JKMU
Journal of
Kerman University of Medical Sciences
https://jkmu.kmu.ac.ir
10.34172/jkmu.2023.33
Vol. 30, No. 4, 2023, 201-206

Original Article

The Role of Abdominal Ultrasound in the Prediction of GDM in Early Pregnancy

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Abstract

Background: To detect gestational diabetes mellitus (GDM) in pregnant women as soon as possible, this study aimed to investigate the role of ultrasound in predicting GDM in early pregnancy by measuring the thickness of abdominal subcutaneous adipose tissue.

Methods: This paper is a longitudinal study performed on pregnant women at 11-14 weeks of pregnancy. All the women referred during this period were screened for the thickness of abdominal subcutaneous adipose tissue, which was measured using trans-abdominal ultrasound. The patients were followed up by performing the oral glucose tolerance test (OGTT) between the weeks of 24 and 28. Finally, abdominal subcutaneous adipose tissue thickness and other variables were compared between women with and without GDM. Oral consent was obtained from patients.

Results: Overall, 210 pregnant women at 11-14 weeks of gestation were enrolled in the study. The mean of abdominal subcutaneous adipose tissue thickness was measured using linear probe ultrasound as 1.72 ± 0.33 mm. The incidence of GDM was significantly associated with maternal age and weight, parity, family history of diabetes, and histories of preeclampsia, hypertension, and recurrent abortion. There was also a statistically significant relationship between GDM and ultrasound-derived subcutaneous adipose tissue thickness at weeks 11-14 of pregnancy ($P<0.0001$). At the cut-off point of 2.01, the sensitivity, specificity, and area under the curve (AUC) values were 91%, 92%, and 0.96, respectively.

Conclusion: Measuring the thickness of the abdominal subcutaneous adipose tissue during early pregnancy may be useful in predicting GDM in the second trimester of pregnancy. Maternal higher age and weight gain, increased parity, and positive family histories of diabetes, preeclampsia, hypertension, and recurrent abortion may also increase the risk of GDM.

Keywords: Abdominal subcutaneous adipose tissue, Gestational diabetes mellitus, Pregnancy, Ultrasound

Citation: Dalili M, Moeinaddini S, Gozashti MH, Torabi M, Mirzaee M, Mahdizadeh A. The role of abdominal ultrasound in the prediction of GDM in early pregnancy. *Journal of Kerman University of Medical Sciences*. 2023;30(4):201-206. doi:10.34172/jkmu.2023.33

Received: November 26, 2022, **Accepted**: January 8, 2023, **ePublished**: August 20, 2023

Introduction

Nowadays, the prevalence of obesity in women living in developing countries is increasing. Obesity during pregnancy, because of triggering insulin resistance, is a risk factor for gestational diabetes mellitus (GDM). One way to evaluate central obesity is to measure the thickness of the abdominal subcutaneous adipose tissue by ultrasound, which can predict some pregnancy complications. In fact, it has been noted to be an even better predictor than body mass index (BMI) (1,2). Measuring this parameter during early pregnancy, before performing an oral glucose tolerance test (OGTT) in the second trimester, may be helpful in predicting GDM in mid-pregnancy (3,4). The risk of developing GDM in pregnancy is about 4-8%, leading the pregnancy to be classified as high-risk. Although GDM screening is recommended for pregnant women between the 24th and 28th weeks, determining the thickness of the

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subcutaneous adipose tissue during the first trimester may deliver a faster predictor for the early detection of GDM. This would offer a more optimal screening method for GDM, providing the possibility of effectively managing the condition and preventing its complications (5). Considering the high prevalence of GDM, it seems necessary to use this method to reliably predict the incidence of the disease as soon as possible (6). No study has validated the model for predicting GDM using subcutaneous abdominal fat measurements. External validation studies are recommended to improve the generalization of this GDM predictor in clinical practice. Numerous studies have been performed on the predictive role of the thickness of the abdominal subcutaneous adipose tissue in the early diagnosis of GDM; however, their results have been contradictory (7). Kennedy et al, in a cohort study, measured abdominal subcutaneous adipose tissue thickness in the first and second trimesters of pregnancy in 1510 pregnant women and showed that this parameter, in addition to predicting GDM, could also foretell other harmful consequences and potential risks factors such as preeclampsia, the possibility of cesarean section (CS), and preterm labor during pregnancy (8). In contrast to these findings, some studies have debated the predictive value of increased abdominal subcutaneous adipose tissue thickness in GDM diagnosis during the second trimester of pregnancy (2,9).

