Added Value of SPECT/CT Fusion in Assessing Suspected Bone Metastasis

Poster No.: C-1595
Congress: ECR 2015
Type: Scientific Exhibit
Authors: M. Mereuta\textsuperscript{1}, G. Cobzac\textsuperscript{2}, G. Andries\textsuperscript{2}; \textsuperscript{1}Cluj-Napoca/RO, \textsuperscript{2}Cluj-Napoca/RO
Keywords: Oncology, Bones, Nuclear medicine conventional, SPECT-CT, Molecular imaging, Metastases
DOI: 10.1594/ecr2015/C-1595

Any information contained in this pdf file is automatically generated from digital material submitted to EPOS by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply ECR’s endorsement, sponsorship or recommendation of the third party, information, product or service. ECR is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.

As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method ist strictly prohibited.

You agree to defend, indemnify, and hold ECR harmless from and against any and all claims, damages, costs, and expenses, including attorneys' fees, arising from or related to your use of these pages.

Please note: Links to movies, ppt slideshows and any other multimedia files are not available in the pdf version of presentations.

www.myESR.org
Aims and objectives

In clinical practice, along with the lung and liver, the bone is a common site for metastases in patients with malignant neoplasms [1]. However, patients without malignancy history but presenting clinical symptoms which are not easy to explain or need to be further evaluated, always underwent imaging examinations to exclude metastases or other malignant conditions involving bones [2].

Nowadays, bone scintigraphy (BS) is one of the most common nuclear medicine studies. Due to the whole-body scan (WBS) and high sensitivity, BS is performed to detect bone metastases, for accurate staging and treatment follow-up. The specificity is low, as skeletal benign lesions accumulate the radiotracer as well [2, 3].

Compared to planar scintigraphy, single photon emission computed tomography (SPECT) improves the sensitivity of bone scanning. However, the low specificity and lack of anatomical details also limit its application in the differentiation of benign and malignant bone lesions. Moreover, computed tomography (CT) has good anatomical resolution and high specificity for bone lesions, but its disadvantages are relatively low sensitivity and a limited area of examination [2-5].

Within the past 10 years, SPECT/CT imaging has added a new dimension to the routine bone scan. The ability to superimpose the detailed anatomy of a CT scan on the physiological data obtained by SPECT imaging has given a new insight into a variety of clinical conditions that often defy diagnosis by other modalities. Moreover, the CT data can be used to provide attenuation correction (AC) and scatter correction that greatly improve SPECT quality and resolution [4, 5]. The addition of localized SPECT/CT for the assessment of indeterminate foci both enables a definitive diagnosis in most cases and improves diagnostic confidence [5, 6]. SPECT and CT scans fusion offers an important advantage over assessment of two separate data sets for improved anatomic localization of a suspected site of increased radiotracer uptake at bone scanning. This provides increased diagnostic confidence in differentiating between malignant and benign lesions when analyzing findings of scans performed, even in the case of a single bone lesion in oncologic patients [6].

The experience of the Nuclear Medicine Department from the County Emergency Clinical Hospital Cluj-Napoca is presented, underlining the quality and depth of the information provided by SPECT/CT fusion method, in comparison with scintigraphy alone and non-fused scintigraphy and CT.
Methods and materials

In a descriptive retrospective study were enrolled data from 304 consecutive patients that had indication for SPECT/CT (differential diagnosis benign-malignant, characterization of different types of bone lesions located in difficult areas, uncertain on WBS or that need guidance for puncture biopsy [7]), examined between 2009 and 2014.

The radiopharmaceutical of choice was $^{99m}$Tc-HDP (hydroxymethylene diphosphonate) which has a physical half-life of 6 hours and low gamma energy. It was injected intravenously and the dose was dependent on the pathology and the body weight, with an average activity administered of about 500 MBq (300-740 MBq) (8-20 mCi). The protocols that were used were adapted to our laboratory from EANM Guidelines, according to national regulations [7].

