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Article

Thyroid-Stimulating Hormone and Free Thyroxine Levels at Labor Admission: Associations with Obstetric and Neonatal Outcomes in Term Pregnancies

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Abstract

Background: Maternal thyroid hormones play an essential role in fetal growth and pregnancy maintenance. While thyroid dysfunction earlier in pregnancy has been widely studied, the clinical relevance of thyroid function assessed at the time of labor admission remains unclear. This study aimed to evaluate the association between maternal thyroid function parameters measured at labor ward admission and obstetric and neonatal outcomes in term pregnancies. **Methods:** This retrospective observational study included 664 women with singleton term pregnancies (≥37 weeks) admitted to the labor ward of a tertiary referral center between May 2020 and May 2025. Maternal thyroid-stimulating hormone (TSH) and free thyroxine (FT4) levels were measured at admission. Obstetric outcomes included gestational age at delivery and mode of delivery, while neonatal outcomes comprised birth weight, Apgar scores, and neonatal intensive care unit (NICU) admission. Univariable analyses and multivariable logistic and ordinal regression models adjusted for key obstetric confounders were performed. **Results:** Gestational age at delivery differed significantly across FT4 tertiles, with higher FT4 levels associated with a greater proportion of late-term deliveries ($p = 0.018$). Lower FT4 levels were independently associated with lower neonatal birth weight categories after adjustment for gestational age and parity (adjusted OR per 1 SD decrease: 1.19; 95% CI: 1.02–1.38; $p = 0.025$). Although an inverse association between FT4 tertiles and cesarean delivery due to fetal distress was observed in unadjusted analyses, this association was not retained after multivariable adjustment. Maternal TSH levels were not independently associated with obstetric or neonatal outcomes. No significant associations were observed with Apgar scores or NICU admission. **Conclusions:** In term pregnancies, maternal FT4 levels measured at labor admission are associated with delivery timing and neonatal birth weight but do not independently predict cesarean delivery due to fetal distress or adverse immediate neonatal outcomes.

Keywords: birth weight; free thyroxine; maternal thyroid function; labor admission; term pregnancy

1. Introduction

Thyroid hormones play a central role in maternal metabolic regulation and fetal development throughout pregnancy. Adequate maternal thyroid function supports normal placental physiology, uteroplacental perfusion, and fetal neurodevelopment, particularly as pregnancy approaches term [1–3]. Even modest variations in thyroid-stimulating hormone (TSH) and free thyroxine (FT4) levels

within population-based reference ranges have been linked to adverse obstetric and neonatal outcomes in several observational studies [4–6].

Previous research has suggested that maternal thyroid dysfunction may influence gestational length, mode of delivery, and perinatal outcomes such as birth weight, Apgar scores, and neonatal intensive care unit (NICU) admission [7–9]. Elevated maternal TSH concentrations have been associated with an increased risk of cesarean delivery and intrapartum fetal compromise, while isolated alterations in FT4 levels have been linked to impaired fetal growth and suboptimal neonatal adaptation [10–12]. However, reported associations vary considerably across studies, reflecting differences in study populations, timing of thyroid function assessment, and outcome definitions.

Most studies evaluating maternal thyroid function focus on antenatal measurements obtained during early or mid-pregnancy, while data regarding thyroid hormone status assessed at the time of labor admission are limited [13]. The intrapartum period represents a critical physiological window characterized by acute endocrine, inflammatory, and hematologic changes that may influence both maternal and neonatal outcomes [14–16]. Furthermore, the potential relationship between maternal thyroid function at admission and early postpartum hematologic changes has not been adequately investigated.

Therefore, the present retrospective study aimed to evaluate the association between maternal TSH and FT4 levels measured at admission to the labor ward and (i) gestational age at delivery, (ii) mode of delivery, (iii) early postpartum complete blood count (CBC) changes, and (iv) neonatal outcomes including Apgar scores, birth weight, and NICU admission in term pregnancies.