This study aimed to investigate the role of ultrasound in predicting GDM in early pregnancy based on the thickness of the abdominal subcutaneous adipose tissue. This method may be useful in the early detection and screening of the disease in pregnant women and in preventing its possible complications.

Material and Methods

Study design and setting

This was a one-year longitudinal study performed on pregnant women referred to Afzalipour hospital in Kerman, southeastern Iran, for prenatal care from March 1, 2020, to March 1, 2021. All the patients referred in the study period underwent measurements for maternal weight and abdominal subcutaneous adipose tissue thickness, which was determined by trans-abdominal ultrasound. According to the recommendations of the American diabetes association guidelines, the patients were followed up by the OGTT, for which they were fed 75 grams of glucose between the 24th and 28th weeks of pregnancy. The diagnostic criteria for GDM were having either fasting blood glucose (FBS) of ≥ 92 mg/dL or glucose levels above 180 mg/dL and 153 mg/dL at the first and second hour after glucose administration, respectively (10). Based on the results of this test, the participants were divided into two groups: with and without GDM. Abdominal subcutaneous adipose tissue thickness and other variables were then compared between the two groups. Ultrasound parameters were measured by a gynecologist, and the patients' follow-up data were collected by a gynecologist medical assistant. All the collected information was recorded in a pre-prepared questionnaire.

Study population

All pregnant women with a gestational age between the weeks of 11 and 14 were included in the study. A previous diabetes diagnosis, a history of metabolic syndrome, multiple pregnancies, a history of laparotomy, structural and chromosomal abnormalities of the fetus, and patient unwillingness to participate were exclusion criteria.

Measurements

Ultrasound was performed by a *maternal-fetal medicine* fellow with more than ten years of experience in this field. Abdominal subcutaneous adipose tissue thickness was determined by transabdominal ultrasound using the Voluson E8 Expert device (GE Healthcare, Chicago, IL, US) and applying a high-frequency linear probe (7.5 MHz). The diagnostic accuracy of ultrasound as a screening tool for GDM was investigated (11). First, the patients were asked to lie on their backs, and the probes were placed on the upper part of the mother's abdomen (one centimeter above the umbilicus in the sagittal position). The maximum thickness of subcutaneous adipose tissue was measured from the skin to the rectus abdominis muscle during exhalation (12).

Variables and outcomes

Maternal age and weight, parity, type of delivery, a family history of diabetes, and histories of GDM, preeclampsia, hypertension, recurrent abortion, and preterm delivery, as well as the results of OGTT (FBS and glucose levels at the first and second hour) and the thickness of the subcutaneous adipose tissue on ultrasound, were recorded. These variables were then compared between pregnant women with and without GDM.

Statistical analysis

Sample size

The sample size was calculated to be 210 according to the following formula:

$$n = \frac{z_1^2 - \frac{a}{2} pq}{d^2}$$, P = 0.22, q = 0.78, d = 0.041, α = 0.05 (13).

Mean and standard deviations were used to describe quantitative variables, and frequency and percentage were used to describe qualitative variables. Associations between qualitative variables were evaluated using the chi-square or Fisher's exact test. The mean differences of quantitative variables (subcutaneous adipose tissue thickness, maternal age and weight, and parity) between women with and without GDM were investigated by

either the Student's t-test (in case of normal distribution) or its non-parametric counterpart (the Mann-Whitney U test). To determine the cut-off point predicting the risk of GDM and its sensitivity and specificity, ROC curve analysis was performed. Logistic regression was used to determine the relationship between abdominal subcutaneous adipose tissue thickness and the risk of GDM after adjustment for other variables (maternal age and weight, and parity). All statistical procedures were conducted in SPSS version 20 software, and a *P* value of < 0.05 was considered statistically significant.

