ORIGINAL ARTICLE

Cholesterol and Serum Albumin Levels as Predictors of Cross Infection, Death, and Length of Hospital Stay

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Hypothesis: The levels of cholesterol, its fractions (high-density lipoprotein cholesterol [HDL-C] and low-density lipoprotein cholesterol [LDL-C]), and serum albumin reflect nutritional status and are related to in-hospital death, nosocomial infection, and length of stay in the hospital.

Design: A prospective cohort study of hospitalized patients.

Setting: The Service of General Surgery of a tertiary hospital.

Patients: A consecutive series of 2989 patients admitted for more than 1 day.

Main Outcome Measures: Nosocomial infection, in-hospital death, and length of stay.

Results: During follow-up, 62 (2%) of the patients died, 382 (13%) developed a nosocomial infection, and 257 (9%) developed a surgical site infection. Serum albumin (lowest quintile vs highest quintile: adjusted odds ratio [OR], 1.9; 95% confidence interval, 1.2-2.9) and HDL-C (lowest quintile vs highest quintile: OR, 2.0; 95% confidence interval, 1.3-3.0) levels showed an inverse and highly significant relationship with nosocomial infection (mainly due to surgical site infection) in crude and multivariate analyses (controlling for the Study on the Efficacy of Nosocomial Infection Control [SENIC] index, the American Society of Anesthesiologists' score, cancer, and age). Regarding total and LDL-C levels, only their lowest quintiles increased the risk of nosocomial infection. Serum albumin and HDL-C levels showed an inverse trend ($P<.001$) with mortality, with high multivariate-adjusted ORs in the lowest quintile (serum albumin: OR, 5.8; 95% confidence interval, 0.8-44.6; HDL-C: OR, 7.2; 95% confidence interval, 0.9-55.0), whereas no trend was appreciated with other cholesterol fractions or ratios. Serum albumin, HDL-C, and LDL-C levels showed independent, significant ($P<.001$), and inverse relationships with length of stay.

Conclusion: The levels of serum albumin and cholesterol fractions, mainly HDL-C, which are routinely measured at hospital admission, are predictors of in-hospital death, nosocomial infection, and length of stay.

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SEVERAL COMMUNITY studies[1-4] have reported a relationship between a low serum albumin level and an increased risk of death. In the hospital setting, many reports have related serum albumin level to in-hospital mortality,[5-9] length of stay (LOS),[9-11] and nosocomial infection.[5,12-17] These reports suggest that the routine measurement of serum albumin level at hospital admission is a risk marker for a bad prognosis for hospital stay. Total cholesterol (TC) and its fractions, like serum albumin, are markers of nutritional status[6] and are universally used as cardiovascular disease–related epidemiological features; nevertheless, their role as markers of bad prognosis in surgical patients has been less frequently studied.

In community studies,[18-20] a low high-density lipoprotein cholesterol (HDL-C) level, a high low-density lipoprotein cholesterol (LDL-C) level, and TC were independent predictors of cardiovascular disease–related mortality. A low HDL-C level was also reported as a predictor of all-cause mortality in several countries.[21-23] Serum cholesterol level and its fractions have not been frequently studied in hospitalized patients. Hypocholesterolemia is a predictor of death in geriatric patients[6] and in patients with acute renal failure.[8] To our knowledge, only 1 previous study[24] has reported a relationship between a low HDL-C

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PATIENTS AND METHODS

STUDY POPULATION

Our study was performed at the Ciudad de Jaén General Hospital, a 680-bed tertiary center with a referral population of 650 000 (in the province of Jaén, Andalusia, southern Spain). The study population was recruited from the patients attending the Service of General Surgery during 2 periods (from November 1, 1992, to June 30, 1994, and from December 1, 1995, to January 30, 1997). Those patients who were admitted to the service for short observation and transferred or discharged in less than 1 day were excluded. Informed consent was obtained from every eligible subject, and none refused to participate. A total of 2989 patients were enrolled.

DATA COLLECTION

Patients were interviewed at the outpatient office or within the first 24 hours after hospital admission. The following data were gathered before surgical intervention: smoking status, alcohol consumption, height (to the nearest centimeter), weight (without shoes and dressed in light clothes), the levels of TC and its fractions (HDL-C and LDL-C), the serum creatinine level, liver failure, immunodeficiency, the American Society of Anesthesiologists' preoperative assessment score, neoplasms, the serum albumin level, diabetes mellitus status, and glucose intolerance. The serum albumin level could not be measured at hospital admission in 46 patients, whereas the levels of cholesterol and its fractions were missed in 65 patients. The severity of illness was classified according to the criteria proposed by McCabe and Jackson[25] as rapidly fatal (death anticipated during hospitalization), ultimately fatal (death anticipated within 5 years), and nonfatal (disease unlikely to be fatal within 5 years).

