Relationship between vertebral fracture prevalence and abdominal aortic calcification in men

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Abstract

Objective. To study the relationship between the prevalence of vertebral fractures (VFs) using VF assessment (VFA) in asymptomatic men and the prevalence and severity of abdominal aortic calcification (AAC).

Methods. We enrolled 709 men with mean (s.d.) age 62.4 (8.6) (range 45–89) years. Lateral VFA images and scans of the lumbar spine and proximal femur were obtained using a GE Healthcare Lunar Prodigy densitometer. VFs were defined using a combination of the Genant semi-quantitative (SQ) approach and morphometry. VFA images were scored for AAC using a validated 24-point scale.

Results. VFA images showed that 68 (14.2%) of the participants had at least one grade 2/3 VF, 82% did not have any detectable AAC, whereas the prevalence of significant atherosclerotic burden, defined as an AAC score of ≥5, was 2.8%. The group of men with grade 2/3 VFs had a statistically significant higher AAC score and higher proportion of subjects with extended AAC, and lower weight, height and lumbar spine and hip BMD and T-scores than those without a VFA-identified VF. Multiple regression analysis showed that the presence of grade 2/3 VFs was significantly associated with BMI [odds ratio (OR 0.915; 95% CI 0.589, 0.975; P = 0.006], AAC score ≥5 (OR 4.509; 95% CI 1.505, 13.504; P = 0.007) and osteoporosis in any site (OR 5.159; 95% CI 3.116, 8.540; P ≤ 0.0001).

Conclusion. In elderly men, extended AAC is an indicator of the increased risk for prevalent VFs regardless of age, BMI, history of fractures, smoking and BMD.

Key words: vertebral fracture assessment, dual-energy X-ray absorptiometry, osteoporosis, men, vertebral fractures, abdominal aortic calcification.

Introduction

Atherosclerosis and osteoporosis are two common diseases in the elderly population, and their prevalence is increasing worldwide with the increase of the ageing populations. Although multiple reports have suggested a link between atherosclerosis and osteoporosis [1–4], making an unequivocal connection between these two age-dependent conditions has been difficult [5].

Cardiovascular disease continues to be the leading cause of mortality among both men and women in the industrialized countries [6]. Identification of those at risk of cardiovascular disease and for whom aggressive preventive measures should be directed has relied on clinical risk factors such as hypertension, cigarette smoking, obesity, family history and diabetes mellitus. However, 40% of the population is at intermediate risk when judged by these risk factors, and it is unclear just how aggressively their modifiable risk factors, such as LDL cholesterol, should be treated [7].

Recently modern technology has focused on carotid and coronary arterial beds, and new techniques such as electron beam and helical CT can now estimate the degree of coronary calcification. Thus imaging of the aorta has received less attention. Arterial calcification is a marker of cardiovascular disease, and abdominal aortic calcification (AAC) has been shown to be strongly associated with generalized arteriosclerosis [8]. AAC scored semi-quantitatively with a 24-point scale on lateral lumbar spine radiographs was shown to be predictive of cardiovascular disease incidence and mortality independently of other clinical risk factors [9, 10].
In contrast to women, few studies have focused on the relationship between osteoporosis and cardiovascular disease in men. Extended calcifications in the abdominal aorta were associated with a 2- to 3-fold increase in the risk of osteoporotic fractures regardless of BMD and falls in one longitudinal study (MINOS) [11] and not with the hip fracture risk in another long-term follow-up study of middle-aged men (Framingham) [12]. However, data on the association between cardiovascular disease and low BMD in men remain globally discordant.

It has recently been shown that lateral spine images obtained with X-ray densitometry to detect prevalent vertebral fractures (VFs) can detect AAC with reasonably good sensitivity and specificity [13]. Lateral spine imaging with dual-energy X-ray absorptiometry (DXA), called VF assessment (VFA), has been shown to be a reliable alternative to standard radiography to detect vertebral deformities, particularly those that are grade 2/3 by Genant semi-quantitative (SQ) criteria, and can be easily performed at the time of bone densitometry with very little additional time and radiation exposure. The abdominal aorta can often be visualized on these images just anterior to the lumbar spine. Thus, if the extended AACs are associated with an increased susceptibility to fracture, they could be a useful clinical indicator of the risk of fracture easily assessed on VFA. Therefore our objective was to assess the relationship between the severity of aortic calcifications and BMD, and VF prevalence and severity in a large series of Moroccan men.

