RESEARCH ARTICLE

Lipid Profile Modulation and Dynamics before and after Laparoscopic Cholecystectomy in Gallstone Disease: A Comparative Analysis

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Abstract

Background: Cholelithiasis is a prevalent condition often associated with deranged lipid metabolism. Although cholecystectomy is a standard treatment, its impact on lipid profiles remains an area of ongoing investigation. This study aimed to assess the changes in fasting lipid profiles following laparoscopic cholecystectomy in patients with gallstone disease.

Materials and methods: A hospital-based comparative observational study was conducted over 2 years in the Departments of General Surgery and Biochemistry at Employees State Insurance Corporation–Postgraduate Institute of Medical Sciences and Research, New Delhi. A total of 116 patients aged 18–70 years who underwent laparoscopic cholecystectomy were included. Patients on lipid-lowering drugs or with comorbidities affecting lipid metabolism were excluded. Fasting lipid profiles were measured preoperatively and at 1 week, 1 month, and 3 months postoperatively. Parameters assessed included total cholesterol (TC), triglycerides (TG), high-density lipoprotein (HDL), low-density lipoprotein (LDL), and very low-density lipoprotein (VLDL). Data were analyzed using paired-sample *t*-tests; $p < 0.05$ was considered statistically significant.

Results: There was a significant reduction in mean levels of TC (from 199.99 to 169.95 mg/dL), TG (from 189.58 to 156.95 mg/dL), LDL (from 129.17 to 90.95 mg/dL), and VLDL (from 37.91 to 31.39 mg/dL) over the 3-month postoperative period ($p < 0.001$). High-density lipoprotein levels showed a significant increase from 32.91 to 47.60 mg/dL ($p < 0.001$). The most marked changes were observed at the 1- and 3-month follow-ups.

Conclusion: Cholecystectomy leads to significant improvements in lipid profiles in patients with gallstone disease, particularly with reductions in atherogenic lipids and an increase in protective HDL. These findings suggest a potential cardiometabolic benefit of cholecystectomy. Further long-term studies with larger populations are warranted.

Keywords: Cholecystectomy, Cholelithiasis, Cholesterol, Lipid profile.

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Introduction

Cholelithiasis, or gallstone disease, was first described in 1420 by Antonio Benivenius, a Florentine pathologist, and remains one of the most common conditions encountered in surgical practice.[1] The discovery of gallstones in the mummies of young Egyptian women by archaeologists further confirms the ancient existence of this disease.[2]

In the United States, the incidence of cholelithiasis is approximately 10%.[3] In India, the prevalence ranges from 6 to 9% among the adult population.[4] Notably, in Northern India, the incidence is about 2.29%, with gallstones being seven times more common than in other regions.[5] This increased prevalence is attributed to dietary habits—specifically, diets high in saturated fats and low in fiber. Other risk factors include sedentary lifestyle, age, gender, and ethnicity.

The formation of cholesterol gallstones is associated with three key abnormalities: (1) supersaturation of cholesterol in bile, (2) decreased activity of cholesterol 7α-hydroxylase, the rate-limiting enzyme for bile acid synthesis, and (3) disrupted enterohepatic circulation of bile acids, which increases bile saturation.[6]

Gallstones are primarily composed of cholesterol, bilirubin, and calcium salts, along with smaller amounts of protein and other substances. They are classified into three types: (1) pure cholesterol stones, (2) black or brown pigment stones, and (3) mixed composition stones.[7]

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Several studies have demonstrated that about 50% of patients with cholelithiasis have an abnormal lipid profile, including

hypertriglyceridemia, hypercholesterolemia, and low high-density lipoprotein (HDL)-cholesterol levels. This dyslipidemia increases the risk of coronary artery disease and stroke.[8–10] In individuals with cholesterol stones, the concentration of cholesterol in bile exceeds that of other phospholipids, suggesting that altered lipid metabolism plays a central role in gallstone pathogenesis.

Some evidence indicates that lipid profiles improve following cholecystectomy. This improvement is thought to result from a reduction in the size of the bile acid pool and an increase in the frequency of enterohepatic circulation, which together lead to lower total cholesterol (TC) and low-density lipoprotein (LDL)-cholesterol levels.

