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SHORT COMMUNICATION

The impact of coaxial core biopsy guided by FDG PET/CT in oncological patients

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Abstract
Objective When deciding on therapy, FDG PET/CT-positive results should be confirmed by histology if possible. We evaluated the impact of percutaneous PET/CT-guided biopsies on histological confirmation of PET/CT-positive lesions.
Methods We prospectively evaluated 126 patients who had undergone a PET/CT scan with positive results with an indication for histological evaluation of lesions. Imaging was performed in a PET/CT scanner with a fluoroscopic imaging system. A total of 130 lesions were accessed by PET/CT-guided biopsy. The technical feasibility, clinical success and complication rates of PET/CT-guided biopsies were evaluated.
Results Of 130 PET/CT-positive lesions, 128 (98.5 %) were successfully accessed and representative tissue samples obtained. Two lesions were reaccessed due to inconclusive histological results. Histology showed that 99 of the 130 lesions (76.2 %) were malignant, and 31 lesions (23.8 %) were benign (inflammatory cells or necrotic tissue); these patients had no recurrence of disease after a minimum follow-up of 6 months. Also, in 23 of the 130 lesions (17.7 %), the patient was referred for the PET/CT-guided biopsy due to a previous nontumoral biopsy result, and of these 23 lesions, 21 were found to be malignant. The complication rates were: pneumothorax in 15/130 (11.5 %; resolved spontaneously), haemoptysis in 2/130 (1.5 %) and severe haemothorax in 1/130 (0.8 %); there was no procedure-related mortality.
Conclusion PET/CT-guided biopsy is feasible and may optimize the diagnostic yield of image-guided interventions. Also, PET/CT-positive lesions with no morphological correlation may now be accessible to percutaneous interventions.

Keywords Guided biopsy · Cancer · FDG PET/CT

Introduction

During the last decade, positron emission tomography (PET) with ^{18}F-fluorodeoxyglucose (FDG PET/CT) has been introduced as one of the main procedures in the evaluation and management of oncological patients, including initial staging, early response evaluation, posttreatment assessment of and follow-up. In fact, for some types of cancer FDG PET assessment has become essential [1, 2]. Meta-analyses [3–5] have shown that FDG PET/CT has higher accuracy than imaging methods for assessing anatomy (CT and MRI) in the differentiation of tumour and fibrosis in residual masses after therapy [6–10]. In spite of the high negative predictive value of FDG PET, false-positive results might occur. Bearing in mind that a positive FDG PET scan can guide management, determining treatment, whether surgery, chemotherapy or radiotherapy, with the risk of morbidity and mortality, in many cases it is recommended that the results be confirmed histopathologically.

This study aims of this study were to assess the feasibility, results and impact of FDG PET/CT-guided biopsies, including technical and clinical success rates.

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Methods

A total of 126 patients were referred to the PET/CT division of a diagnosis centre (Quanta Diagnosis and Therapy) for biopsy of a suspicious lesion. After evaluation of the PET/CT scan, the results were discussed with the referring physician who made the final decision as to whether biopsy was indicated.

Written informed consent was obtained from all patients eligible for this prospective study between August 2010 and February 2012. Complete blood counts, including platelet and coagulation studies, were requested before performing the biopsy. Exclusion criteria were: platelet count less than 100,000/μl, altered coagulation parameters and clinical contraindication for the procedure.

FDG PET/CT imaging

Whole-body FDG PET/CT imaging was performed following an uptake period of 60–90 min after intravenous administration of 296–444 MBq (8–12 mCi) of FDG. Imaging was performed in a PET/CT STE-16 scanner (GE STE 16-slice CT scanner; GE Healthcare, Waukesha, WI) with a CT fluoroscopic imaging system.

Two experienced board-certified nuclear medicine physicians interpreted the FDG PET scans. Areas of nonphysiological abnormalities with increased FDG uptake over the background were classified as positive for disease.

Biopsy procedure

An 18G semiautomated core biopsy needle with a coaxial guide needle were used to perform the biopsies.

