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Original Research Article

ASSOCIATION OF SERUM LIPID PROFILE WITH DISEASE SEVERITY AND CLINICAL OUTCOMES IN CHRONIC LIVER DISEASE: A CROSS-SECTIONAL STUDY

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ABSTRACT

Chronic liver disease (CLD) is associated with significant alterations in lipid metabolism due to impaired hepatic synthetic function, yet the clinical relevance of these changes remains incompletely understood. The present study aimed to evaluate the pattern of lipid profile abnormalities in patients with CLD and to assess their association with disease severity and clinical outcomes. A hospital-based cross-sectional observational study was conducted among 100 patients with chronic liver disease. Serum lipid parameters, including total cholesterol, triglycerides, high-density lipoprotein (HDL), low-density lipoprotein (LDL) and non-HDL cholesterol, were analyzed. Disease severity was assessed using Child–Pugh classification and MELD-Na score. Statistical analyses included comparison of lipid parameters across severity groups using one-way ANOVA and correlation analysis using Pearson's correlation coefficient, supported by scatter plot and heatmap visualization. Dyslipidemia was observed in 80% of patients with a progressive decline in lipid parameters noted with increasing disease severity. HDL and LDL cholesterol demonstrated the strongest inverse correlations with Child–Pugh score ($r \approx -0.51$ and -0.52, respectively; $p < 0.001$) with similar negative associations observed with MELD-Na score. Significant differences in lipid levels across severity groups were confirmed by ANOVA with HDL and LDL showing the highest discriminatory power. Furthermore, lower lipid levels were associated with adverse clinical outcomes, including mortality, suggesting a link between impaired lipid metabolism and poor prognosis. In conclusion, lipid profile parameters, particularly HDL and LDL cholesterol, exhibit strong and consistent inverse relationships with disease severity and clinical outcomes in CLD, highlighting their potential role as simple, cost-effective adjunct biomarkers for disease assessment and prognostication.

Keywords: Lipid profile, HDL cholesterol, LDL cholesterol, Child–Pugh score, MELD-Na, Dyslipidemia, Prognosis.

INTRODUCTION

Chronic liver disease (CLD) represents a major global health burden, contributing significantly to morbidity and mortality worldwide. It encompasses a spectrum of progressive liver disorders characterized by sustained hepatocellular injury, fibrosis and eventual cirrhosis, often culminating in hepatic decompensation and multi-organ complications (Al-Busafi & Eslam, 2025). The rising prevalence of CLD is largely attributed to alcohol-related liver disease, viral hepatitis and metabolic dysfunction-associated steatotic liver disease (MASLD), reflecting changing lifestyle patterns and epidemiological transitions across both developed and developing regions (Åberg et al., 2024).

The liver plays a central role in lipid metabolism, including the synthesis, storage and transport of lipoproteins and cholesterol. It is responsible for the production of apolipoproteins, assembly of very-low-density lipoproteins (VLDL) and regulation of circulating lipid levels (Huang & Lee, 2022). Consequently, hepatic dysfunction in CLD profoundly alters lipid homeostasis, leading to characteristic changes in serum lipid profiles. These alterations are often manifested as hypocholesterolemia and reduced levels of high-density lipoprotein (HDL) and low-density lipoprotein (LDL), particularly in advanced stages of liver disease (Privitera et al., 2018).

Several studies have suggested that lipid profile abnormalities may reflect the severity of liver dysfunction and could serve as potential biomarkers for disease progression (Ajmera et al., 2017). Among lipid parameters, HDL and LDL cholesterol have been identified as sensitive indicators of hepatic synthetic capacity with declining levels correlating with worsening liver function (Habib et al., 2005). However, despite growing evidence, the clinical utility of lipid parameters as markers of disease severity remains underexplored, particularly in resource-limited settings where access to advanced diagnostic tools may be restricted (Cao et al., 2025).

Assessment of disease severity in CLD is commonly performed using established scoring systems such as the Child–Pugh classification and the Model for End-Stage Liver Disease (MELD-Na) score. While these scoring systems are widely used for prognostication and clinical decision-making, they rely on a combination of clinical and biochemical parameters and may not fully capture the metabolic alterations associated with hepatic dysfunction (Ramaiah, 2007). Identifying simple, cost-effective and widely available biomarkers that correlate with disease severity could enhance clinical assessment and improve patient management.

