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Even modest hypoalbuminemia affects outcomes of colorectal surgery patients

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Abstract
BACKGROUND: A small decrease in the serum albumin from the normal level is a common condition in preoperative laboratory tests of colorectal surgery patients; however, there is limited data examining these patients. We sought to identify outcomes of such patients.
METHODS: The National Surgical Quality Improvement Program database was used to evaluate all patients who had modest levels of hypoalbuminemia (3%serum albumin , 3.5 g/dL) before colorectal resection from 2005 to 2012. Multivariate analysis using logistic regression was performed to quantify complications associated with modest hypoalbuminemia.
RESULTS: A total of 108,898 patients undergoing colorectal resection were identified, of which 16,962 (15.6%) had modest levels of preoperative hypoalbuminemia. Postsurgical complications significantly associated (P ,.05) with modest hypoalbuminemia were as follows: hospitalization more than 30 days (adjusted odds ratio [AOR], 1.77), deep vein thrombosis (AOR, 1.64), unplanned intubation (AOR, 1.42), ventilator dependency for more than 48 hours (AOR, 1.30), and wound disruption (AOR, 1.22).
CONCLUSIONS: Modest hypoalbuminemia is a common preoperative condition in patients undergoing colorectal resection. Our analysis demonstrates that modest hypoalbuminemia has associations with increased postoperative complications, especially pulmonary complications.

Malnutrition has a prevalence of 30% to 50% in hospitalized patients and is one of the most important conditions known to increase morbidity, mortality, length of hospitalization, and cost for patients.[1] Furthermore, malnutrition causes a significant increase in postoperative complications by impairing host immune function, causing muscle dysfunction, decreasing collagen synthesis, and delaying tissue healing.[1,2] It is important to recognize malnourished patients before surgical intervention to minimize the morbidity and mortality of these patients.

There are a number of tools available that allow assessment of the preoperative nutritional status of patients and help to identify malnourished patients.[3–5] Preoperative serum albumin level has been identified as a reliable measure of a patient's perioperative nutritional status. Low albumin levels have been proved to be strongly associated with delayed recovery of bowel function and postoperative complications. Furthermore, low levels of albumin have been shown to be a strong predictor of mortality and morbidity of major general surgery procedures.[6–8]

Numerous studies have identified complications as a consequence of hypoalbuminemia in hospitalized patients with the goal of controlling morbidity and mortality.[9] Some of these complications include prolonged ventilator support, pneumonia, poor tissue healing, and delayed recovery of postoperative bowel function.[4,9] However, there is limited data examining associations between modest decreases in serum albumin levels frequently seen in patients undergoing colorectal procedures and postoperative complications. Therefore, a large nationwide study analyzing the contemporary rate and the impact of modest decrease in the serum albumin level is needed.

There is a broad difference in postoperative complications attributable to hypoalbuminemia according to the types of surgical procedures. Therefore, it would be helpful to study complications as a consequence of hypoalbuminemia as adjusted by groups of procedures.[6] The primary objective of our study was to investigate outcomes of postoperative complications in patients undergoing colorectal surgery with moderate hypoalbuminemia. Using a large national database to analyze 13 postoperative complications, we aim to report on the incidence, risk factors, complications, and outcomes associated with the modest levels of hypoalbuminemia in patients undergoing colorectal procedures.

Methods

This study was performed using the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) database from January 1, 2005, to December 31, 2012. ACS NSQIP is a nationally validated, risk-adjusted, outcomes-based program to measure and improve the quality of surgical care in the United States.[10] ACS NSQIP provides preoperative to 30-day postoperative surgical outcomes based on clinical data. We considered patients who had undergone colorectal resections for the diagnoses of benign or malignant colorectal tumors, diverticular diseases, and ulcerative colitis using the appropriate procedural and diagnosis codes as specified by the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM). Patients undergoing colorectal procedures were defined based on the following Current Procedural Terminology codes: 44,140 to 44,160; 44,204 to 44,212; 45,110; 45,126; and 45,395. Patients who did not undergo colon or rectal resection were excluded from this study. Patients' diagnoses were defined based on the following ICD-9 codes: malignant neoplasm of colon and rectum (153.0 to 153.9, 154.0, 154.1, 230.3, and 230.4), benign neoplasm of colon and rectum (211.3 and 211.4), diverticulosis or diverticulitis (562.10 to 562.13), Crohn disease (555.1 and 555.2), and ulcerative colitis (556.0 to 556.9). Preoperative modest hypoalbuminemia was defined as the presence of serum albumin

level between 3 and 3.4 g/dL based on preoperative laboratory results. The serum albumin level was based on preoperative laboratory results within 14 days of operation (the mean time was 5 days).