1. Initially patients were submitted to the FDG PET/CT scan before the biopsy. The results were used to define the biopsy site and needle path, taking into account the relationship between the anatomical structures and the suspicious lesion.
2. Patients were positioned and immobilized in the proper position, depending on the location of the lesion and biopsy approach.
3. After conventional aseptic and antiseptic sterilization, draping towels were placed and anaesthesia with lidocaine 1.0 % without epinephrine was administered. Intravenous administration of diazepam during the biopsy procedure was not required, but in tense patients the medication could be used for light sedation.
4. A suitable coaxial needle was inserted at the previously located puncture site. The angle and direction of the needle were adjusted according to the position of the suspicious lesion under the guidance of CT fluoroscopic imaging. The point of the coaxial needle was positioned in the border of the suspected lesion, and default PET/CT images were acquired to confirm its correct position.
5. The core of coaxial needle was pulled out and an 18G semiautomatic biopsy needle inserted. Satisfactory puncture was confirmed on the CT scan and the biopsy site was recorded (if the lesion was small or difficult to differentiate from important structures such as peripheral vessels, enhanced CT could be used to optimize the imaging), and then specimen of 1 or 2 cm were obtained.
6. Three or four specimens were collected.
7. After removal of the needle, manual compression was performed for 2 to 3 min at the puncture site.
8. The specimens were fixed in 10 % formalin and sent for histopathological examination.
9. Patients were observed for at least 3 h after the procedure to ensure haemodynamic stability and their the respiratory condition monitored. CT was performed immediately and 3 h after the biopsy in patients in whom

Table 1 Clinical characteristics of the patients evaluated

Characteristic	*N*	%
Male gender	68	52.3
Biopsy success	128	98.5
Site of biopsy		
Abdominal mass	13	10.0
Adrenal	2	1.5
Kidney	4	3.1
Liver	16	12.3
Lung	50	38.5
Lymph node	12	3.2
Mediastinal mass	12	3.2
Pancreas	6	4.6
Soft tissue	15	11.5
Original cancer		
Breast	7	5.4
Cervical	3	2.3
Colorectal	11	8.5
Gastric	3	2.3
Head and neck	5	3.8
Lung	48	36.9
Lymphoma	15	11.5
Melanoma	3	2.3
Prostate	4	3.1
Suspected lesion	18	13.8
Unknown primary	5	3.8
Other	8	6.2
Histology		
Oncological lesion	99	76.2
Complications	18	13.8

the needle were transfixin pleura, liver or stomach wall was necessary and expected as part of procedure.

Statistical analysis

The technical success rate (acquisition of the specimen for histological evaluation was achieved), the histological results (malignant vs. benign) and the complication rates (including pneumothorax, haematoma, haemoptysis and mortality) were evaluated.

The results of the PET/CT scans were considered crucial when: (1) a lesion with only increased metabolism was identified by PET, with no corresponding anatomical lesion on CT; (2) a heterogeneous mass with a component of fibrosis/necrosis associated with areas of FDG uptake considered possible viable tumour was identified; and (3) an increased number of lymph nodes in a chain, only some of which showed increased metabolism was identified.

Results

A total of 130 lesions were biopsied in 126 patients. Technical success was achieved in the biopsy procedure with removal of a metabolically active fragment in 128 lesions (98.5 %); two lesions were reaccessed due to inconclusive histological results. The patients' clinical information is presented in Table 1.

In 23 of the 130 lesions (17.7 %), the metabolic information provided by FDG PET was considered crucial in defining the location for the biopsy: 11 patients showed increased metabolism only by PET with no corresponding anatomical lesion on CT (liver, soft tissue lesions; Fig. 1); 10 patients had a heterogeneous mass with a component of fibrosis associated with viable tumour was identified; and 2 patients underwent a restaging FDG PET/CT scan due to lymphoma with an increased number of lymph nodes, only some of which showed increased metabolism (Fig. 2).

