Pictorial Essay

Clinical Utility of ^{18}F-FDG PET/CT in brachial plexopathy secondary to metastatic breast cancer

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ABSTRACT

Role of fluorodeoxyglucose positron emission tomography/computed tomography (PET/CT) in breast cancer is rapidly evolving. Brachial plexopathy is a rare clinical entity in follow-up of operated breast cancer patients, who presents with disease recurrence in the axilla. Conventionally, magnetic resonance imaging is the imaging modality of choice for diagnostic evaluation in these cases and only few case reports/short studies have explored the utility of PET/CT in this clinical indication. We present here a short case series to demonstrate the utility of PET/CT as an important adjunctive imaging modality to magnetic resonance to supplement diagnosis of brachial plexopathy, differentiate radiation-induced brachial plexopathy from neoplastic plexopathy, accurately restage the disease and to monitor response to chemotherapy.

Keywords: Breast cancer, fluorodeoxyglucose positron emission tomography/computed tomography, magnetic resonance imaging, metastatic, neoplastic brachial plexopathy, radiation induced plexopathy

INTRODUCTION

Brachial plexopathy a form of peripheral neuropathy causes pain, sensory loss, weakness, and loss of tendon reflexes in C5-T1 segmental distribution. The most common cause of nontraumatic plexopathy involving the brachial plexus is metastatic disease, most frequently seen from recurrent carcinoma breast.[1] Metastases carcinoma breast causing brachial plexopathy is a severely disabling disease and fortunately rare with an incidence of 0.5% and is thought to occur through lymphatic spread.[2] Differentiation of neoplastic brachial plexopathy (NBP) from radiation-induced plexopathy (RBP) is clinically difficult and forms the major indication for imaging. Magnetic resonance imaging (MRI) with or without positron emission tomography/computed tomography (PET/CT) is the standard approach for evaluation of these sets of patients. In addition to supplementing the clinical diagnosis of plexopathy, imaging also aids in assessing total tumor burden to plan appropriate treatment and to assess response to treatment. Through this short cases series, we aim to define the clinical indications for PET/CT in neoplastic plexopathy secondary to metastatic breast carcinoma.

MATERIALS AND METHODS

Retrospective analysis of 11 patients was done who were referred for PET/CT for evaluation of suspicious NBP. ^{18}F-fluorodeoxyglucose PET/CT (^{18}F-FDG PET/CT) scans were acquired after injecting ^{18}F-FDG intravenously 60 min before the study and at a dose of 3–5 MBq/kg or 0.08–0.15 mCi/kg. Extent of scan was from base of the skull to mid-thigh. After obtaining a scout image, breath hold CT was acquired followed by the whole body CT and then PET acquisition at 2 min/bed position. CT parameters for breath-hold CT includes slice thickness - 3 mm, pitch - 1.08, field of view (FOV) - 356 mm, voltage - 20 kV with automated mA correction, image matrix - 512 × 512. Body CT was acquired in caudocranial direction with parameters that

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included slice thickness - 2 mm, pitch - 0.83, voltage - 120 kV, FOV - 600 mm, rotation time - 0.5 s, automated mA, and image matrix - 512 × 512. About 80 ml of low-osmolar nonionic intravenous contrast was administered in all eligible patients at a rate of 1.8 ml/s, and scan delay was 50 s. PET/CT results were validated against clinical/magnetic resonance (MR) findings and clinical follow-up.

RESULTS

Our case series included 11 female patients mean age of patients was 60 years (range 48–72), and mean duration of onset of symptoms was 6 years postsurgery (range 3–11 years). Baseline PET/CT was positive for neoplastic plexopathy in 9 patients with evidence of distal metastasis in 5 patients. PET/CT was negative for disease in the axilla in 2 patients and discordant with positive MR findings, these were diagnosed as RBP. Follow-up PET/CT was available in 6 patients and showed progressive disease in 5, partial response in 1, and complete metabolic response in 1 patient.

