The frequency of osteoporosis in the thoracic surgery patient population: An opportunity assessment from thorax computed tomography scans

Göğüs cerrahisi hasta popülasyonunda osteoporoz sıklığı: Toraks bilgisayarlı tomografi tetkiklerinden fırsatçı değerlendirme

Abstract

Aim: To investigate the frequency of osteoporosis in thoracic surgery patients and highlight the clinical significance for physicians.

Methods: Thoracic computed tomographies (CT) of 306 patients were examined for medullary density of the T12 vertebra. Men and women, as well as those under 70 and over 70, were compared in terms of Hounsfield units (HU). To evaluate the diagnostic performance of the age parameter in predicting osteoporosis, receiver operating characteristic (ROC) analysis, and logistic regression analysis were used. The rib cortical defects identified in this study group and their causes were explained.

Results: HUs of 51 subjects (or 16.7%) were less than 110 (osteoporosis); 177 people (57.8%) were higher than 160 (normal). HU values ranged from 111 to 159 (borderline) for 78 individuals (25.5%). There was no significant difference between males and females. It was discovered that the difference between the population under 70 and the population over 70 was statistically significant (p<0.001). For predicting osteoporosis, the age exhibited an area under the curve of 0.857 (CI 0.806-0.908). The threshold value was 57 for women and 55 for men. Osteoporosis was shown to be accurately predicted by age with a 95.7 percent accuracy rate (p<0.001). Six patients were determined to have rib cortical defects seen on CT scans during the evaluation for osteoporosis, and two more patients had fractures noted during surgery.

Conclusion: Within the 306 patients, only 57.8% had bone density within the normal range. The age parameter is valuable with high accuracy (95%) in predicting osteoporosis. The presence of osteoporosis over the age of 57 in women and over 55 in men should be evaluated and measures should be taken to protect the bones during the operation and postoperative care.

Keywords: Osteoporosis; thoracic surgery; tomography

Öz

Amaç: Göğüs cerrahisi hastalarında osteoporoz sıklığını araştırmak ve doktorlar için klinik önemini vurgulamak.

Yöntemler: 306 hastanın toraks bilgisayarlı tomografileri (BT) T12 vertebra medüller yoğunluğu (Hounsfield unit-HU) açısından incelendi. Erkekler ve kadınlar; "70 yaş altı" ve "70 yaş ve üzeri" gruplar karşılaştırıldı. Yaş parametresinin osteoporozu öngörmedeki tanısal performansını değerlendirmek için alıcı işlem karakteristikleri (receiver operating characteristic-ROC) analizi ve lojistik regresyon analizi kullanıldı. Bu çalışma grubunda tespit edilen kosta kortikal defektleri ve nedenleri açıklandı.

Bulgular: 51 hastanın (veya %16,7) HU'ları 110'un altında idi (osteoporoz); 177'sinin (%57,8) 160'ın üzerindeydi (normal). 78 kişi (%25,5) için HU değerleri 111 ila 159 (sınır) arasında değişmekte idi. Erkekler ve kadınlar arasında anlamlı bir fark yoktu. 70 yaş altı nüfus ile 70 yaş üstü nüfus arasındaki farkın istatistiksel olarak anlamlı olduğu belirlendi (p<0,001). Osteoporozu tahmin etmek için yaş, 0.857'lik bir eğri altında kalan alan (CI 0.806-0.908) sergiledi. Osteoporozun yüzde 95,7 doğruluk oranıyla (p<0,001) yaşa göre doğru bir şekilde öngörüldüğü gösterildi. Kadınlarda eşik değer 57, erkeklerde 55 idi. 6 kişide BT taramalarında kosta korteks defektleri görülürken 2 hastada ise ameliyat sırasında kırık meydana geldi.

Sonuç: Bu popülasyonun yalnızca %57,8'i normal aralıkta kemik yoğunluğuna sahipti. Yaş, osteoporozu öngörmede yüksek doğruluk ile değerli bir parametre olabilir. Kadınlarda 57, erkeklerde 55 yaş üstü osteoporoz varlığı değerlendirilmeli, operasyon ve postoperatif bakım sırasında kemikleri korumaya yönelik önlemler alınmalıdır.

