

Computed Tomography Detection of Abdominopelvic Metastasis and Its Association with Hormonal Receptor Status in Breast Cancer Patients at Ocean Road Cancer Institute: a cross-sectional study

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Abstract

Background: Breast cancer is among the most common cancers in women globally. Most Tanzanian women diagnosed with breast cancer are at an advanced stage. This study aimed to examine the role of CT scan in detecting Abdominopelvic metastasis and its association with hormonal receptor status and staging among women with breast cancer.

Methodology: A descriptive cross-sectional study was conducted at ORCI from July 2020 to December 2022, enrolling 140 patients with breast cancer. Abdominopelvic CT findings, staging, and hormone status data were recorded. A checklist developed by the Principal Investigator (PI) was used. The PI and a senior Radiologist read CT images. Data analysis was performed using SPSS Version 25. Multiple logistic regression was used to examine the factors associated with metastases. Statistical significance was set at a p-value of less than 0.05

Results: Majority (92%) of patients with breast cancer were > 40 years old, with a mean age of 53.71±11 years. Approximately 52.9% had

abdominopelvic metastasis, and the liver was the most common (47.9%) site involved. Most of the patients (81%) had advanced-stage 4 and were hormonal receptor-negative. Positive Estrogen Receptor (ER) (AOR: 5.23, 95% CI: 2.32-11.76, $p < 0.001$, positive Progesterone Receptor (PR) (AOR: 0.64, 95% CI: 0.55-0.74, $p < 0.001$) and Triple Negative Breast Cancer (TNBC) (AOR: 1.28, 95% CI: 1.15-1.42, $p < 0.001$) were significantly associated with abdominopelvic metastases.

Conclusion: The majority of metastases were characterised by hypodense lesions and a non-enhancing pattern. The most common location of metastasis is the liver. A predominance of advanced-stage tumours and a significant proportion of cases with triple-negative hormonal receptor statuses suggest a high disease burden and challenges in treatment selection. The findings underscore the importance of comprehensive tumor profiling in guiding treatment decisions.

Keywords: breast cancer, metastasis, hormonal receptor status, CT-Scan

Introduction

Globally, breast cancer is the single most widely diagnosed cancer (Łukasiewicz *et al.*, 2021). In 2020, breast cancer contributed to 11.7% of all cancers diagnosed in both men and women, according to the Global Cancer Observatory (GLOBOCAN) (Łukasiewicz *et al.*, 2021)(Sung *et al.*, 2021). Among women, in the same year, 24.5% of all diagnosed cancers were breast cancer (Basudan, 2022). Apart from being

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the leading cancer diagnosis among women, breast cancer is also the leading cause of cancer-related mortality worldwide (Łukasiewicz *et al.*, 2021). Deaths due to breast cancer were found to be 684,996 globally in 2020 (Łukasiewicz *et al.*, 2021; Basudan, 2022). While the disease burden seems low in Africa, mortality due to breast cancer is staggeringly high (Anyigba, Awandare and Paemka, 2021). In 2020, estimates from GLOBOCAN data reported that 186,598 (8.3%) incident cases and 85,787 (12.5%) of all deaths due to breast cancer occurred in Africa (Anyigba, Awandare and Paemka, 2021).

Factors contributing to the development of breast cancer can be categorized into non-modifiable and modifiable factors (Łukasiewicz *et al.*, 2021). Non-modifiable factors include, but are not limited to, being female, older age, having a family history of breast cancer, genetic mutations, reproductive factors such as pregnancy at a late age, fewer pregnancies, and a history of radiation therapy (Łukasiewicz *et al.*, 2021; Anyigba, Awandare and Paemka, 2021; Tao *et al.*, 2015). Modifiable factors include medication such as hormonal replacement therapy (HRT), a high Body Mass Index (BMI), reduced physical activity, alcohol intake, smoking, and others (Łukasiewicz *et al.*, 2021; Tao *et al.*, 2015).

