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Five-Year Mortality Rates Following Elective Shoulder Arthroplasty and Shoulder Arthroplasty for Fracture in Patients Over Age 65

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Background: To effectively counsel patients prior to shoulder arthroplasty, surgeons should understand the overall life trajectory and life expectancy of patients in the context of the patient's shoulder pathology and medical comorbidities. Such an understanding can influence both operative and nonoperative decision-making and implant choices. This study evaluated 5-year mortality following shoulder arthroplasty in patients ≥65 years old and identified associated risk factors.

Methods: We utilized Centers for Medicare & Medicaid Services Fee-for-Service inpatient and outpatient claims data to investigate the 5-year mortality rate following shoulder arthroplasty procedures performed from 2014 to 2016. The impact of patient demographics, including fracture diagnosis, year fixed effects, and state fixed effects; patient comorbidities; and hospital-level characteristics on 5-year mortality rates were assessed with use of a Cox proportional hazards regression model. A p value of <0.05 was considered significant.

Results: A total of 108,667 shoulder arthroplasty cases (96,104 nonfracture and 12,563 fracture) were examined. The cohort was 62.7% female and 5.8% non-White and had a mean age at surgery of 74.3 years. The mean 5-year mortality rate was 16.6% across all shoulder arthroplasty cases, 14.9% for nonfracture cases, and 29.9% for fracture cases. The trend toward higher mortality in the fracture group compared with the nonfracture group was sustained throughout the 5-year postoperative period, with a fracture diagnosis being associated with a hazard ratio of 1.63 for mortality (p < 0.001). Medical comorbidities were associated with an increased risk of mortality, with liver disease bearing the highest hazard ratio (3.07; p < 0.001), followed by chronic kidney disease (2.59; p < 0.001), chronic obstructive pulmonary disease (1.92; p < 0.001), and congestive heart failure (1.90; p < 0.001).

Conclusions: The mean 5-year mortality following shoulder arthroplasty was 16.6%. Patients with a fracture diagnosis had a significantly higher 5-year mortality risk (29.9%) than those with a nonfracture diagnosis (14.9%). Medical comorbidities had the greatest impact on mortality risk, with chronic liver and kidney disease being the most noteworthy. This novel longer-term data can help with patient education and risk stratification prior to undergoing shoulder replacement.

Level of Evidence: Therapeutic <u>Level III</u>. See Instructions for Authors for a complete description of levels of evidence.

The utilization of total shoulder arthroplasty (TSA) has substantially increased in recent years[1], with recent estimates suggesting a growth rate of approximately 5% to 9% per year[2]. This trend will likely continue, given increasing life expectancies and the exponentially increasing incidence rates of shoulder arthroplasty[1,3].

Previous studies have reported complication rates following shoulder arthroplasty[4,5]; however, information is limited regarding long-term survival and patient outcomes[6,7]. Furthermore, the long-term value to the patient following shoulder arthroplasty is poorly defined. The first steps in understanding long-term value are simply to define patient survivorship following a shoulder replacement and to identify the risk factors associated with mortality. Understanding the differences in outcomes and survival rates between patients undergoing elective arthroplasty for degenerative indications and those undergoing arthroplasty for fracture has implications for resource allocation and is valuable information for orthopaedic surgeons and patients[8-10].

Osteoporotic fractures present a substantial social and economic burden[11]. Proximal humeral fractures, which are common fragility fractures, account for 4% to 10% of adult fracture cases[12]. Prior studies have established 1-year mortality rates of 7.83% to 13.05% following a proximal humeral fracture[13,14], but longer-term mortality risk following operative treatment has not been reported. Understanding the population of patients who are living after having undergone a shoulder arthroplasty for fracture has several health policy and planning implications[1,15]. As patients live longer, the incidence of osteoporotic fractures will continue to increase[11], and it will be important to better define longer-term outcomes for use in patient and family education.