Preoperative factors that were analyzed include patient characteristics (age, gender, and race) and 16 comorbidity conditions as conveyed in Table 1, including congestive heart failure (CHF) 30 days before surgery, currently on dialysis (preoperatively), diabetes mellitus with oral agents or insulin, weight loss more than 10% in last 6 months, steroid use for chronic condition, history of severe chronic obstructive pulmonary disease (COPD), current smoker within 1 year, moderate or severe dyspnea, the presence of ascites on physical examination or imaging within 30 days before operation, partial or total dependency in activities performed in the course of a normal day in a person's life (bathing, feeding, dressing, toileting, and mobility) before surgery as a measure of functional health status, disseminated (stage 4) cancer, American Society of Anesthesiologists (ASA) score more than 2, chemotherapy for malignancy in the last 30 days before operation, radiotherapy for malignancy 90 days before operation, alcohol abuse as defined by more than 2 drinks/d 2 weeks before admission, and hypertension requiring medication. Other factors analyzed include postsurgical complications (superficial surgical site infection [SSI], deep incisional SSI, organ space SSI, wound disruption, pneumonia, unplanned intubation, ventilator dependency for .48 hours, urinary tract infection, cardiac arrest requiring cardiopulmonary resuscitation, myocardial infarction, deep vein thrombosis [DVT], acute renal failure, and hospitalization for .30 days from admission date), pathologic conditions (colorectal cancer, diverticulosis or diverticulitis, Crohn disease, ulcerative colitis, and benign colorectal tumor), procedure type (total colectomy, partial colectomy, abdominoperineal resection, and pelvic exenteration), surgical techniques (laparoscopic vs open), and wound classification (clean, clean/contaminated, contaminated, and dirty). The overall rate of preoperative modest hypoalbuminemia and the rate of postoperative complications by procedure type and serum albumin level were examined. Risk-adjusted analysis was performed to identify independent predictors of postoperative complications after colorectal surgery. Male gender, Caucasian race, and benign colorectal tumor were used as reference data points for comparison in line with the literature.[8,11]

Statistical analysis

Statistical analysis was performed with SPSS software, version 22 (SPSS Inc., Chicago, IL). Logistic regression analysis was used to estimate the association between preoperative modest hypoalbuminemia and each outcome, including in-hospital mortality and all the considered postoperative complications. P values less than .05 were considered statistically significant. For each outcome, the adjusted odds ratio (AOR) with a 95% confidence interval was calculated and reported to estimate the relative risk associated with modest hypoalbuminemia. Adjustments were made for age, gender, race, hypertension, smoking, diabetes mellitus, dyspnea, preoperative pneumonia, preoperative myocardial infarction, cardiac angina, operation in 30 days before surgery, emergent admission, ASA score more than 2, steroid use, COPD, weight loss, dependency before surgery as a measure of functional health status, disseminated cancer, radiotherapy,

alcohol abuse, chemotherapy, ascites, CHF, dialysis, and pathology type. Also, odd ratios of outcomes, including mortality, morbidity, and complications, were adjusted for the type of procedure, type of surgery (laparoscopic vs open), and wound classification. Logistic regression was also used to describe the weights assigned to preoperative variables that best discriminate patients with preoperative modest hypoalbuminemia from those without.

Table 1 Demographics of patients who have undergone colon and rectal surgery in the United States, NSQIP 2005–2012 (univariate analysis)

