

Relationship Between Serum Thyroid-Stimulating Hormone and Lipid Profile Parameters, Including the Lipid Tetrad Index, in Patients with Hypothyroidism

Kamini Swetha¹, Neha Agrawal²

¹Ph.D Scholar, Department of Biochemistry, IMCH&RC, Malawanchal University, Indore, Madhya Pradesh, India. ²Research Supervisor, Department of Biochemistry, IMCH&RC, Malawanchal University, Indore, Madhya Pradesh, India

Abstract

Background: Hypothyroidism is commonly associated with dyslipidaemia and an increased atherogenic lipid burden. Thyroid hormone deficiency may influence total cholesterol, triglycerides, LDL-C, and HDL-C. Composite lipid indices may provide an integrated assessment of lipid-related risk. **Material and Methods:** This observational cross-sectional study included 300 patients with hypothyroidism. Serum TSH, FT4, total cholesterol, triglycerides, HDL-C, and LDL-C were evaluated. The Lipid Tetrad Index was calculated using the formula: (total cholesterol × triglycerides × LDL-C)/HDL-C. Correlation analysis was performed to evaluate the relationship between serum TSH and lipid parameters. **Results:** The mean serum TSH concentration was 9.34 ± 5.35 mIU/L, while the mean Lipid Tetrad Index was 4.17 ± 1.48 . Serum TSH showed statistically significant positive correlations with total cholesterol ($r = 0.320$, $p < 0.001$), triglycerides ($r = 0.254$, $p < 0.001$), LDL-C ($r = 0.288$, $p < 0.001$), and Lipid Tetrad Index ($r = 0.117$, $p = 0.043$). No statistically significant correlation was observed between serum TSH and HDL-C ($r = 0.052$, $p = 0.368$). **Conclusion:** Increasing serum TSH concentrations were associated with adverse changes in conventional lipid parameters and a higher Lipid Tetrad Index. Comprehensive lipid evaluation may therefore be important in patients with hypothyroidism.

Keywords: Hypothyroidism; thyroid-stimulating hormone; dyslipidaemia; cholesterol; triglycerides; Lipid Tetrad Index.

Received: 22 August 2026

Revised: 10 September 2026

Accepted: 29 September 2026

Published: 06 October 2026

INTRODUCTION

Thyroid hormones play an important role in maintaining normal lipid homeostasis. They influence hepatic cholesterol metabolism, lipoprotein synthesis and clearance, LDL receptor activity, triglyceride metabolism, and energy expenditure.^[1-3]

Hypothyroidism is frequently associated with dyslipidaemia, particularly increased total cholesterol and LDL-C concentrations. Triglycerides may also be elevated, whereas alterations in HDL-C are more variable.^[1-4]

The severity of thyroid dysfunction is commonly assessed using serum TSH. Increasing serum TSH concentrations have been associated with progressively unfavorable changes in lipid metabolism in both overt and subclinical hypothyroidism.^[5,6]

Systematic reviews and meta-analyses have demonstrated that hypothyroidism is associated with significant alterations in total cholesterol and LDL-C. Improvement in thyroid function following levothyroxine therapy may also result in favorable changes in lipid parameters.^[7,8]

Although conventional lipid parameters provide important clinical information, individual measurements may not completely represent the overall atherogenic burden. Composite lipid indices have therefore been proposed to integrate multiple lipid abnormalities.^[9,10]

The Lipid Tetrad Index used in the present study was calculated as:

Lipid Tetrad Index = (Total Cholesterol × Triglycerides × LDL-C)/HDL-C

The simultaneous incorporation of total cholesterol, triglycerides, LDL-C, and HDL-C may provide an integrated representation of lipid-related metabolic risk.

Therefore, the present study evaluated the relationship between serum TSH, conventional lipid parameters, and the Lipid Tetrad Index in patients with hypothyroidism.

MATERIALS AND METHODS

This study was designed as an observational cross-sectional analytical study at tertiary care hospital at a tertiary-care teaching hospital in Indore, Madhya Pradesh, India, and this study included a total of 300 patients with hypothyroidism. The study was undertaken to evaluate thyroid function, conventional lipid parameters, and the composite lipid-related risk represented by the Lipid Tetrad Index (LTI).