Materials and methods

Subjects

A total of 791 Caucasian men (age range 45–89 years) living in the Rabat area participated in the present study. Inclusion and exclusion criteria were described elsewhere [14]. Briefly, men were recruited prospectively through advertisements and word of mouth between December 2009 and April 2011. Original inclusion criteria were age >45 years and no previous osteoporotic fracture or known diagnosis of osteoporosis. Men with liver or renal disease, endocrine or metabolic abnormalities and receiving medicine known to influence bone mineralization, such as CSs, heparin, anticonvulsants, vitamin D or bisphosphonates, were excluded. The procedures of the study were in accordance with the Declaration of Helsinki and local ethics committee (institutional review board of the Faculty of Medicine of Rabat) approval was obtained for the study. All the participants gave informed and written consent. Medical histories, obtained by the DXA technologists before scanning, included current medication use, fracture history and current use of tobacco and alcohol. Height and weight were measured in light indoor clothes without shoes. BMI was calculated by dividing weight in kilograms by height in metres squared. Though the sample was not a true probability sample, care was taken to ensure the representativeness of the general population with particular regard to the inclusion of a wide range of body sizes and activities. We did not exclude individuals using inhalation steroids or with certain lifestyle habits such as heavy smoking, being sedentary, being athletic or having a high or low calcium intake, which are examples of voluntary factors that may have some impact on bone metabolism.

BMD measurement

BMD was determined by a Lunar Prodigy Vision DXA system (Lunar Corp., Madison, WI, USA). The DXA scans were obtained by standard procedures supplied by the manufacturer for scanning and analysis. All BMD measurements were carried out by two experienced technicians. Daily quality control was carried out by measurement of a Lunar phantom. At the time of the study, phantom measurements showed stable results. The phantom precision expressed as the coefficient of variation percentage was 0.08. Moreover, reproducibility has been assessed in clinical practice and showed a smallest detectable difference of 0.04 g/cm² (spine) and 0.02 (hips) [15, 16]. Patient BMD was measured at the lumbar spine (anteroposterior projection at L1–4) and at the femurs (i.e. femoral neck, trochanter and total hip). The World Health Organization (WHO) classification system was applied, defining osteoporosis as a T-score of −2.5 or less and osteopenia as −2.5 < T-score < −1. Study participants were categorized by the lowest T-score of the L1–4 lumbar spine, femur neck or total femur.

VFA was classified using a combination of the Genant SQ approach and morphometry in the following manner: each VFA image was inspected visually by two clinicians (M.G. and A.M. who had a previous training session in VFA) to decide whether it contained a fracture in any of the visualized vertebrae and assigned a grade based on Genant SQ scale 16, where grade 1 (mild) fracture is a reduction in vertebral height of 20–25%, grade 2 (moderate) a reduction of 26–40% and grade 3 (severe) a reduction of >40%. In case of disagreement, each vertebra that was judged as fractured by visual inspection by any of the investigators was measured using built-in morphometry to reach a consensus. Subjects with no fractures were included in the non-fracture group, whereas those with grade 1 or higher fractures were included in the fracture group. However, as many studies rarely report mild deformities as fractures, and to realize comparisons with the literature, we performed a double analysis including and excluding grade 1 fractures from the fracture group. The spinal deformity index (SDI), as described by Kerkeni et al. [18], was then calculated by summing in each patient the grade of each vertebra from T4 to L4. In theory, the SDI value can vary between 0 (no fracture) and 39 (all the assessed vertebrae are grade 3).