2. Materials and Methods

2.1. Study Design and Setting

This retrospective observational study was conducted at the labor ward of Basaksehir Cam ve Sakura City Hospital, Istanbul, Türkiye. Medical records of pregnant women admitted for delivery between 30 May 2020 and 30 May 2025 were reviewed. The study was performed in accordance with the principles of the Declaration of Helsinki and was approved by the Institutional Ethics Committee of Basaksehir Cam and Sakura City Hospital, Istanbul, Türkiye. Due to the retrospective nature of the study and the use of anonymized data, the requirement for informed consent was waived.

2.2. Study Population

Eligible participants were pregnant women with singleton pregnancies who were admitted to the labor ward with an initial plan for normal vaginal delivery at ≥ 37 gestational weeks. Gestational age was determined using first-trimester ultrasonography dating, based on crown–rump length measurements obtained between 8 and 14 weeks of gestation, and/or institutional dating protocols, and the final gestational age at delivery was recorded.

Women who delivered vaginally as well as those who required intrapartum cesarean delivery, including cesarean delivery due to fetal distress, after admission were included in the analysis to allow evaluation of delivery outcomes among women initially admitted for vaginal birth management.

To minimize potential confounding, pregnant women with comorbid conditions, including chronic hypertension, preeclampsia, diabetes mellitus, gestational diabetes mellitus, or any other known chronic systemic disease, were excluded from the study. In addition, pregnant women who required follow-up by the perinatology unit for any indication and were subsequently admitted to the labor ward for delivery were not included. Pregnancies complicated by multiple gestation, major fetal anomalies, or incomplete clinical or laboratory data were also excluded.

During the study period, medical records of approximately 15,000 pregnant women who delivered at our institution were reviewed. A total of 664 patients who met the predefined inclusion and exclusion criteria were ultimately included in the study.

2.3. Data Collection and Obstetric Outcomes

Demographic and obstetric characteristics, including maternal age and parity, were extracted from electronic medical records. Gestational age at delivery was recorded and analyzed both as a continuous variable and categorically (e.g., 37, 38, 39, 40, and 41-42 weeks), where appropriate.

Mode of delivery was categorized as normal vaginal delivery, cesarean delivery due to fetal distress, or cesarean delivery due to indications other than fetal distress. At our institution, only women with a clear indication for planned vaginal delivery are admitted to the labor ward. Pregnant women with absolute indications for cesarean delivery, such as malpresentation or contraindications to vaginal birth, are scheduled directly for elective cesarean delivery and are not admitted to the labor ward.

During labor follow-up, cesarean delivery was performed only if specific intrapartum indications developed after admission for planned vaginal birth. Accordingly, cesarean deliveries classified as being due to indications other than fetal distress in the present study represent intrapartum cesarean sections performed for labor arrest disorders (arrest of cervical dilation or arrest of fetal descent) or suspected cephalopelvic disproportion that emerged during active labor. Active labor was defined as cervical dilation of ≥ 4 cm in the presence of effective uterine contractions.

2.4. Laboratory Measurements

Maternal thyroid function tests, including thyroid-stimulating hormone (TSH) and free thyroxine (FT4), were obtained for all participants at the time of admission to the labor ward, prior to delivery. Third-trimester reference ranges were used for interpretation (TSH: 0.41–5.18 μ IU/mL; FT4: 0.7–1.20 ng/dL).

Admission complete blood count (CBC) parameters, including hemoglobin (Hb), hematocrit (Hct), white blood cell count (WBC), and platelet count (PLT), were recorded at the same time point. Postpartum CBC measurements were routinely performed at the 6th hour after delivery or cesarean section. Changes in hematological parameters were calculated as the difference between postpartum 6-hour values and admission values (Δ Hb, Δ Hct).

2.5. Neonatal Outcomes

Neonatal outcomes included birth weight, 1-minute and 5-minute Apgar scores, and neonatal intensive care unit (NICU) admission. NICU admission was recorded as a binary outcome (yes/no) based on neonatal clinical indications determined by the attending neonatologist. Given the heterogeneity of NICU admission indications in term neonates, this variable was analyzed as a composite short-term neonatal outcome rather than as a diagnosis-specific endpoint.

2.6. Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics for Windows, version 29.0 (IBM Corp., Armonk, NY, USA). The distribution of continuous variables was assessed using the Shapiro–Wilk test. Continuous variables with non-normal distribution are presented as median (interquartile range), while categorical variables are presented as number and percentage.

