Efficacy of PET/CT in planning of percutaneous guided CT bone biopsy

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Aims and objectives

Adequate disease staging and restaging of cancer patients is crucial to plan the best course of treatment. The diagnostic effectiveness of positron emission tomography with 18-fluorine-2-deoxyglucose\(^{18}\)F-FDG integrated with computed tomography for certain tumors as non-small cell lung cancer, lymphoma, melanoma and breast cancer, among others, is widely known. Additional information provided by PET/CT when compared to that obtained with conventional imaging has an impact in the treatment of over one third of cases [1-4].

However, PET/CT findings can be false negative and false positive due to an overlap of SUV (standard uptake value) maximum values in benign and malignant bone lesions. Accumulation of 18F-FDG does not only occur in malignant bone tumors. Benign bone tumors, post-traumatic lesions and inflammatory changes may show high FDG avidity and simulate a malignant tumor, either primary or metastatic. Thus, bone biopsy is crucial for an adequate diagnosis and treatment [5-7].

CT-guided percutaneous biopsy of bone lesions is well-established as a technique, it is a minimally invasive and effective procedure with a low rate of complications compared to surgical biopsy [8-11]. As to CT-guided percutaneous biopsy of bone lesions, accuracy rates reported are as high as 96%, with 0 to 7.4 complication rates.

Benefits are more obvious in the case of deeper lesions in the pelvis or spine that are small or are closely related to nervous or vascular structures. [11-12] [4,16]

Usefulness of biopsies based on PET findings is well-established, in particular in lesions that are not visible with conventional imaging techniques (CT or RMI). It provides excellent spatial information, which makes for an accurate guidance of the biopsy needle towards the region of increased radiotracer uptake. [13-15]

The technique of PET guided percutaneous biopsy of bone lesions has been described by several authors [16-20] who propose a sequential method ("step by step technique") by performing a CT-guided percutaneous biopsy immediately after the PET.

The general objective of the study is to determine the effectiveness of planning the CT-guided percutaneous biopsy based on the PET/CT findings.
Methods and materials

All patients agreed to the CT-guided percutaneous biopsy, the PET/CT study and the use of images by signing an informed consent.

Patients: 32 CT-guided biopsies of bone were retrospectively analysed in 30 patients, all of which were performed by the same radiologist (MP) between 2011 and 2017. All patients had undergone PET/CT studies in the same health center, a month before the biopsy.

The variables evaluated were: age, sex, history of cancer, number and type of injury (lytic, sclerotic, mixed, with soft tissue component and no evident CT, size, localization, metabolic behavior of PET/CT and SUV max value, histology (type of lesion, immunohistochemistry and receptors). We assessed whether the lesion identified in PET/CT modified the election of the biopsy site.

Patients with benign findings were followed for at least six months with clinical and imaging follow-up visits.

PET/CT images were obtained as follows: Two hybrid 16 and 64 PET/CT medical imaging equipment were used. All patients fasted for at least six hours prior to the study and, 4 mBq/kg de $^{18}$F-FDG were injected intravenously after capillary blood glucose levels were determined. PET images were obtained 60 minutes after the administration of the contrast, integrated with CT images, as per the whole body protocol (base of skull/middle third femoral diaphysis). No oral or intravenous contrast was administered.

PET/CT images were analyzed as follows: Images were assessed in work stations. Two physicians (specialized in nuclear medicine and radiology) reviewed the studies by qualitative and semi-quantitative analysis (SUV maximum).

CT-guided bone biopsy: All biopsies were percutaneous, CT-guided and based on PET/CT results or findings. Anesthesia or sedation was used depending on the clinical condition of patients. Prophylactic antibiotics were provided. The patient’s position, the needle-puncture site, needle, direction and taking of the sample were chosen based on the type of lesion, localization, cortical compromise and PET/CT findings.

Bonopty® T-Lok TM 8ga x 4 in and Franseen 16 g. (®Cook Medical) bone biopsy needles were used with a coaxial technique. We are obtaining from 1 to 3 samples and sent the to the Pathology Department in sterile jars preserved in 10% neutral buffered formalin (not performed extemporaneously).

After bone de-calcification, paraffin was used for fixation purposes, staining were done with hematoxylin and eosin and Giemsa in Paget disease. Immunohistochemistry techniques (particularly used in unknown primary cancer metastases) were applied as
usual, being the pathologist the one who selected the antibody panel according to the most probable suspected diagnosis.

Normal 0 21 false false false ES-TRAD JA X-NONE
Results

30 patients were included in the study and 32 lesions were biopsied. 12 were female and 18 male, average age was 60.9, ranging from 40 to 78 years old.

