Frequency and Pattern of Metastases in Treated Breast Cancer Patients Detected on ^{18}F-FDG PET-CT: One Year Experience at INMAS Mohakhali

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ABSTRACT

Background: Breast cancer is one of the most common malignancies among women worldwide. Early detection of recurrence and metastatic disease is crucial for optimal management. 18F-FDG PET-CT plays an important role in evaluating treated breast cancer patients.

Objective: To determine the frequency and pattern of metastases in treated breast cancer patients using FDG PET-CT.

Methods: This retrospective observational study included 94 treated breast cancer patients who underwent FDG PET-CT over a period of one year at the Institution of Nuclear Medicine and Allied Sciences, Mohakhali, Dhaka. The presence, sites, and patterns of metastases were analyzed.

Results: Out of 94 patients, metastatic disease was detected in 36 patients (38.3%), while 58 patients (61.7%) showed no evidence of metastasis. Multiple site metastases were more common (61.1%) than single-site metastases (38.9%). The most common site of metastasis was lymph nodes (66.7%), followed by bone (61.1%), liver (27.8%), and lung (16.7%). Less common sites included the ovary (5.6%) and contralateral breast (5.6%). Mixed-pattern metastases were the most frequent presentation (61.1%).

Conclusion: ^{18}F-FDG PET-CT is a valuable imaging modality for detecting metastatic disease in treated breast cancer patients, with nodal and skeletal metastases being the most common. Mixed pattern involvement is frequently observed. Thus, PET-CT plays a vital role in the evaluation of metastases, guiding further treatment decisions and management.

Keywords: Carcinoma breast, 18F- FDG PET-CT, metastatic pattern.

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INTRODUCTION

Breast cancer is the most common malignancy among women worldwide and remains a leading cause of cancer-related mortality (1). Despite significant advances in early detection and treatment, a substantial proportion of patients develop recurrent or metastatic disease during follow-up, which significantly impacts prognosis and survival (2).

Accurate detection of metastatic disease is essential for appropriate staging, treatment planning, and prognostication. Conventional imaging modalities such as computed tomography (CT), magnetic resonance imaging (MRI), and bone scintigraphy have traditionally been used for evaluation; however, these techniques may have limitations in detecting early or occult metastases (3), which can lead to delayed treatment and poorer outcomes for patients.

^{18}F-fluorodeoxyglucose positron emission tomography combined with computed tomography (^{18}F-FDG PET-CT) has emerged as a powerful imaging modality that provides both metabolic and anatomical information in a single examination. It has demonstrated high sensitivity and specificity in detecting both locoregional recurrence and distant metastases in breast cancer patients (4, 5).

Breast cancer most commonly metastasizes to the bone, lungs, liver, and lymph nodes, with the pattern of spread influenced by tumor biology and stage at diagnosis (6). Whole-body PET-CT imaging allows comprehensive evaluation of these sites and may detect unexpected or atypical metastatic locations, thereby influencing clinical management.

Present study aims to evaluate the frequency and pattern of metastases in treated breast cancer patients using FDG PET-CT at a tertiary care center.

PATIENTS AND METHODS

A cross-sectional observational study was conducted at the Institute of Nuclear Medicine and Allied Sciences (INMAS), Mohakhali, over a one-year period from January 1, 2025, to December 31, 2025. The study included a total of 94 treated breast cancer patients who underwent FDG PET-CT.

Eligible patients had histopathologically confirmed breast cancer with completed primary treatment (surgery with or without chemotherapy and/or radiotherapy), and underwent ^{18}F FDG- PET-CT for evaluation of recurrence or follow-up.

Patients were excluded if the PET-CT was performed as a baseline study or if there was incomplete clinical history or imaging data.

Imaging Protocol: A total-body scan was performed using SIEMENS Healthineers Biograph mCT PET/CT scanner, one hour after intravenous administration of ^{18}F-FDG, following a contrast-enhanced CT scan. Image reconstruction was carried out using the list-mode Biograph mCT HD algorithm. The images were reformatted into transaxial, coronal, and sagittal planes. Semi-quantitative assessment of FDG uptake was expressed as the maximum standardized uptake value (SUVmax).

Data Collection and Statistical Analysis

Data on patient age, presence of metastasis, site of metastasis, and pattern of spread were collected, recorded and shown in Table 1.

Statistical analysis was performed using SPSS version 26. Categorical variables were presented as frequencies and percentages, while continuous variables were expressed as mean ± standard deviation.

