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ORIGINAL ARTICLE

Medical comorbidities and perioperative allogeneic red blood cell transfusion are risk factors for surgical site infection after shoulder arthroplasty

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Background: Multiple perioperative factors have been implicated in infection risk after shoulder arthroplasty. The purpose of this study was to determine surgical site infection (SSI) risk due to medical comorbidities or blood transfusion after primary or revision shoulder arthroplasty.

Methods: Comprehensive data on medical comorbidities, surgical indication, perioperative transfusion, and SSI were obtained for 707 patients who underwent primary or revision hemiarthroplasty or total shoulder arthroplasty in a single hospital system. Multivariate Poisson regression was used to determine the independent association between allogeneic red blood cell transfusion, medical comorbidities, and SSI after controlling for procedure.

Results: The SSI rate was 1.9% for primary hemiarthroplasties and 1.3% for primary total shoulder arthroplasties. Among patients without prior shoulder infection, revision arthroplasty or prior open reduction and internal fixation had higher SSI risk than primary arthroplasties (incidence risk ratio [IRR], 11.4; 95% confidence interval [CI], 3.84-34.0; $P < .001$); among primary arthroplasties, SSI risk factors included male gender (IRR, 60.0; CI, 4.39-819; $P = .002$), rheumatoid arthritis (IRR, 8.63; CI, 1.84-40.4; $P = .006$), and long-term corticosteroid use (IRR, 37.4; CI, 5.79-242; $P < .001$). Perioperative allogeneic red blood cell transfusion significantly increased SSI risk and was dose dependent (IRR, 1.68 per unit packed red blood cell; CI, 1.21-2.35; $P = .002$).

Conclusion: Gender, rheumatoid arthritis, and long-term (>1 year) corticosteroid use affect SSI risk after shoulder arthroplasty. Revision surgery, particularly in the setting of prior infection, increased risk of future infection. Finally, allogeneic red blood cell transfusion increases SSI risk after shoulder arthroplasty in a dose-dependent manner.

Level of evidence: Level III; Retrospective Cohort Comparison; Treatment Study

Keywords: Total shoulder arthroplasty; surgical site infection; allogeneic red blood cell transfusion; comorbidities; corticosteroid use; revision surgery

Shoulder arthroplasty in the United States is a common procedure that is being performed with increasing frequency.[19] Infection rates after shoulder arthroplasty are low, with an estimated 1.3% 20-year infection rate in hemiarthroplasties[40]

This study was approved by the Biomedical Institutional Review Board of The Ohio State University: No. 2012H0364.

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and 2.8% in total shoulder arthroplasties (TSAs).[41] Surgical site infection (SSI) after joint arthroplasty is costly, with an estimated overall medical cost due to SSI after joint arthroplasty projected to exceed $1.62 billion by 2020[42] and in-hospital care cost approximately double that of non-SSI patients.[38] Even after successful treatment of periprosthetic joint infection, functional outcomes are subpar; Weber et al reported an average Constant score of 36 for patients cleared of shoulder infection with prosthesis removal or exchange,[46] which is in contrast to significantly higher scores reported after anatomic or reverse TSA or hemiarthroplasty.[4,9,45]

Several studies have investigated the association between medical comorbidities as well as patient demographics and risk of SSI after shoulder arthroplasty. Younger age and male sex have been associated with increased SSI rates in shoulders.[39,41] The association between higher SSI rates and male gender may in part be due to frequent involvement of *Propionibacterium acnes* in shoulder infections[27]; this low-virulence organism has been shown to have higher bacterial counts about the shoulders of men.[34] Among primary arthroplasties, Richards et al also noted higher infection rates among reverse TSAs and arthroplasties for treatment of fracture.[39]

