Impact of Thyroid Function Status on Perioperative Characteristics and Early Postoperative Recovery in Cesarean Section

Ann. Ital. Chir., 2026 97, 8: 1423–1432
https://doi.org/10.62713/aic.4655

Gangjun Ying[1], Jie Shen[1]

[1]Department of Obstetrics and Gynecology, Yuhuan Second People's Hospital, 317605 Taizhou, Zhejiang, China

AIM: Thyroid dysfunction is common in pregnancy, but its effects on perioperative outcomes in cesarean section remain unclear. This study aimed to investigate the effects of thyroid dysfunction in the third trimester on perioperative hemodynamic stability and early postoperative recovery in women undergoing cesarean section.

METHODS: Clinical data from women undergoing elective cesarean section at Yuhuan Second People's Hospital between January 2023 and December 2025 were retrospectively collected. Propensity score matching (1:2 nearest neighbor matching, caliper 0.1) was used to balance baseline covariates between groups. After matching, 81 cases were included in the thyroid dysfunction group and 162 cases were categorized in the euthyroid group. Intraoperative hemodynamic parameters (hypotension, hypertension, tachycardia, bradycardia, vasopressor use, and maximum decrease in mean arterial pressure (MAP)), postoperative recovery indicators (pain scores, time to bowel function recovery, onset of lactation, higher Edinburgh Postnatal Depression Scale (EPDS) scores, length of hospital stay, and complications), and neonatal outcomes were compared between the two groups.

RESULTS: After matching, baseline data were well-balanced between the two groups (all standardized differences <0.1). Compared to the euthyroid group, the thyroid dysfunction group had significantly higher rates of intraoperative hypotension, tachycardia, bradycardia, and vasopressor use (all $p < 0.01$), along with a greater maximum decrease in MAP ($p < 0.001$). Postoperative pain scores, time to first flatus and defecation, time to onset of lactation, EPDS scores, and length of hospital stay were significantly increased in the thyroid dysfunction group compared with the euthyroid group (all $p < 0.001$). No significant difference was found between groups in intraoperative hypertension ($p > 0.05$). Subgroup analysis showed that the hypothyroidism subgroup had higher rates of intraoperative hypotension ($p = 0.042$), and longer time to first flatus ($p = 0.004$); the hyperthyroidism subgroup had a higher rate of tachycardia ($p = 0.017$). Regarding neonatal outcomes, the 5-minute Apgar score was slightly lower in the thyroid dysfunction group ($p < 0.05$), but all scores were within the normal range. Neonatal hyperthyroidism occurred in one infant born to a mother with hyperthyroidism.

CONCLUSIONS: Thyroid dysfunction was associated with intraoperative hemodynamic instability and delayed early postoperative recovery in cesarean section, with distinct clinical characteristics between hypothyroidism and hyperthyroidism. Perioperative monitoring and management should be enhanced for these patients.

Keywords: thyroid dysfunction; cesarean section; propensity score matching; perioperative period; postoperative recovery; hemodynamics

Introduction

Thyroid dysfunction is one of the most common endocrine disorders in women of reproductive age. Epidemiological studies indicate that the incidence of overt hypothyroidism during pregnancy is approximately 0.3%–0.5%, while the prevalence of hyperthyroidism is about 0.1%–0.4%, with Graves' disease being the most common cause [1,2]. During pregnancy, thyroid hormones play a crucial role in fetal neurological development, maternal metabolic regulation, and maintenance of cardiovascular function. With delayed childbearing age, the widespread use of assisted reproductive technology, and the extensive implementation of thyroid screening during pregnancy, the clinical detection rate of pregnancy complicated by thyroid dysfunction is continuously increasing, making it a growing clinical concern for obstetricians and anesthesiologists [3].

Thyroid hormones exert extensive and profound regulatory effects on the cardiovascular system. They act directly on cardiomyocytes and vascular smooth muscle cells by modulating beta-adrenergic receptor density, calcium channel activity, and vascular endothelial function, thereby influencing cardiac output, peripheral vascular resistance, and blood pressure stability [4]. In the hypothyroid state, myocardial contractility decreases, cardiac output declines, heart rate slows, and vascular compliance decreases, impairing the body's compensatory capacity for volume changes and

Submitted: 24 March 2026 Revised: 16 June 2026 Accepted: 24 July 2026 Published: 13 August 2026
Correspondence to: Jie Shen, Department of Obstetrics and Gynecology, Yuhuan Second People's Hospital, 317605 Taizhou, Zhejiang, China (e-mail: 13989664801@163.com).
Editor: Roberto Cirocchi

surgical stress [5]. Conversely, hyperthyroidism is characterized by a hyperdynamic circulatory state, increased resting heart rate, and elevated myocardial oxygen consumption, predisposing individuals to arrhythmias and significant blood pressure fluctuations [6]. Although these pathophysiological changes are well-studied in the non-pregnant population, their impact on perioperative hemodynamic stability during the unique physiological state of pregnancy, especially under the stress of cesarean section surgery, lacks systematic evaluation.

Cesarean section, as a common surgical procedure for managing dystocia and high-risk pregnancies, presents unique challenges for anesthetic management. The sympathetic blockade induced by combined spinal-epidural anesthesia can result in peripheral vasodilation and reduced venous return, easily precipitating hypotension. Surgical stimulation, oxytocin administration, and postoperative pain can further trigger blood pressure fluctuations and heart rate changes [7]. For parturients with thyroid dysfunction, these perioperative hemodynamic fluctuations may be more pronounced. However, existing literature primarily focuses on the effects of thyroid dysfunction on pregnancy outcomes (such as miscarriage, preterm birth, fetal growth restriction) or its association with hypertensive disorders of pregnancy and diabetes, while a single study specifically investigating its effect on intraoperative hemodynamic stability and early postoperative recovery following cesarean section are relatively scarce [7].

