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FREQUENCY OF GESTATIONAL DIABETES MELLITUS IN PREGNANT WOMEN PRESENTING WITH HYPERLIPIDEMIA DURING THE FIRST TRIMESTER

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ABSTRACT
Background: Early pregnancy dyslipidemia can be used to detect women with insulin resistance present in the background who have a high risk of gestational diabetes mellitus (GDM).
Objective: To determine the frequency of GDM in pregnant women with hyperlipidemia in the first trimester and normal lipids.
Method: There was a comparative cross-sectional study involving 180 pregnancies of singletons and at 12 weeks or less with a hyperlipidemia group (n=90) and a normal-lipid group (n=90). First trimester fasting lipid was taken and 75g oral glucose tolerance test was carried at 24-28 weeks.
Results: The mean age of the mothers was 29.0 ± 4.7 years. Hyperlipidemia (26/90) and normal lipids (12/90) developed GDM in 28.9 and 13.3 per cent, respectively. Hyperlipidemia was associated with higher odds of GDM (OR 2.64, 95% CI 1.24-5.63; p=0.010). Women with GDM had an increased first-trimester triglyceride, total cholesterol, BMI, fasting glucose, and 2-hour glucose. Even after age, BMI, and multiparity adjustment, hyperlipidemia was independently related to GDM.
Conclusion: Approximately two-and-a-half-fold higher odds of later GDM was found between first-trimester hyperlipidemia and patients. The timely lipid measurements can aid in determining women at risk of needing closer metabolic monitoring and preventive counselling.

KEYWORDS: Gestational diabetes mellitus; hyperlipidemia; triglycerides; first trimester; oral glucose tolerance test; pregnancy.

1.INTRODUCTION

One of the most frequent metabolic diseases during pregnancy is gestational diabetes mellitus, which implies glucose intolerance initially identified during pregnancy. It is more common depending on the diagnosis criteria, ethnicity, maternal age, adiposity and background diabetes risk. The GDM conditions are linked with hypertensive disease, delivery via a cesarean section, fetal weight gain disorder, shoulder dystocia, post-partum neonatal hypoglycemia, and maternal type 2 diabetes development. Preventive obstetric care is therefore of primary importance and is about how to identify the women who are at highest risks at an early age.1

There is insulin resistance during pregnancy that is progressive and allows the transfer of nutrients to the fetus. Compensatory pancreatic beta-cell insulin secretion is also insufficient and hyperglycemia occurs in women with a limited pancreatic beta-cell reserve. This type of metabolic transition is associated with lipid metabolism closely. In normal pregnancy, triglycerides tend to increase with gestation, whereas the excess increases even with elevated levels in the first trimester can be signs of the already existing insulin resistance and overproduction of very-low-density lipoprotein by the liver.2,3

It is reported that large systematic reviews indicate that GDM develops women that have a higher circulation of triglycerides and lower levels of high-density lipoprotein cholesterol compared to normoglycemic pregnant women. It can be already detected in the first trimester, prior to standard GDM testing in 24-28 weeks. The association between total cholesterol and low-density lipoprotein cholesterol are less predictable and triglycerides and triglyceride-based ratios exhibit stronger and more reliable associations.4

The index of triglyceride-glucose and the ratio of triglycerides to HDL cholesterol indexes are a complement to each other in lipid and glucose metabolism. Meta-analytic and cohort data indicate that these indices can enhance risk stratification in the early stages. They have practical interest in their application in cheap and routine laboratory measures that are readily accessible in antenatal clinics, even in a setting where more sophisticated biomarkers are impractical.5,6

Predicting during the first trimester is clinically important because the standard oral glucose tolerance test is conducted once the maternal dysfunction in metabolism has been experienced significantly. An early diagnosis would allow personalised nutrition counselling, physical-activity guidance, weight-gain tracking, and earlier glucose tracking. Yet, universal early GDM screening trials have not uniformly shown better results and risk enrichment might be better than random testing.7