Patients characteristics	Patients with serum albumin $\geq$ 3.5 g/dL (sample size = 71,495)	Patients with serum 3 $\leq$ albumin $<$ 3.5 g/dL (sample size = 16,962)	Odds ratio and 95% confidence interval	*P* value
Age				
Mean, y	61	65	—	—
Median, y	62	67	—	—
Sex				
Female	36,218 (50.8%)	9,130 (53.9%)	1.13 (1.09–1.17)	<.01
Admission				
Emergency admission	83,66 (11.7%)	3,949 (23.3%)	2.29 (2.19–2.38)	<.01
Race				
White	56,662 (86.5%)	13,042 (83.5%)	.86 (.82–.89)	<.01
Black or African American	6,317 (9.6%)	2,065 (13.2%)	1.42 (1.34–1.50)	<.01
Asian	1,702 (2.6%)	324 (2.1%)	.74 (.65–.85)	<.01
Other	794 (1.2%)	184 (1.2%)	1.02 (.97–1.07)	.36
Comorbidity				
Hypertension	35,528 (49.7%)	9,382 (55.3%)	1.25 (1.21–1.29)	<.01
Smoking	12,915 (18.1%)	3,373 (19.9%)	1.12 (1.07–1.17)	<.01
Diabetes mellitus	9,949 (13.9%)	3,110 (18.3%)	1.38 (1.32–1.45)	<.01
Dyspnea	6,349 (8.9%)	2,493 (14.7%)	1.76 (1.68–1.85)	<.01
Chronic steroid use	4,228 (5.9%)	1,863 (11%)	1.96 (1.85–2.07)	<.01
Pneumonia before surgery	113 (.2%)	134 (1.1%)	4.96 (3.85–6.37)	<.01
Preoperative MI	220 (.4%)	178 (1.4%)	3.39 (2.77–4.13)	<.01
COPD	3,534 (4.9%)	1,613 (9.5%)	2.02 (1.90–2.14)	<.01
Cardiac angina	293 (.6)	170 (1.4%)	2.42 (2–2.93)	<.01
Previous operation in 30 d	623 (1.3%)	386 (3.2%)	2.60 (2.29–2.96)	<.01
Weight loss	2,712 (3.8%)	1,472 (8.7%)	2.41 (2.25–2.57)	<.01
ASA score >2	65,477 (96.6%)	14,155 (98.6%)	2.37 (2.05–2.74)	<.01
Dependency before surgery*	2,767 (3.9%)	2,268 (13.4%)	3.83 (3.61–4.06)	<.01
Disseminated cancer	3,347 (4.7%)	1,290 (7.6%)	1.67 (1.56–1.79)	<.01
Radiotherapy	2,315 (4.5%)	356 (2.9%)	.62 (.56–.70)	<.01
Alcohol abuse	1,862 (3.6%)	432 (3.5%)	.96 (.86–1.06)	.46
Chemotherapy	1,368 (2.7%)	383 (3.1%)	1.16 (1.03–1.30)	<.01
Ascites	589 (.8%)	452 (2.7%)	3.29 (2.91–3.73)	<.01
Congestive heart failure	440 (.6%)	439 (2.6%)	4.29 (3.75–4.90)	<.01
Dialysis	423 (.6%)	349 (2.1%)	3.53 (3.06–4.07)	<.01
Procedure				
Partial Colectomy	63,755 (90.2%)	15,082 (89.5%)	.97 (.92–1.02)	.33
Total colectomy	3,888 (5.5%)	1,227 (7.3%)	1.35 (1.26–1.44)	<.01
APR	2,919 (4.1%)	506 (3%)	.72 (.65–.79)	<.01
Pelvic exenteration	146 (.2%)	33 (.2%)	.95 (.63–1.39)	.80
Approach				
Laparoscopic approach	29,936 (42.3%)	4,347 (25.1%)	.45 (.44–.47)	<.01
Pathology				
Colorectal cancer	28,487 (53.8%)	6,422 (59.6%)	.92 (.88–.95)	<.01
Diverticulitis of colon	12,849 (24.3%)	2,567 (23.8%)	.81 (.77–.85)	<.01
Diverticulosis of colon	1,425 (2.7%)	335 (3.1%)	.99 (.87–1.11)	.87
Benign colorectal tumor	7,195 (13.6%)	524 (4.9%)	.28 (.26–.31)	<.01
Crohn disease	1,166 (2.2%)	442 (4.1%)	1.61 (1.44–1.80)	<.01
Ulcerative colitis	1,824 (3.4%)	490 (4.5%)	1.13 (1.02–1.25)	.01

APR = abdominoperineal resection of rectum; ASA = American Society of Anesthesiologists; COPD = chronic obstructive pulmonary disease; MI = myocardial infarction.

*Partial or totally dependency in activities performed in the course of a normal day in a person's life (bathing, feeding, dressing, toileting, and mobility).

Table 2 Risk-adjusted analysis of outcomes associated with modest hypoalbuminemia in colon and rectal surgery patients (multivariate analysis)

Patient-specific factors	Patients with serum albumin ≥ 3.5 g/dL (sample size = 71,495)	Patients with serum 3 ≤ albumin < 3.5 g/dL (sample size = 16,962)	Adjusted odds ratio	95% confidence interval	*P* value
Mortality	1,194 (1.7%)	1,023 (6%)	1.76	1.51–2.05	<.01
Overall morbidity*	14,115 (19.8%)	5,037 (29.7%)	1.17	1.11–1.24	<.01
Prolong hospitalization	1,189 (1.7%)	873 (5.2%)	1.77	1.54–2.02	<.01
Deep vein thrombosis	735 (1%)	380 (2.2%)	1.64	1.37–1.97	<.01
Unplanned intubation	1,387 (1.9%)	779 (4.6%)	1.42	1.24–1.62	<.01
Cardiac arrest	350 (.5%)	235 (1.4%)	1.39	1.04–1.85	.02
Ventilator dependency	1,895 (2.7%)	1,259 (7.4%)	1.30	1.14–1.47	<.01
Acute renal failure	421 (.6%)	242 (1.4%)	1.24	.95–1.62	.10
Deep incisional SSI	1,034 (1.4%)	345 (2%)	1.22	1.04–1.45	.01
Wound disruption	1,030 (1.4%)	407 (2.4%)	1.22	1.04–1.44	.01
Pneumonia	1,711 (2.4%)	863(5.1%)	1.21	1.06–1.38	<.01
Urinary tract infection	2,293 (3.2%)	781 (4.6%)	1.06	.94–1.19	.30
Myocardial infarction	453 (.6%)	176 (1%)	1.04	.80–1.35	.74
Superficial SSI	5,566 (7.8%)	1,441 (8.5%)	1.02	.95–1.11	.49
Organ space SSI	2,903 (4.1%)	853 (5%)	1	.90–1.12	.88

