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Vertebral Body Hounsfield Unitfrom Computed Tomography Images - A Preliminary Study On Screening For Bone Mineral Density

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Abstract
Background:*Osteoporosis is a common cause of morbidity particularly in the aged. A simple method for performing opportunistic bone density screening in CT study involving the vertebral body has already been described in literature. The aim of the study was to establish the Hounsfield Unit for the vertebral body for T12 and L1 vertebrae in CT cases presenting to the Radiodiagnosis department.*
Materials and Methods*: The CT images of abdomen and Thorax which include T12 and L1 vertebrae were included in the study. The vertebrae were analyzed in the bone window in axial and sagittal plane (Radiant software) and ovoid ROI were placed and HU were recorded.*
Results*: 55 cases of various ages and sex were included in the study. The mean HU for T12 and L1 vertebrae has been recorded. The difference in mean HU of T12 and L1 vertebrae, for age groups, above 40 and below 40 was found to be statistically significant.*
Key words*: Hounsfield Unit , vertebrae, bone density*

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I. Background

Osteoporosis is a common cause of morbidity particularly in the aged, which is accurately screened by DEXA scan. Pickhardt et al , had introduced a simple method for performing opportunistic bone density screening in CT study involving the vertebral body. (1)

In their study, the mean HU of anterior vertebral body of L1 was measured in CT taken for Abdomen and Thorax (not directly related to Vertebral pathology) and compared to the DEXA scans.

In a 2015 study in European journal, the optimal mean attenuation threshold for differentiating normal from low bone density at L3/L4 was 145 Hounsfield Units.(2)Although another study from Europe concluded that the diagnostic performance for vertebral HU measurements was modest, with a maximal AUC of 0.74 (0.68 - 0.80). (3)

A Cambridge study in 2016, suggested that L1 vertebral density may be reliably measured on CT images and might be used as an indicator of BMD for opportunistic screening of patients with osteoporosis (4)

Jang et al, in an extensive study of around 20000 samples, concluded that mean L1 trabecular attenuation value of the entire cohort was 160 HU ± 49, whereas patients younger than 30 years had a mean L1 trabecular attenuation value of 226 HU ± 44 and patients 90 years or older had a mean L1 trabecular attenuation value of 89 HU ± 38.Mean L1 attenuation decreased linearly with age at a rate of 2.5 HU per year, averaging 226 HU ± 44 for patients younger than 30 years and 89 HU ± 38 for patients 90 years or older. Women had a higher mean L1 attenuation compared to men until menopause(5).Jang et al 10.1148/radiol.2019181648

In yet another British study published recently, 536 patients (394 females, mean age 65.8) were included, of which 174 had DEXA-defined osteoporosis. L1 attenuation measures were significantly different ($p < 0.01$) between the three DEXA-defined groups of osteoporosis (118 HU), osteopenia (143 HU) and normal bone density (178 HU). (6)

Closer still, a study from Karnataka, in 2020 study compared post and pre menopausal BMD (calculated by the software) with Quantitative CT and statistically significant difference in values were observed. (7)

Around 20000 CT examinations were done in this institution, in 2022-23, in which around 10% were abdomen and chest. This is an opportunity to document the vertebral body HU in CT images for base line documentation.

DEXA scan is not routinely available in our region.

II. Aims of Study

1.To estimate the mean HU of T12 and L1 vertebral body trabeculae of cases referred to Dept of Radiodiagnosis with no definite spinal pathology.
2. To compare the mean value of the HU so derived among the two sex and in different age groups.

III. Methods and Materials

This is a descriptive study on Computed Tomography of abdomen and thorax of 50 cases, which were randomly selected for screening of HU value of T12 and L1 vertebral trabeculae in the anterior part.
Study Duration: Six months, June 2023 to December 2023
Study design: Prospective and retrospective CT images were analyzed.
Study Setting: Department of Radiodiagnosis, Government Medical College, Thrissur, a tertiary health care centre in Kerala.
Sample Size: 50

Inclusion Criteria

CT Abdomen and Thorax images of all ages in which T12 and L1 are visualised and HU can be measured. There should not be any significant bone pathology like fractures, compression or lytic lesions in CT.

Exclusion Criteria

Significant vertebral pathology like lysis, fracture, sclerosis etc.

Methodology

MDCT of the patient referred for thoracic and abdomen pathology are included in the study. 16 slice Seimens CT machine is used for the purpose with peak voltage 120 kV. Plain CT images of thin 1.5 mm sections were analyzed.Those with pathology in vertebral body (eg compression fracture, lytic/ sclerotic metastasis) were excluded from the study.

The vertebrae was analyzed in the bone window in Axial and sagittal plane (Radiant software) and an ovoid ROI was placed in the anterior aspect of vertebral trabeculae (avoiding anterior vessels) of T12 and L1 vertebrae and mean HU was measured. It was placed in the upper third part to avoid cortical bone, sclerotic changes and middle portion of the vertebrae.
The area of ROI was same for T12 and L1 for a particular patient.