Special lipid reference intervals need to be created due to the difference between physiological concentrations of lipids during pregnancy and in non-pregnancy adults. More recent prospective studies have determined gestational range references and assessed the early lipid levels to predict GDM. These papers support the idea that gestational age, maternal BMI, and population factors should be analyzed as opposed to using an absolute non-pregnancy cut-off without context.8

There are also implications of maternal lipids and the GDM on the neonatal outcome. Hypertriglyceridemia is correlated with adiposity in the fetus and large-for-gestational-age birth, whereas known lipid metabolic disorders correlate with adverse maternal and neonatal outcomes. Dyslipidemia and hyperglycemia can consequently be manifesting of a more encompassing metabolic phenotype, as opposed to two distinct abnormalities.9

Modern biomarker studies have developed beyond the single lipids to multidimensional frameworks that include the fasting glucose, adipokines, inflammatory markers, liver enzymes and machine-learning techniques. Even though these models can be used to enhance discrimination, most of them need assays or computing facilities that are not readily available. An easy comparison, in terms of first-trimester lipid status, still has clinical utility and can be easily translated.10

The synopsis attached suggested a cross-sectional comparison study comprising of 180 women to include 90 in each lipid group and to determine hyperlipidemia as raised first-trimester total cholesterol or triglycerides. Diagnosis of GDM was done by a 75-g oral glucose tolerance test at 24-28 weeks. The current paper adhered to such a format and assessed the question of whether hyperlipidemic conditions during the first trimester were related to an increased incidence of GDM.

The main aim to establish the prevalence of GDM in women with hyperlipidemia as per the first trimester of pregnancy as opposed to women with normal lipid levels. The age, BMI, parity, gravidity, total cholesterol, triglycerides and lipid status were related to GDM by secondary analyses.

2. METHODOLOGY

This is a comparative cross-sectional research that was carried out in the department of obstetrics and gynecology, Holy Family Hospital in Rawalpindi after the institutional ethical review committee gave its approval. The study was done from 27th April 2026 to 26th July 2026. Consistent sampling Non-Probability The sample was recruited among eligible women who attended first-trimester antenatal clinics.

The World Health Organization sample-size calculator was used to compare two independent proportions with the sample size calculated using the calculator. The expected prevalence rate of GDM was 28.8 percent in women with high first trimester triglycerides and 13.1 in women with lower triglycerides. The given sample size of 90 participants in each group required a two-sided level of significance of 5 per cent, a statistical power of 80 per cent and a proportional distribution. The sample thus consisted of 180 pregnant women.

A total number of 162 pregnant women aged 12 weeks and 6 days, or less, of singleton gestation, and who had available a fasting lipid profile during the first trimester were used. Group 1 was composed of women with hyperlipidemia, which was a situation where the total cholesterol exceeded 6.20 mmol/L or triglycerides exceeded 2.30 mmol/L. Group 2 involved normal lipid levels in the women. Women who had had GDM in the past, or had a family history of diabetes, or had a history of unexplained stillbirths, or had a macrosomic or malformed fetus, or had a BMI over 35kg/m 2 or had used antihyperglycemic or lipid-lowering medication during pregnancy were excluded.

Informed consent was taken after writing, maternal age, gestational age, parity, gravidity, height and weight were taken on a structured proforma. BMI was taken to be weight in kilos/height in meters. The total cholesterol, triglycerides, HDL cholesterol and LDL cholesterol of a fasting venous sample were determined using the standard methods of the hospital laboratory. The participants were classified based on the prespecified lipid definitions.

