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Patterns of Bone Metastasis in Breast, Colorectal, and Thyroid Cancers: A Systematic Review

Dandy Drestanto Adiwignyo[1], Istan Irmansyah Irsan[1], Satria Pandu Persada Isma[1], Nan Bareno Chairus[2]

[1]Orthopaedic and Traumatology Department, Faculty of Medicine, Universitas Brawijaya – Saiful Anwar General Hospital, Malang, Indonesia

Corresponding Author: Dandy Drestanto Adiwignyo

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ABSTRACT

Introduction: Bone metastases are a major issue in oncology, causing severe complications like pain, fractures, and reduced quality of life. Different cancers have distinct patterns of metastatic spread, with breast and prostate cancers often affecting bones, while thyroid and colon cancers have more variable tendencies. Understanding these patterns is crucial for guiding diagnostic vigilance and optimizing patient management strategies.

Method: This systematic review uses the PRISMA 2020 methodology to search for articles related to bone metastasis sites in stage IV breast, thyroid, and colon cancer. The articles included from 2014-2024, with the main outcome described as the initial diagnosed distribution of bone metastasis sites.

Results: 181 studies on bone metastasis in 1742 patients with stage IV cancer, focusing on breast cancer, colorectal cancer, and thyroid cancer. The predominant site of bone metastases in breast cancer is the rib cage-sternum (30.8%), whereas in colorectal cancer, it is the spinal column (37.9%). In differentiated thyroid cancer, it is also the spinal column (36.78%).

Discussion: Breast cancer's propensity to metastasize to the rib cage and sternum due to anatomical proximity and the rich vascular supply of the thoracic bones. In contrast, the predilection for spinal and pelvic metastases in colorectal cancer and differentiated thyroid cancer patients reflect the venous drainage patterns and the Batson venous plexus, which facilitates the spread of cancer cells to the axial skeleton.

Conclusion: Unique bone metastasis patterns in BC, CRC, and DTC patients emphasize the need for cancer-specific surveillance and management strategies and call for further studies.

Keywords: breast neoplasms, colorectal neoplasms, neoplasm metastasis, thyroid neoplasms.

INTRODUCTION

Bone metastases are a significant challenge in oncology, representing a critical aspect of advanced cancer progression. The skeletal system is the third most common site of metastatic spread after the lungs and liver.[1] Metastatic involvement of bones often results in severe complications, including pain, fractures, hypercalcemia, and reduced quality of life, emphasizing the importance of early detection and intervention.[2] Understanding the distribution of bone metastases is essential to guide diagnostic vigilance and optimize patient management strategies.

Different cancers exhibit distinct patterns of metastatic spread due to factors such as tumor biology, the microenvironment, and specific molecular mechanisms. For

example, breast and prostate cancers frequently metastasize to bones, while thyroid and colon cancers have more variable tendencies.[2] Identifying the most common skeletal sites for metastasis, such as the spine, pelvis, or femur, provides critical insights for clinicians and researchers.[3] In this systematic review, we aim to comprehensively explore the patterns and prevalence of bone metastases in patients with breast cancers, colorectal, and thyroid. Shedd light on the skeletal sites most affected by these malignancies.

METHOD

Literature Search

This systematic review article employs the PRISMA 2020 methodology.[4] This review scours article PUBMED, ScienceDirect, and Cochrane using keywords and Boolean operator of ("breast cancer" OR "colorectal cancer" OR "thyroid cancer") AND ("bone metastases" OR "skeletal metastases" OR "bone lesions"). MeSH term was used when available. Snowball's simplified version of the search term was also used in Google Scholar to supplement valid articles.

Inclusion and Exclusion Criteria

Articles are first filtered only to include publications done in 2014 – 2024. Duplicate article from each database was first consolidated before proceeding into screening based on title and abstract. Observational articles (Cohort, Case-Control, or Cross-Sectional), as well as Randomized Controlled Trials (RCTs) that provide information on the initial diagnosed distribution of bone metastasis sites from stage IV breast, thyroid, and colon cancer, were included for further reading. Articles that are not accessible or missing full paper are not included.

Outcome

The main outcome of this article is to describe the site bone metastasis site from stage IV breast, thyroid, and colon cancer.

RESULT

The initial literature search yielded 2032 records from all databases. After consolidating duplicates and implementing inclusion and exclusion criteria, 181 Studies were identified for full-text reading. A total of 9 articles are included in this study, with the PRISMA table written in Figure 1.

A total of nine studies were included in this article. Cumulatively, there were 1742 patients with bone metastasis, with the most common initial site of cancer being breast cancer (79,51%), colorectal cancer (5,91%), and thyroid cancer (14,58%). All the cancer included was of stage IV. All the studies reported multiple bone sites per patient. The oldest data set ranges from 1980 up until 2020. A total of 15 medical institutions were included in this study. All the studies are retrospective.

