Risk factors and predictors of mortality for proximal humeral fractures

Lyndsay A Wilson, Benjamin WT Gooding, Paul A Manning, W Angus Wallace & John M Geoghegan
Nottingham Shoulder and Elbow Unit, Nottingham University Hospitals NHS Trust, Nottingham, UK

ABSTRACT

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Correspondence

Ben WT Gooding, Nottingham Shoulder and Elbow Unit, Nottingham University Hospitals NHS Trust, City Hospital Campus, Hucknall Road, Nottingham, NG5 1PB.
Tel: +44 (0)1159 249924.
E-mail: bgooding@nhs.net

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Background Risk factors for mortality after proximal humeral fracture, including socioeconomic status, are poorly defined. This retrospective review of prospectively collected data defines the epidemiology and predictors of mortality in association with proximal humeral fractures.

Methods Patients who sustained proximal humeral fractures were identified from fragility fracture and trauma databases between May 2001 and September 2012.

Results In total, 1880 patients with a mean age of 69 years and a male to female ratio of 2:3 were identified. Socioeconomic distribution is skewed towards the lowest and highest quintiles. Low-energy mechanisms caused 88% of fractures. Men sustain fractures when they are aged 10 years younger and via higher-energy mechanisms.

In total, 536 patients (29%) died within the study period with a 1-year mortality of 9.8%, rising to 28.2% at 5 years. Female gender, increasing age, pathological fracture and increased number of co-morbidities were independent variables for increased mortality.

Conclusions The present study, which was conducted over an 11-year period, is the first to combine the epidemiology and risk factors for mortality with socioeconomic rank. One-year mortality risk is twice that of the background matched population. Patient counselling with respect to increased mortality should be considered, especially in higher-risk elderly females with multiple co-morbidities.

INTRODUCTION

In the UK, fractures of the proximal humerus account for between 5–6% of all fractures [1]. They are the third most common fragility fracture (after hip and distal radius fractures) and the incidence is increasing as the population ages [2,3]. The majority occur in patients aged over 60 years, with a female gender bias (male:female = 1:3). Most proximal humeral fractures are sustained as the result of a low-energy fall [2].

Proximal humeral fractures have an excess mortality beyond that of the normal population, estimated at approximately 10% at 1 year [4–7]. Epidemiological studies have a defined age >60 years, female gender, recent decline in health, insulin-dependent diabetes mellitus, infrequent walking and neuromuscular weakness as associated with proximal humeral fractures [2]. The risk factors for mortality after these fractures are less well proven, with those suggested including male gender, increased age at onset of fracture and increased number of co-morbidities [4,7]. To date, the effect of socioeconomic status has not been studied in association proximal humeral fracture epidemiology or mortality.

The present study aimed to define the epidemiology of proximal humeral fractures in a large population of patients presenting to a major teaching hospital and to identify the risk factors predicting excess mortality.

MATERIALS AND METHODS

A retrospective analysis was conducted on prospectively collected data from adult trauma databases within a large university teaching hospital, serving a population of 2.5 million. Patients treated for a proximal humeral fracture in the adult fracture service between May 2001 and September 2012 were identified. These databases are prospectively collated by a combination of dedicated audit clerks and our osteoporosis nurse specialist.

Data were cross-checked against electronic hospital patient records to maintain accuracy and duplicate records were excluded from the database.

Low-energy fractures were defined as a fall from less than 1 m. Postcodes at the time of injury, Google maps and reference maps from the Office of National Statistics (ONS) were used to identify the patient's socioeconomic ranking. ONS data were used to verify mortality with hospital records.

Independent variables analyzed included: age, gender, co-morbidities (dementia, alcohol misuse, cardiovascular disease, cerebrovascular disease, chronic respiratory disease, chronic renal disease, diabetes mellitus, rheumatoid arthritis, Parkinson's disease, malignancy, Paget's disease, smoking, steroid use, substance abuse, neurological disease, hepatobiliary disease), hand dominance, fracture side, pathological fracture,

fracture management and socioeconomic rank (as defined by the English Indices of Multiple Deprivation 2010 [8]).

Statistical analysis

Excel, version 2010 (Microsoft, Redmond, WA, USA) was used as a database. SPSS, version 21 (IBM Corp., Armonk, NY, USA) was used to analyze the data. Comparison of proportions and means between the groups was achieved using either Fisher's exact test or an unpaired Student's *t*-test. Kaplan–Meir survival analysis was performed. Cox proportional hazards regression analysis was used to examine the effects of independent risk factors on postfracture mortality.

