Maternal Visceral Adipose Tissue as a Predictor of Gestational Diabetes Mellitus

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KEYWORDS

Gestational Diabetes Mellitus, Visceral Adipose Tissue, First Trimester, Ultrasonography, Pregnancy, Predictor

ABSTRACT

Background: Gestational Diabetes Mellitus (GDM) is a significant health concern during pregnancy, affecting both maternal and fetal outcomes. Timely identification of women at high risk for GDM is critically important for promptly initiating interventions. This study investigates the potential of first-trimester visceral adipose tissue (VAT) thickness, measured via ultrasound, as a predictor for GDM.

Methodology: This hospital-based prospective cohort study was conducted at Mahatma Gandhi Medical College and Research Institute, Pondicherry. A total of 212 pregnant women attending the antenatal outpatient department for their nuchal translucency (NT) scan at 11-14 weeks of gestation, between December 2022 and February 2024, were enrolled. Pre pregnancy BMI was calculated based on self –reported pre pregnancy weight (kg) or retrieved from medical charts. VAT and SAT (Subcutaneous Adipose Tissue thickness) was measured at the time of ultrasound scan. Women were followed up till delivery. Association of SAT and VAT measurements as a predictor of GDM was determined using multiple regression analysis and ROC analysis was used to determine the cutoff value of SAT, VAT for prediction of GDM.

Results: The prevalence of GDM among the antenatal women was 17.5%. Management of GDM included diet and medical nutrition therapy (10.81%), oral hypoglycemic agents (43.24%), insulin (37.83%), and a combination of both (8.10%). There was no significant difference in age or obstetric score between the GDM and non-GDM groups. However a higher prevalence of GDM was observed in the well-educated group ($p=0.025$). Significant differences were also noted in SAT, VAT, and total adipose tissue (TAT) measurements, with higher values in the GDM group. VAT and TAT demonstrated strong predictive validity for GDM, as indicated by high AUC values and significant p-values (both <0.001). The GDM group had higher mean newborn weights ($p<0.001$), although differences in APGAR scores at 1 and 5 minutes were not statistically significant.

Conclusion: Measuring visceral adipose tissue via ultrasound in early pregnancy shows promise as an effective predictor of gestational diabetes mellitus. Incorporating VAT measurement into routine early pregnancy screening could facilitate early interventions, potentially improving outcomes for both mothers and their infants.

Introduction

Pregnant women commonly develop gestational diabetes mellitus (GDM), the most prevalent metabolic disorder marked by impaired glucose tolerance and typically identified during the second or third trimester. Pregnancy-related GDM is becoming a major issue in public health across the world. An increasing number of people are developing GDM, which is mainly due to the global epidemic of obesity, says the World Health Organization (WHO). Depending on factors such as the population, geographic area, the diagnostic criteria for GDM, and the age of the mother during her first pregnancy, the prevalence of GDM might vary between 2-40% (1). Negative pregnancy outcomes are linked to it, and they pose risks to both the mother and the baby. Currently Diabetes in pregnancy study group of India (DIPSI) test recommended in India is a single step universal screening for pregnant women between 24-28 weeks of gestation (2).

Gestational diabetes mellitus (GDM) impacts approximately 8% of pregnancies in which maternal obesity and high pre-pregnancy BMI are identified as significant risk factors (3). Several anthropometric parameters, such as pre-pregnancy body mass index (BMI) and waist circumference, have been proposed as possible markers of gestational diabetes mellitus (GDM) and for evaluating the likelihood of pregnancy complications associated with obesity and risk stratification. In comparison to BMI and anthropometric indicators of abdominal obesity like waist circumference (WC) and waist-to-hip ratio (WHR), there seems to be a more robust association between abdominal obesity and metabolic pathologies (4).

