

Research Article

Correlation between Serum Cholesterol and Surgical Site Infections

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ABSTRACT

Background: Surgical site infections (SSIs) are among the most common postoperative complications, contributing to increased morbidity, prolonged hospitalization, and healthcare costs. Alterations in serum lipid profiles may influence immune responses, inflammatory processes, and wound healing. The present study aimed to evaluate the association between serum lipid profile parameters and surgical site infections among patients undergoing operative procedures.

Materials and Methods: This hospital-based, cross-sectional observational study was conducted in the Department of Surgery, Regional Institute of Medical Sciences (RIMS), Imphal West, Manipur, from December 2023 to January 2026. A total of 102 adult patients were included. Demographic characteristics, SSI status, and serum lipid profile parameters were recorded. Statistical analysis was performed using SPSS version 25.0. The Chi-square test, Pearson correlation, and independent-samples t-test were employed, with $p \leq 0.05$ considered statistically significant.

Results: The mean age was 48.33 ± 10.21 years, and 58.8% of participants were female. SSI occurred in 43 patients (42.2%). Infection frequency increased significantly with age ($p = 0.008$), reaching 66.7% among patients aged 61-75 years. Gender was not significantly associated with SSI ($p = 0.350$). Mean total cholesterol, triglyceride, LDL, HDL, and VLDL levels were 182.32, 191.20, 102.16, 41.97, and 38.20 mg/dL, respectively.

Conclusion: Increasing age was significantly associated with SSIs, whereas gender showed no significant association. Serum lipid parameters may have clinical relevance, but their predictive utility requires further investigation through larger prospective studies with preoperative lipid assessment.

Keywords: Surgical Site Infection, Serum Cholesterol, Lipid Profile, Postoperative Complications, Risk Factors, Wound Healing.

INTRODUCTION

Surgical site infections (SSIs) are among the most common healthcare-associated infections and remain a major cause of postoperative morbidity, mortality, prolonged hospitalization, and increased healthcare expenditure worldwide[1]. Despite advances in surgical techniques, aseptic practices, antimicrobial prophylaxis, and perioperative management, SSIs continue to pose significant challenges, particularly in low- and middle-income countries. Early identification of patients at increased risk of developing SSIs is therefore essential for improving surgical outcomes and

implementing effective preventive strategies [2]. Surgical site infections are defined as infections occurring at or near the operative site within a specified postoperative surveillance period. According to the Centers for Disease Control and Prevention (CDC), SSIs are classified into superficial incisional, deep incisional, and organ/space infections based on the anatomical structures involved [3-5]. These infections may present with localized inflammation, purulent discharge, wound dehiscence, abscess formation, or systemic manifestations. SSIs account for a substantial proportion of healthcare-associated infections

and are associated with delayed wound healing, additional surgical interventions, prolonged antibiotic therapy, and increased healthcare costs [6-8]. The development of SSIs is multifactorial, involving interactions between microbial contamination, host immune response, and perioperative factors. Established risk factors include advanced age, obesity, diabetes mellitus, malnutrition, smoking, immunosuppression, prolonged operative duration, wound contamination, and higher American Society of Anesthesiologists (ASA) scores[9,10]. Surgical wound classification into clean, clean-contaminated, contaminated, and dirty categories further assists in assessing infection risk. However, conventional risk factors do not completely explain individual variations in postoperative infection susceptibility, highlighting the need to investigate additional metabolic and biochemical predictors [11-15]. Cholesterol is an essential component of cellular membranes and plays important roles in immune regulation, inflammatory responses, and tissue repair. Circulating lipoproteins, particularly high-density lipoprotein (HDL), possess anti-inflammatory and antioxidant properties and may contribute to host defense by binding and neutralizing bacterial endotoxins. Alterations in serum cholesterol levels may influence cytokine activity, immune cell function, and wound healing, potentially affecting susceptibility to postoperative infections [15,16]. Consequently, serum cholesterol has emerged as a potential biochemical marker for evaluating infection risk.

Although the relationship between lipid metabolism and infection has received increasing attention, evidence regarding the association between serum cholesterol levels and SSIs remains limited, particularly in the Indian population. Regional differences in nutritional status, patient characteristics, and healthcare practices further emphasize the importance of local investigations [9,11]. Therefore, the present study was undertaken to

evaluate the correlation between serum cholesterol levels and surgical site infections among patients undergoing operative procedures at a tertiary care center in Northeast India.

