Original Article

Correlation of Fetal Anterior Abdominal Wall Thickness and Other Standard Biometric Ultrasound Measurements to Predict Fetal Macrosomia in Gestational Diabetes

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Abstract

Background: Gestational diabetes mellitus (GDM) is one of the most common medical conditions affecting pregnancy and significantly increasing the risk for maternal and perinatal complications. The aim of the present study is to study the correlation of fetal anterior abdominal wall thickness (FAAWT) and other standard fetal biometric parameters measured by ultrasound between 36 and 39 weeks of gestation with neonatal birth weight in pregnancies complicated by GDM. **Methods:** Prospective cohort study in a tertiary care center including 100 singleton pregnancies with GDM were subjected to ultrasound between 36 and 39 weeks of gestation. Standard fetal biometry (Biparietal diameter, Head Circumference, Abdominal circumference [AC], and Femur Length) and estimated fetal weight were calculated. FAAWT was measured at AC section and actual neonatal birth weights were recorded after delivery. Macrosomia was defined as an absolute birth weight more than 4000 g regardless of the gestational age. Statistical analysis was done and 95% confidence level was considered significant. **Results:** Among 100 neonates, 16 were macrosomic (16%) and third trimester mean FAAWT was significantly higher in macrosomic babies (6.36 ± 0.5 mm) as compared to nonmacrosomic babies (5.54 ± 0.61 mm) ($P < 0.0001$). FAAWT >6 mm (Receiver operating characteristic curve derived) provided a sensitivity of 87.5%, specificity of 75%, positive predictive value of 40%, and negative predictive value (NPV) of 96.9% for prediction of macrosomia. While other standard fetal biometric parameters did not correlate well with actual birth weight in macrosomic neonates, only FAAWT was found to have statistically significant correlation (correlation coefficient of 0.626, $P = 0.009$). **Conclusion:** The FAAWT was the only sonographic parameter to have a significant correlation with neonatal birth weight in macrosomic neonates of GDM mothers. We found a high sensitivity (87.5%), specificity (75%), and NPV (96.9%) suggesting that FAAWT < 6 mm can rule out macrosomia in pregnancies with GDM.

Keywords: Anterior abdominal wall thickness, fetal, gestational diabetes mellitus, macrosomia, ultrasound

Introduction

Gestational diabetes mellitus (GDM) is defined as carbohydrate intolerance of any degree recognized for the first time or having its onset during pregnancy. The definition applies regardless of whether insulin or only diet modification is used for treatment and whether the condition persists after pregnancy or not.[1] The prevalence of GDM in India is estimated to be around 16.55/cent.[2] At any given point of time, it is estimated that around 4 million women are affected by GDM in India.[3]

The off-springs of mothers affected with GDM have increased risk of developing fetal, neonatal, and long-term morbidities. They have higher chances of developing macrosomia. Macrosomia is one of the most common complications of pregnancies with GDM, occurring in 15%–45% of neonates. Furthermore, macrosomia can have associated complications, which include shoulder dystocia, instrumental delivery, and perineal tears, including third-degree tears.[4] These infants are also at higher risk for childhood obesity, insulin

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Received: 16-03-2021 **Revised:** 13-10-2021 **Accepted:** 02-03-2022 **Available Online:** 27-05-2022

Access this article online

Quick Response Code:

Website: www.jmuonline.org

DOI: 10.4103/JMU.JMU_57_21

How to cite this article: Bansal A, Thukral BB, Bagri N, Kanwar A, Khandelwal A, Bajaj B. Correlation of fetal anterior abdominal wall thickness and other standard biometric ultrasound measurements to predict fetal macrosomia in gestational diabetes. J Med Ultrasound 2023;31:29-34.

resistance, hypertension, diabetes, and further morbidities in adult life.[5]

The obstetric management in pregnancies with GDM is based on the early and accurate assessment of fetal growth and well-being.[6] The usual ultrasound technique for the assessment of fetal growth includes the measurement of various fetal biometric parameters, most commonly the biparietal diameter (BPD), femur length (FL), abdominal circumference (AC), and estimated fetal weight (EFW).[6,7] The fetal anterior abdominal wall thickness (FAAWT) is a simple ultrasonographic measurement that can be obtained using the same section used for measuring the AC.