During the hospital stay, information on the following diagnostic and therapeutic procedures was recorded (including starting and ending dates): peripheral catheters, central catheters, mechanical ventilation, parenteral nutrition, histamine$_2$ receptor antagonists, antibiotics, and other medications. Information on variables associated with surgery (type of surgical wound and duration of surgery) was also gathered. The Study on the Efficacy of Nosocomial Infection Control (SENIC) index[26] and the National Nosocomial Infections Surveillance (NNIS) index[27] for assessing intrinsic patient risk of nosocomial infection were computed. The SENIC index was computed by scoring 1 point to each 1 of these 4 risk factors: abdominal operation, operation longer than 2 hours, contaminated or dirt-infected operation, and patient has more than 2 diagnoses. The NNIS index was calculated by assessing 3 risk factors (each receiving 1 point): contaminated or dirt-infected operation, American Society of Anesthesiologists' score higher than 2, and operation longer than *T* hours (varying with the surgical procedure).

Patients with hospital infections were prospectively identified. Three of us (M.M.-C., A.G.-O., and G.M.-G.) visited patients admitted to the Service of General Surgery daily to collect all pertinent data. Data were recorded on a standardized data collection form. Hospital infections were diagnosed according to the Centers for Disease Control and Prevention criteria.[28,29] Surveillance was extended to 30 days after hospital discharge, to detect hospital infections that clinically developed at home. Postdischarge infections are not considered in this report because their risk factors are different from in-hospital infections and the serum albumin level was unrelated to them.[12,17]

BLOOD SAMPLING AND LABORATORY METHODS

Serum samples were obtained from whole blood samples collected in Vacutainer tubes (Becton, Dickinson and Company, Rutherford, NJ) without anticoagulant. Samples were collected after 12 to 14 hours of fasting. Serum samples were analyzed immediately or stored at 4°C and analyzed within 12 hours of collection. All samples were analyzed in the same laboratory.

The serum albumin level was determined by electrophoresis of serum proteins with an automated system (HITE System 600; Olympus Optical Co, Tokyo, Japan), on cellulose acetate, with a buffer of Tris, barbital, and sodium barbitate (pH 8.6-9.0), staining with ponceau 3D, and automated densitometry of the protein fractions. Calibration was performed using control and pathologic serum

level and nosocomial infection in surgical patients. The available information on surgical patients is not enough to recommend or to discard the routine use of HDL-C and/or TC level at hospital admission. We assessed prospectively their value in predicting the postoperative course (death, LOS, and nosocomial infection) in a consecutive series of 2989 patients undergoing various general surgery procedures.

RESULTS

The baseline characteristics of the study population are summarized in **Table 1**. The mean ± SD age of the patients was 53.1 ± 18.1 years (range, 10-92 years); 53% were females, 2% died during the hospital stay, and 13% developed a nosocomial infection. The geometric average LOS was 7.1 days (median, 7 days; interquartile range, 4-10 days).

The results for all-site nosocomial infection are summarized in **Table 2**. Serum albumin level showed in the crude analysis a clear and significant trend with nosocomial infection risk: as albumin level decreased, the rate of infection increased. The same trend was observed after adjusting for the SENIC index, the American Society of Anesthesiologists' score, age, and HDL-C level. Adjustment for additional risk factors of nosocomial infection did not change the output. The same happened with HDL-C level: it was inversely related to all-site nosocomial infection. The levels of TC and LDL-C showed a U relationship with mortality, with a clear increased risk of nosocomial infection in their lowest quintiles, which was responsible for the significance of the trend, although in the middle quintiles the variation of the risk was scarce. Ratios of TC/HDL-C and LDL-C/HDL-C did not show any relationship in multivariate analyses.

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samples (Normal Validate and Pathologic Validate; Organon Inc, West Orange, NJ). The normal range for albumin is 3.4 to 5.0 g/dL.

Total cholesterol, HDL-C, LDL-C, glucose, and serum creatinine determinations were performed with an autoanalyzer (Hitachi 717; Boehringer Mannheim Diagnostics, Mannheim, Germany). Daily calibration was done using precinorm U y precipath U (Boehringer Mannheim Diagnostics).