MATERIALS AND METHODS

The present study was conducted as a hospital-based, cross-sectional observational study in the Department of Surgery, Regional Institute of Medical Sciences (RIMS), Imphal, Manipur, India. The study aimed to evaluate serum lipid profile parameters among patients who developed surgical site infections (SSIs) following operative procedures. The study was conducted over a period of two years and two months, from December 2023 to January 2026, which included patient recruitment, data collection, biochemical investigations, and statistical analysis.

Study Population

The study population comprised adult patients undergoing elective or emergency surgical procedures in the Department of Surgery, RIMS, Imphal. Patients were monitored postoperatively for the development of SSIs. Those who developed SSIs and fulfilled the eligibility criteria were included in the final study population.

Inclusion Criteria

1. Patients aged above 18 years.
2. Patients who underwent operative procedures in the Department of Surgery, RIMS, Imphal.
3. Patients who developed postoperative surgical site infections.

Exclusion Criteria

1. Pregnant patients.
2. Patients with compromised immunity, including HIV-positive individuals.
3. Patients receiving long-term corticosteroid therapy or other immunosuppressive medications.

Sample Size and Sampling Technique

The sample size was calculated using the formula:

$$n = \frac{Z_{\alpha}^2 \times p \times q}{d^2}$$

Where $Z_{\alpha} = 1.96$ at a 95% confidence level, $p = 10.8\%$ (prevalence of hypercholesterolemia among patients with SSI), $q = 89.2\%$, and $d = 6\%$ (absolute precision).

The calculated minimum sample size was approximately 102 patients. Consecutive sampling was used, and eligible patients were recruited sequentially until the required sample size was achieved.

Data Collection

Demographic and clinical information was collected using a predesigned structured proforma. Data included age, sex, type of surgical procedure, duration of surgery, postoperative clinical findings, and length of hospital stay. Patients were monitored postoperatively until discharge for clinical evidence of SSI. The diagnosis was established by the treating surgical team according to standard clinical criteria.

Blood Sample Collection and Biochemical Analysis

Fasting venous blood samples were collected on the first day following the diagnosis of SSI.

Approximately 2.5 mL of blood was obtained through antecubital venipuncture under aseptic precautions and transferred into plain collection tubes. Samples were allowed to clot, followed by centrifugation at 3000 rpm for three minutes to separate serum. Serum total cholesterol, triglycerides, and high-density lipoprotein (HDL) cholesterol were estimated using standardized enzymatic methods on an automated biochemistry analyzer (BECKMAN COULTER DxC 700 AU). Low-density lipoprotein (LDL) cholesterol and very-low-density lipoprotein (VLDL) cholesterol were calculated using the Friedewald formula:

$$\text{VLDL-C} = \frac{\text{Triglycerides}}{5}$$

$$\text{LDL-C} = \text{Total Cholesterol} - \text{HDL-C} - \text{VLDL-C}$$

All lipid concentrations were expressed in mg/dL. The Friedewald equation was applicable when triglyceride concentrations were below 400 mg/dL. The variables assessed included age, sex, total serum cholesterol, triglycerides, HDL cholesterol, LDL cholesterol, and VLDL cholesterol. The primary clinical outcome was the occurrence of SSI following surgery.

Statistical Analysis

Data were entered and analyzed using IBM SPSS Statistics version 25.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean $\pm$ standard deviation, while categorical variables were presented as frequencies and percentages. Associations between categorical variables were evaluated using the Chi-square test, while comparisons of continuous variables between independent

groups were performed using the independent-samples t-test, where applicable. Pearson's correlation coefficient was used to assess relationships between continuous variables. A p-value of ≤ 0.05 was considered statistically significant.

RESULTS

A total of 102 participants were included in the study. The mean age of the participants was 48.33 ± 10.208 years. The mean total cholesterol level was 182.32 ± 39.011 mg/dL, while the mean serum triglyceride level was 191.20 ± 64.815 mg/dL. The mean LDL, HDL, and VLDL cholesterol levels were 102.16 ± 32.368 mg/dL, 41.97 ± 11.529 mg/dL, and 38.20 ± 13.013 mg/dL, respectively. The descriptive statistics of demographic and lipid profile parameters are presented in Table 1 and