Despite the established relationship between lipid and bile acid metabolism, the precise effects of cholecystectomy on lipid profile are not well documented. Therefore, this study aimed to evaluate the impact of cholecystectomy on the lipid profile of patients with gallstone disease by comparing preoperative and postoperative fasting lipid levels.

Materials and Methods

This hospital-based comparative observational study was conducted in the Department of General Surgery and Biochemistry, Employees State Insurance Corporation–Postgraduate Institute of Medical Sciences and Research, New Delhi, for 2 years, after due permission from Institutional Ethical Committee S.No. DM(A) H-19/14/17/IEC/2012-PGIMSR (part II).

Patients who underwent laparoscopic cholecystectomy for cholelithiasis of age-group 18–70 years were included in the study. Patients on lipid-lowering drugs, suffering from obstructive jaundice, carcinoma of gall bladder, renal failure, nephrotic syndrome, chronic liver disease, cardiac failure, cholecystectomy with surgery involving common bile duct (CBD) and/or gastrointestinal tract diseases, pre- and postoperative complications (CBD injury), and patients with recent attack of gall stone-induced pancreatitis were excluded from the study.

The sample size was calculated using data from a study by Menezes et al., which reported a maximum standard deviation of 27.47 for TC in cholecystectomy patients. Assuming a 5% absolute error and a 95% confidence interval ($\alpha = 0.05$), the sample size was determined using the following formula:

$$\text{Formula} = \frac{(Z_{\alpha/2})^2 \times (\text{SD})^2}{d^2}$$

where, $\alpha = 0.05$ (95% confidence interval), Standard deviation (SD) = 27.47, d (absolute error) = 5%, $Z_{\alpha/2} = 1.96$

$$\text{Sample size} = \frac{(1.96)^2 \times 27.47 \times 27.47}{(5)^2} = \frac{3.84 \times 754.60}{25} = 115.9 \sim 116 \text{ patients}$$

(10% nonresponders added = 115.9 + 11.5 ~ 128 patients)

We have done our study by taking 116 patients as per the formula. No patient out of this sample size defaulted; hence, the number required for nonresponders was not taken.

Written informed consent was obtained from all participants. A detailed medical history, clinical examination, and standard preoperative investigations were conducted. Fasting lipid profile was measured preoperatively, and postoperatively at 1 week, 1 month, and 3 months.

Low-density lipoprotein was calculated using Friedewald's formula: LDL = TC – [HDL + (TG/5)]
Very low-density lipoprotein (VLDL) was calculated as:
VLDL = TG/5

The gallbladder specimen was sent for gross examination post-cholecystectomy.

All data were analyzed using the Statistical Package for the Social Sciences (SPSS), version 22.0 (SPSS Inc., Chicago, IL, USA). Quantitative variables were expressed as mean ± SD. A paired-sample *t*-test was used to compare preoperative and postoperative lipid profile values at 1 week, 1 month, and 3 months. A *p*-value of < 0.05 was considered statistically significant.

Results

Out of the 116 patients included in the study, 94 (81%) were females and 22 (18.96%) were males. The patients' ages ranged from 18 to 70 years, with a mean age of 41.92 ± 11.95 years. The majority of patients belonged to the middle-age-group, with 47.41% aged between 20 and 40 years, followed by 41.41% in the 40–60 years age-group (Table 1). Among females, most ($n = 51$) were in the 20–40 years category, whereas the majority of male patients ($n = 12$) were in the 40–60 years group.

Total Cholesterol (TC)

A comparison of TC levels at different intervals—preoperatively, and at 1 week, 1 month, and 3 months postoperatively (Table 2)—showed a significant decline. The mean TC was 199.99 ± 26.93 mg/dL preoperatively, 194.18 ± 26.87 mg/dL at 1 week, 176.84 ± 22.70 mg/dL at 1 month, and 169.95 ± 22.49 mg/dL at 3 months postoperatively. This reduction was statistically significant ($p < 0.001$). The mean decreases from baseline were 5.81 mg/dL at 1 week, 23.15 mg/dL at 1 month, and 30.04 mg/dl at 3 months. Pairwise comparisons indicate that the initial drop was mild, followed by more marked reductions over time.