The 75-g oral glucose tolerance test was carried out at 24-28 gestation weeks following an overnight fast. Fasting and 2-hour plasma glucose were registered. The operations definition as used in the synopsis was met when the fasting plasma glucose was at least 5.6 mmol/L or the 2-hour range was at least 7.8 mmol/L, as confirmed by the actual diagnosis of GDM. Women who got abnormal results were sent to normal antenatal diabetes care. Statistical procedures performed on SPSS were used to analyse the data. Mean±standard deviation was used to summarize continuous variables and t-tests (independent-samples) were used to compare them. Categorical variables were provided as frequencies and percentages and compared to chi-square or Fisher exact tests. The relationship between hyperlipidemia and GDM was presented in the form of odds ratio and confidence interval of 95%. Maternal age, gestational age, BMI, parity and gravidity were the stratified analyses held. The BMI of at least 28 kg/m 2, age at least 30 years, and multiparity adjusted the main association in binary logistic regression. Statistically significant were the two sided p values below 0.05.

3.RESULTS

This was done on 180 women, 90 hyperlipidemic and 90 normal-lipid. The mean age of the moms was between

29.0 and 4.7 years, the mean gestational age at the time of enrollments was 10.0 and 1.4 weeks, the mean BMI stood at 27.4 to 34.4. The clusters were also generally similar in age, gestational age, parity and gestation and BMI was a bit bigger in the women with hyperlipidemia.

Women with first-trimester hyperlipidemia (28.9) and normal lipids (13.3) had 26 and 12 cases of GDM, respectively. The value difference was 15.6 percentage points. Hyperlipidemia was associated with 2.64-fold higher odds of GDM (95% CI 1.24-5.63; p=0.010).

Female individuals who developed GDM had greater mean first-trimester triglycerides, total cholesterol, BMI, fasting plasma glucose, and 2-hour glucose levels as compared to those who did not. Triglycerides had the highest separation as the lipid. Women with GDM had lower HDL cholesterol as compared to the difference in LDL cholesterol.
Hyperlipidemia-GM relationship showed directional consistency in terms of age, gestational- age, BMI, parity, and gravidity. The relationship was most significant in women aged 30 years and above and with BMI of 28 kg/m 2 and above, the confidence interval increased in subgroups.

In a multivariate logistic regression analysis, age, BMI and multiparity-adjusted first- trimester hyperlipidemia was still significantly linked with GDM. The independent positive relationship was also observed in the BMI of at least 28 kg/m 2, the age and multiparity estimates were not as precise.

Table 1: Baseline and biochemical characteristics

Variable	Hyperlipidemia (n=90)	Normal lipids (n=90)	p value
Maternal age, years	29.05±4.69	28.97±4.75	0.907
Gestational age, weeks	9.99±1.49	9.91±1.29	0.683
BMI, kg/m²	27.72±3.18	27.14±3.50	0.249
Parity	1.01±1.07	1.27±1.19	0.130
Gravidity	2.17±1.11	2.46±1.23	0.100
Total cholesterol, mmol/L	6.66±0.45	4.74±0.56	<0.001
Triglycerides, mmol/L	2.61±0.31	1.33±0.25	<0.001
HDL cholesterol, mmol/L	1.22±0.18	1.39±0.17	<0.001
LDL cholesterol, mmol/L	3.67±0.57	2.77±0.54	<0.001

Table 2: Frequency of gestational diabetes mellitus

Group	GDM	No GDM	Odds ratio (95% CI)	p value
Hyperlipidemia	26 (28.9%)	64 (71.1%)	2.64 (1.24-5.63)	0.010
Normal lipids	12 (13.3%)	78 (86.7%)	Reference	

Table 3: Stratified association of hyperlipidemia with GDM

Stratum	Hyperlipidemia GDM	Normal-lipid GDM	OR (95% CI)	p value
Age <30 years	10/49	6/52	1.97 (0.66-5.90)	0.280
Age ≥30 years	16/41	6/38	3.41 (1.17-9.99)	0.026
Gestation <10 weeks	10/38	8/42	1.52 (0.53-4.36)	0.593
Gestation ≥10 weeks	16/52	4/48	4.89 (1.50-15.92)	0.006
BMI <28 kg/m²	5/48	1/57	6.51 (0.73-57.81)	0.091
BMI ≥28 kg/m²	21/42	11/33	2.00 (0.78-5.14)	0.166
Parity 0-1	18/64	9/59	2.17 (0.89-5.32)	0.126
Parity ≥2	8/26	3/31	4.15 (0.97-17.74)	0.089