Anahtar Sözcükler: Göğüs cerrahisi; osteoporoz; tomografi

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INTRODUCTION

Thoracic surgery is necessary everywhere in the world to carry out morbid surgeries. A thoracic surgeon typically performs 135 operations a year in the United States and treats diseases of the lungs, trachea, esophagus, chest wall, mediastinum, and diaphragm. Patients with various racial, socioeconomic, and health insurance backgrounds are given services (1). Therefore, the significance of early diagnosis, on-site and on-time surgical care, and thorough assessment of co-existing illnesses becomes clearer.

One of the conditions that frequently affect this relatively older group is osteoporosis, which can be reliably evaluated using thoracic computed tomography, a common imaging technique in thoracic surgery. Numerous studies have been published that opportunistically evaluate osteoporosis using computed tomography (CT) scans (2-5). However, no study has examined this particular cohort, which consists of evaluation of people for thoracic surgery. This evaluation is crucial in thoracic surgery because it may require the use of complicated surgical techniques and specific operating positions that could put a strain on the bones (6,7).

This study aims to evaluate the frequency of osteoporosis in the patient population evaluated by the thoracic surgery clinic as the primary outcome and to emphasize the clinical and practical effects of this situation for thoracic surgeons and radiologists as a secondary outcome.

MATERIAL AND METHODS

The non-interventional clinical research ethics committee at our university approved the study (Date: 06.07.2022, Decision no: 605). Due to the design being a retrospective observational study, informed consent was not obtained.

Patients

Between August 2014 and July 2022, 3311 patients who were referred from the Thoracic Surgery Clinic to the Radiology Department were examined. We identified 449 patients who had chest CT scans obtained at our hospital (n=130), vertebral fracture (n=1), vertebral tumors or metastases (n=3), and spinal instrumentation (n=2), and 7 pediatric patients under the age of 18 were excluded. A total of 306 patients (108 males, 35.3%; 198 females, 64.7%) were evaluated for medullary density from the T12 vertebral corpus. CT indications, performed surgery or interventions, concomitant pathologies (metabolic, endocrine, and others), and body mass indexes (BMI<18.50 kg/m^2=underweight; 18.50–24.99 kg/m^2=normal; 25.00–29.99 kg/m^2= overweight; ≥30.00 kg/m^2=obese) were recorded. We described the rib cortex defects detected in this study group and their causes.

Computed tomography protocol

During the patient's admission, all thorax CT scans were performed using a Philips Brilliance Big Bore 16-slice scanner while the patient was lying supine. The collimation was 16x0.625 mm, the field of view (FOV) was 360 mm, and the section thickness was 1.0 mm. The scan took about 10 seconds to complete. The lungs were scanned in one breath-hold, from the level of the apices of the lungs down to the diaphragmatic level.

Image analysis

Using a commercially available picture archiving and communication system (Centricity, RIS, GE Healthcare), CT scans were retrospectively examined. Firstly, the mid-vertebral body was located in the sagittal plane, and then the CT attenuation of the T12 vertebra was measured in Hounsfield units (HU) by inserting an oval region of interest (ROI) within a transverse section of the vertebral medulla. While eliminating cortical surfaces and vertebrobasilar structures, ROIs were generated as large as possible (4). It was regarded as normal if HU was greater than 160. Osteoporosis was considered to exist below 110.

Statistical analysis

We found that a sample size of at least 196 patients was required to achieve statistical significance with a power of 95% and a significance level of 0.05 based on power analysis. Statistical Package for the Social Sciences package program, version 22.0 (SPSS Inc., Chicago, IL, USA) was used for the statistical analysis. Categorical data are reported as counts and percentages, while continuous variables are shown as the mean and standard deviation. The one-sample Kolmogorov-Smirnov test was used to

verify the data's distribution. Log transformation was applied when a normal distribution could not be established. Descriptive statistics were applied. We statistically compared the T12 vertebral HU between men and women categories. Additionally, we compared the age groups under and over 70 years old " in terms of T12 vertebral HU since the risk of fracture increases significantly after the age of 70. Using ROC analysis and logistic regression analysis, we assessed the diagnostic performance of the age parameter in predicting osteoporosis. All analyses were two-sided, and $p<0.05$ was considered statistically significant.