Results

Two hundred thirty-one pregnant women between the 11th and 14th weeks of gestation were enrolled in this study, of whom 21 were excluded, and finally, 210 participated in the study. Cases excluded from the study were as follows: diabetes mellitus (9 cases), multiparity (4 cases), history of previous laparotomy (4 cases), patient non-cooperation (3 cases), and fetal disorders (1 case) (Figure 1). The mean age of the pregnant women was 27.56 ± 5.12 y, and their mean weight was 60.49 ± 7.11 Kg. Moreover, 92 (43.8%), 85 (40.5%), and 33 (15.7%) of them had parities of one, two, and three, respectively. Regarding the type of delivery, 122 (58.1%) had normal vaginal delivery (NVD), and CS was performed in 88 (41.9%). The history of diseases in the studied pregnant women has been reported in Table 1.

In terms of the OGTT performed between the 24th and 28th gestational weeks, the mean FBS of the mothers was 85.27 ± 9.50 mg/dL, and blood glucose levels at the first and second hour were 159.23 ± 19.66 mg/dL and 138.75 ± 17.83 mg/dL, respectively. The mean thickness of the abdominal subcutaneous adipose tissue on ultrasound with a linear probe was recorded as 1.72 ± 0.33 mm.

The comparison of the assessed variables between pregnant women with and without GDM revealed statistically significant differences comparing parity, family history of diabetes, and histories of preeclampsia, hypertension, and recurrent abortion, between the two groups. However, GDM was not significantly associated with the history of preterm delivery (Table 2). Regarding quantitative variables, GDM was significantly associated with maternal age and weight. Also, there was a statistically significant relationship between the thickness

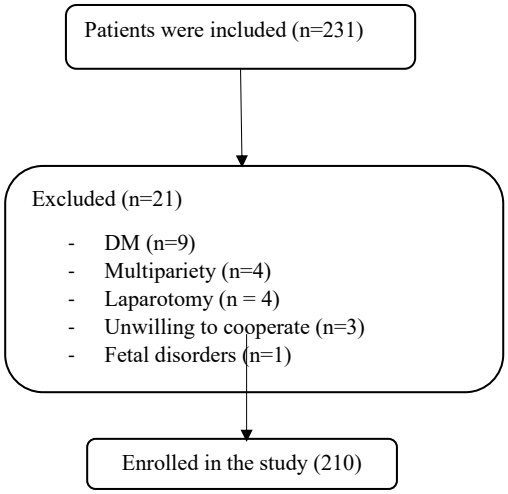

Figure 1. Flow chart showing enrollment of patients

Table 1. Patients' characteristics

Variables	Number (%)	Mean ± SD
Age	210 (100)	27.56 ± 5.12
Maternal Weight		60.49 ± 7.11
Parity		
1	92 (43.8)	
2	85 (40.5)	
3	33 (15.7)	
Type of delivery		
NVD	122 (58.1)	
C/S	88 (41.9)	
History of Diabetes mellitus in family	81 (38.6)	
GDM	34 (16.2)	
Preeclampsia	20 (9.6)	
Hypertension	16 (7.6)	
Recurrent abortion	5 (2.4)	
Preterm	3 (1.4)	
FBS		85.27 ± 9.50
Blood sugar 1 h		59.23 ± 19.66
Blood sugar 2 h		38.75 ± 17.83
Ultrasound (11-14 wk)		1.72 ± 0.33

FBS, fasting blood glucose; NVD, normal vaginal delivery; GDM, gestational diabetes mellitus; CS, cesarean section.

Table 2. Analysis of qualitative variables according to their association with GDM

Variables	GDM		*P* value
	No	Yes	
Parity			0.003
1	86 (3.5)	6 (6.5)	
2	66 (77.6)	19 (22.4)	
3	24 (72.7)	9 (27.3)	
Type of delivery			0.12
NVD	106 (86.9)	16 (13.1)	
C/S	70 (80.2)	18 (19.8)	
History of			
Diabetes mellitus in family	47 (58)	34 (42)	0.0001
Preeclampsia	8 (40)	12 (60)	0.0001
Hypertension	8 (50)	8 (50)	0.001
Recurrent abortion	2 (40)	3 (60)	0.03
Preterm	3 (100)	0 (0)	0.58

NVD, normal vaginal delivery; GDM, gestational diabetes mellitus; CS, cesarean section.

of the abdominal subcutaneous adipose tissue, measured by ultrasound at 11-14 weeks of gestation, and GDM ($P < 0.0001$) (Table 3). Finally, the sensitivity, specificity, and AUC values were calculated to ascertain the predictive value of ultrasound-derived abdominal subcutaneous adipose tissue thickness for GDM. For the cut-off point of 2.01, sensitivity, specificity, and AUC were obtained at 91%, 92%, and 0.96, respectively (Figure 2).

