



Fetal Thymic-to-Thoracic Ratio and Neonatal Adaptation in Pregnancies Complicated by Gestational Diabetes Mellitus: A Prospective Cohort Study

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ABSTRACT

Objective: To compare fetal thymus biometry among pregnant women with insulin-requiring gestational diabetes mellitus (GDM), diet-regulated GDM, and healthy controls, and to investigate the relationship between the fetal thymic-thoracic ratio (TTR) and 1st and 5th minute Apgar scores.

Methods: This prospective cohort study included 145 singleton pregnancies between 28 and 36 weeks of gestation: 44 with insulin-requiring GDM, 46 with diet-regulated disease, and 55 healthy controls with a normal 75 g oral glucose tolerance test. Fetal thymic anteroposterior (AP) and transverse diameters (TTD) and the thoracic AP diameter were measured sonographically, and TTR was calculated. Groups were compared with the Kruskal-Wallis test and associations by Spearman rank correlation.

Results: The groups did not differ in AP thymic diameter ($p=0.371$), TTD ($p=0.844$) or TTR ($p=0.638$). In the whole cohort, the TTR correlated weakly and positively with Apgar scores at the 1st ($p=0.226$, $p=0.006$) and 5th minutes ($p=0.241$, $p=0.004$). Correlations were moderate in the insulin-requiring group ($p=0.410$, $p=0.006$ and $p=0.409$, $p=0.006$, respectively), although pairwise comparison of coefficients showed no significant difference between groups. The AP thymic diameter correlated weakly with both scores, whereas the TTD showed no significant correlation.

Conclusion: Fetal thymus dimensions and TTR were found to be similar among the three study groups. The association of higher TTR values with higher 1st and 5th minute Apgar scores suggests that fetal thymus measurements normalized to thoracic dimensions may be sonographic parameter associated with early neonatal adaptation.

Keywords: Gestational diabetes mellitus, fetal thymus, thymic-to-thoracic ratio, Apgar score, fetal ultrasonography

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INTRODUCTION

Gestational diabetes mellitus (GDM) characterized by carbohydrate intolerance that is first detected or that manifests during pregnancy ranks among the most prevalent metabolic disorders encountered in obstetric practice.¹ Maternal hyperglycemia may precipitate adverse maternal-fetal outcomes, including fetal hyperinsulinemia, accelerated somatic growth, macrosomia, intrauterine hypoxia, and birth trauma.²

First-line therapy for GDM centers on dietary adjustment and lifestyle modification (diet-controlled GDM); however, patients who fail to meet glycemic targets require insulin therapy (insulin-requiring GDM). Pregnancies requiring insulin are typically characterized by severe peripheral insulin resistance, a more

pronounced systemic inflammatory response, and vascular and metabolic alterations that may impair fetal tissue perfusion.³

The fetal thymus serves as the primary lymphoid organ of the immune system and can be visualized via transabdominal ultrasound on the three-vessel view from the second trimester onward. A key characteristic of the thymus is its rapid morphological regression (involution) in response to acute or chronic stress. Accordingly, a reduced thymic size has been proposed as an indirect marker of fetal inflammatory response syndrome and exposure to adverse intrauterine stress.⁴

Because absolute thymic diameters correlate with advancing gestational age, the thymic-thoracic ratio (TTR), defined as the ratio of the anteroposterior (AP) thymic diameter to the



intrathoracic mediastinal diameter, was introduced to quantify thymic alterations independently of gestational age. TTR offers the distinct advantage of standardizing relative fetal thymic volume along a uniform axis, unaffected by gestational age or generalized fetal growth trajectories. Although thymic involution has been well documented in adverse obstetric conditions including preterm premature membrane rupture, hypertensive disorders of pregnancy, and fetal growth impairment, the direction of thymic remodeling in GDM specifically across diet-controlled and insulin-requiring subgroups and how these morphological changes relate to immediate neonatal vigor (Apgar scores) remain ill-defined.^{5,6}

The Apgar score is the most fundamental clinical indicator of a newborn's postnatal physiological adaptation and cardiorespiratory stability. Several prospective cohort investigations have documented an elevated likelihood of depressed Apgar scores at both the 1st and 5th minutes of life among neonates born to women with GDM.⁷ However, no practical marker currently exists that can prenatally predict which GDM-complicated pregnancies will result in adverse neonatal outcomes.