DISCUSSION

Positron emission tomography/computed tomography as an alternative/adjunct to magnetic resonance imaging for diagnosis

MRI is modality of choice for diagnosis of brachial plexopathy and preferred to other imaging modalities for characterization of brachial plexopathy due to its multiplanar capabilities, superior soft-tissue contrast, and absence of any ionizing radiation. However, it does have some limitations. These include poor image quality that may be attributed to motion artifacts and in-homogenous fat suppression in the shoulder region, routine contraindications such as claustrophobia, metallic implants, and deranged renal function (precluding the use of gadolinium contrast).[3] PET/CT can offer complimentary information to MR in diagnosis of NBP, can be used in situations where MR findings are equivocal or when MRI is contraindicated.[4] PET/CT in NBP shows intense focal/linear uptake along the course of involved nerves with or without FDG avid lymph nodes in axilla/supraclavicular region[5] [Figure 1]. The complementary information provided by PET and MR separately in characterizing recurrent axillary and supraclavicular breast cancer makes NBP a good fit to the growing list of indications for PET/MR.

Positron emission tomography/computed tomography to differentiate neoplastic radiation plexopathy from radiation-induced plexopathy

Major clinical dilemma in follow-up breast cancer patients presenting with ipsilateral upper limb pain and/or sensorimotor weakness is to differentiate NBP due to tumor relapse from RBP since the treatment options differ for these entities. Clinical features suggestive of NBP include severe, relentless limb pain (most common symptom), muscle weakness, rapid progression, evidence of metastases elsewhere, and evidence of soft-tissue mass involving the branches of brachial plexus on imaging or biopsy. RBP is a rare slowly progressive neuropathy similar to NBP. Features that favor RBP are predominant paresthesia rather than pain, preferential involvement of upper trunk or C5-6 portion of plexus, history of radiotherapy dose exceeding 60 Gy, and myokymia on needle examination.[6] Clinical examination and electromyography cannot always

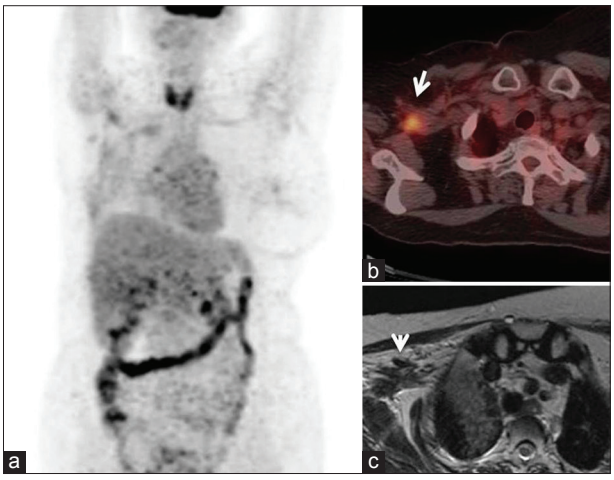

Figure 1: A 65-year-old with history of operated the right breast cancer with pain and weakness in the right upper limb post 2 years of surgery (a) maximum intensity projection image and (b) transaxial fused positron emission tomography/computed tomography image shows fluorodeoxyglucose uptake in soft tissue mass in the right axilla encasing the neurovascular bundle (arrow), (c) axial T2-weighted fat-suppressed magnetic resonance sequence of showing isointense soft-tissue mass in axilla encasing trunks and divisions of brachial plexus (arrowhead). Diagnosis-neoplastic brachial plexopathy

