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# Incidental identification of vertebral compression fractures in patients over 60 years old using computed tomography scans showing the entire thoraco-lumbar spine

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## Abstract

**Introduction** Vertebral compression fractures (VCF) are frequently asymptomatic; incidental diagnosis is a valuable opportunity to identify low bone mass and to start treatment. We aimed to determine the proportion of patients over 60 years old evaluated with chest plus abdominal and pelvic computed tomography (CT) scans, allowing visualization of the entire thoraco-lumbar spine, who incidentally present VCF.

**Materials and methods** We evaluated 300 patients over 60 years old who under went chest plus abdominal and pelvic CT scans. Using sagittal reformats we looked for VCF using the method described by Genant. Accordingly, VCF were classified into mild, moderate or severe. We also determined the percentage of VCF described in the radiological reports.

**Results** In our cohort [median age 72.5 years (61–94)], 45.67% were males and 54.33% were females. In total, 43 patients (14.33%) had at least one VCF; 32 (10.67%) had one VCF, whereas 11 (3.67%) exhibited multiple VCF, with a total of 84 fractures. 42 were mild fractures, 29 moderate and 13 severe. The proportion of males (13.87%) and females (14.72%) with VCF was not different ($p = 0.83$). Patients with VCF were older than those without VCF ($p < 0.01$). Only age but not sex was independently associated with the presence of VCF. Only 32.56% of patients we identified as having a VCF had a description in their report (14 patients).

**Conclusion** An important proportion of patients over 60 years old evaluated with chest plus abdominal and pelvic CT scans present VCF. The reporting of these VCF is insufficient; radiologists and clinicians should include their detection in their search pattern.

**Keywords** Vertebral compression fractures · Opportunistic screening · Osteoporosis · Computed tomography scans · Sagittal reformations · Spinal fractures

## Introduction

Osteoporosis is one of the most important health problems worldwide. The most common manifestation of osteoporosis is the presence of vertebral compression fractures (VCF), which typically occur earlier than other osteoporotic fractures such as hip or proximal humeral fractures [1]. Unfortunately, while osteoporotic vertebral fractures are significant predictors of subsequent vertebral and non-vertebral osteoporotic fractures [2–4], many of them are asymptomatic [5]. These fractures can be detected as incidental findings in patients undergoing chest radiographs for non-spine-related symptoms [6]. In fact, several studies have demonstrated that the prevalence of VCF in adult patients can be as high as 12–25% using chest radiographs as a screening tool [7–11]. The importance of the incidental identification of VCF in patients without back pain should not be underestimated as it represents an excellent opportunity for the patients to become aware of their diagnosis of osteoporosis and to start treatment, which can significantly reduce the risk of future fractures [12]. Unfortunately, most studies have demonstrated that VCF are frequently underreported in chest radiographs reports [7–11].

Computed tomography (CT) scan is a more accurate diagnostic tool to identify and characterize VCF compared

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with plain radiographs [13, 14], and some studies have demonstrated that the midline sagittal reformations of chest or abdomen and pelvis multi-detector CT can be an excellent instrument to detect the presence of VCF opportunistically [15–20]. Previous studies have used either chest or abdomen-pelvis CT scans to evaluate the presence of incidental VCF [15–18]. However, such an approach can only visualize the thoracic or the lumbar spine, but not both areas. Given that VCF can affect both the thoracic and lumbar spine, an ideal assessment should be able to evaluate the entire thoracic and lumbar segments to better estimate the true prevalence of VCF. Despite the frequent use of simultaneous thoracic-abdominal and pelvic CT scans, to the best of our knowledge, only one study has used such reformatted images from chest-abdomen and pelvis, allowing visualization of the entire thoraco-lumbar spine [19]. However, in that study, complete visualization of the thoracic and lumbar spine was only available for a small proportion of the patients, whereas most of the patients had a localized reformat from either a chest or abdominal CT scan.

Since an entire spine image as screening tool should provide a better estimate of the true prevalence of VCF, in this study, we aimed to determine the prevalence of VCF in the complete thoraco-lumbar spine in patients older than 60 years old undergoing multi-detector chest and abdominal and pelvic CT scans using sagittal reformats as a screening tool. Additionally, we sought to identify out the rate of VCF identification in radiological reports.

## Patients and methods

Institutional review board approval was obtained to conduct this study (CEC MEdUC 170,613,002).