Notably, hypothyroidism and hyperthyroidism represent two distinct pathological states of thyroid dysfunction, each with significantly different perioperative implications. Hypothyroid patients are more prone to intraoperative hypotension and bradycardia, with an increased requirement for vasoactive agents [5]. In contrast, hyperthyroid patients may exhibit hypertension, tachycardia, and heightened postoperative pain response, and in rare cases, can precipitate thyroid storm, one of the most dangerous perinatal complications with a mortality rate of 8%–25% [8]. Postoperative recovery is a core indicator for assessing the quality of perioperative management. Thyroid dysfunction may influence postoperative recovery through multiple mechanisms: hypothyroidism was associated with slowed gastrointestinal motility, delayed lactation, and mood disorders [9]; hyperthyroidism is closely associated with increased pain sensitivity and a higher tendency for anxiety and depression [10]. Furthermore, maternal thyroid dysfunction can affect neonatal outcomes, as thyroid hormones and autoantibodies can cross the placenta, potentially leading to neonatal hyperthyroidism in rare cases [11].

Based on this background, this study aims to conduct a retrospective cohort study using propensity score matching to investigate the effects of third-trimester thyroid dysfunction on perioperative hemodynamic stability and early postoperative recovery in women undergoing cesarean section, and to further compare the differences in clinical characteristics between hypothyroid and hyperthyroid patients. The results will provide evidence-based guidance for the perioperative management of parturients with thyroid dysfunction, helping to optimize anesthetic management, improve postoperative recovery, and ensure maternal and neonatal safety.

Methods

Study Population

Clinical data from women who underwent elective cesarean section at Yuhuan Second People's Hospital between January 2023 and December 2025 were consecutively enrolled. Inclusion criteria were: (1) age ≥18 years; (2) singleton full-term pregnancy (gestational age 37–41 weeks); and (3) American Society of Anesthesiologists (ASA) physical status II–III (ASA II: mild systemic disease without functional limitation; ASA III: severe systemic disease) [12].

Exclusion criteria were: (1) multiple pregnancy; (2) complicated with severe pregnancy complications such as hypertensive disorders of pregnancy, gestational diabetes mellitus, or cardiac disease; (3) preoperative infection or fever; (4) history of thyroid surgery or radioactive iodine therapy; (5) preoperative use of beta-blockers or glucocorticoids; (6) contraindications to neuraxial anesthesia or failed neuraxial anesthesia requiring conversion to general anesthesia; (7) intraoperative blood loss >1000 mL; (8) subclinical thyroid dysfunction (elevated thyroid-stimulating hormone (TSH) with normal free thyroxine 4 (FT4), or suppressed TSH with normal FT4); and (9) incomplete key clinical data.

This was a single-center, retrospective, propensity score-matched cohort study. The study protocol was approved by the Ethics Committee of Yuhuan Second People's Hospital (approval number: 2604). Given the retrospective nature of the study and the fact that patient data were anonymized before analysis, the requirement for informed consent was waived. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

Data Collection

Thyroid Function Grouping and Definitions

Based on thyroid function test results in the third trimester (32–36 weeks of gestation), parturients were divided into three groups using trimester-specific reference ranges established by the American Thyroid Association (ATA) 2017 guidelines [1] and validated in a Chinese pregnant population [13]: TSH 0.30–4.98 mIU/L, FT4 0.70–1.31 ng/dL (9.04–16.85 pmol/L). The euthyroid group was defined as both TSH and FT4 within the normal reference range. The overt hypothyroidism group was defined as TSH >4.98 mIU/L and FT4 <0.70 ng/dL. The overt hyperthyroidism group was defined as TSH <0.30 mIU/L and FT4 >1.31 ng/dL. These cutoffs correspond to the 2.5th and 97.5th percentiles for third-trimester pregnant women in our laboratory. For patients in the thyroid dysfunction group, data on anti-thyroid medication use were extracted from elec-

tronic medical records, including medication type (levothyroxine, methimazole, or propylthiouracil), dosage, and duration. The most recent thyroid function test results (within one week prior to cesarean section) were used to determine whether patients had achieved euthyroid status before surgery (only to evaluate preoperative thyroid control status), defined as TSH within the trimester-specific reference range (0.30–4.98 mIU/L) and FT4 within the normal range (0.70–1.31 ng/dL). Treatment characteristics were summarized descriptively and compared between hypothyroid and hyperthyroid subgroups using the chi-square test or Fisher's exact test for categorical variables, and the independent *t*-test or Mann-Whitney U test for continuous variables, as appropriate.

To investigate the overall impact of thyroid dysfunction on the perioperative period, patients with hypothyroidism and hyperthyroidism were first combined into a "thyroid dysfunction group" and compared with the euthyroid group. Simultaneously, to reveal differences between the two types of dysfunctions, a subgroup analysis comparing patients with hypothyroidism and hyperthyroidism was performed within the dysfunction group. The primary analysis combining patients with hypothyroidism and hyperthyroidism into a single "thyroid dysfunction group" was designed as an overall risk screening approach to detect general perioperative associations; it does not imply a unified physiological mechanism. The subsequent subgroup comparisons between hypothyroid and hyperthyroid patients were strictly exploratory and intended to generate hypotheses for future research, given the limited sample size of the hyperthyroid subgroup.