Prior studies have evaluated in-hospital, 30-day, 90-day, and 1-year mortality following shoulder replacement[7,10,16-18], but no prior work, to our knowledge, has quantified mid- and long-term mortality. The purposes of the present study were to evaluate 5-year patient mortality following shoulder arthroplasty in patients ≥65 years old and to stratify this population into fracture and nonfracture groups. To provide some context for these mortality rates, we compared the population of patients who underwent shoulder arthroplasty with the average Medicare beneficiary. We also compared the shoulder arthroplasty population with a total hip arthroplasty (THA) population, as THA is another orthopaedic procedure that is performed for both elective indications and fragility fracture diagnoses. Furthermore, we identified factors associated with an increased risk of mortality in the first 5 years after shoulder arthroplasty.

Materials and Methods
Data Source
We utilized 100% Centers for Medicare & Medicaid Services (CMS) Fee-for-Service (FFS) inpatient and outpatient claims data regarding shoulder arthroplasty procedures performed from 2014 through the third quarter (Q3) of 2016. We studied the 5-year mortality rate in this population with use of 100% CMS Medicare enrollment data from 2014 to Q3 of 2021, with 2021 Q3 data being the most recent data available at the time of our analysis.

We included primary shoulder arthroplasty cases that were coded as inpatient procedures using Diagnosis-Related Group (DRG) codes 483 and 484 and those that were coded as outpatient procedures using Current Procedural Terminology (CPT) code 23472. Outpatient TSAs made up a small fraction of total cases because CMS removed TSA from the inpatient-only list in 2021. The primary International Classification of Diseases, 9th and 10th Revision, Procedure Coding System (ICD-9/10-PCS) procedure code for each case was utilized to verify the use of shoulder arthroplasty. We further divided the TSAs into fracture and nonfracture cases on the basis of the primary International Classification of Diseases, 9th and 10th Revision, Clinical Modification (ICD-9/10-CM) diagnosis code for each case. Because anatomic shoulder arthroplasty and reverse shoulder arthroplasty utilize the same CPT code, we could not develop a consistent methodology to reliably distinguish by arthroplasty type.

Medicare enrollees include people with disabilities and people with end-stage renal disease in addition to seniors. We therefore excluded Medicare patients <65 years old in order to evaluate the impact of age on mortality rates without introducing bias from the skewed distribution of comorbidities among patients <65 years old in the database. For each case, we captured the comorbidity status of the patient at the time of the procedure with use of the complete list of ICD-9/10-CM codes billed with the arthroplasty claim.

To better understand mortality rates following shoulder arthroplasty, we utilized data from the aforementioned Medicare claims and enrollment database to calculate the 5-year mortality rate following THAs performed for fracture as well as that following elective THAs. THAs were identified through DRG 469 and 470, CPT 27130, and primary ICD-9/10-PCS codes, and fracture cases were identified through primary ICD-9/10-CM codes. Additionally, we evaluated mortality rates for all Medicare beneficiaries during the study period.

Statistical Analysis
A Cox proportional hazards regression model was utilized to evaluate the drivers of mortality in the shoulder arthroplasty cohort. The time to death after the index arthroplasty was the dependent variable. We controlled for case-level demographic and comorbidity characteristics and hospital-level characteristics as independent variables and quantified their impact on mortality. Specifically, case-level demographics comprised age, sex, White versus non-White race (as reported in the database), fracture versus nonfracture, year fixed effects, and state fixed effects; case-level comorbidities comprised a body mass index (BMI) of >40 kg/m^2, congestive heart failure (CHF), chronic obstructive pulmonary disease (COPD), cancer, diabetes, kidney disease, and liver disease; and hospital-level characteristics comprised teaching status, urban status, and bed size. We examined the proportional hazards assumption for indicators of fracture and mortality risk over time (Fig. 1). Significance was set at $p < 0.05$.