We studied 477 patients older than 60 years old who consecutively underwent simultaneous multi-detector chest plus abdominal and pelvic CT scans at a tertiary care university hospital from January 1st, 2014 to October 1st, 2015. If a patient underwent more than one scan during the study period, only their first examination was used for assessment. During the same period, 557 patients underwent chest CT scans only and 899 patients were studied with abdominal and pelvic CT scans in our institution; therefore, simultaneous chest plus abdominal and pelvic CT scans represented 24.6% of the total CT scans evaluating chest or abdomen and pelvis.

The CT images were requested for a variety of reasons that were not related to the spine, including fever; suspicion of a chest, abdominal or pelvic malignancy or infection; urolithiasis; and examination of malignancies under treatment. The exclusion criteria included the presence of pathological fractures or instrumentation in the thoracic or lumbar spine; we also excluded patients without a complete visualization of the thoracic and lumbar spine in sagittal reformats. A total of 177 patients were excluded mainly because of a lack of complete sagittal reconstruction (172 patients); the other exclusions were because of pathological fractures (three patients) and spine instrumentation (two patients). The criteria to consider a fracture as pathological were those described by Kubota et al.: destruction of the anterolateral and/or posterior cortex of the vertebral body, destruction of the cancellous bone of the vertebral body, destruction of the end plate, destruction of the pedicle, a paraspinal soft tissue mass, and an epidural mass [21]. Therefore, 300 patients were evaluated.

Each CT scan was obtained with a multi-detector CT scanner (GE, Milwaukee, WI). Sagittal images were reformatted from axial images using bone windows; a section thickness of 1 mm was used to reformat the images. Coronal images were also available if needed. The CT scans were reviewed using the Impax Web3000 program (Agfa-Gevaert, Mortsel, Belgium), which is available at our institution.

At the time of CT scans evaluation, the assessors were blinded to the clinical and personal data of the patients. The entire thoracic and lumbo-sacral spine was evaluated in each patient using bone contrast windows. Sagittal and coronal reconstructions were analyzed to detect the presence of VCF using the semi quantitative method described by Genant et al. [22]. The senior author reviewed all cases with fractures, either VCF or pathological to confirm the diagnosis, and to classify the severity of fractures as also described by Genant et al. into mild fracture (grade 1: reduction in vertebral height 20%–25%, compared with adjacent normal vertebrae), moderate fracture (grade 2: reduction in height 26%–40%), and severe fracture (grade 3: reduction in height greater than 40%), regardless of fracture morphology (wedge, biconcave, or crush) [22]. This methodology has demonstrated an excellent inter- and intra-observer agreement [7, 14, 22, 23]. We did not use other classifications such as the AO spine thoraco-lumbar spine injury classification system or the TLICS because they are intended to be used in traumatic fractures only. Additionally, in patients with at least one VCF, we evaluated the presence of diffuse idiopathic skeletal hyperostosis (DISH) according to the modified Resnick criteria [24], the occurrence of post-traumatic deformity and the presence of thoracic kyphosis (measured from T5–T12) greater than 40°. After fracture assessment, we reviewed official CT reports to determine which fractures were described. Finally, we reviewed at the indications for the studies in each patient to confirm that the studies were requested for reasons that were unrelated to spinal pain in all cases.

To determine sample size, we used data from Muller et al. [17] that suggested that the prevalence of VCF in adults using midline sagittal CT reformations is 24%. Assuming a condition with 24% prevalence and using an error margin

of 5% and a confidence level of 95%, the minimum sample size was 277 cases.

Statistical analyses were performed using Stata statistical software, version 13.0 (Stata Corp., College Station, TX, USA). Variables were tested for normality with the Shapiro–Wilk test. Continuous nonparametric data were described as median values and range. Categorical variables were expressed as percentages. The Mann–Whitney *U* test was used to analyze continuous nonparametric variables. Categorical variables were tested with the Fisher's exact test. A logistic regression analysis was performed to determine the independent effect of sex and age on the presence of VCF. All tests were two-tailed; a $p$ value $< 0.05$ was considered statistically significant.

## Results

We evaluated 300 patients, with a median age of 72.5 years (range 61–94 years). In total, 137 patients (45.67%) were male and 163 (54.33%) were female (Table 1).

**Table 1** Demographic data of patients with and without vertebral fractures

| Demographic data | Vertebral fracture | | |
|---|---|---|---|
| | Yes | No | *p* value |
| *n* | 43 | 257 | |
| Median age (range) years | 77 (62–92) | 72 (61–94) | 0.006* |
| Sex | | | 0.834 |
| M | 19 | 118 | |
| F | 24 | 139 | |

A total of 43 patients (14.33%) had at least one vertebral fracture. Specifically, 32 patients (10.67%) had a single fracture, whereas 11 patients (3.67%) exhibited two or more VCF, resulting in a total of 84 fractures. More than 50% of the fractures were observed between T11 and L3, as shown in Fig. 1. Nine of the 43 (20.93%) patients exhibiting at least one VCF had evidence of DISH; however, this proportion was not significantly different from the proportion of patients without CVF having DISH (70 out of 257; 27.24%, $p = 0.46$). Additionally, six of the 43 patients having at least one fracture had also a post-traumatic deformity. Another seven of these 43 patients had a thoracic kyphosis greater than 40° (measured from T5 to T12).