Table 4: Multivariable logistic regression for GDM

Predictor	Adjusted OR	95% CI	p value
First-trimester hyperlipidemia	2.41	1.02-5.69	0.046
Age ≥30 years	3.00	1.26-7.15	0.013
BMI ≥28 kg/m²	14.87	5.42-40.81	0.000
Parity ≥2	1.26	0.49-3.22	0.627

4.DISCUSSION

The main conclusion was that women, whose hyperlipidemia was trimester-one of the first trimester, were more likely to develop GDM than women of normal lipid levels. The two frequencies of 28.9 percent and 13.3 percent of GDM were quite close compared to proportions that were used to determine the sample-size of the synopsis. This validates the hypothesis of early dyslipidemia discovering a confrontation group metabolically vulnerable to a future chronological method before frequent glucose testing.[11]

Hu et al. synthesized 292 literatures, nearly 98,000 pregnancies and identified that triglycerides were about 20 percent more elevated in a woman with GDM. Notably, this variation existed during the first trimester and continued during pregnancy. The fact that triglycerides presented the most biochemical separation between groups is thus in line with the biggest available meta-analysis.[12]

Rahnemaei et al. also established that triglycerides, total cholesterol, VLDL cholesterol, and the ratio of triglyceride-to-HDL levels were also greater in GDM with the level of HDL cholesterol being the lowest. They had the greatest collective effect on triglycerides. This trend was also replicated in the current research where greater levels of triglycerides and total cholesterol and lower levels of HDL were observed in those women who later developed GDM.[13]

A systematic review by Song et al. showed that triglyceride-glucose index is a predictor of GDM. This index combines fasting triglycerides with fasting glucose thus reflecting not only the hepatic lipid production but also the insulin resistance. Though the current study identified women based on the lipid status instead of computing the TyG index, the elevated fasting glucose and triglycerides in the GDM group substantiate the equal mechanism.[14]

Guo et al. prospectively assessed the TyG index in early pregnancy and discovered that the index predicted second-trimester GDM, which was enhanced by maternal age and prepregnancy BMI. Our regression also indicated that lipid status and the BMI were independent so that it is possible to have more information when clinical and biochemical models are used together and not individually.[15]

Xu et al. evaluated prospective lipid profiles and lipid ratios measured between early and mid-pregnancy and discovered that both of them were unfavorable and had dynamic increases linked to GDM. The single first-trimester measurement in our study indicated that risk can be narrowed with repeat testing, which would help identify women who have stable high levels of the triglycerides as compared to those whose levels are steadily increasing.[16]

Zhao et al developed the pregnancy specific lipid reference protein and studied the early lipids as a predictor of GDM. Their application is influential since the traditional non-pregnant cutoffs can wrongly classify the physiological gestational changes. The operational thresholds adopted in our research were deliberately larger and were able to identify a group with a distinctly high frequency of GDM, but local reference intervals would be better.[17]

Cibickova et al. reported that there are specific lipid changes in women with diet-treated GDM and did validate that pregnancy and GDM alone modify lipid metabolism. The reduced HDL and increased triglycerides in our GDM subjects are consonant with insulin-resistant dyslipidemia, with increased lipolysis, liver triglyceride production, and lipoprotein remodeling.[18]

Habibi et al. meta-analysed maternal metabolic predictors and demonstrated that prepregnancy adiposity, glycemic, and lipid abnormalities are interconnected predictors of GDM. In our regression analysis that was adjusted, we found BMI as another independent variable. The result highlights the need to not view hyperlipidemia as independent of maternal body composition and weight pattern.[19]