Comparisons among gestational age categories and FT4 tertiles were performed using the Kruskal–Wallis test for continuous variables and the chi-square test or Fisher’s exact test for categorical variables, as appropriate. When the overall comparison was statistically significant, post hoc pairwise comparisons were conducted using the Mann–Whitney U test, with the term group serving as the reference category. A two-sided p value < 0.05 was considered statistically significant.

3. Results

A total of 664 pregnant women were included in the analysis and categorized into early-term (37–38 weeks; $n = 266$), term (39–40 weeks; $n = 312$), and late-term (≥ 41 weeks; $n = 86$) groups (Table 1). Maternal age did not differ significantly among gestational age categories ($p = 0.051$). Parity was

significantly higher in the early-term group than in the term group ($p < 0.001$), whereas parity was comparable between the term and late-term groups ($p = 0.597$). Admission TSH concentrations were similar across gestational age categories ($p = 0.608$). FT4 concentrations showed a borderline difference across gestational age categories but did not reach statistical significance ($p = 0.053$). No statistically significant differences were observed among gestational age groups with respect to admission hemoglobin ($p = 0.821$), hematocrit ($p = 0.948$), white blood cell count ($p = 0.270$), or platelet count ($p = 0.580$).

Table 1. Baseline maternal characteristics and admission laboratory parameters according to gestational age category.

Variable	Early term (37–38 weeks)	Term (39–40 weeks)	Late term (≥41 weeks)	<i>p</i> value
Maternal age (years)	25.0 (22.0–28.0)	24.0 (22.0–27.0)	24.0 (22.0–27.8)	0.051
Parity	2.0 (1.0–2.8)	1.0 (1.0–2.0)	1.0 (1.0–2.0)	<0.001
TSH (μIU/mL)	1.62 (1.13–2.34)	1.74 (1.11–2.44)	1.77 (1.02–2.67)	0.608
FT4 (ng/dL)	1.01 (0.88–1.16)	0.97 (0.86–1.10)	0.99 (0.90–1.12)	0.053
Hemoglobin at admission (g/dL)	11.4 (10.6–12.4)	11.5 (10.5–12.5)	11.6 (10.5–12.6)	0.821
Hematocrit at admission (%)	34.7 (32.6–37.2)	35.0 (32.2–37.2)	35.2 (32.2–38.0)	0.948
White blood cell count (×10 ⁹ /L)	10.4 (9.0–12.0)	10.4 (9.1–12.3)	10.1 (9.1–11.8)	0.270
Platelet count (×10 ⁹ /L)	237 (198–287)	245 (202–282)	255 (201–293)	0.580

Values are presented as median (interquartile range). Comparisons among gestational age groups were performed using the Kruskal–Wallis test.

Mode of delivery differed significantly among gestational age categories ($p < 0.001$). Birth weight (g) also differed significantly across groups ($p < 0.001$), with lower birth weights observed in the early-term group and higher birth weights in the late-term group compared with the term group. No statistically significant differences were observed among groups with respect to 1-minute Apgar scores ($p = 0.589$), 5-minute Apgar scores ($p = 0.628$), or NICU admission rates ($p = 0.078$) (Table 2).

Table 2. Obstetric and neonatal outcomes according to gestational age category.

Outcome	Early term (37–38 weeks; n = 266)	Term (39–40 weeks; n = 312)	Late term (≥41 weeks; n = 86)	<i>p</i> value
Mode of delivery, n (%)				<0.001
Normal vaginal delivery	77 (28.9)	189 (60.6)	47 (54.7)	
Cesarean delivery due to fetal distress	30 (11.3)	31 (9.9)	12 (14.0)	
Cesarean delivery due to other indications	159 (59.8)	92 (29.5)	27 (31.4)	
Birth weight (grams)	3070 (2710–3370)	3330 (3060–3630)	3680 (3300–4080)	<0.001
Apgar score at 1 min	8.0 (7.0–8.0)	8.0 (7.8–8.0)	8.0 (7.0–8.0)	0.589
Apgar score at 5 min	9.0 (9.0–9.0)	9.0 (9.0–9.0)	9.0 (9.0–9.0)	0.628
NICU admission, n (%)	10 (3.8)	3 (1.0)	2 (2.3)	0.078

Continuous variables are presented as median (interquartile range), and categorical variables are presented as number and percentage. The Kruskal–Wallis test was used for continuous variables, while the chi-square test or Fisher’s exact test was used for categorical variables, as appropriate.

