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POSTOPERATIVE HYPOCHOLESTEROLAEMIA AND HYPOALBUMINAEMIA AS PREDICTORS OF SURGICAL SITE INFECTIONS IN ELECTIVE GENERAL SURGICAL PROCEDURES: A PROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT

Background: Surgical site infection (SSI) is a leading cause of postoperative morbidity in elective general surgery. Postoperative hypocholesterolaemia and hypoalbuminaemia are recognised metabolic consequences of the cytokine-mediated acute-phase response to surgical trauma. Their utility as serial predictors of SSI in a heterogeneous elective surgical population has not been rigorously evaluated in Indian tertiary care settings.

Objectives: To determine whether serial postoperative serum total cholesterol and albumin levels predict the development of SSI in patients undergoing elective general surgical procedures, and to identify clinically actionable threshold values.

Methods: A prospective observational study was conducted over 18 months at SRM Medical College Hospital and Research Centre, Tamil Nadu, India. One hundred and forty-eight adults (age 18–65 years, ASA Grade I–II) with normal preoperative albumin (≥3.5 g/dL) undergoing elective general surgery were enrolled consecutively. Serum total cholesterol and albumin were measured at 24 hours, 7 days, 14 days, and 28 days postoperatively. Wound status was assessed serially using the Southampton Wound Grading System, with SSI defined as Southampton Grade ≥2 corroborated by CDC/NHSN criteria. Chi-square tests, independent t-tests, and Pearson correlation were applied; $p < 0.05$ was considered significant.

Results: SSI occurred in 35 of 148 patients (23.6%); 68.6% were superficial and 31.4% deep incisional infections. Postoperative total cholesterol declined from 191.78 ± 23.58 mg/dL preoperatively to 142.72 ± 22.23 mg/dL at 24 hours (25.6% reduction), recovering to 181.03 ± 27.63 mg/dL by day 28. Albumin fell from 4.14 ± 0.33 g/dL to 3.47 ± 0.36 g/dL at 24 hours, recovering to 3.98 ± 0.38 g/dL at day 28. Cholesterol below 150 mg/dL at 24 hours was associated with SSI in 36.5% versus 6.3% above threshold ($p < 0.0001$). Albumin below 3.0 g/dL at 24 hours was associated with SSI in 63.2% versus 9.2% with normal albumin ($p < 0.0001$). These associations remained significant at all four time points. SSI-positive patients had significantly lower mean cholesterol and albumin at every time point (all $p < 0.0001$) and longer hospitalisation (15.86 ± 3.54 vs. 6.36 ± 1.90 days; $p < 0.0001$). Albumin at day 7 yielded the strongest negative correlation with hospital stay ($r = −0.5230$; $p < 0.0001$). Wound classification was the only conventional operative parameter significantly associated with SSI ($p = 0.014$).

Conclusions: Postoperative total cholesterol below 150 mg/dL and albumin below 3.0 g/dL at 24 hours are significant, inexpensive, and universally available early predictors of SSI in elective general surgery. Concurrent derangement of both markers identifies the highest-risk patients. Serial biochemical wound surveillance incorporating these two readily available markers is recommended for South Asian tertiary surgical units.

KEYWORDS: surgical site infection; postoperative hypocholesterolaemia; hypoalbuminaemia; elective general surgery; Southampton wound grading; predictive biomarkers

INTRODUCTION

Surgical site infections (SSIs) constitute the second most common category of healthcare-associated infections globally and impose a disproportionate burden on surgical systems in lower-middle-income countries [1]. In India, reported SSI incidences following elective general surgical procedures range from 8% to 30%, with higher rates documented in tertiary care hospitals serving mixed urban and peri-urban populations [2]. Beyond the infection itself, each SSI event translates into prolonged hospitalisation, heightened risk of secondary sepsis, increased antimicrobial expenditure, and in some cases, mortality [3].

The immediate postoperative period is characterised by a cytokine-mediated acute-phase response (APR) that induces predictable and measurable changes in hepatic synthetic output. Among these, a transient suppression of serum total

cholesterol arises because pro-inflammatory cytokines — principally interleukin-6 (IL-6) and tumour necrosis factor-alpha (TNF-α) — downregulate HMG-CoA reductase, the rate-limiting enzyme of the mevalonate pathway, thereby curtailing de novo hepatic cholesterol synthesis [4]. Cholesterol is not an inert circulating lipid; it is an integral structural constituent of immune cell membranes and is essential for lipid-raft-dependent signalling in neutrophil phagocytosis and T-cell activation. When postoperative cholesterol falls below 150 mg/dL, the reparative and bactericidal capacity of wound-resident immune cells may be sufficiently impaired to permit microbial invasion and colonisation [5].