Previous studies have shown that although there was no significant difference in the standard fetal biometric parameters (BPD, FL, AC, and EFW), the mean FAAWT was significantly greater in the GDM group.[8] Despite recent advances in obstetrics, estimation of fetal weight remains a challenge even to the experienced sonographers with a variation of up to 20% in EFW at the extremes of growth.[9,10]

The antenatal diagnosis of fetal macrosomia is very important for labor management and to prevent fetal and maternal trauma during childbirth. FAAWT is a simple ultrasound measurement which when combined with other ultrasound parameters, can well predict fetal macrosomia.[11]

The importance of neonatal birth weight prediction in GDM patients necessitates its antenatal diagnosis for a favorable maternal and fetal outcome. In this prospective study, we, therefore, assessed the role of ultrasonographic measurement of FAAWT as a predictor of macrosomia in GDM patients. We also aim to correlate standard fetal biometry parameters (BPD, Head circumference [HC], AC, FL, and EFW) with neonatal birth weight in pregnancies with GDM.

Materials and Methods

This was a prospective cohort study conducted in a tertiary care Centre with approval from institutional ethical committee (S no. IEC/VMMC/SJH/Thesis/October/2017-188). One hundred singleton pregnancies between 36 and 39 weeks of gestation with gestational diabetes were included after informed written consent for 18 months. The diagnostic criteria used for GDM was one-step approach using the 75-g oral glucose tolerance test (OGTT), with glucose assayed at fasting and after 1 and 2 h, as recommended by The International Association of the Diabetes and Pregnancy Study Groups[12] with threshold values of 92 mg/dl, 180 mg/dl, and 153 mg/dl, respectively. GDM was defined by the presence of one or more OGTT values exceeding these thresholds.

Women with diseases known to affect fetal growth, uncertain gestational age, fetuses with congenital anomalies, and intrauterine growth restriction were excluded from the study.

Ultrasound examination

The ultrasound data in this study were collected the following standardized protocols for data acquisition, transabdominal acquisition using the US scanner Philips iU22 equipped with a 1–5 MHz curvilinear transducer. All ultrasound examinations were performed by a single radiologist. Standard fetal biometry parameters including BPD, Head circumference, AC, FL were measured, and EFW was obtained from the ultrasonographic examination using the Hadlock's formula descriptions.

Biparietal diameter

For measuring the BPD, an axial section of the head at the level of the paired thalami, third ventricle, and cavum septum pellucidum was taken and measurement was made by placing the caliper closer to the transducer (i.e., at the top of the image) at the outer edge of the bony calvarium, while the caliper farther from the transducer was placed on the inner edge of the bony calvarium.[13]

Head circumference

The HC was measured on the same view of the fetal head as the BPD, in the true axial view that included the entire head from the frontal bone to the occipital bone. The HC was measured by using elliptical calipers outlining the outer edge of the skull.[13]

Abdominal circumference

The AC was measured on an axial image of the fetal abdomen at the level of the stomach and intrahepatic portion of the umbilical vein, section was taken as round as possible, and the outer skin surface visible all the way around. The AC was measured via elliptical calipers outlining the outer surface of the skin around the abdomen.[13]

Femur length

For FL measurement, image of the femur was taken as perpendicular to the ultrasound beam as possible and measurement was made by placing the calipers at either end of the ossified diaphysis excluding femoral epiphysis.[13]

Estimated fetal weight

EFW was calculated using BPD, HC, AC, and FL and applying Hadlock's formula.[13]

FAAWT was measured by ultrasound in the standard AC view. Using magnification at the level of the AC, the calipers were placed to measure the distance from the outermost skin edge to the innermost margin of the anterior abdominal wall. FAAWT was measured in millimeters. The mean value of the three measurements was taken [Figure 1].