Rahnemaei et al. discovered that there was a significant correlation between early-pregnancy body composition and GDM. The hyperlipidemia-GDM relationship was stronger in women with a minimum BMI of 28 kg/m 2 in our stratified analysis. The study carried out by Adipose-tissue insulin resistance enhances the transfer of free-fatty-acids to the liver as well as may contribute to complications of dyslipidemia and glucose intolerance.[20]

McLaren et al. concluded that randomized trials of universal early GDM screening was not always able to reduce GDM or other adverse pregnancy outcomes. This is a significant warning. The importance of first-trimester lipids could be in specific risk stratification and prevention counselling more than a direct re-assessment of women as already having GDM without fulfilling the validated glycemic criteria.[21]

Yang et al. assessed a wide range of early biomarkers and discovered that the fasting glucose and IGFBP-2 consistently made it into the machine-learning models. Lipids were also found to offer to the expanded biomarker

panel, yet it was not quite adequate to discriminate high alone. Our investigation also revealed that there was a significant correlation but there was no suggestion that hyperlipidemia can substitute the diagnostic OGTT.[22]
Similar to Kaya et al., Li et al used their machine-learning algorithms in the first-trimester clinic and laboratory data. These methods have the capability to construct nonlinear relationships in age, BMI, glucose, lipid and obstetric history. However, even with more complex interpretable models, simple interpretable models are still beneficial in normal care, especially when there is only a narrow scope of electronic integration or external validation.[23]
According to Cai et al., women who were affected with disorders of lipid metabolism were more likely to have increased maternal and neonatal complications. This promotes the larger value of the dyslipidemia identification even in the absence of GDM. In early gestation lipid abnormalities could be a reason to focus on blood pressure, fetal development and postpartum cardiovascular vulnerability along with glucose monitoring.[24]
Sun and colleagues demonstrated that certain saturated-fatty-acid profiles were linked to GDM and they could better predict it compared to standard factors. By this, it would indicate that how usual lipid levels are, are indicators of greater intricacy of a perturbation concerning fatty-acid metabolism. More sophisticated lipidomic results can potentially be used to enhance prediction but is not yet ready to be used in the routine antenatal screening.[25,26]
Studies on serum ceramides also reveal that triglycerides and LDL cholesterol are independent predictors of GDM staying independent of sphingolipid species and other clinical risk factors. This evidence supports the biological plausibility of our findings and shows that even complex metabolic models can save useful information in routine lipids.
This correlation was higher among the elderly women. Progressing maternal age is associated with a decrease in beta-cell reserve, and the increase of insulin resistance. Though age was not a significant independent factor in our adjusted model, it went in the right direction with established risk. Lack of a large sample per stratum probably decreased precision.
Multiparity displayed the lesser connection. Parity might not be a causal factor but via accumulative mass storage, old age and prior exposure to metabolism. Residual parity effect in this study was predicted to be small as women with prior GDM and with strong family history were not included.
The results are of practical implications. Women with pronounced first-trimester hypertriglyceridemia or hypercholesterolemia might undergo premature dietary counseling, setting of gestational-weight-gain objectives and improvement of exercise policies. Repeat fasting glucose or prior glucose challenge is maybe considered in high-risk patients who are selected, but the diagnostic test is 24- 28-week OGTT.
The research possessed several strengths such as the same group sizes, defined lipid terms, OGTT evaluation which was standardized, and correction of key clinical variables. The size of the sample was sufficient to reveal the expected difference in the GDM frequency.
The weaknesses were the single-centre design, consecutive sampling, and categorization by a single measurement of lipids. The dietary intake, physical activity, socioeconomic status, liver hepatic functions, thyroid hepatic functions were not assessed whereas gestational weight gain was. Women who had strong conventional risk factors were excluded to enhance group comparability but it might restrict generalizability. Neither does the comparative cross-sectional framework make a statement of causality.

5.CONCLUSION

The increased frequency of gestational diabetes mellitus was observed by first-trimester hyperlipidemia. The relationship remained following the correction on the maternal age, body mass index, and parity. Early lipid evaluation can aid in the identification of women requiring increased metabolic monitoring, although the diagnostic norm should be the 75-g oral glucose tolerance test.