This study was designed to determine whether a relationship exists between fetal TTR and neonatal Apgar scores (at 1 and 5 minutes) among healthy pregnant women and women with diet-controlled or insulin-requiring GDM. Evaluate the predictive utility of absolute fetal thymic diameters (AP and transverse) for neonatal Apgar outcomes; We compare fetal thymic biometry across modalities of glycemic management.

METHODS

This prospective cohort study was conducted between June 2026 and August 2026 at a tertiary perinatology center. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and approved by the Ethics Committee of University of Health Sciences Türkiye, İzmir Tepecik Training and Research Hospital (approval number: 2026/05-19; date: 04.06.2026). Prior to participation in the study, all participants were provided with detailed information, and written informed consent was obtained from each participant.

Singleton pregnancies between 28 and 36 completed weeks' gestation were recruited. Three study arms were defined: a diet-controlled GDM cohort (n=46), an insulin-requiring GDM cohort (n=44), and a gestational-age-matched healthy control group (n=55), whose normoglycemia was confirmed by a 75-g oral glucose tolerance test (OGTT) conducted at 24-28 weeks' gestation. To ensure an uncomplicated baseline profile, women with a history of obstetric complications in previous pregnancies, including preterm delivery, gestational hypertension, intrauterine growth restriction, and preeclampsia, were excluded from the control group. Exclusion criteria included maternal systemic disease, multiple pregnancies, fetal structural or genetic anomalies, fetal growth restriction, and maternal smoking. Women who received antenatal corticosteroids to promote fetal

lung maturation were also excluded because of the established effect of glucocorticoids on fetal thymic involution.

Power calculations were carried out with G*Power 3.1, targeting the primary outcome of the TTR-Apgar correlation. With an alpha level of 0.05, 80% power, and an expected effect size of $r=0.235$, at least 138 participants were required. To account for potential loss to follow-up, 145 singleton pregnancies were enrolled (55 controls, 46 diet-controlled GDM, and 44 insulin-requiring GDM). This final sample size provided 80% power ($\alpha=0.05$) to detect a moderate effect size ($f=0.26$) in three-group comparisons.

Universal GDM screening was performed using a one-step 75-g OGTT at 24-28 weeks' gestation. Gestational age was confirmed by combining crown-rump length measurement during first-trimester ultrasonography with dating from the last menstrual period. Women meeting one or more plasma glucose thresholds fasting ≥ 92 mg/dL, 1-hour post-load ≥ 180 mg/dL, or 2-hour post-load ≥ 153 mg/dL were classified as having GDM in accordance with International Association of Diabetes and Pregnancy Study Groups criteria.⁸

Sonographic scans and measurements were conducted by a single seasoned maternal-fetal medicine specialist to preclude inter-observer discrepancy, utilizing a real-time Samsung HS70A ultrasound device (Samsung Medison, Seoul, South Korea; 2017).

On the axial three-vessel view, the fetal thymus appeared as a uniformly echogenic structure in the anterior mediastinum. The thymic transverse diameter (TTD) was obtained at the greatest transverse dimension perpendicular to an imaginary line drawn from the sternal midpoint to the vertebral body.⁹ For the TTR calculation, the AP thymic diameter was defined as the distance from the inner sternal cortex to the leading edge of the transverse aortic arch, and the intrathoracic (AP thoracic) diameter was defined as the distance between the inner sternal cortex and the anterior vertebral margin in the same plane (Figure 1). TTR was computed as the ratio of the thymic AP diameter to the total thoracic AP diameter.

