Fractures of the shaft of the humerus
AN EPIDEMIOLOGICAL STUDY OF 401 FRACTURES

We studied the epidemiology of 401 fractures of the shaft of the humerus in 397 patients aged 16 years or older. The incidence was 14.5 per 100 000 per year with a gradually increasing age-specific incidence from the fifth decade, reaching almost 60 per 100 000 per year in the ninth decade. Most were closed fractures in elderly patients which had been sustained as the result of a simple fall. The age distribution in women was characterised by a peak in the eighth decade while that in men was more even. Simple fractures were by far the most common and most were located in the middle or proximal shaft. The incidence of palsy of the radial nerve was 8% and fractures in the middle and distal shaft were most likely to be responsible. Only 2% of the fractures were open and 8% were pathological. These figures are representative of a population with a low incidence of high-energy and penetrating trauma, which probably reflects the situation in most European countries.

Fractures of the shaft of the humerus account for 1% to 3% of all fractures1-3 and approximately 20% of all fractures involving the bone,4 but little is known about their epidemiology. To demonstrate the true epidemiology of a fracture, a study has to include all fractures occurring within a defined population over a specified period of time. To the best of our knowledge, only the study of Tytherleigh-Strong, Walls and McQueen5 satisfies these criteria. They described the epidemiology of 249 fractures of the shaft of the humerus treated in Edinburgh between 1989 and 1992.

Historically, the treatment of choice for such fractures has been functional bracing, and studies have found that the fractures heal quickly with an acceptable functional outcome.6-8 Other studies have indicated that the incidence of non-union after non-operative treatment is higher in certain patterns of fracture9,10 and that not all patients recover fully after non-operative treatment.6,7 Moreover, good results from plate fixation have been reported in selected cases.11 Recent technical advances such as angular stable screw-plate fixation may well lead to a renewed interest in the internal fixation of such fractures.10,12-17 This anticipated shift in the treatment algorithm requires updated epidemiological data.

Our aim therefore was to investigate the epidemiology of fractures of the shaft of the humerus in patients over the age of 16 years in Stockholm between 1998 and 1999.

Patients and Methods
The study was performed according to the Helsinki declaration,18 and the Local Ethics Committee approved the protocol.

All patients aged 16 years or more admitted to any of the six major hospitals in the County of Stockholm with a fracture of the shaft of the humerus between 1 January 1998 and 31 December 1999 were included in the study. These hospitals serve a population of 1.8 million, of whom 1.4 million are aged 16 years or more. This is approximately 20% of the total population of Sweden.19 The seventh hospital, with a catchment of 76 000 residents, was excluded because the database in the radiology department was incompatible. The patients from the six major hospitals were identified from computer files in their local radiology department. A total of 401 fractures in 397 patients was identified by reviewing the reports of all radiographs of the upper arm, including the shoulder and the elbow (> 20 000). In addition to the major hospitals, there are 21 smaller outpatient clinics in the Stockholm area which handle mainly minor injuries. In order to estimate the number of patients with fractures of the shaft of the humerus who had not been admitted or referred to any of the major hospitals in the study, we examined all radiographs at one of the largest outpatient clinics and found only two additional fractures.
The series contained 361 traumatic fractures which were classified according to the Orthopaedic Trauma Association system.20,21 Of the remaining 40 fractures, 34 (8.5%) were pathological and 6 (1.5%) peri-prosthetic. Open fractures were classified using the Gustilo system.22,23 Information about the mechanism of injury, age, gender, side and presence of injury to the radial nerve was retrieved from the medical records. The mechanism of injury was classified as a simple fall, fall from a height, traffic-related accident, sport-related and miscellaneous (e.g. spontaneous pathological fractures and assault). A simple fall was defined as that from a standing height and a fall from height as that from a higher level, such as falling down stairs or from furniture.

The overall incidence and the age-specific incidence were calculated on the basis of data from Statistics Sweden.24

**Statistical analysis.** The statistical software used was SPSS 13.0 for Windows (SPSS Inc., Chicago, Illinois). The independent samples t-test was used for scale variables in independent groups. Nominal variables were tested by the chi-squared test. All tests were two-sided. Logistic regression analysis was performed to identify causative factors for palsy of the radial nerve. The site of fracture, the pattern, age, and mechanism of injury were treated as independent variables. The values were expressed as the odds ratio (OR) with corresponding 95% confidence intervals (CI) and p-values. The results were considered to be significant at p < 0.05.

### Results

The background data and age distribution for the series are shown in Table I and Figure 1. Most of the fractures were closed injuries in elderly patients resulting from a simple fall. The mean age was 62.7 years (16 to 97). The mean age for females was 68.2 years (16 to 97) and for males 53.9 years (16 to 90) (p < 0.001). The overall age distribution was bimodal with a minor peak in the third decade and a major peak in the eighth decade. The age distribution in women was characterised by a single high peak in the eighth decade, while that in men was more even with minor peaks in the third, sixth and eighth decades.

The subgroups of the 361 traumatic fractures are shown in Table II. Type-A fractures (simple) were by far the most common (220, 61.0%) followed by type-B (wedge; 107, 29.6%) and type-C (complex; 34, 9.4%). The mid-shaft was fractured in 43.2% (156), the proximal end in 40.8% (147) and the distal end in 16% (58) of patients. Type A1.2, a simple spiral fracture of the mid-shaft, was the most common (68, 18.8%) followed by type A1.1, a simple spiral fracture of the proximal shaft (41, 11.4%) and type A3.2, a simple transverse fracture of the mid-shaft (35, 9.7%).