Fig 1.Measuring mean HU at T12 vertebral body

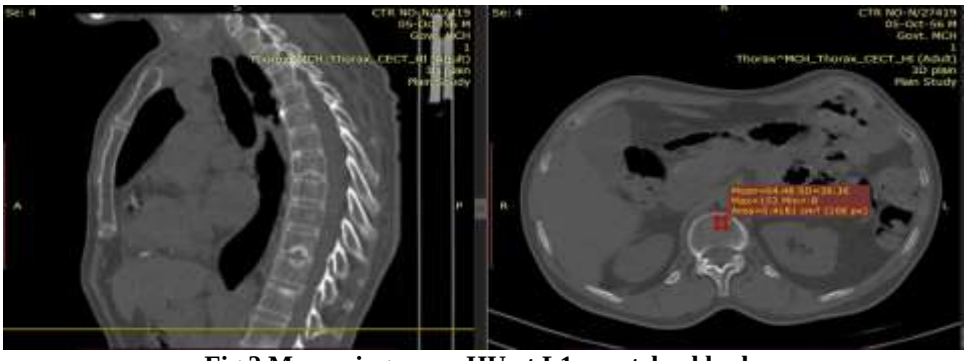

Fig 2.Measuring mean HU at L1 vertebral body

The mean HU for the T12 and L1 vertebrae derived from ROI for each case is entered in excel sheets.

Statistical tools like charts, bar diagram, average, and student T test were used for comparing among the different sex, age distribution etc.

The values derived is further used for calculating mean and for comparison for age group and for sex

IV. Results

57 cases were selected by random (in an interval during the period of study)

All the cases had T12 and L1 included .

No age group was exempted.

One Vertebral collapse, and one scleroses (due to metastasis) were excluded from the study. Hence sample size was 55 . It included 34 males (62%) and 21 females (38%).

The age distribution included 2 years upto 85 years.

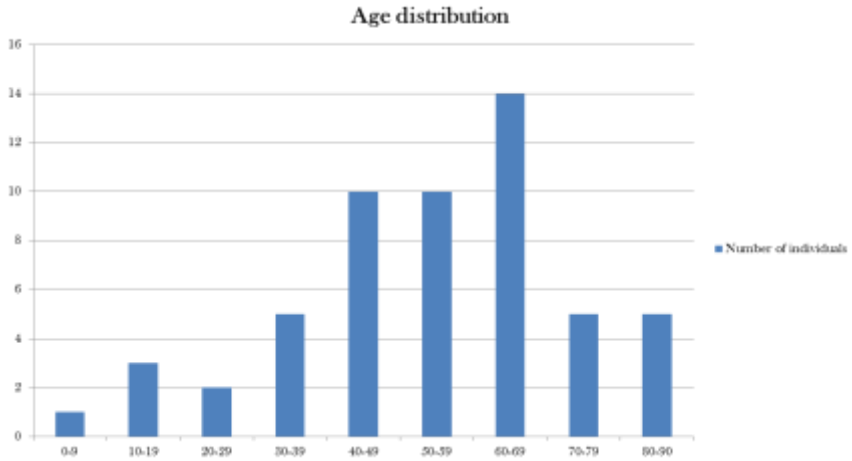

Fig 3: Age distribution of sample population

The following observations were made in the study:

Mean HU of T12 vertebrae : 172

Mean HU of L1 vertebrae : 164

Mean HU of T12 vertebrae (Male): 173

Mean HU of L1 vertebrae (Male): 166

Mean HU of T12 vertebrae (Female): 171

Mean HU of L1 vertebrae (Female): 162

Mean HU of T12 vertebrae (<40y) : 226

Mean HU of L1 vertebrae (<40y): 218

Mean HU of T12 vertebrae (>40y): 155

Mean HU of L1 vertebrae (>40y): 148

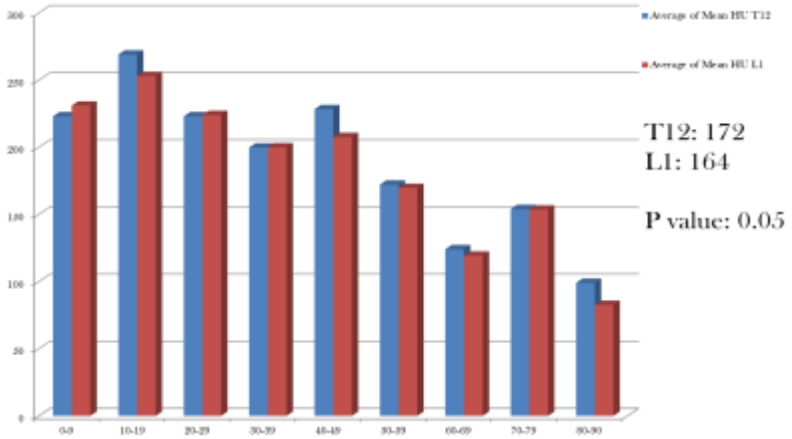

Fig 4: Mean HU plotted along Y axis and age along X axis

In individuals (including males and females) of age less than 40 years
Average of (Mean)HU for T12 vertebrae:226
Average of (Mean) HU for L1 vertebrae:218

