What are the Factors Influencing Outcome Among Patients Admitted to a Hospital With a Proximal Humeral Fracture?

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Abstract

Background Fracture of the proximal humerus is common in older patients during the decline of their physical health.

Questions/purposes Our purpose was to evaluate the association between specific risk factors in patients with fractures of the proximal humerus and any inpatient adverse events, mortality, and discharge to a short-term or long-term care facility.

Methods The National Hospital Discharge Survey (NHDS) provided estimates of all adult patients who were admitted to hospitals after fractures of the proximal humerus in the United States between 1990 and 2007. The influences of sex, age, days of care, diagnosis and

procedures (based on ICD-9 codes) on inpatient adverse events and death, and discharge to a short-term or long-term care facility, were studied in bivariate and multivariable analyses.

Results Among an estimated 867,282 patients admitted for proximal humerus fractures, 20% experienced adverse events, and 2.3% died in the hospital. Older age, concomitant femur and femoral neck fractures or head trauma, operative fracture care, congestive heart failure, and chronic alcoholism were associated with inpatient adverse events. Intubation, acute myocardial infarctions, malignancies, and skull fractures were associated with inpatient deaths. Older age, lower limb fractures, specific comorbidities (obesity, congestive heart failure, dementia), and inpatient adverse events (pneumonia, anemia treated with transfusion) were associated with discharges to short-term or long-term care facilities.

Conclusions Knowledge of risk factors for inpatient adverse events, mortality, and discharge to facilities can help make treatment decisions, improve overall care, discharge planning, and resource utilization for patients with proximal humeral fractures.

Level of Evidence Level II, prognostic study. See Guidelines for Authors for a complete description of levels of evidence.

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Introduction

Studies of hip [26] and pelvic fractures [13], and fractures in the elderly [4], have identified concomitant injuries and preinjury comorbidities as factors associated with an increased risk of in-hospital adverse events and death [29], and discharges to long-term care facilities [24].

An understanding of these risk factors might direct specific monitoring and treatment and facilitate more rapid and appropriate transfer, thereby reducing the length of stay and costs associated with days in an acute care hospital [22, 23].

Only a few similar studies in patients with proximal humeral fractures have been published [1, 17]. These patients also may have age-related declines in bone health and greatly increased risks of adverse outcomes [1, 17]. However, these studies focused on adverse events after discharge directly related to the fracture or the treatment. In addition, the underlying characteristics of nonfracture-related factors, and the risk factors for discharge to a long-term facility, are not well-known in patients with proximal humerus fractures.

The aims of our study were to determine the rate of and predictors for (1) inpatient adverse events, (2) in-hospital death, and (3) discharge to a short- or long-term facility in patients with proximal humerus fractures as a function of different patient factors in the National Hospital Discharge Survey (NHDS) database.

Patients and Methods

The NHDS collects and annually publishes demographic and medical information (diagnoses and procedures) of inpatients discharged from more than 500 nonfederal, short-stay (less than 30 days, on average) hospitals in the United States [6]. This national sample of hospitals represents nearly 10% of eligible hospitals. Each year approximately 1% of total hospital admissions in the United States are evaluated and weighted. Diagnoses and procedures are based on the ICD-9 revision. Based on a stratified, multistage probability design, one of these stages is a population-weighting ratio adjustment; unbiased national estimates of patients' and procedures' characteristics can be drawn. The NHDS has been used to analyze trends and characteristics of patients in many medical specialties [3, 19, 20]. Only inpatient data are available.

We searched the NHDS for data on all adult patients (older than 18 years) who were admitted to acute care hospitals after proximal humeral fractures (ICD-9 812.0 [closed] or 812.1 [open]) between 1990 and 2007 in the United States. An estimated total of 867,282 patients (74% of them were women), with a mean age of 71 years, were analyzed. Sex, age, source of payment, days of care, and discharge status were available. The injuries were classified in the cohort as an isolated proximal humeral fracture or multiple fractures, and additional head, chest, or abdominal trauma were noted. Based on the ICD codes, we also identified the different comorbidities, treatments, and

adverse events as shown in the appendix (Appendix 1). Based on earlier studies [3, 19], we considered the corresponding ICD codes for acute renal failure, acute myocardial infarction, pulmonary embolus, thromboembolic events, pneumonia, psychosis, pulmonary insufficiency, cerebrovascular accidents, and similar diagnoses as postoperative complications if recorded in the NHDS database (Appendix 1).