SSI 5 surgical site infection.
*Includes hospitalization longer than 30 days, ventilator dependency longer than 48 hours, unplanned intubation, deep vein thrombosis, cardiac arrest, pneumonia, acute renal failure, wound disruption, organ space surgical site infection, urinary tract infection, deep incisional surgical site infection, myocardial infarction, and superficial surgical site infection.

Table 3 Risk analysis for postoperative complications associated with serum albumin level: adjusted odds ratios reported per 1 g/dL increase in albumin level (multivariate analysis)

Complication	Adjusted odds ratio	95% confidence interval	*P* value
Morbidity*	.76	.74–.79	<.01
Mortality	.51	.47–.55	<.01
Hospitalization >30 d	.46	.43–.49	<.01
Deep vein thrombosis	.59	.54–.65	<.01
Ventilator dependency >48 h	.60	.57–.64	<.01
Unplanned intubation	.60	.56–.65	<.01
Cardiac arrest	.63	.54–.74	<.01
Acute renal failure	.65	.57–.75	<.01
Pneumonia	.69	.64–.74	<.01
Wound disruption	.75	.69–.82	<.01
Organ space SSI	.84	.79–.88	<.01
Urinary tract infection	.84	.79–.90	<.01
Deep incisional SSI	.84	.77–.92	<.01
Myocardial infarction	.97	.83–1.13	.72
Superficial SSI	1	.95–1.04	.98

SSI 5 surgical site infection.
*Includes hospitalization .30 days, ventilator dependency .48 h, unplanned intubation, deep vein thrombosis, cardiac arrest, pneumonia, acute renal failure, wound disruption, organ space surgical site infection, urinary tract infection, deep incisional surgical site infection, myocardial infarction, and superficial surgical site infection.