Actual neonatal birth weights were recorded after delivery. Variables retrieved include gestational age at which the ultrasound was performed, gestational age at delivery, gender of the neonate, and neonatal birth weight. Macrosomia was defined as an absolute birth weight more than 4,000 g regardless of the gestational age.[14]

Statistical analysis

All the data were entered into an MS Excel spreadsheet and statistical analysis was performed by Statistical Package for Social Sciences (SPSS) version 21.0 (SPSS version 21.0, Manufacturer: IBM Company, New Delhi, India).

95% confidence level was considered significant for all tests. Categorical variables were presented in number and percentage (%) and continuous variables were presented as mean ± standard deviation and median. The normality of data was tested by Kolmogorov–Smirnov test. If the normality was rejected then nonparametric test was used. Quantitative variables were compared using Mann–Whitney Test (as the data sets were not normally distributed) between the two groups. A diagnostic test was used to calculate sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). Spearman rank correlation coefficient was used to assess the association of various parameters with birth weight. Receiver operating characteristic (ROC) curve was used to find out cut-off point of parameters for predicting macrosomia.

Results

A total of 100 pregnant women with GDM were included in the study. The average maternal age being 26 years and the mean average ultrasound age at time of scan was 36 weeks and 4 days. The most common fetal presentation was cephalic (84%) and most of the patients (63%) had anteriorly located placentae. Most of the babies (39%) were delivered between 37 and 37 + 6 weeks of period of gestation (POG) and 19% were delivered preterm. An estimated 15 million preterm births occur annually worldwide, which accounts to 1 in 10 deliveries, with about 81% in South Asia and Sub-Saharan Africa.[15]

Sixteen out of 100 neonates were found to be macrosomic (16%) in the present study. The overall mean birth weight was 3.23 kg while the mean birth weight among macrosomic neonates was 4.21 kg.

The standard fetal biometry parameters (BPD, HC, AC, FL, and EFW) were correlated with overall neonatal birth weight as well as the birth weight in macrosomia and nonmacrosomia group [Tables 1 and 2]. Except BPD, all the parameters showed a significant correlation with the overall neonatal birth weight. In the macrosomia group, only fetal AAWT was found to have a significant correlation with neonatal birth weight ($P = 0.009$). The diagnostic efficacy of various fetal ultrasound parameters was also assessed for the prediction of neonatal birth weight [Table 3]. Fetal AAWT and EFW were significant predictors of neonatal birth weight ($P = 0.0001$).

Third trimester mean FAAWT at 36–39 weeks of POG was significantly higher in macrosomic babies (6.36 ± 0.5 mm) as compared to nonmacrosomic babies (5.54 ± 0.61 mm) with $P < 0.0001$ [Figure 2]. The statistical association between standard fetal ultrasound parameters (BPD, HC, FL, AC, EFW, and FAAWT) and macrosomia was analyzed along with the determination of cut-off values, sensitivity, specificity, PPV, and NPV of these parameters to predict macrosomia [Table 4]. The ROC curve [Figure 3] derived cut-off value of >6 mm for FAAWT for the prediction of macrosomia in pregnancies with GDM provided sensitivity of 87.5% (95% confidence interval [CI] 61.7–98.4), specificity of 75% (95% CI 64.4–83.8), PPV of 40% (95% CI 23.9–57.9) and NPV of 96.9% (95% CI 89.3–99.6). While other standard fetal biometric parameters did not correlate well with the actual birth weight in neonates with macrosomia in GDM patients, only FAAWT was found to have statistically significant correlation (correlation coefficient of 0.626, $P = 0.009$).