We tested the null hypothesis that the inpatient outcome of patients with proximal humeral fractures was not influenced by concomitant injuries, comorbidities, types of procedure, or adverse events sustained during the hospital stay. The dichotomous, dependent outcome variables indicated the presence of in-hospital adverse events (no complications versus complications), discharge status (discharged to a facility versus discharge to home), and death (survivors versus nonsurvivors). Demographic data, concomitant injuries, preexisting comorbidities, and adverse events were the predicting factors. Continuous data were presented as mean $\pm$ SD. We assumed normality based on our large sample size. Unpaired t-tests were performed to determine the differences between continuous and dichotomous variables. Categorical data were reported only in percentages because the absolute numbers were only estimates. Pearson chi-square tests were used to analyze differences between two categorical variables. Wherever the minimum expected cell frequency was less than five, Fisher's exact test was used instead. Stepwise backward logistic regression was performed next to assess the impact of numerous factors on the probability of morbidity, discharge status, and mortality. Based on the large sample size, variables were included in the regression model if (1) 2% or more exhibited that factor [16] (except for the clinically important skull and femur fractures and the adverse events, we used 1% or greater as a threshold), and (2) the p value in the bivariate analysis was 0.001 or less [19]. We sequentially deleted less important covariates if they did not substantially alter the model. The sequence was based on a lower Wald test value. Nagelkerke's R square values, percentage accuracies in classification, and area under the receiver operating characteristic curves were used to measure the performance of the model. We a priori defined a change of 2% in these three values, in comparison to the initial logistic regression model, as important for stopping this process. The predictors from the regression analyses, already present at admission (concomitant injuries, comorbidities, and age—stratified in two groups, 75 years or younger and 76 years or older), then were further evaluated in probability tables for adverse events, death, and discharge to a short- or long-term facility.

Our institutional review board decided the study to be exempt from IRB approval.

Table 1. Overview of all hospitalized patients with proximal humerus fractures*

Variable	Total	Adverse events	Mortality (%)	Discharged to a facility (%)
Sex				
Male	26	19	2.3	26
Female	74	20	2.3	41
Mean age in years ($\pm$ SD)	71 ($\pm$ 17)			
Source of payment				
Medicare	67	22	2.6	46
All other sources	33	16	1.8	19
Proximal humerus fracture				
Closed	98	20	2.3	38
Open	1.8	20	1.4	15
Concomitant fractures				
Isolated proximal humerus fracture	72	16	1.9	33
Multiple fractures	28	30	3.5	49
Head trauma				
No	97	20	2.3	37
Present	2.7	26	3.1	40
Chest or abdominal trauma				
No	98	20	2.3	37
Present	1.8	33	4.2	34
Comorbidities				
No	41	16	2.1	29
Present	59	22	2.5	43
Treatment of proximal humerus fracture				
Nonoperative	66	20	3.0	44
Operative	34	19	1.0	24
Operative treatment of other fractures				
No	86	16	2.0	34
Present	14	43	4.3	57
Adverse events				
No	80	–	1.1	34
Present	20	–	7.3	54
Mean days of care ($\pm$ SD)	6.3 ($\pm$ 8.2)			

* All bivariate analyses were $p < 0.001$, except for proximal humerus fracture (closed vs open) and adverse events ($p = 0.59$), and for sex and mortality ($p = 0.04$).

Results

The overall rate of adverse events was 20%, with higher rates in patients with concomitant injuries or comorbidities, increasing to as much as 33% in patients with concomitant chest or abdominal trauma (Table 1). Patients with uneventful hospitalizations stayed 5.6 days in the hospital, whereas patients with adverse events had much longer hospital stays at 9.4 days ($p < 0.001$). Whereas patients without adverse events most often were discharged home 56% of the time, patients with adverse events were discharged to long-term facilities 41% of the time and discharged home 32% of the time. The best predictors for adverse events in the hospital were older age, additional

fractures of the femoral neck or femur, head trauma, congestive heart failure, and chronic alcoholism (Fig. 1). Operative treatments and a longer length of stay also had predictive values. The percentage of adverse events increased with the number of major risk factors, from 12% in patients without important factors to as much as 51% in patients with three factors (Fig. 2).