Results
The study included 108,667 shoulder arthroplasty cases, of which 96,104 were nonfracture cases and 12,563 were fracture cases. The mortality rate was 16.6% in the shoulder arthroplasty cohort overall, 29.9% in the fracture group, and 14.9% in the nonfracture group. Table I presents full demographic data for the study cohort.
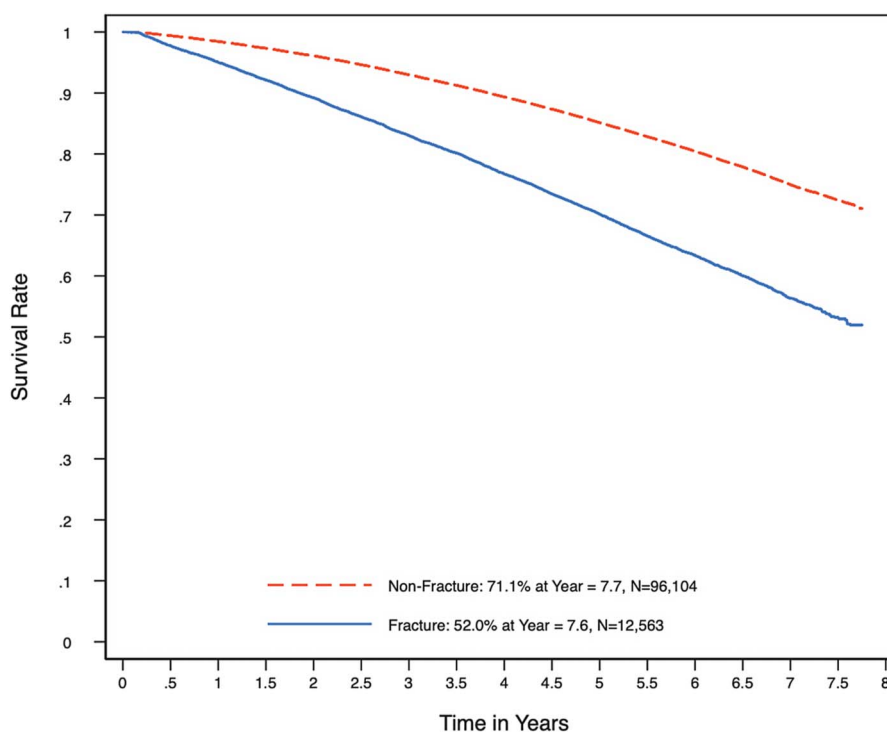
Fig. 1
Survival rates among patients who underwent shoulder arthroplasty for fracture versus nonfracture.

TABLE I Demographic and Comorbidity Profile of the Shoulder Arthroplasty Cohort*				
Variable	All TSAs	Nonfracture	Fracture	P Value
Case-level demographics				
Volume (no. [%])	108,667 (100)	96,104 (88)	12,563 (12)	NA
5-year mortality (%)	16.6	14.9	29.9	<0.001
Age at surgery, all† (yr)	74.3	74.0	76.6	<0.001
Age at death, if deceased† (yr)	81.0	80.5	82.7	<0.001
Female (%)	62.7	59.8	84.9	<0.001
Non-White (%)	5.8	5.9	4.5	<0.001
Case-level comorbidities (%)				
BMI > 40 kg/m^2	4.3	4.3	4.6	0.07
CHF	6.0	5.6	8.7	<0.001
COPD	10.8	10.6	12.4	<0.001
Cancer	1.4	1.2	2.3	<0.001
Diabetes	21.7	21.1	26.6	<0.001
Kidney disease	1.4	1.0	3.8	<0.001
Liver disease	0.4	0.4	0.7	<0.001
Hospital-level characteristics				
Annual surgical volume† (no.)	2,622	2,506	2,167	NA
Urban (%)	79.9	80.4	82.9	0.03
Bed size† (no.)	215.4	218.1	237.2	0.002
Teaching (%)	37.4	37.5	40.9	0.01

*NA = not applicable, BMI = body mass index, CHF = congestive heart failure, COPD = chronic obstructive pulmonary disease. †Values are given as the mean.

