CT Evaluation of Osteopenia Correlates with Thoracolumbar Fracture Incidence

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Purpose: Diagnosis of osteoporosis from CT scan without the need for additional dual-energy x-ray absorptiometry (DXA) imaging could economically and logistically improve care for trauma patients. Our purpose was to quantify bone mineral density (BMD) in seriously injured motor vehicle crash (MVC) occupants using phantom-less CT scans and to correlate BMD with age, fracture incidence, and osteopenia diagnoses.

Methods: CT scans in this study were collected from the Crash Injury Research and Engineering Network (CIREN) database, a National Highway Traffic Safety Administration program that investigates serious injuries resulting from MVCs. Data were gathered from 873 occupants (372 male, 501 female) from 8 CIREN centers. Subjects were at least 15 years old and skeletally mature. A validated, phantom-less CT calibration method to calibrate BMD in the L1-L5 vertebral body trabeculae was applied to all subject CT scans. In this method, the fat and muscle Hounsfield unit (HU) values were linearly regressed against known fat and muscle values (-69 and 77 mg/cc, respectively) to establish a conversion for L1-L5 HU measurements to mg/cc. CT-measured lumbar BMD <145 mg/cc is indicative of osteopenia using a published threshold. CIREN occupant lumbar BMD in mg/cc was correlated with age, documented osteopenia comorbidities and the incidence of vertebral (cervical, thoracic, lumbar), rib, sternum, and other fractures.

Results: Of these 873 occupants, 11% (92 occupants) were documented in CIREN with osteopenia as a comorbidity based on previous diagnosis from medical history or DXA. Of these 92 occupants, 42% (39) had ≥145 mg/cc BMD, suggesting possible misclassification in CIREN. Of the 134 occupants classified as osteopenic in BMD analysis, 60% were not documented as osteopenic in CIREN, suggesting undiagnosed osteopenia; 40% were correctly classified. Age was negatively correlated with BMD ($P \leq 0.0001$) for both males and females. Despite the occupants with <145 mg/cc BMD having a significantly lower mean crash speed than the occupants with≥145 mg/cc (34.1 vs 43.4 km/h, $P = 0.0001$), they were more likely to have fractures. These observations suggest a correlation between low BMD on phantom-less CT and the risk of vertebral fracture. Occupants with <145 mg/cc BMD sustained an average 2.1 additional rib/sternum fractures (2.3 vs 4.4 rib/sternum fractures, $P \leq 0.0001$). Analysis of vertebral fracture incidence in lumbar, thoracic, and cervical regions revealed that a greater proportion of occupants with <145 mg/cc BMD sustained thoracolumbar vertebral body fractures, with 24% of occupants with <145 mg/cc BMD sustaining fractures compared to 17% of occupants with ≥145 mg/cc BMD. The difference between these two proportions of occupants was statistically significant ($P = 0.043$, Fig. 1). A greater proportion of occupants with <145 mg/cc BMD also sustained lumbar (16%

See pages 49 - 106 for financial disclosure information.

vs 13%) and thoracic (10% vs 6%) vertebral body fractures, but the differences were not statistically significant (Fig. 1).

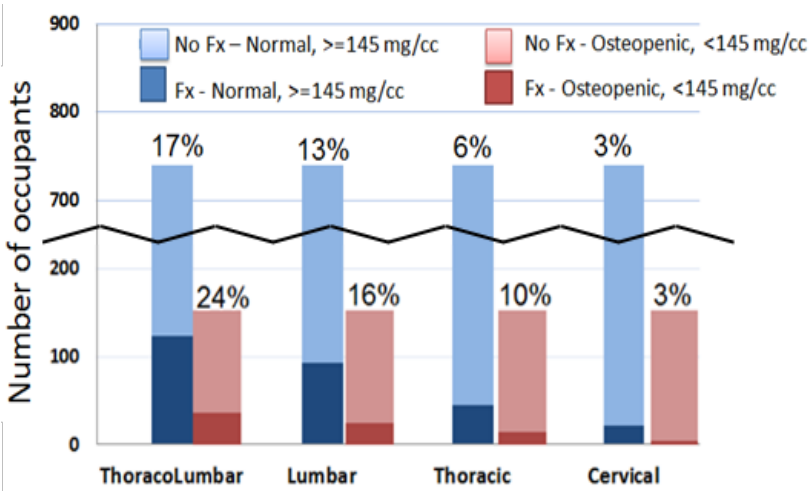

Figure 1. Proportions of vertebral fractures compared between the occupants with >=145 mg/cc and <145 mg/cc lumbar BMD values shown in blue and red bars respectively. The dark-colored bars represent the number of occupants with vertebral fractures stacked with light-colored bars representing the occupants with no fracture. The percentages represent the proportion of occupants with fracture in a specific vertebral region.

Conclusion: Low bone quality is a critical factor in determining the causation of injury and is associated with an increased number of rib/sternum fractures and a greater incidence of thoracolumbar, thoracic, and lumbar vertebral fractures in this study. Recent guidelines for post-fragility fracture treatment in the United States require osteopenia evaluation using DXA. The phantom-less technique could potentially be used in place of DXA in the future for osteopenia classification of patients with extant CT scans. This would result in decreased health-care costs and the elimination of additional radiation exposure. This phantom-less technique can be broadly applied to assess patient bone quality for clinical studies related to MVC, falls, and aging.