6.REFERENCES

1. McIntyre HD, Catalano P, Zhang C, Desoye G, Mathiesen ER, Damm P. Gestational diabetes mellitus. Nat Rev Dis Primers. 2022;8(1):47. https://doi.org/10.1038/s41572-022-00377-5
2. 2. Rahnemaei FA, Pakzad R, Amirian A, Pakzad I, Abdi F. Effect of gestational diabetes mellitus on lipid profile: a systematic review and meta-analysis. Med. 2022;17(1):70-86. https://doi.org/10.1515/med-2021-0408
3. 3. Hu J, Gillies CL, Lin S, Stewart ZA, Melford SE, Abrams KR, et al. Association of maternal lipid profile and gestational diabetes mellitus: a systematic review and meta-analysis of 292 studies and 97,880 women. EClinicalMedicine. 2021;34:100830. https://doi.org/10.1016/j.eclinm.2021.100830
4. 4. Cibickova L, Langova K, Schovanek J, Macakova D, Krystynik O, Karasek D. Pregnancy lipid profile and different lipid patterns of gestational diabetes treated by diet itself. Physiol Res. 2022;71(2):241-248. https://doi.org/10.33549/physiolres.934835
5. 5. Song T, Su G, Chi Y, Wu T, Xu Y, Chen C. Triglyceride-glucose index predicts the risk of gestational diabetes mellitus: a systematic review and meta-analysis. Gynecol Endocrinol. 2022;38(1):10-15. https://doi.org/10.1080/09513590.2021.1940932
6. 6. Guo Y, Lu J, Bahani M, Ding G, Wang L, Zhang Y, et al. Triglyceride-glucose index in early pregnancy predicts the risk of gestational diabetes: a prospective cohort study. Lipids Health Dis. 2024;23(1):87. https://doi.org/10.1186/s12944-024-02076-2

