stage or overall TNM classification (p>0.05). The only exception was the N category (regional lymph nodes) of the TNM classification, which differed significantly between the groups (p=0.04). Nevertheless, the Cochran–Armitage test revealed statistically significant linear trends for disease stage (χ^2=4.1; p=0.04) and for the T and N categories of the TNM classification (χ^2=4.5; p=0.03 and χ^2=6.0; p=0.02, respectively). The test was not performed for the M category (metastases) because this variable was binary. Thus, as disease severity increased, the proportion of patients reporting OOP payments also increased. OOP payments were less frequent among patients with localized disease (stages 0-II), T0, Tis, and T1 tumors, and N0 or N1 nodal status according to the TNM classification, whereas they were more frequent among patients with more advanced disease.

Patients with metastases and those reporting disease progression incurred OOP payments significantly more frequently (p<0.001 and p=0.001, respectively).

DISCUSSION

In a systematic review, Iragorri et al. [17] found that CRC is associated with a higher burden of OOP payments among cancer patients. Furthermore, cancer patients in low- and middle-income countries may incur OOP costs amounting to 42% of their annual income, compared with 16% in high-income countries.

From a clinical perspective, disease stage and TNM classification are important determinants of prognosis in patients with CRC; however, a higher stage is not always associated with a poorer prognosis [9, 10]. For example, according to the NCCN guidelines for rectal cancer, the T category of the TNM classification is of particular prognostic importance. Specifically, the prognosis for stage IIIA (T1-T2) is more favorable than that for the lower stages IIA (T3), IIB (T4a), and IIC (T4b), which are characterized by a greater extent of tumor invasion according to the T category [9, 10]. In the present study, an increase in the T category was accompanied by a statistically significant linear trend toward a higher frequency of OOP payments (p=0.03). Similarly, Rose et al. [18] reported that the magnitude of OOP payments consistently increased with increasing disease stage. The present study also demonstrated a statistically significant linear trend toward a higher frequency of OOP payments with advancing disease stage (p=0.04). However, Donkor et al. [8] found no association between disease stage and financial toxicity, whereas Shao et al. [7] identified disease stage as a significant factor associated with this phenomenon.

The presence of metastases can double OOP payments during CRC treatment [11], which is consistent with the statistically significant difference in OOP payment frequency observed in the present study. Specifically, OOP payments were more frequent among patients with metastases (39.5%) than among those without metastases (21.6%).

The present study also demonstrated statistically significant differences between the OOP payment groups in the N category of the TNM classification, but not in the T or M categories. These findings are consistent with the review by Yu et al. [19], which identified lymph node involvement as a class I negative prognostic factor for CRC, based on strong evidence. According to that review, lymph node involvement is an important determinant of poorer prognosis. The higher frequency of OOP payments observed among patients with lymph node involvement may therefore reflect the greater clinical severity of disease and its potential association with poorer prognosis.

Prolonged time to treatment initiation for chemotherapy is associated with reduced overall and disease-specific survival [20, 21], which aligns with the higher prevalence of OOP payments observed among patients with a waiting period exceeding 2 months in the present analysis.

The findings indicate that the setting of chemotherapy administration (outpatient vs. inpatient) was not associated with the frequency of OOP payments. However, according to Joo et al. [22], outpatient chemotherapy may reduce treatment-related healthcare costs.

Donkor et al. [8] specifically investigated treatment-related financial toxicity among cancer patients in low- and middle-income countries. The authors found that patients who received more than six chemotherapy cycles were nearly twice as likely to experience financial toxicity (p=0.05). In the present study, no statistically significant difference was found between the groups with regard to the number of completed chemotherapy cycles (p=0.09). However, a statistically significant linear trend toward an increasing frequency of OOP payments was observed as the number of completed cycles increased (p=0.03).

According to Ben-Aharon et al. [15], patients' willingness to incur OOP payments in cancer care is influenced not only by disease stage but also by subjective perceptions of treatment benefits, including the potential for symptom relief, improved quality of life, and prolonged survival.

According to the literature, body weight and changes in body weight are important prognostic indicators of survival in patients with CRC.

Specifically, underweight patients (BMI <18.5 kg/m²) have a significantly higher risk of postoperative complications and 30-day mortality and poorer overall survival than normal-weight patients, regardless of cancer stage [16,23]. Hu et al. [12] further reported that weight loss, particularly exceeding 5%, is an unfavorable prognostic factor for survival. Low BMI and weight loss may reflect not only nutritional deficiency but also cancer cachexia and increased metabolic activity associated with more aggressive disease, potentially accompanied by systemic inflammation. Accordingly, underweight patients and those experiencing substantial weight loss may have a higher risk of disease recurrence and mortality. Li et al. [24] also identified underweight as a negative prognostic factor for CRC, while Yu et al. [19] emphasized sarcopenia as another adverse prognostic factor.

