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Treatment choice affects inpatient adverse events and mortality in older aged inpatients with an isolated fracture of the proximal humerus

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Abstract

Background—This study tests the null hypothesis that, among patients aged 65 and older admitted to a United States hospital with an isolated fracture of the proximal humerus (no other injuries or fractures), there are no differences between operative (fixation or arthroplasty) and nonoperative treatments with respect to inpatient adverse events, inpatient mortality, and discharge to a long-term care facility rates accounting for comorbidities.

Methods—Using a large national database representing an estimated 132,005 patients aged 65 and older admitted to a US hospital with an isolated proximal humerus fracture between 2003 and 2007. Sixty-one percent did not have surgery, 22% were treated with open reduction and internal fixation (ORIF), and 17% were treated with arthroplasty.

Results—The risk of an in hospital adverse event was 21% overall and was 4.4 times greater with arthroplasty and 2.7 times greater with ORIF compared to nonoperative treatment. The risk of in hospital death was 1.8% overall and was 2.8 times greater with ORIF compared to nonoperative treatment. Patients treated operatively were less likely to be discharged to a long-term facility compared to patients treated nonoperatively.

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Conclusion—In spite of a tendency to treat the most infirm patients (those that are not discharged to home) nonoperatively, operative treatment (open reduction and internal fixation in particular) is an independent risk factor for inpatient adverse events and mortality in older-aged patients admitted to the hospital with an isolated fracture of the proximal humerus and should perhaps be offered more judiciously.

Level of evidence—Level III, Retrospective Cohort Study, Treatment Study.

Keywords

Comorbidity; complication; operation; proximal humerus fracture; surgery; arthroplasty; open reduction and internal fixation

Many factors influence the decisions between operative and nonoperative treatment and between internal fixation (IF) and arthroplasty in the management of fractures of the proximal humerus. Fracture pattern, displacement, osteoporosis, and the risk of avascular necrosis are commonly discussed influences on the decision process.^{6,10,12,20,22,23,26} However, the inter- and intraobserver reliability of some of these parameters are low.^{4,17} The influence of the patient's pre-injury infirmity and functional demands on treatment decisions and outcome is less well-studied.^{14,20,21} In one recent study, nearly 90% of patients aged 60 or greater with a displaced proximal humerus fracture had important medical comorbidities and the Charlson Index (used to estimate 1-year mortality in hospitalized patients) was associated with the use of arthroplasty rather than internal fixation.²⁰ Factors associated with nonoperative treatment of fractures of the proximal humerus in prior studies include: fracture type, age greater than 70–85, limited functional demands, cognitive impairment, severe comorbidities such as malignancy or diabetes mellitus, a higher Charlson comorbidity Index score, smoking and alcoholism.^{7,8,20,23}

The purpose of this study was to use a large database of inpatients with an isolated proximal humerus fracture to determine predictors of adverse events, inpatient death, and discharge to a long-term facility. Specifically, we tested the null hypothesis that among inpatients with an isolated fracture of the proximal humerus, and accounting for comorbidities, there are no differences between nonoperative and operative (IF or arthroplasty) treatment with respect to inpatient adverse events, inpatient death, or discharge to a long-term facility.

Materials and methods

Data were obtained from the National Hospital Discharge Survey (NHDS), provided by the National Center for Health Statistics.⁹ The NHDS covers discharges from a spectrum of representative hospitals across the country, not including federal, military, and United States Department of Veterans Affairs hospitals. Only short-stay, nonspecialty hospitals (average length of stay less than 30 days) are included in the survey. These hospitals must also have a minimum of 6 beds staffed for patient use. Each year, approximately 1% of total hospital admissions in the United States are abstracted and weighted to represent all such hospital discharges nationwide. Information collected from hospital records includes sex, age, up to 7 diagnoses, up to 4 procedures performed during hospitalization, length of hospital stay, and discharge status.