Allogeneic red blood cell transfusion is associated with higher SSI rates after hip or knee arthroplasty[6,8,18,33] but has not been studied in a shoulder arthroplasty population. Some studies suggest a dose-dependent relationship between blood transfusion and increasing risk of infection.[6,8] Comparative studies of autologous vs. allogeneic blood transfusion suggest this risk is specific to allogeneic blood products.[18,33] A possible confounder between blood transfusion and SSI risk is preoperative anemia, as Greenky et al demonstrated in a large retrospective study that hip and knee arthroplasty patients with preoperative anemia were at higher risk of SSI (4.3% incidence compared with 2.0% without preoperative anemia) and were significantly more likely to receive an allogeneic red blood cell transfusion (54.0%, anemic patients; 13.4%, all other patients).[15]

The purpose of this study was to determine the association between demographic factors, medical comorbidities, and perioperative allogeneic red blood cell transfusion and SSI risk after shoulder arthroplasty. Specifically, this study aimed (1) to determine the association between demographic factors, medical comorbidities, and SSI risk after shoulder arthroplasty after controlling for planned procedure and indication for surgery and (2) to determine the association between allogeneic red blood cell transfusion and SSI risk after controlling for preoperative anemia, medical comorbidities, and planned procedure.

Materials and methods

Data sources

All patients included in the current study (N = 707) underwent shoulder hemiarthroplasty (222 [31.4%]) or TSA (485 [68.6%]) within a single hospital system from January 2000 to October 2011. As a large academic medical center, this represents a diverse population, including 177 arthroplasties performed for fracture (25.0% of total). Comprehensive medical record data were obtained and included all surgeries, hospitalizations, laboratory data, and *International Classification of Diseases, Ninth Revision* (ICD-9) diagnosis codes from 1982 to 2012. Preoperative anemia was defined by presence of an ICD-9 diagnosis code for anemia of chronic disease, iron or nutrition deficiency anemia, or other unspecified chronic anemia or a preoperative hemoglobin value <13.0 g/dL for men and <12.0 g/dL for women per World Health Organization guidelines.[47] Blood transfusion data including type and amount of blood products received within 30 days of surgery were obtained from blood bank records. Leukocyte reduction was routinely performed in the preparation of allogeneic red blood cell products. No patients were recalled specifically for this study; all data were obtained from medical records.

Definition of SSI and identification of cases

We screened all patients who had a return to the operating room or who had an ICD-9 diagnosis code assigned after the date of procedure that may be associated with SSI, including codes for osteomyelitis (730.00-730.99), septic arthritis (711.0), SSI (998.3 and 998.5), cellulitis (682), and infection or inflammatory reaction resulting from the joint implant or other hardware (996.66 or 996.67). An ICD-9 code–based query has been shown to have substantially higher sensitivity for detecting SSIs after arthroplasty than reliance on routine surveillance by hospital epidemiologists.[5] As shoulder infections often have a delayed presentation,[35,37] we did not have a time limit for diagnosis of periprosthetic infection; the maximum length of follow-up in this study was 12 years. The operative reports and medical records of all patients in this group were then reviewed in depth.

For the purpose of this study, SSI was defined as either (1) treatment of a superficial infection within 30 days of surgery with débridement by the treating surgeon or with antibiotics by either the treating surgeon or an infectious disease specialist or (2) treatment of a suspected or confirmed deep infection by return to the operating room for débridement, component exchange, or explantation of components or treatment with therapeutic or long-term suppressive antibiotics by an infectious disease specialist. Positive cultures on return to the operating room were not a requirement for diagnosis of SSI. Tissue cultures have a relatively low positivity in this setting, as Piper et al reported a positive tissue culture rate of 54.5% in the setting of definite periprosthetic shoulder infection.[36]

Statistical analysis

All statistical analyses were performed using a standard software package (Stata 13.1; StataCorp LP, College Station, TX, USA). Descriptive statistics were first generated for the entire sample. The crude (unadjusted) associations between risk of SSI and surgical procedure, surgical indication, demographics, medical comorbidities, and perioperative transfusion were assessed with a series of univariate logistic regression models. Four multivariate models were then created to assess the independent association between preoperatively identifiable variables and SSI risk: (1) all patients; (2) patients without a history of prior infection (septic arthritis, osteomyelitis,