Assessment of aortic calcifications

To score the AAC extension, we used the score described by Kauppila et al. [19]. The anterior and posterior aortic walls were divided into four segments, corresponding to the areas in front of the lumbar vertebrae L1–4. Within each of these eight segments, aortic calcification was recognized visually as either a diffuse white stippling of
the aorta extending out to the anterior and/or posterior aortic walls, or as white linear calcification of the anterior and/or posterior walls. Aortic calcification scored as 0 if there was no calcification, as 1 if one-third or less of the aortic wall in that segment was calcified, as 2 if more than one-third but two-thirds or less of the aortic wall was calcified or as 3 if more than two-thirds of the aortic wall was calcified. The scores were obtained separately for the anterior and posterior aortic wall, resulting in a range from 0 to 6 for each vertebral level and from 0 to 24 for the total score.

Statistical analysis
Results are presented as means (s.d.) and categorical variables are expressed as frequencies. To compare patients with and without VFs, \( \chi^2 \) test and analysis of variance (ANOVA) were used first. Potential risk factors were entered to a stepwise conditional binary regression analysis and the resulting odds ratios (ORs) with 95% CIs were reported. Since a 24-point AAC scale score of \( \geq 5 \) has been shown previously to be associated with a 2.4-fold increased risk of cardiovascular disease mortality [9, 20], this cut-off was used to compare patients with and without extended AAC. The level for significance was taken as \( P < 0.05 \). Excel 2007 and SPSS 15.0 were used for statistical analysis.

Results
Among the recruited population, 709 (89.6%) of the VFA images visualized sufficient space anterior to the lumbar spine to contain the entire abdominal aorta. The mean age, BMI and BMD of participants with VFA images evaluable for AAC were equivalent to the 82 men who did not have evaluable VFA images and who were then excluded from the analysis.

Patient demographics
In this series of 709 men, the mean (s.d.) age, weight and BMI were 62.4 (8.6) (range 45–89) years, 74.9 (12.5) (range 40–120) kg and 26.4 (4.0) (range 16.6–43.8) kg/m\(^2\), respectively (Table 1). According to the WHO classification, 253 (35.7%) men had normal BMD, 348 (49.1%) were osteopenic and 108 (15.2%) were osteoporotic. Eighty-eight (12.4%) men had a history of tobacco use and 52 (7.3) were current smokers. One hundred and forty-three (20.2%) men had a history of traumatic peripheral fracture before the age of 45 years.

Vertebral visualization and fracture identification on VFA
In these 709 men, 91.6% of vertebrae from T4 to L4 and 98% from T8 to L4 were adequately visualized on VFA. The percentage of vertebrae not visualized at T4, T5, and T6 levels was 52.7, 26.2 and 13.5%, respectively.

VFs were identified using VFA in 475 (40.3%) men: 166 (26.0%) had grade 1 and 68 (14.2%) had at least one grade 2/3 VF. The prevalence of grade 2/3 VFs was 42 (38.9%) in men with osteoporosis (\( P < 0.0001 \)) compared with 15 (5.9%) in men with normal BMD and with 39 (11.2%) in men with osteopenia.

AAC evaluation
Histograms of the AAC scores on VFA images showed that 82% of the evaluable participants did not have any detectable AAC, whereas the AAC score distribution ranged between 1 and 15 (Fig. 1). Conversely, the prevalence of significant atherosclerotic burden, defined as a radiographic 24-point AAC score of \( \geq 5 \), was 2.8% and concerned only patients >66 years (Fig. 2).

Risk factors for VFs and AAC
The group of men with moderate/severe VFs had a statistically significant higher AAC score and higher

Table 1 Description of the study population (n = 709)

<table>
<thead>
<tr>
<th>Description</th>
<th>Mean (s.d.)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>62.4 (8.5)</td>
<td>45–89</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>74.9 (12.5)</td>
<td>40–120</td>
</tr>
<tr>
<td>Height, m</td>
<td>1.68 (0.06)</td>
<td>1.43–1.93</td>
</tr>
<tr>
<td>SDI</td>
<td>1.13 (2.1)</td>
<td>0–20</td>
</tr>
<tr>
<td>BMI, kg/m2</td>
<td>26.4 (4.0)</td>
<td>16.6–43.8</td>
</tr>
<tr>
<td>Lumbar spine BMD, g/cm(^2)</td>
<td>1.091 (0.1)</td>
<td>0.610–2.032</td>
</tr>
<tr>
<td>Femoral neck BMD, g/cm(^2)</td>
<td>0.935 (0.1)</td>
<td>0.607–1.425</td>
</tr>
<tr>
<td>Aortic calcifications, n (%)</td>
<td>126 (17.8)</td>
<td>–</td>
</tr>
<tr>
<td>Extended aortic calcifications</td>
<td>20 (2.8)</td>
<td>–</td>
</tr>
</tbody>
</table>

