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Preoperative Anemia Independently Predicts 30-Day Complications After Aseptic and Septic Revision Total Joint Arthroplasty

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ABSTRACT

Background: Preoperative anemia is a common, important risk factor for adverse events after joint arthroplasty surgery. It affects 21%-35% patients undergoing total joint arthroplasty. To date, few studies have investigated the effect of preoperative anemia, specifically in revision total joint arthroplasty surgery.

Methods: The American College of Surgeons National Surgical Quality Improvement Program database was used to identify patients who underwent revision total joint arthroplasty from 2006 to 2014. We matched 6830 patients undergoing aseptic revision (3415 anemic vs 3415 not anemic) and 2650 patients undergoing septic revision (1325 anemic vs 1325 not anemic). In each cohort, patients were propensity score-matched 1:1 by the presence of preoperative anemia. The inpatient hospitalization data, postoperative complications, as well as demographics and comorbidities were compared between patients with or without anemia who underwent revision total joint arthroplasty.

Results: After adjusting for comorbidities via multivariate regression, anemia was associated with an increased risk of overall complications (aseptic: odds ratio [OR], 1.45; 95% confidence interval [CI], 1.24-1.70; $P < .001$; septic: OR, 2.16; 95% CI, 1.83-2.56; $P < .001$), deep infection (aseptic: OR, 1.68; 95% CI, 1.19-2.38; $P = .003$; septic: OR, 1.44; 95% CI, 1.06-1.94; $P = .018$), mortality (aseptic: OR, 2.18; 95% CI, 1.09-4.36; $P = .028$; septic: OR, 3.16; 95% CI, 1.03-9.74; $P = .045$), and increased hospital length of stay (aseptic: adjusted coefficient, 1.02 days; 95% CI, 0.73-1.31; $P < .001$; septic: adjusted coefficient, 2.04 days; 95% CI, 1.53-2.55; $P < .001$).

Conclusion: Preoperative anemia is independently associated with postoperative complications, mortality, and increased length of stay in revision total joint arthroplasty. Further studies are needed to evaluate if preoperative treatment of anemia may modify this risk.

As the number of primary total joint arthroplasties performed in the United States rises, the volume of revision total joint arthroplasties is expected to increase concomitantly in the next several decades [1]. Patients undergoing revision total joint arthroplasty are often times older and sicker, with lower physiological reserve than those undergoing primary joint arthroplasty. Given the impact that preoperative health differences can have on joint arthroplasty outcome, it is important to examine the effect that various comorbidities can have on perioperative complications.

Preoperative anemia is a common, important risk factor for adverse events after joint arthroplasty surgery. It is a comorbidity that increases with advancing age and affects as many as 21%-35% patients who undergo primary or revision total joint arthroplasty [2–4]. Multiple studies have examined the association between the presence of anemia and postoperative complications such as infection, mortality, length of stay, and functional status [5–9]. Anemia is correlated with age and other comorbidities, and although some studies have isolated anemia as an independent variable affecting primary joint arthroplasty outcomes [4,10,11], only one other study to our knowledge has investigated this relationship in revision surgery [12]. No previous literature has stratified the effect of preoperative anemia based on aseptic vs septic revision surgery.

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The purpose of this large-scale database study was to examine anemia as an independent risk factor for early complications in revision total joint arthroplasty, while looking at aseptic and septic revision cohorts. We hypothesize that anemia is independently correlated with complications in these patients. In addition, we hypothesize that anemia is a more influential risk factor in septic revisions compared with aseptic cases, given that infected patients have a greater overall comorbidity burden.

Methods

ACS-NSQIP Participant Use Data File

The American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) is a prospectively maintained, risk-adjusted, surgical outcomes registry [13]. The total number of surgical cases available from this database range from >150,000 in 2006 to >750,000 patients in 2014. All patients are tracked for 30 days postoperatively after the index procedure. The database is managed by risk assessment nurses who collect preoperative medical history of patients and observe postoperative morbidity and mortality associated with each surgical procedure documented in the database. The ACS-NSQIP applies strict definitions, which are described in detail in the user guide, in the documentation of patient comorbidities and complications. The collected data are deidentified to comply with the ACS-NSQIP participant user agreement. To ensure data reliability, the database is subject to regular inter-rater audits, which reported the interobserver disagreement rate to be 1.96% [14].