We identified patients aged 65 and older admitted to a hospital in the United States with an isolated acute proximal humerus fracture, treated either nonoperative or operative with IF or (total and hemi-)arthroplasty, based on the International Classification of Diseases, 9th Revision, Clinical Modification from the NHDS database between 2003 and 2007. We excluded all patients with concomitant injuries, fractures, or concomitant procedures, identified via other injury ICD-9 diagnoses (800–869) and codes for bony procedures (76, 78, 79, 81, 82), in order to study the relationship of the treatment and the adverse events related solely to a proximal humerus fracture. We used ICD-9 codes to identify comorbidities, procedures and adverse events (surgery-related as well as general) after procedures (see addendum for ICD-9 codes).^{5,19} The cohort included an estimated 132,005 patients, 85% women with a mean age of 79 years. Sixty-one percent did not have surgery, 22% were treated with IF, and 17% were treated with arthroplasty (Table I). Patients treated with IF were significantly younger (75 ± 7.2 years) than patients treated with arthroplasty (78 ± 7.1 years) or nonoperative treatment (81 ± 7.4 years, $P < .001$). Patients who underwent arthroplasty had more comorbidities (74%) than patients treated with IF (70%), but less than patients treated nonoperatively (79%, $P < .001$). The most common comorbidities were hypertension (45%) and diabetes mellitus (20%) (Table II). The length of stay averaged 4.5 ± 4.1 days.

Statistical analysis

Our response variables were inpatient adverse events, inpatient death, and discharge to a long-term facility. Explanatory variables included demographic patient data, pre-existing comorbidities, treatment (nonoperative vs IF vs arthroplasty), and new inpatient comorbidities. Continuous data were presented as mean $\pm$ standard deviation ($\pm$ SD). We assumed normality based on our large sample size. Unpaired *t* tests were performed to determine the differences between two continuous variables and ANOVA between three continuous variables. Pearson chi-square tests were used to analyze differences between two categorical variables. Wherever the minimum expected cell frequency was less than 5, the Fisher's exact test was used instead. For each response variable, explanatory variables $P < .001$ (given the large sample size) and an overall occurrence of $\geq 2\%$ ¹⁵ in bivariate analysis were entered into a stepwise backward logistic regression.

Results

Thirty-seven percent of the patients treated with arthroplasty had at least one adverse event, compared to 26% after IF, and 15% after nonoperative treatment ($P < .001$). Transfusion and acute postoperative anemia were significantly more common after arthroplasty (29% and 14%) than after IF (14% and 7.6%) and nonoperative treatment (4.8% and 2.4%, $P < .001$). Acute renal failure and pneumonia were more common in patients treated nonoperatively. Induced mental disorder, iatrogenic hypotension, pulmonary embolism, and pulmonary insufficiency were more common in patients undergoing arthroplasty (Table III). In multivariable analysis arthroplasty and IF were associated with a greater risk of an inpatient adverse event (OR = 4.4, 95% CI 4.3–4.6 and OR = 2.7, 95% CI 2.6–2.8, respectively) (Table IV).

Patients treated with IF had a significantly higher in hospital death rate of 2.3%, compared to 0.4% in the arthroplasty group and 2.0% in the nonoperative group ($P < .001$). IF was an independent risk factor for in hospital death (OR = 2.8, 95% CI 2.5–3.8) (Table V). Malignancy, acute renal failure, pneumonia, male sex, older age, and longer hospital stay were the other predictors of death in our cohort of isolated proximal humeral fracture. Arthroplasty, however, was associated with a lower rate of in hospital death compared to nonoperative treatment (OR = 0.14, 95% CI 0.11–0.19).

Controlling for comorbidities, patients in the arthroplasty and the IF group were less likely to be discharged to a long-term facility than patients treated nonoperatively (OR = 0.33, 95% CI 0.32–0.35 and OR = 0.54, 95% CI 0.52–0.56, respectively) (Table VI).

Discussion

This study used a large database to study differences in inpatient adverse events and mortality and discharge disposition in patients older than 65 years of age admitted to an acute care hospital with a proximal humerus fracture and no other injury. While it gave us great statistical power, we realized that using a database of inpatients meant that we were studying patient that were felt to benefit from admission to the hospital and where the data do not apply to the average patient older than 65 years of age with an isolated fracture of the proximal humerus. Although we do not know the reasons these patients were admitted to the hospital, we can account for comorbidities.