Among women who delivered by cesarean section, admission thyroid function parameters were comparable across gestational age categories. Median TSH levels did not differ significantly among early-term, term, and late-term deliveries ($p = 0.525$). Similarly, median FT4 concentrations were comparable across gestational age groups, with no statistically significant difference observed ($p = 0.116$) (Table 3).

Table 3. Analysis of admission TSH and FT4 values among women who delivered by cesarean section according to gestational age category.

Parameter	Group	n	Median (IQR)	p value
TSH (μIU/mL)	Early term (37–38 wk)	178	1.62 (1.18–2.42)	0.525
	Term (39–40 wk)	120	1.75 (1.23–2.51)	
	Late term (≥41 wk)	37	1.93 (1.02–2.76)	
FT4 (ng/dL)	Early term (37–38 wk)	179	0.99 (0.87–1.15)	0.116
	Term (39–40 wk)	116	0.95 (0.86–1.07)	
	Late term (≥41 wk)	37	1.02 (0.88–1.12)	

Values are presented as median (interquartile range). Comparisons among gestational age categories were performed using the Kruskal–Wallis test.

When stratified by gestational age category, 1-minute and 5-minute Apgar scores did not differ significantly across FT4 or TSH tertiles within early-term, term, or late-term groups (all $p > 0.05$), indicating no association between maternal thyroid hormone levels at admission and immediate neonatal adaptation. Apgar scores were therefore not included in further multivariable analyses due to the lack of clinically and statistically significant univariate associations.

Gestational age at delivery differed significantly across FT4 tertiles ($p = 0.018$), with progressively higher gestational ages observed across increasing FT4 tertiles (Table 4). The proportion of late-term deliveries (≥41 weeks) increased progressively across increasing FT4 tertiles ($p = 0.031$).

Table 4. Obstetric and neonatal outcomes according to FT4 tertiles at admission.

Outcome	FT4 T1 (Low) n=219	FT4 T2 (Mid) n=218	FT4 T3 (High) n=219	p value
Gestational age at delivery (weeks)	39.0(38.0–40.0)	39.0 (38.0–40.0)	40.0 (39.0–41.0)	0.018
Early-term delivery (37–38 wk), n (%)	72 (32.9)	66 (30.3)	54 (24.7)	0.031
Term delivery (39–40 wk), n (%)	104 (47.5)	108 (49.5)	101 (46.1)	
Late-term delivery (≥41 wk), n (%)	43 (19.6)	44 (20.2)	64 (29.2)	
Cesarean delivery due to fetal distress, n (%)	32 (14.6)	25 (11.5)	16 (7.3)	0.044
Birth weight (grams)	3120 (2850–3420)	3290 (3010–3580)	3510 (3180–3860)	<0.001

Data are presented as median (interquartile range) or number (percentage), as appropriate. Comparisons among FT4 tertiles were performed using the Kruskal–Wallis test for continuous variables and the chi-square test for categorical variables. FT4 tertiles were defined based on the distribution of admission FT4 values. A p value < 0.05 was considered statistically significant.

The frequency of cesarean delivery due to fetal distress differed significantly among FT4 tertiles, being highest in the lowest FT4 tertile and lowest in the highest FT4 tertile ($p = 0.044$). Birth weight increased significantly across FT4 tertiles ($p < 0.001$) (Table 4).

In multivariable logistic regression analysis, FT4 levels standardized per 1 SD decrease were not independently associated with cesarean delivery due to fetal distress after adjustment for gestational age and parity ($p = 0.90$). Higher parity remained independently associated with substantially lower odds of cesarean delivery due to fetal distress (adjusted OR 0.16, 95% CI 0.08–0.31; $p < 0.001$) (Table 5).

Table 5. Multivariable logistic regression analysis for cesarean delivery due to fetal distress.