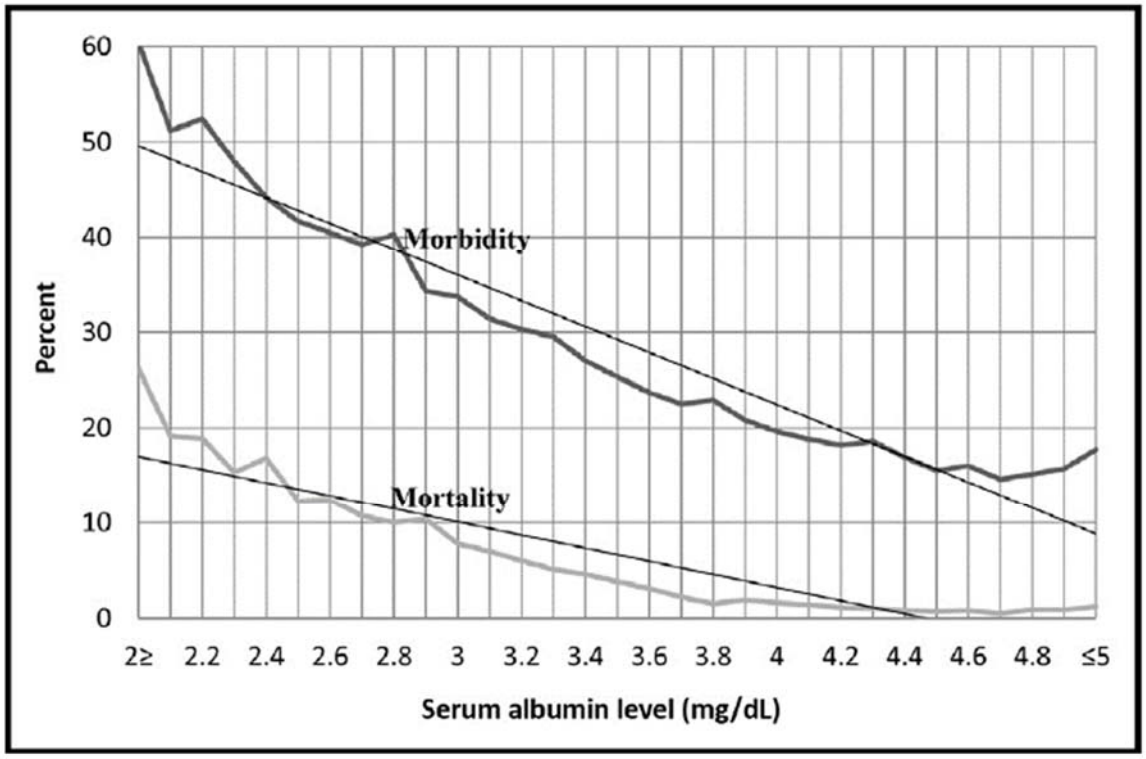

Figure 1 Correlations between serum albumin level with postoperative morbidity and mortality in colorectal resections.

Table 4 Preoperative variables associated with preoperative modest hypoalbuminemia in colon and rectal surgery patients (multivariate analysis)

Patient characteristics	Adjusted odds ratio	95% confidence interval	*P* value
Age			
<70	Reference	Reference	Reference
≥70	1.01	1.01–1.01	<.01
Sex			
Male	Reference	Reference	Reference
Female	1.08	1.03–1.13	<.01
Race			
White	Reference	Reference	Reference
Black or African American	1.42	1.32–1.53	<.01
Asian	.97	.89–1.05	.51
Other	1.02	.95–1.09	.48
Comorbidity			
No comorbidity	Reference	Reference	Reference
Dependency before surgery*	2.42	2.22–2.64	<.01
Congestive heart failure	2.40	1.85–3.10	<.01
Dialysis	2.24	1.69–2.97	<.01
Ascites	2.18	1.82–2.61	<.01
Weight loss	2.16	1.98–2.35	<.01
Pneumonia before surgery	2.03	1.34–3.08	<.01
Chronic steroid use	1.87	1.72–2.04	<.01
ASA score >2	1.71	1.43–2.05	<.01
Previous operation in 30 d	1.60	1.35–1.89	<.01
Disseminated cancer	1.49	1.35–1.63	<.01
Preoperative myocardial infarction	1.46	1.05–2.02	.02
Cardiac angina	1.43	1.09–1.86	.01
Chronic obstructive pulmonary disease	1.30	1.18–1.43	<.01
Smoking	1.20	1.13–1.27	<.01
Diabetes mellitus	1.17	1.10–1.25	<.01
Dyspnea	1.16	1.08–1.25	<.01
Chemotherapy	1.13	.98–1.31	.09
Alcohol abuse	1.03	.91–1.17	.58
Hypertension	.92	.88–1.01	.12
Radiotherapy	.87	.75–1.01	.07

ASA 5 American Society of Anesthesiologists.
*Partial or totally dependency in activities performed in the course of a normal day in a person's life (bathing, feeding, dressing, toileting, and mobility).

Results

We sampled 108,898 patients who underwent colorectal resection from 2005 to 2012. The mean age of patients was 63 years old with a standard deviation of 16 years. Most patients were Caucasian (85.6%) and women (52.2%). Most common comorbidities included hypertension (51.1%), diabetes mellitus (15.7%), COPD (7.2%), and disseminated cancer (5.9%). Demographic data of patients are described in Table 1.

Of all patients who underwent colorectal resection, 16,962 (15.6%) patients had preoperative modest hypoalbuminemia. The median length of stay after surgery was 9 days in patients with modest hypoalbuminemia, whereas patients without hypoalbuminemia remained hospitalized 6 days after surgery. Patients with modest hypoalbuminemia had 2 days longer mean hospitalization compared with patients without hypoalbuminemia (95% confidence interval [CI],
1.83 to 2.35; $P < .01$).

The unadjusted mortality rate in patients with modest hypoalbuminemia and without hypoalbuminemia was 6% and 1.7%, respectively, whereas the adjusted risk of mortality in patients with modest hypoalbuminemia was estimated to be more than in those without hypoalbuminemia (AOR, 1.876; 95% CI, 1.51 to 2.05; $P < .01$).

The risk-adjusted analysis for postsurgical complications associated with modest hypoalbuminemia is reported in Table 2. Specific postsurgical complications linked with modest hypoalbuminemia included hospitalization for more than 30 days from admission date (AOR, 1.77; 95% CI, 1.54 to 2.02; P < .01), deep vein thrombosis (AOR, 1.64; 95% CI, 1.37 to 1.97; P < .01), unplanned intubation (AOR, 1.42; 95% CI, 1.24 to 1.62; P ,.01), and ventilator dependency for more than 48 hours (AOR, 1.30; 95% CI, 1.14 to 1.47; P < .01).