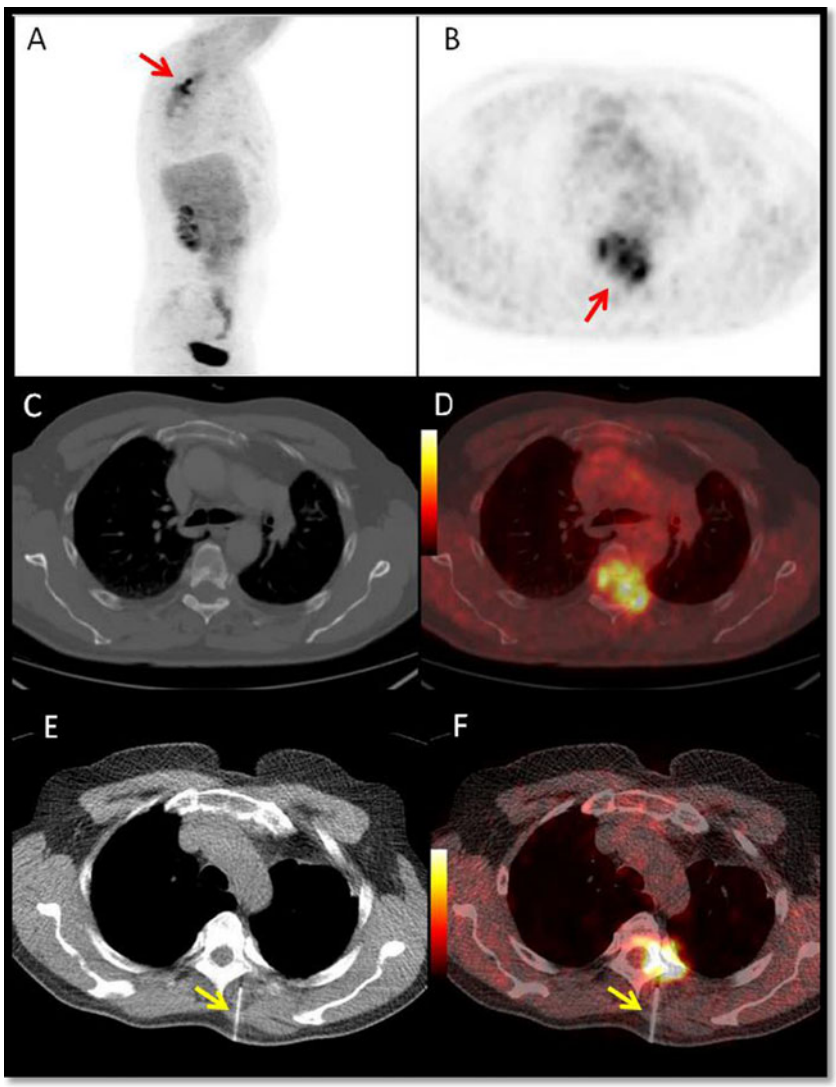

Fig. 1 Male patient with non-small cell lung cancer referred for restaging after surgery and chemotherapy. The maximum intensity projection image (**a**) shows intense uptake in the dorsum (*arrow*) involving the vertebral bodies of the thoracic spine with extension into the left paravertebral region. In the axial images, note the heterogeneous FDG uptake on the PET image (**b**) without a corresponding anatomical lesion apparent on the CT image (**c**). The PET/CT fusion image (**d**) shows the location of the metabolic lesion. The image acquired during PET/CT-guided biopsy (**f**) shows the placement of the coaxial needle (*arrow*) in the proper position for biopsy. Pathological examination of the lesion confirmed recurrent disease