29 patients had a history of hemato-oncological disease: 8 of them breast cancer, 4 lung cancer, 4 prostate cancer, 2 pancreas cancer, 2 myeloma, 2 unknown origin cancer, 7 of them had a history of other oncological diseases and one patient had no history of cancer.

The cause of performing a PET/CT scan was: 10 initial staging, 8 re-staging, 3 to determine the biopsy site, 3 increase of tumor markers, 2 finding by other imaging techniques, other.

The following radiotracers were used: 18F- FDG (25), 11C-Choline (4), 68Ga- PSMA(2), 68Ga-DOTATATE (2), 11C-Methionine (1). In a few cases studies were performed with more than one tracer.

With regard to the type of bone lesion in CT: 13 were lytic lesions, 3 sclerotic lesions, 8 mixed lesions, 6 lesions non-visible on CT and 2 were lesions with articular compromise.

Biopsied lesions were located as follows: 15 in the spine (7 in the lumbar portion, 5 in the toracic portion and 3 in the sacrum), 6 in the pelvis, 5 in the scapula, 3 in the ribs, 2 in the long bone and one in the sternum.

Re-biopsies were performed in 2 cases: in patient number 1, since no malignancy was obtained in the first sample, and in patient number 4, to assess changes in the immunohistochemical profile.

Out of the 32 lesions: 31.3% were a PET finding, retrospectively visible in the CT, in 43.7% of cases the needle puncture site was chosen to depend on the SUV maximum value and in 25% of cases with no lesion the CT was guided by the hypermetabolic focus (Fig 1).

The SUV max value averaged 6.3 in the studies performed with $^{18}$F-FDG, ranging from 2.7 to 14.7.

Histopathology was performed by the same pathologist in 81.2% of cases (JC). All samples were satisfactory. No complications arose in regard to puncture. Histology results evidenced the following: 43.7% metastatic lesions, 12.5% primary bone tumor, 6.3% myeloma, 3.1% hairy-cell leukemia, 9.4% Paget disease, 6.3 inflammatory/ infectious conditions and 18.7% normal bone. (Fig.2)
In five patients the histopathology reported normal bone. One of them had a confirmation of malignancy through a re-biopsy. In the remaining, clinical/imaging evolution showed absence of malignancy.

Results for all patients are shown in the table: age, sex, tracer, indication for PET/CT, type and localization of bone lesion, guide, SUV maximum value and histopathology. (Tabla 1)

A few selected cases are presented with the PET/CT correlation, CT-guided biopsy and histopathology.

**Patient Nº5**: Male, 69 years old. Bilateral Non Small Lung Carcinoma 10 years before. Surgery and chemotherapy. CT: left solitary pulmonary nodule. Bone lesion in the 4th left rib.

Restating PET-CT shows a solitary pulmonary nodule and bone rib lesion, both hipermetabolic. The rib lesion presents characters of a cartilaginous tumor (expansive lesion with cartilaginous matrix calcifications, so a guided biopsy is requested. (Fig 3). The biopsy was directed to the metabolically active area.

**Patient Nº 7**: Male, 71 years old. Multiple myeloma in remission since 2011. HSCT in 2012. Initial injuries in 5th left rib and vertebrae L4 and L5. Increased IgA peak. PET/CT for restaging. (Fig. 4). The puncture site was changed to the SUV maximum value.

**Patient Nº 8**: 71 years old man. Prostate cancer. Biochemical recurrence. Restating PET/CT shows a solitary bone rib small lesion with high uptake. ( Fig.5). The lesion was a PET finding, retrospectively visible in the CT.

**Patient Nº 10**: Male 71 years old. Fever unknown origin. (Fig. 6). The biopsy was directed to the metabolically active area.

**Patient Nº 18**: Male 72 years old. Lower limb pain. The X-ray and CT shows multiple small lytic lesions sited at the marrow and the cortex of left femur. Two CT-guided biopsies were performed with the same pathology report: Normal Bone. One year later, CT show increased injury extension of lytic lesions in left femur, tibia and fibula. PET-CT: multiple hypermetabolic lesions. The third CT-guided biopsy was performed in a tibial hypermetabolic lesion (Fig.7).