Anterior and posterior whole body planar images were acquired in a continuous mode, using parallel-hole, low-energy, high-resolution collimators, with the patient in the supine position. Images were acquired on the 140-keV photopeak with a 15% symmetrical window and matrix size was 256x1024. The images were recorded using a hybrid system that combines a dual - head variable - angle gamma camera with an integrated 2-slice diagnostic CT scanner for rapid AC. Immediately after acquisition, the planar and other additional images (such as 3 phase dynamic aquisition or spot views- performed only if necessary) were evaluated by a nuclear medicine physician regarding the additional imaging in the form of SPECT and SPECT/CT (Table 1).

Table 1. Parameters used for image acquisition, addapted to our laboratory. Filtered back projection and Butterworth filter were used for data reconstruction. References: Department of Nuclear Medicine, County Emergency Clinical Hospital, Cluj-Napoca/ RO.

<table>
<thead>
<tr>
<th>SPECT</th>
<th>CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detectors in $180^\circ$ position</td>
<td>Acquisition- continuous spiral scan, 1,5 pitch</td>
</tr>
<tr>
<td>Routine scan time - 13 min</td>
<td>X-ray tube operated at 130 kV and 20 mA</td>
</tr>
<tr>
<td>Reconstruction- iterative methods- photon AC based on X-ray transmission map and scatter correction</td>
<td>In-plane spatial resolution of 2.5 mm, 10 mm in axial direction</td>
</tr>
<tr>
<td>Matrix size 128x128</td>
<td>Scan time:1 sec/slice (30-40 sec CT study)</td>
</tr>
<tr>
<td>LEHR parallel hole collimators for $^{99m}$Tc</td>
<td>Attenuation map-end of CT acquisition time</td>
</tr>
<tr>
<td>128 projections over a 360° orbit - time per projection of 20 s</td>
<td>Matrix size 512x 512</td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td></td>
<td>2.5 mm slice thickness and slice spacing</td>
</tr>
</tbody>
</table>
Results

From the total number of patients that had bone scans during these 6 years (2048 patients), 15% had indication for SPECT/CT examination.

The peak in age distribution of these examinations was represented by the decade 6 (34.86%), underlining the growing incidence of breast cancers, pathology that represents the largest proportion of all of those sent for examination (49.14%).

The majority of cases in which SPECT/CT was performed was represented by malignant disease characterization (79.95%), justified by the large number of oncological patients sent with suspicion of bone metastasis. 77.5% of them had multiple lesions on WBS, but by the means of SPECT/CT 56.45% proved to be benign. From the rest of 20.05% patients presenting with 1 single lesion on WBS 51.8% proved to be benign (Fig. 1) (Fig. 3 - Case 1. One solitary lesion in an oncological patient that proved to be benign).

Around 21% of the patients examined using SPECT/CT presented for bone primary lesions (Fig. 4 - Case 2. Suspicion of rheumatoid arthritis - incidental finding of a bone metastasis), in 46.87% of them the suspicion was of bone tumors (Fig.5, 6 - Case 3. Patient presenting for bone tumor characterization proved to be malignant and already having bone metastases). From the patients presenting for bone tumor characterization, the diagnosis was of benign in almost 55.55% of the patients referred for possible malignant tumors. One from a total of 5 patients sent with suspicion of benign bone tumor turned out to be malignant (Fig. 2).

Having the functional and morphologic data in one examination, additional imagistic examinations are not required, with the exception of a small group of patients, concerning a more accurate anatomical description or evaluation of local invasion.

The therapeutic management changed in 48.35% of the patients examined using SPECT/CT, in 43.33% of those who presented with primary bone tumors and 55.41% of the patients sent for oncological staging.

The mean effective radiation dose received by patients undergoing a CT guided SPECT is approximately 3.22 Gy, comparable to that provided by a simple radiography, four times lower than a diagnostic CT.
Fig. 1: Distribution of the number of patients needing staging having got visceral neoplastic diseases and the results. 11.66% from 204 patients needing staging had 1 benign lesion confirmed by SPECT/CT

© Emergency Clinical County Hospital - Cluj-Napoca/RO
Fig. 2: Distribution of the number of patients having different types of bone neoplastic diseases and the results. From 16 patients that came with uncharacterized bone neoplastic disease, we found one patient that had a primary malignant bone tumor that already metastased at this level.