For an examination of intra-observer reliability, AE repeated the measurements two weeks after measuring the HU values. The procedure was also carried out by a thoracic surgeon (MS) to assess inter-observer reliability. When taking the measurements, the two observers were unaware of the clinical data.

RESULTS

Computed tomography indications were mediastinal pathology (n=78), parenchymal disease (n=56), chest pain (n=45), evaluation of pulmonary nodules (n=39), primary lung cancer/staging (n=35), pleural abnormalities (n=28), trauma (n=17), thoracic wall abnormalities (n=8). Performed surgeries or interventions were pleural tube insertion (n=67), mediastinoscopy (n=52), wedge resection (n=26), lobectomy (n=18), and pneumonectomy (n=7).

The most encountered comorbidities were chronic lung disease (n=56, 18.3%), hypertension (n=52, 17%), coronary artery disease (n=42, 13.7%) diabetes mellitus (n=39, 12.7%), malign neoplasm (n=35, 11.4%), and hypothyroidism (n=8, 2.6%). No significant difference was found in terms of frequency in men and women. BMIs were normal for 62.1% (n=190) of the patients, overweight for 23.9% (n=73), obese for 10.5% (n=32), and underweight for 3.5% (n=11). No significant difference was found in the groups.

The mean age and distribution were similar in female (n=198) and male (n=108) patients (48±18 years in males, 48±17 years in females, p=0.800). The mean T12 vertebral HU value in males and females was not statistically different (178±63-HU in males, 172±55-HU in females, p=0.398) (Figure 1). 51 individuals (16.7%) had a T12 HU value that was lower than 110 (osteoporosis). T12 HU of 177 individuals was greater than 160 (57.8%) (Normal). T12 HU value of 78 individuals (25.5%) ranged from 111 to 159 (Borderline).

Among individuals under the age of 70 (n=270), age (43±15 years in men, 45±15 years in women, p=0.394) and mean T12 vertebral HU (189±60-HU in men, 178±54 HU in women, p=0.141) were not statistically different between male and female (Figure 2).

Age (76.5% in men, 76.4% in women, p=0.946) and mean T12 vertebral HU value (120.5% in men, 114.0% in women, p=0.671) were not statistically different between males and females among people above the age of 70 (n=36) (Figure 3).

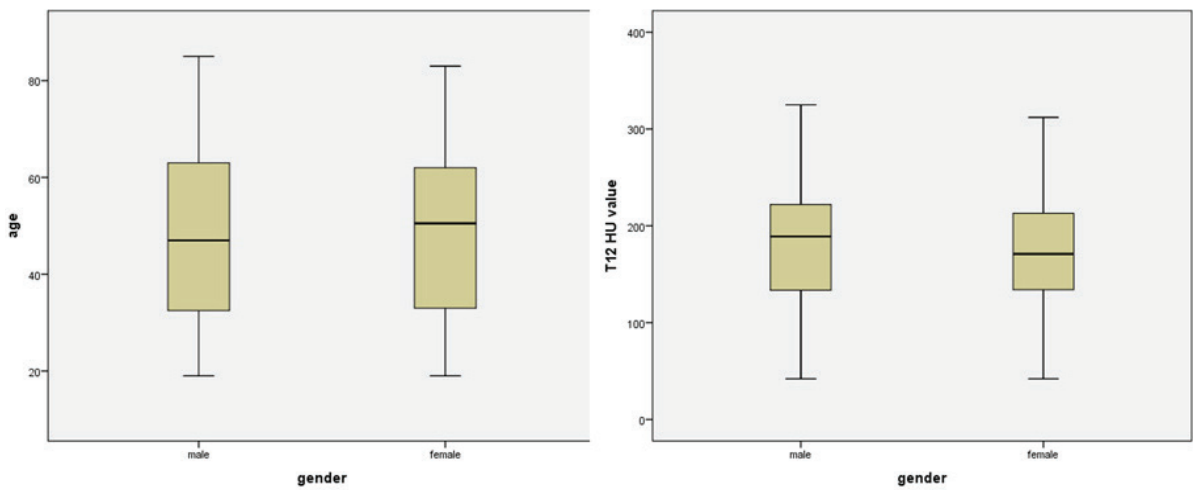

Figure 1. Age and T12 vertebra value distribution among males and females (HU: Hounsfield Unit, T12: Thoracal 12)