Discussion

Regarding the high prevalence of GDM, the timely diagnosis of this condition can be of critical importance to reduce its complications. This study showed that higher maternal age, maternal weight gain, a higher parity, and positive histories for diabetes in the family, preeclampsia, hypertension, and recurrent abortion were associated with an increased risk of GDM. It was also shown that increased thickness of the abdominal subcutaneous adipose tissue at 11-14 weeks of pregnancy may be a reliable predictor for the early diagnosis of GDM.

Table 3. Analysis of quantitative variables according to their association with GDM

Variables	GDM (mean SD)		*P* value
	No	Yes	
Age	27.14 ± 0.37	29.73 ± 0.87	0.007
Maternal weight	59.94 ± 0.51	63.32 ± 1.36	0.008
FBS	82.42 ± 0.54	100.05 ± 0.82	0.0001
Blood sugar 1 h	153.66 ± 1.18	188.05 ± 1.80	0.0001
Blood sugar 2 h	133.75 ± 1.05	164.61 ± 2.13	0.0001
Ultrasound (11-14 wk)	1.62 ± 0.01	2.22 ± 0.02	0.0001

FBS, fasting blood glucose; GDM, gestational diabetes mellitus.

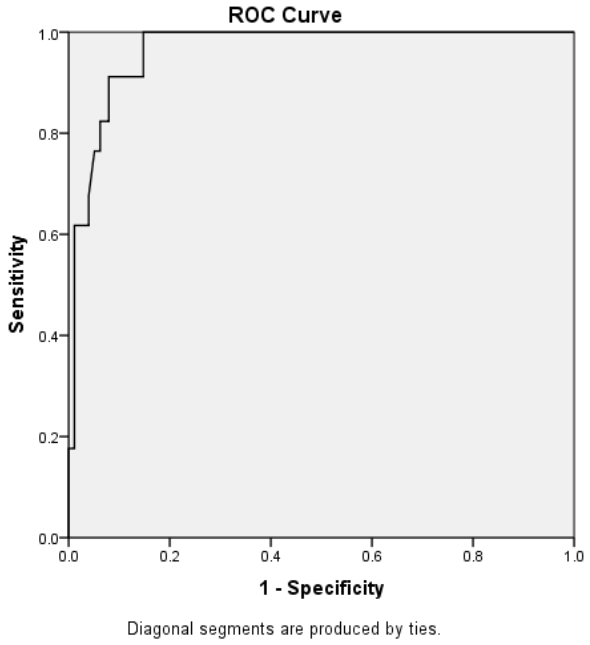

Figure 2. Receiver operating characteristic curve for ultrasound predicting GDM

Maternal age and weight, along with a family history of diabetes, are deemed to be reliable predictors for the early diagnosis of GDM. In a case-control study, D'Ambrosi et al reported that GDM was significantly linked with maternal age, BMI, and family history of diabetes (14). Also, Nassr et al, in a prospective study on 389 pregnant women in their 18-24 weeks of pregnancy, showed that maternal weight and family history of diabetes were independent predictors of GDM (15).

Increased parity is an important risk factor for the occurrence of pregnancy complications and even fetal death and defects (16). Schwartz et al, in a meta-analysis study, showed that with increasing parity, the risk of GDM recurrence also increased during pregnancy (17). Accordingly, we observed a significant association between an increased parity number and the risk of GDM development.

Hypertensive disorders are more common in women with GDM, who also present a significantly higher risk of developing preeclampsia and hypertension during pregnancy (18). Nzelu et al reported that people with a history of hypertension are likely to develop GDM more than twice in comparison with others (19). Thus, a mutual relationship seems to be present between gestational hypertension and GDM (20). Our study also showed a significant relationship between the incidence of GDM and gestational hypertension and preeclampsia.

In women with GDM, the risk of abortion significantly rises, reaching more than three times in comparison with women without GDM. Therefore, GDM is a risk factor for abortion in pregnant women, which was certified by Moosazadeh et al in a systematic review and meta-analysis study (21). Also, Kanmaz et al, in a case-control study, showed that GDM incidence significantly increased in pregnancies with a higher risk of abortion (22).