Arkenbosch et al. [23] reported that underweight is frequently associated with a more severe disease course and more advanced tumor stage. Conversely, Arkenbosch et al. [23], Li et al. [24], and Zhang et al. [25] described the potential protective effect of overweight and the "obesity paradox," which has been associated with better overall and disease-specific survival in some patient populations. Yu et al. [19] identified higher nutritional status scores as an important independent prognostic factor for improved overall survival.

It may be hypothesized that greater energy reserves enable patients to better tolerate the toxic effects of chemotherapy, particularly in advanced stages of disease. However, the relationship between body weight and prognosis is not linear, and obesity may also be associated with an increased risk of adverse outcomes. Furthermore, Hu et al. [12] reported a lower risk of death among patients with stable body weight or weight loss of up to 5%.

In the present study, OOP payments were more frequent among underweight patients (BMI <18.5 kg/m²) and those with substantial weight loss (≥10%) ($p<0.05$). This finding may reflect patients' perception of weight loss as an indicator of poor prognosis and their greater willingness to incur OOP payments in the context of an unfavorable perceived prognosis. However, this interpretation remains hypothetical and requires further investigation.

CONCLUSIONS

The study findings indicate that patients with a higher frequency of OOP payments were characterized by a more advanced course of colorectal cancer and a longer waiting period before initiation of chemotherapy (more than 2 months). OOP payments were more frequently observed among patients with more advanced disease according to the TNM classification, metastases or disease progression, those receiving palliative chemotherapy, and those who had completed a greater number of chemotherapy cycles. Notably, OOP payments were associated with indicators of nutritional depletion, including lower BMI, BMI <18.5 kg/m², substantial (≥10%) weight loss over 5 years, and a more pronounced decrease in BMI over the same period. Overall, these findings highlight the need to improve the entire cancer care pathway for patients with CRC.

To reduce OOP payments among CRC patients receiving chemotherapy, healthcare facilities should consider implementing an electronic waiting list, ensuring closer monitoring of patients with disease progression, metastases, or nutritional depletion, and establishing regular managerial oversight of delays in the provision of medical services.

Article Declarations

Perspectives for further research. These include conducting the planned multivariate analysis of the association between OOP payments and clinical and anthropometric indicators, as well as a broader range of socio-demographic and other relevant factors.

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Research ethics. Protocol №206 dated 25.05.2026 by the Commission on Bioethical Expertise and Research Ethics of the Bogomolets National Medical University. The study participants were informed about the objective of the study. Respondents were guaranteed anonymity and the use of data exclusively in a depersonalized aggregated form. All respondents provided voluntary informed consent for data collection and processing.

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ОСОБЛИВОСТІ ЧАСТОТИ ПЛАТЕЖІВ З ВЛАСНОЇ КИШЕНІ ПАЦІЄНТІВ ПРИ ХІМІОТЕРАПІЇ КОЛОРЕКТАЛЬНОГО РАКУ З РІЗНИМИ КЛІНІЧНИМИ ТА АНТРОПОМЕТРИЧНИМИ ПОКАЗНИКАМИ

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РЕЗЮМЕ

Вступ. Попри прогрес у доступності медичних послуг після запровадження чинної реформи охорони здоров'я у 2017 році, проблема платежів з власної кишені (ПзВК) залишається актуальною. Колоректальний рак (КРР) входить до трійки найпоширеніших онкологічних захворювань в Україні та посідає друге місце за рівнем смертності.

Мета. Дослідити частоту платежів з власної кишені у пацієнтів, які проходять хіміотерапевтичне лікування колоректального раку, залежно від клінічних та антропометричних показників.

Матеріали та методи. У межах поперечного дослідження було опитано 459 пацієнтів, які проходили лікування з приводу КРР в Україні з 1 липня 2023 року до 30 червня 2024 року в межах хіміотерапевтичного пакета Програми медичних гарантій. Пацієнтів було розподілено на дві групи залежно від наявності або відсутності ПзВК (121 та 338 осіб відповідно). Анкета включала чотири групи питань, а саме: загальну інформацію, ставлення до неформальних платежів, клінічні дані пацієнтів із КРР, зокрема стадію захворювання та TNM-класифікацію, особливості хіміотерапевтичного лікування, а також антропометричні показники – масу тіла та зріст. Для порівняння груп використовували критерій χ^2 або точний критерій Фішера (якщо очікувана частота в будь-якій групі була меншою за 5). Для аналізу наявності лінійного тренду використовували тест Кохрана–Армітажа. Статистичну обробку даних проводили за допомогою мови програмування R версії 4.3.1 з графічною оболонкою EZR версії 1.64.

