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Age Is Just a Number: Patient Age Does Not Affect Outcome Following Surgery for Osteoporotic Vertebral Compression Fractures

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Abstract

Study Design: Retrospective study.

Objective: Multiple studies have shown that osteoporotic patients are at an increased risk for medical and surgical complications, making optimal management of these patients challenging. The purpose of this study was to determine the relationship between patient age and the likelihood of surgical complications, mortality, and 30-day readmission rates following surgery for osteoporotic vertebral compression fractures (OVCFs).

Methods: A retrospective analysis of the American College of Surgeons National Surgery Quality Improvement Project (ACS-NSQIP) database from 2007 to 2014 identified 1979 patients who met inclusion criteria. A multivariate logistic regression analysis was conducted to calculate odds ratios (OR), with corresponding *P* values and 95% confidence intervals, of the relationship between age (treated as a continuous variable) and perioperative mortality, surgical complications, and 30-day readmission rates.

Results: Younger patients were statistically more likely to endure a minor (OR = 0.98; P = .002) or major complication (OR = 0.97; P = .009). The older a patient was, on the other hand, the higher the likelihood that patient would be readmitted within 30 days of surgery (OR =1.02; P = .004). Mortality within the 30-day perioperative period was not statistically correlated with age.

Conclusions: The impact of age on adverse outcomes following surgery for OVCF is mixed. While younger patients are more likely to endure complications, older patients are more likely to be readmitted within 30 days following surgery. Patient age showed no correlation with mortality rates. In the setting of surgical treatment for an OVCF, a patient's age can help determine the risk of complications and the rate of readmission following intervention.

Keywords

age, mortality, readmission, outcomes, NSQIP, vertebral body fracture, fragility, osteoporosis, failed back surgery, compression

Introduction

More than 2 million fragility fractures are reported in the United States annually, leading to the hospitalization of more than half a million elderly patients and costing the health care system over $5.1 billion each year.[1,2] Of these fragility fractures, approximately one-third are osteoporotic vertebral compression fractures (OVCFs).[3] OVCFs can cause severe pain, dysfunction, and enduring postural changes that may lead patients to seek surgical intervention.[4,5] Given the rising

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incidence of osteoporotic fractures in the population[6] and the frailty exhibited by many OVCF patients,[7] literature relating to the clinical management of this condition is becoming progressively more relevant. Current options for the treatment of OVCFs include benign neglect, bracing, medication, cement augmentation procedures (such as vertebroplasty or kyphoplasty), and surgery. While treatment modalities are based on various clinical factors, several studies have shown that cement augmentation and surgical intervention may offer better long-term pain relief than medical management alone for a subset of patients.[8-11] Prior to recommending an invasive procedure, however, one must consider the risk-profile of each patient. The current study attempted to determine the relationship between patient age and the likelihood of complications, mortality, and 30-day readmission following surgery or cement augmentation for an OVCF.

Methods

This retrospective study utilized data from the American College of Surgeons National Surgery Quality Improvement Project (ACS-NSQIP) ranging from 2007 through 2014. Because information within this database is de-identified, this study was exempt from institutional review board (IRB) approval. Following a methodology similar to that implemented by other studies,[12-14] patients who sustained an OVCF in the lumbar or thoracic region of the spine were found by using Current Procedural Terminology (CPT) codes and International Classification of Disease (ICD-9 or ICD-10) codes. ICD-9 codes 733.13 805.2, and 805.4 (utilized for the years 2007-2013) and ICD-10 codes M48.56XA, S22.009A, S22.068A, and S22.089A (used for 2014) were included in this study. To ensure all target patients in the ACS-NSQIP database were identified, patients assigned any of the following CPT codes were also included: 22 510, 22 511, 22 512, 22 513, 22 514, or 22 515; these CPT codes refer to vertebral cement augmentation procedures.

Patients without a definitive age recorded, those with an OVCF in the cervical, sacral, or unclassified region of the spine, and/or those with spinal or central nervous system tumors were excluded. For purposes of conducting a logistic regression analysis, the following patient characteristics were considered: sex, body mass index (BMI), functional status prior to surgery, pre-operative comorbidities, American Society of Anesthesiologists (ASA) status, post-operative complications, mortality, reoperations, and 30-day readmissions. If greater than ten percent of patients were missing data for a given variable, that variable was excluded from the study.