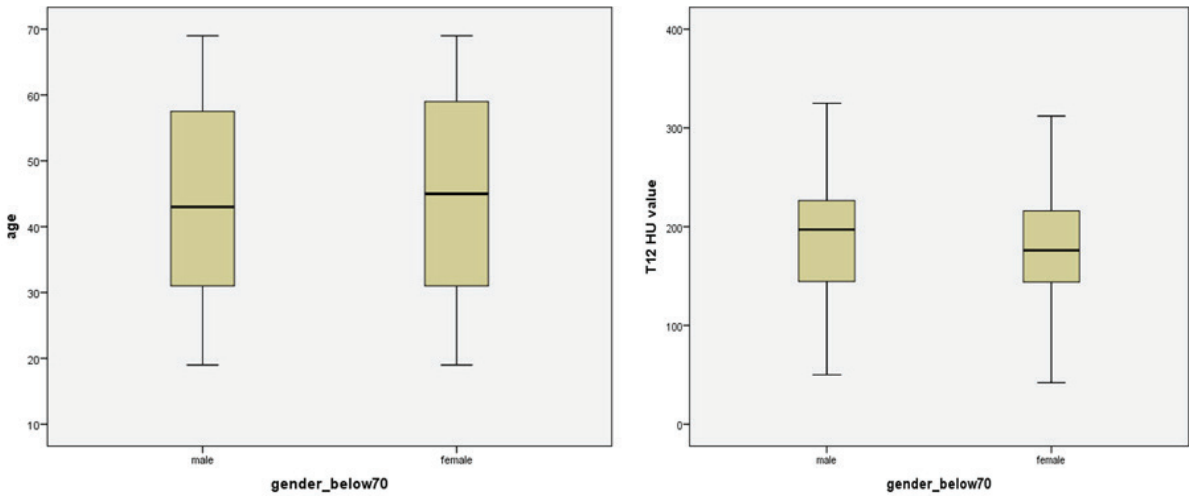

Figure 2. Under the age of 70, age and T12 vertebra value distribution among males and females (HU: Hounsfield Unit, T12: Thoracal 12)

The mean T12 vertebra HU value in patients aged 70 and older (n=36) was 117±45-HU, whereas it was 183±56-HU in individuals under 70. Statistics showed that the difference was substantial (p<0.001). For the population of men and women aged 70 and over and under the age of 70, the difference was determined to be statistically significant (p<0.001) (Figure 4).

In the overall study group, the age parameter had an AUC of 0.857 (CI 0.806-0.908) for predicting osteoporosis (110 HU and below). In terms of predicting osteoporosis, age had an AUC of 0.836 (CI 0.742-0.930) in males and 0.868 (CI 0.811-0.926) in women. Age 58 can differentiate osteoporosis with 86% sensitivity and 74% specificity for the entire study population. 55 years of age showed a 91 percent sensitivity and a 71 percent specificity for men. In order to predict osteoporosis in women, a threshold of 57 years old showed an 87 percent sensitivity and 70 percent specificity (Figure 5).

Only the age variable was found to be significant in the logistic regression analysis, in which the independent variables of age and gender were examined in predicting the presence of osteoporosis. Age was shown to have an accuracy of 95.7 percent in determining the occurrence of osteoporosis (p<0.001).

Six patients in this study group had ribs where thorax CT studies revealed loss of cortical integrity: (1) A 64-year-old male patient with osteoporosis had multiple rib excisions (T12 vertebra HU = 95). (2) Multiple rib resections were carried out on two male patients