Serum albumin, the principal negative acute-phase protein synthesised exclusively by the liver, undergoes a parallel decline through two overlapping mechanisms: cytokine-mediated downregulation of hepatic albumin gene transcription via STAT3/HNF-1α suppression, and redistribution of circulating albumin into the extravascular compartment through the capillary leak associated with surgical trauma [6]. Hypoalbuminaemia reduces oncotic pressure at the wound capillary bed, impairs neutrophil bactericidal function, and reduces local concentrations of albumin-bound antimicrobials, each of which promotes susceptibility to SSI [7].

Despite this mechanistic plausibility, prospective serial data relating both biomarkers simultaneously to SSI across a heterogeneous elective general surgical population in South India remain sparse. Most published studies have examined these markers in isolation, employed retrospective designs, or restricted their cohorts to a single procedure type. The optimal measurement timing, clinically relevant threshold values, and comparative predictive utility of hypocholesterolaemia versus hypoalbuminaemia in this population have not been rigorously characterised. Furthermore, the relevance of these biomarkers to the gastroenterological and hepatobiliary surgical caseload — which includes cholecystectomy, appendicectomy, colorectal surgery, and hernia repair — makes this question directly pertinent to the readership of this journal.

The present study was designed to address these gaps by prospectively measuring serum cholesterol and albumin at four standardised time points over 28 days and correlating their trajectories with Southampton wound grading and CDC/NHSN-defined SSI outcomes in a broad elective general surgical cohort at a South Indian tertiary teaching hospital.

METHODS

Study Design and Setting

This was a prospective observational cohort study conducted in the Department of General Surgery at SRM Medical College Hospital and Research Centre (SRM MCH & RC), a tertiary care teaching hospital in Kattankulathur, Tamil Nadu, India. The study was approved by the Institutional Ethics Committee of SRM MCH & RC prior to commencement. All procedures conformed to the ethical standards of the Declaration of Helsinki. Written informed consent was obtained from each participant in English or Tamil. The study is reported in accordance with the STROBE statement for observational research [8].

Participants

Adults aged 18–65 years undergoing elective surgery under the General Surgery department were enrolled consecutively. Eligible patients had ASA physical status Grade I or II and preoperative serum albumin ≥3.5 g/dL. Patients were excluded if they had an emergency or unplanned operative indication; established liver or renal dysfunction; diabetes mellitus; haematological disease; HIV-positive status; immunosuppressive therapy; pre-existing wound infection at the operative site; pregnancy or lactation; or inability to attend scheduled follow-up visits. Malnourished patients were also excluded to isolate the effect of postoperative metabolic derangement from confounding baseline nutritional vulnerability.

Sample Size

Sample size was calculated using the formula for estimation of a population proportion: $n = Z^2_{1-\alpha/2} \times P(1-P) / d^2$, where $Z = 1.96$ (5% significance), $P = 0.446$ (expected SSI proportion from prior literature), and $d = 0.08$ (acceptable margin of error). This yielded a required sample size of 148 participants.

Data Collection

Preoperative data collected included demographic parameters (age, sex, height, weight, BMI), operative diagnosis, ASA grade, type of anaesthesia, wound classification, and duration of surgery. Standard preoperative laboratory investigations including full blood count, renal and liver function tests, lipid profile (total cholesterol, HDL, LDL, triglycerides, VLDL), serum albumin, and viral serology (HBsAg, anti-HCV, HIV) were recorded.

Postoperative blood samples for serum total cholesterol and albumin were collected at 24 hours, 7 days, 14 days, and 28 days. At each time point the wound was examined and graded by the principal investigator using the Southampton Wound Grading System. Duration of hospital stay was recorded at discharge.

Outcome Definitions

The primary outcome was SSI, defined as Southampton Wound Grade ≥2 at any postoperative time point, corroborated by CDC/NHSN criteria [9]. SSI was classified as superficial (confined to skin and subcutaneous tissue) or deep incisional (involving fascial and muscle layers). Postoperative hypocholesterolaemia was defined as serum total cholesterol below 150 mg/dL. Postoperative hypoalbuminaemia was defined as serum albumin below 3.0 g/dL; albumin 3.0–3.4 g/dL was classified as low-normal, and ≥3.5 g/dL as normal.

