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Bone Metastasis Evaluation Using Bone Scintigraphy

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ABSTRACT

Background: The diagnosis of bone metastasis in patients with a history of cancer remains challenging. Diagnostic evaluation may be prolonged owing to difficulties in distinguishing between bone metastasis and common orthopedic diseases.

Objectives: This study aimed to evaluate bone metastasis using scintigraphy in patients with various types of cancer.

Materials and Methods: A retrospective study carried out at Batterjee Medical College, Radiologic Sciences program, and King Abdulaziz University Hospital included 200 consecutive patients with a history of malignant disease (60% Females and 40% Males) referred for bone scintigraphy. Using a database of the King Abdulaziz University Hospital, the prevalence of bone metastasis from each type of primary cancer was noted.

Results: The results showed that most of the participants were above 50 years old, with primary cancer sites, including 88 breast cancer (44%) cases, prostate cancer (15%), and lung and colon (11%). Bone metastasis location included spine (186), Ribs (n= 136), pelvis (n= 133), Lower Extremities (n= 108), and Skull (n= 59), respectively.

Conclusions: The most common malignancy is breast cancer, followed by prostate carcinoma, and most bone metastasis locations include the spine, ribs, and pelvis.

1. INTRODUCTION

Skeletal metastases are the most common malignant tumors in bone. Cancer such as breast, lung, and prostate exhibit a particular predisposition to spread metastases to the bone via the bloodstream and infiltrate the bone

marrow, which makes metastases the most common type of malignant in adults (Boyce et al., 1998). Certain types of cancer are particularly likely to give rise to skeletal metastases, and breast carcinoma is among the most frequent malignant types, with prevalences of up to 70% (Pulido et al., 2017). Metastases can occur in any

bone in the body, starting with the most often found in bones in the spines, especially in the thoracic spine. Other common sites are ribs, pelvis, lower extremity, skull, sternum, shoulder and scapula, upper extremity, and axial and appendicular skeletal (Oncolink.org.,2024). The early diagnosis of skeletal metastases has a significant impact on the overall treatment strategy and is an essential determinant of the course of illness and the quality of life.

Diagnostic imaging aims to detect skeletal metastases early, when suspected, based on clinical or laboratory findings or in high-risk patients. Other important issues include assessing the risk of fracture and the response to treatment (Ali et al., 2021; Oif.org., 2019). Different types of bone metastases vary in their metabolic activity and reaction to the bone; therefore, it is essential to choose the suitable imaging method(s) for each. Bone Scintigraphy using radionuclide Technetium-99m (Tc-99m) labeled with a phosphonate agent enables visualization of the bone metabolism activity (osteoblast/osteoclast activity) and bone turnover that occurs in response to an extensive range of pathologies (Ncbi.nlm.nih.gov.,2019). Thus, it is a susceptible diagnostic nuclear medicine imaging technique for detecting bone metasetes in the early phase of some types of cancer (Jnm.snmjournals.org.,2019). However,

scintigraphy may be relatively insensitive for tumors that cause reactive osteolysis or isolated bone marrow infiltration, such as renal-cell carcinoma and lymphoma. Moreover, bone matrix regeneration after successfully treating bone metastasis can induce metabolic activation, sometimes misinterpreted as progressive disease—the so-called flare phenomenon (Vassiliou et al., 2011).

Metastases in the axial skeleton that are not intensely hypermetabolic may escape detection in the planar images of conventional scintigraphy. This limitation can be overcome by using contemporary SPECT and SPECT-CT apparatus types that increase the sensitivity and specificity of skeletal scintigraphy (Ben-Haim et al., 2009; Beheshti et al., 2009). In a study with a mixed group of patients, adding SPECT to scintigraphy raised the negative predictive value of normal scintigraphy findings to 98% (Chua et al., 2009). The specificity is increased if the SPECT is immediately compared with or acquired

simultaneously with a CT scan. The visualization by CT of degenerative processes in bone or (for example) osteoporotic vertebral body fractures enables better pathophysiologic assessment of any hypermetabolic areas that may appear on scintigraphy. When SPECT-CT is used, the sensitivity and specificity for metastases of certain types of cancer, e.g., prostate cancer, rises above 90% (Even-Sapir et al., 2006).