STATISTICAL ANALYSES

For every serum albumin level and cholesterol fraction (distributed in quintiles), the incidence of nosocomial infection and mortality was calculated by dividing the number of events by the number of patients within that category. The univariate relationships between biochemical variables and in-hospital death and nosocomial infection were tested using the relative risk and its 95% confidence interval. Logistic regression analysis was used to adjust for potential confounders.[30] For nosocomial infection, the SENIC index was used for adjustment because it is one of the best predictors of nosocomial infection in patients undergoing surgery[26,31]; estimates were also adjusted for infection existing at hospital admission because infection alters serum lipid levels, decreasing the levels of TC and HDL-C.[32] The mortality results were adjusted for the NNIS index because it is an independent predictor of death in patients undergoing general surgery.[33,34] To assess the statistical significance of a trend in multivariate analyses, quintiles of each biochemical variable were introduced in the logistic regression model as a continuous variable.[30]

The LOS distribution was normalized by a natural logarithmic transformation. A stepwise linear regression analysis was developed to detect independent predictors of LOS. The relationships between serum albumin and cholesterol fractions (in quintiles) and LOS were assessed by an analysis of variance. To estimate the adjusted LOS for each quintile, the variables included in the linear regression analysis were controlled for using an analysis of covariance.

For specific sites of infection, clear relationships were appreciated with surgical site infection (**Table 3**) in crude and multivariate analyses with serum albumin and HDL-C levels. With TC and LDL-C levels, borderline trends were observed, although significance was not achieved in any quintile. Given the few respiratory tract infections, we compared extreme quintiles (**Table 4**). Those with the lowest quintile of serum albumin, TC, HDL-C, and LDL-C levels exhibited a higher risk of respiratory tract infections. After adjusting for several variables (the NNIS index, age, mechanical ventilation, upper abdominal surgery, and chronic obstructive lung disease), all the associations disappeared, apart from that of LDL-C level, which remained statistically significant (the confidence interval excluded the null value). There was no association with urinary tract infection, and the number of patients with sepsis is too small to allow any reliable analysis (results not shown).

Table 1. Characteristics of the 2989 Study Patients*

Variable	Value
Female sex	1579 (53)
Type of nosocomial infection	
All sites	382 (13)
Surgical site	257 (9)
Respiratory tract	44 (1)
Urinary tract	46 (2)
Sepsis	5 (<1)
Death	62 (2)
Scheduled surgery	2404 (80)
ASA score	
1	1268 (42)
2	1200 (40)
3	446 (15)
4	75 (3)
Age, y†	53.1 ± 18.1
No. of diagnoses†	1.4 ± 0.7
Duration of the intervention, min†	75.2 ± 44.4
Length of stay, d‡	
Preoperative	1.0 ± 3.6
Total	7.1 ± 2.1
Serum albumin level, g/dL†	4.39 ± 0.65
TC level, mg/dL†§	195 ± 51
HDL-C level, mg/dL†§	50 ± 16
LDL-C, mg/dL†§	120 ± 41
Ratio†	
LDL-C/HDL-C	2.7 ± 1.9
TC/HDL-C	4.3 ± 2.5

*Data are given as number (percentage) of patients unless otherwise indicated. ASA indicates American Society of Anesthesiologists; TC, total cholesterol; HDL-C, high-density lipoprotein cholesterol; and LDL-C, low-density lipoprotein cholesterol.

†Data are given as mean ± SD.

‡Data are given as geometric mean ± SD.

§To convert TC, HDL-C, and LDL-C to millimoles per liter, multiply by 0.02586.

The relationship with in-hospital death is detailed in **Table 5**. Serum albumin and HDL-C levels exhibited an inverse relationship with the risk of dying: mortality augmented when these variables diminished. Patients in the lowest quintiles showed the highest risk of dying. The trend was attenuated, albeit statistically significantly, after controlling for the NNIS index and age. The inclusion in the multivariate model of other predictors of death (severity of illness, stay at the intensive care unit, and cancer) did not change the results. No relationship was observed with any other cholesterol variable or ratio.

To study the relationship with LOS, a stepwise linear regression model was developed. The variables included in the model were serum albumin level, HDL-C level, LDL-C level, American Society of Anesthesiologists' score, nosocomial infection, age, antibiotic prophylaxis, preoperative stay, cancer, duration of the operation, type of surgical wound, glycemia, community-acquired infection, and stay at the intensive care unit. With these variables, an adjusted $r^2=0.61$ was obtained. The associations between LOS and quintiles of serum albumin and cholesterol fractions are displayed in **Table 6**. An inverse trend can be easily appreciated in the table in crude and multivariate analyses (adjusting for the variables included in the linear regression

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Table 2. Serum Albumin Level, Cholesterol Levels, and Risk of All-Site Nosocomial Infection*