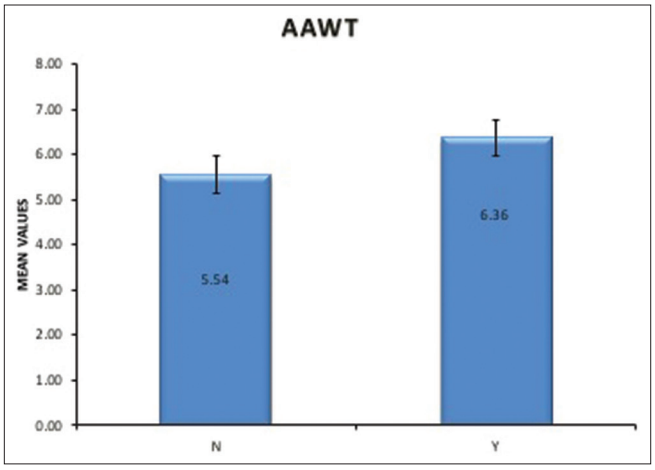

Figure 1: Gray scale ultrasound image shows measurement of fetal anterior abdominal wall thickness as obtained from the standard abdominal circumference section at 36 weeks and 4 days of gestation

Table 1: Distribution of the variables between gestational diabetes mellitus women with and without macrosomia

Variables	Macrosomia		*P*
	Absent	Present	
BPD	8.99±0.21	9±0.19	0.73
HC	32.15±0.54	32.06±0.85	0.381
AC	32.27±0.52	32.57±0.47	0.047
FL	7.1±0.14	7.05±0.24	0.817
EFW (g)	3234.94±167.6	4218.5±132.42	0.201
FAAWT (mm)	5.54±0.61	6.36±0.5	<0.0001

BPD: Biparietal diameter, FL: Femur length, AC: Abdominal circumference, EFW: Estimated fetal weight, HC: Head circumference, FAAWT: Fetal anterior abdominal wall thickness

Table 2: Correlation of various fetal ultrasound parameters with neonatal birth weight

Fetal biometry Parameter	Neonatal birth weight (overall)		Neonatal birth weight (macrosomia group)	
	Correlation coefficient	*P*	Correlation coefficient	*P*
BPD	0.082	0.414	−0.465	0.069
HC	0.27	0.006	0.167	0.536
AC	0.478	<0.0001	0.3	0.258
FL	0.387	0.0001	−0.077	0.778
EFW	0.59	<0.0001	0.258	0.334
FAAWT	0.403	<0.0001	0.626	0.009

BPD: Biparietal diameter, FL: Femur length, AC: Abdominal circumference, EFW: Estimated fetal weight, HC: Head circumference, FAAWT: Fetal anterior abdominal wall thickness

Table 3: Prediction of neonatal birth weight by various fetal ultrasonography parameters

	Unstandardized coefficients		Standardized coefficients	*P*	95.0% CI for B	
	B	SE	β		Lower bound	Upper bound
AAWT	0.207	0.049	0.353	0.0001	0.110	0.304
AC	0.087	0.069	0.118	0.2074	−0.049	0.224
EFW	0.001	0.000	0.374	0.0001	0.000	0.001

CI: Confidence interval, SE: Standard error, AAWT: Anterior abdominal wall thickness, AC: Abdominal circumference, EFW: Estimated fetal weight

Table 4: Receiver operating characteristic analysis of various fetal ultrasonography parameters

Parameter	AUC	*P*	Cut-off	Sensitivity	Specificity	PPV	NPV
BPD	0.527	0.731	>8.9	62.5	54.76	20.8	88.5
HC	0.569	0.4394	>32.2	56.25	69.05	25.7	89.2
AC	0.655	0.0488	>32.4	50	88.1	44.4	90.2
FL	0.518	0.8573	>7.1	56.25	72.62	28.1	89.7
EFW	0.601	0.2006	>2952	62.5	63.1	24.4	89.8
FAAWT	0.862	<0.0001	>6	87.5	75	40	96.9