Address for correspondence: Dr. Neha Agrawal, Research Supervisor, Department of Biochemistry, IMCH&RC, Malawanchal University, Indore, Madhya Pradesh, India. E-mail: nehaagrawal1234@gmail.com

DOI:
10.21276/amt.2026.v13.i3.1096

How to cite this article: Swetha K, Agrawal N. Relationship Between Serum Thyroid-Stimulating Hormone and Lipid Profile Parameters, Including the Lipid Tetrad Index, in Patients with Hypothyroidism. Acta Med Int. 2026;13(3):494-499.

Biochemical assessment included the measurement of serum thyroid-stimulating hormone (TSH) and free thyroxine (FT4) to evaluate thyroid function. The lipid profile was assessed by estimating total cholesterol, triglycerides, high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C).

Calculation of Lipid Tetrad Index

The Lipid Tetrad Index was calculated using the following formula:

$$\text{LTI} = (\text{Total Cholesterol} \times \text{Triglycerides} \times \text{LDL-C}) / \text{HDL-C}$$

Statistical Analysis: The collected data were compiled, tabulated, and analysed using appropriate statistical methods. Correlation analysis was performed to assess the strength and direction of the association between serum thyroid-stimulating hormone (TSH) concentrations and conventional lipid parameters, including total cholesterol, triglycerides,

HDL-C, and LDL-C, as well as the Lipid Tetrad Index (LTI).

The magnitude and direction of the observed relationships were evaluated using the appropriate correlation coefficient. All statistical tests were two-sided, and a p-value of less than 0.05 ($p < 0.05$) was considered statistically significant.

RESULTS

The study population had a mean age of 43.32 ± 12.53 years. Of the total participants, 191 (63.7%) were female and 109 (36.3%) were male, indicating a predominance of female patients. The mean body mass index (BMI) of the participants was 25.86 ± 4.26 kg/m². The mean duration of hypothyroidism was 4.26 ± 2.76 years. Regarding treatment status, 240 participants (80.0%) were receiving levothyroxine therapy at the time of the study. [Table 1]

Table 1: Baseline characteristics of the study population

Characteristic	Value
Age (years), mean $\pm$ SD	43.32 ± 12.53
Female, n (%)	191 (63.7)
Male, n (%)	109 (36.3)
BMI (kg/m ²), mean $\pm$ SD	25.86 ± 4.26
Duration of hypothyroidism (years), mean $\pm$ SD	4.26 ± 2.76
Levothyroxine therapy, n (%)	240 (80.0)

Thyroid Function Parameters: The mean serum TSH concentration was 9.34 ± 5.35 mIU/L, and the mean FT4

concentration was 1.02 ± 0.12 ng/dL. [Table 2]

Table 2: Thyroid function parameters

Parameter	Mean $\pm$ SD
TSH (mIU/L)	9.34 ± 5.35
FT4 (ng/dL)	1.02 ± 0.12

Lipid Profile and Lipid Tetrad Index: The mean Lipid Tetrad Index (LTI) among the study participants was $4.17 \pm$

1.48, indicating the overall composite lipid-related burden in the study population.

Table 3: Lipid-related biochemical parameters

Parameter	Mean $\pm$ SD
Lipid Tetrad Index	4.17 ± 1.48

Correlation Between Serum TSH and Lipid Parameters:

Correlation analysis demonstrated that serum TSH had statistically significant positive correlations with several lipid parameters. Serum TSH showed a significant positive correlation with total cholesterol ($r = 0.320$, $p < 0.001$), indicating that higher TSH concentrations were associated with increased total cholesterol levels. Similarly, serum TSH showed significant positive correlations with triglycerides (r

$= 0.254$, $p < 0.001$) and LDL-C ($r = 0.288$, $p < 0.001$). However, the correlation between serum TSH and HDL-C was not statistically significant ($r = 0.052$, $p = 0.368$). Overall, these findings indicate that higher serum TSH concentrations were associated with an adverse lipid profile, particularly for total cholesterol, triglycerides, and LDL-C. [Table 4]

Table 4: Correlation between serum TSH and conventional lipid parameters

Lipid parameter	Correlation coefficient (r)	p-value	Interpretation
Total cholesterol	0.320	<0.001	Significant positive correlation
Triglycerides	0.254	<0.001	Significant positive correlation
LDL-C	0.288	<0.001	Significant positive correlation
HDL-C	0.052	0.368	Not significant

Correlation Between Serum TSH and Lipid Tetrad Index: Serum TSH demonstrated a statistically significant

positive correlation with the Lipid Tetrad Index ($r = 0.117$, $p = 0.043$). [Table 5]