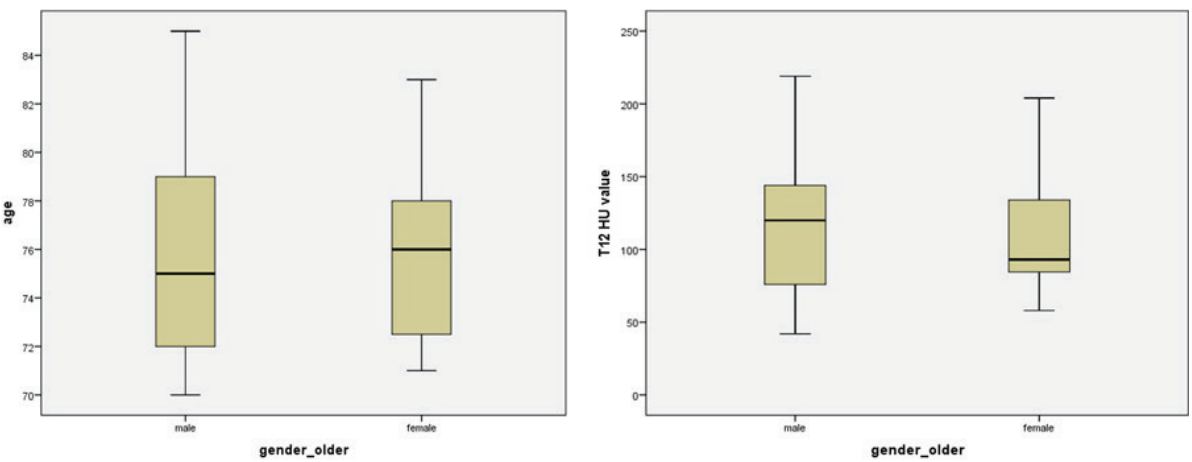

Figure 3. Above the age of 70, age and T12 vertebra value distribution among males and females (HU: Hounsfield Unit, T12: Thoracal 12)

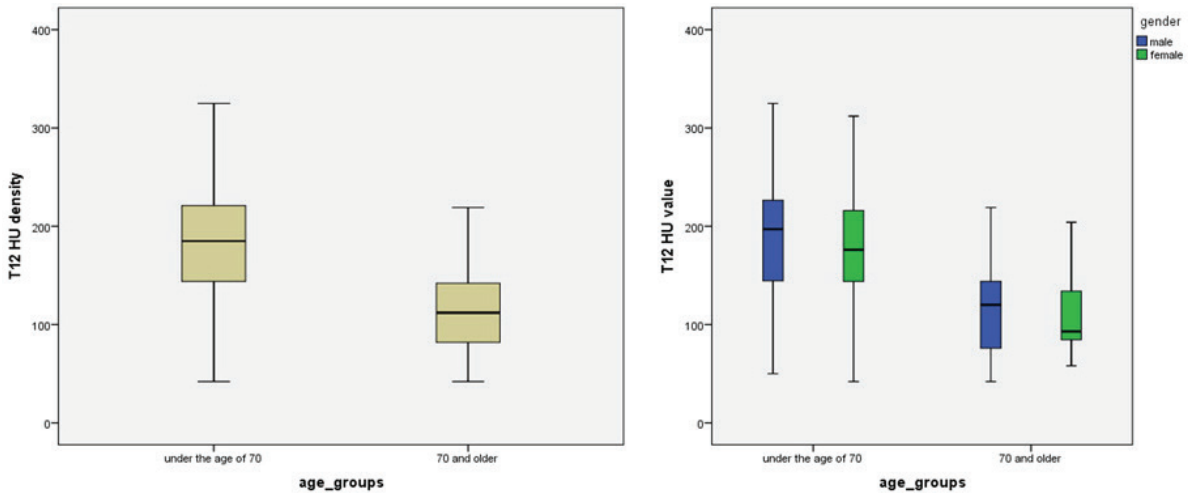

Figure 4. For the whole study population, men and women aged 70 and over and under the age of 70, the differences in T12 HU density are statistically significant (HU: Hounsfield Unit, T12: Thoracal 12)

