



# Factors associated with in-hospital pulmonary embolism after shoulder arthroplasty

Bradley L. Young, BS, Mariano E. Menendez, MD, Dustin K. Baker, BS,  
Brent A. Ponce, MD\*

*Division of Orthopaedic Surgery, University of Alabama at Birmingham, Birmingham, AL, USA*

**Background:** Despite that pulmonary embolism (PE) is a feared complication after shoulder arthroplasty, little is known about its perioperative associated factors.

**Materials and methods:** We used the Nationwide Inpatient Sample to gather a sample of 422,372 patients who underwent shoulder arthroplasty between 2002 and 2011. This population was divided into 2 cohorts on the basis of those who experienced perioperative PE (0.25%) and those who did not. Demographics were compiled for both cohorts. Multivariable logistic regression analysis was used to account for confounding variables and to determine significant predictors of perioperative PE.

**Results:** After adjusting for patient demographic and clinical variables in multivariable regression modeling, the top 4 independent predictors for PE were primary diagnosis of proximal humerus fracture, deficiency anemia, congestive heart failure, and chronic lung disease. Other pertinent risk factors included increasing age, obesity, fluid and electrolyte abnormalities, undergoing total shoulder arthroplasty rather than hemiarthroplasty, and subsequent days of postoperative care.

**Conclusions:** Knowledge of these factors might help in preoperative counseling and prove useful for implementation of quality improvement strategies to reduce the occurrence of PE. Surgeons may consider initiating thromboprophylaxis in patients with any of the aforementioned comorbidities.

**Level of evidence:** Level III, Database Analysis Case Control Design, Epidemiology Study.

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**Keywords:** Nationwide Inpatient Sample; shoulder arthroplasty; pulmonary embolism; perioperative complications

The demand for shoulder arthroplasty has experienced substantial growth during the past decade, even more so than hip and knee replacements.<sup>12</sup> Despite its increasing popularity and demonstrated cost-effectiveness, shoulder

arthroplasty is not free of risk, especially given the increasing age and comorbidity burden of surgical candidates. In particular, pulmonary embolism (PE) constitutes a severe medical complication after shoulder arthroplasty.

The Centers for Disease Control and Prevention estimate that nearly 280,000 people are hospitalized for PE each year, and 12% die within 1 month of diagnosis.<sup>3,34</sup> PE has been deemed the most preventable cause of hospitalization. In 2008, the Centers for Medicare and Medicaid Services included PE in their list of “never events,” for which related costs of treatment were no longer reimbursed.

Institutional Review Board approval was not required for this study as the Nationwide Inpatient Sample contains only de-identified information and is publicly available.

\*Reprint requests: Brent A. Ponce, MD, Division of Orthopaedic Surgery, University of Alabama at Birmingham, 1313 13th Street South, Suite 203, Birmingham, AL 35205, USA.

E-mail address: [bpnce@uabmc.edu](mailto:bpnce@uabmc.edu) (B.A. Ponce).

Pulmonary emboli put enormous financial strain on the United States health care system and economy. A recent analysis approximates that the total annual health care cost for a single PE is close to \$17,000, which is dwarfed by concomitant disability claims and productivity loss experienced by employers.<sup>20</sup>

PE has been recognized as a major complication in almost all types of surgery, including orthopedics.<sup>16,25,32</sup> Perioperative PE is associated with significant morbidity and mortality in arthroplasty patients. The majority of PE focus in the orthopedic literature concerns hip or knee arthroplasty as PE rates in lower extremity arthroplasties may be as high as 0.4% to 0.8% for unilateral knee and 1.5% for hip.<sup>5,17,36</sup> In addition to shoulder arthroplasty's being a less common procedure than lower extremity arthroplasty, the rates of PE are lower, ranging from 0.2% to 0.54%.<sup>18</sup> Together, these may account for less literature concerning PE associated with shoulder arthroplasty. To our knowledge, no study has investigated risk factors for PE using a large, nationally representative sample. In light of the increasing frequency of elective shoulder arthroplasty and the detrimental outcomes and financial consequences associated with PE in shoulder arthroplasty, it may be beneficial to establish predictors of perioperative PE to better allocate resources and to ensure that patients and physicians can make more informed decisions.