There were significant differences in inpatient adverse events, inpatient mortality, and discharge to a long-term facility between patients aged 65 and older with an isolated proximal humerus fractures treated either operatively or nonoperatively and with IF or arthroplasty accounting for associated comorbidities. Patients were more likely to experience a complication and be discharged to home after operative treatment, and more likely to die in hospital with internal fixation.

The main strength of this study is the large sample size, which allows analysis of numerous factors in multivariable statistical models. Even though the numbers are based on estimates, they are representative of the average United States hospital,¹⁶ and thereby adjust for regional variations in the treatment of proximal humerus fracture.³

Nevertheless, these results should be interpreted in light of several limitations. First, the ICD-9 based NHDS-dataset did not provide information about fracture type, displacement, associated glenohumeral dislocation, failed nonsurgical management prior to surgery, and the indications for either nonoperative or operative treatment. Second, there is some ambiguity of the coding system while it remains unclear how accurate the clinical diagnoses were converted into ICD-9 codes by the medical coder²⁹; it is also questionable if the ICD-9 codes reflect the severity of some diseases accurately.¹⁸ However, given our large sample size, the coding error bias can be assumed to be distributed equally in the 3 groups of patients. Third, NHDS limits the number of ICD-9 codes that can be entered to 7 per patient. This might misrepresent some of the more infirm patients that might have more than a dozen comorbidities; however, the most important comorbidities are likely captured in the

database. Fourth, only inpatient data were available, meaning that we are studying a select group of patients and could therefore not study re-admission or long-term outcome such as failure rates. These data apply best to the patient that is over 65 and admitted to an acute care hospital with a fracture of the proximal humerus fracture and no other fractures. For nonoperatively treated fracture, the reason for admission might be something other than the fracture (eg, unsafe at home, congestive heart failure); but we cannot easily discern this. We feel that accounting for comorbidities in the statistical model should account for some of these differences; but the finding that nonoperatively treated patients were less likely to be discharged to home suggests that we have not accounted for all of them. Lastly, surgeon volume¹³ and surgeon sub-specialty (shoulder vs upper extremity vs trauma surgeon)²⁰ was not recorded in the NHDS.

The published rates of adverse events associated with fracture of the proximal humerus vary primarily on the basis of which complications are analyzed and the duration of follow-up. In our large inpatient database study of patients 65 and older, the in-hospital adverse event risk was high (21%), especially after operative treatment where it was 26% for IF and 37% for arthroplasty. Most of the adverse events seems directly or indirectly related to blood loss and transfusion. The mean reported blood loss in shoulder arthroplasty is around 600 ml,²⁷ compared to about 200 ml in open reduction and internal fixation of proximal humeral fractures.²⁴ The findings that malignancy, chronic heart, renal, and pulmonary diseases were significant risk factors for adverse events are consistent with prior studies.^{11,25} While obesity increased the risk of infections in spine surgery,²⁸ it lowered the risk of adverse events in our and many other studies.^{1,2} This phenomenon has been referred to as the “obesity paradox”. Surgeon volume has also an impact on the complications rates; however, as already mentioned, they were not available and not evaluated in this study.¹³

Two percent of inpatients with an isolated proximal humerus fracture die in hospital. Fracture of the proximal humerus may be part of a terminal event, particularly in patients with malignancy, acute renal failure, or pneumonia. It is not clear why internal fixation was also an independent risk factor in this sample, after accounting for other comorbidities. It was not a risk factor in a recent study using data from a different inpatient database: the Nationwide Inpatient Sample (NIS).¹³ Nevertheless, one must consider there may be a subset of infirm patients currently being treated with open reduction and internal fixation who might be better served by nonoperative treatment. The fact that arthroplasty was associated with a lower risk of mortality might be spurious. We suspect it is based on the total number of inpatient deaths being low, particularly among patients treated with arthroplasty, so that even 1 or 2 more deaths might alter the statistical results substantially.