Perioperative Management and Anesthesia Protocol

All patients underwent routine preoperative fasting for 8 hours. Upon entering the operating room, an upper extremity intravenous line was established, and Ringer's lactate solution was infused. Routine monitoring included electrocardiogram (ECG), heart rate (HR), non-invasive blood pressure (NIBP), and pulse oximetry (SpO_2). Patients were placed in the left lateral position, and combined spinal-epidural anesthesia was performed at the $L_{2–3}$ or $L_{3–4}$ interspace. Hyperbaric 0.5% bupivacaine (8–10 mg, dose adjusted according to patient height) was injected into the subarachnoid space, followed by placement of an epidural catheter for backup use. After anesthesia, patients were positioned supine with a left lateral tilt of 15°–30°, and the sensory block level was maintained at T_6–T_8. Intraoperatively, based on changes in vital signs and patient complaints, supplemental epidural 2% lidocaine or intravenous adjuncts (e.g., propofol or fentanyl) were administered. Routine oxygen supplementation (5 L/min) was provided via face mask.

Clinical Data Collection and Outcome Measures

The following data were collected from the hospital's electronic medical record system. Demographic characteristics: age, body mass index (BMI), gestational week, parity, history of previous cesarean section. Comorbidities: chronic hypertension, chronic diabetes mellitus, ASA classification. Baseline vital signs: systolic blood pressure (SBP), diastolic blood pressure (DBP), and HR measured upon entering the operating room in a quiet state. Anesthesia and intraoperative management: all patients received combined spinal-epidural anesthesia. ECG, HR, NIBP, and SpO_2 were routinely monitored. The incidence of intraoperative hypotension (SBP <90 mmHg or >20% decrease from baseline), hypertension (SBP >160 mmHg or DBP >110 mmHg), tachycardia (HR >120 bpm), bradycardia (HR <50 bpm), use of vasoactive agents, and the maximum decrease in mean arterial pressure (MAP) (difference between baseline MAP and the lowest intraoperative MAP) were recorded. Postoperative recovery indicators: visual analogue scale (VAS) pain scores at 6 and 24 hours postoperatively [14], time to first flatus, time to first defecation (reflecting bowel function recovery), time to onset of lactation (time when the parturient perceived breast fullness and successful lactation), Edinburgh Postnatal Depression Scale (EPDS) score [15], postoperative length of hospital stay, and postoperative complications (e.g., fever and wound infection). Neonatal outcomes: birth weight, 1-minute and 5-minute Apgar scores, and neonatal complications (e.g., neonatal hyperthyroidism).

Statistical Analysis

All statistical analyses were performed using R software (version 4.5.2, R Foundation for Statistical Computing, Vienna, Austria). Continuous variables were first assessed for normality using the Shapiro–Wilk test. For comparisons between two independent groups (euthyroid vs. dysfunction, or hypothyroid vs. hyperthyroid), normally distributed continuous data were presented as mean ± standard deviation (SD) and compared using the independent samples *t*-test (Welch's correction for unequal variances); non-normally distributed continuous data were presented as median with interquartile range (IQR) and compared using the Mann-Whitney U test. Categorical variables were presented as number (%) and compared using the chi-square test (with Yates' continuity correction when appropriate), or Fisher's exact test when any expected cell frequency was less than 5.

Propensity score matching (PSM) was used to balance baseline covariates between the thyroid dysfunction group and euthyroid group. The dependent variable was thyroid dysfunction (yes/no). Covariates, including age, BMI, gestational week, parity, history of previous cesarean section, chronic hypertension, chronic diabetes mellitus, baseline SBP, baseline HR, and ASA classification, were entered into a logistic regression model to calculate the propensity

Table 1. Comparison of baseline characteristics between the two groups after matching.

Variable	Before matching				After matching			
	Normal (n = 6650)	Dysfunction (n = 86)	*p*	SMD_before	Normal (n = 162)	Dysfunction (n = 81)	*p*	SMD_after
Age (years), median (IQR)	32.00 (29.00, 35.00)	34.00 (31.00, 36.00)	<0.001	0.474	34.00 (31.00, 36.00)	34.00 (31.00, 36.00)	0.976	0.022
BMI (kg/m^2), median (IQR)	27.00 (25.00, 29.08)	27.60 (25.13, 30.08)	0.049	0.188	27.85 (25.80, 29.98)	27.90 (24.90, 30.10)	0.875	0.070
Gestational age (weeks), median (IQR)	39.00 (38.00, 40.00)	39.00 (38.00, 40.00)	0.258	0.114	39.00 (38.00, 39.00)	39.00 (38.00, 40.00)	0.858	0.032
Parity, multiparous, n (%)			0.016	0.129			0.586	0.037
No	3950 (59.40)	40 (46.51)			82 (50.62)	38 (46.91)		
Yes	2700 (40.60)	46 (53.49)			80 (49.38)	43 (53.09)		
Previous cesarean section, n (%)			0.530	0.024			0.380	0.049
No	5652 (84.99)	71 (82.56)			124 (76.54)	66 (81.48)		
Yes	998 (15.01)	15 (17.44)			38 (23.46)	15 (18.52)		
Chronic HTN, n (%)			0.197	0.029			1.000	<0.001
No	6459 (97.13)	81 (94.19)			154 (95.06)	77 (95.06)		
Yes	191 (2.87)	5 (5.81)			8 (4.94)	4 (4.94)		
Chronic DM, n (%)			0.467	0.017			1.000	0.006
No	6528 (98.17)	83 (96.51)			157 (96.91)	79 (97.53)		
Yes	122 (1.83)	3 (3.49)			5 (3.09)	2 (2.47)		
SBP (mmHg), median (IQR)	115.00 (108.00, 122.00)	121.00 (113.00, 128.75)	<0.001	0.611	120.50 (113.00, 126.00)	121.00 (113.00, 126.00)	0.949	0.013
HR (bpm), median (IQR)	80.00 (74.00, 85.00)	86.00 (79.25, 91.00)	<0.001	0.651	85.00 (80.00, 90.00)	86.00 (79.00, 91.00)	0.772	0.022
ASA physical status III, n (%)			0.017	0.078			0.719	0.019
No	5977 (89.88)	84 (97.67)			155 (95.68)	79 (97.53)		
Yes	673 (10.12)	2 (2.33)			7 (4.32)	2 (2.47)		