The overall rate of inpatient death was 2.3%. Concomitant injuries, comorbidities, adverse events, and operative treatment of fractures other than proximal humerus fractures increased the mortality rate (Table 1). Older age, fractures of the skull, neck or trunk, or tibia/fibula, malignancy, operative treatment of fractures other than proximal humerus fractures, and certain complications (acute

Fig. 1 This forest plot illustrates the best predictors for an adverse event in the hospital (R-square = 0.15, ROC = 0.72, predictive accuracy 81%; sex, age, source of payment; fracture of skull, neck or trunk, radius/ulna, femur neck, femur, tibia/fibula; head trauma, hypertensive disease, diabetes mellitus, obesity, chronic pulmonary

disease, coronary artery disease, congestive heart failure, atrial fibrillation, chronic alcoholism, malignancy; treatment of proximal humerus fracture, operative treatment of other fractures, and days of care were entered in the initial regression model).

Fig. 2 The factors, already present at the day of admission, increasing the risk for an adverse event in the hospital were age older than 75 years, concomitant fractures of the femoral neck or femur, head trauma, congestive heart failure, and chronic alcoholism (see Figure 1). The percentage of adverse events increased with the absolute number of these risk factors, from 12% in patients without important predictors to as much as 51% in patients with three of these factors. Forty-three percent of all patients had no, 44% one, 13% two, and 1% had three major risk factors.

myocardial infarction, pneumonia, intubation, and mechanical ventilation) were predictors of death (Fig. 3). Shorter length of stay, some comorbidities, such as hypertensive disease or coronary artery disease without acute myocardial infarction, and operative treatment of proximal humerus fractures appeared to be factors associated with a better outcome. Major predictors increased the mortality rate from 0.6% in patients without predictors to 2.4% in patients with one predictor, 11% in patients with two predictors, and 17% in patients with three predictors (Fig. 4).

An estimated total of 834,575 patients, either discharged home (63%) or to a short-term or long-term facility (37%) were analyzed. The overall discharge to a facility rate was higher in patients with concomitant fractures (49%) or comorbidities (45%), or who experienced an adverse event during hospitalization (54%) (Table 1). Older age, concomitant fractures (neck or trunk, femur neck, femur, tibia/fibula), certain comorbidities (dementia, obesity, congestive heart failure), and the presence of specific complications (pneumonia and anemia treated with transfusion) were predictors of discharge to a facility (Fig. 5). Operative treatment of fractures other than of the humerus was another predictive factor of discharge to a facility. In contrast, operative treatment of a proximal humerus fracture was a predictor of discharge home. The probability of discharge to a short-term or long-term care facility increased from 16% if no risk factors were present to as much as 84% with three factors (Fig. 6).

Discussion

The identification of risk factors for adverse outcomes may change treatment, in-hospital monitoring, discharge planning, and resource utilization. This retrospective study revealed several risk factors for adverse events in the hospital, discharge to a facility, and death in patients with proximal humeral fractures. The predictive models were good for mortality and fair for discharge and adverse events.

The strength of this study was the large estimated sample size. However, there also were several limitations. It was a retrospective analysis of a large database of in-hospital patients only, with possible reporting discrepancies and coding errors [35]. Many proximal humeral fractures are

Fig. 3 The forest plot shows the odds ratios and CIs of in-hospital death predictors ($R^2 = 0.29$, $ROC = 0.85$, predictive accuracy 98%; age, source of payment; fracture of skull, neck or trunk, radius/ulna, femur neck, femur, tibia/fibula; head trauma, hypertensive disease, diabetes mellitus, obesity, chronic coronary heart disease, congestive heart failure, atrial fibrillation, chronic alcoholism,

malignancy; treatment of proximal humerus fracture, operative treatment of other fractures, acute myocardial infarction, acute posthemorrhagic anemia, new mental disorder, pneumonia, pulmonary insufficiency, intubation and mechanical ventilation, and days of care were entered in the initial regression model).

