

Incidental Vertebral Fractures Discovered With Chest Radiography in the Emergency Department

Prevalence, Recognition, and Osteoporosis Management in a Cohort of Elderly Patients

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Background: Vertebral fractures are common and usually an indication for osteoporosis treatment. However, screening is not recommended, and many fractures go undetected. Our objectives were to determine the utility of chest radiographs for detecting previously unrecognized vertebral fractures; document rates of recognition; and evaluate osteoporosis treatments.

Methods: In 2001, we conducted a cohort study in a random sample of 500 patients older than 60 years who presented to our emergency department and underwent chest radiography for any indication. The primary outcome was prevalence of moderate-to-severe vertebral fractures determined by independent radiograph review using validated semiquantitative techniques. Secondary outcomes were rates of fracture recognition according to official radiologists' reports and rates of osteoporosis diagnosis and treatment. We conducted multivariable regression analyses to determine correlates of study-defined and officially reported fractures.

Results: We excluded 36 patients with inadequate ra-

diographs and 5 for other reasons. Mean age was 75.2 years; 47% were women; and 80% were white. The prevalence of moderate-to-severe vertebral fractures according to independent review was 72 (16%) of 459; 29 (40%) of these fractures were not recorded in the official radiologists' report ($\kappa=0.64$; 95% confidence interval [CI], 0.53-0.75). A history of osteoporosis was the only independent correlate of having a vertebral fracture identified by independent review (adjusted odds ratio [OR], 2.18; 95% CI, 1.14-4.17) or by official report (adjusted OR, 4.97; 95% CI, 0.95-25.86). Of the 72 patients with fractures, only 18 (25%) had histories of osteoporosis or received osteoporosis medications.

Conclusions: One in 6 elderly patients who underwent chest radiography in our emergency department had clinically important vertebral fractures. Nevertheless, only 43 (60%) of these fractures were reported, and only 25% of patients with fractures received a diagnosis of or treatment for osteoporosis.

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OSTEOPOROSIS IS A CHRONIC progressive condition that leads to decreased bone mass and skeletal fragility.¹⁻³ In turn, this leads to fracture, disability, deformity, and even death.¹⁻⁴ At least 1 million Canadian and 10 million US residents are afflicted.¹⁻³ The annual cost of treating osteoporosis and its sequelae is \$13.8 billion a year in the United States, compared with \$7.5 billion for heart failure and \$6.2 billion for asthma.³ The most common fracture associated with osteoporosis is the vertebral compression fracture.⁴⁻¹⁰

Population-based studies using different methodologies and fracture definitions have estimated that 12% to 25% of people aged 50 to 60 years have 1 or more osteoporosis-related vertebral fractures.⁴⁻⁸ The best Canadian data, from the Canadian Multicenter Osteoporosis Study,⁷ suggest that 22% of men

and 24% of women older than 50 years have vertebral fractures on spine radiographs. Despite how common fractures are in surveillance studies, only 30% of vertebral fractures come to medical attention.^{4,8} Nevertheless, the other 70% of asymptomatic fractures are still associated with mortality, morbidity, decreased quality of life, and increased risk of future osteoporosis-related fractures.^{4,8-10} To our knowledge, no current guidelines recommend screening among the elderly population at large with formal spine radiographs, perhaps because the cost is thought to be prohibitive, because most people (75%-88%) would not have a vertebral fracture, or because of concerns about radiation exposure.

A potentially useful strategy that does not require additional radiographs would be to evaluate imaging studies performed for other reasons, to see whether vertebral fractures could be detected. Many elderly patients receive chest radiographs for any

number of indications. Given that these chest radiographs are already being performed and interpreted by radiologists, we hypothesized that a chest radiograph ordered for other reasons could play a role in opportunistic case finding for osteoporosis through identification of vertebral fractures. Although this seems a straightforward hypothesis, there are few published reports of the potential utility of the chest radiograph in detecting vertebral fractures.¹¹⁻¹⁵ Furthermore, the studies published to date have examined only the official radiologists' reports rather than independently examined the radiographs,¹³ have been limited to elderly postmenopausal women,^{12,14} or have considered only hospitalized patients.¹² The most rigorous study to examine this question to date was undertaken in patients almost 10 years ago and was restricted to hospitalized elderly white women.¹²

To better appreciate the potential role of chest radiographs for opportunistic screening for vertebral fractures, a large study that includes men and women, considers inpatients and outpatients, independently reviews chest radiographs rather than relies on radiologists' official reports, and is undertaken in the current era of multiple options for the treatment of osteoporosis is needed. We undertook this study with the following 4 purposes: (1) to independently review chest radiographs to define the prevalence of clinically important moderate-to-severe vertebral fractures in a large cohort of elderly patients who presented to an emergency department for any reason; (2) to compare the true-positive rate of study-defined vertebral fractures with the prevalence of officially reported fractures in the original radiograph reports; (3) to examine rates of osteoporosis diagnosis and treatment in elderly patients with moderate-to-severe vertebral fractures; and, (4) to conduct multivariable analyses to look for potential independent correlates of the presence or absence of study-defined and officially reported vertebral fractures.

