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ORIGINAL PAPER

The influence of gender on early adverse events, hospital charges and length of stay after shoulder arthroplasty

Bryan M. Saltzman[1] · **Bryce Basques**[1] · **Timothy Leroux**[1] · **Rachel M. Frank**[1] · **Gregory P. Nicholson**[1] · **Nikhil N. Verma**[1] · **Anthony A. Romeo**[1]

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Abstract
Purpose To identify differences in demographics, diagnosis, arthroplasty type, early adverse events, length of stay, and hospital costs between men and women undergoing shoulder arthroplasty.
Methods We used a nationally representative U.S. population database to determine annual rates of shoulder arthroplasty (SA) in patients (2002–2011). Early adverse events, length-of-stay and hospitalization costs were determined, and compared between patient genders.
Results A cohort of 372,753 patients underwent total-SA (TSA) (59.7% females). Females were significantly older, more often had Medicare insurance, had a higher proportion of fracture diagnosis, more often underwent hemiarthroplasty (HA), and had significantly lower odds of any adverse event, MI, and sepsis, but higher odds of peripheral nerve injury. Females had significantly greater hospital lengths of stay for all combined procedures, and isolated TSA, reverse-TSA, and HA. Hospital costs were significantly lower in females for all combined procedures and HA.
Conclusions Male patients had significantly higher odds of adverse events, death, MI, and sepsis following SA. Female patients had significantly longer lengths of stay but lower hospital charges following SA.

Keywords Gender · Shoulder arthroplasty · Population study · Utilization · Trends · Adverse events

Level of evidence: III

✉ Bryan M. Saltzman
bryan.m.saltzman@gmail.com

[1] Department of Orthopedic Surgery, Rush University Medical Center, 1611 W Harrison St Suite 300, Chicago, IL 60612, USA

Introduction

Shoulder arthroplasty (SA) volume has dramatically increased in the United States over the last two decades as its efficacy in the management of various glenohumeral joint pathologies has become well documented [1–4]. Specifically, from 2000 to 2008, the number of anatomic TSA and hemiarthroplasty (HA) procedures nearly tripled, with the volume of surgeries increasing from approximately 14,000 to 47,000 [3]. In New York state alone, for example, over the 20-year period from 1991 to 2010, there was a 393% increase in the utilization of anatomic total SA (TSA) and reverse TSA (RTSA) and a 98% increase in HA use in the second decade (2001–2010), likely due to the expanding indications for these procedures [2]. In addition, more recent data have demonstrated a rise in the number of RTSA procedures performed in the United States, and in 2011, RTSA accounted for one-third (33%) of all shoulder arthroplasty procedures; anatomic TSA (44%) and HA (23%) providing the remaining proportion of arthroplasties during that year [5].

In the setting of an increasingly outcomes-driven and cost-conscious health care system, research has focused on identifying pre-operative risk factors that correlate with specific outcomes after orthopaedic procedures, including shoulder arthroplasty. For example, pre-operative medical comorbidities, post-traumatic or rheumatoid arthritis, morbid obesity, American Society of Anesthesiologists (ASA) score, advanced age, and longer operative time have been recognized as significant risk factors for complications, length of hospital stay, and overall hospital costs after anatomic TSA [6–8]. Further, the risk of early revision after shoulder arthroplasty is increased in patients younger than 65 years, in patients who smoke, and in patients classified as obese and morbidly obese [9].

The influence of gender on outcomes following joint arthroplasty has been a topic of discussion in recent years. Following lower extremity arthroplasty, gender has been shown to influence hospital costs, morbidity and mortality [10–13]. To date, it remains unknown how patient gender influences outcomes following shoulder arthroplasty, and it is unclear if there are demographic differences between males and females undergoing shoulder arthroplasty. This study aims to use a nationally representative population database in the United States to identify differences in demographics, diagnosis, arthroplasty type, early adverse events, length of stay, and hospital costs between men and women undergoing shoulder arthroplasty. Secondarily, this study aims to stratify the cohort by implant type in order to determine if there are implant-specific differences in early adverse events, length of stay, and hospital costs between males and females undergoing shoulder arthroplasty. The authors hypothesized that there would be no significant differences in diagnosis, arthroplasty type, complications, costs, length of stay, or adverse events between males and females undergoing shoulder arthroplasty.