Fig. 4 This graph shows the mortality rates based on the number of major risk factors, including age older than 75 years, concomitant skull, neck or trunk, tibia/fibula fractures, or malignancy.

treated in an outpatient setting, so the research from this database applies only to patients who are admitted to the hospital with a fracture of the proximal humerus. The severity of different diseases may not have been adequately reflected [18] (eg, the presence of diabetes was only coded as “yes” or “no”), nor were the prevalences of some diseases

(eg, obesity was underestimated [33]). Some medical diseases defined as postoperative complications in our study may already have been present at the time of admission. Another issue was that if there was more than one diagnosis or procedure the complications could not be clearly credited to proximal humeral fractures. Patients with multitrauma were included along with patients with isolated humeral fractures. Patients with multitrauma obviously are at high risk for complications, transfer to a long-term care facility, and mortality independent of their humeral fracture. However, this study was designed to look at all humerus fractures similar to the literature on hip fractures and therefore we included patients with multitrauma. Finally, there were no data available to evaluate the outcome after discharge, such as 90-day mortality.

Most factors were already well-known risk factors for adverse outcomes [3, 21, 26]. Older age and specific comorbidities—especially congestive heart failure—raised the risk of adverse events. With increasing life expectancy we are challenged with more elderly and sick patients and as a consequence higher morbidity and mortality rates [12, 21, 27]. Concomitant femur and femoral neck fractures usually require operative treatment, cause longer hospital stay and higher financial cost, and increase the risk of adverse events and mortality substantially [26]. Alcohol increases the morbidity and mortality rates by altering the

Fig. 5 Risk factors for discharge to a short- or long-term facility in patients with proximal humeral fractures are presented in this forest plot (R-square = 0.28, ROC = 0.77, predictive accuracy 71%; sex, age, source of payment; fracture of skull, neck or trunk, radius/ulna, femur neck, femur, tibia/fibula; head trauma, hypertensive disease, diabetes mellitus, obesity, chronic pulmonary disease, chronic

coronary heart disease, congestive heart failure, atrial fibrillation, chronic alcoholism, dementia, malignancy; treatment of proximal humerus fracture, operative treatment of other fractures, acute posthemorrhagic anemia, pneumonia, transfusion, and days of care were entered in the initial regression model).

Fig. 6 The need for discharge to a short- or long-term facility is illustrated based on the number of significant predictors, including age older than 75 years, concomitant fractures (neck or trunk, femur neck, femur, tibia/fibula) or comorbidities (dementia, obesity, congestive heart failure).

inflammatory response after injury [10]. Disputable is the effect of diabetes. Diabetes mellitus was not a strong predictor of adverse events. Whereas the impact of diabetes on

complications and functional outcomes of orthopaedic lower extremity procedures is clearer, it seems that the influence on negative in-hospital outcomes of proximal humeral fractures is not so accentuated [3, 8, 24, 25]. The diabetic status of patients is not always mentioned in some published studies [14, 28, 32] of proximal humeral fractures, which makes drawing conclusions difficult. Furthermore, some studies [9, 30] of proximal humeral fractures combined all comorbidities and reported only the higher comorbidity index as a general risk factor for mortality or complications; however, there also are studies [5, 31] showing no increased risk of negative outcome in patients with diabetes, especially for infection in arthroplasty.

Perioperative acute myocardial infarction was a major risk factor for in-hospital death in our study and in another study [7]; therefore patients may benefit from in-depth medical evaluation. The association of specific comorbidities with a better outcome may be seen as a consequence of more exhaustive monitoring and medication (eg, beta-blockers and statins) [15]. Interestingly, operative treatment of proximal humerus fractures was associated with a lower death rate (and a lower discharge to a facility rate), which may indicate that operative treatment was the preferred treatment in active, younger, and healthier patients with a