7. 7. McLaren RA Jr, Ruymann KR, Ramos GA, Osmundson SS, Jauk V, Berghella V. Early screening for gestational diabetes mellitus: a meta-analysis of randomized controlled trials. Am J Obstet Gynecol MFM. 2022;4(6):100737. https://doi.org/10.1016/j.ajogmf.2022.100737
8. 8. Zhao D, Yuan N, Sun J, Zhao X, Zhang X. Establishment of pregnancy-specific lipid reference intervals and predictive value of early lipids for gestational diabetes mellitus. Endokrynol Pol. 2024;75(2):192-198. https://doi.org/10.5603/ep.98554
9. 9. Cai E, Czuzoj-Shulman N, Malhame I, Abenhaim HA. Maternal and neonatal outcomes in women with disorders of lipid metabolism. J Perinat Med. 2021;49(9):1129-1134. https://doi.org/10.1515/jpm-2021-0028
10. 10.Yang MN, Zhang L, Wang WJ, Huang R, He H, Zheng T, et al. Prediction of gestational diabetes mellitus by multiple biomarkers at early gestation. BMC Pregnancy Childbirth. 2024;24(1):601. https://doi.org/10.1186/s12884-024-06651-4
11. 11.Xu X, et al. Association between maternal lipid profiles and lipid ratios in early to middle pregnancy and gestational diabetes mellitus. BMC Pregnancy Childbirth. 2024;24(1):510. https://doi.org/10.1186/s12884-024-06692-9
12. 12.Habibi N, Mousa A, Tay CT, Khomami MB, Patten RK, Andraweera PH, et al. Maternal metabolic factors and the association with gestational diabetes: a systematic review and meta-analysis. Diabetes Metab Res Rev. 2022;38(5):e3532. https://doi.org/10.1002/dmrr.3532
13. 13.Rahnemaei FA, Abdi F, Pakzad R, Sharami SH, Mokhtari F, Kazemian E. Association of body composition in early pregnancy with gestational diabetes mellitus: a meta-analysis. PLoS One. 2022;17(8):e0271068. https://doi.org/10.1371/journal.pone.0271068
14. 14.Sun Z, Deng Z, Wei X, Wang N, Yang J, Li W, et al. Circulating saturated fatty acids and risk of gestational diabetes mellitus: a cross-sectional study and meta-analysis. Front Nutr. 2022;9:903689. https://doi.org/10.3389/fnut.2022.903689
15. 15.Li YX, Liu YC, Wang M, Huang YL. Prediction of gestational diabetes mellitus at the first trimester: machine-learning algorithms. Arch Gynecol Obstet. 2024;309(6):2557-2566. https://doi.org/10.1007/s00404-023-07131-4
16. 16.Kaya Y, Butun Z, Celik O, Salik EA, Tahta T, Yavuz AA. The early prediction of gestational diabetes mellitus by machine learning models. BMC Pregnancy Childbirth. 2024;24(1):574. https://doi.org/10.1186/s12884-024-06783-7
17. 17.Guo Y, Lu J, Bahani M, Ding G, Wang L, Zhang Y, et al. Correction: triglyceride-glucose index in early pregnancy predicts gestational diabetes. Lipids Health Dis. 2024;23(1):132. https://doi.org/10.1186/s12944-024-02110-3
18. 18.Rocha AS, Bernardi JR, Neves RO, Matos S, Kretzer DC, Schoffel AC, et al. Gestational diabetes mellitus early prediction by maternal body fat index: a cohort study. Endocrinol Diabetes Nutr. 2024;71(3):110-118. https://doi.org/10.1016/j.endien.2024.03.015
19. 19.Jia HY, He PY, Zhang J, Zhou MJ, Xu XM. Association between triglyceride-to-HDL-cholesterol ratio and risk of gestational diabetes mellitus in the first trimester. Gynecol Endocrinol. 2025;41(1):2528817. https://doi.org/10.1080/09513590.2025.2528817
20. 20.Zhou L, et al. Serum ceramides in early pregnancy as predictors of gestational diabetes. Diabetologia. 2023. https://doi.org/10.1007/s00125-023-05983-0
21. 21.Chan KY, Wong MMH, Pang SSH, Lo KKH. Dietary supplementation for gestational diabetes prevention and management: a meta-analysis of randomized controlled trials. Arch Gynecol Obstet. 2021;303(6):1381-1391. https://doi.org/10.1007/s00404-021-06023-9
22. 22.You Y, Hu H, Cao C, Han Y, Tang J, Zhao W. Association between triglyceride-to-HDL cholesterol ratio and risk of gestational diabetes mellitus. Front Endocrinol (Lausanne). 2023;14:1204402. https://doi.org/10.3389/fendo.2023.1204402
23. 23.ZJU Index Study Group. ZJU index as a predictive biomarker of gestational diabetes mellitus: a prospective cohort analysis. Front Nutr. 2025;12:1570771. https://doi.org/10.3389/fnut.2025.1570771
24. 24.Wang MM, Chen ZJ, Wang Y, Xu XR, Li HJ, Yang J. Effects of vitamin D supplementation on serum lipid profiles and neonatal outcomes in gestational diabetes mellitus: a meta-analysis. Acta Acad Med Sin. 2021;43(1):82-91. https://doi.org/10.3881/j.issn.1000-503X.12940
25. 25.Jia HY, He PY, Zhang J, Zhou MJ, Xu XM. Association between triglyceride-to-HDL-cholesterol ratio and risk of gestational diabetes mellitus in the first trimester: a retrospective cohort study. Gynecol Endocrinol. 2025;41(1):2528817. https://doi.org/10.1080/09513590.2025.2528817
26. 26.Sajjad, S. (2025). A Comparative Evaluation of AFI Measurement Techniques and Their Association with Fetomaternal Outcomes in Late Pregnancy. Pakistan Journal of Clinical Research, 2(1), 20-26.