METHODS

SUBJECTS AND SETTING

In 2001, 5083 people older than 60 years underwent evaluation and chest radiography in the emergency department of a large teaching hospital in Edmonton, Alberta. Using the personal identifiers of this potentially eligible cohort stored within the computerized records of the emergency department information systems and the random number generator capacity within this database, we randomly selected 500 patients (approximately 10% of the sample) for detailed review of the radiographs and medical charts. Specifically, any patient who was 60 years or older, who was seen and treated in the emergency department, and who underwent standard posteroanterior and lateral chest radiography for any reason from January 1 through December 31, 2001, was eligible for inclusion. Research staff excluded 41 subjects because they did not have a lateral projection for review ($n=20$), their films were of such poor quality that most of the vertebrae could not be visualized ($n=16$), they died ($n=3$), or they left against medical advice ($n=2$). Emergency physicians and radiologists were unaware of the study at the time of seeing the patient or reviewing the radiographs, respectively. The study was approved by the University of Alberta (Edmonton) Health Research Ethics Board.

PRIMARY OUTCOME

The main variable of interest was the presence or absence of a clinically important moderate-to-severe vertebral fracture on chest radiograph. We were interested in the presence or absence of a vertebral fracture easily seen by most observers reporting chest radiographs, that is, a method that would not require direct measurement of vertebral body heights. We therefore used semiquantitative techniques initially defined by Genant et al,¹⁵ which we previously demonstrated to be reliable and valid.¹¹ These techniques involved comparing height ratios for anterior, middle, and posterior regions of each vertebra that was seen in the lateral projection from level T2 through L2 and grading them according to severity from grades 0 (normal) to 3 (severe).^{11,15} We defined a priori that a clinically important vertebral fracture was one that was at least moderate to severe (\geq grade 2), translating into a 25% or greater loss of vertebral body height with wedge, crush, or biconcave morphology.^{11,15}

We previously reported these methods and the results of an evaluation of 100 chest radiographs for prevalent vertebral fractures, including interrater reliabilities across 3 different study radiologists (simple agreement, 87%-89%; κ , 0.56-0.58) and between our reference standard radiologist and quantitative digital vertebral morphometry (simple agreement, 89%; $\kappa=0.67$).¹¹

Operationally, chest radiographs of all patients were bookmarked in the hospital's digital archiving system. This allowed study reviewers to independently view radiographs, but blinded them to official radiologist reports as well as other clinical data. Chest radiographs were initially reviewed by 1 study radiologist (N.K.), and all films with a moderate-to-severe fracture were reviewed again and confirmed by a reference standard radiologist (H.J.) with published expertise in interpreting films for osteoporosis trials.

OTHER MEASUREMENTS

Research staff independently abstracted the official radiologist report for any qualifying chest radiograph. These radiographs were interpreted and reported by any 1 of 15 full-time board-certified radiologists working at the hospital. Official reports were reviewed to determine whether they documented the presence of a vertebral fracture. A fracture was considered to have been present if there was any notation in the report mentioning a vertebral fracture, deformity, compression, wedging, or loss of height.

Our research staff also independently (ie, without knowledge of the presence of study-defined vertebral fractures) reviewed each patient's emergency department and inpatient medical charts and collected data that included sociodemographic characteristics, chief complaint, admission status, current medications, and presence of comorbidities, including a history of osteoporosis and osteoporosis treatments. We did not have access to patients' ambulatory medical records, other than for records of their dispensed prescription medications.

STATISTICAL ANALYSIS

We report the prevalence of moderate-to-severe vertebral fractures as a simple proportion stratified by age and sex. We compared the true-positive prevalence of study-defined moderate-to-severe vertebral fractures with the prevalence of vertebral fractures in the official radiograph reports using simple agreement and chance-adjusted κ .¹⁶ We present patient characteristics according to the presence or absence of study-defined vertebral fractures using 2-tailed t tests, χ^2 tests, and odds ratios (ORs) with 95% confidence intervals (95% CI) and associated P values. Lastly, we built multivariable logistic regression models to examine the independent correlates of the presence or absence of study-

defined moderate-to-severe vertebral fractures. We adjusted models for age and sex, and considered for inclusion variables associated with the presence of fracture that were considered clinically relevant or statistically significant at $P < .10$. We used a similar strategy to examine the independent correlates of an officially reported vertebral fracture. All analyses were conducted using SAS software version 8.2 (SAS Institute Inc, Cary, NC).