Anatomic staging of breast cancer is classified into five major stages, with Stage 0 being the lowest stage and Stage IV being the highest (Table 1) (Kalli *et al.*, 2018). Stage 0 involves a smaller-sized tumor with no involvement of lymph nodes and no metastases. Stage IV, on the other hand, involves any-sized tumour, having any lymph node involvement and metastasis to other organs (Kalli *et al.*, 2018; Teichgraeber, Guirguis and Whitman, 2021). Like any other cancer, breast cancer has the potential to spread to distant organs. Common organs for breast cancer metastasis are usually the lungs, brain, liver, and bones. This stage of breast cancer disease is fatal and accounts for the majority of deaths due to cancer (Borisch, 2008). This is because, at this stage, there are no effective drugs to effectively cure metastatic tumors, and surgical procedures for already-metastasized tumours are difficult and pose more risk to patients (Borisch, 2008). Regrettably, in Tanzania, the majority of breast cancer patients are in this advanced stage (Sakafu *et al.*, 2022; Mansouri *et al.*, 2020; Komen, 2017). It is therefore imperative to detect cancer metastasis in its early stages through regular biochemical and imaging studies to improve patient outcomes (Teichgraeber, Guirguis and Whitman, 2021; Borisch, 2008).

Several imaging studies are to be considered when investigating breast cancer metastasis. These tests include Positron Emission Tomography (PET) scan, chest CT, abdominopelvic CT, and bone scans (Teichgraeber, Guirguis and Whitman, 2021; Bhushan, Gonsalves and Menon, 2021). Abdominopelvic CT is commonly used to detect breast cancer metastases in the abdomen and pelvic organs (Teichgraeber, Guirguis and Whitman, 2021; Bhushan, Gonsalves and Menon, 2021). Identifying metastases unexpectedly among asymptomatic patients using abdominopelvic CT can alter initial management plans by oncologists (Kim *et al.*, 2011).

The pattern and rapidity of metastasis from initial diagnosis have been suggested to depend on hormone receptor status. Sometimes, metastases go unnoticed as the association between hormonal receptor status and abdominopelvic metastasis CT patterns is not well known. Among the breast cancer patients undergoing CT imaging for the assessment of abdominopelvic metastasis, the association between the metastasis and hormonal status is not documented to our knowledge. This highlights the crucial value of further evaluation of breast cancer for metastasis using other modalities such as abdominopelvic CT. This study aimed to examine the role of CT-Scan in detecting Abdominopelvic metastasis and its association with hormonal receptor status and staging among Breast Cancer.

Methods

Design of the study

This cross-sectional study was carried out from June 2023 to December 2023 for a period of six (6) months at Ocean Road Cancer Institute (ORCI), whereby clinical and radiological patients' data obtained from July 2020 to December 2022 were reviewed and studied.

Setting for study

The study was conducted at the Department of Radiology at ORCI. ORCI is a known specialised facility for cancer treatment. It is located in Dar es Salaam, within Ilala Municipality. The institute admits a total of more than 50,000 patients every year and has a bed capacity of 273. The institute is equipped with experts which including 7 radiologists, 14 radiographers, and 23 oncologists. The radiology department has modern imaging equipment, including conventional radiography, Ultrasound, MRI, CT scan, and PET CT this facilitates effective patient diagnosis of cancer, including detection of metastases.

Study population and sampling

This study reviewed clinical and radiological data of patients with breast cancer who underwent abdominal and pelvic CT from July 2020 to December 2022 at ORCI. A total of 140 subjects who fulfilled the inclusion criteria were included in this study.

Inclusion criteria

From July 2020 to December 2022, all patients with primary breast cancer who underwent abdomen and pelvis CT (CTAP), and all patients who underwent investigations for hormone status at ORCI were included.

Exclusion criteria

Patients with breast cancer with no abdominal and pelvic CT scan data, and those with no investigation for hormone status.