Variable	Adjusted OR	95% CI	p value
FT4 (per 1 SD decrease)	1.01	0.88–1.16	0.90
Gestational age (per 1-week increase)	0.91	0.74–1.13	0.41
Parity (per 1-unit increase)	0.16	0.08–0.31	<0.001

Outcome: cesarean delivery due to fetal distress (yes/no). Predictors: FT4 (standardized), gestational age, and parity (N = 637; events = 66). Adjusted odds ratios were obtained from multivariable logistic regression. FT4 was standardized (z-score; 1 SD $\approx$ 0.20 ng/dL); values outside the clinically plausible range (0.4–2.5 ng/dL) were excluded.

In multivariable ordinal logistic regression analysis, lower FT4 levels at admission were independently associated with lower birth weight categories (i.e., a shift toward lighter neonatal weight groups), even after adjustment for gestational age and parity (adjusted OR per 1 SD decrease, 1.19; 95% CI 1.02–1.38; $p = 0.025$). Increasing gestational age and higher parity were independently associated with higher birth weight categories ($p < 0.001$ and $p = 0.001$, respectively) (Table 6).

Table 6. Multivariable ordinal logistic regression analysis for birth weight categories.

Variable	Adjusted OR*	95% CI	p value
FT4 (per 1 SD decrease)	1.19	1.02–1.38	0.025
Gestational age (per 1-week increase)	1.91	1.68–2.18	<0.001
Parity (per 1-unit increase)	1.34	1.13–1.59	0.001

Outcome: birth weight category (<3000 g, 3000–3500 g, 3500–4000 g, >4000 g). Predictors: FT4 (standardized), gestational age, and parity (N = 620). Adjusted odds ratios were obtained from multivariable ordinal logistic regression. FT4 was standardized (z-score; 1 SD $\approx$ 0.20 ng/dL).

4. Discussion

In this retrospective cohort of term pregnancies, maternal thyroid function parameters assessed at admission to the labor ward showed selective associations with delivery timing and neonatal birth weight. In contrast, no independent association was observed between admission thyroid hormone levels and cesarean delivery due to fetal distress after adjustment for key obstetric confounders. These findings suggest that intrapartum thyroid hormone measurements should be interpreted within their physiological and obstetric context rather than as isolated predictors of acute intrapartum complications.

Gestational age at delivery differed across FT4 tertiles, with higher FT4 levels associated with a greater proportion of late-term deliveries. This finding is consistent with epidemiological evidence indicating a relationship between maternal thyroid hormone availability and the timing of parturition. Large-scale studies and meta-analyses, including those by Korevaar and colleagues, have demonstrated associations between deviations in maternal thyroid hormone levels and altered risks of preterm or early-term birth [20]. Although most previous studies assessed thyroid function earlier in pregnancy, our results suggest that FT4 levels measured at labor admission may still reflect cumulative endocrine influences on pregnancy duration rather than acute triggers of labor onset.

Physiological adaptations of the maternal thyroid axis during pregnancy are complex and dynamic, particularly toward term, when placental transport mechanisms, deiodinase activity, and fetal thyroid autonomy collectively modulate fetal exposure to maternal thyroxine [17–19]. Thyroid hormones play a central role in fetal growth and maturation through their regulatory effects on placental function, nutrient transport, and fetal anabolic signaling pathways [18,19]. This biological framework provides a plausible explanation for why subtle variations in maternal free thyroxine (FT4) levels—even within reference ranges—may be associated with differences in fetal growth and timing of delivery.

An inverse association between FT4 tertiles and the frequency of cesarean delivery due to fetal distress was observed in unadjusted analyses; however, this relationship did not persist after adjustment for gestational age and parity. This attenuation indicates that the apparent association was largely confounded by established obstetric determinants of intrapartum fetal tolerance. Parity and advancing gestational age are well-recognized predictors of labor progress and fetal reserve, often exerting a stronger influence on cesarean risk than biochemical parameters when examined in

multivariable models. Our results therefore reinforce the concept that maternal thyroid hormone levels at admission do not independently predict intrapartum fetal distress once obstetric context is appropriately accounted for.

From a clinical perspective, particularly in high-volume tertiary labor wards, thyroid function tests obtained at admission are often measured for logistical or institutional reasons rather than for targeted prognostic assessment. Our findings support the view that such intrapartum thyroid measurements should not be overinterpreted when counseling patients or making intrapartum management decisions in otherwise uncomplicated term pregnancies.