BPD: Biparietal diameter, FL: Femur length, AC: Abdominal circumference, EFW: Estimated fetal weight, HC: Head circumference, FAAWT: Fetal anterior abdominal wall thickness, AUC: Area under curve, PPV: Positive predictive value, NPV: Negative predictive value

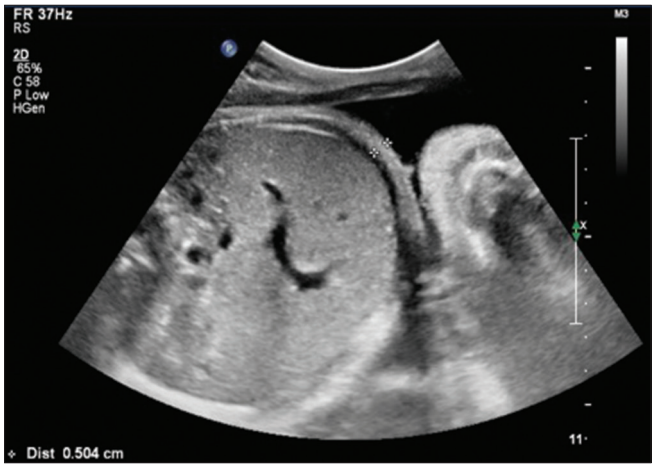

Figure 2: Mean fetal anterior abdominal wall thickness (mm) values in neonates with and without macrosomia

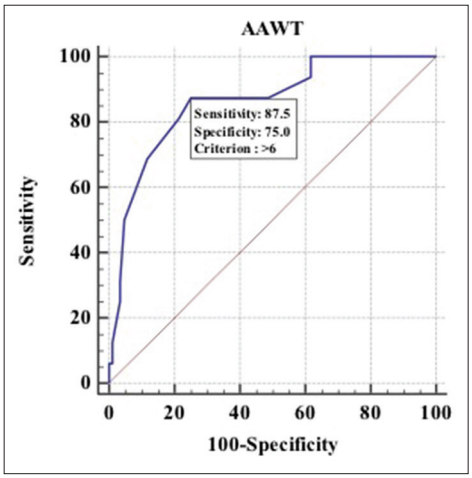

Figure 3: Receiver operating characteristic curve for fetal anterior abdominal wall thickness

Discussion

Gestational diabetes is a crucial condition because of associated fetal and maternal complications and despite the clinical progress in its management, the incidence of fetal macrosomia still remains significantly high.[16] In the present study, 36–39 weeks of POG was chosen as this is the most critical period for decision making about further line of management.

Ours is a tertiary center, in a resource-constrained country, which could account for increased prevalence of live preterm birth in the present study sample. The goal of relatively early induction of labor (37–37 + 6 weeks) in GDM at a tertiary center like ours was to prevent stillbirth or excessive fetal growth and its associated complications. However, these benefits need to be counted against the implications of increased rates of cesarean section and neonatal morbidity.

The present study was an attempt to ascertain FAAWT as a predictor of neonatal birth weight in pregnancies with gestational diabetes and it was found to be a statistically significant predictor (P = 0.0001). The correlation between standard ultrasound fetal biometric parameters (BPD, HC, AC, FL, and EFW) and FAAWT and actual neonatal birth weight (both overall and macrosomic group) was also assessed. All the parameters except BPD were found to have a significant positive correlation with overall neonatal birth weight. However, they did not correlate well with birth weight in macrosomic infants. Only FAAWT was found to have a significant correlation with birth weight in macrosomic infants with correlation coefficient of 0.626 (P = 0.009). These findings were in agreement with a study by Wong *et al*. who found that birth weight was underestimated by ultrasound in >15% in fetuses in diabetic pregnancies as compared to only 5.4% in nondiabetic pregnancies.[17] Higgins *et al*. found

a positive correlation between FAAWT and actual neonatal birth weight ($P < 0.01$).[18]