This study, therefore, intends to determine the performance of bone scintigraphy in detecting the extent of metastatic bone disease among a selected population of patients diagnosed with various types of cancer and classify the most affected skeletal area.

2. MATERIALS AND METHODS

2.1. Data collection

This is a retrospective study carried out at Batterjee Medical College, Radiologic Sciences program, and King Abdulaziz University Hospital. History pathologically proven cancer patients referred for whole-body bone scans were prospectively enrolled. List the findings in detail according to the study variables recorded in the data-collecting sheets.

2.2. Participants

Participants were recruited from a King Abdulaziz University Hospital database and included 200 consecutive patients (60% women and 40% men referred for bone scintigraphy) diagnosed with malignant disease. Inclusion criteria included patients with a history of malignant disease, and exclusion criteria included patients with no history of malignant disease.

2.3. Nuclear Medicine Equipment

Discovery NM/CT 670 dual detector free geometry integrated nuclear imaging system was used for all patients. It is a medical tool intended for detecting, localizing, and diagnosing diseases and organ function for the evaluation of diseases, trauma, abnormalities, and disorders such as cardiovascular disease, neurological disorders, and cancer. The physician can also use the system output to stage and restage tumors and plan, guide, and monitor therapy.

2.4. Radiopharmaceutical agents

Technetium— ^{99m}Tc methylene diphosphonate (^{99m}Tc -MDP) of 20 mCi (740 MBq) was intravenously injected over a few seconds into all patients included in this study. Unless contraindicated, all patients were instructed to drink plenty of water and frequently urinate between the time of injection and the time of delayed imaging to ensure adequate hydration, thus ensuring a good tissue-to-background ratio.

2.5. Imaging procedures

The rationale for performing the procedure and the details of the procedure itself should be explained to the patient in advance. Anterior and posterior images were acquired of the whole skeleton 2–4 hours after tracer administration for all patients; using a low-energy high-resolution parallel-hole collimator (LEHR), a 20% window centered at the photopeak of 140 keV, and matrix size to 256×256 with a large field of view. Multi-planar views for 5 minutes over the area of concern were obtained if needed. Display of the whole-body image [see Fig 1 and 2] after adjusting the contrast to ensure readability without overwhelming small details.

4.6. A questionnaire of risk factors and patient clinical data assessment.

A questionnaire designed to include Patient characteristics (Patient Age, Gender, Primary pathology, Therapy history, Tc- 99m MDP whole-body findings).

2.6 Ethical Considerations

The study underwent a rigorous approval process by BMC's institutional review board (IRB), ensuring the highest ethical standards. All participants provided informed consent and understood the study's purpose, procedures, risks, and benefits. Confidentiality was maintained throughout the study, and anonymized data were used for analysis.

2.7. Statistical Analysis

Statistical analysis was performed using SPSS software. One-way ANOVA was used to compare mean blood pressure reductions among the groups, with post-hoc Tukey's HSD test to identify significant differences. Chi-square tests were used to compare the incidence of adverse effects across the groups.

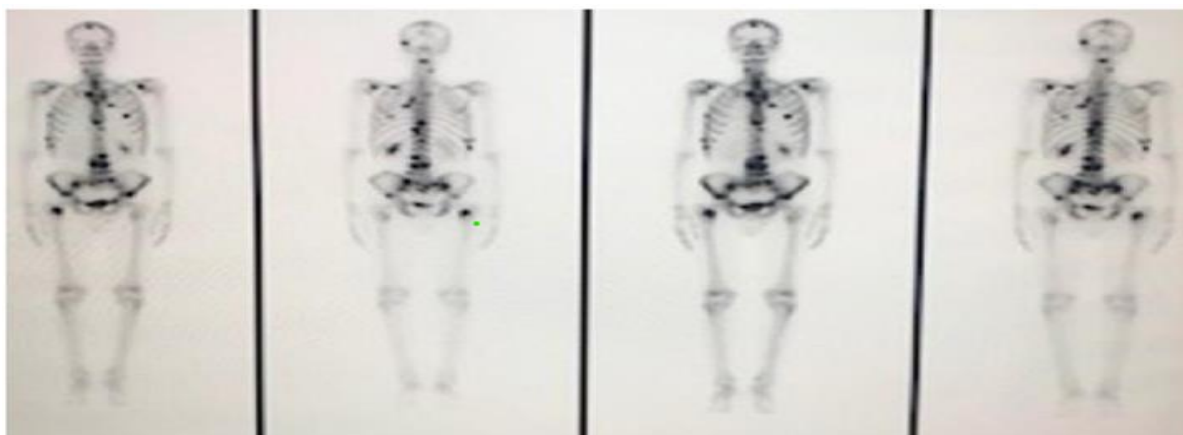


Figure 1. The whole-body bone scan of a male patient diagnosed with primary gastric cancer shows metastatic disease spread over the axial skeleton.