Statistical Analysis

All statistical procedures were executed in IBM SPSS Statistics (version 31.0; IBM Corp., Armonk, NY, USA). The normality of continuous variables was tested with the Shapiro-Wilk method; non-normally distributed data were reported as the median and interquartile range (25th-75th percentile), whereas categorical data were presented as counts and percentages [n (%)]. Non-parametric group comparisons were made with the Kruskal-Wallis test, and where a global difference was detected, pairwise post-hoc analyses incorporating Bonferroni correction for multiplicity were performed. Categorical variables were analyzed using Pearson's chi-square test or Fisher's exact test, depending on expected cell frequencies. Spearman rank correlation coefficients were computed to quantify the strength of the TTR-Apgar relationship, initially across the full cohort and subsequently within each

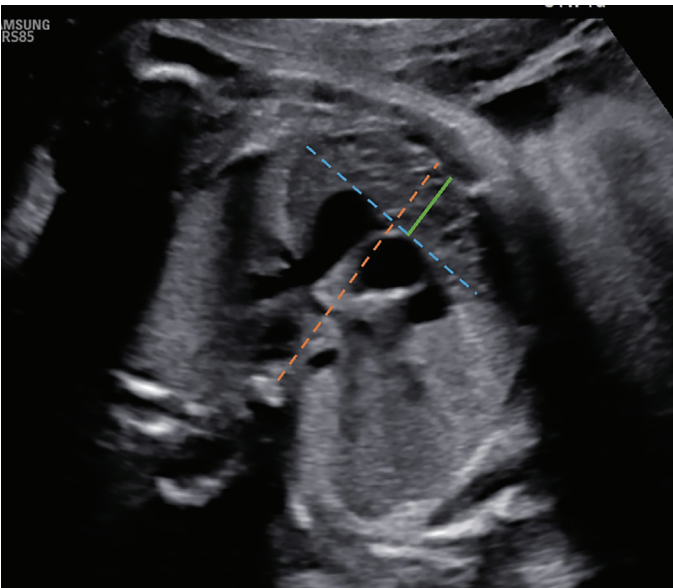


Figure 1. Measurement of the fetal thymus and thorax on the axial three-vessel view (two-dimensional grayscale ultrasonography). Green solid line: thymic anteroposterior diameter; orange dashed line: thoracic anteroposterior diameter; blue dashed line: thymic transverse diameter

subgroup. The magnitude of each correlation coefficient was classified as negligible (0.00-0.10), weak (0.10-0.39), moderate (0.40-0.69), strong (0.70-0.89), or very strong (0.90-1.00) following Schober et al.¹⁰ To test for statistically significant divergence among subgroup-specific correlation values, Fisher’s r-to-z transformation was applied.

All statistical tests were two-sided and a p value <0.05 was considered statistically significant. Adjusted p values were reported for post-hoc multiple comparisons.

RESULTS

The final study population comprised 145 pregnant women: 44 (30.3%) with insulin-requiring GDM, 46 (31.7%) with diet-controlled GDM, and 55 (37.9%) serving as healthy controls.

The demographic and obstetric features of all three cohorts are presented in Table 1. The median gestational age at which

sonographic thymus assessment was performed was 32.0 weeks across all groups, and measurements were carried out at similar gestational ages. Maternal age differed significantly among the cohorts (p=0.031), and post-hoc pairwise comparisons revealed that this disparity was primarily attributable to the difference between the insulin and control groups (adjusted p=0.042). Maternal body mass index (BMI) also varied significantly across groups (p<0.001), being lower in the control group than in both the insulin and diet cohorts. Gravidity, parity, and rates of prior pregnancy loss were comparable across all three arms.

Fetal biometric and thymic measurements are summarized in Table 2. No significant differences were observed among the three groups regarding AP thymic diameter (p=0.371) or TTD (p=0.844). Similarly, the TTR was comparable across cohorts, with values of 0.405 (0.336-0.442) in the insulin-requiring group, 0.407 (0.368-0.442) in the diet-controlled group, and 0.395 (0.352-0.441) in the control group; there was no statistically significant intergroup variation (p=0.638). BPD and HC were equivalent across groups. Although omnibus comparisons demonstrated statistical significance for AC (p=0.032) and FL (p=0.041), post-hoc pairwise comparisons revealed no individual contrast that remained significant after Bonferroni correction. Thoracic diameter differed significantly across cohorts (p=0.033), and post-hoc testing demonstrated larger thoracic diameters in the insulin-requiring group than in controls (adjusted p=0.039).

