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Original Article

Opportunistic Computed Tomography Screening Shows a High Incidence of Osteoporosis in Ankylosing Spondylitis Patients With Acute Vertebral Fractures

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Abstract

Advanced ankylosing spondylitis is associated with reductions in bone mineral density (BMD), contributing to pain and predisposing to fractures. Quantifying this reduction is complicated because overgrowth of bone and loss of trabecular bone occur concurrently. Traditional methods such as dual-energy X-ray absorptiometry struggle to generate accurate estimates of BMD in these patients. The aim of this study was to evaluate the utility of computed tomography (CT) attenuation in generating estimates of BMD in patients with severe AS who had sustained vertebral fractures. Patients with severe AS and bridging syndesmophytes who presented, with acute fractures of the spine, were reviewed to assess whether they had a CT scan in the 6 mo before or after injury that included an image of the L1 vertebra; if it did, the scans were selected for analysis. A total of 17 patients were evaluated. Using a CT attenuation threshold of 135 HU balanced for sensitivity and specificity, 14 of 17 (82%) patients were osteoporotic. Using a CT attenuation threshold for higher sensitivity (160 HU), 15 of 17 (88%) patients were osteoporotic. Even using the L1 CT attenuation threshold of 110 HU for higher specificity, 14 of 17 (82%) patients were osteoporotic. CT attenuation demonstrates that a high proportion of AS patients who sustain fractures have osteoporosis. This overcomes some of the difficulties that have been encountered with the use of dual-energy X-ray absorptiometry in this group of patients. This simple and accessible method saves on time, cost, and exposure to radiation and can help in the planning of a patient's management.

Key Words: Ankylosing spondylitis; bone mineral density; CT attenuation; fracture; osteoporosis; vertebral.

Introduction

The chronic inflammation associated with ankylosing spondylitis (AS) most frequently affects the spine; the formation of syndesmophytes and the subsequent bridging of these syndesmophytes is the process that underlies the ankylosis of the spine in advanced disease. Although the process of ankylosis involves the formation of new bone, especially in the cortex of the vertebrae, it is well established that despite this neo-ossification, the overall quality of the bone is reduced *(1–3)*. Patients with AS have significantly lower bone mineral density (BMD) *(4)*, which in turn predisposes to an increase in fracture risk *(5,6)*.

Accurate characterization of the extent of bone loss and BMD can be problematic in patients with AS as the use of lumbar spine measurements from dual-energy X-ray absorptiometry (DXA) may not be accurate. New bone formation that is characteristic of AS causes an overestimation of the total BMD, and values can be normal or high, even when osteoporosis is present *(4)*. Recent work by Pickhardt et al demonstrates the utility of using conventional abdominal

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computed tomography (CT) imaging (usually ordered for reasons other than to assess bone density) to assess bone density. One can differentiate osteopenia from osteoporosis, with a sensitivity and specificity of more than 90%, in patients whose values for CT attenuation reach predefined thresholds for osteoporosis using DXA (T score ≤ -2.5). Thus, abdominal CT scans which include images of the L1 vertebra obtained for any clinical indication can be used to assess bone health, if the L1 vertebra is not fractured.

Given the difficulty in accurately measuring lumbar bone density in patients with AS, we investigated the utility of this technique in patients with advanced AS who presented to the surgical services with fractures of at least 1 vertebra.

Methods

Following Intuitional Review Board approval, we reviewed the records of patients seen at Regions Hospital between 2004 and 2013 with a diagnosis of AS who had radiographic evidence of bridging syndesmophytes and who had sustained a vertebral fracture. Those patients who also had an incidental CT scan of their abdomen or lumbar vertebrae either during their acute admission or within the 6-mo period before or after their injury were entered into the study.

Patients were scanned in a General Electric scanner (VCT 64 slice or LightSpeed 16 slice; GE Healthcare, Waukesha, WI). The CT scanners that were used for acquiring images were calibrated daily during the period of time in which all initial images were taken.