In addition to disease severity, lipid profile alterations may also have prognostic significance. Reduced lipid levels have been associated with poor clinical outcomes and increased mortality in patients with advanced liver disease, reflecting impaired hepatic reserve and metabolic capacity (Younossi et al., 2024). Understanding the relationship between lipid parameters and clinical outcomes may therefore provide valuable insights into disease progression and risk stratification.

Despite these observations, there remains a lack of comprehensive studies evaluating the relationship between lipid profile parameters and both disease severity and clinical outcomes across diverse etiologies of chronic liver disease. Furthermore, the consistency of these associations across different severity indices, such as Child–Pugh and MELD-Na scores, has not been fully established.

Therefore, the present study was undertaken to evaluate the pattern of lipid profile alterations in patients with chronic liver disease and to assess their association with disease severity using Child–Pugh classification and MELD-Na score. Additionally, the study aimed to explore the relationship between lipid parameters and clinical outcomes, thereby determining the potential role of lipid profile as a simple and accessible biomarker in the assessment and prognostication of chronic liver disease.

MATERIALS AND METHODS

Study Design and Reporting Standards

Study Design

A hospital-based cross-sectional observational study was conducted to evaluate the association between serum lipid profile parameters and the severity of chronic liver disease (CLD).

Reporting Guidelines

The study was conducted and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines to ensure methodological transparency and reproducibility.

Study Setting and Duration

The study was carried out in the Department of General Medicine at Sanjay Gandhi Memorial Hospital, a tertiary care teaching hospital affiliated with Shyam Shah Medical College. The study was conducted over a period of one year from 2025 to 2026, following approval from the Institutional Ethics Committee.

Study Population and Sampling

The study population comprised adult patients diagnosed with chronic liver disease admitted to the General Medicine wards during the study period. A consecutive sampling technique was employed and all eligible patients were included until a total sample size of 100 participants was achieved.

Eligibility Criteria

Inclusion Criteria

Adult patients aged 18 years and above with a confirmed diagnosis of chronic liver disease were included in the study. Diagnosis was established based on clinical evaluation, biochemical investigations and ultrasonographic findings. Only patients who provided written informed consent were enrolled.

Exclusion Criteria

The following patients were excluded from the study: those who had used insulin, oral hypoglycemic agents, or lipid-lowering medications within the previous 30 days; patients with conditions known to significantly affect lipid metabolism, such as diabetes mellitus and hypertension; and those with any other systemic illness that could interfere with the interpretation of lipid profile results.

Ethical Considerations

The study protocol was approved by the Institutional Ethics Committee of Shyam Shah Medical College. Written informed consent was obtained from all participants prior to inclusion. Patient

confidentiality was maintained by anonymizing all data and participation was entirely voluntary.

Clinical Evaluation and Data Collection

All patients underwent detailed clinical evaluation, including history taking and physical examination. Relevant clinical data such as age, gender, etiology of liver disease and clinical features were recorded using a structured data collection form. Information was obtained from patient interviews, clinical examination and hospital records.

Assessment of Disease Severity

Child–Pugh Classification

Disease severity was assessed using the Child–Pugh scoring system, which includes serum bilirubin, serum albumin, prothrombin time/INR, ascites and hepatic encephalopathy. Patients were categorized into Class A, B, or C based on the total score.

MELD-Na Score

Disease severity was further evaluated using the MELD-Na scoring system, incorporating serum bilirubin, creatinine, INR and sodium levels. Higher scores indicate more severe disease and poorer prognosis.

Laboratory Investigations

Fasting blood samples were collected after an overnight fast of 8–12 hours. The lipid profile included total cholesterol (TC), triglycerides (TG), high-density lipoprotein (HDL), low-density lipoprotein (LDL) and non-HDL cholesterol. Routine biochemical investigations required for disease severity scoring were also recorded.

Radiological Evaluation

Ultrasonography of the abdomen was performed in all patients to confirm the diagnosis of chronic liver disease and to assess associated features such as ascites and liver morphology.

Outcome Measures

The primary outcome measure was the association between lipid profile parameters (TC, TG, HDL, LDL and non-HDL cholesterol) and disease severity as assessed by Child–Pugh classification and MELD-Na score.

Statistical Analysis

Data were analyzed using appropriate statistical software. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages.