Materials and methods

We conducted a retrospective cohort study using the Healthcare Cost and Utilization Project (HCUP) Nationwide Inpatient Sample (NIS) from 2002 to 2011 [14]. The NIS comprises a 20% stratified sample of all hospital discharges in the United States, representing the largest all-payer hospital inpatient database in the country. The NIS includes information about patient characteristics (e.g. age, gender, insurance status, and medical comorbidities), hospital characteristics (e.g. location and size), and hospitalization outcomes (e.g. morbidity, mortality, costs, and length of stay). The NIS allows identification of hospitalizations according to procedures and diagnoses using International Classification of Diseases Ninth Revision, Clinical Modification (*ICD-9-CM*) codes.

Hospitalizations were selected for the study based on *ICD-9-CM* procedural codes for anatomic TSA (81.80), RTSA (81.88), and shoulder HA (81.81).

Pre-operative patient data withdrawn from the NIS included age, gender, insurance status, and 29 medical comorbidities. An Elixhauser Comorbidity Index (ECI) was generated for each patient based on the presence or absence of these 29 comorbid conditions. The ECI was chosen because of its validated capacity to accurately predict mortality as well as to represent patient burden of comorbidities in administrative database studies [15–17].

Peri-operative complications were also chosen based on *ICD-9-CM* diagnosis codes. The following acute complications were investigated: death, acute kidney injury, cardiac arrest, thromboembolic event, myocardial infarction, peripheral nerve injury, pneumonia, sepsis, stroke, surgical site infection, and wound dehiscence. "Any adverse event" was defined as the occurrence of one or more of the above adverse events in a patient.

In addition, length of stay and total hospital charges were available for each patient. Length of stay represents the number of calendar days a patient stayed in the hospital. All hospital charges were converted to costs using the HCUP Cost-to-charge Ratio files. Costs were adjusted for inflation using the U.S. Bureau of Labor statistics yearly inflation calculator to represent costs in the year 2011, which was the most recent year used in the present study.

Statistical analysis

Statistical analyses were conducted using Stata® version 13.1 (StataCorp, College Station, TX, USA). All analyses took into account the complex survey design of the NIS. Discharge weights, strata and cluster variables were included to correctly estimate variance and to produce national estimates from the stratified sample. Pearson's chi-squared test was used to compare age, ECI, procedure type, diagnosis, and insurance status between male and female patients.

Multivariate logistic regressions were subsequently used to compare the rates of adverse events between males and females that received any procedure, anatomic TSA, RTSA, and HA. Male gender was used as the reference. Multivariate regression adjusted for baseline differences in age, ECI, diagnosis, and insurance status. All tests were two-tailed, and the statistical difference was established at a two-sided α level of 0.05 ($p < 0.05$).

Results

Demographics

Table 1 demonstrates the overall and gender-specific demographics of the resultant patients extracted from the NIS database. In total, there were 372,753 patients who underwent HA, anatomic TSA or RTSA during the period of interest, including 150,222 (40.3%) men and 224,531 (59.7%) women. Female patients were significantly older than males (70.8 years vs 66.0 years, $p < 0.001$). The most common insurance type across both males and females was Medicare insurance; however, a significantly higher proportion of females presented with Medicare insurance (73.5% vs 55.9%, $p < 0.001$), and a significantly higher proportion of males presented with private insurance (34.7% vs 20.6%, $p < 0.001$). The most common diagnosis for both males and females was glenohumeral osteoarthritis (OA), but a significantly higher proportion of females underwent shoulder arthroplasty for a diagnosis of fracture (21.4% vs 9.3%, $p < 0.001$). Lastly, the most common shoulder arthroplasty for both men and women was an