Body mass index (BMI) may not be able to tell the difference between subcutaneous and visceral belly fat, or between the proportions of muscle and fat in relation to total body weight (5). Research in epidemiology and metabolics has shown that centrally placed visceral fat is more harmful than subcutaneous adipose tissue when it comes to the negative metabolic (2) effects of excess fat (6–8). Consequently, the thickness of visceral fat is a more reliable indicator of the likelihood of GDM because it more closely mirrors the distribution of total body fat. Early screening or dietary and lifestyle changes for women at high risk for GDM due to higher visceral adipose tissue might be possible. Preeclampsia, premature labor, foetal development limitation, and early pregnancy loss may all be predicted with the use of a first trimester dating scan. However predictors of GDM have not been recommended so far. Using ultrasonography to quantify the depth of visceral adipose tissue in the first trimester as a predictor for gestational diabetes mellitus (GDM) is the goal of this study, which seeks to establish a link between the two. This study, therefore, aims to fill the existing gap in the literature by providing evidence on the predictive value of first-trimester ultrasound measurements of visceral adipose tissue in anticipating the development of GDM.

Methodology

Study design, population and setting

The present study is a hospital-based prospective cohort. This study recruited pregnant women in the gestational age range of 11 to 13 weeks who sought medical care at the Obstetrics and Gynecology Outpatient Department (OG OPD) of Mahatma Gandhi Medical College & Research Institute, Puducherry, between December 2022 and February 2024.

Inclusion Criteria

- Pregnant women aged 18 years and older.
- Pregnant women between 11 to 13 weeks of gestation.

Exclusion Criteria

- Pregnancies with known fetal malformations or aneuploidy.
- Presence of scar tissue in the abdominal site that would prevent accurate ultrasound visualization of visceral adipose tissue (VAT).
- History of Type 1 or Type 2 diabetes mellitus.
- History of GDM in a previous pregnancy.
- Antenatal women on corticosteroid therapy.

Sample Size Calculation

Assuming the prevalence of gestational diabetes among pregnant women is 16.2% (8) , considering potential dropouts and using 5% absolute precision,a total of 212 participants were enrolled in the study.

Study procedure

Following ethical committee approval, antenatal women who met the inclusion and exclusion criteria and provided informed consent were included in the study. A detailed history and physical examination were conducted for each participant.

Maternal Visceral Adipose Tissue (VAT) Measurement

The assessment of VAT was conducted by a single trained sonographer using ultrasound calipers within the Voluson P8 ultrasound machine, following the methodology outlined by Armellini et al. (9). The participant was positioned supine and measurements were obtained using a 5.2 MHz curvilinear probe positioned on the anterior abdomen along the xipho-umbilical line, 1 cm above the umbilicus.(Figure 1) The VAT was determined by measuring the angle formed by the posterior corner of the linea alba and the anterior corner of the abdominal aorta. Subcutaneous fat thickness (SAT) was measured in the same plane as the perpendicular distance from the skin to the linea alba, which was used as a reference standard in the study.

Anthropometric Measurements

The pre-gravid BMI was produced using the maternal weight before pregnancy and maternal height recorded at the time of study inclusion.

Laboratory Investigations

The DIPSI test was administered to the study participants. The test involved the administration of 75 g of glucose, regardless of the participant's previous meal, followed by a venous blood sample taken after 2 hours. A blood glucose level of >140 mg/dl was considered indicative of gestational diabetes.

Timing of Measurements

- 24-28 weeks
- Around 34 weeks

Study Parameters

The independent variables included age (years), parity, education level, socioeconomic status, gestational age (weeks), family history of diabetes, pre-pregnancy BMI (kg/m^2), visceral adipose tissue (VAT) thickness (mm), subcutaneous adipose tissue (SAT) thickness (mm), total adipose tissue (TAT) thickness (mm), newborn birth weight (kg), mode of delivery, and APGAR score.

Outcomes variables

Maternal Outcomes

The primary maternal outcome assessed was the development of GDM, characterized by a DIPSI test result of >140 mg/dl between 24-28 weeks of gestation.

Fetal Outcomes

The fetal outcomes assessed included:

- APGAR scores at birth
- Newborn weight
- Mode of delivery (vaginal birth or cesarean section)

Statistical methods

Statistical analysis was done using SPSS version 21. ROC analysis was done to determine the cut off for SAT, VAT, TAT and BMI. A p-value less than 0.05 was considered as statistically significant.