RESULTS

A total of 1880 patients were identified, comprising 757 patients from the inpatient trauma database, 613 patients from the outpatient trauma database and 734 patients from the fragility fracture database. Duplicate records were excluded. Although the inpatient data were captured for all patients admitted with a proximal humeral fracture over the 11-year study period, there were some gaps in the data collection for outpatient presentations. These were for the periods 2001 to 2004 and 2006 to 2007 (i.e. 4 years of missing outpatient data in total).

Epidemiology

In total, 1880 patients were identified at a mean age of 69.13 years (range 15 years to 101 years, median 71.5 years). Of these, 548 (29%) were male and 1332 patients were female. Proximal humeral fractures occur 9.52 years earlier in males ($p < 0.0001$, average age in males 62.38 years versus 71.89 years for females).

In total, 88% (1648) of patients sustained their fractures via low-energy mechanisms. In addition, 49% patients injured their left arm, 48% injured their right arm and eight patients (0.4%) sustained bilateral injuries. There were 53 patients who did not have their fracture side recorded. Hand dominance was recorded in 541 patients of whom 52% injured their dominant arm.

Fracture dislocations were present in 6.7% of patients, with 1.4% having pathological fractures. Some 2.2% of patients sustained other injuries at the time of their proximal humeral fracture (21 ipsilateral upper limb fractures, seven contralateral upper limb fractures, seven ipsilateral lower limb fractures, four contralateral lower limb fractures and three rib fractures).

Fractures were graded according to Neer's classification [9]. For the fractures, 51% were two-part fractures, 28% were three-part fractures and 9% were four-part fractures. Images were not available for review for 219 patients as a result of images being destroyed after the Hospital's conversion to an electronic radiology viewing system.

In total, 462 (24.57%) patients underwent operative fixation of their proximal humeral fracture.

The incidence of co-morbidities in our proximal humeral fracture patients is shown in Table 1. There were 835 patients (44%) who had no documented co-morbidities, 549 patients (29%) had one documented co-morbidity, 305 patients (16%) had two documented co-morbidities, 144 patients (8%) had three documented co-morbidities and 47 patients (3%) had four or more documented co-morbidities at the time of their injury.

The distribution of patients across socioeconomic ranks shows a skew towards the lowest and highest quintiles (Fig. 1).

Table 1 Incidence of co-morbidity seen in the proximal humeral fracture population

Co-morbidity	Number	Percentage	Quality and Outcomes Framework UK prevalence
Cardiovascular disease	513	27.29%	19.6%
Chronic respiratory disease	204	10.85%	7.6%
Malignancy (previous 10 years)	170	9.04%	1.8%
Smoking	167	8.88%	
Diabetes mellitus	164	8.72%	5.8%
Cerebrovascular disease	145	7.71%	1.7%
Alcohol misuse	106	5.64%	
Dementia	91	4.84%	0.5%
Rheumatoid arthritis	58	3.09%	
Chronic renal disease	41	2.18%	4.3%
Neurological disease	36	1.91%	0.8%
Parkinson's disease	34	1.81%	
Steroid use	24	1.28%	
Hepatobiliary disease	19	1.01%	
Substance abuse	7	0.37%	
Paget's disease	1	0.05%

Fig. 1 Distribution of patients by socioeconomic rank as defined by the English Indices of Multiple Deprivation 2010.

Fig. 2 Kaplan–Meier analysis showing cumulative survival against days from injury.

Mortality

During the study period, 536 patients (29%) died. Forty patients (2%) were dead at 30 days with 88 (5%) dead at 90 days. Kaplan–Meier analysis (Fig. 2) predicts 1-year mortality to be 9.8%, 2-year mortality to be 14.9%, 3-year mortality to be 20.3% and 5-year mortality to be 28.2%.

Cox proportional hazards modelling was used to identify the independent variables as significant predictors of increased mortality after proximal humeral fracture. Two cases (0.1%) were dropped as a result of incomplete data. In total, 536 events occurred within the study period with 1342 patients censored.

Female gender, increasing age at time of injury, pathological fracture and number of co-morbidities were all identified as independent variables showing a significant increase in hazard ratios in patients after proximal humeral fracture (Table 2).

DISCUSSION

As with previous epidemiological studies, we found proximal humeral fractures to be more prevalent in females (male:female = 2:3). Similarly, our database shows that proximal humeral fractures are predominantly sustained in elderly patients from falls from a standing height or less.

