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Assessment of bone mineral density in male and female patients at screening CT colonography

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Abstract

Assessment of trabecular bone mineral density at screening CT colonography (CTC) provides additional information for patients who may be at risk of fractures due to osteoporosis. Measurement using Hounsfield unit values does not add radiation dose to a patient as it is part of a low dose screening examination. Examples of measuring the HU of the first lumbar vertebra at CTC are presented.

Keywords osteoporosis, region of interest, Hounsfield unit, male osteoporosis, osteopenia

Introduction

The risk of fractures in elderly males and females with osteoporosis is a major health problem.^[1] More than 8.9 million osteoporotic fractures occur each year worldwide.^[2] Literature underscores that osteoporosis is a silent disease; its fracture sequelae place a burden on health services as well as impacting on the social and health conditions and mortality in the elderly.^[2] Common risk factors include: low body mass index, early menopause, smoking, excessive alcohol intake, lack of vitamin D, prolonged use of glucocorticoids, immobility, and history of fragility fracture.^[3] Measurement of skeletal mass usually excludes males; most studies report on osteoporosis and its consequences of fractures in post-menopausal women.^[1] A comparative study of the incidence of symptomatic fractures in elderly men and women in Australia found that there is a fracture risk in men.^[1] Despite the known risk of osteoporosis sequelae, literature reports underutilisation of available preventive strategies.^[2] The diagnosis of osteoporosis is based on the assessment of bone mineral density (BMD).^[3] Dual-energy X-ray absorptiometry (DXA or DEXA) is the most used modality to determine BMD. Other modalities such as ultrasound and computed tomography may also be used.^[3,4] This paper reports on measuring BMD at screening CTC. One of the advantages of CTC is the visualisation of extra-colonic organs and structures.^[5] This means 2D images obtained at CTC can be used to measure the BMD of the lumbar spine.^[6] This paper describes how

to measure trabecular BMD on 2D images of the lumbar spine at screening CTC.

Measurement of BMD

In DXA examinations there are usually two scores presented: T-score and Z-score. Both indicate the amount a person's BMD varies from a mean. The scores are calculated using specific statistics formulae. A T-score indicates a comparison of the BMD of a patient with that of a healthy 30 year old: T-score -1.0 = normal; -1.0 to -2.5 = osteopenia; and ≥ -2.5 = osteoporosis. The Z-score is used to compare amount of bone present with that of others in the same age group, same size and gender. These scores are used for both women and men.^[3] The purpose of assessing BMD is to identify those at risk of fractures. The findings of two studies undertaken during 2008/09 showed that concurrent screening for osteoporosis during screening CTC examinations saves patients' time and is cost-effective.^[6,7] In one of the studies the DXA reference standard was used to compare the BMD assessment at CTC.^[6] Each study reported that measuring BMD at CTC does not add radiation dose to a patient.^[6,7] Both underscored that making use of CT scans to determine BMD of the first lumbar vertebra (L1) during a screening CTC would enhance patient management because, if diagnosed early,

osteoporosis is treatable.^[6,7] An advantage of obtaining BMD measurements is that male and female patients who undergo screening CTC can be assessed for fracture risk. Reporting the HU value of L1 at screening CTC will aid in treatment and management of both males and females with osteopenia or osteoporosis.

How to measure BMD at screening CTC

The HU range of L1 or L2 at CTC is presented in Table 1. Measurement of BMD at CTC is done using the region of interest (ROI). The ROI must only include trabecular bone of a vertebra to obtain an accurate HU reading. Figures 1a and b illustrate incorrect ROI placement. It is important that ROI placement is correct to obtain the HU values of trabecular bone (Figures 1c and d). Figures 2a and b show osteoporosis at CTC in female patients. Figures 3a and b show osteoporosis in a male patient.

As evident in Figures 2 and 3 the HU values are <100 indicating osteoporosis. Figure 3b shows a grade 3 fracture. There is $\geq 40\%$ loss of vertebral height according to the Genant classification which is based on vertebral shape, and loss of vertebral height involving anterior, posterior and/or middle vertebral body. Grade 0 =

Table 1. HU range of BMD

BMD	HU
Normal	>160
Osteopenia	>100 to <160
Osteoporosis	<100

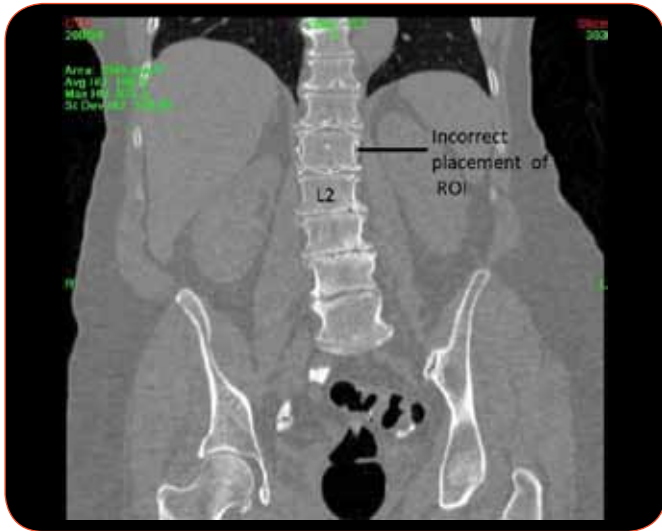


Figure 1a. Incorrect ROI placement on coronal 2D image at CTC as it extends beyond trabecular bone.