Outcome measures for this study included minor postoperative complications, major postoperative complications, patient mortality, 30-day readmission due to any cause, and 30-day readmission related to OVCF. As in a previous study by Chung et al,[14] the following issues were considered minor postoperative complications: pneumonia, urinary tract infection, deep vein thrombosis, or surgical site complications. Major postoperative complications included cardiac arrest, acute myocardial infarction, sepsis, septic shock, stroke, pulmonary embolism, acute renal failure, a coma lasting more than 24 hours, and reintubation. For purposes of data presentation only, patients were grouped into 1 of the following 3 categories based on their age: <70, 70 to 79, and ≥ 80 years. Of note, these groups were not utilized for purposes of the multivariate logistic regression analysis, in which age was treated as a nondichotomous, continuous variable.

Statistical Analysis

Using multivariate logistic regression, odds ratios (ORs) with corresponding *P* values and 95% confidence intervals (CIs) were calculated. This statistical tool was used to determine the direct correlation between age (treated as a continuous variable) and the primary outcome measures while accounting for possible confounders. The analysis provided data relating to minor and major complications, mortality rates, and 30-day readmissions for any cause. To determine which variables should be utilized in the logistic regression, a series of bivariate analyses between age and the variable in question was conducted; those that generated *P* values less than .05 were included in the multivariate analysis. Any variable for which fewer than five incidences occurred within the patient dataset was excluded. For statistical purposes, a patient listed as greater than 90 years of age in the ACS-NSQIP database was treated as a 90-year-old.

Results

After applying inclusion and exclusion criteria, 1979 patients were found in the ACS-NSQIP database. At the time of surgery, 676 patients were younger than 70 years, 576 were between the ages of 70 and 79 years, and 727 were at least 80 years of age. This distribution is illustrated in Figure 1. Data was partially missing for 65 of the patients in our study (BMI, 31 patients; functional status, 31 patients; and ASA status, 3 patients), yielding a final total of 1914 patients available for multivariate logistic regression analysis.

Table 1 provides demographic characteristics and functional status data for all patients in this study, sorted by age group. Of note, age groups were utilized simply for purposes of presenting data. A patient's age group did not affect the results of the

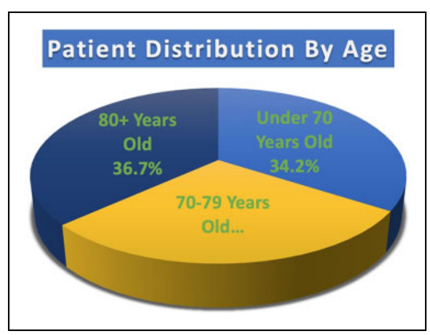

Figure 1. Patient distribution by age.

Table 1. Patient Characteristics by Age Group.

	Age <70 y (n = 676)	SD or %	Age 70-79 y (n = 576)	SD or %	Age 80+ y (n = 727)	SD or %	Total (n = 1979)	SD or %
Parameter								
Age (years)[a]	61.34	5.40	74.64	2.95	85.18	3.41	73.92	10.82
Sex (female)	404	59.8%	399	69.3%	525	72.2%	1328	67.1%
Body mass index (kg/m^2)	28.37	7.09	27.22	6.26	24.98	5.20	26.74	6.45
Smoking history	161	23.8%	71	12.3%	38	5.2%	270	13.6%
Steroid use for chronic condition	114	16.9%	106	18.4%	73	10.0%	293	14.8%
On dialysis	10	1.5%	7	1.2%	9	1.2%	26	1.3%
Mean preoperative albumin	3.64	0.72	3.55	0.61	3.54	0.60	3.58	0.65
Functional status prior to surgery								
Independent	604	90.4%	487	85.6%	570	80.2%	1661	85.3%
Partially dependent	58	8.7%	77	13.5%	130	18.3%	265	13.6%
Totally dependent	6	0.9%	5	0.9%	11	1.5%	22	1.1%
Unknown	8	—	7	—	16	—	31	—

[a] For statistical purposes, patients aged 90+ years are assumed to be 90 years of age.

logistic regression analysis, in which age was treated as a nondichotomized, continuous variable. Overall, the relative proportion of women in an age group increased with increasing age. BMI and smoking rates were relatively lower in progressively older populations. Steroid use showed no clear correlation with age while dialysis rates were low across all populations. Preoperative albumin levels were similar across the 3 age groups displayed in Table 1. Preoperative functional status diminished with increasing age; a smaller proportion of patients were independent in the ≥80-year age group relative to those in the 70- to 79-year age range. The latter group in turn exhibited a less favorable distribution of preoperative functional status in comparison with those in the <70-year age group.