The English Indices of Multiple Deprivation (IMD) have been previously used to assess the effect on hip fracture incidence and mortality [10], although the association with proximal humeral fracture has never been examined. The IMD 2010 assesses pockets of population with a mean of 1500 inhabitants [Lower Super Output Areas (LSOAs)] across seven domains to give a comprehensive view of the level of social deprivation. Each LSOA is then ranked according to their score, with 1 being

the most deprived and 32 482 being the least deprived. Our database showed a skew towards proximal humeral fractures occurring in patients in the upper and lower most quintiles, although the IMD ranks are not evenly distributed across the catchment area for our institution, with a higher number of LSOAs in the middle to upper quintiles compared to the lower quintiles (0% to 20%, 171 LSOAs; 20% to 40%, 178 LSOAs; 40% to 60%, 196 LSOAs; 60% to 80%, 208 LSOAs; 80% to 100%, 192 LSOAs). When the number of proximal humeral fractures per LSOA in our local area is calculated, this still shows an increased incidence at extremes of socioeconomic rank (Fig. 3). However, as with hip fractures, no statistically significant increase in mortality was seen between socioeconomic quintiles for proximal humeral fractures [10].

The present study showed that proximal humeral fractures are occurring an average of 10 years earlier in male patients compared to female patients. These male patients are also more likely to have sustained their proximal humeral fracture from higher-energy mechanisms of injury than females (32.4% versus 7.9%; $p < 0.0001$). This suggests the trend of females presenting with proximal humeral fractures comprising individuals with fragility fractures sustained from low-energy falls, whereas males are more likely to present with high-energy injuries at a younger age. This distinction is important because the threshold for the surgical treatment of fragility fractures where poor quality bone may hinder stable fixation is likely to be higher than for higher-energy fractures in younger patients.

General Practice QOF (Quality and Outcomes Framework) data collated by the Health and Social Care Information Centre were used where available to compare the incidence of independent co-morbidities recorded in the present study with that of the UK population. In all but chronic renal disease, the incidence seen in the proximal humeral patients was higher than that of the general population (Table 1). As with all retrospective database reviews, the data available may underestimate the true level of patient co-morbidity, rendering the positive associations of increased co-morbidity even stronger. We have attempted to make the databases as accurate as possible by cross-checking database entries with existing hospital electronic patient records.

The fracture pattern was examined using Neer's classification [9] to determine whether this impacted upon patient mortality. Because a four-part fracture is a more significant injury than a two-part fracture, it was hypothesised that four-part fractures would have a higher hazard ratio (Exp B). The data showed that the hazard ratio appeared to decrease with increasing fracture severity (two-part Exp B = 1.676; three-part Exp B = 1.288; four-part Exp B = 0.847). On evaluation of the mechanism of injury, a similar proportion of the fractures were being sustained by low mechanisms of injury in each group, suggesting fragility type fractures (two-part = 86.46%; three-part = 90.13%; four-part = 86.78%). However, 51.66% of patients with a four-part fracture sustained from a low-energy mechanism were admitted to hospital as a result of their fracture, with only 35.16% of three-part fractures and 34.70% of two-part fractures being admitted to hospital

Table 2 Cox proportional hazard modelling showing hazard ratios (Exp B) for independent variables