Fig. 1 Frequency distributions of the AAC 24-point score on VFA.
proportion of subjects with extended AAC, and lower weight, height and lumbar spine and total hip BMD and T-scores than those without a VFA-identified VF (Table 2). Table 3 shows a significant positive correlation between the AAC score and age and the SDI, and a significant negative correlation between the AAC score and lumbar spine and total hip BMD. Analysis according to cigarette smoking status showed that the group of current smokers had a significantly higher percentage of VFs and extended AAC and a higher AAC score than the group of ex-smokers or the group of patients who never smoked (Table 4).

When all the variables significantly associated with high VF prevalence in the univariate analysis were combined in a multiple stepwise conditional regression analysis, it showed that the presence of grade 2/3 VFs was

![Fig. 2 Prevalence of AACs in our study population according to age categories.](image)

**Table 2** Comparison between patients with and patients without VFs

<table>
<thead>
<tr>
<th></th>
<th>Patients without VFs (n = 475)</th>
<th>Patients with grade 1 VFs (n = 166)</th>
<th>Patients with grade 2/3 VFs (n = 68)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (s.d.), years</td>
<td>62.3 (8.6)</td>
<td>62.0 (8.0)</td>
<td>64.0 (9.2)</td>
<td>0.008</td>
</tr>
<tr>
<td>Weight, mean (s.d.), kg</td>
<td>76.1 (12.9)</td>
<td>73.5 (12.6)</td>
<td>70.7 (12.9)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Height, mean (s.d.), m</td>
<td>1.68 (0.06)</td>
<td>1.67 (0.06)</td>
<td>1.66 (0.06)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>BMI, mean (s.d.), kg/m²</td>
<td>26.6 (4.0)</td>
<td>26.5 (4.1)</td>
<td>24.8 (3.4)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Current tobacco use, n (%)</td>
<td>23 (4.8)</td>
<td>11 (6.6)</td>
<td>16 (26.5)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>AAC score 0-24, mean (s.d.)</td>
<td>0.5 (1.5)</td>
<td>0.3 (0.9)</td>
<td>1.3 (2.8)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Lumbar spine BMD, mean (s.d.), g/cm²</td>
<td>1.117 (0.17)</td>
<td>1.083 (0.18)</td>
<td>0.943 (0.15)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Lumbar spine T-score, mean (s.d.)</td>
<td>-0.59 (1.2)</td>
<td>-0.90 (1.4)</td>
<td>-2.1 (1.3)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Total hip BMD, mean (s.d.), g/cm²</td>
<td>0.943 (0.14)</td>
<td>0.956 (0.15)</td>
<td>0.828 (0.15)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Total hip T-score, mean (s.d.)</td>
<td>-0.82 (1.0)</td>
<td>-0.56 (1.1)</td>
<td>-1.3 (1.0)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>T-score ≤ -2.5 at any site, n (%)</td>
<td>36 (7.6)</td>
<td>41 (20.0)</td>
<td>47 (42.0)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Extended aortic calcifications (score ≥ 5), n (%)</td>
<td>11 (2.3)</td>
<td>1 (0.6)</td>
<td>8 (9.6)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

**Table 3** Correlation between demographic characteristics, BMD, AAC score and SDI

<table>
<thead>
<tr>
<th></th>
<th>BMI</th>
<th>AAC</th>
<th>LS BMD</th>
<th>TH BMD</th>
<th>SDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>-0.11a</td>
<td>0.44a</td>
<td>-0.18a</td>
<td>-0.20a</td>
<td>0.10a</td>
</tr>
<tr>
<td>BMI</td>
<td>-</td>
<td>-0.06</td>
<td>0.32a</td>
<td>0.35a</td>
<td>-0.15a</td>
</tr>
<tr>
<td>AAC</td>
<td>-</td>
<td>-</td>
<td>-0.10a</td>
<td>-0.16a</td>
<td>0.21a</td>
</tr>
<tr>
<td>LS BMD</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.60a</td>
<td>-0.33a</td>
</tr>
<tr>
<td>TH BMD</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-0.25a</td>
</tr>
</tbody>
</table>