Результати. За результатами дослідження встановлено статистично значущу різницю між групами за здійсненням ПзВК щодо компонента N класифікації TNM ($p=0,04$), а також статистично значущий лінійний тренд щодо стадії захворювання та компонентів T і N класифікації TNM ($\chi^2=4,5$; $p=0,03$ та $\chi^2=6,0$; $p=0,02$ відповідно), часу очікування лікування та кількості завершених циклів хіміотерапії ($\chi^2=4,3$; $p=0,04$ та $\chi^2=4,9$; $p=0,03$ відповідно). Зі збільшенням значень цих змінних спостерігалася вища частота ПзВК. Крім того, частіше здійснювали платежі пацієнти, які отримували паліативну хіміотерапію ($p=0,001$), мали метастази ($p<0,001$) або прогресію захворювання ($p=0,001$), нижчий індекс маси тіла (ІМТ) ($p<0,001$), більший відсоток втрати маси тіла за 5 років ($p=0,024$) та більш виражене зниження ІМТ за 5 років ($p<0,001$). Водночас статистично значущих відмінностей між групами пацієнтів за формою організації хіміотерапії (амбулаторною чи стаціонарною) не виявлено ($p>0,05$).

Висновки. За результатами дослідження встановлено, що пацієнти з вищою частотою ПзВК характеризувалися більш тяжким перебігом колоректального раку та тривалішим періодом очікування початку хіміотерапевтичного лікування (понад 2 місяці). Частіше ПзВК спостерігали серед пацієнтів із більш поширеним пухлинним процесом за TNM-класифікацією, наявністю метастазів або прогресії захворювання, які отримували паліативну хіміотерапію та мали більшу кількість завершених циклів хіміотерапії. Окремо слід відзначити зв'язок ПзВК із показниками нутритивного виснаження, зокрема нижчим індексом маси тіла, ІМТ <18,5, значною (≥10%) втратою маси тіла за 5 років та більш вираженим зниженням ІМТ за цей період. Зазначені результати обґрунтовують необхідність удосконалення всього маршруту онкологічної допомоги пацієнтам із КРР.

З метою зменшення ПзВК у пацієнтів із КРР під час отримання хіміотерапії на рівні закладів охорони здоров'я (ЗОЗ) доцільно запровадити електронний лист очікування, посилити увагу до пацієнтів із прогресією захворювання, метастазами або нутритивним виснаженням, а також забезпечити регулярний управлінський контроль за затримками в наданні медичних послуг.

Ключові слова: витрати на охорону здоров'я, індекс маси тіла, медична онкологія, організація охорони здоров'я, соціально-економічні фактори, стадіювання новоутворень, фінансування охорони здоров'я.

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CLINICAL ASSESSMENT OF THE LIPID PROFILE IN PATIENTS WITH METABOLIC-ASSOCIATED STEATOTIC LIVER DISEASE COMBINED WITH HYPOTHYROIDISM

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ABSTRACT

Introduction. A number of studies confirm a close pathophysiological relationship between thyroid dysfunction and metabolic liver disorders. In this regard, assessment of thyroid status in patients with metabolic-associated steatotic liver disease (MASLD) is of important clinical and prognostic significance. Therefore, monitoring and timely correction of thyroid function may be considered an integral component of a comprehensive therapeutic approach in patients with MASLD.

Aim. To evaluate the lipid profile, including total cholesterol, low-density lipoprotein cholesterol (LDL-C), very-low-density lipoprotein cholesterol (VLDL-C), high-density lipoprotein cholesterol (HDL-C), and triglycerides, in patients with MASLD combined with subclinical hypothyroidism, overt hypothyroidism, and normal thyroid function.

Materials and Methods. A total of 70 patients with MASLD were enrolled in the study and divided into three groups. Group 1 included 28 patients with MASLD and subclinical hypothyroidism. Group 2 comprised 22 patients with MASLD combined with overt hypothyroidism associated with diffuse nodular goiter and autoimmune thyroiditis. Group 3 included 20 patients with MASLD without thyroid dysfunction and served as the control group.

Results. In Group 1, lipid profile analysis revealed increased levels of total cholesterol, LDL-C, triglycerides, and VLDL-C, accompanied by decreased HDL-C levels. In Group 2, significantly elevated levels of total cholesterol, LDL-C, triglycerides, and VLDL-C were observed, together with a marked reduction in HDL-C compared with Group 3. In patients with MASLD without hypothyroidism, lipid parameters remained within reference ranges or demonstrated only mild elevations.