BMI, body mass index; HTN, hypertension; DM, diabetes mellitus; SBP, systolic blood pressure; HR, heart rate; ASA, American Society of Anesthesiologists; IQR, interquartile range; SMD, standardized mean difference.

score. Nearest neighbor matching (1:2 matching, caliper = 0.1) was performed. Matching efficacy was assessed using standardized mean differences (SMDs), with an SMD <0.1 indicating good balance between groups.

After matching, baseline characteristics were compared again between the two groups using the same statistical methods as those applied to the unmatched population to evaluate covariate balance. In addition, the SMDs were calculated to provide a more robust measure of balance. Subgroup analyses within the thyroid dysfunction group (hypothyroid vs. hyperthyroid) also followed the same statistical principles. All tests were two-sided, and a p-value < 0.05 was considered statistically significant.

Results

Propensity Score Matching

The initial cohort included 86 parturients with thyroid dysfunction and 6650 parturients with normal thyroid function. After 1:2 propensity score matching, 81 cases in the dysfunction group and 162 cases in the normal group were successfully matched. Baseline covariates were well-balanced between the two groups after matching (all SMDs <0.1), indicating good matching efficacy (Table 1). Among the dysfunction group, 67 had hypothyroidism and 14 had hyperthyroidism.

Impact of Thyroid Dysfunction on Perioperative Characteristics and Early Postoperative Recovery

Compared to the euthyroid group, the thyroid dysfunction group exhibited more pronounced perioperative hemodynamic fluctuations and worse postoperative recovery indicators (Table 2). The dysfunction group had significantly higher rates of intraoperative hypotension, tachycardia, bradycardia, and vasopressor use (all $p < 0.01$), along with a greater maximum decrease in intraoperative MAP ($p < 0.001$). Postoperative pain scores, time to bowel function recovery (first flatus, first defecation), time to onset of lactation, EPDS scores, and length of hospital stay were significantly higher in the dysfunction group than in the euthyroid group (all $p < 0.001$). Postoperative complications were significantly higher in the dysfunction group ($p = 0.009$).

Comparison of Perioperative Characteristics and Early Postoperative Recovery Between Hypothyroid and Hyperthyroid Patients

Within the thyroid dysfunction group, exploratory subgroup analyses comparing hypothyroid and hyperthyroid patients revealed the following differences (Table 3). The hypothyroidism subgroup had significantly higher rates of intraoperative hypotension ($p = 0.042$) compared to the hyperthyroidism subgroup, and a longer time to first flatus ($p = 0.004$). The hyperthyroidism subgroup had a significantly higher rate of tachycardia ($p = 0.017$). No statistically significant differences were found between the two subgroups regarding intraoperative hypertension, vasopressor use rate, maximum MAP decrease, postoperative VAS scores at 6 and 24 hours and EPDS scores, postoperative pain scores, bradycardia, time to first defecation, onset of lactation, length of hospital stay, or postoperative complications ($p > 0.05$). Among the 67 hypothyroid patients, 58 (86.57%) were treated with levothyroxine at a mean dose of 50 µg/day (range 25–100 µg/day). Among the 14 hyperthyroid patients, 12 (85.71%) were treated with methimazole at a mean dose of 5 mg/day (range 2.5–10 mg/day).

Neonatal Outcomes in Parturients With Thyroid Dysfunction

There were 81 neonates born to mothers in the dysfunction group and 162 in the normal group (Table 4). No statistically significant differences were observed in birth weight or 1-minute Apgar scores between the two groups ($p > 0.05$). The 5-minute Apgar score was slightly lower in the dysfunction group compared to the normal group ($p = 0.022$), but the mean values in both groups were within the normal range (≥7), indicating no clinical significance. Among the dysfunction group, one neonate (1.23%) born to a mother with hyperthyroidism presented with tachycardia and irritability after birth, was diagnosed with neonatal hyperthyroidism, and improved after treatment with propylthiouracil.

Discussion

This retrospective propensity score-matched cohort study demonstrated that third-trimester thyroid dysfunction was associated with higher rates of intraoperative hypotension, bradycardia, and vasopressor use, as well as worsened early postoperative recovery (higher pain scores, delayed bowel function and lactation, higher EPDS scores, and longer hospital stay). Subgroup analysis revealed distinct patterns: hypothyroidism was associated with a higher incidence of intraoperative hypotension and bradycardia, while hyperthyroidism was associated with a high incidence of tachycardia and greater postoperative pain. However, given the small sample size of the hyperthyroid group (n = 14), these subgroup findings should be interpreted as exploratory rather than confirmatory. The primary combined analysis serves as a broad risk assessment and does not suggest that hypothyroidism and hyperthyroidism share identical pathophysiological pathways affecting perioperative outcomes.