Figure 1. Regarding demographic distribution, the majority of participants belonged to the age group of 46–60 years (43.1%), followed by 31–45 years (42.2%) and 61–75 years (14.7%). Females constituted 58.8% of the study population, while males accounted for 41.2%. Surgical site infection (SSI) was observed in 43 participants (42.2%), whereas 59 participants (57.8%) did not develop SSI. The distribution of participants according to age, gender, and SSI status is illustrated in Table 2 and Figure 2. The association between age groups and SSI demonstrated that among participants who developed SSI, 51.2% belonged to the 46–60-year age group, followed by 25.6% in the 31–45-year group and 23.3% in the 61–75-year group. Among participants without SSI, the corresponding proportions were 37.3%, 54.2%, and 8.5%, respectively. A statistically significant association was reported between increasing age and SSI occurrence ($p = 0.008$),

as shown in Table 3. Gender-wise analysis revealed that among participants with SSI, 46.5% were males and 53.5% were females. Among participants without SSI, 37.3% were males and 62.7% were females. Although the proportion of males was slightly higher in the SSI group, the association between gender and SSI was not statistically significant ($p = 0.350$), as presented in Table 4. Relative risk analysis indicated that participants aged 46–60 years had a 1.95-fold higher risk of developing SSI ($RR = 1.95$; 95% CI: 1.08–3.51), while those aged 61–75 years had a 2.61-fold higher risk ($RR = 2.61$; 95% CI: 1.40–4.85), compared with participants aged 31–45 years. Male participants demonstrated a 1.24-fold higher risk of SSI compared with females ($RR = 1.24$; 95% CI: 0.78–1.97); however, this association was not statistically significant because the confidence interval included unity. These findings are presented in Table 5 and Figure 3.

Table 1. Descriptive Statistics of Demographic and Lipid Profile Parameters Among Study Participants (N = 102)

Parameters	Mean	Standard deviation
Age (years)	48.33	10.208
Total cholesterol (mg/dL)	182.32	39.011
Serum triglycerides (mg/dL)	191.20	64.815
LDL cholesterol (mg/dL)	102.16	32.368
HDL cholesterol (mg/dL)	41.97	11.529
VLDL cholesterol (mg/dL)	38.20	13.013

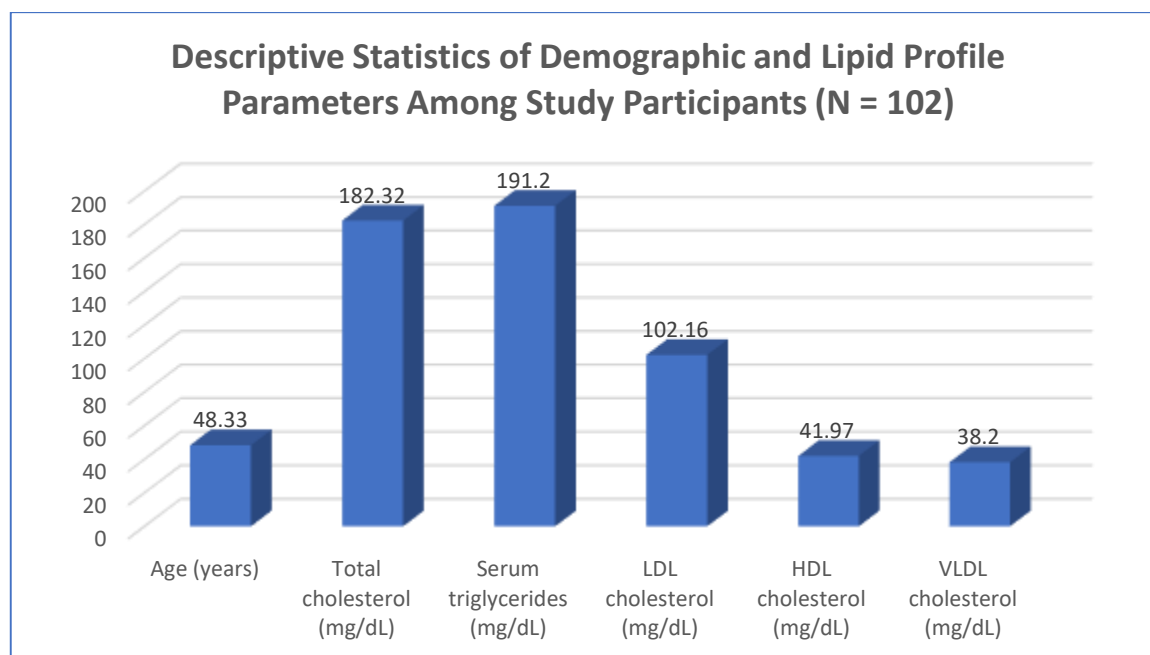


Figure 1 Descriptive Statistics of Demographic and Lipid Profile Parameters Among Study Participants (N = 102)