Delivery occurred at a significantly earlier gestational age in the insulin-requiring group compared with controls (adjusted p=0.002; overall p=0.002). Neonatal birth weight likewise differed among groups (p=0.008); infants born to insulin-treated mothers were heavier than those in the control arm (adjusted p=0.007). Neither the route of delivery (p=0.233) nor the fetal sex distribution (p=0.395) varied significantly across cohorts. Apgar scores at 1 and 5 minutes were similar across the three groups (p=0.588 and p=0.818, respectively) (Table 3).

Regarding the primary outcome, the relationship between TTR and Apgar scores was analyzed. Across the entire study population, a weak but statistically significant positive correlation was identified between TTR and both 1st-minute Apgar scores (p=0.226, p=0.006) and 5th-minute Apgar scores (p=0.241, p=0.004) (Table 4). When

Table 1. Comparison of maternal and obstetric characteristics between groups				
Variable	Insulin-requiring (n=44)	Diet-controlled (n=46)	Control (n=55)	p
Maternal age, years	30.0 (28.0-34.2)	28.0 (25.2-31.0)	27.0 (24.0-33.0)	0.031
BMI, kg/m ²	31.9 (28.4-36.8)	30.6 (27.9-34.9)	28.3 (25.9-30.0)	<0.001
Gravidity	2.5 (2.0-4.0)	2.0 (1.0-3.0)	2.0 (1.0-3.0)	0.054
Parity	1.0 (1.0-2.0)	1.0 (0.0-2.0)	1.0 (0.0-1.5)	0.200
Previous abortions	0.0 (0.0-1.0)	0.0 (0.0-0.8)	0.0 (0.0-0.0)	0.186
Gestational age at scan, weeks	32.0 (30.8-34.0)	32.0 (30.0-34.0)	32.0 (30.0-33.0)	0.685
Data are presented as median (25 th -75 th percentile). Between-group comparisons were performed with the Kruskal-Wallis test. p values in bold indicate statistical significance (p<0.05). BMI: Body mass index				

cohorts were evaluated individually, this association was most pronounced within the insulin-requiring GDM group, where TTR demonstrated moderate positive correlations with 1st- and 5th-minute Apgar scores ($p=0.410$, $p=0.006$ and $p=0.409$, $p=0.006$, respectively). In contrast, no significant correlations between TTR and Apgar scores were observed in the diet-controlled or control cohorts. However, direct intergroup comparisons of correlation coefficients yielded no statistically significant difference ($p>0.14$), precluding a definitive conclusion that this relationship is exclusive to the insulin-requiring cohort. For secondary outcomes, weak positive correlations were detected in the overall cohort

between AP thymic diameter and both 1st-minute Apgar scores ($p=0.182$, $p=0.028$) and 5th-minute Apgar scores ($p=0.201$, $p=0.015$). Although these associations were also evident in the insulin group, they did not reach statistical significance in the diet or control groups. TTD showed no significant correlation with 1st- or 5th-minute Apgar scores either in the entire population or within separate cohorts.

Overall, although fetal TTR remained comparable across the three study groups, higher TTR values were weakly correlated with improved 1st- and 5th-minute Apgar scores. At the group level, this relationship was most evident in the insulin-requiring GDM

Table 2. Comparison of fetal biometry and thymus measurements between groups

Variable	Insulin-requiring (n=44)	Diet-controlled (n=46)	Control (n=55)	p
BPD, mm	84.0 (78.2-88.7)	81.0 (77.5-86.0)	82.7 (76.9-87.7)	0.511
HC, mm	304.1 (290.1-323.1)	292.0 (288.2-316.6)	300.6 (285.9-314.3)	0.227
AC, mm	292.2 (276.0-330.4)	279.5 (262.2-299.7)	283.8 (262.7-301.9)	0.032
FL, mm	63.1 (60.2-66.6)	58.5 (56.6-65.2)	59.9 (56.8-64.7)	0.041
Thymic AP diameter, mm	16.2 (13.6-18.7)	15.1 (13.4-17.8)	15.2 (12.4-16.9)	0.371
Thymic transverse diameter, mm	26.9 (23.6-30.9)	26.6 (23.6-30.4)	27.6 (24.4-30.2)	0.844
Thoracic diameter, mm	41.3 (36.5-47.7)	37.8 (33.8-41.6)	38.0 (33.0-42.9)	0.033
Thymic-thoracic ratio	0.405 (0.336-0.442)	0.407 (0.368-0.442)	0.395 (0.352-0.441)	0.638