Conclusions. The presence of subclinical or overt hypothyroidism in patients with MASLD is associated with more pronounced disturbances in lipid and carbohydrate metabolism.

Keywords: metabolic-associated steatotic liver disease, thyroid gland, hypothyroidism, biochemical blood analysis, cholesterol, low-density lipoprotein cholesterol (LDL-C), triglycerides, very low-density lipoproteins (VLDL), high-density lipoprotein cholesterol (HDL-C).

INTRODUCTION

According to current estimates, the global prevalence of metabolic dysfunction-associated steatotic liver disease (MASLD) in the general population has increased from approximately 25% in 2016 to more than 30%, and its prevalence continues to rise. It is estimated that approximately 10-30% of individuals with isolated hepatic steatosis may progress to steatohepatitis and advanced liver disease; however, this risk is substantially higher in the presence of type 2 diabetes mellitus (T2DM), among patients with which hepatic steatosis has been reported in 42-65% of cases. Among patients without diabetes, subclinical hypothyroidism has also been reported at a substantial frequency.

MASLD is one of the most common chronic liver diseases worldwide and is closely associated with metabolic syndrome and its components. Contemporary epidemiological studies indicate that the prevalence of MASLD exceeds 30-35%, with a markedly increased risk among individuals with insulin resistance, obesity, T2DM, and hypothyroidism [1]. The thyroid gland plays a pivotal role in the regulation of energy and lipid metabolism. Thyroid hormones, particularly triiodothyronine (T3) and thyroxine (T4), stimulate the expression of low-density lipoprotein (LDL) receptors and regulate the activity of lipoprotein lipase, hepatic lipase, and enzymes involved in fatty-acid β-oxidation. Reduced thyroid function, including subclinical hypothyroidism, may impair

these processes and contribute to the accumulation of atherogenic lipoproteins in the bloodstream [2].

Triiodothyronine (T3) and thyroxine (T4) are principal regulators of gene expression controlling β-oxidation of fatty acids, lipolysis, apolipoprotein synthesis, and cholesterol metabolism. Under physiological conditions, thyroid hormones stimulate:

- hepatic lipase and lipoprotein lipase activity, ensuring triglyceride catabolism;
- LDL receptor expression in hepatocytes, accelerating LDL clearance;
- transformation of very low-density lipoproteins (VLDL) into high-density lipoproteins (HDL), thereby maintaining lipid balance.

In hypothyroidism, particularly overt hypothyroidism, these mechanisms are impaired: apolipoprotein A1 and apolipoprotein B synthesis decreases, triglyceride metabolism slows, and LDL clearance is reduced. Consequently, VLDL and LDL accumulate in plasma, accompanied by a reduction in HDL levels. This "triad" is characteristic of atherogenic dyslipidemia observed in both hypothyroidism and MASLD.

A number of studies confirm a close pathophysiological relationship between thyroid dysfunction and metabolic liver injury. W. Xiong (2025) [3] demonstrated that the TSH level may be an important risk factor for the occurrence and development of MAFLD. The relationship between them is influenced by age. Also, patients with MASLD typically exhibit a characteristic dyslipidemia: elevated total cholesterol (TC), LDL, VLDL, and triglycerides (TG), along with reduced HDL levels. Pathogenetically, this is associated with increased hepatic lipoprotein synthesis and impaired catabolism due to insulin resistance.

When MASLD is combined with subclinical hypothyroidism, atherogenic alterations become more pronounced: Patients with SCH showed significantly higher T-Chol, STG, and LDL-C levels, as well as significantly lower levels of HDL-C in comparison to the healthy controls [4]. These changes are explained by decreased LDL receptor expression in hepatocytes, reduced lipoprotein lipase activity, and impaired β-oxidation of fatty acids.

Thus, even moderate TSH elevation within the range of subclinical hypothyroidism is associated with statistically significant alterations in the lipid spectrum. The highest VLDL and TG levels are observed in overt hypothyroidism, indicating marked disturbances in lipid metabolism.

Particular attention has been paid to VLDL as a marker of dyslipidemia. In hypothyroidism, increased synthesis of apolipoprotein B100 – the principal protein component of VLDL-combined with reduced hepatic lipase activity results in VLDL accumulation in circulation. This condition promotes the development of an atherogenic lipid profile, further exacerbating hepatic steatosis and increasing cardiovascular risk.