Postoperative morbidity and mortality of patients are reported by serum albumin level in Table 3 and Fig. 1. The highest morbidity (60.4%) and mortality (26.2%) rates occurred at serum albumin levels lower than 2 g/dL, and the lowest morbidity (14.6%) and mortality (.5%) rates occurred at serum albumin level of 4.7 g/dL (Fig. 1). The rate of decline in mortality and morbidity reported in Fig. 1 was estimated by logistic regression to be approximately 49% and 24%, respectively, for each 1 g/dL increase in serum albumin level (P < .05) (Table 2). Using the same methodology, similar results are reported for each of the 10 postoperative complications in Table 2.

Table 4 describes the associations between 29 preoperative variables and preoperative modest hypoalbuminemia. Factors such as history smoking, diabetes, steroid use, COPD, cardiac angina, history of surgery in 30 days, history of unintentional weight loss before surgery, ASA score more than 2, poor functional status, metastatic disease, and CHF have strong associations with preoperative modest hypoalbuminemia.

Colon cancer patients had a higher rate of modest hypoalbuminemia compared with rectal cancer patients (AOR, 1.55; 95% CI, 1.37 to 1.75; P < .01). Table 5 and Fig. 2 report associations between patients' pathology and site of the colorectal tumor with preoperative hypoalbuminemia.

Table 5
Risk-adjusted analysis of pathologies associated with preoperative hypoalbuminemia compared with patients without hypoalbuminemia in colon and rectal surgery patients (multivariate analysis)

Pathology	Patients with serum albumin ≥ 3.5 g/dL (reference)	Patients with serum 3 ≤ albumin < 3.5 g/dL				Patients with serum albumin <3 g/dL			
		Count (rate)	Adjusted odds ratio	95% Confidence interval	*P* value	Count (rate)	Adjusted odds ratio	95% Confidence interval	*P* value
Diverticulitis	12,849 (28%)	2,567 (27.8%)	1.01	.95–1.08	.58	2,635 (31.2%)	1.06	.99–1.13	.09
Benign colorectal tumor	7,195 (15.7%)	524 (5.7%)	.30	.27–.34	<.01	193 (2.3%)	.13	.10–.15	<.01
Ulcerative colitis	1,824 (4%)	490 (5.3%)	1.10	.96–1.26	.15	1,077 (12.8%)	2.19	1.94–2.47	<.01
Diverticulosis	1,425 (3.1%)	335 (3.6%)	.98	.84–1.14	.82	574 (6.8%)	1.54	1.33–1.78	<.01
Crohn disease	1,166 (2.5%)	442 (4.8%)	1.92	1.66–2.23	<.01	509 (6%)	2.01	1.73–2.34	<.01
Right-sided colon cancer*	7,476 (16.3%)	2,263 (24.5%)	1.23	1.15–1.32	<.01	1,636 (19.4%)	.82	.75–1.02	.10
Rectal cancer	6,250 (13.6%)	890 (9.7%)	.65	.58–.72	<.01	456 (5.4%)	.38	.33–.44	<.01
Sigmoid cancer	4,475 (9.8%)	918 (10%)	.90	.82–1	.06	746 (8.8%)	.68	.60–.76	<.01
Transverse colon cancer	1,828 (4%)	525 (5.7%)	1.17	1.03–1.33	.01	394 (4.7%)	.84	.71–1	.06
Left-side colon cancer†	1,095 (2.4%)	224 (2.4%)	.88	.73–1.06	.18	195 (2.3%)	.71	.57–.89	<.01
Carcinoma in situ of colon or rectum	291 (.6%)	41 (.4%)	.50	.33–.77	<.01	18 (.2%)	.20	.09–.40	<.01

*Cecum and ascending colon cancers.
†Descending colon cancers.

