-effective, easily available and noninvasive technique to study the congenital malformations and to monitor foetal growth in pregnancies complicated by diabetes. It is also helpful in instituting early pharmacological therapy to the pregnant females affected by diabetes. Doppler evaluation is particularly important in monitoring SGA foetuses (any cause), but it provides no significant benefit in evaluation of LGA foetuses.

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