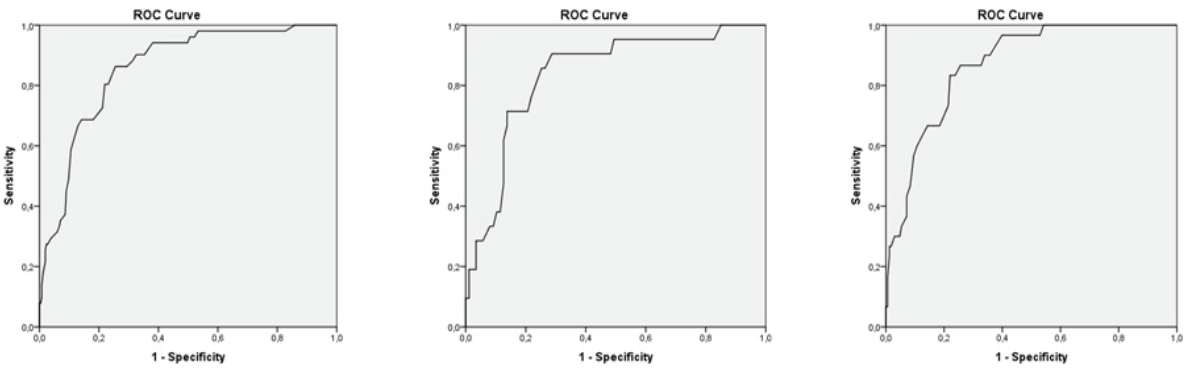

Figure 5. ROC analysis results for the whole study population, men and women in terms of age (ROC: receiver operating characteristic)

with normal bone density (T12 vertebra HU; 170 and 176, respectively) who were ages 31 and 59. (3) A surgical fracture occurred in a second 63-year-old male patient with borderline bone density (T12 vertebra HU=141). (4) Multiple rib fractures were present in a 20-year-old patient with normal bone density (T12 vertebra HU=213) from prior trauma. (5) A 27-year-old female patient with normal bone density (T12 vertebra HU=219) experienced the loss of rib cortical integrity and fixation materials. In addition to these 6 patients, 2 other people who underwent surgery later in the study's population had rib fractures developed during the course of their initial surgery. This information was obtained from the surgical reports. These were two male patients, both 63 years old, with HU densities of 42 and 68, respectively.

DISCUSSION AND CONCLUSION

In our study, we found that osteoporosis is not uncommon in this thoracic surgery patient population (16.7% osteoporosis, 25.5% borderline density) and only 57.8% had bone density within the normal range. The age parameter is a valuable parameter with high accuracy (95%) in predicting the osteoporosis status of the patients. The presence of osteoporosis should be especially evaluated over the age of 57 in women and over 55 in men and measures should be taken to protect the bones during the operation and postoperative care.

The endocrine and paracrine functions of bone, a tissue that frequently interacts with other tissues, are essential to metabolism, aging, and general health (8). The most prevalent condition affecting bones globally

is osteoporosis and it is the most common metabolic bone disease in the elderly (9,10). The condition is generally overlooked, though, which results in underdiagnoses and undertreatment (2, 5, 11). Even in our study group, patients with normal density were less than two-thirds of the study group.

Modern imaging modalities and advanced image processing have the ability to provide a thorough understanding of the pathologic changes that take place in bone tissue during osteoporosis and open the door to new imaging techniques for osteoporosis diagnosis, monitoring, and prediction (9). A decline in bone density and a worsening of the quality of bone microarchitecture are two characteristics of osteoporosis, a disorder affecting the bones. Dual-energy X-ray absorptiometry (DEXA) is the most widely used method of disease screening (12). It provides an accurate estimate of the risk of fracture when combined with other clinical indicators (9). While covering a wide range of anatomical structures, this approach produces superpositional images. As a result, an inaccurately increased bone mineral density can be detected, and it might be challenging to anticipate the true risks to bone health (4). In contrast to DEXA, CT preferentially measures the trabecular bone mineral density and is less prone to confounding variables such as spinal degenerative changes, aortic calcification, bone size, and body mass index. Because it is typically lost more quickly than cortical density as the disease worsens, trabecular density is thought to be a more sensitive indicator of changes in overall bone strength (13, 14). Osteoporosis diagnoses are more likely to be made when density measurements are below 180-190 HU (15). On the other hand, according to a different study, utilizing screening thresholds of 160 HU and 110 HU, respectively, physicians could detect osteoporosis with greater than 90% sensitivity and specificity (16). Additionally, thresholds of 99-121 HU or 122-164.5 HU indicated no variations in sensitivity ($p = 0.92$) but only minor differences in specificity (0.75 vs 0.76, $p=0.01$) (3). In our study group, densities above 160 were considered normal, while those below 110 were considered osteoporosis.