Results

Out of the total participants, 37 individuals were diagnosed with GDM, representing 17.45% of the participants. **Table 1** summarizes the demographic characteristics of the study population, comparing GDM and No GDM groups. The mean age was slightly higher in the GDM group at 28.38 years (SD = 4.8) compared to 27.3 years (SD = 4.25) in the No GDM group, though not statistically significant. Mean gestational age was similar between the groups. A higher proportion of GDM participants were primiparous (67.57%) compared to the normal group (58.29%), while multiparous rates were lower in the GDM group (32.43%). Education level showed significant differences, with more GDM participants having education up to secondary level (35.13% vs. 17.71%). Socio-economic status and family history of diabetes did not significantly differ between the groups. Mode of delivery showed a trend towards more operative deliveries in the GDM group (54%), although not statistically significant.

Table 1. Demographic characteristics of the study population

Parameter	Category	GDM	No GDM	P value
Age (years), mean (SD)		28.38 (4.8)	27.3 (4.25)	1.37
Gestational Age (weeks)), mean (SD)		12.74 (0.74)	12.83 (0.93)	0.51
Obstetric Score, n (%)	Multiparous	12 (32.43)	73 (41.71)	0.295
	Primiparous	25 (67.57)	102 (58.29)	
Education Level, n (%)	Till Secondary	13 (35.13)	31 (17.71)	0.025
	> Secondary	24 (64.86)	144 (82.28)	
Socio-Economic Status, n (%)	Upper SES	27 (72.97)	123 (70.28)	0.761
	Lower SES	10 (27.02)	52 (29.71)	
Family History, n (%)	Yes	8 (21.62)	22 (12.57)	0.151
	No	29 (78.38)	153 (87.43)	
GDM management	Diet/MNT	4	10.81	
	OHA	16	43.24	
	Insulin	14	37.83	
	OHA + insulin	3	8.10	
Mode of Delivery, n (%)	Operative and Instrumental	20 (54)	68 (38.85)	0.095
	Normal vaginal	17 (45.9)	107 (61.14)	

Table 2 compares maternal and fetal outcomes between the GDM and No GDM groups. The mean BMI was slightly higher in the GDM group at 24.8 kg/m² (SD = 5.2) compared to 23.5 kg/m² (SD = 3.4) in the No GDM group, approaching statistical significance ($p = 0.063$). Subcutaneous adipose tissue (SAT) thickness was significantly higher in the GDM group at 17.17 mm (SD = 4.12) compared to 15.19 mm (SD = 4.12) in the No GDM group ($p = 0.013$). Visceral adipose tissue (VAT) and total adipose tissue (TAT) were also significantly greater in the GDM group, with VAT at 44.46 mm (SD = 8.15) versus 31.72 mm (SD = 5.09) and TAT at 61.5 mm (SD = 10.2) versus 46.87 mm (SD = 6.55), both with p-values < 0.001. Additionally, babies born to GDM mothers had a significantly higher birth weight (3.25 kg, SD = 0.38) compared to those in the No GDM group (2.9 kg, SD = 0.48) ($p < 0.001$). However, there were no significant differences in APGAR scores at 1 minute and 5 minutes between the groups.

Parameter	GDM	No GDM	Mean Diff	t	P value
BMI kg/m^2	24.8 (5.2)	23.5 (3.4)	1.3	1.9	0.063
SAT (mm)	17.17 (4.12)	15.19 (4.12)	1.90	0.25	0.013
VAT (mm)	44.46 (8.15)	31.72 (5.09)	12.74	12.28	<0.001
TAT (mm)	61.5 (10.2)	46.87 (6.55)	14.7	11.1	<0.001
Baby Weight (kg)	3.25 (0.38)	2.9 (0.48)	0.36	4.24	<0.001
APGAR at 1 Min	8 (0)	7.93 (0.5)	0.07	0.84	0.4029
APGAR at 5 Min	9 (0)	8.99 (0.15)	0.01	0.46	0.6467

Table 3. The predictive validity of BMI, SAT, VAT and TAT for predicting GDM

Variable	Cut off	AUC	Sensitivity	Specificity	P value
BMI kg/m^2	24	0.577	57.14%	57.63%	0.0875
SAT (mm)	15.15	0.627	0.730	0.514	0.013
VAT (mm)	36.7	0.8713	0.811	0.880	<0.001
TAT (mm)	52.75	0.865	0.838	0.863	<0.001

. **Table 3** confirms VAT as the most predictive, with 81.1% sensitivity and 88% specificity at a 36.7 mm cut-off. TAT also shows high predictive validity, while SAT and BMI are less effective, particularly BMI with a lower AUC and modest sensitivity and specificity.