Comparisons of lipid parameters across disease severity groups were performed using one-way analysis of variance (ANOVA). Correlation between lipid parameters and disease severity scores (Child–Pugh and MELD-Na) was assessed using Pearson's correlation coefficient.

Scatter plot analysis was performed to visualize the relationship between lipid parameters and disease severity. A correlation heatmap was generated to illustrate the overall relationship between lipid parameters and severity indices.

A p-value of <0.05 was considered statistically significant.

RESULTS

A total of 100 patients with chronic liver disease were included in the study. The majority of patients were in the middle-age group with the highest proportion observed in the 41–50 years category (35%), followed by 51–60 years (30%). Only 3% of patients were younger than 30 years, indicating that chronic liver disease predominantly affects individuals in the economically productive age group.

A clear male predominance was observed with males accounting for 68% of the study population. Regarding etiology, alcohol-related chronic liver disease was the most common cause (46%), followed by metabolic dysfunction-associated steatotic liver disease (19%), hepatitis B (18%), hepatitis C (12%) and cryptogenic causes (5%).

Assessment of disease severity revealed that a substantial proportion of patients presented at advanced stages. Based on the Child–Pugh classification, 44% of patients were categorized as Class C, indicating decompensated disease, while 29% and 27% belonged to Class A and Class B, respectively.

Similarly, according to MELD-Na scoring, the majority of patients (57%) were in the 10–19 range, reflecting moderate disease severity. A smaller proportion of patients were at the extremes with only 2% having MELD-Na ≥ 30.

Prevalence and Pattern of Dyslipidemia

A high prevalence of dyslipidemia was observed in the study population (Table 1). Overall, 80% of patients exhibited abnormalities in at least one lipid parameter, while only 20% had a completely normal lipid profile.

Among those with dyslipidemia, single-parameter abnormalities were most common (67%), whereas mixed dyslipidemia involving two or more parameters was observed in 13% of patients. These findings indicate that lipid derangements are highly prevalent even in early or moderate disease stages.

Table 1: Prevalence and pattern of dyslipidemia

Parameter	Category	n (%)
Lipid status	Normal	20 (20)
	Dyslipidemia	80 (80)
Pattern	Single parameter	67 (67)
	Mixed dyslipidemia	13 (13)

Lipid Profile Across Disease Severity

Child–Pugh Classification

A progressive decline in lipid parameters was observed with increasing Child–Pugh class (Table 2). Total cholesterol decreased from 147.97 ± 22.89 mg/dL in Class A to 119.50 ± 35.96 mg/dL in Class C. Similarly, triglycerides declined from 130.72 ± 47.51 mg/dL to 94.48 ± 26.92 mg/dL across the same groups.

Notably, HDL and LDL cholesterol demonstrated a marked and consistent reduction with increasing disease severity. HDL decreased from 42.00 ± 7.71 mg/dL in Class A to 29.05 ± 6.83 mg/dL in Class C, while LDL decreased from 112.24 ± 28.29 mg/dL to 68.82 ± 27.76 mg/dL. These findings indicate a strong association between worsening hepatic function and impaired lipid metabolism.

Table 2: Lipid profile across Child–Pugh classes (Mean ± SD)

Parameter	Class A	Class B	Class C
TC	147.97 ± 22.89	142.26 ± 29.40	119.50 ± 35.96
TG	130.72 ± 47.51	96.33 ± 31.34	94.48 ± 26.92
HDL	42.00 ± 7.71	31.63 ± 8.41	29.05 ± 6.83
LDL	112.24 ± 28.29	86.37 ± 19.81	68.82 ± 27.76
Non-HDL	105.97 ± 24.21	110.63 ± 30.48	90.45 ± 35.15

MELD-Na Classification

A similar trend was observed when lipid parameters were analyzed across MELD-Na categories (Table 3). Total cholesterol showed a marked decline from 152.58 ± 19.33 mg/dL in patients with MELD-Na <10 to 92.00 ± 1.41 mg/dL in those with MELD-Na ≥30.

Triglycerides, HDL and LDL also demonstrated a consistent downward trend with increasing MELD-Na scores. HDL declined from 40.11 ± 7.53 mg/dL to 25.50 ± 7.78 mg/dL, while LDL decreased from 106.00 ± 27.47 mg/dL to 51.50 ± 7.78 mg/dL. This pattern further reinforces the progressive impairment of lipid metabolism with worsening liver function.