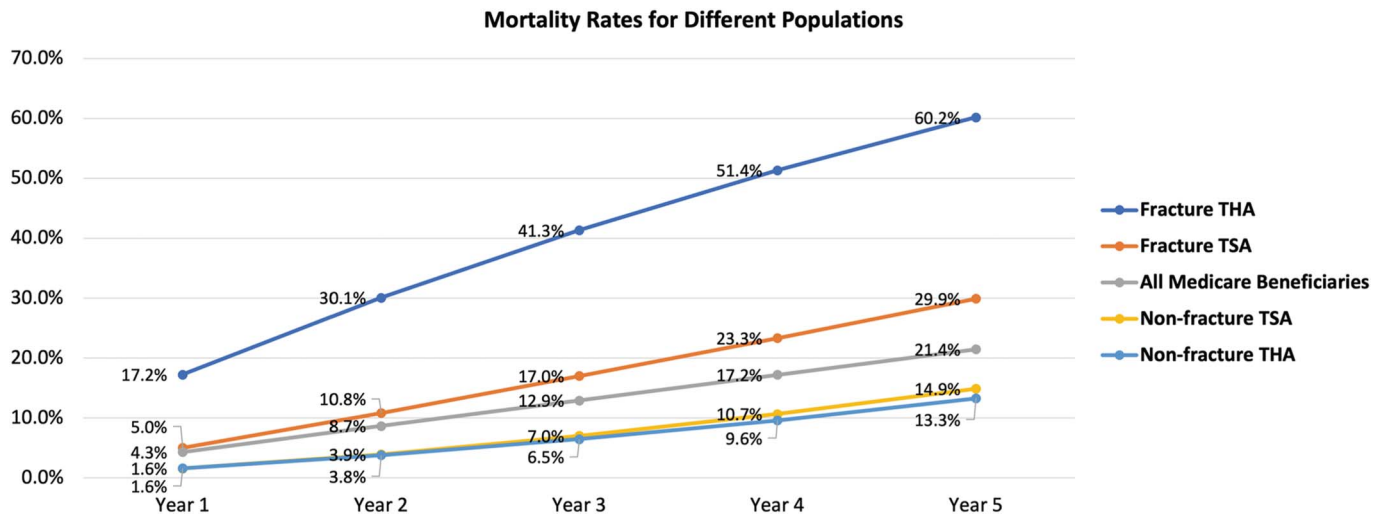**Mortality Rates for Different Populations**

Fig. 2

Five-year mortality rates, stratified by year, for each of the following populations: total shoulder arthroplasty (TSA) cases with a fracture diagnosis, TSA cases with a nonfracture diagnosis, total hip arthroplasty (THA) cases with a fracture diagnosis, THA cases with a nonfracture diagnosis, and all Medicare beneficiaries.

Patients with THA for fracture had the highest 5-year mortality rate at 60.2% (Fig. 2). Patients with shoulder arthroplasty for a fracture diagnosis had the second highest 5-year mortality rate at 29.9%. Patients with TSA and THA for a nonfracture diagnosis had the lowest 5-year mortality rates at 14.9% and 13.3%, respectively. The Medicare beneficiary mortality rate was 21.4%. Five-year mortality was more likely with increasing age; this trend was observed across all study populations (Fig. 3).

In the Cox proportional hazards regression model, fracture cases were associated with an increased risk of 5-year mortality, as indicated by a hazard ratio of 1.63 (95% confidence interval [CI], 1.58 to 1.69; p < 0.001). Older age and a diagnosis of CHF, COPD, cancer, diabetes mellitus, kidney disease, or liver disease at the time of the index arthroplasty were each associated with an increased risk of mortality (Table II). Among the aforementioned comorbidities, liver disease was associated with the most increased risk of 5-year mortality, with an odds ratio of 3.07 (95% CI, 2.68

