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Low-trauma rib fracture in the elderly: Risk factors and mortality consequence

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ABSTRACT

Purpose: Low trauma rib fracture (hereinafter, rib fracture) is common in the elderly, but its risk factors and mortality consequence are rarely studied. We sought to define the epidemiology of rib fracture and the association between rib fracture and postfracture mortality.

Methods: The study was part of the Dubbo Osteoporosis Epidemiology Study, which was designed as a population-based prospective study, and consisted of 2041 women and men (aged ≥ 60). The incidence of rib fracture was ascertained from X-ray reports. Bone mineral density (BMD) was measured by DXA (GE-Lunar). The time-dependent Cox model was used to access the relationship between rib fracture and mortality.

Results: During the median follow-up of 13 years, 59 men and 78 women had sustained a rib fracture, making the annual incidence of 4.8/1000 person-years. Each SD (0.15 g/cm^2) lower in femoral neck BMD was associated with ~2-fold increase in the hazard of fracture (hazard ratio [HR] 1.9; 95% CI, 1.4 to 2.6 in men; and HR 2.1; 95% CI, 1.6 to 2.8 in women). Among those with a rib fracture, the incidence of subsequent fractures was 10.2/100 person-years. Compared with those without a fracture, the risk of mortality among those with a fracture was increased by ~7.8-fold (95% CI, 2.7 to 22.5) in men and 4.9-fold (95% CI 2.0 to 11.8) in women within the first year postfracture.

Conclusions: A rib fracture signifies an increased risk of subsequent fractures and mortality. The increased risk of mortality during the first 2.5 years postfracture suggests a window of opportunity for treatment.

1. Introduction

Osteoporotic fractures, also called fragility fractures or low-trauma fractures, are fractures occurring after a fall from standing height or less, without the appearance of trauma. Osteoporotic fracture is a significant risk factor for mortality and morbidity [1,2]. In the elderly population, rib fracture is one of the most common fractures [3,4]. At the population level, rib fracture accounts for approximately one quarter of all incident non-spine fractures in elderly men [3]. A large scale population-based longitudinal study found that the incidence of rib fracture was 3.5 per 1000 person years [3], with men having a higher incidence than women [4]. Moreover, individuals with a history of rib fracture had a higher risk of future limb fractures with a relative hazard of 2.3 compared to those had no prior fracture [5]. Taken together, these data suggest that in the elderly, rib fracture is a common disorder, and that a rib fracture is associated with an increased risk of subsequent fractures.

Although rib fracture is common, its risk factors have not been well documented. Few previous studies found that the risk of rib fracture was increased with advancing age [3,6,7], lower bone mineral density (BMD) [3,6], a history of prior fracture [3,6] and fall [6]. However, these studies were based on limited sample sizes [3,6] or short duration of follow-up [3,6], or focused on elderly men [3]. The relative contributions of these risk factors to the variability in rib fracture risk have not been evaluated. In recent years, it has been clear that major fractures such as hip fracture and vertebral fracture are associated with increased risk of mortality [8–10]. However, whether rib fracture is associated with an increased risk of mortality remains unknown.

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We hypothesized that elderly men and women have a higher risk of rib fracture because they have lower BMD, which is, in turn, associated with a greater risk of mortality. The present study was designed to test the hypothesis by pursuing four specific aims: (1) to define the incidence of rib fractures in men and women aged 60 years and older; (2) to define the association between bone mineral density and rib fracture; (3) to determine the contribution of risk factors to rib fracture via the population attributable risk; and (4) to determine the association between rib fracture and mortality. Addressing these aims will help better understand the magnitude and consequences of rib fracture in the general population.

2. Study design and methods

2.1. Setting and participants

This study is part of the Dubbo Osteoporosis Epidemiology study (DOES) for which details and protocol have been described elsewhere [11]. DOES is a population-based prospective investigation of risk factors for osteoporotic fractures. The study is based at Dubbo, a city of approximately 400 km from Sydney, New South Wales, Australia. The Dubbo city and surrounding areas have been selected as the setting for the study because the geographical characteristics of the area are suitable for long-term epidemiological study. The population of Dubbo included 1581 men and 2095 women aged 60 years or above, of whom 98.6% were Caucasian and 1.4% were indigenous. The present study consisted of 2041 participants (1132 women and 909 men) aged ≥60 years, who were recruited between 1989 and 1994. The median follow-up period was 12.7 years (IQR: 8.7 year to 18.9 year). In this study, we excluded individuals with non-rib incident fractures before the study enrollment. This study was approved by the St Vincent's Hospital Ethics committee and written informed consent was obtained from all participants.