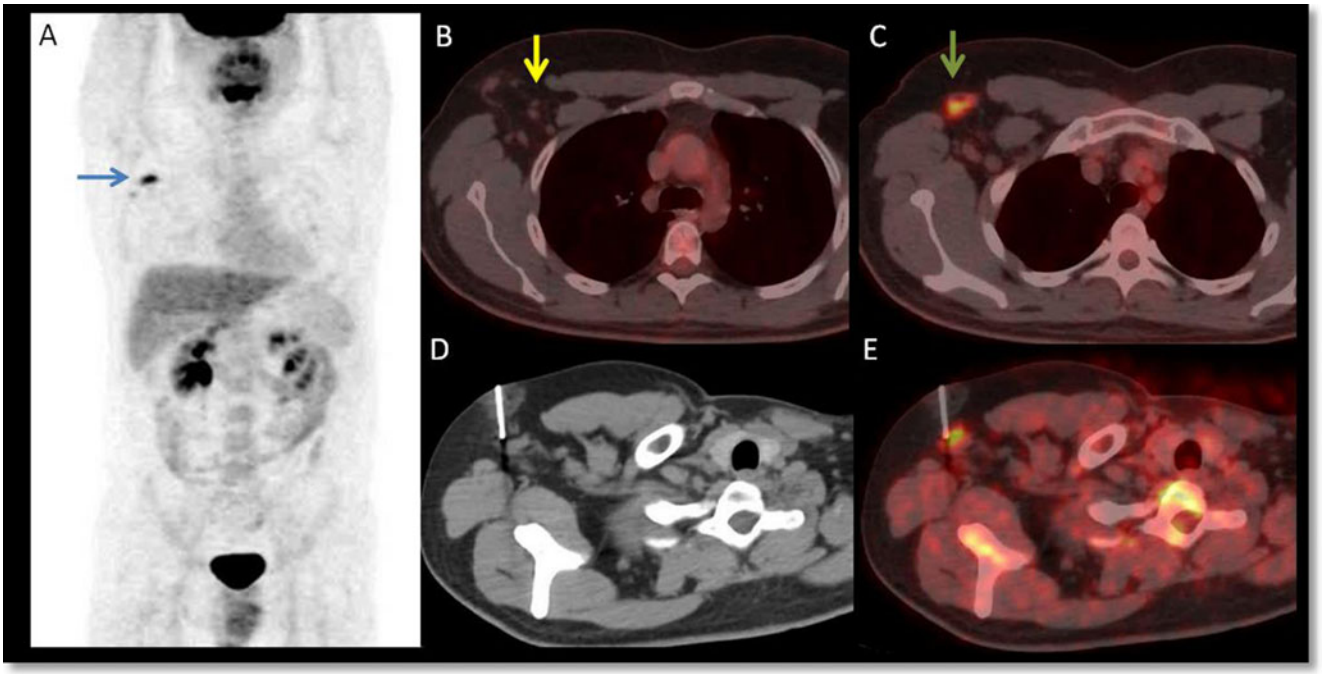

Fig. 2 Male patient with non-Hodgkin lymphoma referred for evaluation of response to first-line treatment. The maximum intensity projection image (**a**) demonstrates focal areas of increased metabolism in the right axilla (*arrow*). Axial PET/CT fusion images show some lymph nodes in the right axilla without signs of metabolic disease (**b**, *arrow*) and others with increased metabolism, suggesting active disease (**c**, *arrow*). The coaxial needle was placed in the border of the suspicious lymph node (**d**) and the PET/CT image (**e**) confirmed the correct location of the needle near the suspicious lymph nodes. Pathological examination of the lesion showed only inflammatory cells without lymphoma activity. The patient remained in complete remission 6 months after the PET/CT study

Of the 130 lesions biopsied, histology showed that 99 (76.2 %) were malignant and 31 (23.8 %) were benign (inflammatory cells or necrotic tissue). Patients with benign histology had no recurrence of disease at a median follow-up of 14.2 months (SD 6.2 months). Also, in 23 of the 130 lesions (17.7 %), the patient was referred for the biopsy-guided PET/CT due to a previous nontumoral biopsy result, and of these 23 lesions, 21 were found to be malignant.

The complication rates were: pneumothorax in 15/130 (11.5 %; resolved spontaneously), haemoptysis in 2/130 (1.5 %), and severe haemothorax in 1/130 (0.8 %); there was no procedure-related mortality. Of the 126 patients, 125 (99.2 %) were discharged on the day of the procedure in good condition and with no significant complaints.

Discussion

The use of FDG PET/CT is widespread and increasing, mainly for oncological applications, and especially in lymphoma, non-small cell lung cancer, breast cancer and colorectal cancers [11]. However, false-positive results have been found in about 10–26 % of all patients [12–14]. Therefore, histological documentation is generally the cornerstone in therapeutic decision making regarding the institution of a new therapy. This is especially true for single lesions and lesions with exclusively FDG uptake without corresponding anatomical findings on CT [15]. In this study, of the 130 lesions biopsied, histology showed that 76.2 % were malignant and 23.8 % were benign, with no recurrence of disease after a minimum follow-up of 6 months. This is extremely important in deciding on further treatment bearing in mind that therapy has important adverse effects, including an impact on survival [16].

Needle positioning guided by PET/CT, similar to the procedure described by Veit et al. [21] in an ex vivo liver model, proved to be feasible and no relevant complication occurred in a routine clinical setting, with an additional clinical impact in 50 % of the patients. Other colleagues have shown success in PET/CT-guided biopsy in small series of patients with similar results [22, 23]. In our study samples were successfully collected in 98.5 % of PET/CT-guided biopsy procedures, with a reasonable rate of complications (11.5 %), with only one major complication (severe haemothorax), and no procedure-related mortality. These complication rates are comparable to those associated with CT-guided core biopsies [24–26].

Image-guided biopsy is well established in the radiological community. Even though success rates for CT-guided biopsies of morphologically clearly circumscribed lesions are reported to range between 70 % and 90 % [17–20], in 23

of 130 lesions (17.7 %) evaluated in this study, the patient was referred for PET/CT-guided biopsy due to a previous conventional biopsy with a nontumoral result. In these patients, after PET/CT-guided biopsy 21 lesions were found to be malignant on histology.

It is important to note that in our consecutive series of cases, in 23 of 130 lesions (17.7 %), the metabolic information provided by PET was considered crucial in defining the location for biopsy of lesions that had increased metabolism identified only by PET (with no corresponding anatomical lesion on CT), of heterogeneous masses (with component of fibrosis associated with viable tumour) and of lymph nodes shown in increased numbers in a chain, only some of which showed increased metabolism. This confirms that PET/CT-guided biopsy might improve the histological verification when compared to alternative conventional techniques, probably reducing inconclusive biopsy or unreliable results, and the inherent strain for the patient may be avoided. In order to increase the success rate of image-guided biopsies and to decrease the number of second or even third image-guided biopsies, it is helpful to puncture the part of the lesion showing the highest metabolism.

A randomized trial comparing the accuracy of the FDG PET/CT-guided procedure to conventional image-guided procedures would be desirable in the light of these results.

Conclusion

PET/CT-guided biopsy is feasible and may optimize the diagnostic yield of image-guided interventions. Also, a lesion with FDG uptake and no corresponding anatomical lesion may now be accessible to percutaneous interventions.

Conflicts of interest None.

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