This purpose of this study was to use nationally representative data to identify perioperative factors associated with the development of in-hospital PE after shoulder arthroplasty.

## Materials and methods

### The Nationwide Inpatient Sample

The Nationwide Inpatient Sample (NIS), sponsored by the Agency for Healthcare Research and Quality, is an annual survey of hospital discharges conducted by the Healthcare Cost and Utilization Project. Currently, this database is the largest publicly available, all-payer, inpatient discharge database in the United States.<sup>14</sup> The first NIS was available in 1988, and hospital participation in the program has increased each year. The annual sample is a 20% stratification from all participating community hospitals, which excludes federal, military, and psychiatric institutions. Each year, discharge weight files are available to allow valid national estimates. In 2011, the sample drawn from >8 million hospital stays in 1000 nonfederal hospitals represented 97% of the U.S. population after weighting.<sup>9</sup>

The large sample population provided by the NIS allows researchers to analyze trends in such health care aspects as costs, quality, and outcomes.<sup>9</sup> Moreover, its emphasis on demographic, clinical, and resource data bestows on the NIS the unique ability to draw correlations and conclusions using rare conditions and special populations of patients. It includes information on up to 25 diagnoses and 15 procedures for each hospital stay. This information is recorded with the *International Classification of*

*Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) codes. A number of recent studies have used this database to address the effect that patient and hospital characteristics can have on inpatient outcomes in myriad medical conditions.<sup>13,27,31</sup>

### Patient selection and analysis

Our study population consisted of adults ( $\geq 18$  years old) undergoing shoulder arthroplasty between January 1, 2002, and December 31, 2011. Discharges with a procedure code (ICD-9-CM) for total (81.80, 81.88) or partial (81.81) shoulder arthroplasty were identified and included in the analysis. We then categorized this population into 1 of 2 cohorts: (1) patients without a diagnosis of postoperative PE (ICD-9-CM 415.1) and (2) patients who had a diagnosis code for PE listed during their hospital stay. We then analyzed the extent to which the following variables could predict in-hospital PE after shoulder arthroplasty: (1) primary diagnosis, (2) age, (3) gender, (4) race, (5) and select medical comorbidities.

### Statistical analysis

Because of the large weighted sample size, normal distribution of the data was assumed. Pearson  $\chi^2$  test was employed for analysis of categorical data and independent samples *t* test for continuous data. Multivariable logistic regression modeling was used to determine factors independently associated with the development of in-hospital PE. All predictor variables were included simultaneously in the regression model. We used the area under the receiver operating characteristic curve to evaluate the discriminatory ability of our model. Statistical significance was set at  $P < .05$ . SPSS version 22.0 (IBM SPSS, Chicago, IL, USA) was used for all statistical analyses and data modeling.

## Results

During the 10-year study period, an estimated total of 422,372 patients underwent shoulder arthroplasty. Of these patients, 59.3% underwent total shoulder arthroplasty (TSA) and 40.7% underwent hemiarthroplasty (HA). The frequency of in-hospital PE was 0.25%, or 2.5 events per 1000 shoulder arthroplasties (Table I).

Patients with an in-hospital diagnosis of PE were more likely to be older ( $72 \pm 11$  years vs.  $69 \pm 11$  years;  $P < .001$ ), black (3.6% vs. 3.1%;  $P = .038$ ) or Hispanic (4.2% vs. 2.9%;  $P = .038$ ), female (67.5% vs. 60.3%;  $P < .001$ ), and insured under Medicare (73.8% vs. 66.3%;  $P < .001$ ) or Medicaid (3.8% vs. 2.6%;  $P < .001$ ). In addition, perioperative PE was more frequent in medium- (27.8% vs. 23.7%;  $P < .001$ ) and large-sized (62.8% vs. 61.2%;  $P < .001$ ) hospitals based on bed size standards set by the Healthcare Cost and Utilization Project and in teaching institutions (48.9% vs. 45.6%;  $P = .030$ ).

We then analyzed these 2 cohorts for the presence of medical comorbidities (Table II). Patients in the PE cohort presented with a significantly higher incidence of

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