Measurements

Extensive data on anthropometry, comorbidities, clinical history and lifestyle have been collected through direct interview a structured questionnaire at baseline and subsequent visits. Only baseline data were used for the present analysis. Risk factors included cigarette smoking, alcohol consumption, physical activity, history of falls in the last 12 months and a prior fracture after age 50. Current and past cigarette smoking was ascertained as the number of pack-years. At baseline, body weight (without heavy clothing and shoes) was obtained using an electronic scale. Height was measured without shoes with a wall-mounted stadiometer. BMI was calculated as weight in kilogram divided by square of height in meter (kg/m^2). Based on the WHO definition, individuals with a BMI < 25 kg/m^2 were classified as 'normal-weight', BMI between 25 and 29 kg/m^2 were 'overweight', and individuals with BMI ≥ 30 kg/m^2 were classified as 'obese' [12].

Bone mineral density (BMD) was measured at the femoral neck by dual-energy X-ray absorptiometry (DXA), using GE LUNAR DPX-L densitometer (GE-LUNAR, Madison, Wisconsin, USA). The radiation dose is < 0.1 μGy and the coefficient of reliability for femoral neck BMD was 0.97 in our institution using test-retest techniques on a subgroup of 92 subjects. The study population was subdivided into osteoporotic group (BMD T-score ≤ −2.5) and non-osteoporotic group (BMD T-score > 2.5).

2.2. Ascertainment of fracture and mortality

All rib fracture events were ascertained from X-ray reports from the two (and at times three) radiology practices servicing the Dubbo study regions and clinical details and confirmed via a telephone interview. The X-ray was conducted when participant went to see the doctors. This method of complete fracture ascertainment has been validated. A low-trauma rib fracture is defined as a broken bone in any one or more of the 12 pairs of rib bones in the rib cage occurring from a less or standing-height fall without the appearance of trauma. Circumstances surrounding the fracture event are obtained from personal interview in addition to information on the radiology request form. Fractures due to major trauma and pathological fractures (fractures from Paget's disease or cancer) were excluded from the analysis.

Mortality data, including cause of death, are collected through local sources with verification from the Registry of Births, Deaths and Marriages in NSW.

2.3. Data analysis

Data analysis was performed according to a designed plan. The difference between incidence proportions were tested by the traditional Chi squared test. When the number of events was low (i.e., < 5), we used the Fisher's exact test. We then constructed the Kaplan-Meier curve for fracture, stratified by sex. The association between each and combined risk factors at baseline and incident rib fracture was formally analyzed by the Cox proportional hazards model. In this model, the time from study entry to fracture was considered outcome, and risk factors included age, BMI, cigarette smoking, baseline bone mineral density, prior fracture and fall during the past 12 months. The hazard ratio for fracture was expressed per standard deviation lower in BMD.

The relationship between rib fracture and mortality was analyzed by a time-dependent Cox model [13]. In this model, incident rib fracture was considered a time-dependent variable, and age, prior fall, prior fracture, cardiovascular disease, diabetes, hypertension, neurology, respiratory, rheumatoid arthritis were covariates. For participants who had no incident fracture, the time of follow-up was counted from the date of study entry to the date of death or the date of the last visit or the date of withdrawal from the study. For incident rib fracture cases, each individual had two lines of data: the first line was from the study entry to the date of rib fracture, the second line covered from the date of fracture to the date of death (or the date of the last visit or the date of withdrawal from the study).

In order to quantify the relative contribution of risk factors to fracture, we estimated the population attributable risk (PAR) for each statistically significant factor. For each risk factor, PAR quantifies the theoretical number of fractures that would be reduced if the risk factor were not present. The estimation of PAR was based on the Dahlqwist and Sjölander's method [14]. In this method, each risk factor was dichotomized into low risk vs high risk, and was then included in the time-variant analysis. For BMD, we dichotomized the measurement into "osteoporosis" (i.e., T-score ≤ 2.5) and non-osteoporosis (i.e., T-score > 2.5). For age, we used the age of 70 as the threshold for defining "advancing age". All data analyses were performed with the R Statistical Software (Foundation for Statistical Computing, Vienna, Austria).

3. Results

3.1. Baseline characteristics of participants

The study included 2041 (1132 women and 909 men) whose average age was ~70 years at baseline (mid-1989). During the duration of follow-up (median 12.7 years, range: 11 days to 28 years), 59 (6.5%) men out of 909 and 78 (6.9%) women out of 1132 had sustained a rib fracture. Baseline characteristics of participants stratified by fracture status and sex are described in Table 1. On average, men and women with a rib fracture had significantly lower baseline femoral neck BMD and lumbar spine BMD than those without a fracture. Moreover, compared with the non-fracture group, individuals with a rib fracture had a higher prevalence of prior fracture and falls during the previous 12 months. However, there were no statistically significant differences in body mass index, smoking and comorbidities between fracture and non-fracture participants.