Variable	B	SE	p-value	Exp B (95% confidence interval)
<i>Age</i>	<i>0.074</i>	<i>0.005</i>	<i><0.001</i>	<i>1.077 (1.067 to 1.086)</i>
Alcohol misuse	−0.344	0.482	0.476	0.709 (0.276 to 1.824)
Cardiovascular disease	−1.215	0.460	0.008	0.297 (0.121 to 0.731)
Chronic renal disease	−0.793	0.489	0.105	0.453 (0.174 to 1.180)
Chronic respiratory disease	−1.085	0.452	0.016	0.338 (0.139 to 0.820)
Dementia	−0.618	0.460	0.180	0.539 (0.219 to 1.329)
Diabetes mellitus	−1.103	0.457	0.016	0.332 (0.135 to 0.813)
Dominant hand	0.005	0.144	0.972	1.005 (0.757 to 1.334)
Fracture pattern				
Neer two-part	0.516	0.204	0.011	1.676 (1.124 to 2.498)
Neer three-part	0.253	0.177	0.152	1.288 (0.911 to 1.822)
Neer four-part	−0.166	0.197	0.399	0.847 (0.576 to 1.246)
Fracture side				
Right	−0.073	0.217	0.736	0.930 (0.607 to 1.423)
Left	0.051	0.096	0.599	1.052 (0.871 to 1.271)
<i>Gender: Female</i>	<i>0.505</i>	<i>0.100</i>	<i><0.001</i>	<i>1.657 (1.362 to 2.017)</i>
Hepatobiliary disease	1.178	0.606	0.052	0.308 (0.094 to 1.011)
Malignancy in last 10 years	−0.844	0.460	0.066	0.430 (0.175 to 1.059)
Neurological disease	−1.386	0.624	0.026	0.250 (0.075 to 0.850)
<i>Number of comorbidities</i>	<i>1.489</i>	<i>0.441</i>	<i>0.001</i>	<i>4.433 (1.868 to 10.523)</i>
Operative management	0.246	0.132	0.063	1.279 (0.987 to 1.658)
Paget's disease	−0.147	1.131	0.055	0.414 (0.168 to 1.018)
Parkinson's disease	−1.782	0.519	0.001	0.168 (0.061 to 0.465)
<i>Pathological fracture</i>	<i>2.096</i>	<i>0.269</i>	<i><0.001</i>	<i>8.132 (4.796 to 13.786)</i>
Rheumatoid arthritis	−1.621	0.507	0.001	0.198 (0.073 to 0.534)
Smoking	−0.882	0.459	0.055	0.414 (0.168 to 1.018)
Socioeconomic quintile				
0% to 20%	−10.220	212.538	0.962	0.000 (0.000 to 2.980×10 ¹⁷⁶)
20% to 40%	0.189	0.135	0.161	1.208 (0.927 to 1.575)
40% to 60%	0.149	0.149	0.317	1.161 (0.867 to 1.553)
60% to 80%	0.180	0.144	0.213	1.197 (0.902 to 1.589)
80% to 100%	0.125	0.146	0.392	1.133 (0.851 to 1.510)
Steroid use	−1.145	0.556	0.039	0.318 (0.107 to 0.946)
Substance abuse	−10.851	132.617	0.935	0.000 (0.000 to 1.483×10 ¹⁰⁸)

Italics represent statistically significant hazard ratios.

($p = 0.0001$). The apparent reduction in hazard ratio seen in four-part fractures might be a result of more of these patients receiving enhanced medical and social input as a direct result of their hospital admission.

Unfortunately, none of the fracture patterns achieved a significance value of $p < 0.01$, although two-part fractures, which made up 51% of our study group, came close, with $p = 0.011$ (three-part, $p = 0.152$; four-part, $p = 0.399$). A larger study sample would be required to determine whether the fracture pattern had a true impact on patient mortality and whether the hazard ratios observed in the present study can be verified.

As with previous studies, increasing age and increasing numbers of co-morbidities are associated with an increased

risk of death after proximal humeral fracture [3]. By contrast to previous studies [4,7], we found that female gender was associated with an increased risk of mortality. When combined with the demonstrated overall increased incidence of fracture in females and the trend toward females sustaining more low-energy fractures at older ages, this increased mortality in females appears to be consistent.

Gender and age-specific ONS population and mortality data were used to clarify the background mortality rate for this population. The 1-year mortality rate after proximal humeral fracture was found to be 9.8%. This is more than double the 4.25% background mortality calculated for this population. This excess mortality continues to rise to 14.9% at 2 years

Fig. 3 Incidence of proximal humeral fracture by Lower Super Output Area (approximately 1500 patients) as defined by the English Indices of Multiple Deprivation 2010.

(background mortality 8.76%), to 20.3% at 3 years (background mortality 13.56%) and to 28.2% at 5 years (background mortality 24.42 %). Thus, the treating physician should consider informing these patients that the diagnosis confers a significant increased risk of mortality for at least 5 years.

The present study of 1880 patients, which was conducted over an 11-year period, is one of the largest reported studies into proximal humeral fracture epidemiology and mortality.

Conclusions

This retrospective review of prospectively collected data over an 11-year period in a large teaching hospital comprises 1880 proximal humeral fractures.

Increased age, female gender and extremes of socioeconomic rank all pre-dispose to sustaining proximal humeral fractures. Males are more likely to sustain higher-energy fractures at younger ages.

Proximal humeral fractures confer a more than two-fold increase in mortality at 1 year (9.8%), which continues to increase to 28.2% mortality at 5 years.

Cox proportional hazards modelling has demonstrated that the independent risk factors for increased mortality from this fracture are female gender, pathological fracture, increasing numbers of co-morbidities and increasing age at injury. Therefore, given the success in mortality reduction observed in hip fracture patients, these high-risk proximal humeral fracture patients might also benefit from a front door orthogeriatric assessment and multidisciplinary team review at the time of their injury.

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