RESULT

A total of 94 treated breast cancer patients were included in the study. The age distribution showed the highest number of patients in the 41–50 years age group (40.4%), followed by 51–60 years (21.3%), >60 years (17.0%), 31–40 years (12.8%), and 21–30 years (8.5%).

Metastatic disease was detected in 36 patients (38.3%), while 58 patients (61.7%) showed no evidence of metastasis on FDG PET-CT.

Among patients with metastases, multiple-site involvement was more common, seen in 22 patients (61.1%), whereas single-site metastasis was observed in 14 patients (38.9%).

Table-1: Age distribution of the study participants (n=94)

Age group (years)	Frequency	Percentage (%)
21-30	8	8.5
31-40	12	12.8
41-50	38	40.4
51-60	20	21.3
> 60	16	17.0
Total	94	100.0
Mean ± SD	47.6 ±11.0	

The mean age of the study population was 47.6 ±11.0 years, with the majority of patients belonging to the 41-50 years age group.

Table-2: Detection of metastasis among the study participants (n=94)

Metastasis	Frequency	Percentage (%)
Present	36	38.3
Absent	58	61.7
Total	94	100.0

Metastatic disease was detected in 36 patients (38.3%), while 58 patients (61.7%) showed no evidence of metastasis on FDG PET-CT.

Table 3: Site-wise distribution of metastases among the study participants (n=94)

Site	Frequency	Percentage (%)
Lymph nodes	24	66.7
Bone	22	61.1
Liver	10	27.8
Lung	6	16.7
Ovary	2	5.6
Contralateral breasts	2	5.6
Total	36	100.0

Lymph nodes were the most frequent site of metastasis, followed closely by skeletal involvement.