Data are presented as median (25th-75th percentile). Between-group comparisons were performed with the Kruskal-Wallis test. p values in bold indicate statistical significance ($p<0.05$). BPD: Biparietal diameter, HC: Head circumference, AC: Abdominal circumference, FL: Femur length, AP: Anteroposterior

Table 3. Comparison of delivery and neonatal outcomes between groups

Variable	Insulin-requiring (n=44)	Diet-controlled (n=46)	Control (n=55)	p
Gestational age at delivery, weeks	37.0 (37.0-38.0)	38.0 (37.0-38.0)	38.0 (37.5-39.0)	0.002
Birth weight, g	3440 (3182-3750)	3305 (2681-3558)	3180 (2794-3520)	0.008
Cesarean delivery, n (%)	33 (75.0)	33 (71.7)	33 (60.0)	0.233
Male sex, n (%)	26 (59.1)	27 (58.7)	26 (47.3)	0.395
Apgar score at 1 st minute	8.0 (8.0-8.0)	8.0 (8.0-8.0)	8.0 (7.5-8.0)	0.588
Apgar score at 5 th minutes	9.0 (9.0-9.0)	9.0 (9.0-9.0)	9.0 (9.0-9.0)	0.818

Continuous variables are presented as median (25th-75th percentile) and categorical variables as n (%). Continuous variables were compared with the Kruskal-Wallis test and categorical variables with the chi-square test. p values in bold indicate statistical significance ($p<0.05$)

Table 4. Spearman correlations between thymus measurements and Apgar scores

Measurement	Apgar score at 1 st minute				Apgar score at 5 th minutes			
	All	Insulin-requiring	Diet-controlled	Control	All	Insulin-requiring	Diet-controlled	Control
Thymic-thoracic ratio	0.226 (0.006)	0.410 (0.006)	0.135 (0.371)	0.132 (0.336)	0.241 (0.004)	0.409 (0.006)	0.149 (0.324)	0.150 (0.275)
Thymic AP diameter	0.182 (0.028)	0.329 (0.029)	0.175 (0.246)	0.062 (0.653)	0.201 (0.015)	0.316 (0.037)	0.171 (0.256)	0.130 (0.345)
Thymic transverse diameter	0.092 (0.271)	0.129 (0.404)	0.101 (0.505)	0.054 (0.695)	0.132 (0.114)	0.111 (0.473)	0.094 (0.533)	0.172 (0.210)

Values are Spearman correlation coefficients (p value). Values in bold indicate statistical significance ($p<0.05$). No correction for multiple comparisons was applied; subgroup analyses are exploratory. AP: Anteroposterior

cohort. Thymic AP diameter displayed a weaker association with Apgar scores, whereas TTD showed no significant correlation with neonatal scores.

DISCUSSION

In this prospective investigation, we evaluated the course of fetal thymic biometry and TTR in groups with insulin-requiring GDM, diet-controlled GDM, and healthy controls, as well as the relationship between these measurements and neonatal Apgar scores. The main finding of our study was that TTR, which did not differ significantly between groups, was positively associated with both the 1st- and 5th-minute Apgar scores. In the subgroup analysis, this positive trend was most pronounced in cases of insulin-requiring GDM. However, the inability to demonstrate a significant difference in the direct comparison of correlation coefficients between groups precludes interpretation of this finding as specific to pregnant women using insulin. Given that a weaker association was observed between the AP diameter of the thymus and Apgar scores, and no significant association was found between the TTD and Apgar scores, this suggests that TTR, which normalizes fetal thymus size relative to thoracic dimensions, carries a different clinical significance than isolated millimeter diameters.