The percentage of osteoporosis screening is reported to be low. Due to the costs of care and radiation exposure, DEXA is not typically performed prior to surgeries in clinical practice (12). But before many surgeries, CT scans are acquired. As a result, osteoporosis can be assessed by using them as opportunities, as in our case such studies exist. Hounsfield units were employed to assess bone density and abdominal, pelvic, or lumbar spine CT images were utilized for opportunistic metabolic bone disease screening (4). The HU levels by CT and DEXA scores have been shown to have a strong correlation (13,15,17,18). The results of the spine CT scans may help with early osteopenia screening, osteoporosis prevention, and the avoidance of vertebral compression fractures (5). The diagnostic sensitivity and specificity of CT images for the diagnosis of osteoporosis were pooled, and a meta-analysis determined suitable threshold values to opportunistically detect osteoporosis (3). High inter-rater reliability is demonstrated by HU measurement. In conclusion, it appears that HU measurement is an appropriate method for quickly and correctly evaluating bone quality (19).

Osteoporosis may cause serious side effects during and following surgeries, including fractures and fusion failure (20). It has been demonstrated that bone density affects implant failures and complications as well (21). According to a study on iatrogenic rib fractures and the risks of death associated with them, complications from treatment—particularly cardiopulmonary resuscitation—are to blame for 80.1% of iatrogenic rib fractures (22). Additionally, during pulmonary resections, accidental rib fractures, which can happen in thoracotomy, are frequently linked to higher postoperative morbidity (6). Increased screening rates might lessen difficulties brought on by osteoporosis (12). Additionally, without additional radiation exposure or economic cost, HU measurements enable practitioners to perform preoperative osteoporosis screenings (12).

Computed tomography can be used for opportunistic osteoporosis screening to help identify individuals who should receive DEXA screening (15). The literature contains instances of this type of work. In 27 patients with chronic pancreatitis, the L1 level of CT-derived bone density was assessed, and it was discovered that CT-derived bone density predicted DEXA-based osteoporosis. To rule out osteoporosis in patients with chronic pancreatitis, the authors suggested that CT scans can be repurposed for "opportunis-

tic" screening (17). An Australian population screening for osteoporosis discovered a correlation between CT L1 attenuation and L1 DEXA T-scores. Density readings below 190 and below 180 HU, respectively, increased the likelihood of an osteoporosis diagnosis in Australian women and the entire cohort (15). The most common comorbidity in a study on the lung cancer screening group (n=775) was osteoporosis, which was found in 44.2 percent of patients and 24.8 percent of controls. The scientists reached the conclusion that CT data helped identify previously undiscovered comorbidities like osteoporosis (20). Furthermore, a cervical CT investigation demonstrated that CT scans deliver accurate results regardless of the measuring plane, age or sex, or level of degeneration (23).

There were some limitations. Our patient population consists of a respectable and also a limited number of individuals who have undergone thorough evaluations by thoracic surgeons and had un-enhanced CT scans performed in our hospital. It should be noted that it might not represent the entire clinic, though. Naturally, subjects who did not have baseline or control tests completed at our hospital were not included in this study (potential population bias). Contrast-enhanced CTs, CT examinations obtained outside our hospital, CT examinations taken in positron emission tomography, and other direct radiography examinations were not included. In addition, stratifying any metabolic, endocrine, or other disorder that may affect bone density together with gender and age is necessary in order to compare results with homogeneous groups or multiple control groups. The retrospective design and lack of a DEXA-based control examination are additional drawbacks.

Osteoporosis is a widespread disease in the world. The threshold values that can be used to spot an abnormal bone mass should therefore be understood. Radiologists should include relevant comments to their interpretation reports evaluating osteoporosis with all other disorders, particularly before surgery, in light of this circumstance. In conclusion, without increasing medical costs or radiation exposure, the HU measuring approach can provide significant information through the analysis of current CTs to detect osteoporosis among thoracic surgery patients.

Conflict-of-interest and financial disclosure

The authors declares that they have no conflict of interest to disclose. The authors also declare that they did not receive any financial support for the study.

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