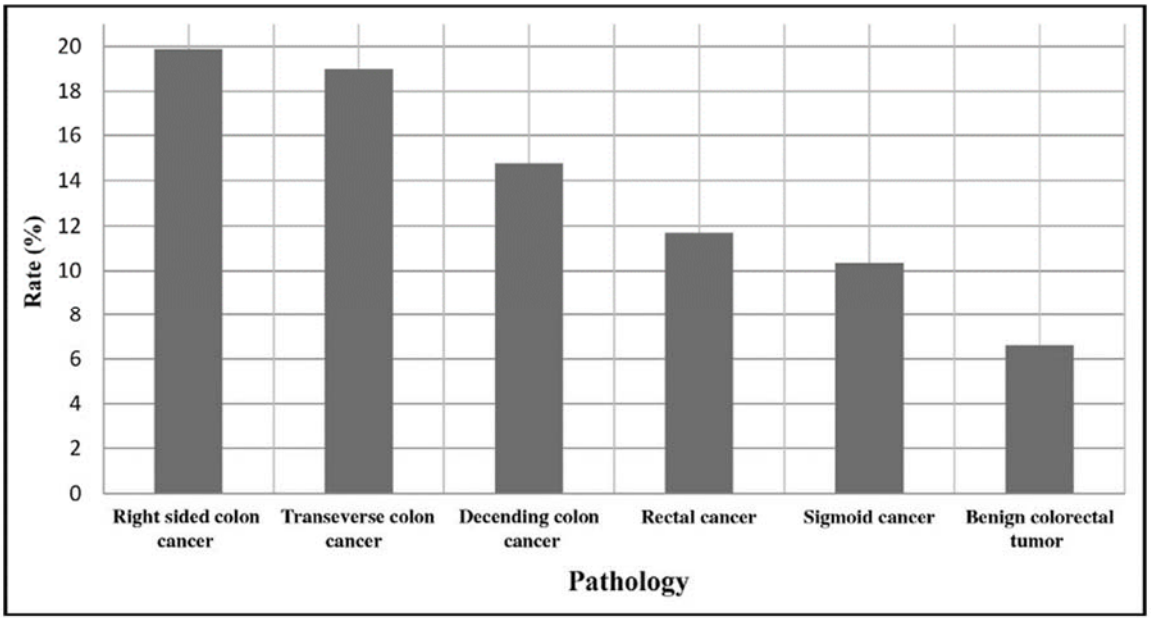

Figure 2 Rate of preoperative modest hypoalbuminemia according to the colorectal tumor site.

Comments

Any decrease in serum albumin level from normal value has serious effects on outcomes of colorectal surgery patients. Preoperative hypoalbuminemia, even a modest degree, is associated with worse prognosis, increased rates of mortality and morbidity, and an observed increase in hospitalization length after colorectal operations. In-hospital mortality risk of patients undergoing colorectal resections increases 49% (AOR, .51) with only a decrease of 1 g/dL serum albumin level from the normal level (Table 2). In line with the available literature, modest hypoalbuminemia was also found to be significantly associated with increased mean hospitalization period of the affected patients. The high rate of mortality and morbidity in patients who had hypoalbuminemia has been previously introduced.[8] Our data show that even a minimal decease in the serum albumin level less than 3.5 g/dL is associated with significant mortality and morbidity. Also, this study introduces a linear correlation between the serum albumin level and postoperative mortality and morbidity. Even a modest decrease in the serum albumin level affects postoperative morbidity and mortality of patients (Table 3). For example, a 1 g/dL decrease in serum albumin level from the level of 4 was found to be associated with a 49% and 24% increase in mortality and morbidity, respectively (Table 3). Associations of serum albumin level with postoperative mortality and morbidity make it a simple prognostic tool for preoperative nutritional risk assessment and postoperative complications prediction.

This study reinforces the value of serum albumin level as an accurate preoperative marker to predict postoperative mortality and complications in colorectal surgery. Our data, which represents the largest to date on this topic, show that even in modest levels, hypoalbuminemia is a significant risk factor for 8 postoperative complications after colorectal operations (Table 2), and this is in line with the literature.[8,12] Interestingly our data revealed that modest hypoalbuminemia does not significantly increase superficial

and organ space SSI rates. Despite these findings, further analysis showed that mortality, overall morbidity, and especially cardiopulmonary complications were all significantly higher in the presence of modest hypoalbuminemia. Furthermore, this study confirmed the previously reported association between hypoalbuminemia and cardiac arrest, ventilator dependency, DVT, and pneumonia observed in general surgical patients.[8,13]

We found 8 postoperative complications that had a significant association with modest hypoalbuminemia, with cardiopulmonary complications having the strongest association. Specifically the strongest associations were found between hypoalbuminemia and cardiac arrest, followed by respiratory complications and DVT (Table 3). Among surgical site complications, 4 complications including superficial SSI, deep SSI, organ space SSI, and wound disruption have associations with hypoalbuminemia,8 but in analyzing hypoalbuminemia at modest levels, the significant associations persist only for wound disruption and deep SSI. We also found a linear relation between these 2 surgical site complications and the serum albumin level. With each 1 g/dL decrease in the serum albumin level from the normal level, the risks of wound disruption and deep SSI increased by 25% and 16%, respectively (Table 3).