Data collection

Data were collected from the patients' files and electronic records using a structured checklist. The checklist contains three major sections: patient demographic characteristics, imaging and evaluation, tumor staging, and hormonal status characteristics. Demographic characteristics included the age of the patient, level of education, and occupation of the patient. For Imaging and Assessment, CT scan images were read by the principal investigator and a senior Radiologist. A final radiological diagnosis was reached by consensus. Tumour stage, human epidermal growth factor receptor 2 (HER2) status, Estrogen Receptor (ER) status, Progesterone Receptor (PR) status, and Triple-Negative Breast Cancer (TNBC) results were recorded directly from the system server at ORCI.

Data analysis

The acquired data were stored and examined using SPSS version 25, Statistical Software for Social Sciences. Data were cleaned, coded, and entered into SPSS before being analyzed. While continuous data were described using means and standard deviations, categorical data were presented as frequencies and percentages. Logistic regression was used to assess factors associated with abdominal pelvic metastasis in patients with breast cancer. Statistical significance was determined by a p-value of less than 0.05.

Results

Sociodemographic characteristics of the participants

A total of 140 patients with breast cancer were studied. The majority were between 50-59 years old (37.9%). Additionally, the mean age was 53.71 years with a standard deviation of 11.59. The majority of the participants had a primary education, 40.7%.

Regarding occupation, a significant portion of the participants were unemployed, representing nearly half of the sample (49.3%), followed by those who were self-employed (32.1%), and those who were employed (18.6%), respectively (Table 1).

Table 1: Sociodemographic characteristics (N=140)

Variables	Frequency	Percent (%)
Age	Mean $\pm$ SD (53.71$\pm$11.59)	
<40 years	10	7.1
40-49 years	40	28.6
50-59 years	53	37.9
>60 years	37	26.4
Education level		
Non-formal education	41	29.3
Primary education	57	40.7
Secondary education	26	18.6
College/University	16	11.4
Occupation		
Employed	26	18.6
Self-Employed	45	32.1
Unemployed	69	49.3

Abdomen and pelvis metastatic pattern by CTAP in breast cancer patients

The pattern of abdomen and pelvic metastasis among the participants revealed Hypodense lesions were the most prevalent metastasis characteristic on non-contrasted CT, accounting for 89.3% of cases. Hypo-enhancement patterns were again predominant (89.3%) on contrasted CT. The most common locations of metastasis were in the liver, with nearly half of the participants (47.9%) exhibiting metastasis in this organ. Other locations, such as the stomach, pancreas, spleen, colon, abdominal lymph nodes, ovaries, uterus, and adnexa metastasis were less frequent (Figure 1). An anticipated incidental lesion in the lumbar spine (5.7%) as osteolytic or osteoblastic lesions, was noted.

Table 2: Abdomen and pelvis metastatic pattern by CTAP in breast cancer patients

Variables	Frequency(n)	Percent (%)
Metastasis Characteristics on Non-contrasted CT		
1. Metastasis to solid abdominopelvic organs:		
Hypodense lesion	125	89.3
Isodense lesion	0	0.0
Hyperdense lesion	0	0.0
2. Metastasis to Bones		
Osteolytic	7	5.0
Osteoblastic	8	5.7
Metastasis Characteristics On contrasted CT		
Non-enhancement pattern	140	100.0
Enhancement pattern	0	0.0