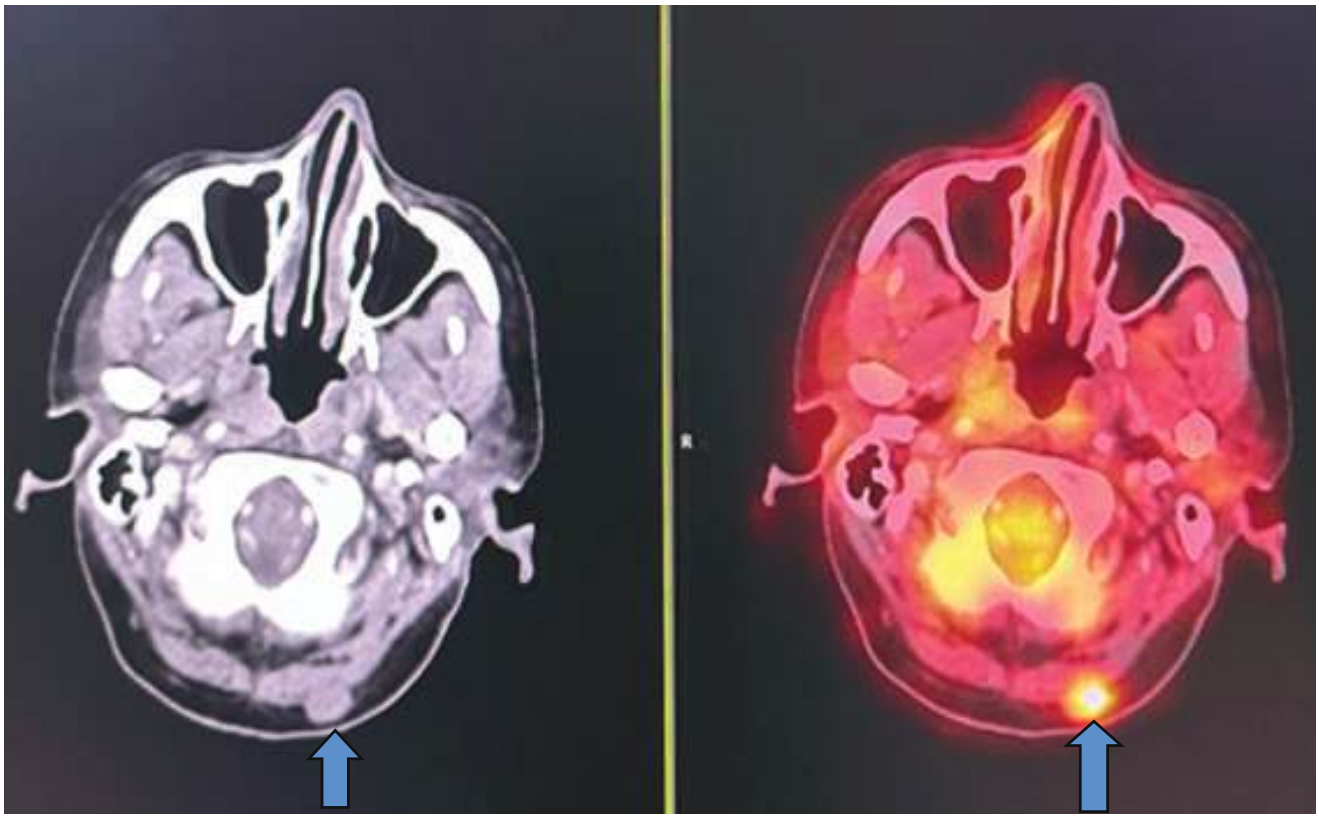

Figure 1: Nodal infiltration from treated primary breast cancer in a 67 year old patient treated with NACT, RT and surgery. Enlarged FDG avid (SUV:7.28) left occipital lymph node is noted (blue arrow).

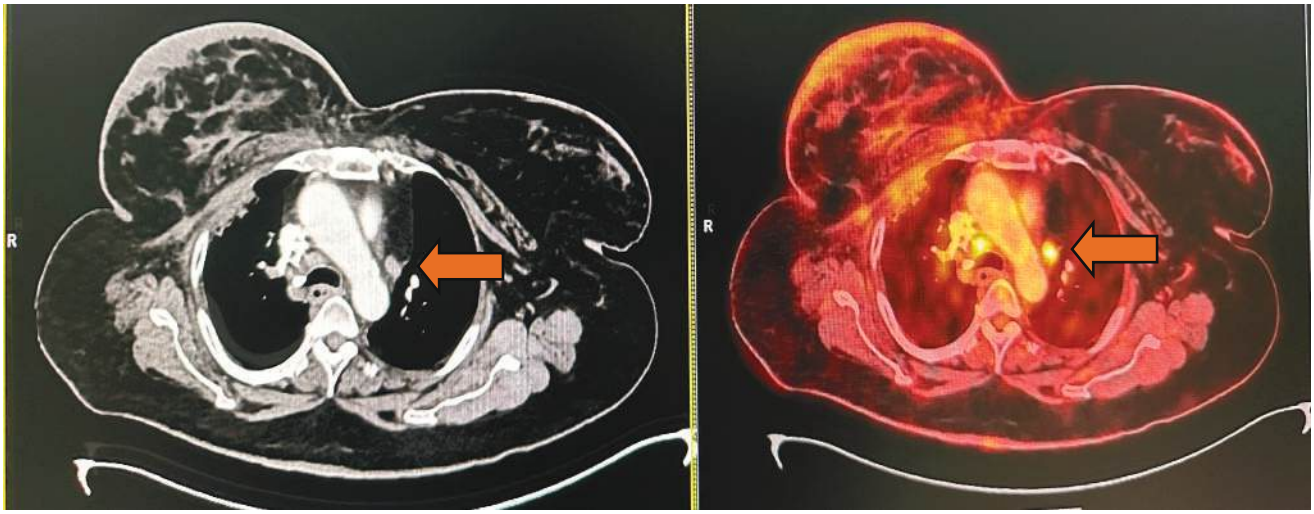

Figure 2: Enlarged FDG avid (SUV: 9.26) mediastinal lymph nodes in a 59 year old woman, suggesting nodal infiltration from treated primary breast cancer (orange arrow). Post operative and post radiation changes are also noted in right breast.

Table 4 : Pattern of metastasis among the study participants (n=36)

Pattern	Frequency	Percentage (%)
Mixed pattern	22	61.1
Bone only	4	11.1
Nodal only	4	11.1
Lung only	2	5.6
Liver only	2	5.6
Contralateral breast only	2	5.6
Total	36	100.0

Mixed pattern metastasis involving multiple organs was the most common presentation rather than single site metastasis.