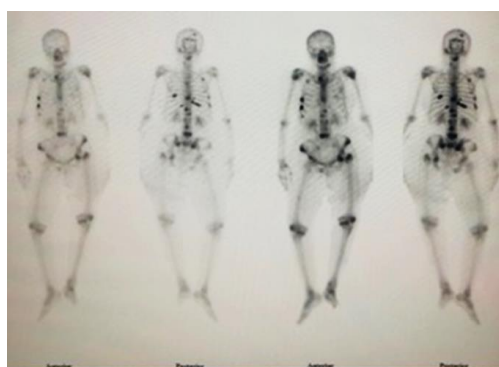


Figure 2. 70 Female with primary breast cancer shows metastatic spread

This section reports the findings of this research study based on the results of the methodology applied. Figure 3 presents the patient's five age groups in years. Figure 4. Shows the primary cancer sites. Cancer can originate in almost any part of the body. Some of the most common

primary cancer sites include breast, prostate, colon, lungs, and other sites. Determination of the primary tumor site is crucial because it helps identify the type of cancer. After all, different types of cancer require different treatments, which helps in tumor staging, which helps in treatment planning. Figure 5 shows the location of bone metastases. Figure 6 shows the affected sites of spines, and Figure 7 shows the affected sites of the pelvis. Figure 8 shows the affected Sites of the lower extremity. Figure 9 shows the type of treatment. The location of cancer metastasis is crucial for deciding the treatment options and, in choice, the effective therapy for the specific, such as radiation therapy, which is often effective for metastases in the brain or bone. At the same time, chemotherapy might be more suitable for lung or liver metastases.

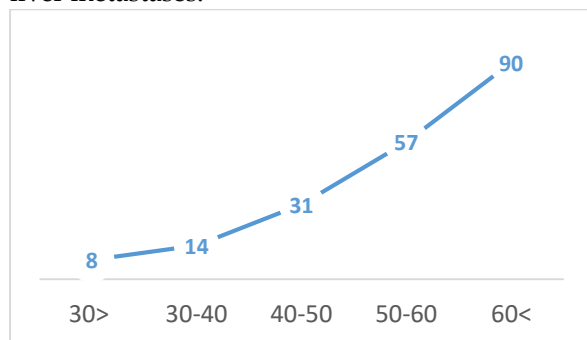


Figure 3. Patients age group (years)