Hyperthyroidism seems to have a protective effect on the incidence of NAFLD [5]. A small cross-sectional study in China found that the prevalence of NAFLD in patients with hyperthyroidism was 11.9%. Interestingly, higher T3 levels were associated with lower liver fat content (p=0.009) and a decreased risk of NAFLD (OR 0.267, 95% CI 0.087-0.817, p=0.021) [6]. A large case-control study in Germany confirmed these findings and found that hyperthyroidism was associated with a lower risk of NAFLD (OR 0.85, 95% CI 0.77-0.94, p<0.001) [7].

Given these findings, assessment of thyroid status in patients with MASLD has important clinical and prognostic implications. Recent studies have demonstrated that even correction of subclinical hypothyroidism with levothyroxine therapy contributes to improvement in lipid parameters, reduction of hepatic steatosis, and normalization of TC and TG levels. Therefore, monitoring and timely correction of thyroid function should be considered an essential component of the comprehensive management of patients with MASLD.

AIM

To evaluate the lipid profile (total cholesterol, LDL cholesterol, VLDL cholesterol, HDL cholesterol, triglycerides) in patients with MASLD and normal thyroid function, as well as in patients with MASLD combined with subclinical and overt hypothyroidism.

MATERIALS AND METHODS

The study protocol was reviewed and approved by the Bioethics and Research Ethics Committee operating at O. O. Bohomolets National Medical University. The investigation was conducted within the Department of Internal Medicine No. 1 from 2025 to 2026 and was approved by the Chair and the Executive Secretary of the Bioethics Committee. All participants provided written informed consent prior to enrollment. This was a prospective study.

A total of 70 patients with MASLD were included and subsequently divided into three groups. Group 1 consisted of 28 patients with MASLD and subclinical hypothyroidism. Group 2 included 22 patients with MASLD combined with overt hypothyroidism (associated with diffuse nodular goiter and autoimmune thyroiditis). The control group comprised 20 patients with MASLD without thyroid dysfunction.

Inclusion criteria

The following inclusion criteria were applied: men and women aged 30-60 years; patients with diagnosed

hypothyroidism (subclinical hypothyroidism was defined as TSH >4 mIU/L and free T4 10-25 pmol/L, further stratified according to TSH levels into mild [TSH 4.5-10.0 mIU/L] and marked [TSH >10.0 mIU/L]; overt hypothyroidism was defined as TSH >4.0 mIU/L and free T4 <10 pmol/L); as well as patients with metabolic-associated steatotic liver disease (MASLD), diagnosed based on the presence of at least two metabolic criteria:

1. overweight or obesity;
2. type 2 diabetes mellitus;
3. evidence of metabolic dysregulation, namely ≥2 of the following:
   a) waist circumference in Caucasian individuals: ≥102 cm in men and ≥88 cm in women (≥90 cm and ≥80 cm for Asian men and women, respectively);
   b) antihypertensive treatment or blood pressure ≥130/85 mmHg;
   c) serum triglycerides ≥1.7 mmol/L (150 mg/dL) or treatment for hypertriglyceridemia;
   d) serum HDL cholesterol <1.0 mmol/L (<40 mg/dL) in men and <1.3 mmol/L (<50 mg/dL) in women, or treatment for hypercholesterolemia;
   e) prediabetes defined as fasting plasma glucose 5.6–6.9 mmol/L (100-125 mg/dL), or 2-hour post-load glucose 7.8–11.0 mmol/L (140-199 mg/dL), or HbA1c 5.7–6.4% (39-46 mmol/mol);
   f) high-sensitivity C-reactive protein (hs-CRP) >2 mg/L;
   g) HOMA-IR ≥2.5.

Ultrasound examination was performed using the Soneus P7 device (UltraSign, Ukraine) at the Department of Internal Medicine No. 1, O. O. Bohomolets National Medical University.

The degree of hepatic steatosis was assessed based on the ultrasound attenuation coefficient. Values of 1.0-2.19 dB/cm corresponded to S0, indicating no steatosis; 2.20-2.29 dB/cm to S1, indicating mild steatosis; 2.30-2.90 dB/cm to S2, indicating moderate steatosis; and values >2.90 dB/cm to S3, indicating severe steatosis.

Liver fibrosis was assessed using shear-wave elastography (SWE) based on liver stiffness values expressed in kPa. Values of 0-5.8 kPa corresponded to stage F0 (no fibrosis), 5.9-7.2 kPa to F1 (initial fibrosis), 7.3-9.5 kPa to F2 (moderate fibrosis), 9.6–12.5 kPa to F3 (advanced fibrosis), and values >12.6 kPa to F4 (liver cirrhosis).