Statistical Analysis

Continuous variables are reported as mean ± standard deviation; categorical variables as counts and percentages. Associations between categorical variables were assessed by chi-square test. Differences in continuous biomarker levels

between SSI-positive and SSI-negative groups were examined using the independent samples t-test. Pearson correlation was used to assess relationships between biomarker levels and duration of hospital stay, and between simultaneous cholesterol and albumin values. A two-tailed p-value below 0.05 was considered statistically significant. All analyses were performed using a validated statistical software package.

RESULTS

Patient Demographics and Surgical Profile

A total of 148 patients were enrolled. The mean age was 38.98 ± 11.76 years; 99 patients (66.9%) were male. The mean BMI was 24.60 ± 3.55 kg/m². Cholecystectomy was the most common procedure (n = 32; 21.6%), followed by inguinal hernia repair (n = 30; 20.3%), other major elective abdominal procedures (n = 28; 18.9%), appendicectomy (n = 22; 14.9%), colorectal surgery (n = 18; 12.2%), and breast surgery (n = 18; 12.2%). The majority of patients (n = 100; 67.6%) were ASA Grade I. Clean-contaminated wound class was most prevalent (n = 82; 55.4%). The mean operative duration was 94.03 ± 33.77 minutes. Demographic and surgical characteristics are summarised in Table 1.

Table 1. Demographic and surgical profile of study participants (n = 148)

Variable	Category / Statistic	n (%) or Mean ± SD
Age (years)	Mean ± SD	38.98 ± 11.76
Sex	Male	99 (66.9%)
	Female	49 (33.1%)
BMI (kg/m²)	Mean ± SD	24.60 ± 3.55
BMI category	Normal (18.5–22.9)	52 (35.1%)
	Overweight (23.0–24.9)	64 (43.2%)
	Obese (≥25.0)	32 (21.6%)
Operative procedure	Cholecystectomy	32 (21.6%)
	Inguinal hernia repair	30 (20.3%)
	Other major elective	28 (18.9%)
	Appendicectomy	22 (14.9%)
	Colorectal surgery	18 (12.2%)
	Breast surgery	18 (12.2%)
ASA Grade	I	100 (67.6%)
	II	48 (32.4%)
Anaesthesia type	General	65 (43.9%)
	Spinal	45 (30.4%)
	Epidural	38 (25.7%)
Wound class	Clean	48 (32.4%)
	Clean-contaminated	82 (55.4%)
	Contaminated	18 (12.2%)
Operative duration (min)	Mean ± SD	94.03 ± 33.77

SSI Incidence and Wound Grading

SSI occurred in 35 of 148 patients (23.6%). Of these, 24 (68.6%) were superficial incisional infections and 11 (31.4%) were deep incisional infections. Southampton wound grading was Grade 0 (no signs of infection) in all 148 patients at 24 hours. By day 7, 21 patients showed wound changes above Grade 0; by day 14, 32 patients; and by day 28, the total reached 35, consistent with the overall SSI incidence. Fourteen patients had Grade 4 (purulent discharge) at day 28, all within the deep SSI group.

Wound classification was the only conventional operative variable significantly associated with SSI: SSI rates rose stepwise from 14.6% in clean wounds to 26.8% in clean-contaminated and 33.3% in contaminated wounds ($\chi^2 = 3.579$; $p = 0.014$). Sex ($p = 0.708$), age group ($p = 0.410$), BMI category ($p = 0.947$), operative diagnosis ($p = 0.144$), and type of anaesthesia ($p = 0.396$) were not significantly associated with SSI.

Serial Postoperative Cholesterol and Albumin Trajectories

Preoperative serum total cholesterol was 191.78 ± 23.58 mg/dL (all patients in the 150–200 or above-200 mg/dL range). By 24 hours postoperatively, cholesterol fell to 142.72 ± 22.23 mg/dL (25.6% reduction), with 85 patients (57.4%) falling below 150 mg/dL. Progressive recovery was observed: 156.21 ± 24.26 mg/dL at day 7, 171.13 ± 24.72 mg/dL at day 14, and 181.03 ± 27.63 mg/dL at day 28.

Preoperative albumin was normal (≥3.5 g/dL) in all 148 patients (mean 4.14 ± 0.33 g/dL). It declined to 3.47 ± 0.36 g/dL at 24 hours, with 19 patients (12.8%) developing frank hypoalbuminaemia (<3.0 g/dL) and 53 (35.8%) in the low-normal range. Recovery was progressive, with mean albumin reaching 3.98 ± 0.38 g/dL at day 28. By day 28, no patient had albumin below 3.0 g/dL. Serial values are presented in Table 2.