Triglycerides (TG)

Triglyceride levels also showed a statistically significant decrease across the study period (Table 3). The mean TG level was 189.58 ± 28.25 mg/dL preoperatively, which declined to 181.25 ± 25.89 mg/dL at 1 week, 161.76 ± 20.19 mg/dL at 1 month, and 156.95 ± 18.68 mg/dL at 3 months postoperatively ($p < 0.001$). The corresponding mean reductions were 8.33, 27.82, and 32.62 mg/dL, respectively.

High-density Lipoprotein (HDL)

High-density lipoprotein levels improved significantly over time (Table 4 and Fig. 1). The mean HDL was 32.91 ± 5.76 mg/dL preoperatively, rising to 36.08 ± 6.05 mg/dL at 1 week, 44.49 ± 26.05 mg/dL at 1 month, and 47.60 ± 6.51 mg/dL at 3 months postoperatively. The increase was statistically significant ($p < 0.001$), with mean differences of –3.17, –11.59, and –14.70 mg/dL at 1 week, 1 month, and 3 months, respectively, compared with baseline.

Low-density Lipoprotein (LDL)

Low-density lipoprotein levels also demonstrated a significant decline postoperatively (Table 5). The mean LDL was 129.17 ± 27.62 mg/dL preoperatively, dropping to 121.85 ± 26.28 mg/dL at

Table 1: Age and gender distribution

	Total patients		*Female patients*		*Male patients*	
Age-group (years)	*Frequency*	*Percentage*	*Frequency*	*Percentage*	*Frequency*	*Percentage*
0–20	2	2.3	2	2.12	0	0
20–40	55	63.25	51	54.06	4	18.16
40–60	48	55.2	36	38.16	12	54.48
60–80	10	12.65	05	5.3	06	27.24

Table 2: Total cholesterol of patients before and after surgery

TC	*Mean*	*SD*	*N*
Preoperatively	199.99	26.933	116
At 1 week postoperatively	194.18	26.879	116
At 1 month postoperatively	176.84	22.709	116
At 3 months postoperatively	169.95	22.495	116

Table 3: Mean TG of patients before and after surgery

TG	*Mean*	*SD*	*N*
Preoperatively	189.58	28.259	116
At 1 week postoperatively	181.25	25.890	116
At 1 month postoperatively	161.76	20.195	116
At 3 months postoperatively	156.96	18.680	116

Table 4: Mean HDL before and after surgery

HDL	*Mean*	*SD*	*N*
Preoperatively	32.91	5.769	116
At 1 week postoperatively	36.08	6.058	116
At 1 month postoperatively	44.49	6.051	116
At 3 months postoperatively	47.60	6.515	116

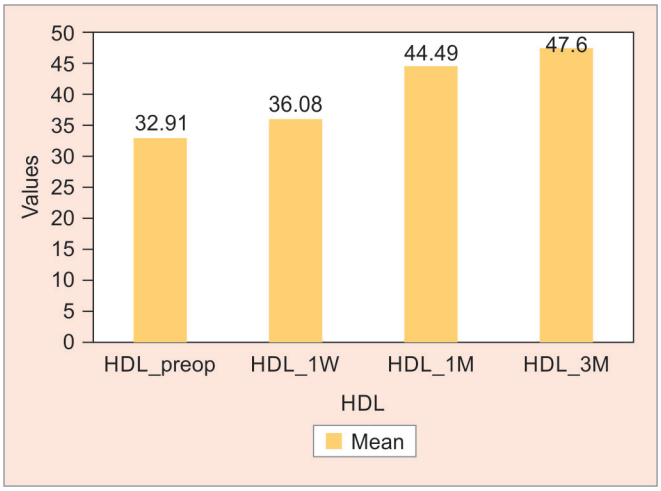


Fig. 1: Mean HDL before and after surgery

1 week, 99.99 ± 23.24 mg/dL at 1 month, and 90.95 ± 22.35 mg/dL at 3 months. These reductions were statistically significant ($p < 0.001$), with mean differences of 7.32, 29.18, and 38.22 mg/dL, at 1 week, 1 month, and 3 months, respectively.