Variable (Quintiles)	No. of Patients: Infected	No. of Patients: Total	Risk, %	RR (95% CI)	OR (95% CI)†
Serum albumin level, g/dL					
≤3.9	146	591	24.7	3.5 (2.5-5.0)	1.9 (1.2-2.9)
4.0-4.3	83	576	14.4	2.0 (1.4-3.0)	1.7 (1.1-2.6)
4.4-4.6	64	668	9.6	1.4 (0.9-2.0)	1.2 (0.8-1.9)
4.7-4.9	49	625	7.8	1.1 (0.7-1.7)	1.1 (0.7-1.7)
≥5.0	34	483	7.0	1.0‡	1.0‡
Test for trend, *P* value	. . .	. . .	. . .	<.001	<.001
TC level, mg/dL§					
≤151	135	584	23.1	2.2 (1.7-2.9)	1.5 (1.0-2.3)
152-182	75	606	12.4	1.2 (0.8-1.6)	1.1 (0.7-1.6)
183-207	51	576	8.9	0.8 (0.6-1.2)	0.7 (0.5-1.1)
208-238	55	596	9.2	0.9 (0.6-1.2)	0.8 (0.5-1.2)
≥239	63	593	10.6	1.0‡	1.0‡
Test for trend, *P* value	. . .	. . .	. . .	<.001	.02
HDL-C level, mg/dL§					
≤37	145	591	24.5	3.5 (2.5-4.9)	2.0 (1.3-3.0)
38-45	77	616	12.5	1.8 (1.2-2.6)	1.4 (0.9-2.1)
46-52	55	549	10.0	1.4 (1.0-2.1)	1.3 (0.8-2.0)
53-61	57	580	9.8	1.4 (0.9-2.1)	1.4 (0.9-2.1)
≥62	41	588	7.0	1.0‡	1.0‡
Test for trend, *P* value	. . .	. . .	. . .	<.001	.002
LDL-C level, mg/dL§					
≤86	130	585	22.2	2.0 (1.5-2.7)	1.6 (1.1-2.3)
87-109	68	594	11.4	1.0 (0.8-1.4)	1.0 (0.7-1.4)
110-128	53	574	9.2	0.8 (0.6-1.2)	0.8 (0.5-1.2)
129-154	60	589	10.2	0.9 (0.7-1.3)	0.9 (0.6-1.3)
≥155	64	583	11.0	1.0‡	1.0‡
Test for trend, *P* value	. . .	. . .	. . .	<.001	.02
Ratio					
LDL-C/HDL-C					
≤1.70	69	585	11.8	1.0‡	1.0‡
1.71-2.19	60	585	10.3	0.9 (0.6-1.2)	0.9 (0.6-1.3)
2.20-2.71	70	584	12.0	1.0 (0.7-1.4)	0.9 (0.6-1.3)
2.72-3.42	76	585	13.0	1.1 (0.8-1.5)	0.9 (0.6-1.4)
≥3.43	100	585	17.1	1.4 (1.1-1.9)	0.9 (0.6-1.4)
Test for trend, *P* value	. . .	. . .	. . .	.002	.82
TC/HDL-C					
≤3.03	62	585	10.6	1.0‡	1.0‡
3.04-3.62	60	583	10.3	1.0 (0.7-1.4)	0.9 (0.6-1.4)
3.63-4.38	72	585	12.3	1.2 (0.8-1.6)	0.9 (0.6-1.4)
4.39-5.22	78	587	13.3	1.3 (0.9-1.7)	1.0 (0.6-1.4)
≥5.23	103	584	17.6	1.7 (1.2-2.2)	0.9 (0.6-1.4)
Test for trend, *P* value	. . .	. . .	. . .	<.001	.92

*RR indicates relative risk; CI, confidence interval; OR, odds ratio; TC, total cholesterol; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; and ellipses, data not applicable.

†Adjusted for serum albumin level, HDL-C level, the Study on the Efficacy of Nosocomial Infection Control (SENIC) index, American Society of Anesthesiologists' score, cancer, and age.

‡Reference.

§To convert TC, HDL-C, and LDL-C to millimoles per liter, multiply by 0.02586.

model). Patients in the lowest quintiles of serum albumin, HDL-C, and LDL-C levels showed a clearly higher LOS.

COMMENT

The main limitation of this study is the low number of some effects. It may imply lack of statistical power to draw significant conclusions on mortality and other nosocomial infection sites apart from surgical site. Nevertheless, despite the few deaths, clear and significant trends were observed for HDL-C and serum albumin levels. Regarding lower respiratory tract infections, the number was small and may be responsible for the lack of association in multivariate analysis found in larger studies.[5]

We would like to emphasize the prospective design of our study. Serum albumin and cholesterol levels were not measured in a selected series of patients in whom physicians believed that these variables would add relevant clinical information, but the study was planned to measure serum albumin and cholesterol fractions at hospital admission in all participants.