Table 2. Distribution of Study Participants According to Age, Gender, And Surgical Site Infection Status (N = 102)

Parameters	Categories	Frequency (n)	Percentage (%)
Age (years)	31–45	43	42.2
	46–60	44	43.1
	61–75	15	14.7
Gender	Male	42	41.2
	Female	60	58.8
Surgical site infection	Present	43	42.2
	Absent	59	57.8

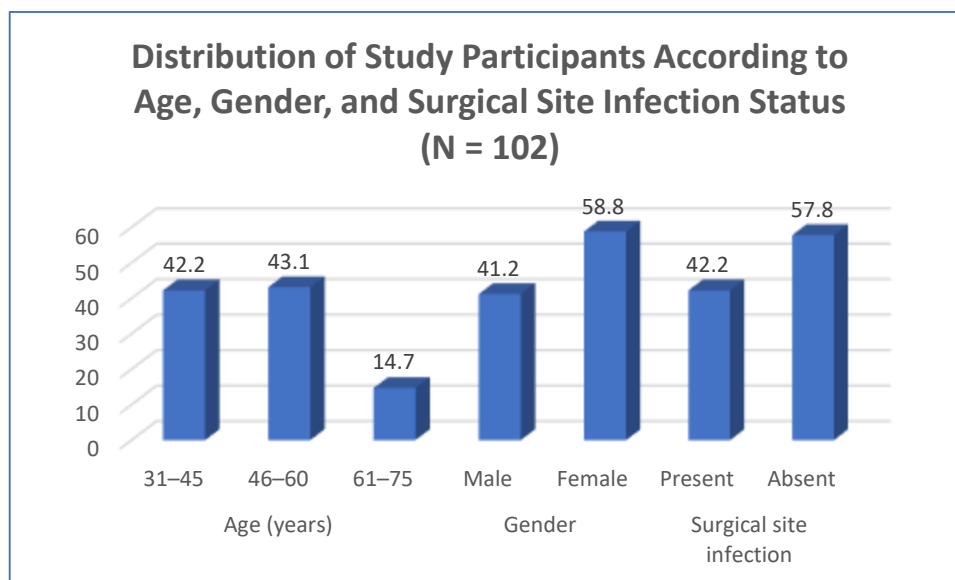


Figure 2 Distribution of Study Participants According to Age, Gender, and Surgical Site Infection Status (N = 102)

Table 3. Association Between Age Groups and Surgical Site Infection (N = 102)

Age group (years)	SSI present (n = 43)	SSI absent (n = 59)	Total (N = 102)	p-value
31–45	11 (25.6%)	32 (54.2%)	43	
46–60	22 (51.2%)	22 (37.3%)	44	
61–75	10 (23.3%)	5 (8.5%)	15	
Total	43 (100%)	59 (100%)	102	0.008*

Statistical test: Chi-square test. Percentages are calculated within SSI groups. * $p \leq 0.05$ was considered statistically significant.

Table 4. Association Between Gender and Surgical Site Infection (N = 102)

Gender	SSI present (n = 43)	SSI absent (n = 59)	Total (N = 102)	p-value
Male	20 (46.5%)	22 (37.3%)	42	
Female	23 (53.5%)	37 (62.7%)	60	
Total	43 (100%)	59 (100%)	102	0.350

Statistical test: Chi-square test. Percentages are calculated within SSI groups. $p \leq 0.05$ was considered statistically significant.

Table 5. Relative Risk of Surgical Site Infection According to Age Group and Gender (N = 102)

Risk factors	Comparison	Relative risk (RR)	95% CI
Age 46–60 years	Versus 31–45 years	1.95	1.08–3.51
Age 61–75 years	Versus 31–45 years	2.61	1.40–4.85
Male gender	Versus female	1.24	0.78–1.97

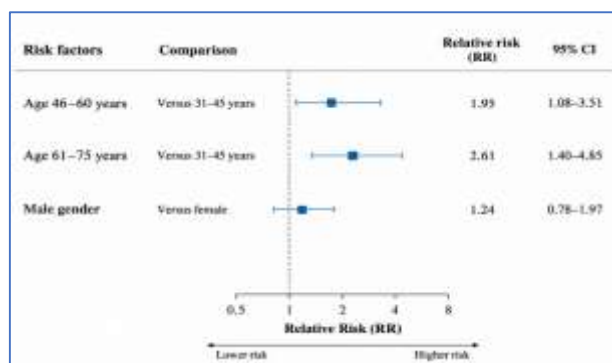


Figure 3 Relative Risk of Surgical Site Infection According to Age Group and Gender