Available literature regarding the impact of maternal diabetes on fetal thymic development remains inconsistent; while several cohorts describe thymic enlargement, the prevailing evidence indicates that fetal thymic dimensions are diminished in diabetic gestations.^{11,12}

Dörnemann et al.¹³ reported that TTR levels were reduced in diabetic pregnant women but that there was no statistically significant difference among the three subgroups (diet-controlled GDM, insulin-requiring GDM, and pregestational diabetes). In other recent studies, it has been reported that fetal thymus sizes were smaller in the diet-controlled GDM, insulin-requiring GDM, and pregestational diabetes groups compared to the control group, with the lowest values observed in the pregestational diabetes group.¹⁴ Contrary to these findings, our data revealed comparable TTR, AP diameter, and TTD across the insulin-requiring, diet-controlled, and healthy control cohorts.

This heterogeneity across the literature may be explained by two opposing pathophysiological forces acting concurrently on the thymic tissue. Fetal hyperinsulinemia and insulin-like growth factors, both triggered by maternal hyperglycemia, can stimulate somatic growth and cellular proliferation within the fetal thymus, an organ characterized by a high density of insulin receptors. Conversely, the chronic low-grade inflammation, oxidative stress, and heightened glucocorticoid exposure inherent to GDM can accelerate thymocyte apoptosis, driving structural involution. The equivalent thymic dimensions observed across our study cohorts may reflect a functional equilibrium between these counterbalancing anabolic and apoptotic pathways. Moreover,

because our cohort comprised tightly controlled GDM patients and excluded pregestational diabetes with end-organ vascular disease, the development of a hostile intrauterine milieu severe enough to precipitate overt thymic regression was likely prevented.

Another critical consideration in fetal thymic assessment is the gestational timing of the sonographic evaluation. In our study, the decision to perform measurements between 28 and 36 weeks of gestation was guided by two primary rationales. First, the structural sequelae of GDM, namely fetal hyperinsulinemia, organomegaly, and subclinical inflammatory stress in the microenvironment, reach their most pronounced phenotypic expression during the third trimester. Second, technical constraints dictate this window: prior to 28 weeks, the acoustic contrast delineating thymic tissue margins remains ill-defined, whereas beyond 36 weeks, advancing ossification of the sternum and rib cage generates substantial acoustic shadowing that compromises anterior mediastinal visualization. In our cohort, thymic biometry was measured at a median of 32 gestational weeks across all study groups, with no significant intergroup differences in the timing of the examinations. This methodological uniformity minimizes the confounding effect of gestational age on our outcomes. Because absolute thymic dimensions expand with advancing gestation, comparing raw linear diameters across different gestational ages can introduce substantial bias. The principal clinical strength of the TTR, by indexing the thymic AP diameter to the intrathoracic diameter within the same plane, lies in its capacity to standardize individual variations in fetal biometry and somatic growth.

Notably, the thoracic AP diameter was larger in the insulin-requiring group, consistent with its higher abdominal circumference and birth weight, which reflect accelerated somatic growth. Although the thymic AP diameter also tended to be larger in this group (16.2 vs. 15.2 mm in controls), TTR remained comparable. This suggests that thymic growth in insulin-requiring GDM is proportional to thoracic growth rather than reflecting selective enlargement or involution, and it illustrates the advantage of using a ratio over absolute diameters when fetal size differs between groups.

The most striking finding from our TTR analysis lies not in biometric comparisons between cohorts, but in its association with neonatal outcomes. Although TTR values were comparable across the study groups, higher TTR measurements in the overall population correlated significantly with higher 1st- and 5th-minute Apgar scores. While the modest correlation coefficients suggest that this relationship is not strong, it nonetheless demonstrates a statistically consistent directionality. It is well established that the fetal thymus responds to intrauterine stress with rapid involution, and robust evidence from systematic reviews and meta-analyses has linked reduced thymic size to heightened neonatal morbidity, including preterm birth, chorioamnionitis, and early-onset neonatal sepsis.^{15,16} Consequently, TTR appears to reflect the biological response of the fetus to the intrauterine environment

rather than serving as a disease-specific marker for any single maternal diagnosis.