Our results on the relationship between serum albumin level and mortality agree with those of most re-

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Table 3. Serum Albumin Level, Cholesterol Levels, and Risk of Surgical Site Nosocomial Infection*

Variable (Quintiles)	No. of Patients: Infected	No. of Patients: Total	Risk, %	RR (95% CI)	OR (95% CI)†
Serum albumin level, g/dL					
≤3.9	102	591	17.3	3.6 (2.3-5.6)	1.7 (1.0-3.0)
4.0-4.3	53	576	9.2	1.9 (1.2-3.1)	1.6 (0.9-2.6)
4.4-4.6	39	668	5.8	1.2 (0.7-2.0)	1.1 (0.6-1.9)
4.7-4.9	35	625	5.6	1.2 (0.7-2.0)	1.2 (0.7-2.1)
≥5.0	23	483	4.8	1.0‡	1.0‡
Test for trend, *P* value	. . .	. . .	. . .	<.001	<.006
TC level, mg/dL§					
≤151	94	584	16.1	2.3 (1.6-3.3)	1.5 (0.9-2.4)
152-182	47	606	7.8	1.1 (0.7-1.7)	0.7 (0.6-1.6)
183-207	36	576	6.2	0.9 (0.6-1.4)	0.6 (0.5-1.3)
208-238	36	596	6.0	0.9 (0.6-1.3)	0.6 (0.5-1.3)
≥239	41	593	6.9	1.0‡	1.0‡
Test for trend, *P* value	. . .	. . .	. . .	<.001	.06
HDL-C level, mg/dL§					
≤37	108	591	18.3	3.8 (2.5-5.7)	2.3 (1.4-3.7)
38-45	51	616	8.3	1.8 (1.2-2.6)	1.4 (0.8-2.3)
46-52	28	549	5.1	1.4 (1.0-2.1)	1.0 (0.6-2.3)
53-61	38	580	6.6	1.4 (0.9-2.1)	1.4 (0.8-2.4)
≥62	26	588	4.4	1.0‡	1.0‡
Test for trend, *P* value	. . .	. . .	. . .	<.001	.001
LDL-C level, mg/dL§					
≤86	87	585	14.9	2.2 (1.5-3.1)	1.5 (0.9-2.4)
87-109	45	594	7.6	1.1 (0.7-1.6)	1.0 (0.6-1.7)
110-128	36	574	6.3	0.9 (0.6-1.4)	0.9 (0.5-1.4)
129-154	43	589	7.3	1.1 (0.7-1.6)	1.1 (0.6-1.7)
≥155	40	583	6.9	1.0‡	1.0‡
Test for trend, *P* value	. . .	. . .	. . .	<.001	.09
Ratio					
LDL-C/HDL-C					
≤1.70	44	585	7.5	1.0‡	1.0‡
1.71-2.19	38	585	6.5	0.9 (0.6-1.3)	0.9 (0.5-1.4)
2.20-2.71	50	584	8.6	1.1 (0.8-1.7)	1.0 (0.6-1.5)
2.72-3.42	50	585	8.5	1.1 (0.8-1.7)	0.9 (0.6-1.5)
≥3.43	69	585	11.8	1.6 (1.1-2.2)	1.0 (0.6-1.5)
Test for trend, *P* value	. . .	. . .	. . .	.004	.96
TC/HDL-C					
≤3.03	39	585	6.7	1.0‡	1.0‡
3.04-3.62	38	583	6.5	1.0 (0.6-1.5)	0.9 (0.3-1.5)
3.63-4.38	53	585	9.1	1.4 (0.9-2.0)	1.1 (0.5-1.7)
4.39-5.22	49	587	8.3	1.3 (0.8-1.9)	0.9 (0.1-1.5)
≥5.23	72	584	12.3	1.8 (1.3-2.7)	1.0 (0.6-1.7)
Test for trend, *P* value	. . .	. . .	. . .	<.001	.92

*Abbreviations are explained in the first footnote to Table 2.
†Adjusted for serum albumin level, HDL-C level, the Study on the Efficacy of Nosocomial Infection Control (SENIC) index, American Society of Anesthesiologists' score, cancer, and age.
‡Reference.
§To convert TC, HDL-C, and LDL-C to millimoles per liter, multiply by 0.02586.

