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# Hypoalbuminemia Independently Predicts Surgical Site Infection, Pneumonia, Length of Stay, and Readmission After Total Joint Arthroplasty

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ABSTRACT

This study investigates the association between preoperative hypoalbuminemia, a marker for malnutrition, and complications during the 30 days after total joint arthroplasty. Patients who underwent elective primary total hip and knee arthroplasty as part of the American College of Surgeons National Surgical Quality Improvement Program were identified. Outcomes were compared between patients with and without hypoalbuminemia (serum albumin concentration <3.5 g/dL) with adjustment for patient and procedural factors. A total of 49 603 patients were included. In comparison to patients with normal albumin concentration, patients with hypoalbuminemia had a higher risk for surgical site infection, pneumonia, extended length of stay, and readmission. Future efforts should investigate methods of correcting nutritional deficiencies prior to total joint arthroplasty. If successful, such efforts could lead to improvements in short-term outcomes for patients.



Total joint arthroplasty (TJA) is one of the most common surgical procedures performed in the United States, and the demand for TJA procedures is predicted to grow [1,2]. Although TJA is a safe, elective procedure, a small percentage of TJA procedures do result in major complications [3–6].

Although many previously identified risk factors for complications after TJA cannot be altered, other risk factors may potentially be modified prior to surgery [3–6]. One potential risk factor that is appealing for preoperative intervention is malnutrition [7]. Serologic laboratory values, anthropometric measurements, and standardized assessments can all be used as markers for malnutrition [7]. In particular, hypoalbuminemia (serum albumin concentration <3.5 g/dL) is one of the simplest and most widely used markers for malnutrition [7,8].

Preoperative malnutrition has been identified in a number of studies as a risk factor for surgical site infection (SSI) and delayed wound healing after TJA [9–18]. For example, in a prospective study of 213 patients, malnutrition (defined by an abnormal triceps skin fold) was associated with development of SSI [9]. Similarly, in a retrospective evaluation of 375 patients undergoing revision TJA for aseptic failure, malnutrition (defined by abnormal albumin concentration, lymphocyte count, or transferrin concentration) was associated with development of acute postoperative periprosthetic joint infection [10].

There have been fewer investigations into the association of malnutrition with other postoperative complications. One example of such an investigation is a prospective study of 2161 patients undergoing TJA [11]. In this study, malnutrition (defined by abnormal albumin or transferrin concentrations) was associated with hematoma formation, renal complications, and cardiac complications. However, this study may have lacked the sample size to sufficiently evaluate the full range of potential complications, many of which are rare events.

The American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) is a prospective surgical registry that samples patients from community and academic centers nationwide [19]. The program prospectively identifies patients undergoing major surgical procedures, including TJA, and tracks them for 30 days for the development of postoperative complications. The program also prospectively collects preoperative laboratory data, including preoperative serum albumin concentration. In this context, regarding patients undergoing primary TJA, the present study uses the ACS-NSQIP to determine (1) preoperative associations with hypoalbuminemia and (2) the association between preoperative hypoalbuminemia and several specific postoperative complications.

## Methods

A retrospective analysis of prospectively collected data was conducted. Patients who underwent primary total hip arthroplasty (THA) or total knee arthroplasty (TKA) were identified as part of the ACS-NSQIP

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in 2011 to 2013. Patients were identified using primary *Current Procedural Terminology* codes 27130 for primary THA and 27447 for primary TKA. The additional associated *Current Procedural Terminology* code fields and *International Classification of Disease, Ninth Revision* diagnosis code field were then used to exclude patients who were not definitively undergoing elective primary TJA. Specifically, patients whose cases involved prosthesis revision, hardware removal, major ligament reconstruction, additional unrelated procedures, acute trauma, or preoperative infection were excluded. Patients described as undergoing surgery nonelectively by the ACS-NSQIP were excluded. Finally, patients without preoperative serum albumin laboratory values were excluded.

The ACS-NSQIP collects baseline data on demographics, comorbidities, and preoperative laboratory values [19]. Demographic data includes age, sex, and body mass index (BMI). Comorbidity data include diabetes mellitus, congestive heart failure, dyspnea on exertion, hypertension, end-stage renal disease, and chronic obstructive pulmonary disease. Preoperative serum laboratory values include hematocrit and serum albumin concentration. Insulin-dependent diabetes mellitus was defined through individual review of patient medical records as diabetes for which a patient uses insulin as a medication. Non–insulin-dependent diabetes, on the other hand, was defined through individual review of patient medical records as diabetes for which a patient uses only noninsulin medication for control. Patients not taking any medication are considered to not have diabetes. For the present study, *anemia* was defined as preoperative hematocrit below 36 for women or 41 for men (2 SDs below the mean for each sex) [20]. Consistent with previous studies [7], *hypoalbuminemia* was defined as serum albumin concentration less than 3.5 g/dL.

The ACS-NSQIP follows up patients prospectively during the first 30 postoperative days for the development of postoperative complications [19]. Patients were considered to have had a serious complication occur if any of the following occurred during the first 30 postoperative days: systemic sepsis (either with or without shock), myocardial infarction, stroke, cardiac arrest, pulmonary embolism, mortality, coma more than 24 hours, or unplanned intubation (either unplanned intubation after the procedure or ventilator requirement for >48 hours after surgery). Patients were considered to have had any complication occur if any of the following occurred during the first 30 postoperative days: any of the serious complications, deep vein thrombosis, graft/prosthesis/flap failure, wound dehiscence, SSI, peripheral nerve injury, renal insufficiency (either acute renal failure or progressive renal insufficiency), urinary tract infection, or pneumonia.