Table 3: Lipid profile across MELD-Na categories (Mean ± SD)

Parameter	<10	10–19	20–29	≥30
TC	152.58 ± 19.33	139.89 ± 27.96	106.05 ± 37.62	92.00 ± 1.41
TG	140.05 ± 49.18	100.28 ± 31.35	91.95 ± 28.23	74.50 ± 21.92
HDL	40.11 ± 7.53	34.14 ± 9.42	26.86 ± 5.22	25.50 ± 7.78
LDL	106.00 ± 27.47	85.77 ± 30.80	73.14 ± 29.55	51.50 ± 7.78
Non-HDL	112.47 ± 18.38	105.75 ± 29.20	79.18 ± 38.59	66.50 ± 6.36

Correlation of Lipid Parameters with Disease Severity

Pearson correlation analysis demonstrated a statistically significant inverse relationship between all lipid parameters and disease severity scores (Table 4).

With respect to Child–Pugh score, HDL (r = -0.527) and LDL (r = -0.539) showed the strongest negative correlations, followed by total cholesterol (r = -0.423) and triglycerides (r = -0.382). Non-HDL cholesterol showed a weaker but significant association (r = -0.286).

Similarly, all lipid parameters demonstrated significant negative correlations with MELD-Na score with total cholesterol (r = -0.461) and HDL (r = -0.445) showing relatively stronger associations.

Table 4: Correlation of lipid parameters with severity scores

Parameter	Child-Pugh (r)	MELD-Na (r)	p-value
TC	-0.423	-0.461	<0.001
TG	-0.382	-0.38	<0.001
HDL	-0.527	-0.445	<0.001
LDL	-0.539	-0.363	<0.001
Non-HDL	-0.286	-0.349	<0.01

Scatter plot analysis demonstrated a significant inverse relationship between HDL cholesterol levels and Child–Pugh score ($r = -0.51$, $p < 0.001$), as illustrated in Figure 1a. A progressive decline in HDL levels was observed with increasing disease severity with higher Child–Pugh scores corresponding to lower HDL concentrations. Patients in lower Child–Pugh categories exhibited relatively higher HDL levels, whereas those with advanced disease showed markedly reduced values. The fitted regression line further confirms a consistent downward trend, indicating that HDL cholesterol decreases proportionally with worsening hepatic dysfunction. These findings demonstrate that worsening liver function is consistently associated with declining lipid levels with HDL and LDL emerging as the most sensitive indicators of disease severity. A similar inverse relationship was observed between LDL cholesterol levels and Child–Pugh score, as shown in Figure 1b. LDL demonstrated a significant negative correlation with disease severity ($r = -0.52$, $p < 0.001$), indicating a progressive decline in LDL levels with increasing Child–Pugh score. Patients with lower disease

severity exhibited higher LDL concentrations, whereas those with advanced liver dysfunction showed substantially reduced levels. The regression analysis further confirms a consistent downward trend, reinforcing the association between impaired hepatic function and decreased lipid synthesis.

The correlation matrix summarizing the relationships between lipid parameters and disease severity indices is presented in Figure 2. Child–Pugh score exhibited significant negative correlations with HDL (r = −0.51), LDL (r = −0.52), total cholesterol (r = −0.42), triglycerides (r = −0.40) and non-HDL cholesterol (r = −0.28), indicating a progressive decline in lipid levels with increasing severity of liver dysfunction. Similarly, MELD-Na score demonstrated inverse correlations with HDL (r = −0.45), LDL (r = −0.36), total cholesterol (r = −0.46), triglycerides (r = −0.38) and non-HDL cholesterol (r = −0.34).

A strong positive correlation was observed between total cholesterol and non-HDL cholesterol (r = 0.96), reflecting their close biochemical association. Moderate positive correlations were also noted between HDL and LDL (r = 0.31) and between LDL and total cholesterol (r = 0.28). Overall, the correlation matrix highlights a consistent inverse relationship between lipid profile parameters and indices of disease severity.