RESULTS

Our final cohort of 459 randomly selected patients who were seen in the emergency department and underwent chest radiography for any reason had a mean age of 75.2 years (SD, 8.5 years); 48% were 75 years or older; about half (47%) were women; and most (80%) were white. Cardiac (23%) and pulmonary (27%) symptoms made up most of the presenting complaints, and only 6 patients presented with back pain. More than half (57%) of all patients were discharged home, and the rest were admitted to the hospital, primarily (88%) to medical wards. Overall, 67 (15%) of 459 patients had documented histories of osteoporosis in the chart. Other characteristics are presented in **Table 1**, stratified by the presence or absence of vertebral fractures.

STUDY-DEFINED VERTEBRAL FRACTURES

We found that 72 (16%) of 459 patients older than 60 years had a moderate-to-severe vertebral fracture present on chest radiograph. The **Figure** displays the prevalence of vertebral fractures stratified by age and sex and illustrates that prevalence increases with age and that women tend to have a higher prevalence than do men at most ages. Except for older age and a history of osteoporosis, there was little to distinguish patients with a vertebral fracture from those without (Table 1). In multivariable models adjusted for age and sex, the only significant correlate of the presence of a study-defined vertebral fracture on chest radiograph was a history of osteoporosis (adjusted OR, 2.18; 95% CI, 1.14-4.17).

VERTEBRAL FRACTURES DOCUMENTED IN THE OFFICIAL RADIOLOGY REPORT

Forty-three of 72 study-defined vertebral fractures were documented in the official radiology reports, for a rate of agreement of 60% (95% CI, 48%-71%) and a true-positive rate of vertebral fractures of 16% vs an officially documented rate of 9% ($\kappa = 0.64$; 95% CI, 0.53-0.75). **Table 2** presents data stratified by the presence of officially reported vertebral fractures. The presence or absence of any other abnormalities on chest radiograph (eg, pulmonary edema, pneumonia) did not influence rate of reporting (Table 2). In multivariable analyses adjusted for age and sex, again only a history of osteoporosis was associated with correct identification and reporting of a vertebral fracture (adjusted OR, 4.97; 95% CI, 0.95-25.86).

OSTEOPOROSIS MANAGEMENT IN FRACTURE PATIENTS

Of the 72 patients with study-defined vertebral fractures, only 18 (25%) had documented histories of osteo-

Table 1. Characteristics of an Elderly Cohort of 459 Patients Presenting to the Emergency Department Who Had a Chest Radiograph Performed, Stratified by the Presence or Absence of a Study-Defined Vertebral Fracture

Characteristic	No. (%) of Patients		P Value
	Without a Vertebral Fracture (n = 387)	With a Vertebral Fracture (n = 72)	
Age ≥ 75 y	183 (47)	43 (60)	.058
Male	205 (53)	35 (49)	.50
Discharged home	197 (51)	40 (56)	.49
Admitted to a medicine service	169 (44)	29 (40)	.75
Admitted for back pain	5 (1)	1 (1)	.95
Comorbidities and medical history			
Congestive heart failure	109 (28)	21 (29)	.86
Cardiovascular disease	73 (19)	16 (22)	.51
COPD	97 (25)	17 (24)	.76
Diabetes mellitus	60 (16)	11 (15)	.96
Current smoking	42 (11)	6 (8)	.52
Oral corticosteroid use	31 (8)	6 (8)	.93
Back pain	24 (6)	8 (11)	.13
Any previous fracture	25 (6)	5 (7)	.88
Osteoporosis	49 (13)	18 (25)	.006
Current medications			
Bisphosphonates	38 (10)	14 (19)	.02
Calcitonin	0	1 (1)	.02
Hormone therapy	22 (6)	3 (3)	.31
Raloxifene hydrochloride	0	0	
Calcium supplements	34 (9)	7 (10)	.80
Vitamin D supplements	8 (2)	2 (3)	.71
Official radiologist report			
Vertebral fracture present	10 (3)	43 (60)	<.001
Any demineralization mentioned	9 (2)	3 (4)	.37
Any radiographic abnormality other than a vertebral fracture	141 (36)	27 (38)	.86

Abbreviation: COPD, chronic obstructive pulmonary disease.