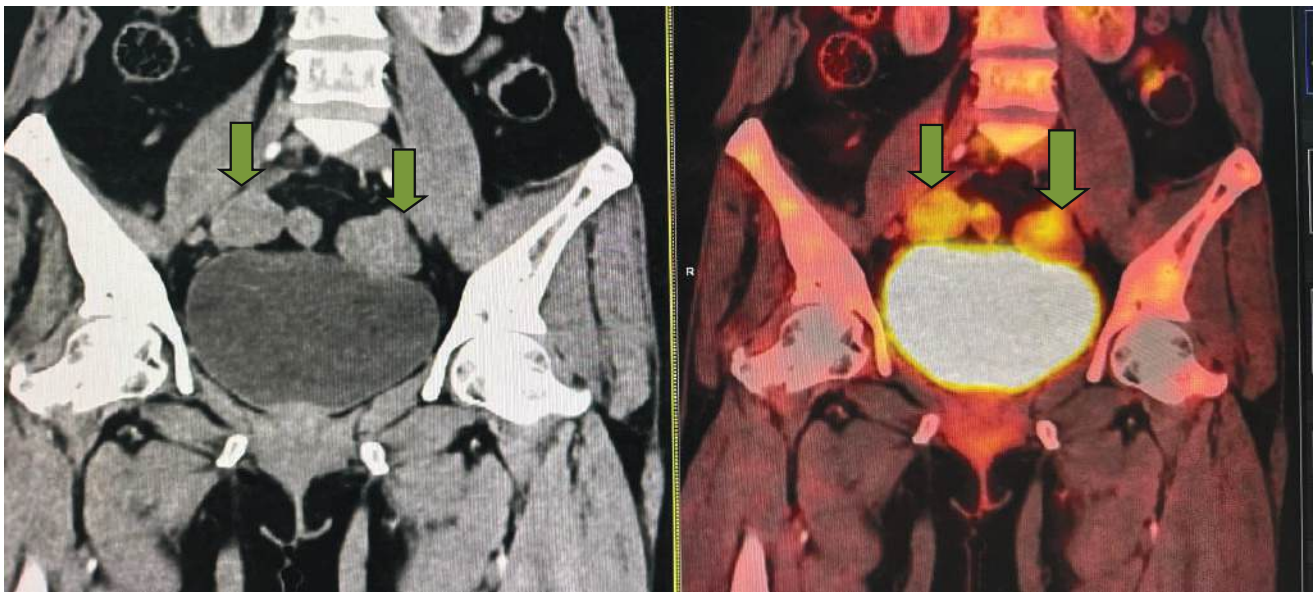

FIGURE 3: Bilateral ovarian metastases (Krukenberg tumor) from primary breast carcinoma (post treated). Heterogeneously enhancing FDG avid (SUV: 6.02) lesions are noted in both ovaries (green arrow).

DISCUSSION

Metastatic disease was identified in 38.3% of treated breast cancer patients in this study, underscoring the substantial burden of disease recurrence despite prior therapy. This finding aligns well with previously published literature, where recurrence and metastasis rates in post-treatment breast cancer populations range between 30% and 50%, depending on tumor biology, stage at diagnosis, and treatment modalities employed (5,7,8). The persistence of such a high recurrence rate highlights the critical need for sensitive imaging techniques for early detection and accurate staging.

Lymph nodes were the most common site of metastasis in this study (66.7%), followed closely by skeletal involvement (61.1%). Breast cancer is well known for its propensity for lymphatic dissemination, and nodal metastasis often represents an early step in systemic spread. The high detection rate of nodal disease in this study may be attributed to the superior sensitivity of ^{18}F-FDG PET-CT in identifying metabolically active lymph nodes, even when they are morphologically normal or subcentimetric on conventional imaging modalities such as CT or MRI (4,9). This metabolic advantage allows PET-CT to detect early disease involvement, thereby improving staging accuracy.

Skeletal metastases were also highly prevalent, consistent with the well-established predilection of breast cancer for osseous spread. Bone is recognized as the most frequent site of distant metastasis in breast cancer due to tumor–bone microenvironment interactions that favor tumor cell proliferation (6,10). FDG PET-CT has demonstrated higher sensitivity than conventional bone scintigraphy, particularly in detecting early marrow-based lesions before cortical destruction occurs (3,6,11). This early detection is crucial for timely initiation of systemic therapy and prevention of skeletal metastases.

Visceral metastases were comparatively less frequent in this study, with liver involvement observed in 27.8% and lung metastases in 16.7% of patients. These findings are consistent with prior reports indicating that visceral metastases typically occur later in the disease course and are less common than skeletal involvement (5,8,12). However, their presence is often associated with a poorer prognosis. FDG PET-CT offers significant advantages in detecting small, metabolically active lesions in the liver and lungs, which may be missed on conventional imaging due to size or equivocal morphological features (9,13).