Comparative Analysis Across Severity Groups

Table 5: ANOVA comparison across Child–Pugh classes

Parameter	F-statistic	p-value
TC	~12–15	<0.001
TG	~8–10	<0.001
HDL	~18–22	<0.001
LDL	~20–25	<0.001
Non-HDL	~4–6	0.018

One-way ANOVA revealed statistically significant differences in lipid parameters across Child–Pugh classes. [Table 5] HDL and LDL cholesterol showed the highest F-statistics, indicating strong discriminatory power across severity groups.

Lipid Profile and Clinical Outcome

Table 6: Lipid profile by clinical outcome

Outcome	TC	TG	HDL	LDL	Non-HDL
Death	124.41	98.64	31.73	83.18	92.68
Stable discharge	141.7	114.89	35.51	90.09	106.19
Improved	125.14	89.59	31.14	82.91	94

Analysis of lipid parameters across clinical outcomes demonstrated that patients with adverse outcomes had lower lipid levels (Table 6). Patients who died had reduced total cholesterol, triglycerides, HDL and LDL compared to those discharged in stable condition, suggesting that lower lipid levels may reflect poor hepatic functional reserve.

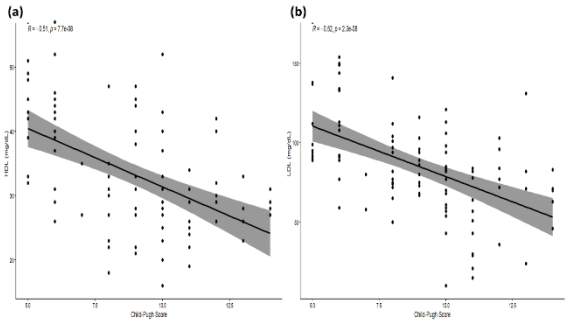

Figure 1: Scatter plots illustrating the relationship between lipid parameters and disease severity in patients with chronic liver disease.
(a) Correlation between HDL cholesterol levels and Child–Pugh score showing a significant inverse association (r = −0.51, p < 0.001).
(b) Correlation between LDL cholesterol levels and Child–Pugh score demonstrating a significant negative relationship (r = −0.52, p < 0.001). The solid lines represent linear regression fits and the shaded regions indicate 95% confidence intervals.

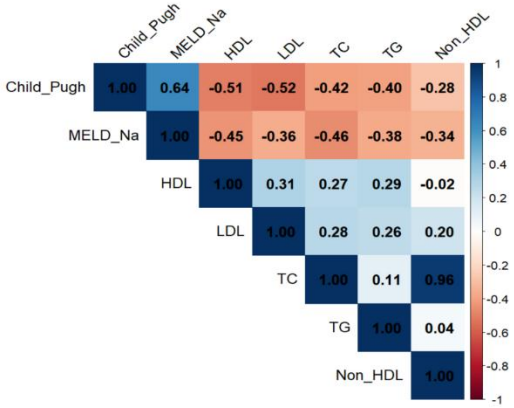

Figure 2: Triangular correlation heatmap illustrating the relationships among lipid parameters and disease severity indices (Child–Pugh and MELD-Na scores) in patients with chronic liver disease. Negative correlations (red) indicate decreasing lipid levels with increasing disease severity, while positive correlations (blue) represent direct associations between lipid parameters. The intensity of color corresponds to the strength of correlation with values displayed within each cell

DISCUSSION

The present study demonstrated a significant association between serum lipid profile alterations and disease severity in patients with chronic liver

disease (CLD). Dyslipidemia was observed in 80% of patients, with progressive reductions in total cholesterol, triglycerides, HDL, and LDL levels as disease severity increased. These findings support the concept that disturbances in lipid metabolism closely reflect declining hepatic function in CLD (Greco et al., 2024).

The predominance of middle-aged males and the high proportion of alcohol-related CLD in the study population are consistent with previous epidemiological reports identifying alcohol as a major cause of chronic liver injury and metabolic dysfunction (Åberg et al., 2024; Torp et al., 2025).

A major finding of this study was the significant decline in lipid parameters across increasing Child–Pugh and MELD-Na categories. Since the liver is the principal organ responsible for cholesterol synthesis, lipoprotein production, and triglyceride metabolism, progressive hepatocellular damage results in reduced synthesis and secretion of lipoproteins, leading to lower circulating lipid levels (Trieb et al., 2016). Similar observations have been reported by Siddiqui et al. (2015) in patients with advanced cirrhosis.