There were eight open fractures, seven type I and one type III according to the Gustilo system.22,23 Seven (1.7%) fractures were associated with multiple trauma.

The type of cancer causing pathological fracture is shown in Table III. Breast cancer was the most common in women and prostate cancer in men.
Palsy of the radial nerve occurred in 34 patients (8.5%); 33 had a fracture which could be classified using the orthopaedic trauma associations system while one had a peri-prosthetic fracture that could not be classified using this system. The number of injuries to the radial nerve which occurred with each type of fracture is shown in Table IV. The highest percentage were related to type-A and type-B fractures in the middle and distal shaft. Multivariate regression analysis showed that there was an increased risk of palsy of the radial nerve with fractures of the middle or distal shaft (Table V).

The overall incidence of fractures of the shaft of the humerus was 14.5 per 100,000 per year. The age- and the gender-specific incidence are shown in Figure 2. The former gradually increased from the fifth decade and was highest in the ninth decade. The pattern was the same for the gender-specific incidence, but there were no male patients over the age of 90 years.

Discussion

The epidemiology of fractures of the humeral shaft has attracted little attention in the past and in 30 years there have been only a few pertinent studies. Most have focused on the outcome of selected groups of patients, often those admitted to a trauma centre.
Our results are in agreement with the age, distribution, gender, mechanism of injury and fracture pattern of those of the single previous comparable study by Tytherleigh-Strong et al.\textsuperscript{5} Both studies showed a bimodal age distribution with a minor peak in the third decade consisting mainly of men sustaining high-energy trauma and a second major peak in the eighth decade, mostly women with osteoporotic fractures resulting from simple falls. Other studies\textsuperscript{6,8,25,26} have suggested a younger age of distribution, probably because they contained a greater proportion of injuries from high-energy trauma referred to designated centres. Another reason for the differing results may be that the epidemiology of fractures of the shaft of the humerus reflects the overall incidence of high-energy trauma in the population studied. Our study and that of Tytherleigh-Strong et al\textsuperscript{5} reflect the relatively low incidence of high-energy trauma in Sweden and the United Kingdom compared with the relatively higher incidence in the USA.\textsuperscript{7,8,26} Furthermore, our finding of a low incidence of open fractures and patients with multiple injuries is probably the result of a low incidence of high-energy trauma in Sweden.

The overall incidence of humeral fractures at all ages was lower than that reported by Tytherleigh-Strong et al,\textsuperscript{5} although with the same age pattern and a gradually increasing incidence from the fifth decade. This reflects the influence of osteoporosis on the risk of sustaining such a fracture. A total of 75% of all fractures were found in patients over the age of 50 years. This should be taken into account if surgical intervention is being considered.

Although most fractures are simple (type A), fixation may be compromised by weak osteoporotic bone. In most of our patients the fracture was through the middle (43.2%) or proximal (40.8%) part of the shaft. This differs somewhat from the findings of Tytherleigh-Strong et al\textsuperscript{5} who used the AO classification,\textsuperscript{27} and reported an incidence of fractures of the mid-shaft of 64% and of the proximal part in 25%. This may be explained by the different methods of classifying fractures of the proximal shaft and by the fact that pathological fractures were included in their study. However, we agree with their finding of a lower incidence of distal fractures.

Of our patients, 8% had palsy of the radial nerve, which is similar to the finding of Koch et al\textsuperscript{6} and Bleeker et al.\textsuperscript{25} Others\textsuperscript{7,26,28} have reported a higher incidence of radial nerve palsy, in the range of 11% to 18%, probably due to a greater number of patients with high-energy and penetrat-

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<th>Table V. Regression analysis of factors relating to palsy of the radial nerve (95% confidence interval (CI))</th>
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\textsuperscript{*} OTA, Orthopaedic Trauma Association
\textsuperscript{†} not significant
ing injury. Most cases of palsy of the radial nerve are the result of fractures in the middle part of the humeral shaft. These accounted for 5.5% in our study which is in agreement with the results of other studies in which the figures range from 64% to 94%.6,25,28 However, the risk of radial nerve palsy seems to be greatest in the less common fracture of the distal shaft in which the nerve is trapped in the lateral intramuscular septum and is therefore particularly vulnerable.29

Pathological fractures formed 8.5% of the series. This is comparable with the 6% reported by Tytherleigh-Strong et al.3 Unsurprisingly, the most common cause of pathological fracture was breast cancer in women and prostate cancer in men. These patients pose a significant problem for the treating surgeon because of their general condition and because pathological fractures rarely heal regardless of the method of treatment. Nevertheless, fixation of the fracture is mandatory in most of these patients in order to relieve their pain and to improve their quality of life.30

Because of the way in which the Swedish health-care system is organised, patients with fractures of the shaft of the humerus are almost exclusively admitted or referred to major hospitals. We therefore have good reason to believe that our series represents most of the patients who sustained a fracture of the humeral shaft in Stockholm during the prescribed period of time and that the sample is representative of the whole population. Our study provides epidemiological data on these fractures in a population with a limited amount of high-energy and penetrating trauma, a situation which probably prevails in most European countries. This data may be used to facilitate the planning of treatment for patients with this particular fracture.

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References