In hypothyroidism, downregulation of myocardial beta-adrenergic receptors reduces cardiac contractility and output, while increased peripheral vascular resistance impairs compensatory responses to sympathetic blockade [16]. The sympathetic blockade induced by combined spinal-epidural anesthesia can result in peripheral vasodilation and reduced venous return, potentially triggering more severe hypotension in hypothyroid patients [17]. Eftekharian et al. [5] reported no significant differences in MAP or heart rate between hypothyroid and euthyroid groups undergoing spinal anesthesia for cesarean section. The discrepancy with our

Table 2. Impact of thyroid dysfunction on perioperative characteristics and early postoperative recovery.

Variables	Dysfunction (n = 81)	Normal (n = 162)	Statistic	*p*
Intraoperative hypotension, n (%)			$\chi^2 = 16.97$	<0.001
No	50 (61.73)	138 (85.19)		
Yes	31 (38.27)	24 (14.81)		
Intraoperative hypertension, n (%)			$\chi^2 = 0.50$	0.480
No	75 (92.59)	155 (95.68)		
Yes	6 (7.41)	7 (4.32)		
Tachycardia, n (%)			$\chi^2 = 11.49$	0.001
No	67 (82.72)	155 (95.68)		
Yes	14 (17.28)	7 (4.32)		
Bradycardia, n (%)			$\chi^2 = 21.87$	<0.001
No	66 (81.48)	159 (98.15)		
Yes	15 (18.52)	3 (1.85)		
Vasopressor use, n (%)			$\chi^2 = 22.74$	<0.001
No	41 (50.62)	130 (80.25)		
Yes	40 (49.38)	32 (19.75)		
Postoperative complications, n (%)			$\chi^2 = 6.74$	0.009
No	61 (75.31)	143 (88.27)		
Yes	20 (24.69)	19 (11.73)		
Max MAP decrease (mmHg), median (IQR)	19.40 (14.90, 22.90)	9.80 (7.62, 13.30)	Z = –10.04	<0.001
Postoperative 6 h VAS score, median (IQR)	5.00 (4.00, 5.00)	3.00 (2.00, 4.00)	Z = –7.34	<0.001
Postoperative 24 h VAS score, median (IQR)	6.00 (4.00, 7.00)	4.00 (3.00, 5.00)	Z = –4.70	<0.001
Time to first flatus (h), median (IQR)	37.60 (31.70, 44.40)	27.80 (24.45, 32.50)	Z = –7.55	<0.001
Time to first defecation (h), median (IQR)	67.90 (54.40, 73.60)	52.40 (45.95, 59.63)	Z = –6.89	<0.001
Onset of lactation (h), mean ± SD	31.15 ± 6.98	26.97 ± 6.16	$t = 4.77$	<0.001
EPDS score, median (IQR)	8.00 (7.00, 11.00)	5.00 (4.00, 7.00)	Z = –7.45	<0.001
Hospital stay (d), median (IQR)	6.00 (5.00, 6.00)	4.00 (4.00, 5.00)	Z = –8.02	<0.001

MAP, mean arterial pressure; VAS, visual analogue scale; EPDS, Edinburgh Postnatal Depression Scale.

findings may be associated with differences in sample size, hypothyroidism severity, and anesthetic protocols.

Hyperthyroid patients, on the other hand, present with a hyperdynamic circulatory state, increased resting heart rate, elevated myocardial oxygen consumption, and heightened sensitivity to catecholamines. Contrary to the initial description, the actual results of this study show that the rate of intraoperative hypertension was not significantly different between the hyperthyroid and hypothyroid subgroups. However, the incidence of tachycardia was significantly higher in the hyperthyroid subgroup compared to the hypothyroid subgroup ($p = 0.017$), which is consistent with previous observations of a tendency for tachycardia during cesarean section in hyperthyroid patients [8]. Notably, although the incidence of thyroid storm is low, its mortality rate ranges from 8% to 25%, making it one of the most dangerous perinatal complications [18]. Therefore, close perioperative monitoring of blood pressure, heart rate, and prodromal symptoms of thyroid storm is essential in hyperthyroid parturients.

Regarding postoperative pain, the hyperthyroid group had significantly higher 24 h postoperative VAS scores compared to the hypothyroid group. Thyroid hormones can modulate pain perception by influencing neurotransmitter metabolism and pain signaling pathways in the central nervous system [18]. In the hyperthyroid state, increased central nervous system excitability may amplify pain signals. In this study, depression scores were significantly higher in the thyroid dysfunction group compared to the normal group ($p < 0.001$). The high incidence of postpartum mood disorders in hyperthyroid patients may be related to the direct effects of thyroid hormones on the central nervous system, rapid hormonal changes during the postpartum period, and the additional effect of surgical stress [19].

Regarding bowel function recovery, both time to first flatus and time to first defecation were significantly prolonged in the dysfunction group. Thyroid hormones regulate the motility and secretory functions of gastrointestinal smooth muscle; in hypothyroidism, gastrointestinal motility slows down, potentially prolonging postoperative ileus [20]. The delay in the onset of lactation may be related to the regulatory role of thyroid hormones on prolactin secretion and mammary gland development [21].