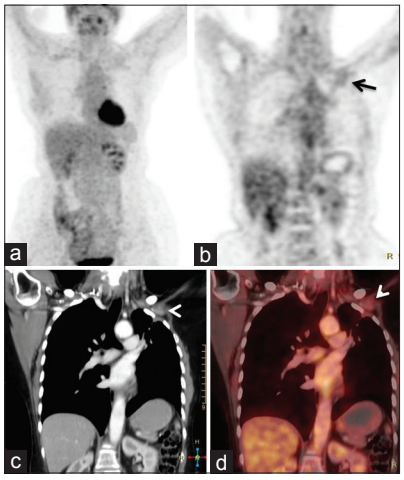

Figure 2: 69-year-old woman with operated left breast cancer, presenting 11 years after surgery with paresthesia in the left arm and forearm with minimal weakness or pain. Magnetic resonance showed ill-defined enhancing soft tissue mass (not shown here). (a) Maximum intensity projection and (b) coronal positron emission tomography images shows low-grade diffuse fluorodeoxyglucose uptake in the axillary region. (c) Coronal computed tomography and (d) coronal fused positron emission tomography/computed tomography images show low grade fluorodeoxyglucose uptake in the ill-defined soft-tissue mass encasing the neurovascular bundle in the axilla. Diagnosis-radiation induced plexopathy

differentiate RBP and NBP, and imaging evaluation is usually necessary.[7,8] PET/CT is particularly useful in the clinical dilemma of differentiating RBP from NBP, where MR findings may be indeterminate. Since the pathophysiology of the RBP is chronic fibrosis, increased FDG uptake is less likely. On MRI, radiation fibrosis shows diffuse thickening and minimal or no enhancement along the brachial plexus. These usually display low signal intensity on both T1- and T2-weighted images although T2 hyperintensity and contrast enhancement in RBP is not uncommon[9] [Figure 2]. Hence, MRI cannot always readily differentiate RBP from NBP.[10] PET/CT in RBP shows low-grade/minimal, diffuse FDG uptake in the enhancing/nonenhancing fibrotic tissue in axilla/supraclavicular region [Figure 3]. In fact, PET/CT appears to be the most appropriate imaging modality to differentiate tumor recurrence from RBP as recommended by the American College of Radiology.[11]

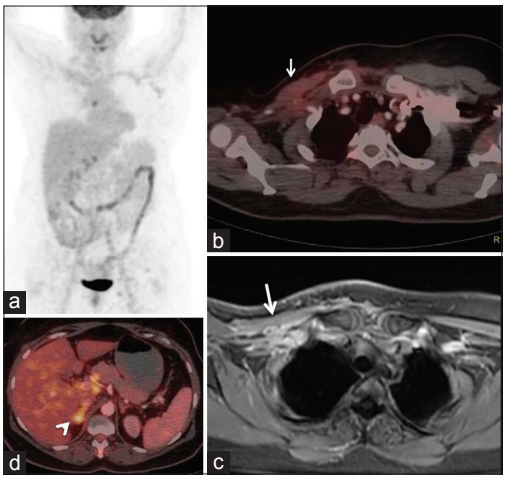

Figure 3: 50-year-old woman with history of the right breast cancer, presenting with pain in right shoulder 3 years after surgery (a) maximum intensity projection, (b) trans-axial positron emission tomography/computed tomography image shows no significant fluorodeoxyglucose uptake in ill-defined soft tissue mass encasing the neurovascular bundle (thin white arrow), (c) axial T1 postcontrast magnetic resonance sequence of showing intensely hyperenhancing soft-tissue mass in axilla encasing subclavian vessels and cords of brachial plexus (thick white arrow), (d) transaxial positron emission tomography/computed tomography images showing uptake in right adrenal nodule. Diagnosis-radiation induced plexopathy with distant metastasis