Table 1 Demographics of patient population by gender

		All patients	Male	Female	p^a
Overall		372,753	150,222	224,531	
Age					*<0.001*
	18–59	19.3%	26.7%	14.3%	
	60–69	28.7%	32.3%	26.4%	
	70–79	34.7%	30.3%	37.6%	
	80+	17.3%	10.7%	21.7%	
Diagnosis					*<0.001*
Cuff		6.7%	6.1%	7.0%	
OA		65.0%	73.6%	59.2%	
Other		9.9%	10.2%	9.7%	
Rheumatoid arthritis		1.9%	0.8%	2.6%	
Fracture		16.6%	9.3%	21.4%	
Procedure					*<0.001*
Hemiarthroplasty		38.7%	33.5%	42.2%	
Reverse TSA		7.1%	6.4%	7.6%	
Anatomic TSA		54.2%	60.1%	50.2%	
Mean Elixhauser comorbidity index		0.99 + 3.83	0.98 + 3.62	1.01 + 3.96	0.882
Insurance status					*<0.001*
Medicare		66.4%	55.9%	73.5%	
Medicaid		2.6%	2.6%	2.5%	
Private		26.3%	34.7%	20.6%	
Self-pay		0.7%	0.8%	0.6%	
Other		4.0%	6.0%	2.7%	

[a] Values in *italics* show statistical significance ($p < 0.05$)

anatomic TSA, but a significantly higher proportion of women underwent HA (42.2% vs 33.5%, $p < 0.001$) and a significantly higher proportion of men underwent anatomic TSA (60.1% vs 50.2%, $p < 0.001$) (Fig. 1). The mean Elixhauser comorbidity index for the entire cohort was 0.99, and there was no significant difference between male and female patients ($p = 0.882$).

Early adverse events

As illustrated in Table 2, the overall incidence of major adverse events was low across the entire cohort (3.0%). When combining all three shoulder arthroplasty procedures, female patients had a significantly lower odds of any adverse event (odds ratio [OR], 0.9; $p = 0.014$), death (OR, 0.5; $p = 0.002$), myocardial infarction (MI) (OR, 0.7; $p = 0.017$), and sepsis (OR, 0.6; $p = 0.012$), but had higher odds of peripheral nerve injury (OR, 1.6; $p = 0.033$) compared with male patients. Table 2 reports the odds of an adverse event in female patients compared with male patients stratified by three shoulder arthroplasty procedures (anatomic TSA, RTSA, and HA). Women with anatomic TSA had significantly lower odds for death, acute kidney injury (AKI), and MI; women with RTSA had significantly lower odds for any adverse events and AKI; women with HA had significantly lower odds for any adverse events, death, MI, sepsis and stroke.

Hospital length of stay and costs

Female patients had a significantly greater hospital length of stay for all combined procedures, and anatomic TSA, RTSA, and HA in isolation. However, hospital costs were significantly lower in females for all combined procedures and HA (Table 3; Fig. 2).

Discussion

In the present analysis, females had significantly lower likelihoods for early overall post-operative adverse events, death, MI, and sepsis across the entire cohort and at times when stratified by implant type. Interestingly, this trend was observed despite there being no difference in overall comorbidity between males and females, and females being significantly older. In evaluating adverse events with HA in particular, where it may be hypothesized that many of the older male and female patients with a diagnosis of fracture would fall into this treatment option, again the