Patients' CT scans were reviewed, axial images of the L1 vertebra were obtained, and a region of interest (ROI) was identified. As described by Pickhardt et al *(7)*, we made sure that the ROI only captured trabecular bone, thus excluding the artificially elevated measures in the cortex of L1 that can occur with AS. Hounsfield units (HU) were measured for each patient who had a ROI identified. Values were obtained for area of ROI, mean HU, maximum HU count, and minimum HU count. Summary statistics were then computed for the cohort.

Thresholds outlined by Pickhardt et al which were used to differentiate osteoporosis from osteopenia and normal BMD were used for comparison; the threshold for 90% specificity was 110 HU, the threshold set for balanced sensitivity and specificity was mean HU of 135, and the threshold set for a sensitivity of 90% in making this distinction was mean HU of 160 *(7)*. To distinguish normal bone from low BMD, thresholds set for 90% sensitivity, balanced sensitivity and specificity, and 90% specificity were $\leq$135, $\geq$160, and $\geq$190 HU, respectively *(7)*.

Results

Seventeen patients with AS and fractures, as well as incidental CT scan results, were found after excluding AS patient without incidental CT scans. There were 15 males and 2 females with a mean age of 69.9 yr (range: 49–85). The majority of patients in this cohort 12 of 17 (71%) patients sustained their fractures through relatively trivial mechanisms involving falls from standing height or less or similar levels of force, whereas 5 of 17 (29%) patients were involved in motor vehicle collisions at varying velocities (Table 1).

A total of 14 of 17 (82%) patients had a BMD below the threshold of $\leq$110 HU (Fig. 1), with mean HU in this cohort of 68.9 HU (range: 1.8–103.3; standard deviation, 31.6), whereas 3 (18%) patients had a BMD above the 110 HU threshold with mean HU in this cohort of 192.8 HU (range: 147.2–257.6); this threshold is associated with 90% specificity. Of the whole cohort of 17 patients with acute spine fractures, only 1 patient had ''normal'' BMD, using the threshold for 90% specificity for differentiating between normal and low BMD.

Of the patients who had osteoporosis, 9 of 14 (64%) patients were managed nonsurgically, whereas the remainders were managed surgically. Of the 3 patients who had mean BMD greater than 110 HU, 2 had low velocity mechanisms of injury and all were treated surgically, with instrumentation present adjacent to (but not within) the L1 body, in 1 case.

Although the decision to operate frequently involves a consideration of a patient's overall health and physiological ability to cope with the surgical ''insult,'' it is unknown whether bone density was specifically factored into the decision to manage patients either surgically or nonsurgically, although fixation of constructs can be more challenging with lower quality bone.

Discussion

The ability to screen patients with AS for assessment of bone density using CT scans that may have been ordered for reasons other than their AS affords several potential advantages. The expense and extra exposure to radiation from DXA can be avoided. In addition, osteoporosis can be a feature of advancing disease; as such, this new approach to imaging may provide a simple way to track disease progression.

One of the complicating features of AS is the presence of new bone overlying areas of bone loss; this can make accurate measurements difficult (Fig. 1) *(4)*. The selection of a specific ROI, while avoiding the cortex of L1, provides a simple and repeatable method to provide estimates of bone density, with relatively good accuracy. The threshold set by Pickahrdt et al for an acceptable balance between sensitivity and specificity *(7)* found osteoporosis in 82% of our cohort, whereas the higher threshold, which provided 90% sensitivity, found osteoporosis in 88%. The threshold set for 90% specificity also found osteoporosis in 82% as none of the osteoporotic patients had BMD $\geq$110 HU.

Although osteoporosis is known to be common in patients with AS, it is often underdiagnosed and thus undertreated *(4)*, and although there remains some question about how to best treat osteoporosis in AS *(8,9)*, the ability to make a rapid diagnosis on the basis of another investigation affords the patient and clinician some choice in attempting to forestall negative consequences associated with fractures and their