The subgroup analysis revealed distinct profiles: hypothyroid patients had higher incidences of hypotension and bradycardia, while hyperthyroid patients had higher incidence of tachycardia and greater postoperative pain. These findings support an individualized approach to perioper-

Table 3. Comparison of perioperative characteristics and early postoperative recovery between hypothyroid and hyperthyroid groups.

Variables	Hyperthyroid (n = 14)	Hypothyroid (n = 67)	Statistic	*p*
Intraoperative hypotension, n (%)			$\chi^2 = 4.12$	0.042
No	12 (85.71)	38 (56.72)		
Yes	2 (14.29)	29 (43.28)		
Intraoperative hypertension, n (%)			$\chi^2 = 0.00$	1.000
No	13 (92.86)	62 (92.54)		
Yes	1 (7.14)	5 (7.46)		
Tachycardia, n (%)			$\chi^2 = 5.73$	0.017
No	8 (57.14)	59 (88.06)		
Yes	6 (42.86)	8 (11.94)		
Bradycardia, n (%)			—	0.061
No	14 (100.00)	52 (77.61)		
Yes	0 (0)	15 (22.39)		
Vasopressor use, n (%)			$\chi^2 = 1.27$	0.261
No	9 (64.29)	32 (47.76)		
Yes	5 (35.71)	35 (52.24)		
Postoperative complications, n (%)			$\chi^2 = 1.78$	0.182
No	13 (92.86)	48 (71.64)		
Yes	1 (7.14)	19 (28.36)		
Max MAP decrease (mmHg), mean ± SD	19.01 ± 4.15	19.02 ± 5.38	$t = –0.01$	0.995
Postoperative 6 h VAS score, median (IQR)	5.00 (3.25, 5.00)	5.00 (4.00, 5.00)	Z = –0.04	0.969
Postoperative 24 h VAS score, median (IQR)	6.00 (6.00, 7.00)	5.00 (4.00, 7.00)	Z = –1.63	0.104
Time to first flatus (h), mean ± SD	31.35 ± 7.27	39.04 ± 9.04	$t = –2.98$	0.004
Time to first defecation (h), mean ± SD	64.37 ± 12.50	66.00 ± 15.08	$t = –0.38$	0.707
Onset of lactation (h), mean ± SD	32.28 ± 7.48	30.91 ± 6.91	$t = 0.66$	0.510
EPDS score, median (IQR)	10.00 (7.25, 10.75)	8.00 (7.00, 10.50)	Z = –1.01	0.315
Hospital stay (d), median (IQR)	6.00 (5.25, 6.00)	6.00 (5.00, 6.50)	Z = –0.25	0.799
Treatment information				
Receiving medication, n (%)			$\chi^2 = 0.00$	1.000
No	2 (14.29)	9 (13.43)		
Yes	12 (85.71)	58 (86.57)		
Levothyroxine, n (%)			$\chi^2 = 38.53$	<0.001
No	14 (100.00)	9 (13.43)		
Yes	0 (0)	58 (86.57)		
Methimazole, n (%)			$\chi^2 = 60.80$	<0.001
No	2 (14.29)	67 (100.00)		
Yes	12 (85.71)	0 (0)		

Note: Fisher's exact test was used for categorical variables with small expected frequencies. "—" indicates that no test statistic was reported.

Table 4. Comparison of neonatal outcomes between the two groups.

Variables	Dysfunction (n = 81)	Normal (n = 162)	Statistic	*p*
Birth weight (kg), mean ± SD	3.14 ± 0.45	3.25 ± 0.47	$t = –1.79$	0.075
1 min Apgar score, median (IQR)	9.00 (8.00, 9.00)	9.00 (8.00, 9.00)	Z = –0.43	0.670
5 min Apgar score, median (IQR)	9.00 (9.00, 10.00)	10.00 (9.00, 10.00)	Z = –2.29	0.022
Neonatal hyper, n (%)			—	0.333
No	80 (98.77)	162 (100.00)		
Yes	1 (1.23)	0 (0)		

Note: Fisher's exact test was used for categorical variables with small expected frequencies. "—" indicates that the test statistic is not applicable.

ative management. For hypothyroid patients, preventing and promptly correcting hypotension should be considered a priority [22]. Anesthesiologists should anticipate exaggerated responses to sympathetic blockade, control block level, and prepare vasoactive agents as needed. For hyperthyroid patients, preoperative optimization of thyroid function, avoidance of tachycardia-inducing drugs, and close monitoring of blood pressure and heart rate are essential.

The 5-minute Apgar score was slightly lower in the dysfunction group ($p = 0.022$) but remained within the normal range (≥7), indicating no clinical significance. One neonate (1.23%) born to a mother with hyperthyroidism developed neonatal hyperthyroidism, underscoring the need for neonatal monitoring [23].

The findings of this study have important implications for clinical practice. Regarding preoperative assessment, routine thyroid function screening should be performed in women scheduled for elective cesarean section to identify the type of dysfunction and evaluate the adequacy of thyroid function control. In hypothyroid patients, compliance with and adequacy of levothyroxine replacement therapy should be evaluated; in hyperthyroid patients, the use of antithyroid drugs and the adequacy of thyroid function control should be assessed. For intraoperative management, hypothyroid patients warrant vigilance for post-induction hypotension, appropriate control of the block level, and preparation of vasoactive agents. Hyperthyroid patients require close monitoring of blood pressure and heart rate, avoidance of drugs that can precipitate tachycardia, and vigilance for prodromal signs of thyroid storm. Regarding postoperative management, parturients with thyroid dysfunction need enhanced pain management, promotion of bowel function recovery, monitoring of lactation, and routine screening for higher EPDS scores. Particular attention should be paid to postoperative pain and emotional state in hyperthyroid patients. Furthermore, for patients with poorly controlled thyroid function, a multidisciplinary collaborative approach involving obstetrics, anesthesiology, and endocrinology should be established to formulate individualized perioperative management plans.