To decide which factors to incorporate in our multivariate logistic regression analysis, a series of bivariate analyses were conducted using ACS-NSQIP data. In addition to patient age, the following factors and comorbidities bore a statistical impact ($P < .05$) on primary outcome measures: patient sex, preoperative serum albumin levels, preoperative functional status, COPD, coagulopathy, cerebrovascular accident, obesity, steroid use, weight loss of >10% in the past 6 months, and an ASA class >2. Each of these factors was accounted for in the regression analysis to discern the true impact of age on major and minor complications related to surgery, perioperative mortality rates, and 30-day readmission rates. Factors that were not found to be statistically significant included congestive heart failure, diabetes mellitus, dialysis, hypertension, and smoking. Comorbidities with fewer than 5 incidences in our study population, such as ascites or renal failure, were also excluded from analysis.

Relevant data from the logistic regression analysis, including ORs, *P*, and 95% CIs, are provided in Figure 2. Age was statistically correlated with both minor (OR = 0.98; $P = .002$) and major complications (OR = 0.97; $P = .009$) as well as 30-day readmission rates (OR = 1.02; $P = .004$). Based on our analysis, age was found to have no predictive value regarding patient mortality (OR = 1.00; $P = .768$). We did not identify any statistical trend relating to age and hospital length of stay.

Discussion

Zhang et al[15] showed that advanced patient age is a risk factor for failure of medical management in patients with OVCFs. This suggests that the relative benefit of surgery may increase with increasing age, since in younger patients both surgery and conservative management may be suitable treatment options. Our study corroborates this by quantitively showing that

	Minor Complication			Major Complication			Mortality			30-Day Readmission		
	Odds Ratio	P-Value	95% CI	Odds Ratio	P-Value	95% CI	Odds Ratio	P-Value	95% CI	Odds Ratio	P-Value	95% CI
Age												
Age	0.98	0.002	0.96-0.99	0.97	0.009	0.95-0.99	1.00	0.768	0.98-1.02	1.02	0.004	1.01-1.03
Gender												
Female	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Male	0.90	0.560	0.63-1.29	1.14	0.569	0.73-1.76	1.58	0.050	1.00-2.48	1.41	0.017	1.06-1.87
Preoperative Functional Status												
Independent	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Partially Dependent	1.58	0.031	1.04-2.42	2.49	<0.001	1.52-4.07	1.70	0.054	0.99-2.91	1.39	0.069	0.97-2.00
Completely Dependent	2.79	0.048	1.00-7.74	2.95	0.076	0.89-9.73	5.68	0.001	2.04-15.75	0.99	0.991	0.29-3.45

Figure 2. Multivariate logistic regression analysis for minor complications, major complications, mortality, and 30-day readmissions. Variables with statistically significant *P* values are highlighted in orange.

advanced age is not associated with increased rates of surgical complications or mortality following surgery for OVCF. Additionally, we found that younger patients are statistically more likely to sustain a minor (OR = 0.98; $P = .002$) or major complication (OR = 0.97; $P = .009$) following surgery for OVCF.

In 2018, Blattert et al[16] showed that older patients with OVCF were more likely to undergo medical management and that physicians were more inclined to pursue nonoperative treatment for these patients due to their age. This suggests that there is a selection bias toward treating only the healthiest elderly patients with invasive treatment options and may be the reason for the similar complication rates, 30-day readmission rates, and mortality rates following surgery for OVCF found in this study. This is particularly relevant in light of the finding of Cooper et al[17] that as age increases so too does the prevalence of OVCF. Based on our statistical analysis, there was no difference in the aforementioned complications as a result of a patient's age. Instead, the frailty and poor health of younger individuals with an OVCF may be more relevant. Studies have shown that the prevalence of OVCF increases with age, affecting approximately 40% of women by the age of 80 years.[18] While OVCF may be relatively common in elderly patients, it is probably the most medically frail patients with multiple comorbidities who sustain OVCF at a younger age. Based on the findings in this study and the study by Zhang et al,[15] considering a noninvasive approach for younger patients with OVCF may be more prudent.