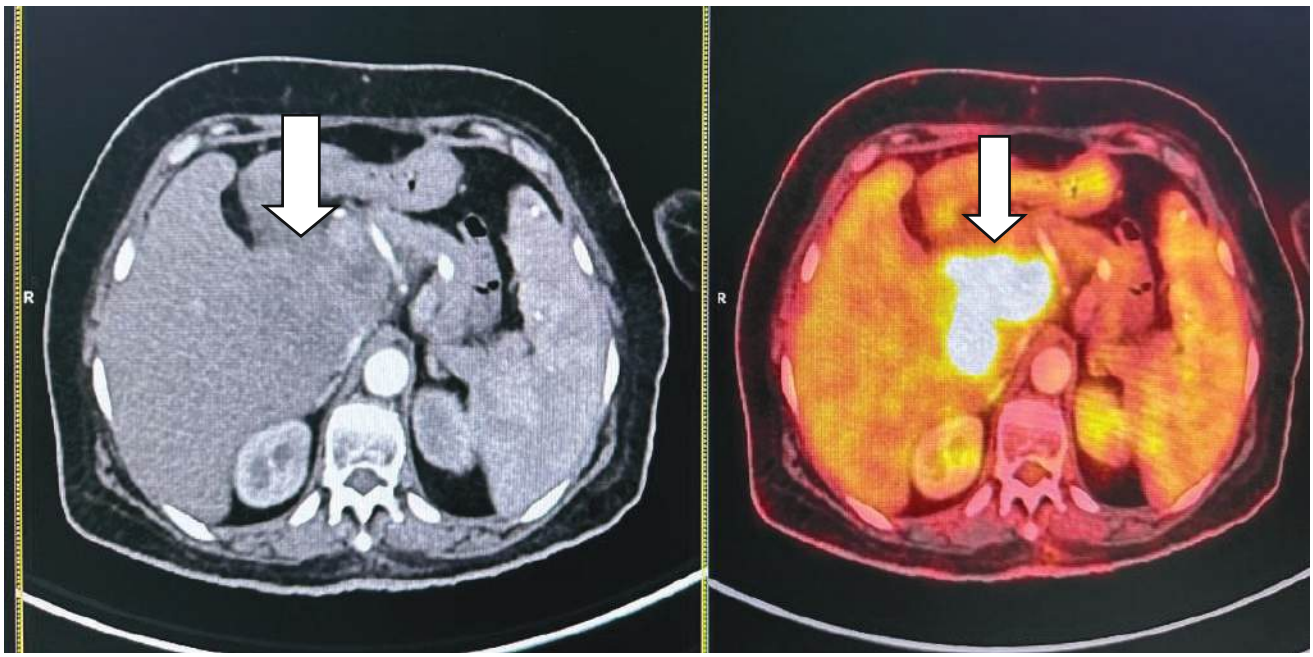

Figure 5: Hepatic metastasis from primary breast cancer. Intense FDG avid (SUV: 15.90) enhancing lesion noted at caudate lobe of liver (white arrow).

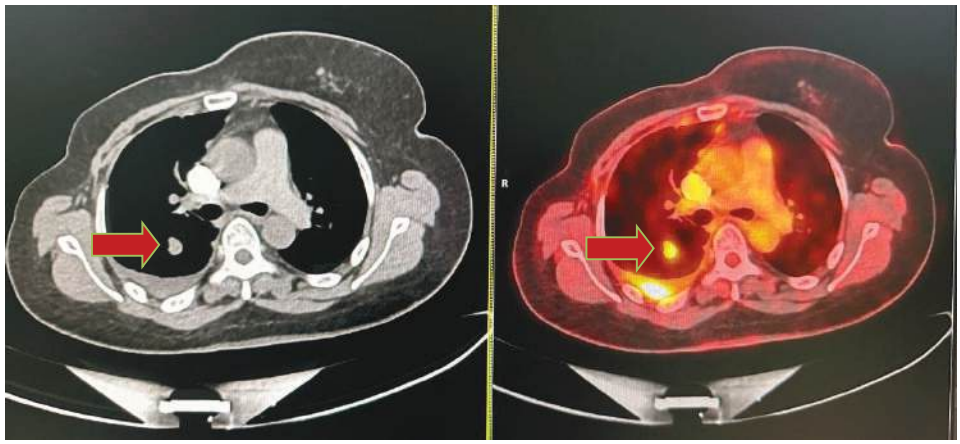

Figure 6: Pulmonary metastases from primary breast cancer in a 56-year-old-woman treated with surgery and NACT. FDG avid (SUV: 5.26) enhancing soft tissue density nodule is seen at the lower lobe of right lung (red arrow). There is right sided malignant pleural effusion.

