Distribution of Skeletal Metastases in Common Malignant Tumours: Observational Study at INMAS, Mohakhali

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ABSTRACT

Background: Bone scan is a sensitive method for detecting bone metastases but not very specific. This means it can identify most cases of bone metastases but may also show false positives due to other conditions like arthritis or healing fractures (1). However, combining clinical data with bone scan results helps doctors narrow down the possible causes. The study aims to investigate how common cancers spread to bones using 99m Technetium-Methyl Diphosphonate (^{99m}Tc-MDP).

Study design: Single-center-based retrospective study

Patients and Methods: 181 consecutive patients with malignancy (prostate cancer: 39, breast cancer: 108, lung cancer: 25, gastrointestinal cancers: 03, and others: 06) underwent bone scans.

Results: Total 111 (61.32%) out of 181 patients had abnormal bone scans attributable to metastatic tumors. Bone metastases were found in 58.3%, 30.7%, 66.6%, 64%, and 80% of patients with breast, prostate, GI, and lung cancers and others, respectively. The most frequently involved area was the spine, followed by the ribs and pelvic bones. The spine was the most frequent site of bone metastases in breast and lung cancers. Except for the spine, common locations of bone metastases from breast cancer were ribs and sternum. In prostate cancer, the most frequent sites were the spine and pelvis, with similar incidences. In lung cancer, ribs, followed by the spine, were the most frequent sites of bone metastases. 91 (50.2%) of the cancer patients studied had symptoms of bone pain. The highest incidence was associated with metastatic lesions in bone scans. Significant correlation between the location of bone pain and evidence of bone metastasis in the same region was noticed in the pelvis, skull, sternum, spine, and femur.

Conclusion: The spine, pelvis, breast, lung, and sternum are most frequently invaded in prostate, breast, and lung cancers, with bone pain in these areas being more significant for metastatic bone involvement.

Keywords: Bone scan, bone metastases, metastatic pattern, cancer

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INTRODUCTION

Common cancers, such as breast, prostate, and lung cancers, often spread to bones, either when they are first diagnosed or later during follow-up. These bone metastases cause significant health issues and affect the patient's prognosis (1, 2).

Bone scans are highly sensitive and can examine the entire skeleton, making them crucial for evaluating bone metastases (1). However, while bone scans are good at detecting metastases, they are not very specific; this means they can show other issues like arthritis or fractures. The clinical data and bone scan patterns help doctors narrow down the possible diagnoses.

In this study, we investigated how breast, prostate, gastrointestinal (GI), lung cancers, and others spread to bones using bone scintigraphy (bone scans) and examined the relationship between bone scan findings and bone pain symptoms.

Diagnosing and treating bone metastases early benefits patients significantly. Treatment focuses on relieving symptoms, maintaining or restoring function, and improving quality of life. This requires understanding the primary disease. Studies often look at bone metastases from a single type of tumor. Patients with bone metastases from breast, prostate, and thyroid cancer tend to have better outcomes than those with lung and gastrointestinal cancer. Thus, survival depends on the type of primary tumor.

Radioisotopes accumulate in areas with more blood flow and bone-forming activity. Metastasis sites have higher vascularity and osteoblastic activity, leading to greater uptake. 99m Technetium bound to MDP is commonly used for this (3). This study aimed to observe the patterns of bone metastasis in different cancer patients using whole-body bone scans with ^{99m}Tc-MDP.

PATIENTS AND METHODS

The study was a single-center-based retrospective study. 181 consecutive patients (55 males and 126 females; average age 50.63 ± 12.9 years; age range 9 to 88 years) with histologically proved malignant disease (39 prostate, 108 breast, 25 lung, 03 gastrointestinal cancers, and 5 others) referred to the Institute of Nuclear Medicine and Allied Sciences (INMAS), Mohakhali, underwent bone scan. Each patient received 20 mCi of the Tc99m-MDP intravenously. After approximately 3 hours, scintigraphy was performed using a dual-head gamma camera, SPECT (Symbia Intevo Bold, Siemens). Whole-body scans in anterior and posterior projections and in individual spot views were obtained. All bone scans were reviewed by well-trained nuclear medicine physicians. Bone scan results were compared with available radiographs and assessed considering all available clinical information; any positive findings were considered as metastatic bone disease when they could not be attributed to any other known disorder in the patient (such as degenerative changes). In patients for whom previous conventional bone scans were available, we compared the scan findings with previous bone scan results.