ports.[5-9] Serum albumin level is considered an objective measure of nutritional status.[6] Malnutrition and inflammation suppress albumin synthesis.[35] In patients undergoing dialysis, it is believed that inflammation plays a more important role because it produces a switch of protein synthesis in the liver from albumin to acute phase proteins (C-reactive protein and cytokines [interleukins 1 and 2 and tumor necrosis factor]), which are elevated in these patients.[36,37] The proportion of patients with renal failure in our sample was small (32 patients, 6 deaths, and a mean±SD serum albumin level of 3.6±0.8 vs 4.4±0.1 g/dL for the remaining patients). Thus, this mechanism is unlikely to explain all the deaths in patients with a low serum albumin level. Other potential mechanisms may be involved: (*a*) the ability of serum albumin to adsorb small molecules, thus suppressing the effects of mediators released from activated or damaged cells[38]; (*b*) a generalized increase in vascular permeability due to underlying disease[39]; and (*c*) the antioxidant capacity of serum albumin.[39]

The results on the association between a low serum albumin level and an increased risk of nosocomial infection, mainly surgical site infection, also agree with those of previous reports.[5,12-17] If nosocomial infection lengthens the duration of hospitalization, it is expected that serum albumin level shows an association with LOS. Even

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Table 4. Serum Albumin Level, Cholesterol Levels, and Risk of Respiratory Tract Nosocomial Infection*

Variable	No. of Patients: Infected	No. of Patients: Total	Risk, %	RR (95% CI)	OR (95% CI)†
Serum albumin level, g/dL					
≤3.9 (Quintile 1)	21	591	3.6	3.8 (2.1-6.9)	1.2 (0.6-2.6)
≥4.0 (Quintiles 2-5)	22	2352	0.9	1.0‡	1.0‡
TC level, mg/dL§					
≤151 (Quintile 1)	21	584	3.6	3.7 (2.1-6.7)	1.5 (0.7-3.3)
≥152 (Quintiles 2-5)	23	2371	1.0	1.0‡	1.0‡
HDL-C level, mg/dL§					
≤37 (Quintile 1)	20	591	3.4	3.3 (1.8-5.9)	2.3 (1.2-2.4)
≥38 (Quintiles 2-5)	24	2333	1.0	1.0‡	1.0‡
LDL-C level, mg/dL§					
≤86 (Quintile 1)	23	585	3.9	4.4 (2.4-7.9)	2.3 (1.1-4.9)
≥87 (Quintiles 2-5)	21	2340	0.9	1.0‡	1.0‡
Ratio					
LDL-C/HDL-C					
≤3.42 (Quintiles 1-4)	32	2339	1.4	1.0‡	1.0‡
≥3.43 (Quintile 5)	12	585	2.1	1.5 (0.8-2.9)	1.0 (0.5-2.2)
TC/HDL-C					
≤5.22 (Quintiles 1-4)	33	2340	1.4	1.0‡	1.0‡
≥5.23 (Quintile 5)	11	584	1.9	1.3 (0.7-2.6)	0.9 (0.4-1.9)

*Abbreviations are explained in the first footnote to Table 2.
†Adjusted for serum albumin level, HDL-C level, National Nosocomial Infections Surveillance index, upper abdominal surgery, chronic obstructive lung disease, mechanical ventilation, and age.
‡Reference.
§To convert TC, HDL-C, and LDL-C to millimoles per liter, multiply by 0.02586.

after taking the effect of nosocomial infection into account in multivariate analysis, serum albumin level was still a predictor of LOS, in agreement with other studies.[9-11]

To our knowledge, no previous report assessed the use of cholesterol level as a marker of poor prognosis in surgical patients. Only 1 report,[24] using the first 1207 patients from this study, has related cholesterol fractions to nosocomial infection risk. With more than twice the number of patients of that report, we observed similar results: a low HDL-C level behaves as a risk factor for nosocomial infection, mainly surgical site infection. In the previous report,[24] the few lower respiratory tract infections did not allow relating them with cholesterol and its fractions. Now, with more than 40 infections, HDL-C level was unrelated to this infection site in multivariate analysis, although patients in the lowest quintile show a 3-fold raw incidence vs patients with higher levels. The LDL-C level remained a significant predictor after adjusting for the most common risk factors of respiratory tract infection.

Because low HDL-C levels increase the risk of nosocomial infection, especially surgical site infection, and a low LDL-C level increases the risk of lower respiratory tract infection, it would be expected that these variables increase the LOS. Even after controlling for nosocomial infection in multivariate analysis, the 2 cholesterol fractions showed an inverse trend with LOS.