Table 5: Correlation between serum TSH and Lipid Tetrad Index

Variable	Correlation coefficient (r)	p-value	Interpretation
Lipid Tetrad Index	0.117	0.043	Significant positive correlation

DISCUSSION

The present observational cross-sectional study evaluated the relationship between serum thyroid-stimulating hormone (TSH) concentrations and conventional lipid parameters, including total cholesterol, triglycerides, high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), and the composite Lipid Tetrad Index (LTI), among 300 patients with hypothyroidism. The study population had a mean serum TSH concentration of 9.34 ± 5.35 mIU/L and demonstrated statistically significant positive correlations between TSH and total cholesterol, triglycerides, LDL-C, and LTI. However, the correlation between TSH and HDL-C was not statistically significant. Overall, these findings indicate that increasing thyroid dysfunction, as reflected by higher serum TSH concentrations, is associated with a progressively adverse lipid profile and increased composite lipid-related risk.

Relationship Between Serum TSH and Total Cholesterol

In the present study, serum TSH demonstrated a statistically significant positive correlation with total cholesterol ($r = 0.320$, $p < 0.001$). This was the strongest association observed among the conventional lipid parameters evaluated. The finding suggests that increasing severity of thyroid dysfunction is associated with increasing serum total cholesterol concentrations.

This observation is consistent with the established physiological role of thyroid hormones in hepatic cholesterol metabolism. Thyroid hormone deficiency reduces hepatic LDL receptor expression and decreases the clearance of circulating LDL-containing lipoproteins. In addition, alterations in cholesterol synthesis, bile acid metabolism, and lipoprotein turnover may contribute to the accumulation of circulating cholesterol in hypothyroidism.^[1-3]

The findings of the present study are consistent with the broader evidence demonstrating an association between hypothyroidism and hypercholesterolaemia. A systematic review and meta-analysis by Kotwal et al,^[11] demonstrated that hypothyroidism is associated with adverse alterations in serum lipids, particularly total cholesterol and LDL-C. The same analysis showed substantial reductions in total cholesterol following levothyroxine replacement therapy in patients with overt hypothyroidism, supporting the biological relationship between thyroid hormone deficiency and impaired cholesterol metabolism.^[11]

Similarly, a more recent systematic review by Akhtar et al,^[12] reported that levothyroxine therapy generally produces favourable reductions in total cholesterol and LDL-C in patients with hypothyroidism. These findings further support the interpretation that thyroid dysfunction contributes substantially to dyslipidaemia and that restoration of thyroid hormone status may improve lipid metabolism.

Therefore, the positive association between TSH and total cholesterol observed in the present study is in agreement with the established metabolic consequences of hypothyroidism

and reinforces the importance of evaluating cholesterol levels in patients with elevated TSH concentrations.

Relationship Between Serum TSH and LDL-C

The present study demonstrated a statistically significant positive correlation between serum TSH and LDL-C ($r = 0.288$, $p < 0.001$). This finding indicates that higher TSH concentrations were associated with higher LDL-C levels among the study participants.

Elevated LDL-C is considered one of the most important lipid abnormalities associated with hypothyroidism. Reduced thyroid hormone activity decreases hepatic LDL receptor-mediated uptake and clearance of circulating LDL particles, resulting in prolonged LDL residence time and increased plasma LDL-C concentrations.^[1-3]

The present findings are supported by the systematic review and meta-analysis of Kotwal et al,^[11] which demonstrated significant reductions in LDL-C following levothyroxine therapy, particularly in overt hypothyroidism. Their findings provide strong evidence that thyroid hormone status has an important influence on LDL metabolism.^[11]

Evidence from randomized trials in subclinical hypothyroidism has also demonstrated improvement in total cholesterol and LDL-C following levothyroxine treatment. A systematic review and meta-analysis by Li et al,^[13] reported significant reductions in total cholesterol and LDL-C following thyroid hormone replacement, although changes in HDL-C and triglycerides were less consistent.^[13]

These observations are relevant to the present study because LDL-C represents a major atherogenic lipid fraction. The positive association between serum TSH and LDL-C therefore suggests that worsening thyroid dysfunction may contribute to an increasing atherogenic burden and potentially greater long-term cardiovascular risk.

Relationship Between Serum TSH and Triglycerides

A statistically significant positive correlation was also observed between serum TSH and triglycerides ($r = 0.254$, $p < 0.001$). This indicates that patients with higher TSH concentrations tended to have higher triglyceride levels.