The proportion of males with VCF (19 patients, 13.87%) was not significantly different from the proportion of females with VCF (24 patients, 14.72%), $p = 0.83$. The proportion of females with multiple VCF (9/163; 5.5%) was larger than the proportion of males with multiple VCF (2/137; 1.5%); however, the difference did not reach statistical significance ($p = 0.07$).

Patients with at least one VCF (median age = 77 years) were significantly older than those without a fracture (median age = 72 years) ($p < 0.01$). However, median age of patients with multiple VCF (78 years) was not significantly different from median age of those without multiple VCF (72 years), $p = 0.24$.

Logistic regression analysis demonstrated that adjusting by sex and age, only age [odd ratio 1.05 (1.01–1.09)], but not sex [odd ratio 0.92 (0.50–1.71)] was independently associated with the presence of VCF.

According to the Genant classification, we identified 42 mild (50%), 29 moderate (34.5%) and 13 severe (15.5%) fractures.

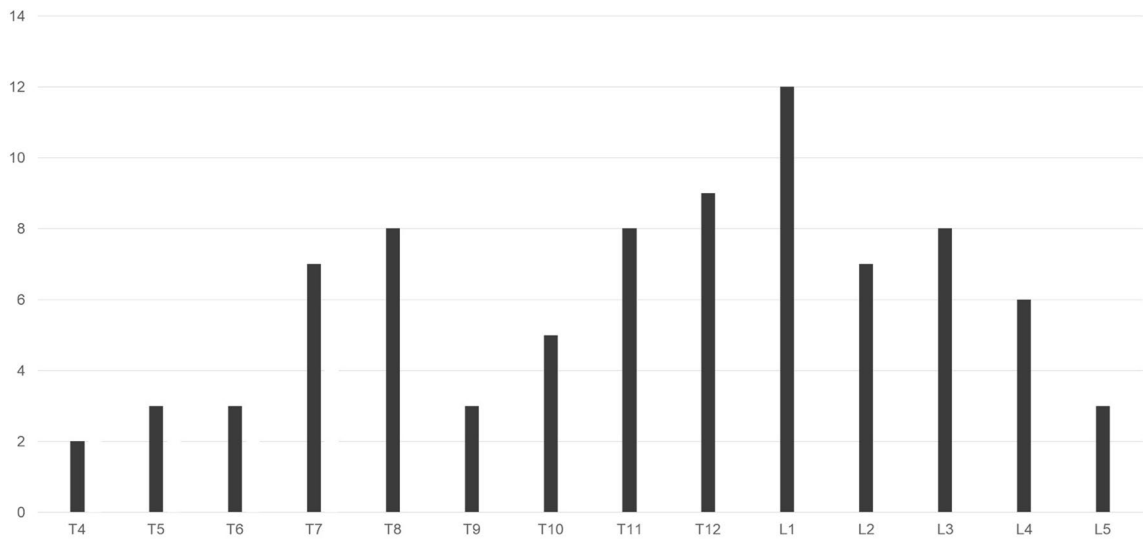


**Fig. 1** Distribution of VCF in the thoracic and lumbar spine

The presence of at least one VCF was described in the radiology report of 14 of 43 patients having a fracture (32.56%). Overall, mild fractures were less frequently described in the radiology report (3 of 24 patients) than moderate and severe fractures (11 of 19 patients), $p=0.03$. In detail, mild fractures (3 of 24 patients) were less frequently reported than moderate fractures (7 out of 13 patients, $p=0.02$), or than severe fractures (4 of 6 patients, $p=0.02$); no significant difference was found comparing the number of patients with reported moderate and severe fractures ($p=0.66$).

Finally, no age difference was observed comparing patients who had only mild fractures to patients with at least one moderate or severe fracture (median 74.5 and 80 years, respectively, $p=0.15$).

## Discussion

In our study, using sagittal reformations of chest, abdomen and pelvic CT scans allowing visualization of the entire thoraco-lumbar spine, we found that 14.33% of patients older than 60 years had at least one VCF. VCF were more frequent with advancing age.