A notable observation in this study was the predominance of mixed-pattern of metastases (61.1%), indicating multi-organ involvement. This finding reflects advanced disease stage and highlights the importance of whole-body imaging in comprehensive disease assessment. The ability of PET-CT to evaluate the entire body in a single examination enables accurate determination of disease extent, which is essential for staging, prognostication, and treatment planning (4,7,9). Multi-site involvement often necessitates systemic therapy rather than localized treatment approaches, thereby directly influencing clinical decision-making.

Single-site metastasis was observed in 38.9% of patients, with isolated nodal and skeletal metastases being the most common. Identification of oligometastatic disease is clinically significant, as it opens the possibility for targeted therapeutic strategies such as stereotactic body radiotherapy or metastasectomy in selected patients (14). Early detection of limited metastatic burden may therefore improve outcomes and delay disease progression.

Rare metastatic sites, including the ovaries and contralateral breast, were also identified in this study. The detection of bilateral ovarian metastases (Krukenberg tumors) emphasizes the ability of FDG PET-CT to identify atypical and clinically unsuspected metastatic sites. Such findings are important as they may significantly alter staging and management, including systemic therapy selection and surgical considerations (15). Additionally, identification of contralateral breast involvement has implications for distinguishing metastatic disease from a second primary malignancy.

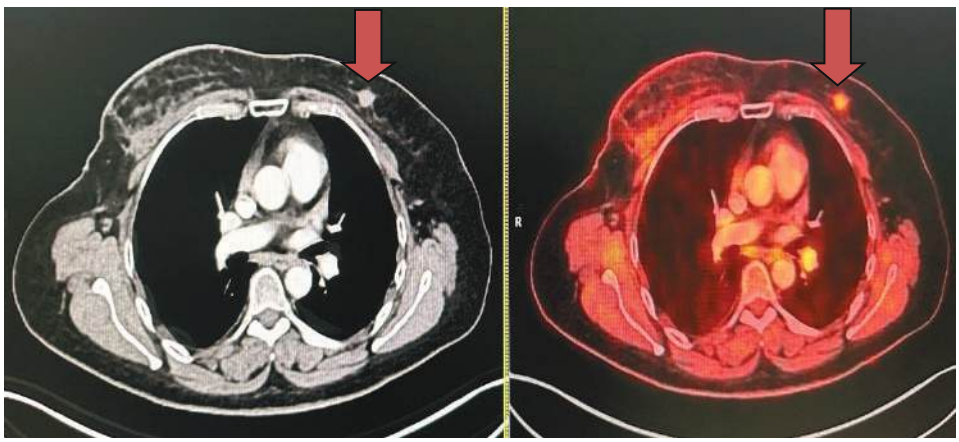

Figure 7: Metastasis in contralateral (left) breast from treated primary right breast cancer. FDG avid (SUV: 3.12) enhancing, irregular soft tissue density lesion is marked (red arrow) at the upper inner quadrant of left breast. Post operative and post radiation changes are also noted (Right).

Overall, FDG PET-CT proved to be a highly valuable imaging modality for detecting both typical and atypical patterns of metastasis in treated breast cancer patients. Its ability to combine metabolic and anatomical information allows for superior sensitivity and specificity compared to conventional imaging modalities. Furthermore, PET-CT plays a crucial role in restaging, treatment response assessment, and surveillance, ultimately contributing to more personalized and effective patient management (3–5,9,13).

CONCLUSION

FDG PET-CT is an effective imaging modality for detecting metastatic disease in treated breast cancer patients. Lymph nodes and bone are the most commonly involved sites, and mixed pattern metastases are frequently observed. PET-CT plays a crucial role in comprehensive disease evaluation and guiding further management.

LIMITATION AND FUTURE RECOMMENDATION

The relatively small sample size and single-center design may limit the generalizability of the results; therefore, larger sample sizes and multicenter studies are recommended to enhance external validity.

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