These results suggest that serum albumin measurement should be used more frequently before surgery as a prognostic tool by surgeons. Serum albumin level is a low cost key element in nutritional assessment that has been previously identified.8 It is an objective nutritional assessment element with the ability to detect protein–energy malnutrition in early clinically unrecognizable situations, such as in patients, that do not demonstrate weight loss and high protein requirement situations (stress of illness, trauma, and infection).[8,14,15] Serum albumin level has also been validated as a component of the Acute Physiology and Chronic Health Evaluation III score that is used to predict morbidity and mortality in critically ill patients.[16,17]

We found that an ASA score greater than 2 is a reliable marker to predict hypoalbuminemia even in modest levels in colorectal surgery. Using the power of the large NSQIP database, this study identified 18 significant preoperative factors associated with modest hypoalbuminemia in colorectal patients. ASA score has been previously introduced as a marker of mortality in general surgery.[8] In addition, this study introduces elevated ASA score as a reliable marker to identify patients with modest levels of hypoalbuminemia in colorectal surgery.

There are numerous preoperative comorbidities, which have associations with modest levels of hypoalbuminemia. We found more than 19 comorbid conditions associated with modest hypoalbuminemia in univariate analysis of data. After adjustment with multivariate analysis of data, 16 comorbid conditions had significant associations with modest hypoalbuminemia. Comorbidities of weight loss, CHF, and ascites have strong associations with modest hypoalbuminemia. Comorbidity of alcohol abuse does not have significant associations with modest hypoalbuminemia. Further studies are indicated to see if the reason for hypoalbuminemia in patients with comorbidities is malnutrition or if it reflects an acute-phase response.

Patient pathology also appears to play a role in hypoalbuminemia. Patients with Crohn disease had an increased risk of hypoalbuminemia. Even after adjustment for 24 confounding factors, Crohn disease had a significant association with hypoalbuminemia. This is most likely explained by the high prevalence of malnutrition and use of steroids in patients with Crohn disease.[18]

Patients having colon cancer have a higher rate of preoperative modest hypoalbuminemia (19.4%) compared with patients with rectal cancer (7.3%) (Table 5). Once again, among colorectal tumors, right-sided colon cancers had the highest rate of modest hypoalbuminemia. The risk decreases in transverse colon malignancies, and the lowest risk exists in benign colorectal tumors (Fig. 2 and Table 5). However, there is limited published data regarding associations between hypoalbuminemia and tumor site in colorectal surgery. Further studies are indicated to evaluate this relationship.

Perioperative nutritional care aiming to decrease postoperative complications should be further evaluated in patients with hypoalbuminemia. Enhancement of recovery time in colorectal surgery by perioperative multimodel care programs including early postoperative nutritional care has been introduced in the literature.[19,20] Obviously, the reduction in recovery time observed cannot be entirely related to nutritional support, and further studies should investigate the etiology and pathophysiology of hypoalbuminemia in surgical patients.

Study limitations

This study is a large retrospective review and is, therefore, subject to typical inherent biases for retrospective studies, such as selection bias. Data in this study were extracted from the NSQIP, which collects data from more than 500 hospitals in the United States. Thus, there is a wide variety of in-hospital settings and surgeons' expertise that can affect the study. Patients in this study did not form a homogeneous group, and their primary diagnoses varied broadly. Some patients may have received preoperative supplementation or resuscitation with albumin, which may have altered serum albumin measurements. Because of the restrictions of the database, some of the potentially important postoperative complications that are known to correlate with hypoalbuminemia were not included in this study (ie, anastomotic leakage).[21] Patients cannot be tracked; therefore, we do not have data beyond 30 days from the date of surgery and long-term outcomes. Likewise, coding errors may exist because of the use of discharge data (ICD-9 codes).[22] Despite these limitations, this study is one of the first to report on postoperative complications of modest hypoalbuminemia in colorectal resection procedures in this population subset.

Conclusions

Modest hypoalbuminemia is a common condition in colorectal patients. Its presence has a strong association with increased morbidity and mortality. Hypoalbuminemia can be used as a prognostic factor to predict the risk of adverse surgical outcomes. With each decrease of 1 unit of serum albumin level from the normal level, mortality and morbidity of patients increased 49% and 24%, respectively. Colon cancer had a higher risk of hypoalbuminemia compared with the rectal cancer. Among colorectal tumors, right-sided colon cancers were associated with higher rate of modest hypoalbuminemia, with lower rates in left-sided tumors. The highest associations between modest hypoalbuminemia and postsurgical complications in colorectal patients exist in nonsurgical site complications, especially prolonged hospitalization. Presence of Crohn's in pathology of patients is a predictor of hypoalbuminemia.

The clinical consequences of these findings suggest the need for application of both surgical and nutritional screening protocols in our colorectal surgery patients. Including interventions such as smoking cessation before surgery, nutritional supplementation as needed before or after surgery, and rectifying hypoalbuminemia even in modest scenarios may lead to improvement of surgical outcomes.

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