Table 5: Mean LDL before and after surgery

LDL	*Mean*	*SD*	*N*
Preoperatively	129.170690	27.6268584	116
At 1 week postoperatively	121.851724	26.2870459	116
At 1 month postoperatively	99.994828	23.2431153	116
At 3 months postoperatively	90.953448	22.3584764	116

Table 6: Mean VLDL before and after surgery

VLDL	*Mean*	*SD*	*N*
Preoperatively	37.915517	5.6518808	116
At 1 week postoperatively	36.251724	5.1788950	116
At 1 month postoperatively	32.350000	4.0407382	116
At 3 months postoperatively	31.391379	3.7360190	116

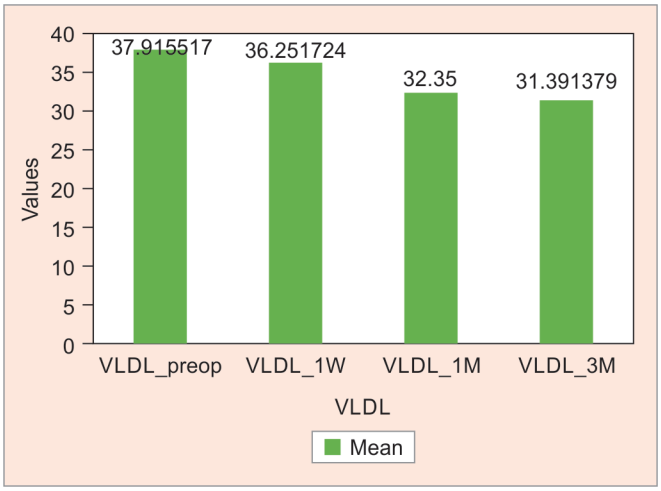


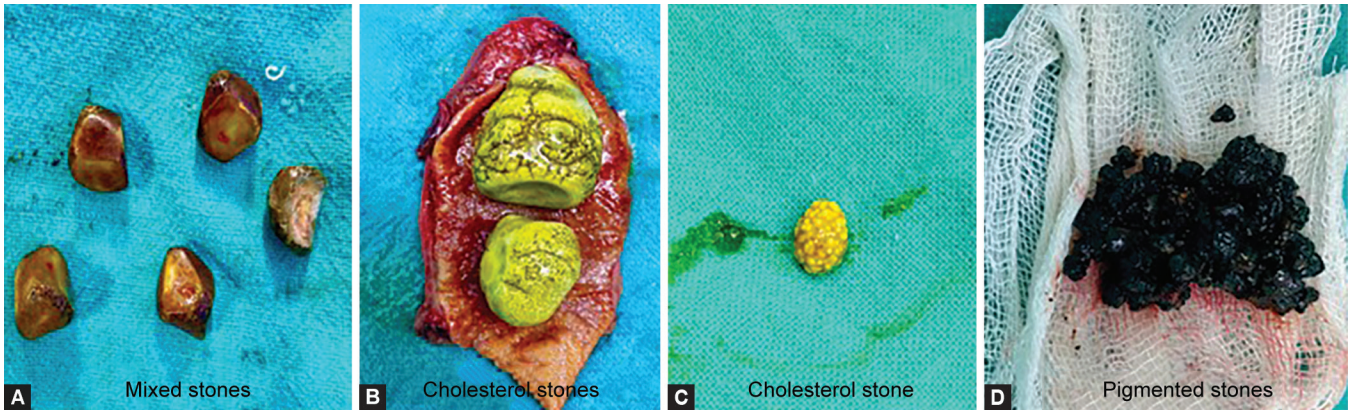
Fig. 2: Mean VLDL values before and after surgery

Very Low-density Lipoprotein (VLDL)

Mean VLDL values decreased significantly during the study period (Table 6 and Fig. 2). The preoperative mean was 37.91 ± 5.65 mg/dL, which reduced to 36.25 ± 26.28 mg/dL at 1 week, 32.35 ± 4.04 mg/dL at 1 month, and 31.39 ± 3.37 mg/dL at 3 months postoperatively. The differences were statistically significant ($p < 0.001$), with mean reductions of 1.66, 5.57, and 6.52 mg/dL at each respective follow-up point.