DISCUSSION

The present hospital-based observational study evaluated demographic characteristics and serum lipid profile parameters in relation to surgical site infections (SSIs) among 102 patients undergoing operative procedures. The mean age was 48.33 ± 10.21 years, with the majority belonging to the 46–60 years age group (43.1%), followed by 31–45 years (42.2%). Females constituted 58.8% of participants, while males accounted for 41.2% (Tables 1 and 2). Comparable findings were reported by Arora et al. (2025)[17], who studied 107 patients undergoing clean elective surgery and observed a mean age of 43.50 ± 16.29 years, with 54 males and 53 females. These findings indicate that postoperative infection studies commonly involve middle-aged surgical populations, although demographic distributions vary according to patient selection and surgical procedures. In the present study, SSI was observed in 43 patients (42.2%), whereas 59 patients (57.8%) remained infection-free (Table 2). This proportion was considerably higher than that reported by the GlobalSurg Collaborative (2018)[18], which evaluated 12,539 patients across 66 countries and documented an overall SSI incidence of 12.3%. Infection rates varied from 9.4% in high-HDI countries to 14.0% and 23.2% in middle- and low-HDI countries, respectively. Similarly, Arora et al. (2025)[17] reported SSI in 23 of 107 patients (21.5%). Differences in infection rates may reflect variations in surgical complexity, wound contamination, patient characteristics, postoperative surveillance, and institutional infection-control practices. Age demonstrated a statistically significant association with SSI in the present study ($p = 0.008$). The proportion developing SSI increased from 25.6% among patients aged 31–45 years to 50.0% among those aged 46–60 years and 66.7% among those aged 61–75 years (Table 3). Compared with the youngest age group, patients aged 46–

60 years had a relative risk of 1.95 (95% CI: 1.08–3.51), while those aged 61–75 years had a relative risk of 2.61 (95% CI: 1.40–4.85) (Table 5). These findings suggest an age-related increase in postoperative infection risk, potentially associated with comorbidities, reduced physiological reserve, and impaired wound healing. Gender was not significantly associated with SSI ($p = 0.350$). Infection occurred in 20 of 42 males (47.6%) and 23 of 60 females (38.3%) (Table 4). Male patients had a relative risk of 1.24 (95% CI: 0.78–1.97), indicating that the observed difference was not statistically conclusive (Table 5). This suggests that gender alone may have limited predictive value for SSI in the present population. The mean total cholesterol, triglyceride, LDL, HDL, and VLDL levels in the present study were 182.32 ± 39.01 , 191.20 ± 64.82 , 102.16 ± 32.37 , 41.97 ± 11.53 , and 38.20 ± 13.01 mg/dL, respectively (Table 1). Sharma et al. (2025)[19], in a study of 100 surgical patients, reported SSI in 42.3% of patients with hypocholesterolemia, compared with 11.1% with hypercholesterolemia and 8.9% with normal cholesterol ($p = 0.00087$). Similarly, a study involving 1,031 gastrointestinal surgical patients reported an adjusted odds ratio of 5.39 (95% CI: 2.28–12.76) for incisional SSI among patients with cholesterol below 159 mg/dL compared with those having levels of 200–239 mg/dL. These findings support an association between cholesterol status and postoperative infection, although the direction and magnitude of this association require evaluation in the present dataset.

CONCLUSION

The present study demonstrated a substantial occurrence of surgical site infections (42.2%) among patients undergoing operative procedures. Increasing age was significantly associated with SSI development, with the highest infection proportion observed among elderly patients. Gender showed no statistically

significant association with SSI. Serum lipid profile abnormalities may have clinical relevance in postoperative infections, although their predictive value requires further investigation. Early identification of risk factors and appropriate preventive strategies may help reduce SSI-related morbidity and improve surgical outcomes.

Limitations

The present study was conducted at a single tertiary care centre with a relatively small sample size, limiting the generalizability of the findings. Its cross-sectional observational design prevented the establishment of causal relationships between serum lipid levels and surgical site infections. Furthermore, lipid profiles were assessed after SSI diagnosis, limiting their predictive significance. Potential confounding factors, including diabetes mellitus, nutritional status, wound classification, and duration of surgery, were not adequately controlled.

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