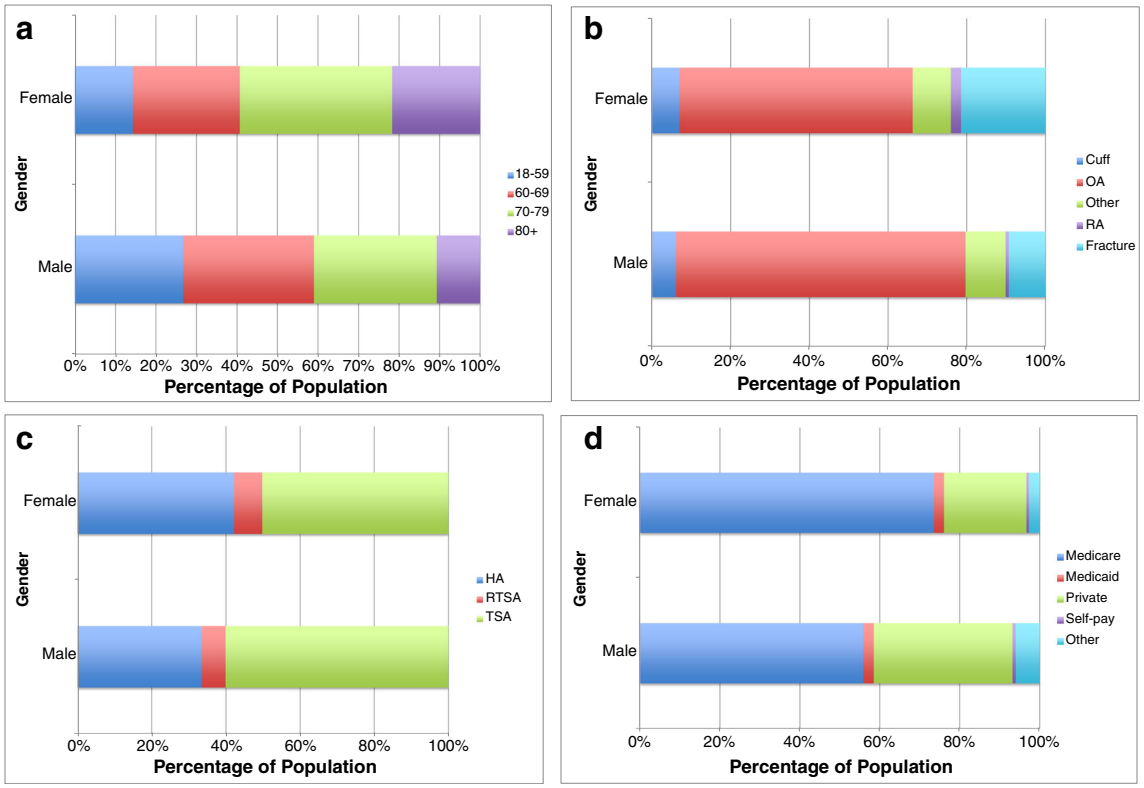

Fig. 1 Demographics of patient population by gender, including breakdown by **a** age, **b** diagnosis, **c** procedure, and **d** insurance status. *OA* osteoarthritis, *RA* rheumatoid arthritis, *HA* hemiarthroplasty, *RTSA* reverse total shoulder arthroplasty, *TSA* total shoulder arthroplasty

differences in odds for major complications including death, MI, sepsis and stroke are striking despite the similar comorbidity index. Although the data garnered from our study do not allow us to delineate the reason for this finding, it mirrors observations made following lower extremity arthroplasty [18, 19]. It is clear that future research efforts should focus on determining the reasons for this observed difference in risk, with the ultimate goal to mitigate this difference and prevent significant complications following shoulder arthroplasty.

Within the current NIS cohort, females (who made up the majority of the identified cohort) who undergo shoulder arthroplasty were older than their male counterparts undergoing the same procedure, which is in line with our finding that the female patients in this cohort were more likely to identify with Medicare insurance than males. Such differences in

Table 2 Multivariate comparison of adverse events for HA, TSA and RTSA by female gender (male gender used as reference)

	All procedures			TSA			RTSA			HA		
	Percent	Odds ratio	p^a	Percent	Odds ratio	p^a	Percent	Odds ratio	p^a	Percent	Odds ratio	p^a
Any adverse event	3.0%	*0.9*	*0.014*	1.8%	0.9	0.212	3.6%	0.8	0.117	4.3%	*0.9*	*0.017*
Death	0.2%	0.5	*0.002*	0.1%	0.4	*0.015*	0.2%	3.0	0.174	0.3%	0.5	*0.005*
Acute kidney injury	1.4%	0.5	0.056	0.9%	0.8	*0.015*	2.3%	0.6	*0.015*	1.8%	0.8	0.065
Thromboembolic event	0.1%	1.1	0.921	0.1%	1.0	0.999	0.1%	1.5	0.646	0.1%	0.4	0.217
Myocardial infarction	0.3%	0.7	*0.017*	0.2%	0.6	*0.024*	0.3%	2.7	0.123	0.4%	0.6	*0.006*
Peripheral nerve injury	0.2%	1.6	*0.033*	0.1%	1.1	0.753	0.1%	1.5	0.623	0.3%	2.0	*0.013*
Pneumonia	0.8%	1.0	0.734	0.5%	1.0	0.872	0.9%	0.8	0.558	1.2%	0.9	0.340
Sepsis	0.2%	0.6	*0.012*	0.1%	0.4	0.063	0.2%	2.3	0.304	0.3%	0.6	*0.022*
Stroke	0.1%	0.7	0.095	0.1%	1.2	0.713	0.1%	1.2	0.804	0.2%	0.5	*0.006*
Surgical site infection	0.1%	0.7	0.088	0.1%	1.0	0.960	0.2%	0.4	0.128	0.2%	0.6	0.118