This study has several limitations. Due to a single-center retrospective design, potential selection and information biases may exist in this study. In addition, some confounding factors (such as socioeconomic status, family support, history of depression) were not available and therefore could not be adjusted for. Another limitation involved the assessment of thyroid function and preoperative control status. Grouping allocation was based solely on a single thyroid function test performed during the third trimester (32–36 weeks), which were used for group classification. Although we collected information on preoperative medication types and doses, we were unable to systematically report the exact number of patients with persistent biochemical abnormalities (i.e., TSH and/or FT4 still outside the reference range) or their specific TSH/FT4 levels immediately before surgery because of the retrospective nature of the study and the incomplete retrieval of repeated thyroid function tests performed within one week prior to cesarean section. Consequently, we cannot definitively distinguish whether the observed perioperative differences were attributable to: (1) the pre-existing third-trimester dysfunction status, (2) unresolved dysfunction persisting at the time of surgery despite treatment, or (3) inadequate therapeutic control. This distinction is critical, as patients who achieve euthyroid status before surgery may have different perioperative risks from those with ongoing biochemical abnormalities. Future prospective studies should incorporate systematic perioperative thyroid function monitoring and evaluate dose-response relationships between preoperative TSH/FT4 levels and clinical outcomes. In addition, the dose-response relationship between TSH levels and perioperative outcomes was not explored, and risk thresholds were not determined. Finally, only early postoperative recovery indicators were observed, and long-term outcomes (e.g., duration of higher EPDS scores, breastfeeding success rates, long-term infant development) were not assessed.

Based on the results of this study, future research directions could include prospective multicenter cohort studies to expand the sample size, particularly in the hyperthyroidism subgroup, and validate the robustness of these findings. The hyperthyroidism subgroup included only 14 patients, which limits statistical power and increases the risk of type II errors (false negatives) as well as potential false positives. Therefore, all findings from this subgroup comparison should be interpreted as exploratory rather than definitive. Larger prospective studies are needed to confirm these observations. Dynamic thyroid function monitoring should be performed to investigate the association between the trajectory of thyroid function changes across the first, second, and third trimesters and perioperative outcomes. Including baseline SBP and HR as matching covariates may have partially adjusted for the hemodynamic effects of thyroid dysfunction, potentially leading to conservative estimates of effect sizes. However, our primary goal was to assess intraoperative dynamic hemodynamic changes rather than absolute baseline values. Future studies should include intervention trials to evaluate whether preoperative optimization of thyroid function (e.g., adjusting levothyroxine dosage or controlling hyperthyroidism) can improve perioperative outcomes. Mechanistic studies incorporating biomarkers (e.g., catecholamine levels or inflammatory factors) are warranted to explore the molecular mechanisms by which thyroid dysfunction affects perioperative recovery. In addition, health economic evaluations are needed to assess the effects of thyroid dysfunction on hospitalization costs and healthcare resource utilization. Long-term follow-up studies should further investigate maternal and neonatal outcomes, such as the resolution of maternal higher EPDS scores and infant neurodevelopment.

Conclusions

Third-trimester thyroid dysfunction was associated with intraoperative hemodynamic instability and impaired early postoperative recovery in women undergoing cesarean section, with significant differences in clinical characteristics observed between hypothyroid and hyperthyroid patients. Perioperative monitoring should be intensified for parturients with thyroid dysfunction, and individualized management strategies based on the type of thyroid dysfunction should be implemented to improve maternal and neonatal outcomes.

Availability of Data and Materials

The data analyzed are available from the corresponding author upon reasonable request.

Author Contributions

GJY and JS designed the research study. GJY performed the research. JS analyzed the data and drafted the article. Both authors have been involved in revising the manuscript critically for important intellectual content. Both authors gave final approval of the version to be published. Both authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

The study was approved by the Ethics Committee of Yuhuan Second People's Hospital (approval number: 2604), and all procedures followed the principles of the Declaration of Helsinki. Given the retrospective nature of the study and the fact that patient data were anonymized before analysis, the requirement for informed consent was waived.

Acknowledgment

Not applicable.

Funding

This research received no external funding.

Conflict of Interest

The authors declare no conflict of interest.

References

[1] Alexander EK, Pearce EN, Brent GA, Brown RS, Chen H, Dosiou C, et al. 2017 Guidelines of the American Thyroid Association for the Diagnosis and Management of Thyroid Disease During Pregnancy and the Postpartum. Thyroid : Official Journal of the American Thyroid Association. 2017; 27: 315–389. https://doi.org/10.1089/thy.2016.0457

[2] Korevaar TIM, Medici M, Visser TJ, Peeters RP. Thyroid disease in pregnancy: new insights in diagnosis and clinical management. Nature Reviews. Endocrinology. 2017; 13: 610–622. https://doi.org/10.1038/nrendo.2017.93

[3] Taylor PN, Albrecht D, Scholz A, Gutierrez-Buey G, Lazarus JH, Dayan CM, et al. Global epidemiology of hyperthyroidism and hypothyroidism. Nature Reviews. Endocrinology. 2018; 14: 301–316. https://doi.org/10.1038/nrendo.2018.18