The effect of hypothyroidism on triglyceride metabolism is biologically plausible. Thyroid hormones influence the activity of several enzymes involved in the metabolism and clearance of triglyceride-rich lipoproteins. Reduced thyroid hormone activity may impair lipoprotein lipase-mediated clearance and alter hepatic lipid metabolism, resulting in increased circulating triglyceride concentrations.^[1-3]

The relationship between hypothyroidism and triglycerides, however, has been somewhat more variable across previous studies than the relationship with total cholesterol and LDL-C. Differences in obesity, insulin resistance, dietary factors, diabetes mellitus, disease severity, and levothyroxine treatment status may influence triglyceride concentrations and contribute to variation between study populations.

The present findings nevertheless support evidence that triglyceride abnormalities may form part of the dyslipidaemic pattern associated with hypothyroidism. Recent systematic

evidence has also reported improvement in triglyceride concentrations following levothyroxine therapy in hypothyroid populations, although the magnitude of change may vary according to the severity of thyroid dysfunction and patient characteristics.^[11,12]

Thus, the significant positive correlation observed in the present study suggests that increasing TSH concentrations may be associated not only with cholesterol abnormalities but also with impaired triglyceride metabolism.

Relationship Between Serum TSH and HDL-C

In contrast to total cholesterol, LDL-C, and triglycerides, the present study did not demonstrate a statistically significant correlation between serum TSH and HDL-C ($r = 0.052$, $p = 0.368$).

This finding is consistent with the heterogeneous results reported in previous investigations regarding the effect of hypothyroidism on HDL-C. Unlike LDL-C, the relationship between thyroid dysfunction and HDL-C is influenced by multiple metabolic mechanisms, including HDL synthesis, cholesteryl ester transfer, hepatic lipase activity, and reverse cholesterol transport. Consequently, HDL-C concentrations may not change uniformly with increasing TSH concentrations.

Evidence from systematic reviews has also shown that changes in HDL-C following thyroid hormone replacement are less consistent than changes in total cholesterol and LDL-C. For example, randomized evidence in subclinical hypothyroidism demonstrated significant reductions in total cholesterol and LDL-C without a statistically significant effect on HDL-C.^[13] Similarly, variation in HDL-C responses has been observed across studies of thyroid dysfunction and levothyroxine treatment.^[11]

The absence of a significant association between TSH and HDL-C in the present study should therefore be interpreted within this context. HDL-C alone may not adequately reflect the complex changes in lipoprotein metabolism occurring in hypothyroidism, which supports the value of evaluating multiple lipid parameters simultaneously.

Relationship Between Serum TSH and the Lipid Tetrad Index

An important finding of the present study was the statistically significant positive correlation between serum TSH and the Lipid Tetrad Index ($r = 0.117$, $p = 0.043$). Although the magnitude of the correlation was relatively weak, its statistical significance suggests that increasing thyroid dysfunction was associated with an increase in composite lipid-related risk.

The Lipid Tetrad Index incorporates total cholesterol, triglycerides, LDL-C, and HDL-C into a single composite measure:

$$\text{Lipid Tetrad Index} = (\text{Total Cholesterol} \times \text{Triglycerides} \times \text{LDL-C}) / \text{HDL-C}$$

The advantage of such a composite index is that it simultaneously incorporates several atherogenic and protective lipid components. In the present study, the positive association between TSH and LTI reflects the combined contribution of increasing total cholesterol, LDL-C, and triglycerides with changing thyroid status.

The finding is particularly relevant because conventional

lipid parameters may individually underestimate the overall metabolic burden associated with hypothyroidism. Composite lipid indices may provide additional information by integrating multiple components of dyslipidaemia.

Previous research has similarly suggested that composite atherogenic indices may demonstrate significant associations with thyroid dysfunction. For example, a case-control study from South India reported significantly higher atherogenic index values among women with subclinical hypothyroidism and demonstrated a significant positive correlation between TSH and the Atherogenic Index of Plasma.^[14]

The present findings therefore extend this concept to the Lipid Tetrad Index and suggest that composite lipid assessment may be useful in identifying the cumulative lipid-related consequences of thyroid dysfunction.

However, because the correlation between TSH and LTI in the present study was relatively weak ($r = 0.117$), the result should be interpreted cautiously. Lipid metabolism is influenced by several additional factors, including age, sex, body mass index, dietary habits, insulin resistance, physical activity, duration of hypothyroidism, and treatment status. Therefore, TSH alone is unlikely to determine the complete lipid profile of an individual patient.