Increased abdominal subcutaneous adipose tissue thickness may help predict the risk of the development of GDM in pregnant women. Kansu-Celik et al indicated that pregnant women with increased abdominal subcutaneous adipose tissue thickness may be tender to the development of GDM, and determining the threshold point for abdominal subcutaneous adipose tissue thickness measurements may help us define risky pregnant women in early pregnancy. Receiver-operating characteristic curve analysis showed that abdominal subcutaneous adipose tissue thickness above 16.75 mm predicted GDM with a sensitivity of 71.7%, a specificity of 57.1%, a positive predictive value of 32.3%, and a negative predictive value of 87.6% (23). In a case-control study on 333 pregnant women, Yang et al examined the relationship between abdominal subcutaneous adipose tissue thickness and GDM and reported a significant predictive value for this parameter in the early diagnosis of GDM during the second trimester of pregnancy. In

other words, measuring this index by ultrasound during the first pregnancy trimester can be helpful in predicting GDM in the second trimester (24). Our study showed a significant relationship between increased abdominal subcutaneous adipose tissue thickness in early pregnancy and the likelihood of GDM occurrence during the second trimester. Women with abdominal subcutaneous adipose tissue thickness of more than 2.01 mm at the 11th to 14th gestational weeks were significantly more likely to develop GDM between the 24th and 28th weeks, suggesting an important role for ultrasound in screening pregnant women to early diagnose GDM and prevent its possible complications. In our study, the sensitivity and specificity of the ultrasound-derived abdominal subcutaneous adipose tissue thickness at the cut-off value of 2.01 were 91% and 92%, respectively, with an AUC of 0.96. In other words, pregnant women with an abdominal subcutaneous adipose tissue thickness of more than 2.01 mm had an increased chance of developing GDM with a sensitivity of 91% and a specificity of 92%. Several other studies have reported different results regarding the optimal cut-off point. In their study, Saif Elnasr and Ammar described the sensitivity and specificity of 60% and 80% at the cut-off point of 2 cm, respectively, for predicting GDM (25). In another study, the sensitivity and specificity of this ultrasound-derived parameter at the cut-off point of 2.4 were 75% and 92%, respectively (7). Despite these conflicting results, it may be cost-effective and applicable to measure abdominal subcutaneous adipose tissue thickness using ultrasound for GDM screening. This is because, according to available guidelines, the first GDM screening test is performed at the 24th to 28th weeks of gestation; however, determining this parameter by ultrasound during the first trimester will provide at least a faster diagnostic clue to predict the risk of GDM development in the second trimester (26).

Limitations

There were several limitations in the study. First, it was a single-center study. Since there was only one *maternal-fetal medicine* fellow available and it was possible to work with her only in one hospital, the study was conducted only in one center. Also, women with twin pregnancies, those with a history of laparotomy, and women giving birth to infants with fetal disorders were excluded from the study. Finally, some patients did not consent to participate in the study.

Conclusion

The detection of GDM in early pregnancy is essential to prevent its complications. For this purpose, ultrasound may be a good screening tool by detecting the increased thickness of the abdominal subcutaneous adipose tissue in early pregnancy, which would reliably predict GDM during the second trimester of pregnancy.

Acknowledgments

This study was supported by the Clinical Research Center of Afzalipour Academic Hospital, Kerman University of Medical Science, Kerman, Iran.

Authors' Contribution

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Project administration: Maryam Dalili, Shahrzad Moeinaddini.
Resources: Shahrzad Moeinaddini, Mehdi Torabi.
Software: Moghaddameh Mirzaee, Mehdi Torabi.
Supervision: Maryam Dalili, Mohammad Hossein Gozashti, Mehdi Torabi.
Validation: Maryam Dalili, Shahrzad Moeinaddini.
Visualization: Shahrzad Moeinaddini, Mehdi Torabi.
Writing – original draft: Mehdi Torabi, Shahrzad Moeinaddini.
Writing – review & editing: Mehdi Torabi, Moghaddameh Mirzaee.

Competing Interests

The authors declare that there is no conflict of interest.

Ethical Approval

The study was approved by the Ethics Committee of the Kerman University of Medical Sciences (IR.KMU.AH.REC.1400.038). Informed consent was obtained from the patients before entering the study.

Funding

This study was sponsored by the Kerman University of Medical Sciences.

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