TSA total shoulder arthroplasty, *RTSA* reverse total shoulder arthroplasty, *HA* hemiarthroplasty

[a] Values in *italics* show statistical significance ($p < 0.05$)

Table 3 Multivariate comparison of length of stay and hospital charges for HA, TSA and RTSA by female gender (male gender used as reference)

	All procedures			TSA			RTSA			HA		
	Mean + SD	Beta	p^a	Mean + SD	Beta	p^a	Mean + SD	Beta	p^a	Mean + SD	Beta	p^a
Length of stay (days)	2.8 + 2.9	+0.3	*<0.001*	2.3 + 1.8	+0.3	*<0.001*	2.7 + 2.4	+0.3	*<0.001*	3.5 + 3.9	+0.1	*0.007*
Hospital costs (US$)[b]	15,363 + 9963	−239	*0.014*	15,656 + 7916	+101	0.269	22,390 + 11,374	+185	0.565	14,072 + 11,602	**−643**	**<0.001**

SD standard deviation, *TSA* total shoulder arthroplasty, *RTSA* reverse total shoulder arthroplasty, *HA* hemiarthroplasty

[a] Values in *italics* show statistical significance ($p < 0.05$)

[b] Reported in 2011 dollars, adjusted for inflation

gender distribution by age have not been similarly reported in previous literature on anatomic TSA [20]; however, it is not surprising given our concurrent observation that females were more likely to undergo shoulder arthroplasty for fracture—an injury that is commonly seen in elderly patients with poorer bone quality [21, 22]. To further this, we also observed that females more commonly underwent HA, which again reflects the aetiology that is being treated. It is important to bear in mind that the utilization of the RTSA for fracture is increasing dramatically [23], and future evaluation of the NIS database may demonstrate this paradigm shift in preferred surgical treatment.

Length of stay following shoulder arthroplasty was significantly longer among female patients, a finding that has been previously reported not only for anatomic TSA [24] but also THA [10, 12], and TKA [11]. Given that the multivariate analysis controlled for differences in age between male and female patients, we suspect that some of the observed difference in length of stay reflects a difference in factors not accounted for in our analysis, such as the frailty of the patient, additional complications not considered, and the independence of the patient, which ultimately would influence the disposition of the patient (home versus nursing home or other). Despite all of this, the absolute difference in length of stay between males and females was only 0.3 days, and the clinical and economical implications of this difference may not be significant. Our identified cohort size may be inclusive and large enough to account for the higher rate of complications in men following TSA, and ultimately narrow the difference in length of stay that has otherwise been reported to be greater than 0.3 days.

Our data suggest that females incur significantly less hospital charges after shoulder arthroplasty, specifically for HA. This is contrary to prior literature [25], which has suggested that gender was not associated with differences in hospital charges following shoulder arthroplasty. This is surprising given the greater length of hospital for females, which is a variable that would be expected to have an association with higher costs [25]; however, we have found that males have a significantly higher rate of in hospital adverse events which would ultimately require more costly diagnostic investigations and treatment, negating the cost difference that may arise from a difference in length of stay. Ultimately, we do acknowledge that the impact of an individual cost difference of US$239 may seem small compared to a mean individual hospital charge of US$15,000; however, when consideration is given the number of male patients who undergo shoulder arthroplasty on an annual basis, the difference becomes quite