One can surmise a likely selection bias based on the differences of pre-admission comorbidities, and the fact that patients discharged to a long-term facility were older, had more congestive heart failure, diabetes mellitus, and acute renal failure, and were more likely to be treated nonoperatively. Presumably, operatively treated patients were often inpatients because they were recovering for surgery. Although there are likely factors affecting decision-making that we cannot account for in a database study, these groups do provide interesting comparisons, particularly because large datasets allow us to account for comorbidities.

Conclusion

Our results seem to reflect a general bias towards treating the most infirm older inpatients with an isolated proximal humerus fracture nonoperatively and discharging them from the hospital to long-term care facilities, particularly those with severe comorbidities such as malignancy, chronic heart, renal failure, and pneumonia or advanced pulmonary diseases. On the other hand, even after accounting for comorbidities, open reduction and internal fixation was associated with a higher risk of inpatient adverse events and inpatient death than nonoperative treatment. In our opinion, these findings suggest that open reduction and internal fixation (and likely operative treatment in general) carries important short-term medical risks that should be factored into management decisions—particularly in older, more infirm patients—likely much more so than pathoanatomy of the shoulder.

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Table 1

Overview: bivariate analysis of 132005 patients with a proximal humerus fracture

Parameter	Total n = 132005%	Nonoperative n = 80488%	Arthroplasty shoulder n = 21975%	IF proximal humerus n = 29542%	P value
Sex					
Male	15	15	17	15	<.001
Female	85	85	83	85	
Age (years±SD)	79 ± 7.7	81 ± 7.4	78 ± 7.1	75 ± 7.2	<.001
Comorbidities					
Comorbidities present	76	79	74	70	<.001
Adverse events					
Adverse events present	21	15	37	26	<.001
Days of care (days±SD)	4.5 ± 4.1	4.6 ± 4.1	4.5 ± 4.8	4.2 ± 3.3	<.001
Discharge status					
Routine/discharged home	43	34	61	56	<.001
Left against medical advice	0.3	0.2	0	0.9	
Discharged/transferred to short-term facility	6.2	8.3	1.3	4.2	
Discharged/transferred to long-term facility	35	41	27	25	
Alive, disposition not stated	10	13	6.7	7.1	
Dead	1.8	2.0	0.4	2.3	
Not reported	3	2.1	4.1	4.8	
Mortality	1.8	2.0	0.4	2.3	<.001

IF, internal fixation; SD, standard deviation.

Table II

Present comorbidities: bivariate analysis of 132005 patients with a proximal humerus fracture

Parameter	Total n = 132005%	Nonoperative n = 80488%	Arthroplasty shoulder n = 21975%	IF proximal humerus n = 29542%	P value
Hypertensive disease	45	44	48	43	<.001
Diabetes mellitus	20	20	25	13	<.001
Obesity	2.1	0.9	4.4	3.6	<.001
Chronic pulmonary disease	13	16	10	10	<.001
Chronic renal disease	2.4	2.4	4.2	1.2	<.001
Chronic liver disease	0.2	0.2	0	0.2	<.001
Chronic coronary artery disease	13	13	12	12	<.001
Congestive heart failure	11	13	9.7	9.9	<.001
Atrial fibrillation	11	13	9.3	8.7	<.001
Chronic alcoholism	1.2	1.4	0.4	1.3	<.001
Dementia	4.3	6.6	1.7	0.3	<.001
Nutritional deficiency	1.3	1.7	1.5	0.2	<.001
Malignancy	3.6	4.1	2.5	3.1	<.001
Osteoporosis	12	12	10	11	<.001

IF, internal fixation.