The ACS-NSQIP also follows up patients for postoperative hospital length of stay and unplanned readmission to any hospital [19]. In order to limit the effects of outliers on the analysis, postoperative hospital length of stay was capped at 30 days.

The level of significance was set at $\alpha = .05$ ($P < .05$). All tests were 2 tailed. Of note, the ACS-NSQIP does not provide information on surgeon or institution, so adjustment for clustering by these factors was not possible.

First, bivariate and multivariate Poisson regression with robust error variance [21] was used to identify risk factors for hypoalbuminemia among the following demographic, comorbidity, and laboratory characteristics: procedure type (primary THA or TKA), age (18-39, 40-49, 50-59, 60-69, 70-79, 80-89, or ≥90 years), sex (male or female), BMI (≤18.5, 18.5-25, 25-30, 30-35, 35-40, 40-45, 45-50, or ≥50 kg/m$^2$), diabetes mellitus (no diabetes mellitus, non–insulin-dependent diabetes mellitus, insulin-dependent diabetes mellitus), congestive heart failure, dyspnea on exertion, hypertension, end-stage renal disease, chronic obstructive pulmonary disease, current smoking status, and anemia.

Next, 30-day postoperative outcomes were compared between patients with hypoalbuminemia and patients with normal serum albumin concentration. These comparisons were conducted both before and after multivariate adjustment for the demographic, comorbidity, and laboratory characteristics listed in the prior paragraph. Bivariate and multivariate Poisson regression with robust error variance was used to compare rates of any complications, serious complications, specific complications, and unplanned readmission. Only specific complications with an incidence of at least 0.1% were individually analyzed. Bivariate and multivariate linear regression was used to compare postoperative length of stay.

Required ACS-NSQIP statement: "The American College of Surgeons National Surgical Quality Improvement Program and the hospitals participating in the ACS NSQIP are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors."

## Results

A total of 101 523 patients were initially identified, of whom 49 603 (48.9%) had preoperative serum albumin laboratory values available for analysis. These 49 603 patients constituted the study population. Of these patients, 19 975 (40.3%) underwent primary THA and 29 628 (59.7%) underwent primary TKA.

The prevalence of hypoalbuminemia was 4.0% (95% confidence interval [CI], 3.8%-4.1%; Fig. 1). In the multivariate analysis (Table), hypoalbuminemia was independently associated with age strata ($P < .001$), female sex ($P < .001$), BMI strata ($P < .001$), diabetes mellitus ($P < .001$), dyspnea on exertion ($P < .001$), end-stage renal disease ($P < .001$), chronic obstructive pulmonary disease ($P < .001$), current smoker status ($P < .001$), and anemia ($P < .001$). For age and BMI, these associations were bimodal, with increased rates of hypoalbuminemia at both extremes (Fig. 2A and B; Table). For diabetes mellitus, the prevalence was highest for patients with insulin-dependent diabetes mellitus (Fig. 2C; Table).

All subsequent analyses were adjusted for the demographic, comorbidity, and laboratory characteristics listed in Table. Both adjusted and unadjusted values are presented. In comparison to patients with normal serum albumin concentration, patients with hypoalbuminemia had a higher risk for occurrence of any complications (7.3% vs 4.0%; unadjusted relative risk [RR], 1.8 [95% CI, 1.6-2.2; $P < .001$]; adjusted RR, 1.5 [95% CI, 1.2-1.7; $P < .001$]; Fig. 3). Similarly, patients with hypoalbuminemia had a higher risk for occurrence of serious complications (2.1% vs 1.2%; unadjusted RR, 1.8 [95% CI, 1.3-2.5; $P < .001$]; adjusted RR, 1.4 [95% CI, 1.0-1.9; $P = .042$]).

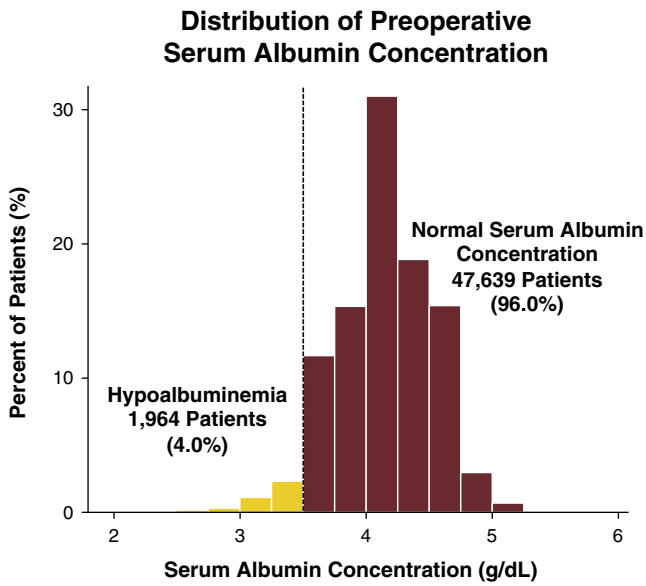


**Fig. 1.** Distribution of preoperative serum albumin concentration. In total, 47 639 patients (96.0%) had normal serum albumin concentration, whereas 1 964 patients (4.0%) had hypoalbuminemia (serum albumin concentration <3.5 g/dL).