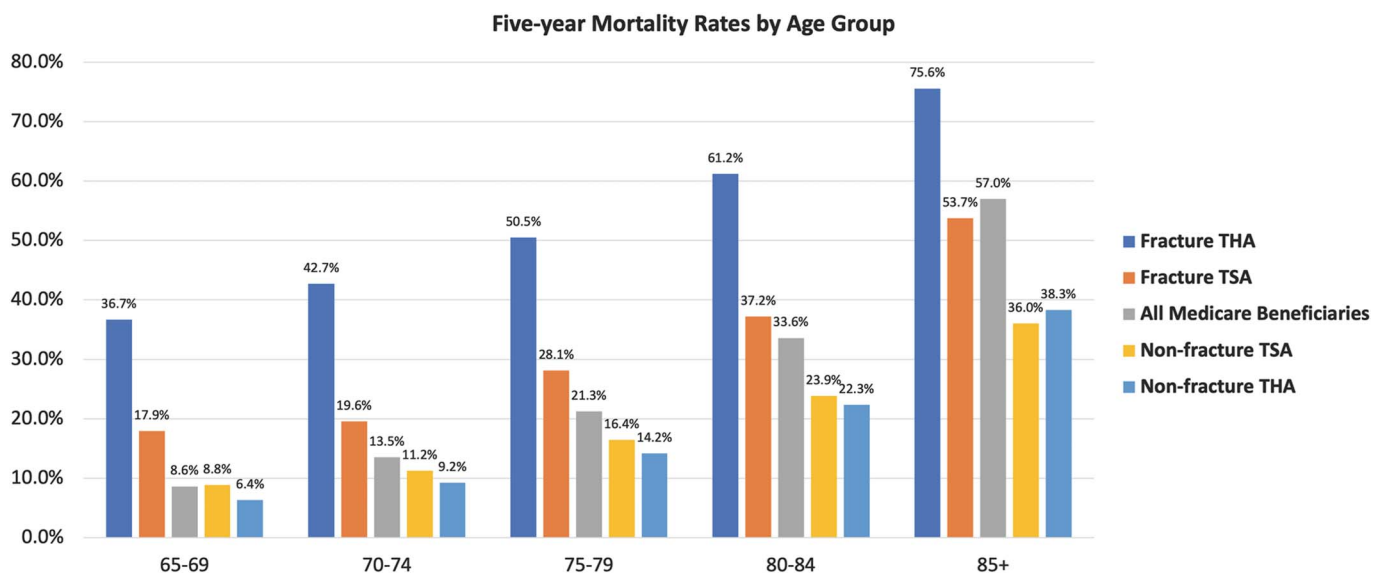**Five-year Mortality Rates by Age Group**

Fig. 3

Five-year mortality rates, stratified by age category, for each of the following populations: total shoulder arthroplasty (TSA) cases with a fracture diagnosis, TSA cases with a nonfracture diagnosis, total hip arthroplasty (THA) cases with a fracture diagnosis, THA cases with a nonfracture diagnosis, and all Medicare beneficiaries.

TABLE II Cox Proportional Hazards Regression Analysis of Factors Associated with Increased 5-Year Mortality Risk*			
Variable	Odds Ratio	95% CI	P Value
Age	1.09	1.08-1.09	<0.001
Female	0.78	0.76-0.80	<0.001
Non-White	0.94	0.88-0.99	0.03
Fracture	1.63	1.58-1.69	<0.001
BMI > 40 kg/m^2	1.13	1.06-1.21	<0.001
CHF	1.90	1.82-1.99	<0.001
COPD	1.92	1.85-1.99	<0.001
Cancer	1.84	1.69-2.01	<0.001
Diabetes	1.35	1.31-1.39	<0.001
Kidney disease	2.59	2.40-2.79	<0.001
Liver disease	3.07	2.68-3.52	<0.001
Urban hospital	0.94	0.89-0.99	0.01
Hospital bed size	1.00	1.00-1.00	0.24
Teaching hospital	1.00	0.97-1.04	0.90

*CI = confidence interval, BMI = body mass index, CHF = congestive heart failure, COPD = chronic obstructive pulmonary disease. In addition to the listed variables, this analysis controlled for year fixed effects and state fixed effects. A p value of <0.05 was significant.

to 3.52; p < 0.001), followed by kidney disease, with an odds ratio of 2.59 (95% CI, 2.40 to 2.79; p < 0.001); COPD, with an odds ratio of 1.92 (95% CI, 1.85 to 1.99; p < 0.001); and CHF, with an odds ratio of 1.90 (95% CI, 1.82 to 1.99; p < 0.001). Elevated BMI was associated with a slightly increased mortality risk, with an odds ratio of 1.13 (95% CI, 1.06 to 1.21; p < 0.001). Female sex was associated with a decreased mortality risk, with an odds ratio of 0.78 (95% CI, 0.76 to 0.80; p < 0.001).