Figure 1: Schematic representation of adipose tissue depth measurements in pregnant women

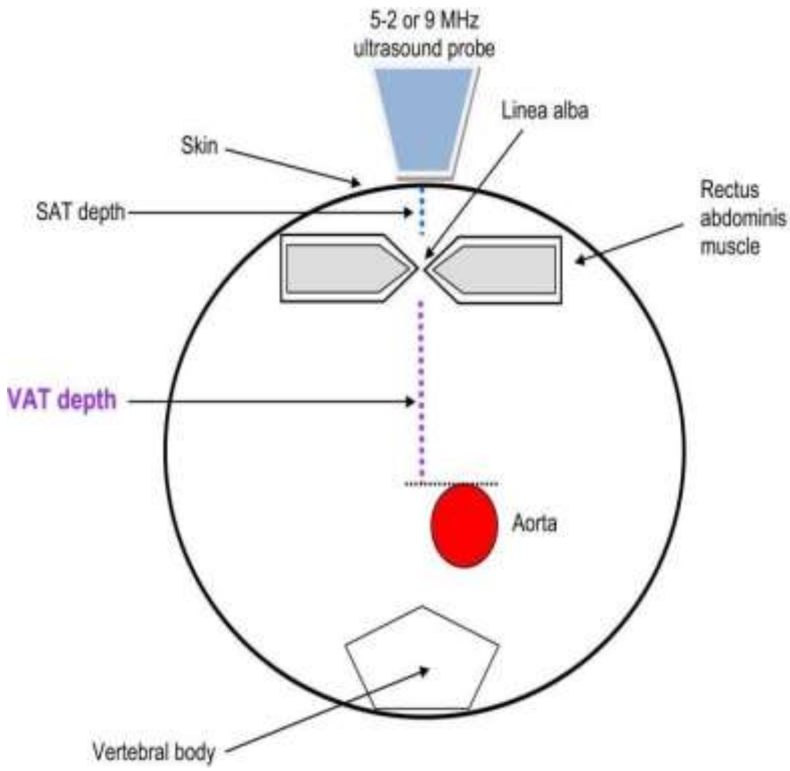
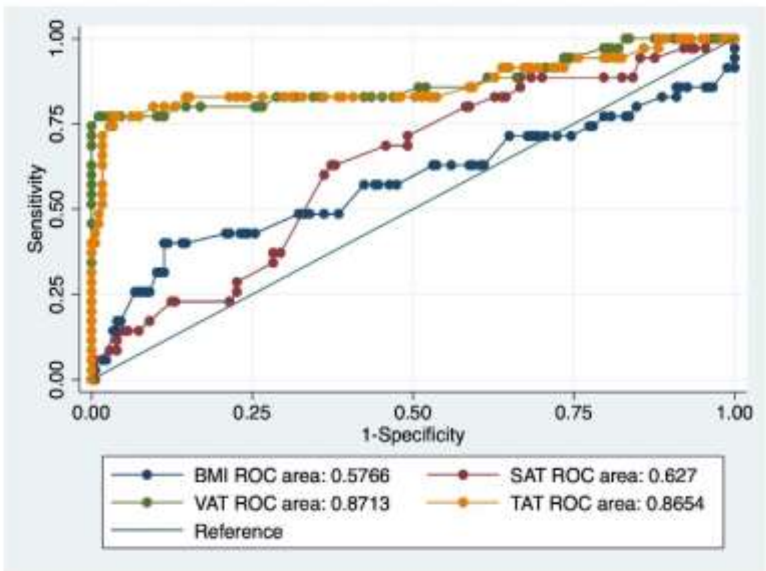


Figure 2 illustrates the ROC curves and AUC values for BMI, SAT, VAT, and TAT in predicting gestational diabetes mellitus (GDM). VAT has the highest AUC of 0.8713, indicating strong predictive ability, followed by TAT with an AUC of 0.8654. SAT and BMI have lower AUCs of 0.627 and 0.5766, respectively, showing less effectiveness in predicting GDM