Table III

Present adverse events: bivariate analysis of 132005 patients with a proximal humerus fracture

Parameter	Total n = 132005%	Nonoperative n = 80488%	Arthroplasty shoulder n = 21975%	IF proximal humerus n = 29542%	P value
Local complications*	0.4	0.5	0.1	0.5	<.001
Acute posthemorrhagic anemia	5.5	2.4	14	7.6	<.001
Complications not elsewhere classified	1.7	1.0	4.1	2.0	<.001
Acute renal failure	2.2	2.9	1.8	0.4	<.001
Ventricular arrhythmias & arrest	0.7	0.8	0.2	0.8	<.001
Iatrogenic hypotension	0.2	0	1.2	0.2	<.001
Pulmonary embolism	0.5	0.2	1.9	0.3	<.001
Induced mental disorder	1.4	1.2	2.3	1.1	<.001
Pneumonia, pulmonary congestion	2.5	3.8	0.4	0.7	<.001
Pulmonary insufficiency	0.7	0.2	1.8	1.2	<.001
Deep venous thrombosis	0.4	0.1	0.6	1.4	<.001
Intubation or mechanical ventilation	0.9	0.2	1.7	2	<.001
Transfusion of blood	11	4.8	29	14	<.001
Conversion of cardiac rhythm	0.5	0.5	0	0.7	<.001

IF, internal fixation.

* Hematoma, seroma, wound infection, wound, disruption.

Table IV

Predictors of adverse events

Parameter	Sig.	OR	95% CI	
			Lower	Upper
Arthroplasty (vs nonoperative)	<.001	4.4	4.3	4.6
Malignancy	<.001	3.7	3.5	4.0
IF (vs nonoperative)	<.001	2.7	2.6	2.8
Congestive heart failure	<.001	1.7	1.6	1.8
Chronic coronary artery disease	<.001	1.5	1.4	1.5
Chronic renal disease	<.001	1.3	1.2	1.4
Sex (Female)	<.001	1.2	1.2	1.3
Chronic pulmonary disease	<.001	1.2	1.2	1.3
Days of care	<.001	1.13	1.13	1.14
Age (years)	<.001	1.03	1.02	1.03
Diabetes mellitus	<.001	.81	.78	.84
Dementia	<.001	.52	.48	.57
Obesity	<.001	.40	.36	.46
Osteoporosis	<.001	.36	.34	.38

CI, confidence interval; IF, internal fixation; OR, odds ratio.

Table V

Predictors of death

Parameter	Sig.	OR	95% CI	
			Lower	Upper
Malignancy	<.001	7.6	6.8	8.5
Acute renal failure	<.001	6.5	5.7	7.4
Pneumonia	<.001	3.1	2.5	3.8
IF (vs nonoperative)	<.001	2.8	2.5	3.1
Sex (male)	<.001	1.8	1.6	2.0
Age (years)	<.001	1.09	1.09	1.10
Days of care	<.001	1.09	1.09	1.10
Hypertensive disease	<.001	.58	.53	.64
Arthroplasty (vs nonoperative)	<.001	.14	.11	.19
Chronic pulmonary disease	<.001	.14	.11	.18
Chronic coronary artery disease	<.001	.06	.04	.10
Atrial fibrillation	<.001	.04	.02	.07

CI, confidence interval; *OR*, odds ratio; *IF*, internal fixation.

Table VI

Predictors of discharge to long-term facility

Parameter	Sig.	OR	95% CI	
			Lower	Upper
Acute renal failure	<.001	2.3	2.1	2.6
Congestive heart failure	<.001	2.2	2.1	2.3
Diabetes mellitus	<.001	2.0	1.9	2.1
Transfusion	<.001	1.6	1.5	1.7
Chronic pulmonary disease	<.001	1.5	1.4	1.5
Pneumonia	<.001	1.3	1.1	1.4
Sex (Male)	<.001	1.3	1.2	1.3
Days of care	<.001	1.13	1.13	1.14
Age (years)	<.001	1.07	1.07	1.08
Dementia	<.001	.76	.72	.81
Hypertensive disease	<.001	.72	.70	.74
Acute posthemorrhagic anemia	<.001	.65	.61	.69
IF (vs nonoperative)	<.001	.54	.52	.56
Arthroplasty (vs nonoperative)	<.001	.33	.32	.35
Obesity	<.001	.32	.28	.36

CI, confidence interval; *OR*, odds ratio.