Discussion

Our study demonstrated that patients ≥65 years old who underwent shoulder arthroplasty for fracture had significantly higher mortality rates than those who underwent shoulder arthroplasty for a nonfracture diagnosis. The trend toward higher mortality in the fracture group was sustained throughout the 5-year postoperative period (Fig. 1), with a fracture diagnosis being associated with 1.63 times higher odds of mortality (p < 0.001; Table II). Older age and medical comorbidities were the 2 other main risk factors for 5-year mortality. Although this study did not comprehensively explore the long-term value of shoulder arthroplasty, as we were unable to evaluate patient-reported outcomes, we believe that this analysis is a first step, providing novel data that can help surgeons to frame preoperative surgical discussions that include overall mortality risk and potential patient-specific risk factors associated with mortality.

Our findings suggest that increased 5-year mortality risk following shoulder arthroplasty is multifactorial. Fragility fracture and medical comorbidities both contributed to increased mortality risk. Although it was out of the scope of this study to evaluate mortality risk in patients with nonoperatively treated fractures, proximal humeral fragility fractures that do not require surgery or hospital admission are still substantial injuries with potential sequelae beyond diminished shoulder function[13]. As a result of the limitations of the Medicare database, we did not have the ability to reliably isolate proximal humeral fractures that were treated nonoperatively or with open reduction and internal fixation (ORIF), and therefore such cases were not included in the analysis. Furthermore, given the retrospective nature of this analysis, we felt that there would have been inherit bias introduced with regard to patient age and comorbidity status when evaluating and comparing proximal humeral fracture cases treated nonoperatively versus those treated with ORIF.

We identified a 5-year mortality risk for patients undergoing shoulder arthroplasty for fracture (29.9%) that was lower than that for patients undergoing THA for fracture (60.2%). However, these rates were higher than the rate for the average Medicare beneficiary (21.4%), indicating that fragility fractures are associated with an increased patient mortality risk at 5 years even when treated operatively (Fig. 2). This increased mortality risk in the fragility fracture population is consistent with previous literature[14,18-20]. Brown et al.[19] reported that a fragility fracture at any site is associated with an increased 1-year mortality risk and a diminished 6-year survival probability. Furthermore, consistent with the findings of the present study, Brown et al. reported that a hip fragility fracture is associated with a higher mortality risk than a non-hip fragility fracture[21].

In the present study, we found lower rates of 5-year mortality among patients who underwent elective shoulder and hip arthroplasty for a nonfracture diagnosis (14.9% and 13.3%, respectively; Fig. 2) than among other patient populations. Short-term mortality risk following primary shoulder arthroplasty has been well defined in the literature, with rates of 0.09% for in-hospital mortality[16], 0.25% for 30-day mortality[17], and 0.8% to 1.3% for 90-day mortality[18,22]. Longer-term mortality risk following TSA has not been directly studied, but indirect data can be gathered from prior literature. Sheth et al.[23] evaluated 10-year clinical outcomes following reverse shoulder arthroplasty. Of their initial cohort of 471 patients, they found that 225 had died prior to follow-up, indicating a 47.8% 10-year mortality rate in this population. Evans et al.[6] evaluated the 20-year outcomes of 1 implant design following anatomic shoulder arthroplasty. Of the 40 patients in their cohort, 29 had died, indicating a 72.5% mortality rate at the 20-year follow-up. One downside of both of these studies is that the low numbers of patients can introduce some degree of statistical fragility to the findings regarding mortality. Our cohort of 96,104 nonfracture shoulder arthroplasty cases demonstrated a 14.9% mortality rate at 5 years.