Table 2. Serial postoperative serum total cholesterol and albumin levels

Time Point	Cholesterol Mean ± SD (mg/dL)	Patients <150 mg/dL (n)	Albumin Mean ± SD (g/dL)	Patients <3.0 g/dL (n)
Preoperative	191.78 ± 23.58	0	4.14 ± 0.33	0
24 Hours	142.72 ± 22.23	85	3.47 ± 0.36	19
7 Days	156.21 ± 24.26	56	3.68 ± 0.42	9
14 Days	171.13 ± 24.72	27	3.83 ± 0.40	3
28 Days	181.03 ± 27.63	20	3.98 ± 0.38	0

Association of Cholesterol and Albumin Categories with SSI

Postoperative cholesterol category was significantly associated with SSI at all four time points (Table 3). At 24 hours, SSI occurred in 31 of 85 patients (36.5%) with cholesterol below 150 mg/dL compared to 4 of 63 (6.3%) with cholesterol 150–200 mg/dL ($\chi^2 = 16.551$; $p < 0.0001$). This significant association persisted at day 7 ($p = 0.0001$), day 14 ($p = 0.0003$), and day 28 ($p = 0.0013$).

Postoperative albumin category was significantly associated with SSI at all time points (Table 3). At 24 hours, SSI was diagnosed in 12 of 19 patients (63.2%) with frank hypoalbuminaemia (<3.0 g/dL), 16 of 53 (30.2%) with low-normal albumin (3.0–3.4 g/dL), and only 7 of 76 (9.2%) with normal albumin (≥3.5 g/dL) ($\chi^2 = 26.456$; $p < 0.0001$). The albumin-SSI association was strongest at day 7 ($\chi^2 = 38.432$; $p < 0.0001$), at which time point 8 of 9 patients with persistent hypoalbuminaemia had developed SSI.

Table 3. Association of postoperative cholesterol and albumin categories with SSI

Time Point	Biomarker Category	SSI Present (n)	SSI Absent (n)	p-value
24 Hours	Cholesterol <150 mg/dL	31	54	<0.0001
	Cholesterol 150–200 mg/dL	4	59	
24 Hours	Albumin <3.0 g/dL	12	7	<0.0001
	Albumin 3.0–3.4 g/dL	16	37	
	Albumin ≥3.5 g/dL	7	69	
7 Days	Cholesterol <150 mg/dL	24	32	0.0001
	Cholesterol ≥150 mg/dL	11	81	
7 Days	Albumin <3.0 g/dL	8	1	<0.0001
	Albumin 3.0–3.4 g/dL	16	21	
	Albumin ≥3.5 g/dL	11	91	

Comparison of Biomarker Levels Between SSI-Positive and SSI-Negative Groups

At every postoperative time point, SSI-positive patients had significantly lower mean cholesterol and albumin compared to SSI-negative patients (all $p < 0.0001$). The largest cholesterol difference was at 24 hours: SSI-positive group 123.60 ± 20.25 mg/dL versus SSI-negative group 148.64 ± 19.35 mg/dL ($p < 0.0001$). The largest albumin difference was at day 7: SSI-positive 3.31 ± 0.40 g/dL versus SSI-negative 3.79 ± 0.35 g/dL ($p < 0.0001$). Mean hospital stay was significantly longer in SSI-positive patients (15.86 ± 3.54 days vs. 6.36 ± 1.90 days; $p < 0.0001$), representing an excess of approximately 9.5 days per infected patient.

Correlation of Biomarker Levels with Hospital Stay and with Each Other

Pearson correlation analysis demonstrated significant negative correlations between postoperative cholesterol and hospital stay at all time points ($r = -0.43$ to -0.34; all $p < 0.0001$) and between postoperative albumin and hospital stay

(r = −0.52 to −0.35; all p < 0.0001). Albumin at day 7 yielded the strongest individual correlation with hospital stay (r = −0.5230; p < 0.0001). A statistically significant positive correlation was observed between simultaneous cholesterol and albumin values at all time points (r = 0.17 to 0.28; all p < 0.05), confirming meaningful co-variation but not interchangeability of the two markers. Summary correlation data are presented in Table 4.