Figure 1b. Incorrect ROI placement on sagittal 2D image at CTC as it extends beyond trabecular bone.



Figure 1c. Correct ROI placement to measure BMD of lumbar vertebra at CTC. There is a vertebral venous plexus in the posterior portion of the vertebral body. Therefore in order to ensure correct placement the back of the ROI should not touch cancellous bone. Open black arrow shows average HU reading of 203.



Figure 1d. Correct ROI placement to measure BMD of L1 on a sagittal 2D scan at CTC. Open black arrow shows average HU reading of 210.



Figure 2a. HU 45 (open white arrow) showing osteoporosis at CTC in a female patient.

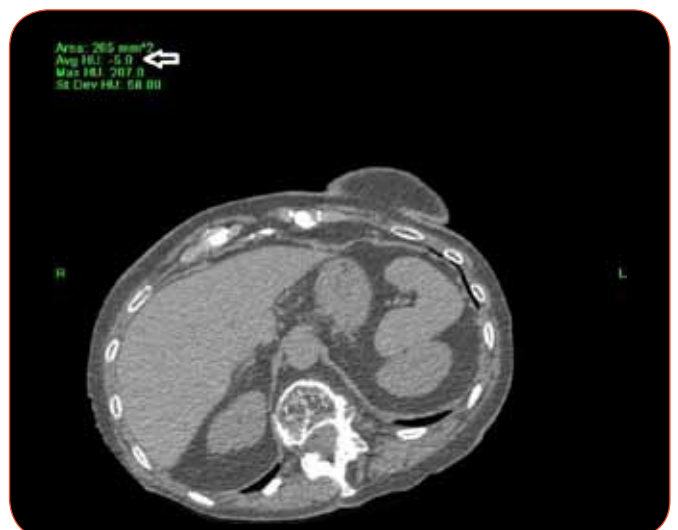


Figure 2b. HU -5 (open white arrow) showing osteoporosis at CTC in a female patient.

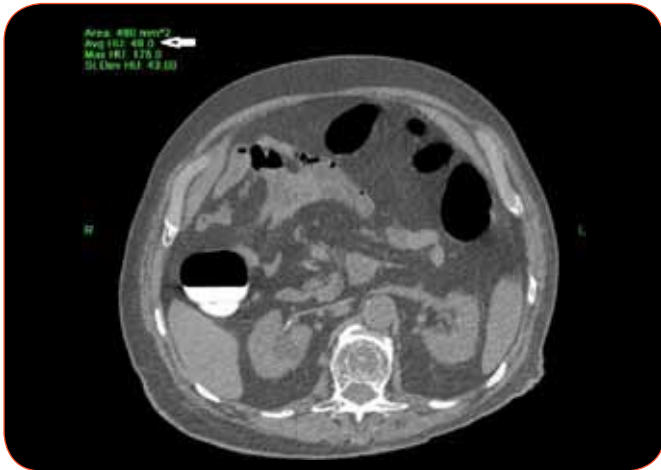


Figure 3a. HU 49 (open white arrow) showing osteoporosis in a male patient with a history of respiratory pathology with prolonged corticosteroid treatment.



Figure 3b. 2D sagittal view of the same male patient showing grade 3 fracture of L1 (circle).



Figure 4a. Coronal 2D at CTC showing osteopenia in a male patient: HU 135 (open black arrow) of L1.



Figure 4b. Sagittal scan at CTC showing osteopenia in a female patient: HU 140 (open white arrow).

normal, grade 1 = mild fracture (20% to 25% loss of height), grade 2 = moderate fracture (25% to 40% loss of height), and grade 3 = severe fracture (>40% loss of height).

Figures 4a and b illustrate osteopenia, namely a HU reading of >100 to <160. Osteopenia can be a risk fracture in males and females.

Discussion

Some authors recommend that colorectal cancer (CRC) screening should commence at 50 years, and stop at age 85 years.^[8] Men and women who present for screening CTC would benefit if an early diagnosis of osteoporosis is made.^[3] Osteoporosis in males is divided into primary and secondary causes.^[9] The former include age-related and idiopathic osteoporosis. The latter include cardiovascular disease, chronic obstructive airways disease, multiple scler-

osis, rheumatoid arthritis, and glucocorticoid excess. Despite the high prevalence of osteoporosis, osteopenia and fractures in men, their testing and treatment rates are low.^[9] Morbidity and mortality is significant in men with osteoporotic hip fractures.^[9] The concurrent screening for osteoporosis and CRC at low dose CTC adds to service delivery to patients. By using the ROI to measure trabecular BMD of L1 of 2D CT scans does not increase radiation dose to a patient.^[6,7] It does provide information to identify fracture risk of patients who undergo screening CTC for CRC.^[6] This means that more patients will then be assessed for osteoporosis. This is important as there has been underutilisation of preventive osteoporosis strategies.^[2] If there is a compressed fracture of L1 the HU of L2 is measured.

Conclusion

Readers of CTC studies should routinely

measure the trabecular BMD of L1 on all patients to identify those at risk of osteoporotic fractures. Measuring trabecular BMD at screening CTC does not add to radiation dose to patients. If a reading is obtained of >100 HU to <160 HU this should be reported as osteopenia so that future BMD screening can be considered. All patients with <100HU values are at risk of osteoporotic fractures and should commence treatment as soon as possible.

Competing interests

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Contributions of authors

JHB and LM wrote the text. JHB provided the images and legends of the figures.

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