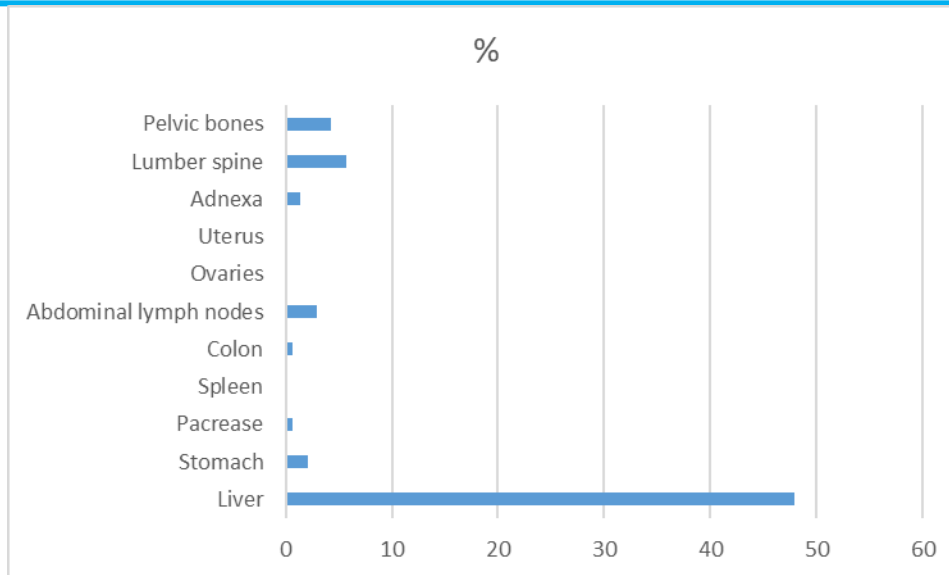


Figure 1: Metastasis occurrence% by location

Tumor stages and hormonal receptor status

The results showed that among breast cancer patients who underwent abdomen and pelvis CT scan to detect metastasis, a significant predominance of advanced stages was noted, with the majority being at Stage 4 (81%), while Stage 3 accounts for a smaller yet substantial portion (18%), 1% stage 2, and no client was detected with tumor stage 1.

HER2 status showed that a considerable proportion of cases are negative (77.1%), with 22.9% being positive. Similarly, ER status indicates a higher percentage of negative cases (62.9%) than positive ones (37.1%). PR status also demonstrates a similar pattern, with more cases being negative (71.4%) than positive (28.6%). Regarding TNBC (Triple-Negative Breast Cancer), approximately half of the patients have (50.7%), while the remaining have other subtypes, indicating a relatively balanced distribution.