VCF are the most common manifestation of osteoporosis. VCF prevalence increases with advancing age, reaching up to 40% in women older than 80 years old [25]. However, VCF are typically under-diagnosed because they are frequently asymptomatic or the patient's back pain is attributed to other causes, and patients do not receive appropriate osteoporosis treatment. Therefore, the incidental identification of VCF from different imaging modalities should represent an opportunity to improve the management of patients at increased risk of future osteoporotic fractures [2–4]. Thoracic-abdominal and pelvic CT scans represent an excellent opportunity to detect VCF related to osteoporosis, given that these techniques are frequently performed in the aging population. Moreover, reformatted sagittal images allow visualization of the entire thoraco-lumbar spine (Fig. 2), without the need for extra time scanning or additional exposure of the patient to radiation. Furthermore, given that the central area of the vertebral body endplate is the weakest part of the endplate, most VCF initially manifest in that area [20]. Thus, midline sagittal CT reformatted images represent an excellent tool to identify these fractures. In fact, sagittal reformations of CT scans can detect VCF more accurately than plain radiographs [14].

Prior studies have demonstrated that VCF are frequent incidental findings on radiological examinations of the chest and abdomen and especially using multi-detector chest or abdominal CT scans. In our study, which allowed visualization of the entire thoraco-lumbar spine with midline sagittal CT reformatted images, 14.33% of patients older than 60 years had at least one VCF. Such percentage is similar to other studies using plain chest radiograph as screening tool [7–11]; however, using CT scans we were able to exclude pathological fractures, which may account for a proportion of older patients showing a thoracic VCF. Of note, since the distribution of fractures included VCF from T4 to L5, we can assure we did not miss VCF that would have been missed in imaging modalities visualizing either the thoracic or the lumbar spine, but not both together. Moreover, we included mild (grade 1) VCF, and not only moderate

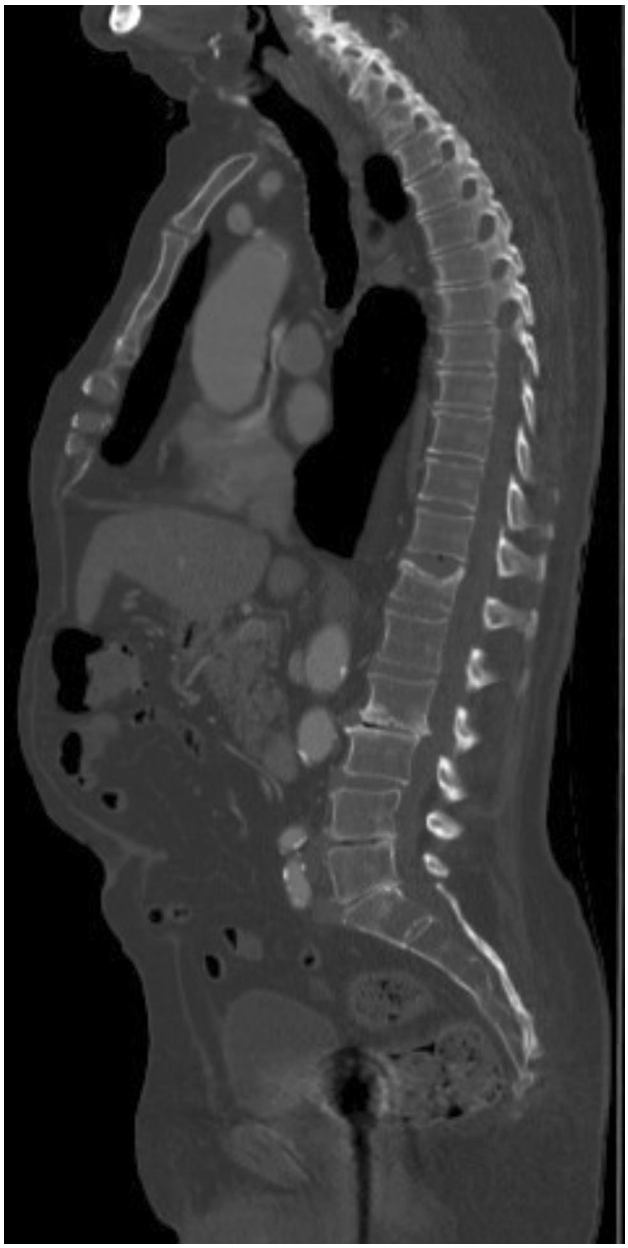

**Fig. 2** Sagittal reformat of chest, abdomen and pelvis computed tomography scan visualizing the entire thoraco-lumbar spine. A fracture at T12 was identified