Exclusion criteria

Exclusion criteria included Wilson–Konovalov disease, viral hepatitis, alcoholic liver disease, autoimmune hepatitis, drug-induced liver injury, and neoplastic processes. Also, use of statins, levothyroxine, glucose-lowering agents, hepatoprotective drugs, or other medications that may significantly affect the lipid profile.

Statistical analysis

Statistical analysis was performed using EZR version 3.4.1 (R Foundation for Statistical Computing) and MedStat version 5.2. The Shapiro–Wilk test was used to assess normality of data distribution. For normally distributed variables, quantitative data were presented as mean ± standard deviation (Mean ± SD); for non-normally distributed variables, data were expressed as median with first and third quartiles (Median [Q1–Q3]). No correction for multiple comparisons was performed.

When comparing three groups with normal data distribution, analysis of variance (ANOVA) with multiple comparisons was applied; for non-normal distribution, the Kruskal–Wallis test was used. Pearson's correlation coefficient (r) was calculated to assess correlations between variables. Differences were considered statistically significant at $p<0.05$.

RESULTS

The main characteristics of patients in the three study groups are presented in Table 1.

Table 1. Study groups

Characteristics	Study groups			p
	Group 1 (n=28)	Group 2 (n=22)	The control group (n=20)	
Mean age (years)	43.86 ± 8.045	44.32 ± 7.99	44.05 ± 8,476	p=0,980
Sex (female/male), %	36%/64%	36%/64%	40%/60%	

General information on the study groups is presented in Table 1. Group 1 consisted of 28 patients with MASLD and subclinical hypothyroidism. Group 2 included 22 patients with MASLD combined with overt hypothyroidism (associated with diffuse nodular goiter and autoimmune thyroiditis). The control group comprised 20 individuals with MASLD without thyroid dysfunction. The groups were comparable in terms of sample size and age (p=0.980). In all groups, male patients predominated.

The characteristics of the study groups according to lipid profile parameters are presented in Table 2.

Comparison of the lipid profile in patients of Group 1 revealed increased levels of total cholesterol, LDL cholesterol, triglycerides, and

Table 2. Comparative characteristics of the study groups according to lipid profile parameters, Mean ± SD

Characteristics	Group 1	Group 2	The control group	p
Total cholesterol, mmol/L	5.989 ± 0.39*	7.15 ± 0.49*	5.69 ± 0.43*	P1 – p<0,01 P2 – p=0,07 P3 – p<0,01
LDL cholesterol, mmol/L	3.836±0.44	5.527±0.43	3.435±0.42	P1 – p<0,01 P2 – p=0,01 P3 – p<0,01
triglycerides, mmol/L	2.13±0.15	2.26±0.25	1.92±0.16	P1 – p=0,07 P2 – p<0,01 P3 – p<0,01
VLDL cholesterol	1.57±0.14	1.88±0.18	1.33±0.16	P1 – p<0,01 P2 – p<0,01 P3 – p<0,01
HDL cholesterol	0.5±0.05	0.2±0.03	0.7±0.11	P1 – p<0,01 P2 – p< 0,05 P3 – p<0,01

Note: p1 – comparison between Groups 1 and 2; p2 – comparison between Groups 1 and 3; p3 – comparison between Groups 2 and 3.

VLDL cholesterol – 5.989 ± 0.39, 3.836 ± 0.44, 2.13 ± 0.15, and 1.57 ± 0.14 mmol/L, respectively – along with a decreased HDL cholesterol level (0.5 ± 0.05 mmol/L).

In contrast, patients in Group 2 demonstrated significantly higher levels of total cholesterol, LDL cholesterol, triglycerides, and VLDL cholesterol – 7.15 ± 0.49, 5.527 ± 0.43, 2.26 ± 0.25, and 1.88 ± 0.18 mmol/L, respectively – together with a marked reduction in HDL cholesterol levels (0.2 ± 0.03 mmol/L), compared with Group 3 (MASLD without hypothyroidism), in whom lipid parameters were within reference ranges or mildly abnormal.

Lipid profile parameters (total cholesterol, LDL cholesterol, VLDL cholesterol, HDL cholesterol, triglycerides levels) in patients of Groups 1, 2, and 3 are presented in diagrammatic form in Fig. 1.

According to the data presented in Fig. 1, lipid profile parameters (total cholesterol, LDL cholesterol, VLDL cholesterol, HDL cholesterol, triglyceride levels) in patients of Groups 1, 2, and 3 were illustrated in diagrammatic form.

DISCUSSION

In the context of MASLD, dyslipidemia is already present (elevated total cholesterol, LDL, VLDL, and triglycerides levels; reduced HDL levels). The addition of thyroid dysfunction further aggravates these alterations. Our findings indicate that even subclinical hypothyroidism has the potential to exacerbate lipid disturbances and increase fasting glucose levels, although not to the same extent as overt hypothyroidism.