Table 5. Serum Albumin Level, Cholesterol Levels, and Risk of In-Hospital Death*

Variable (Quintiles)	No. of Patients: Infected	No. of Patients: Total	Risk, %	RR (95% CI)	OR (95% CI)†
Serum albumin level, g/dL					
≤3.9	49	591	8.3	40.0 (5.6-289.0)	5.8 (0.8-44.6)
4.0-4.3	9	576	1.6	7.5 (0.9-59.4)	3.2 (0.4-26.5)
4.4-4.6	0	668	. . .	. . .	. . .
4.7-4.9	1	625	0.2	0.8 (0.0-12.3)	0.6 (0.0-9.1)
≥5.0	1	483	0.2	1.0‡	1.0‡
Test for trend, *P* value	. . .	. . .	. . .	<.001	<.001
TC level, mg/dL§					
≤151	37	584	6.3	4.7 (2.2-10.0)	0.7 (0.3-1.7)
152-182	8	606	1.3	1.0 (0.4-2.6)	0.4 (0.1-1.3)
183-207	4	576	0.7	0.5 (0.2-1.7)	0.3 (0.1-1.2)
208-238	3	596	0.5	0.4 (0.1-1.4)	0.4 (0.1-1.4)
≥239	8	593	1.3	1.0‡	1.0‡
Test for trend, *P* value	. . .	. . .	. . .	<.001	.98
HDL-C level, mg/dL§					
≤37	44	591	7.4	43.8 (6.1-316.0)	7.2 (0.9-55.0)
38-45	6	616	1.0	5.7 (0.7-47.4)	2.5 (0.3-21.1)
46-52	7	549	1.3	7.5 (0.9-60.7)	4.1 (0.5-34.8)
53-61	2	580	0.3	2.0 (0.2-22.3)	1.3 (0.1-14.9)
≥62	1	588	0.2	1.0‡	1.0‡
Test for trend, *P* value	. . .	. . .	. . .	<.001	.002
LDL-C level, mg/dL§					
≤86	35	585	6.0	3.9 (1.9-8.0)	0.8 (0.3-1.9)
87-109	8	594	1.3	0.9 (0.3-2.2)	0.5 (0.2-1.3)
110-128	4	574	0.7	0.5 (0.1-1.5)	0.3 (0.1-1.1)
129-154	4	589	0.7	0.4 (0.1-1.4)	0.4 (0.1-1.3)
≥155	9	583	1.5	1.0‡	1.0‡
Test for trend, *P* value	. . .	. . .	. . .	<.001	.70
Ratio					
LDL-C/HDL-C					
≤1.70	10	585	1.7	1.0‡	1.0‡
1.71-2.19	10	585	1.7	1.0 (0.4-2.4)	1.6 (0.6-4.2)
2.20-2.71	6	584	1.0	0.6 (0.2-1.6)	0.6 (0.2-1.8)
2.72-3.42	10	585	1.7	1.0 (0.4-2.4)	0.9 (0.3-2.4)
≥3.43	24	585	4.1	2.4 (1.2-5.0)	1.3 (0.5-3.2)
Test for trend, *P* value	. . .	. . .	. . .	.01	.82
TC/HDL-C					
≤3.03	8	585	1.4	1.0‡	1.0‡
3.04-3.62	8	583	1.4	1.0 (0.4-2.7)	1.1 (0.4-3.2)
3.63-4.38	7	585	1.2	0.9 (0.3-2.4)	0.9 (0.3-2.6)
4.39-5.22	11	587	1.9	1.4 (0.6-3.4)	0.8 (0.3-2.3)
≥5.23	26	584	4.5	3.3 (1.5-7.1)	1.3 (0.5-3.5)
Test for trend, *P* value	. . .	. . .	. . .	<.001	.62

*Abbreviations are explained in the first footnote to Table 2.
†Adjusted for serum albumin level, HDL-C level, cancer, National Nosocomial Infections Surveillance index, and age.
‡Reference.
§To convert TC, HDL-C, and LDL-C to millimoles per liter, multiply by 0.02586.