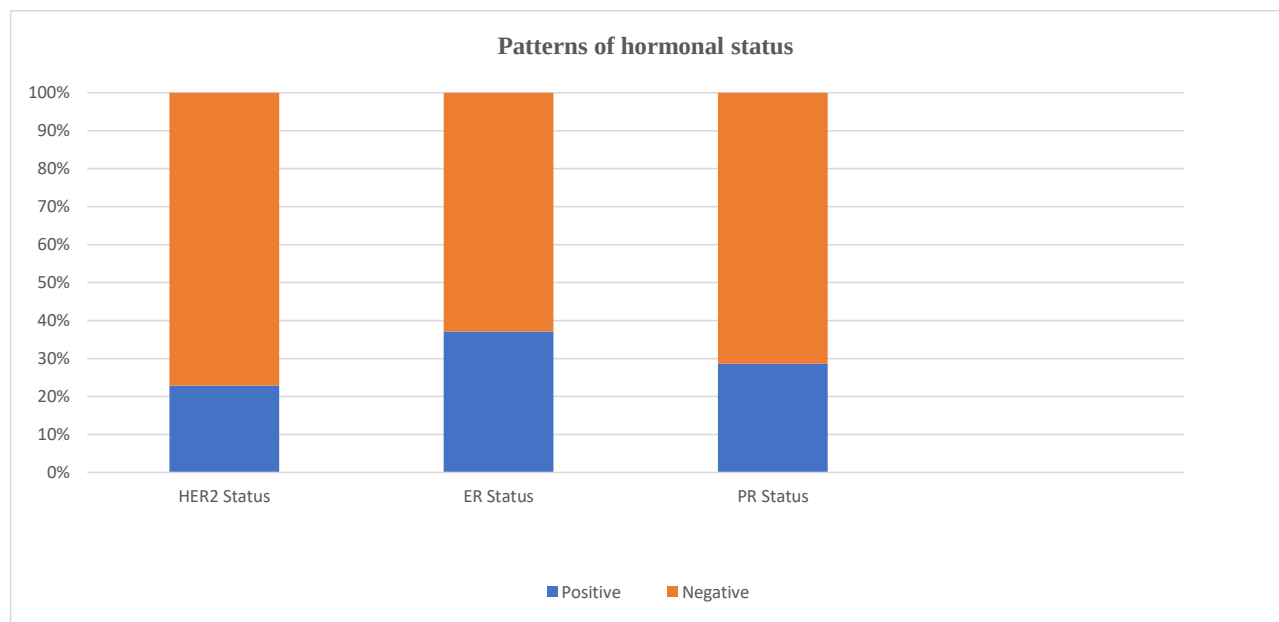


Figure 2: Patterns of hormonal Status

Association of abdominopelvic CT findings (metastasis) and breast cancer hormonal receptor status and stages

Patients with HER2-positive status had higher positive 19(59.4%) abdominopelvic CT scan findings as compared to patients with HER2-negative 55(50.9%), however the observations were not statistically significant (p -value = 0.400). There was a significant difference in percentage distribution of positive CT findings between patients with ER-positive status 40(76.9%) compared to those with ER-negative status 34(38.6%) ($p < 0.001$) as well as PR-positive (85.0%) vs PR-negative status (40.0%) ($p < 0.001$). Patients with TNBC had lower proportion (35.2%) of positive CT findings as compared to those with no TNBC (71.0%) ($p < 0.001$) [Table 3]. Positive abdominopelvic CT findings were higher among patients with Stage 4 tumors, (57.9%) compared to those with Stage 3(30.8%). No patient in this study had tumor stage 1.

Table 3: Association between Abdomen and pelvis CT Scan with hormonal status and stages

Variables	Abdominopelvic Metastasis CT Scan findings		P-Value
	Positive	Negative	
HER2 Status			
Positive	19(59.4)	13(40.6)	0.400
Negative	55(50.9)	53(49.1)	
ER Status			
Positive	40(76.9)	12(23.1)	<0.001
Negative	34(38.6)	54(61.4)	
PR Status			
Positive	34(85.0)	6(15.0)	<0.001
Negative	40(40.0)	60(60.0)	
Tumor stages			
Stage 1	0 (0.0)	0 (0.0)	0.012
Stage 2	1 (100.0)	0 (0.0)	
Stage 3	8(30.8)	18(69.2)	
Stage 4	65 (57.5)	48 (42.5)	
TNBC			
Yes	25 (35.2)	46 (64.8)	<0.001
No	49 (71.0)	20 (29.0)	

Logistic regression of factors associated with abdominopelvic CT scan findings in both bivariate and multivariate analyses

The bivariate and multivariate analyses revealed significant associations between various factors and abdominal pelvic CT scan findings. In the bivariate analysis, Stage 3 (COR: 1.47, 95% CI: 1.39-1.56, $p < 0.001$) and Stage 4 tumors (COR: 3.09, 95% CI: 1.24-7.70, $p = 0.015$) had higher odds. In the multivariate analysis, Stage 2 tumors showed increased odds (AOR: 1.69, 95% CI: 1.52-1.88, $p < 0.001$), while Stage 4 tumors displayed decreased odds (AOR: 0.32, 95% CI: 0.12-0.83, $p = 0.020$), and Stage 3 tumors remained significantly associated (AOR: 1.29, 95% CI: 1.19-1.40, $p < 0.001$).

For ER status, positive cases were significantly associated with higher odds in both bivariate (COR: 0.19, 95% CI: 0.09-0.41, $p < 0.001$) and multivariate analyses (AOR: 5.23, 95% CI: 2.32-11.76, $p < 0.001$). Similarly, positive PR status showed significant associations in both analyses (bivariate: COR: 0.12, 95% CI: 0.05-0.31, $p < 0.001$; multivariate: AOR: 0.64, 95% CI: 0.55-0.74, $p < 0.001$). TNBC-positive cases were significantly associated with higher odds in both bivariate (COR: 4.51, 95% CI: 2.21-9.19, $p < 0.001$) and multivariate analyses (AOR: 1.28, 95% CI: 1.15-1.42, $p < 0.001$).