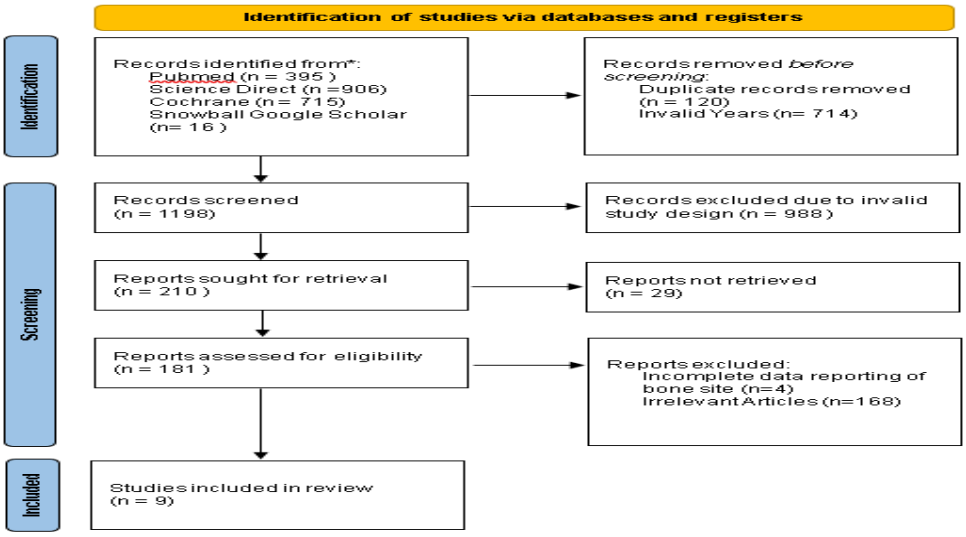

Figure 1. PRISMA 2020 diagram flowchart of articles

Table 1. List of Studies on Common Location of Bone Metastatic Based on Cancer Type

Author	Age Diagnosis	Male: Female	Bone Metastatic Patients	Skull	Spinal column	Rib Cage - Sternum	Extremities	Pelvis	Other	Total Site
Original Cancer Lesion from Breast										
Nie, H, et al., 2021[5]	43 (20-81)	0:984	984	251	489	1335	1358	682	6	4121
Kakhki, V, R, et al., 2013[6]	NA	NA	74	5	18	28	14	9	0	74
Chen, W, Z, et al., 2017[7]	47.29 ± 10.59	1:326	327	68	455	333	285	177	1	1319
Total			1385	5,9%	17,4%	30,8%	30,0%	15,7%	0,1%	5514
Original Case Lesion from Colorectal Cancer										
Jimi, S, et al., 2012[8]	63.8 (65) ± 11.5 (range 43–82)	20:12	32	0	26	11	2	17	0	56
Baek, S, et al., 2016[9]	60.8 ± 10.4	39:24	63	0	49	0	28	39	31	147
Kakhki, V, R, et al., 2013[6]	NA	NA	8	0	5	2	0	1	0	8
Total			103	0,0%	37,9%	6,2%	14,2%	27,0%	14,7%	211
Original Cancer Lesion from Differentiated Thyroid Cancer										
Slook, O, et al., 2018[10]	62.1±14.3	33:31	64	4	30	19	8	24	5	90
Matta-Coelho, C, et al., 2018[11]	64 (53.6 - 71.2)	28:58	86	16	53	32	14	25	0	140
Piñar-Gutiérrez, A, et al., 2023[12]	62 (52–71)	27:3	30	11	38	21	25	20	0	115
Iñiguez-Ariza, M, N, et al., 202013	57.62 +- 14.61	43:31	74	3	46	11	8	41	0	109
Total			254	7,49%	36,78%	18,28%	12,11%	24,23%	1,10%	454

Female patients dominated Breast cancer (BC), while both Colorectal Cancer (CRC) and Differentiated Thyroid Cancer (DTC) have almost equal distribution in both genders. BC also presented with an average younger patient age group of 43 – 47 years old, compared with CRC of 60 -63 years old, and DTC, which ranges from 57 – 64 years old.

BC reported the most common bone metastasis site as Rib Cage – Sternum (30.8%), followed by extremities (30%), Spinal column (17.4%), Pelvis (15.7%), skull (15.9%), and other (0.1%). This is different than what is reported in CRC, where the most common site is the spinal column (37.9%), followed by the pelvis (27%), other (14.7%), extremities (14.2%), and Rib Cage-Sternum (6.2%). Spinal Column is also the most commonly reported site of DTC (36.78%), followed with pelvis (24.23%), Rib Cage-Sternum (18.28%), Extremities (12.11%), skull (7,49%) and others (1.10%).

DISCUSSION

The demographic analysis revealed that BC patients were predominantly female, aligning with the higher incidence of breast cancer in women. In contrast, CRC and DTC patients exhibited a more balanced gender distribution. Age-wise, BC patients presented at a younger average age (43–47 years) compared to CRC (60–63 years) and DTC patients (57–64 years). These findings are consistent with existing literature indicating that breast cancer often affects younger women, while colorectal and thyroid cancers are more prevalent in older populations. [14,15]

Variations in metastatic bone patterns may be attributed to the distinct biological behaviors and metastatic tropisms of each cancer type.[2] Breast cancer's propensity to metastasize to the rib cage and sternum could be due to anatomical proximity and the rich vascular supply of the thoracic bones.[16] In contrast, the predilection for spinal and pelvic metastases in CRC and DTC patients may reflect the venous drainage patterns and the Batson venous plexus, which facilitates the spread of cancer cells to the axial skeleton.[8,17]

The findings of this review underscore the importance of tailored surveillance strategies for patients with advanced cancers. For instance, imaging studies focusing on the thoracic skeleton may be particularly pertinent for BC patients, while spinal and pelvic assessments might be prioritized for CRC and DTC patients. Early detection of bone metastases in these common sites can facilitate timely interventions to manage symptoms and improve quality of life.[18]

Notably, all included studies were retrospective, which may introduce selection bias and limit the generalizability of the findings. Additionally, the data spanned four decades (1980–2020), during which diagnostic modalities and treatment approaches have evolved significantly.[10] These factors should be considered when interpreting the results.

CONCLUSION

In conclusion, this review highlights distinct patterns of bone metastasis among BC, CRC, and DTC patients, emphasizing the need for cancer-specific surveillance and management strategies. Further prospective studies are warranted to validate these findings and explore the underlying mechanisms driving the observed metastatic distributions.

Declaration by Authors

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Conflict of Interest: The authors declare no conflict of interest.

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