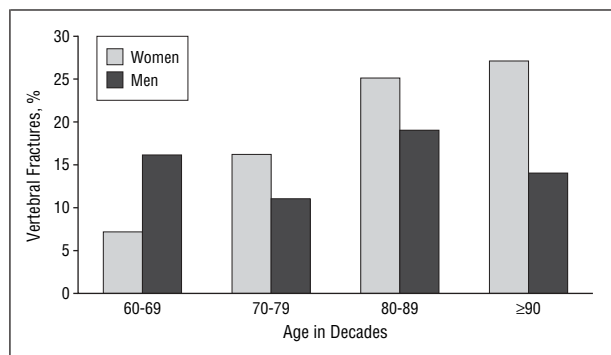


Figure. Prevalence of vertebral fractures, stratified according to age and sex.

porosis (Table 1). Osteoporosis was documented far more often in the medical chart when a patient also had a vertebral fracture on the official radiograph report than when a fracture had not been reported (16 [37%] of 43 vs 2 [7%] of 29 unreported fractures; $P = .004$) (Table 2). All but 1 of the patients with study-defined vertebral fractures and documented osteoporosis were receiving prescription treatments such as bisphosphonates; nevertheless, only 17 (24%) of 72 patients with a study-defined fracture were treated for osteoporosis (Table 1). Even

Table 2. Characteristics of the 72 Patients With a Study-Defined Vertebral Fracture, Stratified by Whether the Official Radiograph Report Mentioned a Vertebral Fracture

Characteristic	No. (%) of Patients		P Value
	Without a Reported Vertebral Fracture (n = 29)	With a Reported Vertebral Fracture (n = 43)	
Age ≥75 y	14 (48)	29 (67)	.10
Male	20 (69)	15 (35)	.005
Discharged home	16 (55)	24 (56)	.96
Admitted to a medicine service	12 (41)	17 (40)	.35
Admitted for back pain	0	1 (2)	.41
Comorbidities and medical history			
Congestive heart failure	8 (28)	13 (30)	.81
Cardiovascular disease	9 (31)	7 (16)	.14
COPD	9 (31)	8 (19)	.22
Diabetes mellitus	7 (24)	4 (9)	.09
Current smoking	3 (10)	3 (7)	.78
Oral corticosteroid use	3 (10)	3 (7)	.61
Back pain	2 (7)	6 (14)	.35
Any previous fracture	1 (3)	4 (9)	.34
Osteoporosis	2 (7)	16 (37)	.004
Current medications			
Bisphosphonates	3 (10)	11 (26)	.11
Calcitonin	0	1 (2)	.41
Hormone therapy	0	2 (5)	.24
Raloxifene hydrochloride	0	0	
Calcium supplements	2 (7)	5 (12)	.51
Vitamin D supplements	1 (3)	1 (2)	.78
Official radiologist report			
Vertebral fracture present	29 (100)	43 (100)	
Any demineralization mentioned	0	3 (7)	.15
Any radiographic abnormality other than a vertebral fracture	11 (38)	16 (37)	.95

Abbreviation: COPD, chronic obstructive pulmonary disease.

among the patients admitted to the hospital (n=198) who also had a vertebral fracture (n=32), there was no documented addition of osteoporosis medications during hospitalization or at discharge.

COMMENT

Osteoporosis-related vertebral compression fractures are common in elderly patients, although many fractures are unrecognized and do not come to medical attention.^{1-4,8-12} In a large, randomly selected cohort of elderly patients who were seen in the emergency department and had a chest radiograph taken for any reason during a 1-year period, we found a 16% prevalence of moderate-to-severe vertebral fractures. However, 29 (40%) of these 72 fractures were not reported in the official radiologists' reports. Of greater concern, perhaps, was that among those with a study-defined and clinically important vertebral fracture, only 25% had a documented history of osteoporosis or were receiving any effective treatments for secondary prevention of fracture.

In population-based studies that use spine radiographs to define prevalence of vertebral deformities and

fractures related to osteoporosis in the elderly, rates tend to be similar between men and women and range from 12% to 25%.⁴⁻⁷ These studies, however, tend to include milder grades of fracture than our a priori cutoff of moderate-to-severe fracture.⁵⁻⁷ They also examine the entire thoracic and lumbar spine, whereas we used only chest radiographs. To our knowledge, only 1 published study is comparable to ours. Gehlbach and colleagues¹² independently evaluated chest radiographs of white women 60 years and older who were admitted to a single US hospital from 1995 to 1997 and reported a prevalence of moderate-to-severe vertebral fracture of 14%, comparable to our 16%. Although our results confirm, extend, and update the findings of Gehlbach and colleagues, we have also overcome some of the limited generalizability of their study by including men, non-white patients, and outpatients in our study. Nonetheless, because of the inherent limitations of spine assessment when using only lateral chest radiographs, it is likely that we (and Gehlbach et al¹²) underestimate the true magnitude of this problem.