Table 4: Logistic regression of factors associated with abdominal pelvic CT scan detection

Factors	Bivariate Analysis		Multivariate Analysis	
	COR (95% CI)	P-Value	AOR (95% CI)	P-Value
Tumor stages				
Stage 1	Ref			
Stage 2	0.84 (0.74-0.95)	0.005	1.69 (1.52-1.88)	<.001
Stage 3	1.47(1.39-1.56)	<0.001	1.29 (1.19-1.40)	<0.001
Stage 4	3.09(1.24-7.70)	0.015	0.32(0.12-0.83)	0.020
ER Status				
Positive	0.19(0.09-0.41)	<0.001	5.23(2.32-11.76)	<0.001
Negative	Ref			
PR Status				
Positive	0.12(0.05-0.31)	<0.001	0.64(0.55-0.74)	<0.001
Negative	Ref			
TNBC				
Yes	4.51 (2.21-9.19)	<0.001	1.28 (1.15-1.42)	<0.001
No	Ref			

Discussion

The sociodemographic profile of breast cancer patients in this study revealed a notable proportion of individuals aged 50-59 years with breast cancer. Most of them had a primary education and were unemployed. These findings reflect a demographic pattern commonly observed in breast cancer populations globally (Arndt *et al.*, 2001). However, reported that African women are diagnosed with breast cancer a decade earlier than their African American and White American counterparts, 50.2 vs 60.8 and 62.4 years, respectively (Anyigba, Awandare and Paemka, 2021). Socioeconomic factors such as education and employment status have been linked to disparities in cancer outcomes, with lower education levels and unemployment often associated with delayed diagnosis and poorer prognosis. Understanding the sociodemographic profile of breast cancer patients is crucial for designing targeted interventions to improve access to screening and treatment services. Efforts to increase awareness and facilitate early detection among underserved populations are essential for reducing breast cancer mortality rates (Chew, Ho and Kua, 2022). However, the study may be limited by potential biases in participant selection and the reliance on self-reported sociodemographic data, which could introduce inaccuracies (Sanchez *et al.*, 2022).

The study identified liver metastasis as the most common pattern observed, with hypodense lesions (hypoattenuating) and hypo-enhancement predominating on CT scans. These findings are consistent with established metastatic patterns in breast cancer, where liver involvement is frequently encountered in advanced disease stages (Karlo *et al.*, 2013) (Rosa Mendoza, Moreno and Caguioa, 2013). The imaging features described provide valuable insights into disease extent and progression, facilitating treatment planning and prognosis assessment (Hani, Attuwaybi and Butler, 2019). Early detection of metastasis is critical for guiding therapeutic decisions and improving patient outcomes. Imaging modalities such as CT scans play a crucial role in identifying metastatic lesions and monitoring treatment response (Park *et al.*, 2022; Jin and Mu, 2015). However, limitations such as the inability to detect microscopic metastases and potential variations in imaging interpretation should be considered (Hani, Attuwaybi and Butler, 2019).

The study revealed a predominance of advanced-stage tumors and a significant proportion of cases with negative hormonal receptor statuses. This suggests a high disease burden and challenges in treatment selection. Similar findings have been reported globally, emphasizing the need for improved early detection and tailored treatment strategies (Arndt *et al.*, 2001). Understanding the

molecular characteristics of breast cancer tumors is crucial for guiding therapeutic decisions and predicting treatment response (Bonanni *et al.*, 2014).

These findings have important implications for clinical practice, emphasizing the importance of comprehensive tumor profiling in guiding treatment decisions. Tailored therapeutic approaches based on tumor characteristics can improve outcomes and optimize resource utilization. However, limitations such as the reliance on archival tissue samples and potential heterogeneity within tumor subtypes should be acknowledged (Bedard *et al.*, 2013).