Studies investigating the direct relationship between fetal thymic biometry and Apgar scores in pregnancies complicated by GDM remain scarce, and the available evidence is inconsistent. While several prospective cohort studies have linked GDM to an increased risk of low 1st and 5th minutes Apgar scores, others focusing on term neonates found no significant disparity in Apgar scores between diabetic and control cohorts.^{17,18}

The absence of differences in Apgar scores between groups in our cohort is attributable to our study population consisting of pregnant women who achieved glycemic control through close antenatal monitoring and who were free of comorbidities. Therefore, the independent association observed between TTR and these scores, despite no difference in Apgar scores between groups, suggests that TTR may reflect individual fetal reserve and adaptive capacity rather than merely indicating GDM.

Although maternal BMI was demonstrably elevated in both GDM arms relative to controls in our sample, TTR remained similar across groups, suggesting that maternal obesity does not directly modify fetal TTR. A study by Yildirim et al.¹⁹ reported an increase in the absolute dimensions of the fetal thymus in obese pregnant women, attributing this increase to metabolic and inflammatory processes; however, that study evaluated absolute thymus size rather than TTR. Since the relationship between BMI and TTR was not assessed by direct correlation analysis or multivariate models in our study, one should not conclude definitively that TTR is independent of BMI.

The strengths of our study include the prospective cohort design, the standardized diagnostic protocol, the explicit separation of GDM phenotypes by treatment modality (diet versus insulin), an adequate sample size confirmed by G*Power analysis, and the performance of all ultrasonographic measurements by the same experienced perinatologist using the same ultrasound system and standard anatomical planes, eliminating inter-observer variability.

Study Limitations

Several limitations merit acknowledgment. Although the enrolled sample met the pre-specified power requirement, the data clustered around higher scores rather than spanning a wide range due to the small number of cases involving severe neonatal asphyxia or markedly low Apgar scores (<7). Second, the thymus was assessed at a single time point during pregnancy, and serial measurements were not performed; consequently, changes in thymic size over time following the diagnosis and treatment of GDM could not be determined. Furthermore, the lack of data on HbA1c levels, fasting and postprandial blood glucose monitoring, and daily insulin requirements limits evaluation of the relationship between thymic dimensions and glycemic control.

Finally, the assessment of neonatal well-being did not include, alongside Apgar scores, monitoring of umbilical artery blood pH, base deficit, the need for neonatal intensive care, or the incidence of neonatal hypoglycemia. Incorporating these factors into the analysis would provide a much clearer picture of the role of fetal TTR in predicting neonatal morbidity.

CONCLUSION

However, the finding that TTR was positively, albeit weakly, correlated with 1st- and 5th-minute Apgar scores suggests that fetal thymic size normalized to thoracic dimensions may be more informative regarding early neonatal adaptation than isolated diameters. TTR may, therefore, represent a candidate sonographic marker of the fetus's capacity to adapt to intrauterine stress, rather than a parameter guiding the diagnostic or therapeutic approach to GDM. Nevertheless, for TTR to be utilized as a clinical predictive tool, multicenter prospective studies involving serial screenings across diverse populations and incorporating objective cord blood parameters are required.

Ethics

Ethics Committee Approval: The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and approved by the Ethics Committee of University of Health Sciences Türkiye, İzmir Tepecik Training and Research Hospital (approval number: 2026/05-19; date: 04.06.2026).

Informed Consent: Prior to participation in the study, all participants were provided with detailed information, and written informed consent was obtained from each participant.

Footnotes

Authorship Contributions

Surgical and Medical Practices: R.T., Z.E.Ç., Concept: R.T., E.D., Design: R.T., E.D., Data Collection or Processing: R.T., S.T.C., Z.E.Ç., Analysis or Interpretation: R.T., E.D., S.T.C., Z.E.Ç., Literature Search: R.T., S.T.C., Z.E.Ç., Writing: R.T.

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