These results are consistent with contemporary studies demonstrating that hypothyroidism is

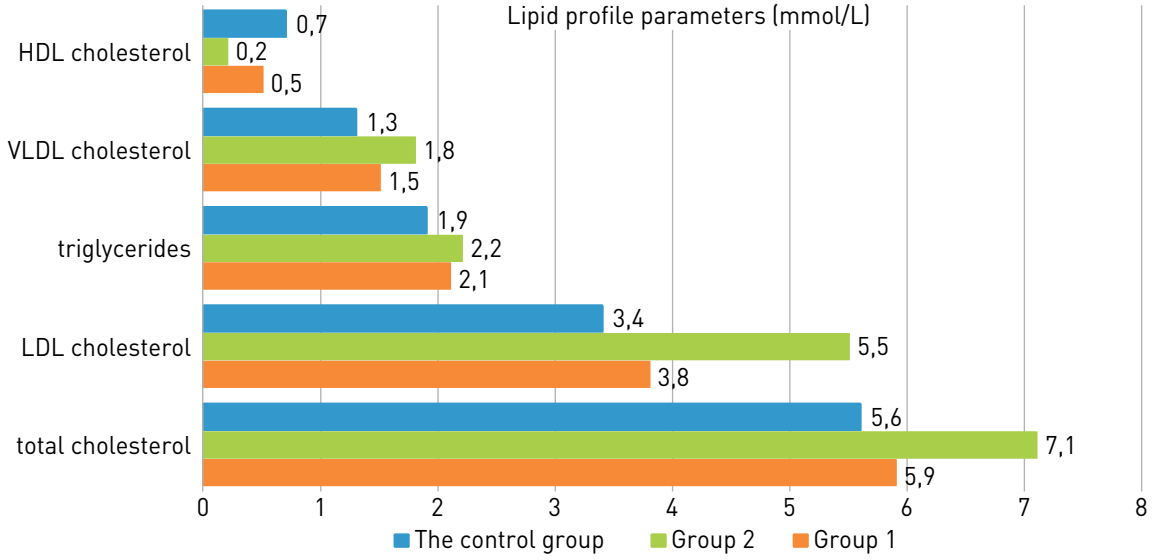

Fig. 1. Lipid profile parameters

associated with more pronounced hepatic steatosis and a more atherogenic lipid profile.

One of the key pathophysiological mechanisms involves reduced expression of glucose transporter type 4 (GLUT4) in skeletal muscle and impairment of other insulin-dependent pathways in hypothyroidism, leading to decreased glucose clearance and elevated fasting glucose levels. This effect diminishes tissue glucose utilization, creating conditions for enhanced lipogenesis due to substrate excess.

Thus, the development of hypothyroidism in patients with MASLD may create a "vicious cycle": elevated TSH levels and reduced T3/T4 concentrations aggravate insulin resistance and glycemic disturbances, which in turn stimulate the synthesis of atherogenic lipoproteins and promote hepatic fat accumulation.

In our study, comparison of the lipid profile in patients of Group 1 revealed increased levels of total cholesterol, LDL cholesterol, triglycerides, VLDL cholesterol, along with decreased HDL cholesterol levels. In Group 2, significantly higher levels of total cholesterol, LDL cholesterol, triglycerides, VLDL cholesterol were observed, together with a marked reduction in HDL cholesterol levels, compared with Group 3 (MASLD without hypothyroidism), where parameters remained within reference ranges or were only mildly elevated.

The relationship between thyroid functional status and metabolic disturbances, particularly dyslipidemia and hyperglycemia, is gaining increasing scientific and clinical relevance in the context of MASLD. This condition represents a systemic manifestation of metabolic syndrome, and alterations in the thyroid hormonal profile may not only reflect the severity of metabolic imbalance but also act as one of its pathogenetic drivers.

CONCLUSIONS

1. In patients of Group 1, increased levels of total cholesterol, LDL cholesterol, triglycerides, and VLDL cholesterol, along with decreased HDL cholesterol levels, were observed compared with Group 3 (MASLD without hypothyroidism), where parameters were within reference ranges.

2. In patients of Group 2, significantly elevated total cholesterol, LDL cholesterol, triglycerides, and VLDL cholesterol levels, together with a marked decrease in HDL cholesterol levels, were identified compared with Group 3, where parameters remained within reference ranges.

3. The presence of subclinical or overt hypothyroidism in patients with MASLD is associated with more pronounced disturbances of lipid metabolism.