The involved area was divided into ten portions: (a) skull, (b) sternum, (c) vertebrae, (d) ribs, (e) pelvic bones, including sacroiliac joints and sacrum, (f) humeri, (g) scapulae, (h) femora, (i) (i) tibiae and fibulae, and (j) clavicles.

Statistical analysis: Initially, frequency of the involvement of particular anatomical regions was ranked. Descriptive analyses were used for statistical analysis through SPSS software.

RESULT

Of the 181 patients, 108 patients (59.7%) had breast cancer, 21 patients (11.6%) had prostate carcinoma, 03 patients (1.7%) had gastrointestinal carcinoma, and 25 patients (13.81%) had lung cancer and others 24 (13.26%) (Figure-1).

Figure 1: Affected body parts Vs percentage

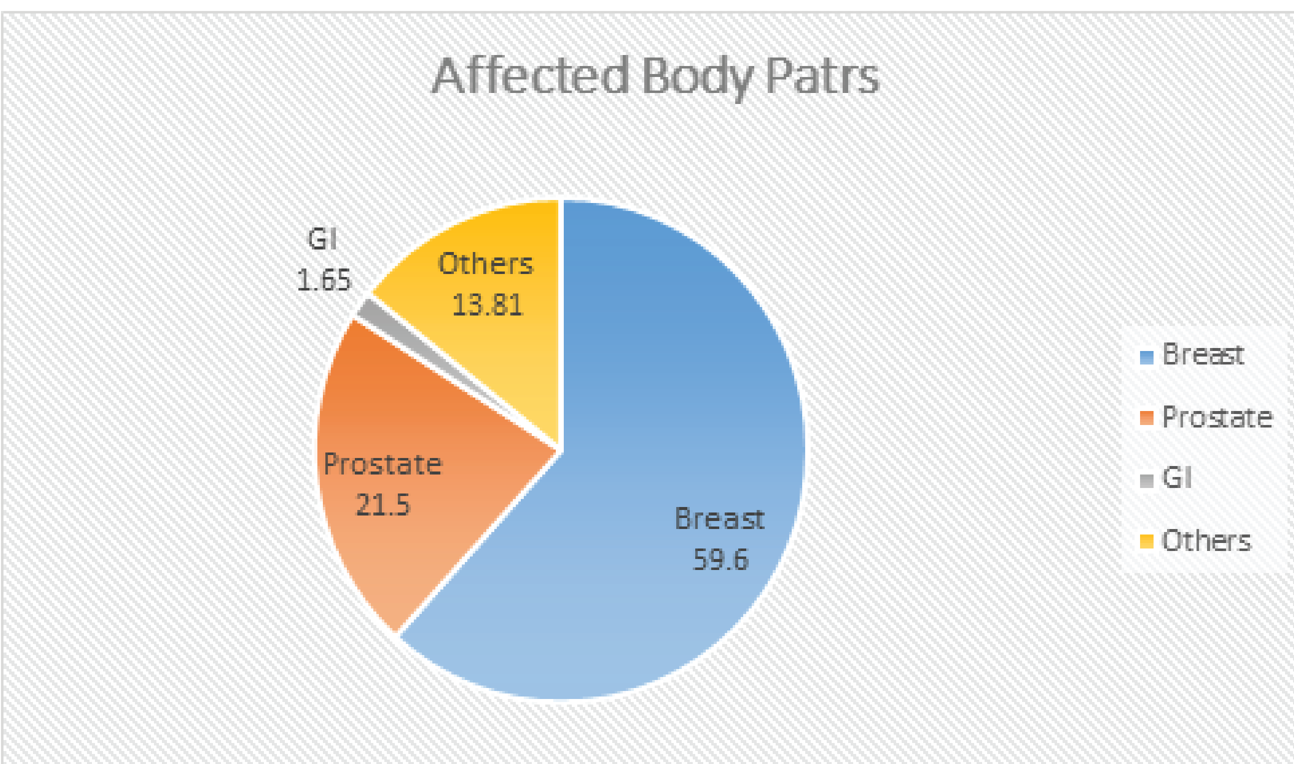

Table 1: Affected body parts including frequency and percentage.