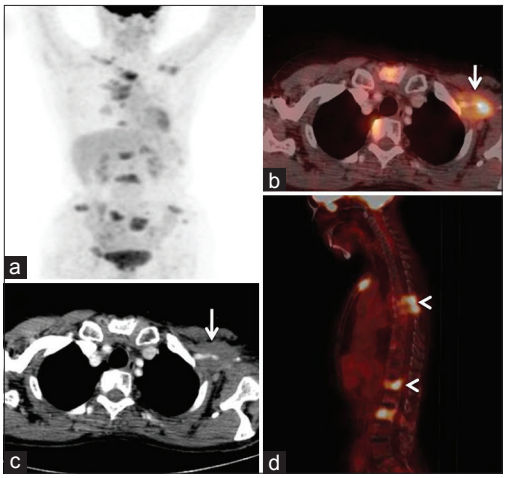

Figure 4: 65-year-old woman presenting with the arm weakness and atrophy of the hand muscles 11 years after surgery. (a) Maximum intensity projection (b) transaxial fused and (c) transaxial computed tomography images shows mass in the axilla showing increased fluorodeoxyglucose uptake in the soft tissue mass in the axilla encasing the brachial plexus (white arrow) and (d) sagittal image shows intense uptake in the left axilla and multiple sites in the region of axial skeleton (white arrowheads). Diagnosis-neoplastic brachial plexopathy with extensive skeletal metastasis

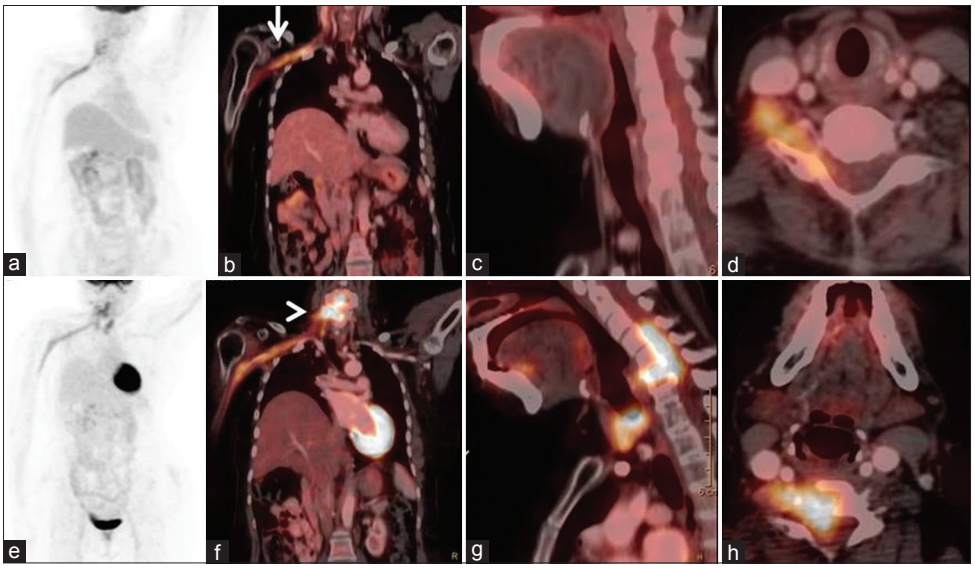

Figure 5: 51-year-old woman with history of the right breast cancer, presenting with pain shoulder 4 years after surgery (a) maximum intensity projection and (b) coronal positron emission tomography/computed tomography image showing linear intense fluorodeoxyglucose uptake in the region of axilla extending into the right supraclavicular region and extending into neck (white arrow). c) sagittal PET/CT neck do not show any evidence of any intra-spinal extension (d) transaxial positron emission tomography/computed tomography images showing uptake in soft tissue mass encasing the C5-6 nerve root. Follow-up positron emission tomography/computed tomography postchemtherapy showed persistent uptake of tracer in the axilla with increase in the proximal extent of disease (white arrowhead) seen here as an fluorodeoxyglucose avid paravertebral soft tissue mass encasing the C4-6 nerve roots (e and f), with lytic erosion of vertebral bodies and extending intraspinally (g and h). Suggesting progressive disease