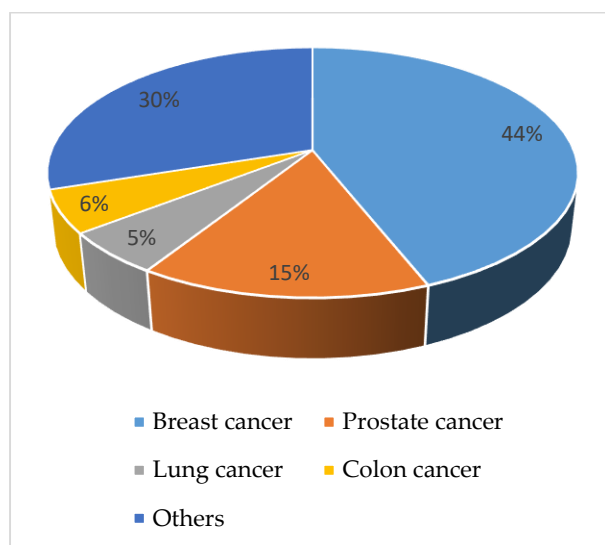


Figure 4. Anatomical location of the primary cancer

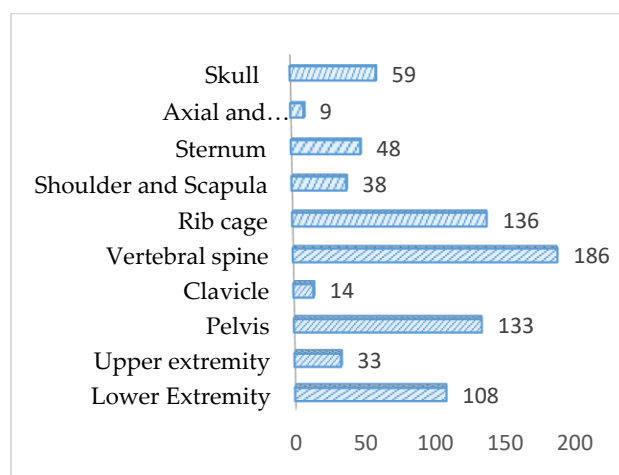


Figure 5. Anatomical location of bone metastases

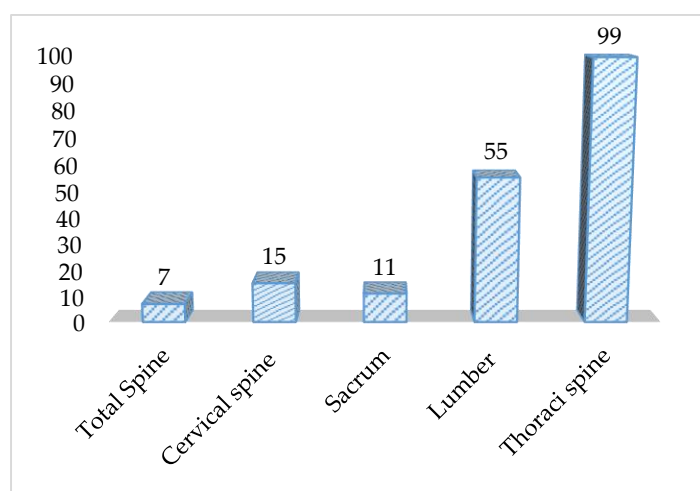


Figure 6. Affected sites within the spine

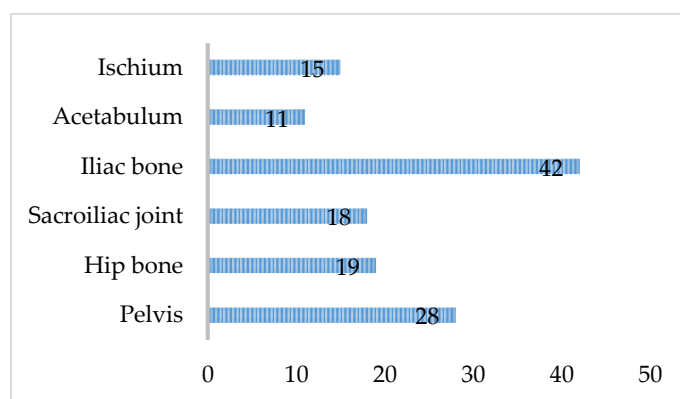


Figure 7. Affected sites within the pelvic region

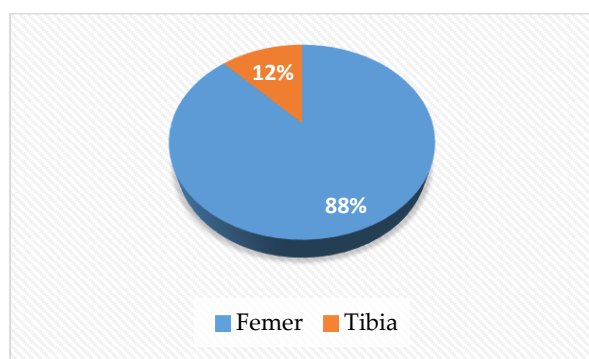


Figure 8. Affected sites within the lower extremity

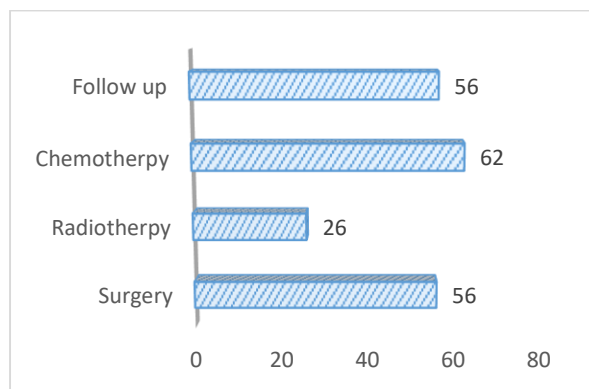


Figure 9. Type of cancer treatment

4. DISCUSSION

The number of bone metastasis patients in different countries varies and is shaped by the incidence of primary cancers and the osteophilic properties of each type of cancer. Bone metastases are prevalent complications associated with certain types of cancers that frequently negatively impact the quality of life and functional status of patients; thus, early detection is necessary for implementing immediate therapeutic measures to reduce the risk of skeletal complications and improve survival and quality of life.

This retrospective study, approved by the BMC Research Committee and conducted at King Abdulaziz University Hospital, aimed to assess the diagnostic usefulness of scintigraphy in assessing the prevalence of bone metastasis in cases with various types of cancer in Jeddah, KSA. Our study included 80 men and 120 women above 50 years [see Fig 3], the most common primary tumors; our data indicated that breast cancer (88 patients; 44%) was the most frequently identified primary tumor. This is followed by prostate cancer (30 patients; 15%) and colon cancer (11 patients; 5.5%), as well as Lung cancer (11 patients; 5.5%) [see Fig 4], which these findings

are consistent with the previous reports suggesting that lung cancers and prostate cancers were the most common primary tumors (Khojasteh et al., 2023; Katagiri et al., 1999).

Regarding the location of bone metastases, we found different bone metastasis locations including the spine (n=186), Ribs (n= 136), pelvis (n= 133), Lower Extremities (n= 108), and Skull (n= 59), respectively (see Fig 5). These findings significantly agreed with previous reports where about 10% of all cancer patients develop metastases to the spine (Fulir, 2019; Breastcancer.org. 2019), then renal and gastrointestinal malignancies each account for about 5% of spinal metastases, while thyroid carcinomas comprise a lower percentage (Oncolink.org. 2024; Cold et al., 2019). Moreover, this study found that the most affected sites of spines are the thoracic spine [see Fig 6], the pelvis Iliac bone (see Fig 7) and in the lower extremity femur [see Fig 8] and most of the patients (31%) treated with chemotherapy (see Fig 9).