Discussion

In our study, patient ages ranged from 18 to 70 years, with a mean age of 41.92 ± 11.95 years. The majority of patients belonged



Figs 3A to D: Images of different types of gall stones

to the middle age-group, with 47.41% aged between 20 and 40 years, followed by 41.37% in the 40–60 years group. Among female patients, 54.06% were within the 20–40 age range, while the majority of male patients (54.48%) were aged between 40 and 60 years. The gross appearance of different gall stones seen in our study can be seen in Figure 3.

Several studies—including those by Jindal et al., Sun et al., Kim et al., and Tazuma—have reported a higher incidence of gallstone disease in females.[11–14] This gender disparity is largely attributed to factors such as the number of pregnancies and the influence of estrogen, which promotes cholesterol supersaturation in bile by increasing hepatic cholesterol secretion.[13] Gallstone disease is commonly observed in women who are obese, of reproductive age, and over 40 years of age.[15] Consistent with these findings, our study also observed a predominance of female patients (81%), with a mean patient age of 41.92 years, aligning with the reproductive age-group and supporting this demographic trend.

In the present study, the mean preoperative serum TC level was 199.99 ± 26.93 mg/dL. Postoperatively, the mean levels declined to 194.18 ± 26.87 mg/dL at 1 week, 176.84 ± 22.70 mg/dL at 1 month, and 169.95 ± 22.49 mg/dL at 3 months. The reduction in cholesterol levels was statistically significant, showing a gradual and more pronounced decline over time. These findings are supported by studies conducted by Jindal et al., Malik et al., Ahi et al., and Al-Kataan et al., which also demonstrated a decrease in total serum cholesterol following cholecystectomy.[11,16–18]

The mean preoperative TG level was 189.58 ± 28.25 mg/dL. This decreased to 181.25 ± 25.89 mg/dL at 1 week, 161.76 ± 20.19 mg/dL at 1 month, and 156.95 ± 18.68 mg/dL at 3 months postoperatively. Similar trends were reported by Jindal et al. and Malik et al., where TG levels significantly declined following surgery.[11,16] In contrast, a study by Al-Kataan et al. reported an initial increase in TG levels on postoperative day 7, followed by a significant decrease by the first month—consistent with the later postoperative trends observed in our study.[18]

The mean HDL level preoperatively was 32.91 ± 5.76 mg/dL. Postoperatively, the values increased to 36.08 ± 6.05 mg/dL at 1 week, 44.49 ± 26.05 mg/dL at 1 month, and 47.60 ± 6.51 mg/dL at 3 months. Studies by Jindal et al., Ahi et al., Al-Kataan et al., and Shu et al. similarly reported a significant rise in serum HDL-C levels after cholecystectomy, suggesting a reversal of the reduced HDL-C levels often seen in gallstone patients.[11,17–19] This phenomenon may be attributed to improved HDL receptor activity in hepatocytes postoperatively.

Preoperatively, the mean LDL level was 129.17 ± 27.62 mg/dL. This decreased to 121.85 ± 26.28 mg/dL at 1 week, 99.99 ± 23.24 mg/dL at 1 month, and 90.95 ± 22.35 mg/dL at 3 months. These reductions were statistically significant and align with findings from Jindal et al., Ahi et al., and Al-Kataan et al., who also observed notable postcholecystectomy declines in LDL-C among patients with gallstone disease.[11,17,18]

The mean VLDL level preoperatively was 37.91 ± 5.65 mg/dL. Postoperative mean values were 36.25 ± 26.28 mg/dL at 1 week, 32.35 ± 4.04 mg/dL at 1 month, and 31.39 ± 3.37 mg/dL at 3 months, reflecting a consistent downward trend.

Conclusion

Based on the findings of this study, it can be concluded that a majority of patients with gallstone disease exhibit abnormal lipid profiles preoperatively. Laparoscopic cholecystectomy was associated with a statistically significant improvement in these parameters. Total cholesterol, TGs, LDL, and VLDL levels decreased notably, while HDL levels increased progressively over time. These changes suggest that cholecystectomy may play a beneficial role in correcting lipid imbalances associated with gallstone disease. Therefore, beyond symptom relief, cholecystectomy may offer additional metabolic advantages. Larger-scale, multicenter studies with longer follow-up periods are recommended to further explore these observations and determine their implications for cardiovascular risk reduction.

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