Compounding the problem of underestimating prevalence is the finding that 40% of vertebral fractures we identified were not reported on the official chest radiograph report. Underreporting of vertebral fractures has been previously documented^{11,12} and calls attention to an opportunity for improving the quality of radiograph reports. Inability to recognize these fractures is not the problem, as we previously demonstrated that residents, general radiology staff, and a reference standard osteoporosis radiologist all had moderate-to-substantial agreement with automated digital vertebral morphometry.¹¹ It might be hypothesized that findings related to vertebral fracture were considered incidental in nature by busy radiologists, particularly for chest radiographs that were obtained to evaluate acute illness in people with mostly cardiopulmonary complaints. If so, we would expect that chest radiographs demonstrating nonvertebral abnormalities would be less likely to have fractures reported than those that did not; however, this was not the case.

The most noteworthy finding of our study is the magnitude of the underdiagnosis and undertreatment of osteoporosis in elderly patients with a vertebral fracture. Fully 75% of these patients with vertebral fractures did not have documented histories of osteoporosis in their emergency department or inpatient medical charts. Although we do not have bone mineral density measurements, because of the patients' ages and race/ethnicity, more than 90% of these vertebral fractures would be expected to be associated with low bone mass.¹⁷ Patients with osteoporosis-related vertebral fractures (irrespective of symptoms) are at 10- to 20-fold increased risk of experiencing a fragility fracture compared with patients with normal bone mineral density and no fractures.^{1-4,18} Moreover, recent studies demonstrate that the risk of new fracture may be as high as 20% within 1 year of an incident vertebral fracture.¹⁹

Several limitations to this study need to be considered. First, we identified only moderate-to-severe vertebral fractures because, compared with milder fracture grades, moderate-to-severe fractures are associated with greater risk of future fracture; moderate-to-severe vertebral fractures are better suited to semiquantitative techniques; and higher

grades of fracture are associated with better intraobserver and interobserver reliability and specificity.^{11,12,15}

Second, we did not have access to primary care physicians' outpatient records, which might have contained additional historical data or bone mineral density measurements. It could be that the self-reported history of osteoporosis in the emergency department and associated hospital inpatient medical charts simply reflected poor record keeping in regard to osteoporosis. We believe this is unlikely because the prevalence of prescription treatments for osteoporosis (to which we had access) was virtually identical to the prevalence of documented osteoporosis. Although documentation of osteoporosis medication may be lacking in some centers, a comprehensive community- and hospital-based Internet pharmacy record for elderly Albertans ensures that reliable and valid data are available at the time of emergency department visits.

Third, concerns about the generalizability of our results can be allayed to some degree given the similarity between our prevalence estimates and population-based estimates reported from North America and Europe.⁵⁻⁸ Our results with respect to rates of diagnosis and treatment of osteoporosis are also consistent with those of North American studies.^{3,12,20,21} Previous studies found that 20% to 30% of women with radiographic evidence of prevalent vertebral fracture reported a history of osteoporosis,^{20,21} and in a cohort of 3500 postmenopausal women drawn from 7 US managed health care organizations, reported rates of treatment 1 year after a symptomatic vertebral fracture were 30%.³

CONCLUSIONS

One in 6 elderly patients who underwent chest radiography in the emergency department had evidence of moderate-to-severe vertebral fractures, but only one quarter of these patients were treated for osteoporosis. Given that treatment with any 1 of a number of agents in the setting of low bone mineral density and prevalent vertebral fracture is associated with a 40% to 50% reduction in the risk of future fractures,¹⁻⁴ we believe that our study has 2 implications. First, a large care gap exists between what the available evidence suggests ought to be done and current patterns of practice in the community. Second, an opportunity exists for health care systems to develop interventions to improve quality of care by undertaking case-finding strategies for elderly patients who have had chest radiographs taken and who are found to have incidental vertebral fractures. As the population ages, the prevalence of osteoporosis-related fractures can only be expected to increase, and it is time for us to begin implementing knowledge translation strategies that will accelerate the adoption of the evidence we already have available to us.²²

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