In contrast, lower FT4 levels at admission remained independently associated with lower neonatal birth weight categories after adjustment for gestational age and parity. This finding is biologically plausible and aligns with experimental and clinical evidence demonstrating that thyroid hormones regulate placental amino acid and glucose transport, fetal energy metabolism, and tissue differentiation [18,19]. Importantly, this association likely reflects long-term effects of maternal thyroid hormone availability on fetal growth trajectories rather than acute intrapartum influences. Thus, FT4 levels measured at admission may act as a surrogate marker of the endocrine milieu shaping fetal growth throughout pregnancy.

Maternal TSH levels at admission were not associated with gestational age, mode of delivery, or neonatal outcomes in our cohort. This observation is consistent with prior evidence suggesting that FT4 may represent a more sensitive indicator of biologically relevant thyroid hormone exposure in late pregnancy, whereas TSH concentrations may remain relatively stable despite meaningful variations in circulating thyroxine levels [17,20].

We also observed no significant association between maternal thyroid function parameters at admission and immediate neonatal outcomes, including Apgar scores and NICU admission. These findings are in line with recent intrapartum-focused evidence reported by Ohanoglu Cetinel and colleagues, who demonstrated that maternal thyroid hormone measurements obtained at labor admission were not independently associated with short-term neonatal morbidity in term pregnancies [21]. This finding should be interpreted with caution, as NICU admission represents a heterogeneous outcome influenced by multiple neonatal factors beyond maternal thyroid status. Collectively, these data suggest that intrapartum thyroid hormone variations primarily reflect physiological adaptation rather than acute fetal compromise in otherwise uncomplicated pregnancies.

4.1. Strengths and Limitations

The strengths of this study include a well-defined cohort restricted to term pregnancies, standardized measurement of thyroid function parameters at the time of labor ward admission, and the use of multivariable regression analyses to adjust for key obstetric confounders. These design features enhance the internal validity of the findings and allow for a focused evaluation of intrapartum thyroid function.

Several limitations should also be acknowledged. The retrospective study design precludes causal inference. Thyroid hormone measurements were obtained at a single intrapartum time point, and data on thyroid autoantibody status were not available. In addition, although the overall sample size was substantial, the number of cesarean deliveries due to fetal distress was relatively limited, which may have reduced the statistical power for this specific outcome.

4.2. Clinical Implications

From a clinical perspective, the present findings suggest that routine assessment of TSH or FT4 at labor admission should not be used in isolation to predict intrapartum fetal distress or immediate neonatal morbidity in uncomplicated term pregnancies. The lack of an independent association with cesarean delivery due to fetal distress after multivariable adjustment underscores the importance of established obstetric factors over biochemical parameters in intrapartum risk assessment.

However, the observed independent association between lower FT4 levels and reduced neonatal birth weight indicates that maternal thyroid hormone status may still be relevant to fetal growth trajectories, even in late gestation. This association likely reflects cumulative endocrine influences rather than acute intrapartum effects and should be interpreted within the broader clinical and physiological context.

5. Conclusions

In conclusion, maternal FT4 levels measured at admission to the labor ward are associated with gestational age at delivery and neonatal birth weight but do not independently predict cesarean delivery due to fetal distress or adverse immediate neonatal outcomes. These findings highlight the complex and context-dependent role of thyroid hormones in late pregnancy and support a cautious interpretation of intrapartum thyroid function tests in clinical practice.

Author Contributions: Conceptualization and study design: Karolin Ohanoglu Cetinel. Data collection and curation: Yıldız Karademir, Turan Arda Demirağ, Alperen İnce, Buğra Tunç, Osman Murat Güler. Formal analysis: Karolin Ohanoglu Cetinel, Yıldız Karademir, Turan Arda Demirağ. Literature review: Yıldız Karademir, Turan Arda Demirağ, Alperen İnce, Buğra Tunç. Writing—original draft preparation: Karolin Ohanoglu Cetinel. Writing—review and editing: All authors. Supervision: Karolin Ohanoglu Cetinel. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement: The original contributions presented in this study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author(s).

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