Valdecantos and Paguirigan-Kayaban and Assimakopoulos *et al*. also found a positive correlation between fetal abdominal subcutaneous tissue thickness (FASTT) and actual birth weight with P 0.001 and <0.001, respectively.[19,20] This might be due to reason that fetal lean body mass is determined by BPD, HC, AC, and FL, while fetal fat body mass which constitutes 12%–14% of birth weight and is responsible for 46% variation noted in neonatal birth weight, is determined by fetal anterior abdominal wall fat tissue.[21]

The present study also analyzed the accuracy of the standard ultrasound fetal biometric parameters (BPD, HC, AC, FL, and EFW) and FAAWT to predict fetal macrosomia in gestational diabetes. There was no statistically significant difference in the mean values of BPD, HC, FL, and EFW in macrosomic group as compared to nonmacrosomic group.

The mean AC in the present study was found to be slightly higher in macrosomic group (32.57 ± 0.47) as compared to AC in nonmacrosomic group (32.27 ± 0.52 cm). The difference between the mean values in two groups was narrow (0.3 cm) compared with the size of measurement itself (~32 cm). This is in agreement with a previous study by Aksoy *et al*., who found a slight variation in AC, which might be due to other important factors such as size of intra-abdominal organs and glycogen deposition in the liver.[8]

The mean FAAWT in the present study was found to be higher in neonates with macrosomia (6.36 ± 0.5 mm) as compared to appropriate for gestational age neonates (5.54 ± 0.61 mm). This difference was found to be statistically significant with $P < 0.001$. Taking a cut-off of >6 mm for prediction of macrosomia provided sensitivity of 87.5%, specificity of 75%, PPV of 40%, and NPV of 96.9%. High sensitivity makes fetal AAWT a good screening parameter to predict macrosomia. Very high NPV suggests that fetal AAWT is a good parameter to rule out macrosomia if fetal AAWT is <6 mm.

In the first study about the role of FAAWT as a predictor of fetal growth, Petrikovsky *et al*. found that ultrasound measurement of FASTT was useful to rule out macrosomia with NPV of >90% for a range of FASTT cut-off values and macrosomia.[22] Higgins *et al*.[18] in a prospective cohort study, analyzed FAAWT values in 125 diabetic women and found cut-off value of >5.5 mm at 36 weeks of POG as a predictor of macrosomia similar to the results of the present study.

Greco *et al*. in a case– control study found mean abdominal subcutaneous thickness in diabetic group was 4.4 ± 0.1 mm at 31 weeks of POG. It was found to be higher as compared to that in healthy group (3.7 ± 0.1 mm) with $P < 0.05$.[23] The present study had relatively higher mean values of FAAWT as the POG was 36–39 weeks.

Bethune and Bell in their study also found fetal abdominal fat layer (FFL) as the most promising measurement as compared to interventricular septal thickness and AC >90th percentile to predict macrosomia in pregnancies with gestational diabetes. A value of FFL ≥5 mm provided sensitivity of 41%, specificity of 96%, and PPV of 70% while AC >90th percentile provided sensitivity of 76%, specificity of 76%, and PPV of 43% to predict macrosomia in early third trimester.[24] This difference in the values compared to that found in our study could be due to difference in POG chosen (early vs. late third trimester) and the value of FFL chosen.

Bhat *et al*. found a positive correlation between FASTT and birth weight and also a cut-off value of 6.25 mm was sensitive to predict macrosomic babies and had a high NPV.[11] Rigano *et al*. in their study also found higher values of fetal abdominal fat tissue thickness in patients with gestational diabetes as compared to nondiabetic pregnancies. However, unlike our study, no statistically significant difference in AC values was found between the two groups.[25] This could be due to the difference in treatment as all the patients in their study had well-controlled blood sugar levels. Similarly, Russell *et al*. in their study found FAAWT values >5 mm in third trimester can predict macrosomia.[26]

Since the present study was a prospective study with the same ultrasound machine and a single observer, the inter-observer bias was thus eliminated. Furthermore, macrosomia was defined as neonatal birth weight >90th percentile for gestational age at delivery and gender, as compared to some earlier studies in which birth weight >4000 g was used as criteria for diagnosing macrosomia in infants.