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Table 6. Serum Albumin Level, Cholesterol Levels, and LOS*

Variables (Quintiles)	LOS (95% CI), d Crude	LOS (95% CI), d Adjusted†
Serum albumin level, g/dL		
≤3.9	11.4 (10.7-12.1)	7.9 (7.6-8.1)
4.0-4.3	7.2 (6.8-7.6)	7.5 (7.3-7.6)
4.4-4.6	6.7 (6.4-7.1)	7.1 (7.0-7.2)
4.7-4.9	5.9 (5.6-6.1)	6.7 (6.5-6.9)
≥5.0	5.4 (5.1-5.7)	6.3 (6.1-6.6)
Test for trend, *P* value	<.001	<.001
TC level, mg/dL‡		
≤151	8.5 (8.0-9.1)	7.0 (6.8-7.2)
152-182	6.9 (6.5-7.3)	7.0 (6.8-7.2)
183-207	6.9 (6.5-7.3)	7.0 (6.9-7.2)
208-238	6.5 (6.2-6.9)	7.1 (7.0-7.2)
≥239	6.9 (6.5-7.2)	7.4 (7.0-7.8)
Test for trend, *P* value	<.001	.11
HDL-C level, mg/dL‡		
≤37	11.2 (10.4-12.0)	7.5 (7.3-7.7)
38-45	7.1 (6.8-7.6)	7.3 (7.1-7.4)
46-52	6.3 (6.0-6.7)	7.1 (7.0-7.2)
53-61	5.9 (5.6-6.2)	6.9 (6.8-7.0)
≥62	5.9 (5.6-6.2)	6.7 (6.5-6.9)
Test for trend, *P* value	<.001	<.001
LDL-C level, mg/dL‡		
≤86	8.1 (7.5-8.6)	7.4 (7.2-7.6)
87-109	6.8 (6.4-7.2)	7.3 (7.1-7.4)
110-128	6.9 (6.5-7.3)	7.1 (7.0-7.2)
129-154	6.9 (6.5-7.3)	6.9 (6.8-7.1)
≥155	6.8 (6.5-7.2)	6.8 (6.6-7.0)
Test for trend, *P* value	.001	.001
Ratio		
LDL-C/HDL-C		
≤1.70	6.2 (5.6-6.5)	7.0 (6.8-7.2)
1.71-2.19	6.4 (6.1-6.8)	7.1 (6.9-7.2)
2.20-2.71	7.1 (6.7-7.5)	7.1 (7.0-7.2)
2.72-3.42	7.2 (6.8-7.6)	7.1 (7.0-7.3)
≥3.43	8.9 (8.4-9.5)	7.1 (6.9-7.4)
Test for trend, *P* value	<.001	.53
TC/HDL-C		
≤3.03	5.9 (5.6-6.2)	7.0 (6.8-7.2)
3.04-3.62	6.4 (6.1-6.8)	7.0 (6.9-7.2)
3.63-4.38	6.9 (6.6-7.3)	7.1 (7.0-7.2)
4.39-5.22	7.2 (6.8-7.7)	7.2 (7.0-7.3)
≥5.23	9.4 (8.8-10.0)	7.2 (7.0-7.4)
Test for trend, *P* value	<.001	.19

*LOS indicates length of stay; CI, confidence interval; TC, total cholesterol; HDL-C, high-density lipoprotein cholesterol; and LDL-C, low-density lipoprotein cholesterol.

†Adjusted for serum albumin level, HDL-C level, LDL-C level, American Society of Anesthesiologists' score, hospital infection, age, antibiotic prophylaxis, preoperative stay, cancer, duration of the operation, type of wound, glycemia, community-acquired infection, and stay at the intensive care unit.

‡To convert TC, HDL-C, and LDL-C to millimoles per liter, multiply by 0.02586.

Cholesterol level is considered an objective measure of nutritional status[6] and a reliable outcome marker of poor prognosis (for mortality) in patients undergoing dialysis.[40] Low apolipoprotein A-I and HDL-C levels are found with an increase in C-reactive protein, a prototypical acute phase protein, which is closely related to all-cause mortality in patients undergoing long-term hemodialysis.[41] Again, the number of patients with renal failure was too small to imply this mechanism as responsible for the increased risk of death observed in patients with low levels of cholesterol and its fractions. Malnutrition may be another possibility to consider.

In cardiovascular epidemiology, the single most predictive lipid factor is the TC/HDL-C ratio. This is the best predictor of outcome and treatment benefit.[42] According to our results, this ratio has no predictive ability for poor prognosis in surgical patients because low HDL-C and low LDL-C levels behave in a similar way.

In conclusion, according to our results, the routine measurement of serum albumin and cholesterol fractions, mainly HDL-C, at hospital admission is recommended. By measuring them, a better prediction of nosocomial infection, in-hospital death, and LOS is achieved. An additional advantage of including these measurements in the hospital routine is the potential improvement of the control of cardiovascular diseases.

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Readership Poll Results

Although the numbers are small, 90% of our responders felt that it was possible to develop a reasonable system for assessing quality care in surgery. Further, the system most favored (by 2:1) was the APACHE II method. We thank you for your responses.

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