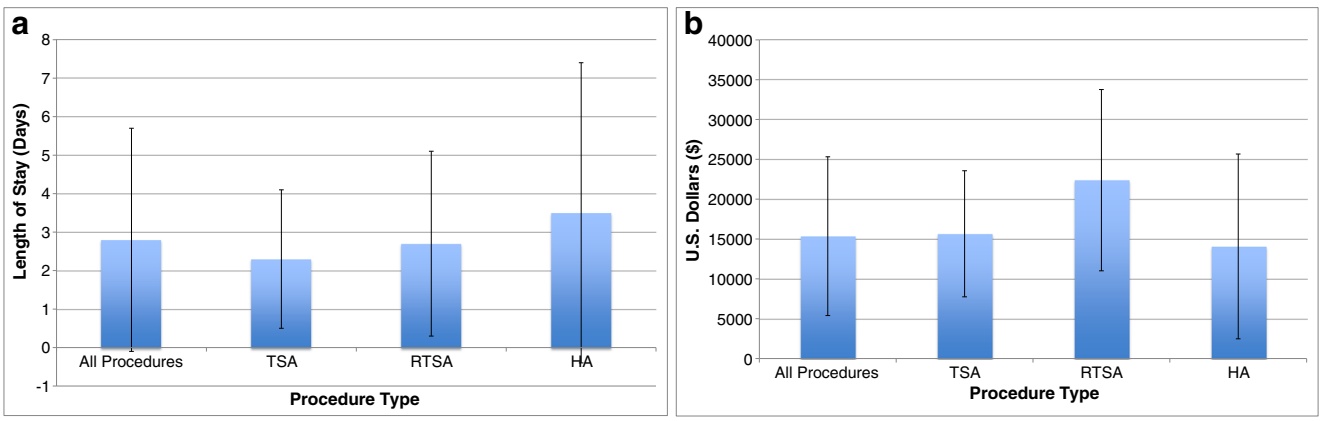

Fig. 2 Comparison of length of stay and hospital charges for hemiarthroplasty, total shoulder arthroplasty, and reverse total shoulder arthroplasty by female gender (male gender used as a reference. *HA* hemiarthroplasty, *RTSA* reverse total shoulder arthroplasty, *TSA* total shoulder arthroplasty

significant and worthy of initiatives to minimize this cost difference.

There are several limitations to this study. Foremost is that the data come from patients between the years of 2002 to 2011; both during and since that time period, there has continued to be a lot of change in the technical implantation, arthroplasty material and design which could affect the ability to draw conclusions from these data for our current patients. Similar to any study using an administrative database search such as the NIS database, the primary limitations are due to reliance on data from a national registry of patients acting merely as a representative sampling of the total patient population that underwent shoulder arthroplasty procedures. The results presented in this study may be affected by undercoding or miscoding within the NIS database. As suggested by Waterman et al. [8], several relevant surgeon- and patient-specific variables are not presented in the NIS data including surgeon experience, hospital volume, and disease severity. Additionally, either the relatively short hospital length of stay after surgery in these patients or that the NIS follows patients only to the 30th postoperative day may contribute to missed identification of complications that can take more than a few days to emerge (i.e. thromboembolic events, pneumonia, or wound dehiscence). Finally, the authors are using only a small period of time to generate a representative cohort and extrapolate this data to propose generalized trends in shoulder arthroplasty surgery.

Overall, findings from the NIS database suggest that disparities do exist between male and female patients undergoing shoulder arthroplasty, most notably male patients had a significantly higher odds of having an overall adverse event, death, MI, and sepsis following shoulder arthroplasty. On the other hand, female patients had a significantly longer length of stay but lower hospital charges following shoulder arthroplasty. Ultimately, the main findings of this study are significant and will not only enable clinicians to appropriately council their male and female patients regarding the early risks of shoulder arthroplasty, but also drive further research to minimize complications among male patients.

Compliance with ethical standards

Conflict of interest No author, their immediate families, or any research foundation with which they are affiliated received any financial payments or other benefits from any commercial entity related to the subject of this article. Thus, on behalf of all authors, the corresponding author states that there is no relevant conflict of interest with this study.

Conflicts of interest that are not directly related to this manuscript preparation are as follows:

Authors Bryce Basques, Rachel M Frank, and Timothy Leroux declare that they have no conflict of interest.

Author Bryan M Saltzman declares the following:

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Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. As this study utilized a publically available National database, it did not require formal review and approval from our institutional review board. This article does not contain any studies directly with human participants performed by any of the authors directly.

Informed consent For this type of study, formal informed consent is not required.

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