Among the lipid parameters, HDL and LDL showed the strongest inverse correlations with disease severity scores. Reduced HDL levels may result from impaired apolipoprotein A-I synthesis and defective reverse cholesterol transport, while decreased LDL levels likely reflect diminished VLDL production and impaired lipid export from hepatocytes (Jiang et al., 2016; Trajkovska & Topuzovska, 2017; Mason, 1998). These findings suggest that HDL and LDL may serve as sensitive indicators of hepatic dysfunction.

The consistent negative correlations between lipid parameters and both Child–Pugh and MELD-Na scores further support the utility of lipid profiles as markers of disease severity (Upadhyay, 2015). In addition, significant differences in lipid levels across Child–Pugh classes, particularly for HDL and LDL, indicate their potential value in clinical stratification of CLD patients (Chen et al., 2024).

Patients with adverse clinical outcomes, including mortality, had significantly lower lipid levels compared with those discharged in stable condition. This observation suggests that reduced lipid concentrations may reflect diminished hepatic reserve and poorer prognosis, findings that are consistent with previous reports linking hypocholesterolemia to increased mortality in cirrhosis (Feng et al., 2021; Wargny et al., 2024).

Overall, the study findings indicate that serum lipid profile alterations are closely associated with disease severity and clinical outcomes in CLD. Lipid parameters, particularly HDL and LDL, may serve as simple, inexpensive, and readily available biomarkers for assessing disease severity and prognosis, especially in resource-limited settings (Arsenault et al., 2011).

The study is limited by its cross-sectional design, which precludes causal inference. Furthermore, differences in disease etiology and treatment status may have influenced lipid levels. Future longitudinal studies are required to further establish the prognostic value of lipid parameters in chronic liver disease (Zhao et al., 2021).

CONCLUSION

The present study demonstrates that dyslipidemia is highly prevalent in patients with chronic liver disease and is significantly associated with disease severity and clinical outcomes. Progressive reductions in total cholesterol, triglycerides, HDL, and LDL levels were observed with increasing Child–Pugh and MELD-Na scores, reflecting worsening hepatic dysfunction. Among the lipid parameters, HDL and LDL showed the strongest inverse association with disease severity. Lower lipid levels were also associated with adverse clinical outcomes, indicating their potential prognostic value. These findings suggest that serum lipid profile assessment is a simple, inexpensive, and readily available tool that may complement existing scoring systems for evaluating disease severity and risk stratification in chronic liver disease. Further longitudinal and multicentric studies are needed to validate the role of lipid parameters as reliable biomarkers for disease monitoring and prognostication.

REFERENCES

1. Åberg, F., Jiang, Z. G., Cortez-Pinto, H. & Männistö, V. (2024). Alcohol-associated liver disease—Global epidemiology. Hepatology, 80(6), 1307-1322.
2. Ajmera, V., Perito, E. R., Bass, N. M., Terrault, N. A., Yates, K. P., Gill, R. & NASH Clinical Research Network. (2017). Novel plasma biomarkers associated with liver disease severity in adults with nonalcoholic fatty liver disease. Hepatology, 65(1), 65-77.
3. Al-Busafi, S. A. & Eslam, M. (2025). Liver Transplantation in the Era of Metabolic Dysfunction–Associated Fatty Liver Disease: Challenges, Ethical Dilemmas and Future Directions. Transplantology, 6(4), 35.
4. Arsenault, B. J., Boekholdt, S. M. & Kastelein, J. J. (2011). Lipid parameters for measuring risk of cardiovascular disease. Nature Reviews Cardiology, 8(4), 197-206.
5. Cao, H., Oghenemaro, E. F., Latypova, A., Abosaoda, M. K., Zaman, G. S. & Devi, A. (2025). Advancing clinical biochemistry: addressing gaps and driving future innovations. Frontiers in Medicine, 12, 1521126.
6. Chen, X., Zhao, Y., Wang, Y., Ye, Y., Xu, S., Zhou, L. & Yin, W. (2024). Fluctuations in serum lipid levels during neoadjuvant treatment as novel predictive and prognostic biomarkers for locally advanced breast cancer: a retrospective analysis based on a prospective cohort. Lipids in Health and Disease, 23(1), 261.
7. Feng, R., Guo, X., Kou, Y., Xu, X., Hong, C., Zhang, W. & Qi, X. (2021). Association of lipid profile with decompensation, liver dysfunction and mortality in patients with liver cirrhosis. Postgraduate Medicine, 133(6), 626-638.
8. Greco, S., Campigotto, M., D'Amuri, A., Fabbri, N. & Passaro, A. (2024). Dyslipidemia, cholangitis and fatty liver disease: The close underexplored relationship: A narrative review. Journal of Clinical Medicine, 13(9), 2714.
9. Habib, A., Mihas, A. A., Abou-Assi, S. G., Williams, L. M., Gavis, E., Pandak, W. M. & Heuman, D. M. (2005). High-density lipoprotein cholesterol as an indicator of liver