Although statistically correlated with complication rates and 30-day readmissions, we found that patient age does not substantially impact the likelihood for adverse surgical outcomes following surgery for OVCF. This study concluded that the risk of a minor complication (OR = 0.97), major complication (OR = 0.98), mortality (OR = 1.00), or 30-day readmission (OR = 1.20), is not related to patient age and therefore should not be a contraindication by itself to surgical intervention. In a previous study, we showed that preoperative serum albumin levels can be useful to help predict postsurgical outcome, as severely malnourished patients with OVCF exhibited a mortality odds ratio of nearly 3.0 relative to patients with OVCF whose serum albumin levels were in the normal range.[7] Similarly, other studies have shown that the Charlson comorbidity index, which attempts to predict the risk of death within 1 year of hospitalization based on comorbid conditions,[19,20] is also valuable for assessing a patient's risk-profile.[7,21-23]

Additionally, it was found that diminishing preoperative functional status is statistically correlated with a higher rate of adverse outcomes. Our data also shows that male gender was more prevalent in the <70-year age group and was correlated with an increased likelihood of mortality. These 2 factors both had better predictive value than patient age when attempting to gauge a patient's risk of an adverse surgical outcome. While age may help inform clinical recommendations for other disease processes and illnesses,[24-26] age did not negatively affect surgical outcomes in patients with OVCF.

While clinically applicable, this study has multiple limitations. We relied on the accuracy and reliability of de-identified spreadsheets from the ACS-NSQIP database without the benefit of being able to view actual patient charts for purposes of verification. To this end, it is possible that patients may have been improperly included or excluded due to potential errors within the ACS-NSQIP database. While the NSQIP database is highly regarded and frequently referenced,[27,28] there was no obvious way to correct for this. Another challenge with the NSQIP database is its use of the term "null" instead of "no" when identifying patients with CNS tumors. While both terms are frequently used in the database, the former term, in comparison to the latter, does not provide the same degree of certainty that a patient does not have a CNS tumor. Nevertheless, either term in this study was considered acceptable for purposes of meeting inclusion criteria. Finally, variables recorded in ACS-NSQIP changed from year to year; some variables were added over time, while others were removed. Although this constraint was carefully tracked and accounted for, it necessitated the exclusion of some variables from our regression analysis.

Regarding 30-day readmission rates, our logistic regression analysis showed that older patients were more likely to be readmitted within 30 days of surgery (OR = 1.02; $P = .004$). While this finding is statistically significant, there are caveats to discuss relating to the record-keeping methodology used in the ACS-NSQIP database. ACS-NSQIP defines a 30-day readmission from the date of surgery and not the date of discharge.[29] As a result, a very sick patient discharged 20 days after surgery has only 10 days to qualify for a 30-day readmission using this methodology. On the other hand, a relatively healthy patient with no complications who is discharged the day after surgery has 29 days to be readmitted to be considered a 30-day readmission. This record-keeping limitation may affect our ability to meticulously assess the relationship between 30-day readmission and patient age. In addition, ACS-NSQIP does not track readmissions that occur after the initial 30-day period following surgery. Based on the results of this study, age, while statistically correlated, does not substantially increase the likelihood of a 30-day readmission.

Other potential limitations include the decision to avoid distinguishing between different surgical modalities. This study did not control for whether a patient underwent a cement augmentation procedure or a more invasive surgical procedure to treat his or her OVCF. It relied on the clinical judgment of the surgeon to identify which procedure would be best. Furthermore, we did not account for the age of the fracture at the time of intervention, or whether a patient had multiple osteoporotic fractures, as this information was not available to us in the ACS-NSQIP database. This may be relevant since others have shown that patients with a concomitant hip fracture in addition to an OVCF are significantly more likely to suffer major complications or death from surgery.[30] As Blattert et al[16] did previously, future studies may evaluate the proportion of patients as a function of age who undergo OVCF surgery; one might take Blattert et al's analysis one step further by comparing the outcomes of surgical patients with those of nonsurgical patients in the same age range. This could help discern whether age in fact biases clinical judgment against surgery. Since our study utilizes the ACS-NSQIP database, by default all patients underwent surgery; we did not have the luxury of assessing non-surgical patients. Alternatively, it may valuable to study other factors that are statistically associated with complications in the setting of OVCF. It may also be worthwhile to investigate the correlation between the factors considered in this study and other fragility fractures. Ravindrarajah et al[31] explored various factors that may be associated with fragility fractures in the pelvis, hip, shoulder, and forearms but did not consider the spine; this may be an interesting area of future research.

Conclusion

The impact of age on adverse outcomes following surgery for OVCF is mixed. Although statistically correlated with surgical complication rates and 30-day readmissions, patient age does not substantially impact the likelihood for adverse surgical outcomes given the range of odds ratios identified in this study. While younger patients are more likely to endure minor (OR = 0.97) and major (OR = 0.98) complications, older patients are more likely to be readmitted within 30 days following surgery (OR = 1.02). Since patient age did not show any association with mortality, in the setting of an OVCF, a patient's age should not be a stand-alone contraindication to surgical intervention.

Declaration of Conflicting Interests

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