An important limitation was lack of longitudinal data, including serial scans at different gestational weeks. Since the sample size was moderate and the study was conducted at a single center, larger and multi-centric studies are required for better correlation of these findings and establishing a standard cut-off value.

Conclusion

Although the standard fetal biometric parameters including BPD, HC, AC, FL, and EFW are most commonly used for fetal assessment, they did not correlate well with actual birth weight. FAAWT was found to be a statistically significant predictor of neonatal birth weight in pregnancies with gestational diabetes ($P = 0.0001$). Thus, the ultrasound assessment of the FAAWT is a highly promising, easily measurable parameter with high sensitivity and NPV for the prediction of fetal macrosomia. Clinicians should be aware of the limitations of traditional fetal biometric parameters in predicting macrosomia in GDM. Further prospective studies performed at a larger scale are required to further reveal the importance of FAAWT.

A beforehand knowledge of fetal macrosomia in pregnancies with GDM is an important factor for an obstetrician to plan proper timing and method of delivery, thus, preventing associated catastrophic complications. Fetal AAWT was found to be likely a highly promising parameter to rule out macrosomia in pregnancies with GDM.

Acknowledgements

We wish to thank the staff in the Department of Radiodiagnosis, VMMC and Safdarjung Hospital for their support and cooperation throughout the study.