Article Declarations

Perspectives for further research. The relationship between thyroid dysfunction, the intestinal microbiome, and the development of metabolic dysfunction-associated steatotic liver disease (MASLD) will be investigated through comparative and correlation analyses. Associations between thyroid hormone status and clinical manifestations in patients with MASLD will be established. The results of the study will be integrated into the educational programs of departments of internal medicine and implemented in the clinical practice of outpatient and inpatient healthcare facilities in Kyiv.

Study Limitations. The authors acknowledge that the limitations of this review are related to the predefined scope of the topic, the selected time period, the types of studies included, and the availability of relevant literature. The literature search was performed using the PubMed database (https://pubmed.ncbi.nlm.nih.gov/).

Primary data and materials. The authors confirm that the study was conducted using primary medical documentation, including medical records, outpatient charts, and laboratory and instrumental examination results of the enrolled patients. All patient data were anonymized before analysis.

Research Ethics. The investigators complied with all protocols and procedures approved by the Biomedical Research Ethics Committee (protocol No 206, dated 25.05.2026), as well as with the requirements of the legislation of Ukraine in the field of healthcare and the principles of the Declaration of Helsinki (2000).

Declaration of AI use. The authors used ChatGPT for language editing of the English text. The authors reviewed and verified all AI-generated content to ensure accuracy and integrity.

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Conflict of Interest. The authors declare that they have no conflicts of interest related to the preparation, conduct, or publication of this study. None of the authors has any financial, commercial, or personal relationships that could have influenced the interpretation of the results. The study was conducted in accordance with the principles of academic integrity and objectivity. All authors have reviewed and approved the final version of the manuscript.

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КЛІНІЧНА ОЦІНКА ЛІПІДНОГО ПРОФІЛЮ У ХВОРИХ НА МЕТАБОЛІЧНО-АСОЦІЙОВАНУ СТЕАТОТИЧНУ ХВОРОБУ ПЕЧІНКИ В ПОЄДНАННІ З ГІПОТИРЕОЗОМ

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РЕЗЮМЕ

Вступ. Ряд досліджень підтверджує наявність тісного патофізіологічного зв'язку між порушеннями тиреоїдної функції та метаболічними ураженнями печінки. Зважаючи на це, оцінка тиреоїдного статусу у пацієнтів із метаболічно-асоційованою стеатотичною хворобою печінки (МАСХП) набуває важливого клінічного та прогностичного значення. Моніторинг і своєчасна корекція тиреоїдної функції можуть розглядатися як складова комплексного підходу до лікування пацієнтів із МАСХП.

Мета. Оцінити ліпідний профіль, зокрема рівні загального холестерину, холестерину ліпопротеїдів низької густини (ХС ЛПНГ), холестерину ліпопротеїдів дуже низької густини (ХС ЛПДНГ), холестерину ліпопротеїдів високої густини (ХС ЛПВГ) і тригліцеридів, у пацієнтів із МАСХП у поєднанні із субклінічним гіпотиреозом, клінічним гіпотиреозом та нормальною функцією щитоподібної залози.

Матеріали та методи. У дослідженні взяли участь 70 пацієнтів із МАСХП, яких розподілили на три групи. До першої групи увійшли 28 пацієнтів із МАСХП та субклінічним гіпотиреозом. Другу групу становили 22 пацієнти з МАСХП у поєднанні з клінічним гіпотиреозом на тлі дифузного вузлового зоба та автоімунного тиреоїдиту. Групу контролю становили 20 пацієнтів із МАСХП без порушення функції щитоподібної залози.

Результати. У пацієнтів першої групи виявлено підвищення рівнів загального холестерину, ХС ЛПНГ, тригліцеридів, ХС ЛПДНГ, а також зниження рівня ХС ЛПВГ. У пацієнтів другої групи спостерігали значне підвищення рівнів загального холестерину, ХС ЛПНГ, тригліцеридів і ХС ЛПДНГ та виражене зниження рівня ХС ЛПВГ порівняно з третьою групою. У пацієнтів із МАСХП без гіпотиреозу відповідні показники перебували в межах референтних значень або були незначно підвищеними.

Висновки. Наявність субклінічного або клінічного гіпотиреозу у пацієнтів із МАСХП асоціюється з більш вираженими порушеннями ліпідного профілю.

Ключові слова: Метаболічно-асоційована стеатотична хвороба печінки, Щитоподібна залоза, Гіпотиреоз, Біохімічний аналіз крові, Холестерин, Холестерин ліпопротеїнів низької щільності (ЛПНЩ), Тригліцериди, Ліпопротеїни дуже низької щільності (ЛПДНЩ), Холестерин ліпопротеїнів високої щільності (ЛПВЩ).

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