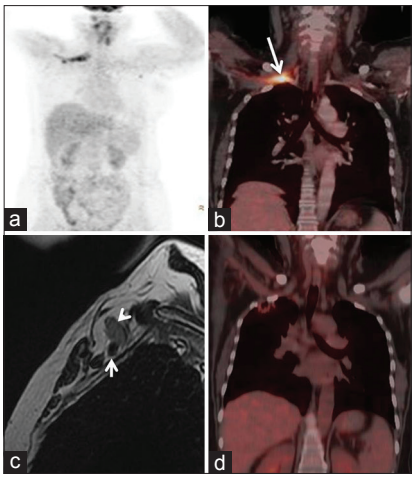

Figure 6: 57-year-old woman with history of the right breast cancer, presenting with weakness in the right upper limb 10 years after surgery (a) maximum intensity projection image a linear intense and (b) coronal fused positron emission tomography/computed tomography image showing fluorodeoxyglucose uptake in the enhancing soft tissue mass in the retroclavicular region (long white arrow) close to neurovascular bundle, (c) correlative sagittal T1-weighted magnetic resonance sequence, showing altered signal and soft-tissue mass encasing the divisions of brachial plexus (arrowhead) superior to subclavian vessels (short wide arrow). (d) Follow-up positron emission tomography/computed tomography images showing complete metabolic response to chemotherapy (white arrow heads)

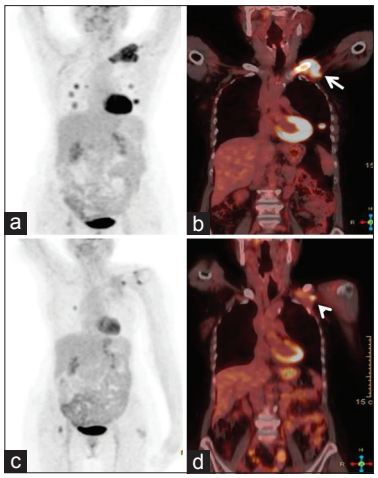

Figure 7: A 72-year-old female presented with pain in the right shoulder 8 years after surgery for left breast cancer. (a) Maximum intensity projection image show intense fluorodeoxyglucose uptake in the left supraclavicualr region and focal uptake in bilateral lung fields. (b) Coronal fused positron emission tomography/computed tomography images show increased fluorodeoxyglucose uptake in the soft-tissue mass encasing the neurovascular bundle in the left supraclavicular region (white arrow). Postchemotherapy maximum intensity projection. (c) Fused coronal positron emission tomography/computed tomography (d) images are suggestive of partial response in the left supraclavicular mass (white arrow head) and bilateral lung metastases

Positron emission tomography/computed tomography to assessing the total disease burden and response to treatment

PET/CT appears to be most beneficial in carcinoma breast when evaluating subsets of patients with suspected locoregional recurrence and alters treatment decisions in up to 40% of patients by identifying clinical occult distant metastasis.[12] In our series, PET/CT identified distant metastasis in 36% (n = 4) of patients at the time of presentation of plexopathy, thereby altering treatment strategies and prognosis [Figure 4]. The most frequent sites for distant metastasis in our series at presentation were the skeleton at baseline and the lung and brain on follow-up imaging.

Response assessment to chemotherapy in carcinoma breast is challenging with only clinical evaluation alone. Morphological imaging has its limitations in diagnostic assessment of sites such as operated bed or sites that received radiotherapy. Numerous studies have shown PET/CT superior to conventional imaging in response evaluation in carcinoma breast.[13] Most patients in our series (45%) with NBP on FDG PET/CT, with or without distant metastasis showed progressive disease after chemotherapy, thereby revealing the treatment refractory nature of this debilitating disease. PET/CT here can be useful for early identification of subsets of patients who will respond and the ones who will not benefit from an intended chemotherapy regimen [Figures 5-7].

CONCLUSION

With increasing use of FDG PET/CT in patients with breast cancer, suspected cases of NBP should be recognized as an appropriate indication for metabolic imaging as it influences treatment management. In these sets of patients, FDG PET/CT plays an important adjunctive role to MRI and can potentially be a one-stop shop for (i) diagnosing neoplastic plexopathy and differentiating it from RBP, (ii) identifying metastatic disease outside the axilla, and (iii) and for monitoring response to treatment.

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Conflicts of interest

There are no conflicts of interest.

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