*aCorrelation is significant at the 0.01 level (two-tailed). LS BMD: lumbar spine mineral density; TH BMD: total hip bone mineral density
associated significantly with BMI (OR 0.915; 95% CI 0.589, 0.975; \(P = 0.006\)), AAC score \(\geq 5\) (OR 4.509; 95% CI 1.505, 13.504; \(P = 0.007\)) and osteoporosis in any site (OR 5.159; 95% CI 3.116, 8.540; \(P \leq 0.0001\)).

**Discussion**

In this series of men over 45 years of age, extended aortic calcifications are indicators of the increased risk for prevalent fracture regardless of age, BMI, smoking, history of traumatic fracture and BMD. As an indicator of the risk of fracture, AAC score \(\geq 5\) is both independent (significant after adjustment for other confounding variables including BMD) and robust (adjustment for other variables has a limited effect on the OR of AAC score).

Our results agree with several studies that concluded that aortic calcification is a strong predictor of low bone density and fragility fractures in men and women from various populations [21]. A longitudinal analysis of bone loss and vascular calcification over a 25-year period in the Framingham Heart Study showed that cortical bone loss measured at the metacarpal was associated with the progression of atherosclerotic aortic calcification in women [22]. A series of publications followed indicating that aortic calcification may represent a strong predictor of low bone density and an increased risk of fracture [3, 11, 12, 23]. However, the results of clinical studies of the relationship between bone fragility and vascular calcification have been inconsistent. Most studies found that arterial calcification and low bone mass are linked, while others failed to identify a link [24]. Overall, it appears that the choice of the parameters used to assess bone loss (DXA, quantitative US or bone markers) and vascular disorders (cardiovascular events, calcification scores) or the composition of the cohorts influenced the published results [25]. On the other hand, the National Health and Nutrition Examination Survey, NHANES III, found that men with a history of myocardial infarction had a higher prevalence of low BMD [26], and more recently, cardiovascular disease in old white men has been inversely associated with BMD [27].

Cardiovascular disease and osteoporosis are major public health problems that frequently coexist and account for significant morbidity and mortality in the ageing population [28, 29]. Clinically atherosclerosis is manifested by coronary heart disease, cerebrovascular disease and peripheral arterial disease. Endothelial dysfunction is the first step in the pathogenesis of atherosclerosis and predicts future cardiovascular events. Atherosclerosis is a long-term process in which deposits of cholesterol, cellular waste products and calcium accumulates in the arterial wall, causing it to thicken. Atherosclerotic calcification is a regulated process with many cellular mechanisms similar to bone formation and resorption [30]. Since osteoblasts and marrow stromal pre-osteoblasts regulate osteoclastic differentiation in bone, some authors have recently suggested that vascular cells also regulate differentiation of osteoclastic precursors in the artery wall. Although vascular smooth muscle cells have been shown to express soluble factors known to regulate the osteoclastic differentiation process [such as receptor activator of nuclear factor kappa-B ligand (RANKL) or osteoprotegerin], the regulatory mechanisms governing this process in the vasculature are not yet clearly identified. The concept of mismatch in osteoclastogenesis and osteoblastogenesis in osteoporosis resulting in enhanced bone resorption can be applied to the process of vascular calcification, in reverse. However, many other concurrent processes modulate the milieu of bone and vascular tissue to result in the apparent paradox of simultaneous progression of atherosclerosis/calcification and demineralization of bone. Many of the established atherogenic factors such as estrogen deficiency, dyslipidaemia, oxidative stress, decreased nitric oxide availability, inflammatory cytokines, homocysteinaemia, and sedentary lifestyle negatively affect osteogenesis and mineralization [31]. Human, animal and in vitro studies reveal that some of these factors may also modulate atherosclerosis/vascular calcification.