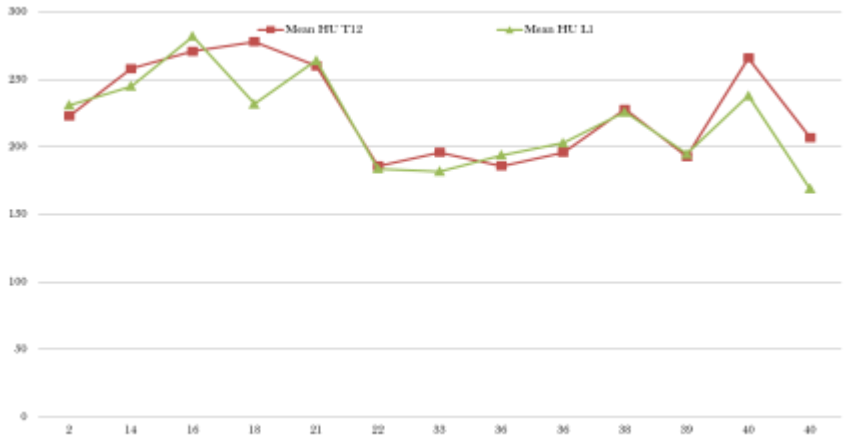

Fig 5: Line diagram of mean HU for age less than 40 years

and in individuals above 40 years
Average of (Mean) HU for T12 vertebrae: 155
Average of (Mean) HU for L1 vertebrae: 148

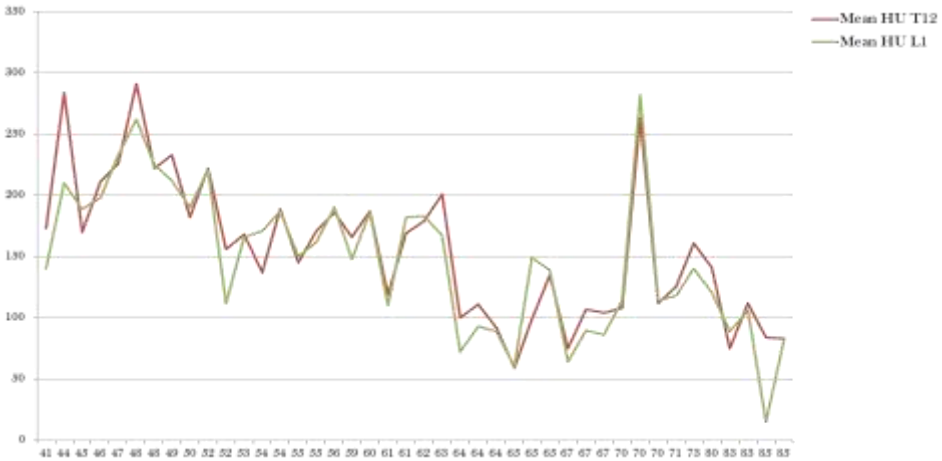

Fig 6: Line diagram of mean HU for age less above 40 years

This difference in mean HU for age group above 40 and below 40 was found to be statistically significantwith p values 0.001 (T12) and ,0.0013 (for L1)

V. Discussion

The HU values of anterior vertebral trabeculae was measured at L1 and T12 vertebral level . The mean for different age groups and sex is documented as above and compared with that available in literature. As expected, the mean HU for L1 was lesser than that of T12 vertebrae in both genders and in all age groups as degenerative changes and osteoporosis are more common in lumbar vertebrae compared to thoracic.

In this study, for T12 vertebrae, the mean HU in less than 40 years was 226 and for above 40 years was 155. Similarly for L1 vertebrae, the mean HU for less than 40 years was 218 and above 40 was 148. The mean HU in vertebrae showed a statistically significant difference in age group above and below 40 years, in L1 and T12 vertebrae. This should correspond to the decreasing density in older age group, which is usually reflected in bone mineral density studies.

This study is limited by sample size and a single observer value. Hence further recommendations are suggested, like more elaborate studies with higher sample size, different vertebral levels, or different bones and comparison study with BMD (DEXA)
Automation and simplification of the variables can greatly accelerate such work.

Safe, practical and feasible storage of data with use of PACS can make such studies more accessible and of practical use.

VI. Conclusions

The mean HU values of anterior vertebrae for various age groups and sex is hereby documented. This study concludes that the difference in mean HU of vertebrae, for age group above 40 and below 40 was found to be statistically significant.

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