Comparison With Previous Studies

The overall pattern observed in the present study is broadly consistent with previous research demonstrating that hypothyroidism is associated predominantly with increased total cholesterol and LDL-C, while changes in triglycerides and HDL-C may be more variable.

The systematic review and meta-analysis by Kotwal et al,^[11] provided strong evidence that treatment of hypothyroidism with levothyroxine is associated with improvement in lipid parameters, particularly total cholesterol and LDL-C. This supports the biological interpretation of the present findings that higher TSH concentrations are associated with an increasingly adverse lipid profile.

Similarly, Akhtar et al,^[12] concluded that levothyroxine therapy generally has beneficial effects on total cholesterol, LDL-C, and triglyceride concentrations in patients with hypothyroidism.^[12]

However, not all population-based studies have demonstrated strong correlations between serum TSH and every lipid parameter. A community-based investigation reported that the relationship between TSH and lipid parameters may vary according to demographic and clinical characteristics, including age, sex, and other metabolic factors.^[15]

These differences between studies may be explained by several methodological and clinical factors:

1. Severity of hypothyroidism: Lipid abnormalities may be more pronounced in overt hypothyroidism than in mild or subclinical disease.
2. Treatment status: Levothyroxine therapy may partially correct thyroid-related lipid abnormalities.
3. Duration of disease: Chronic thyroid hormone deficiency may have different metabolic consequences than recently diagnosed disease.
4. Body mass index and insulin resistance: These factors independently influence triglycerides and other lipid parameters.
5. Age and sex distribution: Lipid metabolism differs

substantially according to demographic characteristics.

6. Study design and sample size: Cross-sectional and longitudinal studies may produce different estimates of association.

These considerations are particularly important in the interpretation of the present findings, as 80% of the study population was receiving levothyroxine therapy. Treatment status may have modified the magnitude of the observed associations between TSH and lipid parameters.

Clinical Implications

The findings of the present study have important clinical implications. The significant positive correlations between serum TSH and total cholesterol, triglycerides, and LDL-C suggest that patients with inadequate thyroid control may be at increased risk of dyslipidaemia.

Therefore, assessment of thyroid function should be considered when evaluating unexplained or persistent abnormalities in the lipid profile. Conversely, lipid evaluation may be clinically valuable in patients with hypothyroidism, particularly in those with elevated or inadequately controlled TSH concentrations.

The significant association between TSH and the Lipid Tetrad Index further suggests that composite lipid measures may provide supplementary information regarding the overall lipid-related burden. Rather than relying exclusively on a single lipid parameter, comprehensive evaluation of total cholesterol, triglycerides, LDL-C, HDL-C, and potentially composite lipid indices may provide a broader assessment of metabolic and cardiovascular risk.

Strengths and Limitations of this study

A major strength of the present study was the relatively large sample size of 300 patients with hypothyroidism and the simultaneous evaluation of conventional lipid parameters together with the Lipid Tetrad Index. The study therefore provides an integrated assessment of the relationship between thyroid dysfunction and lipid-related metabolic abnormalities.

Nevertheless, several limitations should be considered. First, the cross-sectional design identifies associations but cannot establish causality. Second, the study included patients receiving levothyroxine therapy, which may have influenced both TSH concentrations and lipid parameters. Third, factors such as dietary habits, physical activity, insulin resistance, medication use, and other metabolic variables may have affected lipid concentrations. Finally, the relatively weak correlation between TSH and LTI indicates that composite lipid risk is influenced by multiple determinants beyond thyroid function alone.

Future prospective studies with detailed adjustment for metabolic confounders and evaluation of changes in lipid parameters following achievement of euthyroidism would provide additional evidence regarding the temporal relationship between thyroid function and composite lipid risk.