Discussion

The incidence of gestational diabetes mellitus (GDM) in our study was 17.45%, which aligns with global data, including the 16.8% reported by Alves et al. in Brazil (10). Differences in prevalence of gestational diabetes mellitus (GDM) among various studies can be ascribed to variations in study populations, diagnostic criteria, and geographical parameters. One of the main conclusions of this study is that measuring VAT using ultrasound during the first trimester can be a reliable indicator for gestational diabetes mellitus (GDM), even in patients who do not show typical metabolic risk factors like pre-pregnancy obesity. The aforementioned discovery highlights the capacity of VAT measurement as a secure, economical, and effective screening method that can be used to promptly detect pregnant women who are more susceptible to glycemic abnormalities. The early identification of individuals at risk during pregnancy enables healthcare providers to promptly implement interventions that may mitigate the risks to both the mother and the fetus, so improving maternal and fetal outcomes. Moreover, the early identification of gestational diabetes mellitus (GDM) using quantification of visceral adipose tissue thickness (VAT) can also enhance the efficiency of resource allocation in the management of high-risk patients. This ensures that those requiring intensive monitoring and care get timely treatment, hence enhancing overall pregnancy outcomes and potentially reducing healthcare expenses linked to the management of GDM and its complications (11).

In terms of BMI, our findings are consistent with those of D'Ambrosi et al., indicating that BMI was not a significant predictor of GDM in our cohort (12). This suggests that while BMI is commonly used as a general indicator of obesity and related metabolic risks, it may not be as effective in predicting GDM, at least in the population studied. However, it's important to note that other studies, including those by Tunc et al. and Alves et al., have identified BMI as an important predictive factor for GDM (12 to 14). These discrepancies may highlight the need for more nuanced approaches to GDM risk assessment that consider additional or alternative markers beyond BMI alone.
Furthermore, our study revealed a significant correlation between VAT and GDM. This finding supports the results of Bartha et al. and Martin et al., who also showed that higher VAT levels during early pregnancy are linked to a higher risk of developing GDM (15, 16). These findings indicate that VAT may be a more dependable indicator of GDM in comparison to BMI. Furthermore, our study revealed that TAT also showed a noteworthy predictive role, which aligns with the conclusions of Guptha et al. and De Souza et al., who also found that elevated TAT levels are independent predictors of GDM (17, 18). These results emphasise the possible usefulness of VAT and TAT measurements as crucial elements in the early detection of women who are at risk for GDM, which could result in more focused interventions and better outcomes for both the mother and the baby.

Our analysis revealed a statistically significant difference in mean birth weight between the GDM group (3.25 kg) and the non-GDM group (2.9 kg), with a p-value of less than 0.001. The results presented by Aisha Yusuf Ibrahim et al. provide evidence of a positive association between higher maternal VAT depth and the weight of newborns (19). The study conducted by Rocha et al. did not reveal a statistically significant disparity in birth weights between the groups with gestational diabetes mellitus (GDM) and those without GDM. This suggests that the association between vaginal adiposity (VAT) and birth weight may differ among different populations (19). Furthermore, although our study did not discover a notable disparity in the method of delivery, Martin et al. presented evidence of a correlation between elevated VAT and an increased probability of caesarean delivery (20). The alignment of our results with prior studies emphasizes the significance of early VAT measurement as a prognostic instrument for GDM and its associated complications.

This study used a standardized ultrasound protocol for measuring abdominal adiposity, which aligns with the timing of prenatal fetal nuchal translucency measurements and is performed by a single ultrasound sonographer. This approach enhanced the convenience for both the patient and the healthcare provider. However, the technique also has limitations, including the potential for intra- and inter-observer variability in the measurement of VAT during first-trimester ultrasound scans. Additionally, there was no standardized method or established guidelines for these measurements, and the accuracy of adiposity measurement may vary depending on the modality used, such as ultrasound, CT, or MRI. The exact technique and location for measurement also need to be standardized, despite various methods being described in the literature.

Conclusion

Sonographic measurements of SAT, VAT, and TAT demonstrated significant potential in identifying the risk of developing GDM, particularly among Asian Indian women who are predisposed to T2DM due to their unique fat distribution patterns. Identifying women at high risk for GDM through increased visceral adiposity may facilitate earlier screening and prompt dietary and lifestyle interventions, offering a proactive approach to managing GDM risk. This finding paves the way for further research into the integration of visceral adiposity measurements in routine prenatal care.

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