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Diagnostic value of ^{18}F-FDG-PET/CT for the follow-up and restaging of soft tissue sarcomas in adults

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KEYWORDS
^{18}F-FDG-PET/CT;
Soft tissue sarcomas;
Accuracy study;
Recurrent disease

Abstract
Purpose: The purpose of this study was to evaluate the clinical utility of 2-[^{18}F] fluoro-2-deoxy-D-glucose (^{18}FDG) positron emission tomography (PET)/computed tomography (CT) (^{18}F-FDG-PET/CT) in the follow-up of adult patients with soft tissue sarcomas.
Materials and methods: We prospectively evaluated 37 consecutive patients with known soft tissue sarcoma with ^{18}F-FDG-PET/CT examination for suspected recurrence of disease. They were 21 men and 16 women with a mean age of 49.6 ± 10.6 (SD) years (range, 34—75 years). The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy of ^{18}F-FDG-PET/CT examination were calculated on a per patient basis.
Results: ^{18}F-FDG-PET/CT showed an overall diagnostic accuracy of 91.8%, sensitivity of 90% and a specificity of 100%. The positive predictive value and negative predictive value were 100 and 70%, respectively. The ^{18}F-FDG-PET/CT interpretations were correct in 34/37 patients (91.8%). Incorrect interpretations occurred in three patients (8.1%). Reasons for false negative findings were low ^{18}F-FDG uptake of local recurrence in one patient and low ^{18}F-FDG uptake of subcentimetric inguinal lymph node metastases.
Conclusion: ^{18}F-FDG-PET/CT has a high diagnostic value in the follow-up of patients with soft tissue sarcoma.

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Soft tissue sarcomas are uncommon neoplasms of mesenchymal origin [1]. Soft tissue sarcomas account for 0.7% of adult cancers [2]. They arise in mesodermal tissues of extremities in half of the cases, trunk/retroperitoneum in two fifth of the cases or head and neck in one tenth of the cases [3].

Soft tissue sarcomas have a tendency to generate hematogenous metastases. Their risk correlates with tumor size, histological subtype, location and grade [4]. Owing to that pattern of metastatic spread, 2-[^{18}F] fluoro-2-deoxy-D-glucose (^{18}FDG) positron emission tomography (PET)/computed tomography (CT) (^{18}F-FDG-PET/CT) is considered as an effective tool in the evaluation of patients with soft tissue sarcomas particularly those with high-grade lesions [5]. Being a functional imaging modality, ^{18}F-FDG-PET/CT has numerous applications in the diagnosis and management of soft tissue sarcomas. Sarcomas are usually highly ^{18}F-FDG avid tumors [6].

^{18}F-FDG-PET/CT imaging has been used in Soft tissue sarcomas for guidance of biopsies [7], assessment of therapeutic response [8], staging [9], surveillance [10], and prognosis determination [11]. It is an ideal modality to evaluate the extent of disease and help with correct treatment planning [5].

The aim of this study was to evaluate the clinical utility of ^{18}F-FDG-PET/CT in follow-up of adult patients with soft tissue sarcomas.

Patients and methods

Patients

From March 2014 to June 2015, we prospectively evaluated 37 consecutive patients with known soft tissue sarcoma who underwent ^{18}F-FDG-PET/CT examination for the assessment of recurrence of previously treated soft tissue sarcomas. They were 21 men and 16 women with a mean age of 49.6 ± 10.6 (SD) years (range, 34—75 years). Eleven patients had undergone surgical excisions, 20 patients had operations followed by chemotherapy alone while 6 patients had surgeries followed by chemotherapy and radiotherapy. ^{18}F-FDG-PET/CT was performed as regular post-therapeutic 6-month interval follow up in 16 patients. Referring oncologists asked for ^{18}F-FDG-PET/CT in 21 patients who developed symptoms and whose conventional imaging studies were inconclusive. Time interval between the end of treatment and follow-up ^{18}F-FDG-PET/CT ranged between 3 and 14 months. The study was approved by the Hospital Ethical Committee. Informed consents were obtained from all patients.

According to the soft tissue sarcoma histological diagnosis, lesions were categorized as leiomyosarcoma (n = 9, 24.3%), liposarcoma (n = 8, 21.6%), undifferentiated or pleomorphic sarcoma (n = 7, 18.9%), fibrosarcoma (n = 7, 18.9%), malignant peripheral sheath tumour (n = 2, 5.4%), angiosarcoma (n = 2, 5.4%), Kaposi sarcoma (n = 1, 2.7%) and rhabdomyosarcoma (n = 1, 2.7%). The soft tissues sarcomas originated from the upper limbs (n = 6 patients), lower limbs (n = 20 patients), anterior portion of the abdominal wall (n = 2 patients), anterior portion of the chest wall (n = 1 patient), retroperitonum (n = 6 patients), lip (n = 1 patient) and maxillary sinus (n = 1 patient).

^{18}F-FDG-PET/CT protocol

All patients were scanned on integrated PET/CT scanner (Syngo PET VG 50A Biograph 20 VA 44A, Siemens Medical Solutions, Berlin, Germany). Patients fasted for at least 6 hours before receiving an intravenous injection of 370—410 MBq/kg of ^{18}F-FDG. Blood glucose level was measured before injection of the tracer, to ensure a level below 130 mg/dl. After injection, patients were kept lying comfortably in a quiet place for 60 minutes.

First non-contrast low dose CT images were obtained for attenuation correction and fusion images. This was followed by PET scan in 3D mode with an acquisition time of 3 minutes per bed position (axial FOV 16.2 cm). The imaging field encompassed 6 to 8 bed positions depending on patient height. Images were acquired from the base of skull to mid-thigh level with additional images acquired according to the sarcoma location.

Lastly, a diagnostic contrast-enhanced CT scan was obtained using the following parameters (120 mAs, 130 kV, 5 mm slice collimation), with an application of 100 mL non-ionic iodinated contrast agent (Ioversol 74%, [Optiray 350®, Covidien, Germany] in porto-venous phase (70 s delay).

Data analysis and interpretation

PET image datasets were reconstructed using the CT data for attenuation correction. The reconstructed attenuation-corrected PET, CT and fused PET/CT images were viewed using the manufacturer's works station (Syngo™ software, Siemens Medical solutions).

The PET/CT imaging was assessed quantitatively and qualitatively for areas of increased FDG uptake. For visual analysis abnormal FDG uptake was defined as a substantially greater activity in the tissue than in the aortic blood on attenuation—correction images. Maximum standardized uptake value (SUV) was measured at every site of FDG uptake. The diagnosis of malignancy was also supported by a maximum SUV > 2.5 and > 3.5 for malignant extrahepatic and intrahepatic lesions respectively.

Standard of reference

The final diagnosis was made by histopathology whenever available, correlation with other imaging modalities together with clinical and imaging follow-up for at least 6 months. The accuracy of ^{18}F-FDG-PET/CT examinations were assessed by histopathological analysis of surgically removed lesion (n = 12), fine needle biopsy (n = 6), follow-up PET/CT imaging (n = 17 with 13 patients had more than one follow-up PET/CT examinations) and follow-up CT chest examination (n = 2).

Statistical analysis

^{18}F-FDG-PET/CT findings were classified as true positive (lesion was defined as malignant with subsequent confirmed tumour involvement), true negative (lesion defined as benign with no further evidence of disease), false positive (lesion was defined as malignant with no further evidence of disease), or false negative (lesion was defined as benign showing subsequent evidence of malignancy).

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