**Patient Nº 29**: Male, 59 year old, insulin-dependent diabetes, coledocian syndrome. Abdominal MR demonstrated a pancreatic tumor with negative biopsy. Multiple pulmonary nodules in CT with inconclusive biopsy. (Fig. 8). PET/CT shows a solitary vertebrae avid lesion. The planned boarding side side was changed in relation to the result of the PET/CT.
Fig. 1: CT biopsy Guide in relation to the PET/CT image

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Fig. 2: Histopathology of CT-guide biopsy

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**Fig. 3**: Male, 69 year old. Bilateral Non Small Lung Carcinoma 10 years before. Surgery and chemotherapy. CT: left solitary pulmonary nodule. Bone lesion in the 4th left rib.

Restaging PET-CT. a y b) Axial FDG PET /CT show lesion in 4th rib. Expansive tumor with cartilaginous matrix calcification, hypermetabolics and non-hypermetabolics areas.


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**Fig. 4:** Male, 71 year old. Multiple myeloma in remission since 2011. HSCT in 2012. Initial injuries in 5th left rib and vertebrae L4 and L5. Increased IgA peak. PET/CT for restating. a) Coronal MIP FDG PET show avid bone lesion in vertebrae T5 and right rib (arrows) b) Axial PET /CT image rib avid lesion . c-d) Rib and component soft parts of the lesion CT-guide biopsy. e-f) Histopathological specimens: clonal plasma cells population. Myeloma

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**Fig. 5:** Fig. 5. 71 years old man. Prostata cancer. Biochemical recurrence. 68 Ga Colina PET-CT. a) Coronal MIP PET solitary avid bone lesion. Left Rib. b-c) Axial PET/CT litic bone rib lesion with high uptake. d-e) Guided CT biopsy. Coaxial Method. f) Histopathological specimens Pathologic cell population, atypical, with nuclear hyperchromatism, without mitosis. Focally outlines acinar layout. PSAP (prostatic acid phosphatase) cytoplasmic positivity in this population.

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Fig. 6: Male 71 year old. Fever unknown origin. a) Sagital MIP FDG PET avid bone lesion in L5-S1 right facet joint. Also uptake in soft tissue. b) Axial PET/CT Arthritis in facet joint. c) Axial PET/CT Soft tissue uptake. d e) Guidance CT biopsy in facet joint and soft tissues. e) Sagittal reconstruction, needle in articular facet L5-S1. g) Specimen Histologic. Inflamatory infiltrates surounded by fibrosis. Negative cultures, bacteriologial, mycological and Koch’s Bacillus.

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Fig. 7: Male 72 year old. Lower limbs pain. a) X-ray: multiple small lytic lesions sited at marrow and cortex of femur. Two CT-guided biopsies. Pathology report: Normal Bone. b) One year later, CT show increased injury extension of lytic lesions in left femur, tibia and fibula. c) PET-CT: multiple hyper metabolic lesions in lower left limb. d) Third biopsy under CT-guidance in tibial hyper metabolic lesion, the greater uptake. e) Histopathology: Angiosarcoma

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**Fig. 8:** 59 year old man, insulin-dependent diabetes, coledocian syndrome. Abdominal MR demonstrated a pancreatic tumor with negative biopsy. Multiple pulmonary nodules in CT with inconclusive biopsy. a) Coronal MIP FDG PET show avid bone lesion in vertebrae T2 (arrow). Non pancreatic avid lesion. b-c) Axial y Sagital PET/CT image vertebrae avid lesion. d-e) CT-guided biopsy. Left Transpedicular approach in area of grater SUV in PET/TC. The planned boarding side was changed in relation to the result of the PET/CT. 

f-g ) Histopathological specimens: Alveolar spaces with fibrous connective tissue and abnormal glandular lights with cellular luminal content. The tubule-glandular elements located in the alveolar bone spaces mark positively in their cytoplasm and membrane with CK7. Final report: Well-differentiated adenocarcinoma metastases of pancreatic ducts

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Conclusion

In our series, the PET/CT guided the biopsy site according to the following groups:

- biopsy site was defined based on the SUV maximum in 43.7% of cases;
- lesion was not visible in the CT in 25% of cases, cognitive guide was based on PET;
- lesions were PET findings that were retrospectively visible in CT in 31.3% of cases.
(Fig.1)

No complications arose in regard to puncture procedure.

SUV maximum is not a good indicator of malignity in bone. Any injury with bone remodeling may have uptake. In fact, the lesion with higher uptake (SUV max 14.7) in our series corresponded to an articular infection lesion.

CT-guided percutaneous bone biopsy based on PET/CT is effective, and accounts for a better diagnostic yield. PET/CT may vary planning for a lesion biopsy: approach, orientation and sample taking site (higher SUVmax values area). PET imaging may cognitively guide the definition of the biopsy site in the cases where the lesion is not visible in the CT.
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References