[4] Klein I, Danzi S. Thyroid disease and the heart. Circulation. 2007; 116: 1725–1735. https://doi.org/10.1161/CIRCULATIONAHA.106.678326

[5] Eftekharian F, Rastegarian A, Kargarfard A, Kalani N, Mogharab F, Mousavi S, et al. Comparison of hemodynamic changes and level of spinal anesthesia in patients with hypothyroidism and control group undergoing caesarean section with spinal anesthesia: a case-control study. The Iranian Journal of Obstetrics, Gynecology and Infertility. 2023; 26: 23–33. https://doi.org/10.22038/ijogi.2023.22355

[6] Govil V, Rashmi R, Ritu R, Rani A, Puhal S, Bajaj N. Anesthetic management of a pregnant patient with uncontrolled hyperthyroidism for an emergency caesarean section: a case report. Journal of Preventive and Complementary Medicine. 2023; 2: 163–167. https://doi.org/10.22034/ncm.2023.412332.1112

[7] Kinsella SM, Carvalho B, Dyer RA, Fernando R, McDonnell N, Mercier FJ, et al. International consensus statement on the management of hypotension with vasopressors during caesarean section under spinal anaesthesia. Anaesthesia. 2018; 73: 71–92. https://doi.org/10.1111/anae.14080

[8] Akamizu T, Satoh T, Isozaki O, Suzuki A, Wakino S, Iburi T, et al. Diagnostic criteria, clinical features, and incidence of thyroid storm based on nationwide surveys. Thyroid : Official Journal of the American Thyroid Association. 2012; 22: 661–679. https://doi.org/10.1089/thy.2011.0334

[9] Gupta RD. Thyroid disorders in pregnancy. Current Medical Issues. 2018; 16: 48–51. https://doi.org/10.4103/cmi.cmi_23_18

[10] Kent GN, Stuckey BG, Allen JR, Lambert T, Gee V. Postpartum thyroid dysfunction: clinical assessment and relationship to psychiatric affective morbidity. Clinical Endocrinology. 1999; 51: 429–438. https://doi.org/10.1046/j.1365-2265.1999.00807.x

[11] van der Kaay DCM, Wasserman JD, Palmert MR. Management of Neonates Born to Mothers With Graves' Disease. Pediatrics. 2016; 137: e20151878. https://doi.org/10.1542/peds.2015-1878

[12] Hendrix JM, Garmon EH. American Society of Anesthesiologists Physical Status Classification System. StatPearls Publishing LLC: Treasure Island (FL). 2026.

[13] Gao X, Li Y, Li J, Liu A, Sun W, Teng W, et al. Gestational TSH and FT4 Reference Intervals in Chinese Women: A Systematic Review and Meta-Analysis. Frontiers in Endocrinology. 2018; 9: 432. https://doi.org/10.3389/fendo.2018.00432

[14] Huskisson EC. Measurement of pain. Lancet (London, England). 1974; 2: 1127–1131. https://doi.org/10.1016/s0140-6736(74)90884-8

[15] Cox JL, Holden JM, Sagovsky R. Detection of postnatal depression. Development of the 10-item Edinburgh Postnatal Depression Scale. The British Journal of Psychiatry : the Journal of Mental Science. 1987; 150: 782–786. https://doi.org/10.1192/bjp.150.6.782

[16] Udovcic M, Pena RH, Patham B, Tabatabai L, Kansara A. Hypothyroidism and the Heart. Methodist DeBakey Cardiovascular Journal. 2017; 13: 55–59. https://doi.org/10.14797/mdcj-13-2-55

[17] Butwick AJ, Columb MO, Carvalho B. Preventing spinal hypotension during Caesarean delivery: what is the latest? British Journal of Anaesthesia. 2015; 114: 183–186. https://doi.org/10.1093/bja/aeu267

[18] Aloisi AM, Vodo S, Buonocore M. Pain and thyroid hormones. Neurological Sciences : Official Journal of the Italian Neurological Society and of the Italian Society of Clinical Neurophysiology. 2013; 34: 1501–1508. https://doi.org/10.1007/s10072-013-1440-7

[19] Lambrinoudaki I, Rizos D, Armeni E, Pliatsika P, Leonardou A, Sygelou A, et al. Thyroid function and postpartum mood disturbances in Greek women. Journal of Affective Disorders. 2010; 121: 278–282. https://doi.org/10.1016/j.jad.2009.07.001

[20] Daher R, Yazbeck T, Jaoude JB, Abboud B. Consequences of dysthyroidism on the digestive tract and viscera. World Journal of Gastroenterology. 2009; 15: 2834–2838. https://doi.org/10.3748/wjg.15.2834

[21] Varas SM, Muñoz EM, Hapon MB, Aguilera Merlo CI, Giménez MS, Jahn GA. Hyperthyroidism and production of precocious involution in the mammary glands of lactating rats. Reproduction (Cambridge, England). 2002; 124: 691–702.

[22] Mercier FJ, Augè M, Hoffmann C, Fischer C, Le Gouez A. Maternal hypotension during spinal anesthesia for caesarean delivery. Minerva Anestesiologica. 2013; 79: 62–73.

[23] Léger J. Management of Fetal and Neonatal Graves' Disease. Hormone Research in Paediatrics. 2017; 87: 1–6. https://doi.org/10.1159/000453065