Affected Body Parts	Frequency	Percent	Valid Percent	Cumulative Percent
Breast	108	59.7	59.7	59.7
Cervix	2	1.1	1.1	60.8
Endometrium	1	0.6	0.6	61.3
Gall bladder	1	0.6	0.6	61.9
GI	3	1.7	1.7	63.5
Hepatocellular	1	0.6	0.6	64.1
Left Femur	1	0.6	0.6	64.6
left upper thigh	1	0.6	0.6	65.2
Left Ureter	1	0.6	0.6	65.7
Lung	25	13.8	13.8	79.6
Ovary	4	2.2	2.2	81.8
Prostate	21	11.6	11.6	93.4
Renal Cell	2	1.1	1.1	94.5
right cheek	1	0.6	0.6	95.0
Right Sided Pelvic m	1	0.6	0.6	95.6
Stomach	**1**	**0.6**	**0.6**	**96.1**
Thyroid	**1**	**0.6**	**0.6**	**96.7**
Urinary Bladder	5	2.8	2.8	99.4
Uterus	1	0.6	0.6	100.0
Total	181	100.0	100.0	

Of the 181 patients, 111 patients (61.32%) had abnormal bone scans attributable to metastatic tumors. Patients 17 (15.3%) had single bone metastasis, while 15 patients (13.5%) had widespread bone metastases throughout the axial skeleton, and 5 patients (4.5%) had suspicious metastasis.

The mean age of patients with bone metastasis was an average age of 50.63 ± 12.9 years, respectively. Bone metastases were found in 58.3%, 30.7%, 66.6%, 64%, and 80% of patients with breast, prostate, GI, and lung cancers and others, respectively.

Table 2 shows the frequency of specific anatomical regions of bone involvement. Of the 30 patients with metastases to the spine, 3 had lesions in cervical, 20 in thoracic, and 23 in lumbar vertebrae, respectively.

Table 2. Frequency of anatomical distribution of bone metastases in prostate, breast, gastrointestinal (GI) and lung cancers.

Anatomical site	Total	Breast cancer	Prostate cancer	GI cancer	Lung cancer
Spine	30 (18.8%)	18/103 (16.8%)	5/27 (15.6%)	5/13 (38.5%)	2/7 (25%)
Ribs	23 (14.4%)	16/103 (15.0%)	2/27 (6.3%)	2/13 (15.4%)	3/7 (37.5%)
Pelvis	15 (9.4%)	9/103 (8.4%)	5/27 (15.6%)	1/13(7.7%)	0/7
Sternum	12 (7.5%)	12/103 (11.2%)	0/27 (0%)	0/13	0/7
Femur	8 (5.0%)	6/103 (5.6%)	2/27 (6.3%)	0/13	0/7
Scapula	6 (3.8%)	4/103 (3.7%)	2/27 (6.3%)	0/13	0/7
Skull	6 (3.8%)	5/103 (4.7%)	1/27 (3.1%)	0/13	0/7
Humerus	3 (1.9%)	3/103 (2.8%)	0/27 (0%)	0/13	0/7
Clavicle	2 (1.3%)	1/103 (0.9%)	1/27 (3.1%)	0/13	0/7
Tibia & fibula	1 (0.6%)	0/103 (0%)	1/27 (3.1%)	0/13	0/7

91 patients (50.27%) of the cancer studied had symptoms of bone pain. The highest incidence was associated with metastatic lesions in bone scans, 58 (63.7%) (Table 3). We have analyzed the correlation between the location of bone pain and evidence of bone metastatic lesions in the same area. Significant correlation was found for the following locations:

pelvis, skull, sternum, spine, and femur. We performed more detailed analysis of the recorded data and found that there was a correlation between the presence of lumbar pain and lumbar vertebral metastatic lesions, while there was no correlation for the cervical and thoracic vertebrae. There was also a correlation between the presence of pain and metastatic lesions in the proximal half of the femur, while there was no correlation for the distal portion of the femur.