The high proportion of positive abdominopelvic CT scan findings underscores the utility of imaging modalities in disease assessment and staging. Early detection of metastatic spread is crucial for guiding treatment decisions and predicting prognosis. This aligns with global recommendations highlighting the importance of imaging in the management of advanced breast cancer (Casey *et al.*, 2018; Xia *et al.*, 2019). However, limitations such as the inability to detect micro-metastases and potential variations in imaging interpretation should be considered (Pataky *et al.*, 2013).

Patients with HER2-positive status had higher positive 19(59.4%) abdominopelvic CT scan findings as compared to patients with HER2-negative 55(50.9%), however, the observations were not statistically significant (p -value = 0.401). There was a significant difference in percentage distribution of positive CT findings between patients with ER-positive status 40(76.9%), compared to those with ER-negative status 34, (38.6%) ($p < 0.001$), as well as PR-positive (85.0%) vs PR-negative status (40.0%) ($p < 0.001$). Patients with TNBC had a lower proportion (35.2%) of positive CT findings as compared to those with no TNBC (71.0%) ($p < 0.001$). Positive abdominopelvic CT findings were higher among patients with Stage 4 tumors, (57.9%) compared to those with Stage 3(30.8%). No patient in this study had tumor stage 1. These findings provide valuable insights into the determinants of disease detection and inform evidence-based approaches to disease management (Bonanni *et al.*, 2014)(Bedard *et al.*, 2013).

Understanding the association between imaging findings and hormonal statuses is critical for guiding treatment decisions and optimizing patient outcomes. Comprehensive tumor profiling, including molecular subtyping and imaging assessment, facilitates personalized treatment strategies tailored to individual patient needs (Paydary *et al.*, 2019; Papandrianos *et al.*, 2020). However, limitations such as potential variability in imaging interpretation and the dynamic nature of tumor biology should be acknowledged in clinical practice.

The logistic regression analysis revealed significant associations between various factors and the findings of the abdominopelvic CT scan. Tumor stage and hormonal receptor status were identified as significant predictors of disease detection, highlighting their prognostic significance in predicting disease progression and treatment response. These findings underscore the importance of comprehensive tumor profiling in guiding therapeutic decisions and optimizing patient outcomes (Lee *et al.*, 2021). Furthermore, the identification of factors associated with disease detection provides valuable insights into the determinants of disease progression and informs evidence-based approaches to disease management (Ma *et al.*, 1992).

Understanding the predictors of disease detection is crucial for developing targeted interventions to improve diagnostic accuracy and enhance early detection efforts (Paydary *et al.*, 2019). Efforts to optimize imaging protocols and standardize diagnostic criteria are essential for improving the sensitivity and specificity of imaging modalities in disease assessment and staging (Lee *et al.*, 2021; Ulaner, 2019). However, limitations such as potential confounding factors and sample size considerations should be acknowledged in the interpretation of study findings.

Conclusion

Most of the metastases were characterized by hypodense lesions and a non-enhancement pattern in CT images. The most common location of metastasis is the liver. A predominance of advanced-stage tumors and a significant proportion of cases with triple-negative hormonal receptor statuses suggest a high disease burden and challenges in treatment selection. The findings underscore the importance of comprehensive tumor profiling in guiding treatment decisions.

Limitations

This study was a hospital-based monocentric study; hence, it is not representative of the whole population. It is worth noting that incomplete information from the patient's record is due to the retrospective nature of the study.

Ethics approval and consent to participate

The research proposal underwent a comprehensive review and obtained ethical approval from the MUHAS Institutional Review Board (MUHAS-REC-05-2023-1687). Due to the retrospective design of the study, a waiver for informed consent was requested. Permission to collect data was also obtained from the director-general of ORCI. The confidentiality of all information and data was strictly upheld throughout the study. Patient identities were not collected or utilized, and no identifying information was included in the data analysis. Furthermore, access to the data was restricted to the investigators alone.

Consent for publication

Not applicable

Availability of data and materials

All data generated or analyzed during this study are included in this published article. However, the datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests

Funding

The authors declare that they have no competing interests.

Authors' contributions

All authors participated to study design, data collection, data analysis and redaction of the manuscript. They all reviewed the manuscript.

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