Availability of data and materials

The cases and the images are available from the Department of Radiodiagnosis, Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi, India.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Picón MJ, Murri M, Muñoz A, Fernández-García JC, Gomez-Huelgas R, Tinahones FJ. Hemoglobin A1c versus oral glucose tolerance test in postpartum diabetes screening. Diabetes Care 2012;35:1648-53.
2. Rajput R, Yadav Y, Nanda S, Rajput M. Prevalence of gestational diabetes mellitus & associated risk factors at a tertiary care hospital in Haryana. Indian J Med Res 2013;137:728-33.
3. Mithal A, Bansal B, Kalra S. Gestational diabetes in India: Science and society. Indian J Endocrinol Metab 2015;19:701-4.
4. Poomalar GK. Changing trends in management of gestational diabetes mellitus. World J Diabetes 2015;6:284-95.
5. Barker DJ, Gluckman PD, Godfrey KM, Harding JE, Owens JA, Robinson JS. Fetal nutrition and cardiovascular disease in adult life. Lancet 1993;341:938-41.
6. Nizard J, Ville Y. The fetus of a diabetic mother: Sonographic evaluation. Semin Fetal Neonatal Med 2009;14:101-5.
7. Kaman KC, Shakya S, Zhang H. Gestational diabetes mellitus and macrosomia: A literature review. Ann Nutr Metab 2015;66 Suppl 2:14-20.
8. Aksoy H, Aksoy Ü, Yücel B, Saygi Özyurt S, Aydın T, Alparslan Babayiğit M. Fetal anterior abdominal wall thickness may be an early ultrasonographic sign of gestational diabetes mellitus. J Matern Fetal Neonatal Med 2016;29:2028-32.
9. Sacks DA, Chen W. Estimating fetal weight in the management of macrosomia. Obstet Gynecol Surv 2000;55:229-39.
10. Chauhan SP, West DJ, Scardo JA, Boyd JM, Joiner J, Hendrix NW. Antepartum detection of macrosomic fetus: Clinical versus sonographic, including soft-tissue measurements. Obstet Gynecol 2000;95:639-42.
11. Bhat RG, Nathan A, Amar R, Vasudeva A, Adiga P, Bhat PV, *et al.* Correlation of fetal abdominal subcutaneous tissue thickness by ultrasound to predict birth weight. J Clin Diagn Res 2014;8:OC09-11.
12. International Association of Diabetes and Pregnancy Study Groups Consensus Panel; Metzger BE, Gabbe SG, Persson B, Buchanan TA, Catalano PA, Damm P, *et al.* International association of diabetes and pregnancy study groups recommendations on the diagnosis and classification of hyperglycemia in pregnancy. Diabetes Care 2010;33:676-82.
13. Benson CB, Doubilet PM. Fetal biometry and growth. In: Norton ME, editor. Callen's Ultrasonography in Obstetrics and Gynaecology. 6th ed. Philadelphia: Elsevier; 2017. p. 118-31.
14. Macrosomia: ACOG practice bulletin, number 216. Obstet Gynecol 2020;135:e18-35.
15. Liu L, Oza S, Hogan D, Chu Y, Perin J, Zhu J, *et al.* Global, regional, and national causes of under-5 mortality in 2000-15: An updated systematic analysis with implications for the Sustainable Development Goals. Lancet 2016;388:3027-35.
16. Reece EA, Coustan DR. Diabetes Mellitus in Pregnancy. 2nd ed. New York: Churchill Livingston; 1995.
17. Wong SF, Chan FY, Cincotta RB, Oats JJ, McIntyre HD. Sonographic estimation of fetal weight in macrosomic fetuses: Diabetic versus non-diabetic pregnancies. Aust N Z J Obstet Gynaecol 2001;41:429-32.
18. Higgins MF, Russell NM, Mulcahy CH, Coffey M, Foley ME, McAuliffe FM. Fetal anterior abdominal wall thickness in diabetic pregnancy. Eur J Obstet Gynecol Reprod Biol 2008;140:43-7.
19. Valdecantos GD, Paguirigan-Kayaban MJ. Fetal Abdominal Subcutaneous Tissue Thickness (FASTT): Correlation with other biometric measurements and neonatal outcomes in a sample population of Filipino fetuses. Philipp J Obstet Gynecol 2012;36:117-23.
20. Assimakopoulos E, Zafrakas M, Garmiris P, Goulis DG, Athanasiadis AP, Dragoumis K, *et al.* Fetal abdominal subcutaneous tissue thickness measured by ultrasound at term is associated with birth weight and mode of delivery. Clin Exp Obstet Gynecol 2007;34:171-4.
21. Skovron ML, Berkowitz GS, Lapinski RH, Kim JM, Chitkara U. Evaluation of early third-trimester ultrasound screening for intrauterine growth retardation. J Ultrasound Med 1991;10:153-9.
22. Petrikovsky BM, Oleschuk C, Lesser M, Gelertner N, Gross B. Prediction of fetal macrosomia using sonographically measured abdominal subcutaneous tissue thickness. J Clin Ultrasound 1997;25:378-82.
23. Greco P, Vimercati A, Hyett J, Rossi AC, Scioscia M, Giorgino F, *et al.* The ultrasound assessment of adipose tissue deposition in fetuses of "well controlled" insulin-dependent diabetic pregnancies. Diabet Med 2003;20:858-62.
24. Bethune M, Bell R. Evaluation of the measurement of the fetal fat layer, interventricular septum and abdominal circumference percentile in the prediction of macrosomia in pregnancies affected by gestational diabetes. Ultrasound Obstet Gynecol 2003;22:586-90.
25. Rigano S, Ferrazzi E, Radaelli T, Cetin ET, Pardi G. Sonographic measurements of subcutaneous fetal fat in pregnancies complicated by gestational diabetes and in normal pregnancies. Croat Med J 2000;41:240-4.
26. Russell N, Mulcahy C, Foley M, McAuliffe F. Does anterior abdominal wall thickness reflect glycaemic control and can it predict birth weight? Am J Obstet Gynecol 2006;195:S138.