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Original Article

Simplified 10-Year Absolute Fracture Risk Assessment: A Comparison of Men and Women

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Abstract

A simplified (semiquantitative) approach developed by the Canadian Association of Radiologists and Osteoporosis Canada (denoted as CAROC) for absolute fracture risk assessment incorporates age, sex, prior fragility fracture, and systemic corticosteroid use, together with bone mineral density (BMD) to define absolute fracture risk. The CAROC system has been shown to predict fracture rates in women referred for clinical BMD testing, but it is uncertain how this system performs in routine clinical practice in men who are much less likely to undergo BMD testing with potential for referral biases. Thirty-six thousand seven hundred and thirty women and 2873 men aged 50 yr or older at the time of baseline BMD testing were identified in a database containing all clinical dual-energy X-ray absorptiometry test results for the Province of Manitoba, Canada. Population-based health service records from 1987 to 2008 were assessed for fracture codes and medication use. Fracture risk under the CAROC model was categorized as low (<10%), moderate (10−20%), or high (>20%). Ten-year fracture risk estimated by the Kaplan-Meier method showed the same gradient in observed fracture risk for men and women. Despite evidence of greater referral bias in men resulting in a higher rate of clinical risk factors, the performance of the prediction algorithm was not affected.

Key Words: Absolute risk; administrative data; bone mineral density; dual-energy X-ray absorptiometry; fractures; historical cohort study; men; osteoporosis.

Introduction

Osteoporosis is a common condition in Canada, affecting up to 16% of women and 7% of men older than 50 yr *(1)*. Worldwide, the number of fracture sufferers in 2000 was estimated at 56 million, with approx 9 million new osteoporotic fractures each year *(2)*. Moreover, the case fatality rate for hip fractures can exceed 20% *(3,4)*, and all osteoporosis-related fractures can lead to significant long-term disability and decreased quality of life *(5,6)*. The ability to accurately gauge fracture risk is critical in identifying cost-effective thresholds for intervention *(7,8)*.

A simplified (semiquantitative) approach developed by the Canadian Association of Radiologists and Osteoporosis Canada (denoted as CAROC) incorporates age, sex, prior fragility fracture, and systemic steroid use, together with bone mineral

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density (BMD), to define absolute fracture risk (9). Under the CAROC system, an individual's 10-yr absolute fracture risk (combined risk for fractures of the proximal femur, vertebrae, forearm, and proximal humerus) is stratified into 3 10-yr absolute fracture risk zones designated as low risk (less than 10%), moderate risk (10−20%), and high risk (greater than 20%).

We have previously reported fracture rates under the CAROC system in women referred for clinical BMD testing (10). It is uncertain how this system performs in routine clinical practice in men, because men are much less likely to undergo BMD testing, which could introduce selection biases because of unusual or unmeasured risk factors. The current analysis specifically addressed this question in an expanded clinical database with longer follow-up that allows for direct estimation of 10-yr fracture outcomes.

Methods

Patient Population

The population for this retrospective historical cohort study consisted of all women and men aged 50 yr or older at the time of baseline dual-energy X-ray absorptiometry (DXA). Subjects were required to have results for the lumbar spine and proximal femur (total hip, femur neck, and trochanter sites) between May 1998 and March 2007 with medical coverage from Manitoba Health during the observation period, starting April 1987 and ending March 2008. As earlier software versions before May 1998 did not provide total-hip measurements, any records before this date were not included in the analysis. For those with more than 1 eligible set of measurements, only the first record was included. The study was approved by the Research Ethics Board for the University of Manitoba and the Health Information Privacy Committee of Manitoba Health.

In the Province of Manitoba, Canada, health services are provided to virtually all residents through a single public health care system. Bone density testing with DXA has been managed as an integrated program since 1997 and uses targeted case finding rather than population screening (11). Criteria and testing rates for this program have been published (12). The program maintains a database of all DXA results, which can be linked with other population-based computerized health databases through an anonymous personal identifier (13). The DXA database has been previously described with completeness and accuracy greater than 99%. Fractures can be assessed through a combination of hospital discharge abstracts (diagnoses and procedures coded using the International Classification of Disease-9-Clinical Modification system or ICA-10-CA) and physician billing claims (inpatient, outpatient, and office based) (14). Use of systemic corticosteroids and antiosteoporotic medications can be obtained by linkage to the provincial Drug Program Information Network database.

Bone Density Measurements

Dual-energy X-ray absorptiometry scans were performed and analyzed in accordance with manufacturer recommendations. Hip T-scores were calculated from NHANES III White reference values, and lumbar spine T-scores were calculated using the manufacturer USA White reference values. For men, calculations were performed with both female and sex-matched reference data. Vertebral levels affected by artifact were excluded by experienced physicians using conventional criteria (15). Before 2000, DXA measurements were performed with a pencil beam instrument (Lunar DPX; GE Lunar, Madison, WI), and after this date, a fan beam instrument was used (Lunar Prodigy; GE Lunar, Madison, WI). Instruments were cross-calibrated using anthropomorphic phantoms and 59 volunteers. No clinically significant differences were identified (T-score differences < 0.2). Therefore, all analyses are based on the unadjusted numerical results provided by the instrument. Densitometers showed stable long-term performance (coefficient of variation [CV] $< 0.5\%$) and satisfactory in vivo precision (CV: 1.7% for L1−L4 and 1.1% for the total hip) (16).

Canadian Association of Radiologists and Osteoporosis Canada Fracture Risk System

Osteoporotic fracture rates as a function of age, sex, and measured BMD were initially taken from the Malmö, Sweden, population (17). These rates have subsequently been validated in Canadian women (18). Certain clinical factors increase fracture risk independent of BMD. The most important are the following: fragility fractures (19) and prolonged systemic corticosteroid use (e.g., 3-mo or longer duration) (20). The presence of either of these factors substantially elevates fracture risk (19,20). This was operationalized under the CAROC system by increasing the risk categorization to the next level: from low risk to moderate risk or from moderate risk to high risk. When both factors are present (i.e., fragility fractures and prolonged systemic corticosteroid use), the patient is considered to be at high fracture risk, regardless of the BMD result.

Fracture Prediction and Outcomes

Each subject in the study population was assigned a basal fracture risk category according to the CAROC system (low risk: $<10\%$; moderate risk: 10−20%; and high risk: $>20\%$) based on BMD (minimum T-score for the lumbar spine, total hip, femoral neck, and trochanter) and age. Additional analyses were undertaken in which basal fracture risk was based on the femoral neck, because this site was used for modeling osteoporotic fracture rates in the source population (17) and has been designated by the World Health Organization (WHO) as the diagnostic reference site for osteoporosis diagnosis (21).

The final risk category was modified to reflect the presence of additional risk factors: any prior osteoporotic fracture (from 1987 to the date of BMD testing) and/or recent systemic corticosteroid use (in the year before BMD testing). Longitudinal health service records were assessed for the presence of major fracture codes (hip, clinical vertebral, forearm, and humerus) before and after BMD testing that were