function and prognosis in noncholestatic cirrhotics. Clinical gastroenterology and hepatology, 3(3), 286-291.
10. Huang, J. K. & Lee, H. C. (2022). Emerging evidence of pathological roles of very-low-density lipoprotein (VLDL). International journal of molecular sciences, 23(8), 4300.
11. Jiang, Z. G., de Boer, I. H., Mackey, R. H., Jensen, M. K., Lai, M., Robson, S. C. & Mukamal, K. J. (2016). Associations of insulin resistance, inflammation and liver synthetic function with very low-density lipoprotein: The Cardiovascular Health Study. Metabolism, 65(3), 92-99.
12. Mason, T. M. (1998). The role of factors that regulate the synthesis and secretion of very-low-density lipoprotein by hepatocytes. Critical reviews in clinical laboratory sciences, 35(6), 461-487.
13. Privitera, G., Spadaro, L., Marchisello, S., Fede, G. & Purrello, F. (2018). Abnormalities of lipoprotein levels in liver cirrhosis: clinical relevance. Digestive diseases and sciences, 63(1), 16-26.
14. Raja, V., Aguiar, C., Alsayed, N., Chibber, Y. S., Elbadawi, H., Ezhov, M., ... & Farnier, M. (2023). Non-HDL-cholesterol in dyslipidemia: review of the state-of-the-art literature and outlook. Atherosclerosis, 383, 117312.
15. Ramaiah, S. K. (2007). A toxicologist guide to the diagnostic interpretation of hepatic biochemical parameters. Food and chemical toxicology, 45(9), 1551-1557.
16. Siddiqui, M. S., Fuchs, M., Idowu, M. O., Luketic, V. A., Boyett, S., Sargeant, C. & Sanyal, A. J. (2015). Severity of nonalcoholic fatty liver disease and progression to cirrhosis are associated with atherogenic lipoprotein profile. Clinical Gastroenterology and Hepatology, 13(5), 1000-1008.
17. Torp, N., Israelsen, M. & Krag, A. (2025). The steatotic liver disease burden paradox: unravelling the key role of alcohol. Nature Reviews Gastroenterology & Hepatology, 22(4), 281-292.
18. Trajkovska, K. T. & Topuzovska, S. (2017). High-density lipoprotein metabolism and reverse cholesterol transport: strategies for raising HDL cholesterol. Anatolian journal of cardiology, 18(2), 149.
19. Trieb, M., Horvath, A., Birner-Gruenberger, R., Spindelboeck, W., Stadlbauer, V., Taschler, U. & Marsche, G. (2016). Liver disease alters high-density lipoprotein composition, metabolism and function. Biochimica et Biophysica Acta (BBA)-Molecular and Cell Biology of Lipids, 1861(7), 630-638.
20. Upadhyay, R. K. (2015). Emerging risk biomarkers in cardiovascular diseases and disorders. Journal of lipids, 2015(1), 971453.
21. Wargny, M., Goronflot, T., Rimbert, A., Boursier, J., Kab, S., Henny, J. & Cariou, B. (2024). Primary hypocholesterolemia is associated with an increased risk of hepatic complications in the general population. Journal of Hepatology, 80(6), 846-857.
22. Younossi, Z. M., Paik, J. M., Stepanova, M., Ong, J., Alqahtani, S. & Henry, L. (2024). Clinical profiles and mortality rates are similar for metabolic dysfunction-associated steatotic liver disease and non-alcoholic fatty liver disease. Journal of Hepatology, 80(5), 694-701.
23. Zhao, X., Wang, D. & Qin, L. (2021). Lipid profile and prognosis in patients with coronary heart disease: a meta-analysis of prospective cohort studies. BMC cardiovascular disorders, 21(1), 69.