(grade 2) and severe (grade 3) VCF as other studies; such an approach can better determine the actual prevalence of VCF in patients undergoing these scans. Other studies have not included mild (grade 1) fractures because some of them may be difficult to differentiate from non-fracture deformities using a semiquantitative assessment. However, we decided to include these fractures because even a mild VCF is associated with an increased risk of future fractures [2]. However, considering the cross-sectional characteristics of our study, we cannot be certain that some VCF we diagnosed were not post-traumatic or secondary to other diseases such as multiple myeloma that we could not detect. Additionally, we cannot determine how old were VCF detected; nevertheless, the incidental diagnosis of VCF, no matter the date of fracture, is still a very good opportunity to diagnose low bone mass and to start treatment.

While most studies show a larger proportion of VCF in women [9, 19], which could explain why similar studies performed only in females have disclosed up to 24% of patients with VCF [17], we observed a similar prevalence of VCF in men and women. Our study is not the first showing a similar proportion of VCF in males and females [26–28]; different hypotheses have been proposed to explain such finding, including the limitations of the morphometric approach to differentiate deformities due to VCF with other vertebral deformities (including Scheuermann's disease) [22, 29]. Additionally, some vertebral fractures may be secondary to trauma, which is more likely to affect men than women [30]. Nevertheless, we observed that a larger proportion of women than men had multiple VCF, but such difference did not reach statistical significance. We believe that the rather small number of patients with multiple VCF (two men and nine women) may have resulted in a Type II statistical error, explaining that no statistical difference by sex was observed comparing patients with multiple VCF.

In our study, patients with VCF were older than patients without them. This finding is comparable to that reported in previous studies [10], and is consistent with the well-established description of an age-related decline in bone mineral density. Furthermore, similar studies have demonstrated that patients with a VCF detected on CT scans are older than those without a fracture, regardless of sex [31]. While we observed that patients with more than one VCF were older than those without multiple VCF, that difference did not reach statistical significance; again, we hypothesize that a Type II error may explain such result.

Of note, patients with DISH did not show an increased prevalence of VCF; this is important considering that the prevalence of DISH increases with age and that the ankylosed spine is more prone to fracture than a normal spine [32].

Previous studies have shown that only a small percentage of VCF are mentioned in the radiological report, either using plain radiographs or CT as imaging modality [7–11, 16–19, 33]. In our study, only 32.59% of VCF were described in the report. The consequences of under-diagnosing VCF are important, considering the increased risk of future vertebral and non-vertebral osteoporotic fractures in these patients [2–4], and evidence demonstrating that pharmacological treatment of osteoporosis significantly reduces the risk of new fractures [2, 12]. Among the factors that may explain the underreporting of VCF using chest, abdomen and pelvic multi-detector scans, it is likely that, as spinal age-related findings are extremely frequent, radiologists consistently report VCF only if spine scans are requested; however, they may be left unreported if they are not relevant to the clinical question (e.g., staging CT scan in a patient with terminal metastatic cancer or an acutely sick patient from the intensive care unit). Moreover, it has been previously postulated that radiologists usually evaluate mainly the axial images of chest and abdominal and pelvic CT scans [19]. Such methodology may explain the under-diagnosis, given that it has been well documented that axial images can frequently overlook VCF [16, 17].

The clinical implications of VCF incidental detection should be emphasized given that in contrast to fractures in other locations, VCF are frequently asymptomatic [6, 34], and incidental diagnosis in imaging studies depicting parts or the whole spine can represent a valuable opportunity to identifyVCF and to initiate osteoporosis treatment [35]; indeed, the International Osteoporosis Foundation has judged that one best practice standard for health institutions is to develop a system whereby patients with previously unrecognized vertebral fractures are identified and undergo secondary prevention [36]. In fact, even specific physical therapy could decrease the torque over the spine, thereby reducing the possibility of new fractures [37]. Our results show that almost one in six patients over 60 years old undergoing these scans exhibit one or more VCF. These data should prompt radiologists and clinicians evaluating patients undergoing multi-detector chest, abdominal and pelvic CT scans obtained for any reason, even without a history of back pain, to actively look for VCF, especially in this age group. Furthermore, physicians evaluating chest, abdominal and pelvic CT scans should be aware of their important role detecting incidental VCF, independent of the primary reason to request the study.

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## Compliance with ethical standards

**Conflict of interest** Author Julio Urrutia, co-author Pablo Besa, and co-author Cristobal Piza declare that they have no conflict of interest.

**Ethical approval** This article does not contain any studies with human participants or animals performed by any of the authors.

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