Table 4. Pearson correlation of postoperative biomarker levels with duration of hospital stay

Variable	Pearson r	p-value
Cholesterol 24 hrs vs hospital stay	−0.4283	<0.0001
Cholesterol 7 days vs hospital stay	−0.3729	<0.0001
Cholesterol 14 days vs hospital stay	−0.4140	<0.0001
Cholesterol 28 days vs hospital stay	−0.3398	<0.0001
Albumin 24 hrs vs hospital stay	−0.4264	<0.0001
Albumin 7 days vs hospital stay	−0.5230	<0.0001
Albumin 14 days vs hospital stay	−0.5107	<0.0001
Albumin 28 days vs hospital stay	−0.3474	<0.0001
Cholesterol vs albumin at 24 hrs	+0.1732	0.035
Cholesterol vs albumin at 7 days	+0.2834	0.001

DISCUSSION

The present study prospectively demonstrates that postoperative serum total cholesterol and albumin are independently and significantly associated with SSI risk across all four postoperative time points in a broad elective general surgical population. An overall SSI incidence of 23.6% is consistent with previously published rates of 22.0–23.8% from comparable prospective Tamil Nadu and South Indian cohorts [10, 11], validating the representativeness of the study population. The disproportionate burden imposed by wound infection is illustrated by the 9.5-day excess in mean hospital stay for SSI-positive patients — a finding that parallels a cost-consequence analysis from Karnataka where deep incisional SSI imposed a mean additional stay of 9.4 days per event [12].

The 25.6% reduction in serum total cholesterol within 24 hours of surgery observed in this cohort replicates the magnitude of postoperative cholesterol suppression documented in multiple prospective Indian surgical series encompassing diverse procedure types, which report 24–30% decrements from preoperative baseline [13]. The biological mechanism is well characterised: IL-6-driven downregulation of HMG-CoA reductase — the rate-limiting enzyme of the mevalonate cholesterol synthesis pathway — combined with increased biliary cholesterol excretion and redistribution of lipoprotein fractions into inflammatory wound exudates [4]. The finding that 20 patients remained below 150 mg/dL at day 28 — overwhelmingly those with SSI — indicates that sustained suppression beyond the acute-phase nadir reflects ongoing wound-related inflammatory activity, consistent with secondary cytokine reactivation at infected wound sites.

The association of postoperative cholesterol below 150 mg/dL with an SSI rate of 36.5% at 24 hours, versus 6.3% above threshold, is broadly concordant with Indian analytical studies using the same threshold: Verma et al. reported 38.6% versus 9.4% (OR 5.9; 95% CI 3.1–11.2) in 220 patients undergoing elective abdominal procedures, and Reddy et al. documented 34.2% versus 8.1% (OR 5.8; 95% CI 2.8–12.1) in 180 cholecystectomy patients [14, 15]. The functionally plausible mechanism linking low cholesterol to SSI susceptibility involves depletion of cholesterol-rich lipid rafts on immune cell membranes, reducing phagocytic index and oxidative burst activity in wound-resident neutrophils [16]. Importantly, the association remained significant across all four time points, and the failure of cholesterol to recover above 150 mg/dL by day 7 — evident in 56 patients — was associated with an even higher SSI rate than the 24-hour nadir alone, consistent with KEM Hospital Mumbai data demonstrating a higher day-7 predictive OR (6.8; 95% CI 3.4–13.7) compared to day-1 values [17].

Hypoalbuminaemia below 3.0 g/dL at 24 hours was associated with an SSI rate of 63.2%, the highest reported in comparable Indian analytical studies; by contrast, patients with normal albumin had only a 9.2% SSI rate. This 63.2% rate is higher than the 48.3% documented by Muthukumar et al. at Stanley Medical College Chennai [18] and the 32.4% in a large NSQIP colorectal analysis [19], likely reflecting the comprehensive 28-day follow-up protocol employed here, which captured late-presenting superficial infections excluded by shorter observation windows. The day-7 albumin-SSI association was the strongest at any time point ($\chi^2 = 38.432$), with 88.9% of patients with persistent hypoalbuminaemia at day 7 having developed SSI — a finding of high clinical alarm value. Mechanistically, hypoalbuminaemia impairs wound healing through reduced oncotic pressure, impaired neutrophil function, and diminished wound-tissue concentrations of albumin-bound prophylactic antibiotics; JIPMER pharmacokinetic data have shown cefazolin concentrations in subcutaneous wound tissue to be 34.2% lower in patients with albumin below 3.0 g/dL [20].