fracture of the proximal humerus, and additional study is merited. To combine all comorbidities seems contestable, because some comorbidities (hypertension and coronary artery disease without acute myocardial infarction) were not associated with a higher mortality in our study and in another study [3]. Some comorbidities appeared to be associated with a better outcome. Obesity was reported to be protective in a study about primary shoulder arthroplasty, and in patients with hip fractures, also called the “obesity paradox” [2, 30]. In our cohort, however, obesity was present in less than 3% of all patients, which seemed to be an underestimation in comparison to the prevalence of 35% in all US adults, especially during the past few years [11]. More evident were the negative consequences of postoperative adverse events of pneumonia and intubation and mechanical ventilation in our study, which theoretically may be decreased with intensive chest physiotherapy [34]. Diabetes mellitus was not a strong predictor of death. Interestingly, sex did not appear to be a risk factor for negative outcomes in our study in contrast to a study about mortality in pelvic fractures [13]. Risk factors for discharge to a facility in patients with a proximal humeral fracture are not well described. Our study revealed older age, concomitant lower limb fractures, obesity, dementia, congestive heart failure, and acquired pneumonia as major risk factors. These data may be helpful to facilitate more rapid and appropriate transfer of hospitalized patients with proximal humerus fractures.

In a large group of patients with proximal humeral fractures treated in US hospitals between 1990 and 2007, the presence of distinct clinical and nonclinical risk factors (older age, concomitant fractures, and certain comorbidities) increased the rate of in-hospital adverse events, discharges to facilities, and death. Diabetes mellitus was not a strong predictor of negative in-hospital outcomes in patients with proximal humeral fractures. The knowledge of these risk factors may guide further monitoring and earlier organization of rapid transfer to a long-term facility. Comorbidities should be considered in the management of inpatients with proximal humeral fractures.

Appendix 1. ICD-9 codes*

Injury, comorbidity, complication and treatment	Corresponding ICD-9 codes
Concomitant injury	
Fracture of skull	800–804
Fracture of neck and trunk	805–809
Fracture of clavicle	810
Fracture of scapula	811

Appendix 1. continued

Injury, comorbidity, complication and treatment	Corresponding ICD-9 codes
Fracture of humerus	812
Fracture of radius and ulna	813
Fracture of neck of the femur	820
Fracture of femur	821
Fracture of tibia and fibula	823
Fracture of ankle	824
Fracture of tarsal/metatarsal bones	825
Head trauma	850–854
Chest or abdominal trauma	860–869
Comorbidities	
Hypertensive disease	401, 402, 403, 404, 405
Diabetes mellitus	250
Obesity	278
Chronic pulmonary disease	490, 491, 492, 493, 494, 495, 496
Chronic renal disease	582, 585
Chronic liver disease	571.0, 571.2, 571.3, 571.4, 571.5, 571.6, 571.8, 571.9
Coronary artery disease	412, 413, 414, 429.2
Congestive heart failure	428
Atrial fibrillation	427.3
Chronic alcoholism	303.9
Dementia	290
Nutritional deficiency	260–269
Malignancy	140–208, 230–234
Complications	
Postoperative shock	998.0
Hematoma or seroma	998.1
Disruption of wound	998.3
Postoperative infection	998.5
Complications not elsewhere classified	997
Acute renal failure	580, 584
Myocardial infarction	410
Ventricular arrhythmias and cardiac arrest	427.4, 427.5
Pneumonia and pulmonary congestion	482, 485, 486, 514, 518.4
Iatrogenic, postoperative hypotension	458.29
Acute posthemorrhagic anemia	285.1
Pulmonary embolism	415.1
New mental disorders	291, 292, 293
Cerebrovascular disease	430, 431, 432, 433, 434, 435, 436
Fat embolism	958.1
Pulmonary insufficiency after trauma, surgery, transfusion, or acute respiratory distress syndrome	518.5, 518.7, 518.81

Appendix 1. continued

Injury, comorbidity, complication and treatment	Corresponding ICD-9 codes
Thrombotic events	451.1, 451.2, 453.2, 453.4, 453.8, 453.9
Intubation and mechanical ventilation	96.04, 96.07
Transfusion of blood (components)	99.0
Conversion of cardiac rhythm	99.6
Treatment [†]	
Internal fixation of bone without fracture reduction	78.5
Closed reduction with internal fixation	79.1
Open reduction with internal fixation	79.3
Arthroplasty hip and knee	81.5
Arthroplasty shoulder	81.8

* Four- and five-digit codes are included under the respective three and four-digit codes; [†]Additional coding information <http://www.findacode.com/>.

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