Study Population

Using primary Current Procedural Terminology codes, we retrospectively queried the 2006-2014 ACS-NSQIP database for all patients who underwent revision total joint arthroplasty. All Current Procedural Terminology codes queried are available in Table 1. Revision total joint arthroplasty patients were stratified into aseptic and septic cohorts. Septic revisions were those cases that carried a diagnosis of prosthetic-related infection (*International Classification of Diseases, Ninth Revision*, diagnosis codes: 996.6, 996.66, and 996.67) or a nonclean wound as defined by the NSQIP wound classification. A clean wound is defined by NSQIP as an uninfected operative wound in which no inflammation is encountered (class 1). Nonclean wounds included all other wound classifications.

Study Demographics and Outcomes

Patient demographics and comorbidities were analyzed to determine baseline differences between the cohorts and to identify potential confounders. Demographic data for all patients included age, gender, body mass index, and functional status (ability to independently complete activities of daily living). In the NSQIP database, functional status is stratified into independent and dependent categories. An independent patient is one who does not require assistance from another person for activities of daily living. A dependent person conversely is one who requires some (partially dependent) or total (totally dependent) assistance from another person for activities of daily living. A comparison of demographic data was performed between the patient groups who underwent aseptic and septic revisions. The prevalence of medical comorbidities including diabetes, hypertension, history of chronic obstructive pulmonary disease, dyspnea, congestive heart failure, dialysis, steroid use, and bleeding disorder were compared among the groups. In addition, smoking status and American Society of Anesthesiologists (ASA) physical status classification were also compared between the patient groups.

Propensity score matching was used to control for selection bias between anemic and nonanemic patients. The purpose of propensity score analysis is to assess the conditional probability of having a predictor, in our case anemia, based on baseline patient characteristics. Specifically, the logistic regression method for propensity score matching was used in this analysis [15]. In the aseptic and septic revision cohorts, anemic and nonanemic patients were propensity score matched 1:1 for gender, age, procedure, functional status, ASA class, body mass index, and by the presence of medical comorbidities. The threshold for preoperative anemia was defined as a hematocrit value <36% for females and <39% for males. This was based on the World Health Organization definition of anemia (hemoglobin <12.0 and 13.0 g/dL for adult females and males, respectively) [16]. After completing the propensity score matching algorithm, no significant differences were observed in the matched cohorts indicating successful matching.

The 30-day perioperative outcomes analyzed included overall complication rates, major complications, minor complications, transfusion, readmission, length of procedure, and length of stay. Major complications encompassed deep infections, sepsis, septic shock, wound dehiscence, pulmonary embolism, ventilator dependence >48 hours, unplanned intubations, acute renal failure, cardiac arrest, myocardial infarction, stroke, return to operating room, or mortality. Minor complications included superficial surgical site infection, pneumonia, urinary tract infection, deep venous thrombosis, peripheral nerve injury, or renal insufficiency. Clinical criteria defining all complications are available in the Participant Use File Data User Guides (https://www.facs.org/quality-programs/acs-nsqip/program-specifics/participant-use).

Statistical Analysis

After propensity matching, we compared demographics, comorbidities, and complications and perioperative outcomes data between the anemic and nonanemic patients for both aseptic and septic revision cohorts, performing Student t tests for continuous variables and Pearson chi-squared tests for categorical variables. Univariate predictors significant at $\alpha = 0.05$ were entered into a multivariate logistic regression model to adjust for potential confounders. P values were calculated using the Wald test in the multivariate logistic regression. Significance was assessed at $P < .05$.

Table 1
CPT Coding for Revision Total Joint Arthroplasty.

CPT Code	Procedure
27134	Revision of total hip arthroplasty; both components, with or without autograft or allograft
27137	Revision of total hip arthroplasty; acetabular component only, with or without autograft or allograft
27138	Revision of total hip arthroplasty; femoral component only, with or without allograft
27486	Revision of total knee arthroplasty, with or without allograft; 1 component
27487	Revision of total knee arthroplasty, with or without allograft; femoral and entire tibial component

CPT, Current Procedural Terminology.

Results

Our propensity score matched analysis included 6830 patients undergoing aseptic revision (3415 anemic vs 3415 nonanemic) and 2650 patients undergoing septic revision (1325 anemic vs 1325 nonanemic) between 2006 and 2014. The comorbidity