Table 3. Frequency of bone pain and metastatic bone involvement

	No pain	Symptom of bone pain	Total
No bone metastasis	37 (41.1%)	33 (36.2%)	70 (38.6%)
Evidence of bone metastasis	53 (58.8%)	58 (63.7%)	111(62.3%)
Total	90 (49.73%)	91 (50.27%)	181 (100%)

DISCUSSION

Bone is a common site for distant metastases in malignancies. For decades, bone scintigraphy has been an ideal method for evaluating bone metastases and staging cancer, and it remains a preferred procedure in many clinical scenarios (1-14). In the study, the incidence of bone metastasis from breast carcinoma (59.7%) was significantly different from that of prostate breast carcinoma (11.6%). This finding aligns with the research of Wilson et al. (4) and Tofe et al. (5), who also found no significant difference in bone metastasis rates between breast and prostate carcinomas. Although Tofe et al. reported higher incidences of bone metastasis in breast and lung cancers (67% vs. 62%), Wilson's findings were like ours (28% vs. 35%). These variations likely arise from differences in study populations.

Our study also examined the areas most affected by bone metastases. According to our data, the spine was the most frequently involved area, followed by the ribs and pelvic bones (table 2). The spine was the most common site of bony metastases in breast and gastrointestinal (GI) cancers (Table 2). For breast cancer, after the spine, the ribs and sternum were frequently affected (Table 2). In prostate cancer, the spine and pelvis were the most common sites, with similar incidence rates (Table 2). However, prostate cancer showed a lower incidence of rib and sternum involvement compared to breast cancer (Table 2). In lung cancer, the ribs were the most common site, followed by the spine (Table 2).

Malignant tumors metastasize according to predictable patterns, explained by several theories (6). Paget's "seed and soil" theory accounts for the non-random patterns of cancer metastases, a concept still relevant today. Factors such as genetic changes in cancer cells, the preferential binding of cancer cells to bone marrow endothelial cells, and the release of chemo-attractants from bone elements contribute to this process (7).

Ewing's theory suggests that metastatic deposits are primarily a mechanical phenomenon, with cancer cells directed to specific sites based on blood flow and lymphatic anatomy (6). Both theories are likely correct to some extent, as anatomical components like the Batson venous plexus and site-specific molecular interactions contribute to the spread of prostate cancer to the bone (8).

In line with the seed and soil theory, bone metastases occur almost exclusively in areas with active red marrow. Active red bone marrow is attractive for metastatic involvement due to its sinusoidal vascular spaces, which provide a relatively easy barrier for tumor cell penetration (6).

Our findings indicate that the pelvis and spine are the primary sites for prostate cancer metastasis, rather than the ribs and sternum (Table 2). The Batson venous plexus hypothesis suggests that prostatic cancer cells initially metastasize to the pelvis and spine and later to other skeletal parts, such as the ribs (4). In contrast, breast cancer metastases to the ribs are more frequent, possibly due to different spreading pathways. Early-stage breast cancer may directly invade nearby ribs or spread to the ribs via the aorta after lung metastasis (9).

Breast cancer may spread to the sternum via the parasternal lymph nodes (9), leading to frequent involvement of the spine, ribs, and sternum.

Although our study had a small number of lung cancer patients, the ribs and spine were the most common sites of bone involvement (Table 2). Other studies suggest that lung cancers spread via the pulmonary veins and arterial system, involving the appendicular skeleton more frequently than other cancers, supporting Ewing's hypothesis (6).

Our results indicate that the spine, pelvis, and ribs are the main sites of bone metastases, with the extremities, particularly distal portions, being non-predilection sites. Among the extremities, the proximal femurs are the most frequently involved (Table 2).

Of the 58 patients with bone metastases, 63.7% experienced bone pain. Among all patients with bone pain, 62.3% had bone metastasis (Table 3). There was a notable concordance between the area of bone pain and metastatic involvement in the same region, particularly in the skull, sternum, pelvis, lumbar vertebrae, and proximal femurs. This suggests that symptoms in these areas should be carefully evaluated for potential bone metastasis.

As the sample size for GI and lung cancer were small, further research with more patients suffering from these cancers is recommended.

CONCLUSION

The study revealed distinct metastatic patterns in bone lesions, with prostate cancer affecting the pelvis and spine, breast cancer involving the spine, ribs, and sternum, and lung cancer targeting the spine and ribs, highlighting the role of red bone marrow regions in metastasis, the need for improved diagnostic and therapeutic approaches, and the need for further research with larger cohorts.

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