The concurrent assessment of both biomarkers provided additional clinical discrimination. Patients with both cholesterol below 150 mg/dL and albumin below 3.0 g/dL at 24 hours demonstrated the highest SSI rates in the cohort. This biological synergy is mechanistically coherent: both markers are products of hepatic synthetic activity, both are suppressed by the same cytokine cascade, and their co-derangement therefore signals a magnitude of hepatic and immunological perturbation exceeding the effect of either deficit alone. Published evidence supports this additive interaction, with

combined derangement associated with ORs of 8.1–8.9 in Indian cohorts — substantially exceeding individual marker ORs of 4–6 [21, 22]. The modest but significant positive correlations between simultaneous cholesterol and albumin values at all time points (r = 0.17–0.28) confirm that the two markers co-vary biologically but are not interchangeable, and that each provides independent predictive information.

Albumin at day 7 yielded the strongest single negative correlation with hospital stay (r = −0.523), indicating that failure of albumin to recover within the first postoperative week is the most powerful biochemical predictor of prolonged hospitalisation in this cohort. This has immediate clinical implications: identification of patients with day-7 albumin below 3.0 g/dL provides an actionable decision point for escalated wound surveillance and targeted nutritional intervention, at a stage when the wound is still amenable to such modification.

The absence of significant SSI associations with sex, age group, BMI, or anaesthetic type is consistent with a multicentre IAS study from southern India [23] and the general pattern in Indian elective surgical cohorts where nutritional biomarkers rather than anthropometric variables constitute the dominant SSI risk determinants. Wound classification was the only operative variable that reached significance, replicating the established stepwise gradient of SSI risk from clean to contaminated categories. These findings collectively suggest that conventional risk-stratification tools that rely predominantly on demographic and operative parameters are insufficient in isolation to identify the highest-risk patients, and that biochemical markers must be integrated into postoperative surveillance protocols.

Several limitations should be noted. The prospective observational design does not permit causal inference. Enrolment at a single institution limits generalisability. The study did not measure lipoprotein fractions or prealbumin at postoperative time points, both of which may carry additional predictive value. Microbiological culture data were not systematically collected, precluding analysis of pathogen-specific biomarker interactions. Multivariable logistic regression to quantify the independent predictive contribution of each biomarker after adjustment for wound class and operative duration was not performed, and formal area-under-ROC-curve analysis was not conducted; future studies should address these analytical gaps. No interventional arm was included, leaving the therapeutic potential of early nutritional correction in biochemically identified high-risk patients as a hypothesis for future randomised investigation.

CONCLUSIONS

Postoperative serum total cholesterol below 150 mg/dL and albumin below 3.0 g/dL at 24 hours are significant, clinically meaningful, and actionable early predictors of SSI in elective general surgery. Their associations with SSI and prolonged hospitalisation are sustained and statistically robust across all four measurement time points over 28 days. Concurrent derangement of both markers identifies the highest-risk subgroup. Both assays are universally available on automated biochemistry platforms, carry no additional cost burden, and are readily interpretable at the bedside. Routine incorporation of 24-hour postoperative cholesterol and albumin measurement into wound-surveillance protocols at South Asian tertiary surgical units is recommended, with patients demonstrating combined hypocholesterolaemia and hypoalbuminaemia earmarked for intensified wound monitoring and early targeted nutritional intervention. Future studies should incorporate multivariable adjustment, lipoprotein sub-fractionation, and randomised nutritional supplementation arms to fully define the clinical utility of these accessible perioperative biomarkers.

Statements

Statement of Ethics

This study was conducted in accordance with the Declaration of Helsinki. Ethical clearance was obtained from the Institutional Ethics Committee of SRM Medical College Hospital and Research Centre prior to enrolment. Written informed consent was obtained from each participant in English or Tamil. Participation was voluntary; withdrawal at any time did not affect standard care.

Conflict of Interest Statement

The authors declare no conflicts of interest.

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Author Contributions

Dr. Kandeshwaran S: Conceptualisation, data collection, data analysis, manuscript writing. Dr. Abhishek Reji: Perioperative patient follow-up, wound assessment and Southampton Wound Grading, postoperative blood sample coordination, manuscript review. Dr. P. Vijayan: Supervision, study design, critical revision of the manuscript. All authors approved the final manuscript.

Data Availability Statement

The de-identified data that support the findings of this study are available from the corresponding author upon reasonable request, subject to institutional data governance requirements.

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