The mechanisms linking atherosclerosis and vascular calcification to the risk of fracture are not clear. Aortic calcifications and skeletal changes share biochemical pathways, including proteins expressed in bone and atherosclerotic plaques (matrix GLA protein, osteopontin), as well as cytokines regulating bone and vascular metabolism [e.g. osteoprotegerin, bone morphogenetic proteins (mainly BMP-2), IL-6 or TNF-\[\alpha\]] [30]. Despite these intriguing findings, results of clinical studies are inconsistent, perhaps because populations, methods and the anatomical sites chosen to assess osteoporosis and atherosclerosis vary dramatically between and among studies.

A possible link between aortic calcifications and osteoporosis is the metabolic syndrome characterized by...
abdominal obesity, hypertension, glucose intolerance, hypercholesterolaemia, and hyperglyceridaemia. Metabolic syndrome is associated with an increased prevalence of cardiovascular calcifications, lower BMD and higher fracture incidence. Another putative link between aortic calcifications and bone fragility is homocysteine (Hcy). Higher Hcy level has been found to be a predictor of low BMD [32] and fracture [33] as well as a strong indicator of cardiovascular morbidity and mortality [34], and has been correlated with the extent of aortic calcifications. In vitro Hcy may impair the synthesis of covalent cross-links of the type I collagen and potentiate the calcification of vascular smooth muscle cells [35]. However, the role of Hcy as a link between fracture risk and cardiovascular pathology remains purely speculative.

Bone densitometry is now widely recommended for all men age ≥70 years. Simultaneous lateral spine imaging is now also recommended for a sizable subset of the elderly male population to detect prevalent VFs and has been shown to be cost effective for that subset [36]. Sufficient soft tissue is highly likely to be visualized on the VFA image to allow evaluation for AAC, if the technician obtaining the image is instructed to include sufficient soft tissue anterior to the lumbar vertebrae. Simultaneously, identifying an important cardiovascular disease risk factor would improve the utility of this technology for this population even further. Osteoporosis is also associated with incident cardiovascular disease, and hence delineation of cardiovascular disease risk may be particularly important for men referred for bone densitometry. We believe, therefore, that it is reasonable for those who provide bone densitometry services with VFA to instruct their technicians to attempt to visualize adequate space anterior to the lumbar spine such that AAC can be assessed. Moreover, all these arguments suggest that there is no real need to select patients for VFA, as it is now recommended by the International Society of Clinical Densitometry. Taking into account the high prevalence of VFs even in asymptomatic subjects, and even in subjects without densitometric osteoporosis, added to the possibility of detecting AAC, a marker of cardiovascular risk, it is certainly worth performing this low-cost and non-invasive exam in patients needing a BMD assessment. Regardless of whether or not assessments for AAC are planned, physicians who order and/or interpret VFA images to detect prevalent VFs should be aware of the association between AAC and incident cardiovascular disease, and consider advising a cardiovascular risk assessment.

Our study has strengths and limitations. The assessment of BMD and fractures was carefully conducted using standard procedures of acquisition and standard reading of all VFAs. All the morphometric assessments and AAC scoring were made by two experienced investigators after training sessions and after a previous global visualization. The prevalence of AAC was lower than expected in our study, which may reflect the young age of the men in our series (mean 62 years). The main limitation lies in the procedures used to select subjects, who were all volunteers and ambulatory. The Rabat population may not be adequately representative of the whole population. However, since the population living in the area of Rabat is a balanced mixture of the various regions constitutive of the country, we believe the impact on prevalence of VFs or AAC estimate is limited.

In summary, in elderly men, extended aortic calcifications are indicators of the increased risk for prevalent densitometric VF regardless of age, BMI, history of fractures, smoking and BMD. VFA imaging with a bone densitometer can simultaneously detect prevalent VFs and AAC, an important cardiovascular disease risk factor. Clinicians should be aware of the associations between AAC on VFA images and incident cardiovascular disease. If significant AAC is noted on VFA, follow-up assessment of the patient’s overall cardiovascular disease risk management should be indicated.

Rheumatology key messages

- AACs are an important cardiovascular disease risk factor.
- VFA can simultaneously detect prevalent VFs and AACs.
- Extended AACs are independent indicators of increased risk for prevalent VFs.

Disclosure statement: The authors have declared no conflicts of interest.

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