Accordingly, this must be considered in the early diagnosis of bone metastasis to prevent skeletal-related events. It is essential to pay attention to the possibility that bone metastases may be present in follow-up observation, even if there have been no findings that led to the diagnosis of bone metastasis at the first visit. According to the progress of symptoms, it may be necessary to perform additional examinations such as plain radiography or other imaging at an early stage before the occurrence of any severe skeletal-related events. Our results can contribute to improving the early diagnosis of bone metastasis due to occult malignancy.

The present study had some limitations. It is a retrospective observational study that was performed using medical records and images only, and the medical records and images from predecessor clinics might have provided more detailed clinical information. The whole-body bone scintigraphy and some planner static images were only acquired; no SPECT/CT images were acquired. Also, the study was based on a single hospital assessment of 200 patients. Accordingly, this must be considered in the early diagnosis of bone metastasis to prevent skeletal-related events. It is essential to pay attention to the possibility that bone metastases may be present in follow-up observation, even if no findings have led to the diagnosis of bone metastasis at the first visit.

According to the progress of symptoms, it may be necessary to perform additional examinations such as re-examining plain radiography or other imaging early before any severe skeletal-related events occur. Our results can contribute to improving the early diagnosis of bone metastasis due to occult malignancy.

5. CONCLUSION

In the present study, whole-body bone scans were performed for patients with a known history of cancer to detect bone metastasis. The most important finding of this study is that breast cancer is the most common primary tumor, followed by prostate carcinoma. Bone metastases are likely to involve the spine more often than any other segment of the bony skeleton. Other studies have similarly concluded that bone scintigraphy scans help determine the primary lesions of bone metastasis. Further studies may be recommended to consider the diagnosis of bone metastasis in patients with an unknown history of cancer.

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Conflicts of Interest:

The authors declare no conflicts of interest.

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