CONCLUSION

The present study demonstrated that serum thyroid-stimulating hormone (TSH) was significantly positively

correlated with total cholesterol, triglycerides, low-density lipoprotein cholesterol (LDL-C), and the Lipid Tetrad Index among patients with hypothyroidism. In contrast, no statistically significant association was observed between serum TSH and high-density lipoprotein cholesterol (HDL-C). These findings indicate that increasing thyroid dysfunction, reflected by higher serum TSH concentrations, is associated with a progressively adverse lipid profile and an increased overall lipid-related burden. The significant, although relatively weak, association between TSH and the Lipid Tetrad Index further suggests that composite lipid indices may provide supplementary information beyond individual lipid parameters. Therefore, comprehensive assessment of thyroid function and lipid abnormalities may be valuable in the clinical evaluation and management of patients with hypothyroidism. However, because of the cross-sectional nature of the study, these associations should not be interpreted as evidence of causality, and prospective studies are needed to further clarify the relationship between thyroid status and lipid-related cardiovascular risk.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Abha P, Keshari JR, Sinha SR, Nishant K, Kumari R, Prakash P. Association of thyroid function with lipid profile in patients with metabolic syndrome: a prospective cross-sectional study in the Indian population. *Cureus*. 2023;15(9):e44745. doi:10.7759/cureus.44745..
2. Rizos CV, Elisaf MS, Liberopoulos EN. Effects of thyroid dysfunction on lipid profile. *Open Cardiovasc Med J*. 2011;5:76–84.
3. Duntas LH, Brenta G. Cardiovascular risk and subclinical hypothyroidism: focus on lipids and new emerging risk factors. What is the evidence? *Thyroid*. 2007;17(11):1075–1084.
4. Peppia M, Betsi G, Dimitriadis G. Lipid abnormalities and cardiometabolic risk in patients with overt and subclinical thyroid disease. *J Lipids*. 2011;2011:575840.
5. Treister-Goltzman Y, Yarla S, Peleg R. Lipid profile in mild subclinical hypothyroidism: systematic review and meta-analysis. *Minerva Med*. 2021;46(4):428–440.
6. Li X, Wang Y, Guan Q, Zhao J, Gao L. The lipid-lowering effect of levothyroxine in patients with subclinical hypothyroidism: a systematic review and meta-analysis of randomized controlled trials. *Clin Endocrinol (Oxf)*. 2017;87(1):1–9.
7. Nishat S, Mueka IN, Hassan MU, Pandey RK, Lwin BB, Vashishta A, et al. Effect of levothyroxine therapy on the lipid profile of patients with hypothyroidism: a systematic review. *Cureus*. 2024;16(7):e65218.
8. Abreu IM, Lau E, de Sousa Pinto B, Carvalho D. Subclinical hypothyroidism: to treat or not to treat, that is the question! A systematic review with meta-analysis on lipid profile. *Endocr Connect*. 2017;6(3):188–199.
9. Grundy SM, Stone NJ, Bailey AL, Beam C, Birtcher KK, Blumenthal RS, et al. 2018 guideline on the management of blood cholesterol. *Circulation*. 2019;139(25):e1082–e1143.
10. Rodondi N, den Elzen WPJ, Bauer DC, Cappola AR, Razvi S, Walsh JP, et al. Subclinical hypothyroidism and the risk of coronary heart disease and mortality. *JAMA*. 2010;304(12):1365–1374.

11. Kotwal A, Cortes T, Genere N, Hamidi O, Jasim S, Newman CB, et al. Treatment of thyroid dysfunction and serum lipids: a systematic review and meta-analysis. *J Clin Endocrinol Metab.* 2020;105(12):3683-3694. doi:10.1210/clinem/dgaa672.
12. Akhtar F, Khan MA, Saleem A, Yousaf J, Hussain S, Qandeel M, et al. Effects of thyroid hormone replacement therapy on lipid profiles in patients with hypothyroidism. *Cureus.* 2025;17(9):e93130. doi:10.7759/cureus.93130.
13. Li X, Wang Y, Guan Q, Zhao J, Gao L. The lipid-lowering effect of levothyroxine in patients with subclinical hypothyroidism: a systematic review and meta-analysis of randomized controlled trials. *Clin Endocrinol (Oxf).* 2017;87(1):1-9. doi:10.1111/cen.13338.
14. Nishat S, Mueka IN, Hassan MU, Pandey RK, Lwin BB, Vashishta A, et al. Effect of levothyroxine therapy on the lipid profile of patients with hypothyroidism: a systematic review. *Cureus.* 2024;16(7):e65218. doi:10.7759/cureus.65218.
15. Alamdari S, Amouzegar A, Tohidi M, Gharibzadeh S, Kheirkhah P, Kheirkhah P, Azizi F. Hypothyroidism and lipid levels in a community based study (TTS). *Int J Endocrinol Metab.* 2016;14(1):e22827. doi:10.5812/ijem.22827.