Our finding that the highest risks of 5-year mortality were associated with medical comorbidities is consistent with that of previous studies. Singh et al. found that an underlying tumor diagnosis and a higher medical comorbidity index were predisposing factors for increased mortality risk following TSA[22]. Garcia et al.[24] identified a 7.6% rate of malnutrition (albumin

<3.5 g/dL) among patients undergoing shoulder arthroplasty; malnutrition was associated with postoperative blood transfusion, extended length of stay, and mortality. Griffin et al.[25] showed that obesity in patients undergoing TSA was associated with higher costs, perioperative respiratory complications, and increased length of stay; however, there was no significant difference in postoperative mortality rates between patients with and without obesity. Comorbid cardiac disease has been found to be an independent predictor of mortality, whereas peripheral vascular disease has been associated with increased complication rates following TSA[17]. The present study also demonstrated that CHF was associated with 1.90 times higher odds of 5-year mortality (p < 0.001). However, these odds of 5-year mortality were far exceeded by those associated with liver disease (3.07; p < 0.001) and kidney disease (2.59; p < 0.001; Table II). We were unable to reliably subdivide these comorbidities into further entities. This manifested as broad CIs for the hazard ratio for some comorbidities, which was the most pronounced for liver disease. Therefore, it should be understood that these findings represent overall risks and that individual patient odds may vary depending on the nature and severity of the comorbid condition. Nonetheless, preoperative comorbidity management may have the potential to impact short and longer-term mortality risk following shoulder arthroplasty and should be taken into consideration during preoperative counseling.

Given that the present study was based solely on data from the Medicare database, we were unable to evaluate the effects of insurance status or patient socioeconomic background on mortality. Interestingly, Like et al.[26] found that Medicaid insurance status was a risk factor for morbidity and mortality following total shoulder arthroplasty, but their analysis was based on short-term outcomes (i.e., 30 and 90-day readmission rates). Additional research regarding the role of socioeconomic factors in mortality and patient outcomes following shoulder arthroplasty is necessary.

Because of the limitations of the Medicare database, we were unable to isolate all factors that could affect 5-year mortality rates, such as socioeconomic status, other medical treatments, nonorthopaedic surgical procedures, and subsequent traumas. Along these lines, we were not able to accurately identify the cause of death for all patients and therefore did not include this information in our analysis. We were also unable to consistently and reproducibly stratify data by arthroplasty type because anatomic shoulder arthroplasty and reverse shoulder arthroplasty utilize the same CPT code. Given similar limitations in coding, we were unable to reliably distinguish between primary diagnoses of osteoarthritis and rotator cuff arthropathy. The comorbidity status of the patient at the time of procedure was captured with use of the complete list of ICD-9/10-CM codes billed with the arthroplasty claim; such data were subject to potential errors caused by inaccurate billing or comorbidity documentation. Given that the majority of arthroplasty procedures for proximal humeral fractures may have been performed in patients admitted to the hospital, a bias toward cases with more complete comorbidity documentation in the fracture population is possible. In general, comorbidities are underdocumented in the hospital setting, and therefore our study may have underrepresented the true magnitude of the role of medical comorbidities in mortality.

We were not able to include clinical outcomes or patient satisfaction in our analysis. Although determining mortality rates is an important start to understanding the long-term value of care, quality-adjusted life years are an important consideration that we were unable to evaluate in our analysis. Finally, we were unable to accurately isolate a population of patients who were treated nonoperatively for a fragility fracture of their shoulder or hip and therefore were unable to provide a nonoperative control group for fracture when considering patients with a fragility fracture.

Conclusions

There was an overall 16.6% risk of mortality at 5 years following shoulder arthroplasty, which was lower than the mean Medicare beneficiary 5-year mortality rate of 21.4%. Shoulder arthroplasty for fracture had a higher 5-year mortality risk at 29.9%. This, however, was not as substantial as the 60.2% 5-year mortality rate following hip arthroplasty for fracture. Our findings are consistent with prior work showing an increased mortality risk following a fragility fracture. Medical comorbidities had the greatest impact on mortality risk, with chronic liver and kidney disease being the most noteworthy. This study provides novel longer-term data to help with patient education and risk stratification prior to a shoulder replacement for fracture or other elective indications.

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