© Emergency Clinical County Hospital - Cluj-Napoca/RO
Fig. 3: Case 1. A 72 years old female patient with left excised breast cancer addressed for oncological staging. On the WBS (A.) we found a focal uptake area in the left lumbar paravertebral area, another one in the right lombosacral area and multiple other areas of hyperfixation at the level of the joints- that aspect pleads for inflammatory and degenerative lesions. The result of the fusion study (B.) was benign: a focal uptake lesion at the level of the left transverse apophysis L2 vertebrae, being interpreted in the clinical context (posttraumatic) as being a fracture. No bone metastasis were detected.

© Emergency Clinical County Hospital - Cluj-Napoca/RO
**Fig. 4:** Case 2. A 55 years old male patient sent with the suspicion of rheumatoid arthritis. On WBS (A.) we can see a rim uptake area at the level of the left scapula and a hypertrophic osteoarthropathy of the inferior limbs. SPECT/CT (B.) found a left scapular metastasis (on its medial margin) (the lytic lesion breaks the bone cortex) from lung cancer.

© Emergency Clinical County Hospital - Cluj-Napoca/RO
Fig. 5: Case 3. A 37 years old female patient having the initial diagnosis of a primitive unclassified tumor at the level of the distal right femur. WBS shows an inhomogeneous high uptake area in the distal third of the right femur, corresponding to the tumor and multiple areas of uptake in the skeleton, aspect that pleads for multiple bone metastasis (A.). By the means of SPECT/CT hybrid technique it was proved to be an osteosarcoma of the distal 1/3 right femur (showing cortical bone destruction and soft tissue invasion) (B.), and multiple bone metastasis (Fig. 6. C.).

© Emergency Clinical County Hospital - Cluj-Napoca/RO
Fig. 6: Case 3. C. Multiple bone metastasis from the case previously described.

© Emergency Clinical County Hospital - Cluj-Napoca/RO
Conclusion

BS is a sensitive examination, that can identify abnormalities at an early stage, having though low specificity. The addition of SPECT is known to improve the diagnostic accuracy of planar BS, but still the specificity of SPECT remains low. This is due to the fact that localization alone does not help much for these lesions and anatomical correlation is usually required [8].

Römer et al. first evaluated the role of SPECT/CT for characterizing indeterminate bony lesions in patients with malignancy. SPECT/CT was able to clarify 90% such lesions in cancer patients [3].

SPECT/CT is superior to planar scintigraphy and borderline superior to SPECT, proving helpful in providing more specific diagnosis of certain bony lesions, with a superior localization of lesions, increasing the certainty of the reading physicians’ diagnoses, with a significant impact on patient management [9,10].

Strobel et al., when evaluating the etiology of axial bony lesions reported a sensitivity and specificity for the differentiation of benign and malignant bone lesions of 82% and 94% for planar scintigraphy, 91% and 94% for SPECT, and 100% and 100% for SPECT fused with CT [11].

A clear advantage of simultaneous SPECT/CT imaging is reaching a diagnosis from one procedure, with significant time and cost reduction [12]; by the means of low-dose CT, the level of irradiation and need for other imaging investigations are lowered.

SPECT/CT can clarify the true nature of indeterminate foci that, although being characterized on clinical basis or in comparison with prior studies, remain uncertain without the addition of radiographs, CT scans or MRI. This fusion imaging technique has got the advantages of complementarity between anatomic and functional imaging modalities, attenuation correction based on CT co-registration, its specificity being brought up to 92%.
Personal information

Maria Mereu##, M.D.
Department of Nuclear Medicine, County Emergency Clinical Hospital Cluj-Napoca, Romania;
mereuta_maria@yahoo.com

Gheorghe Cobzac, M.D.
Department of Nuclear Medicine, County Emergency Clinical Hospital Cluj-Napoca, Romania;
cobzac_gh@yahoo.com

Gabriel Andrie#, M.D., Ph.D.
Department of Nuclear Medicine, County Emergency Clinical Hospital Cluj-Napoca, Faculty of Medicine, University of Medicine and Pharmacy Cluj-Napoca, Romania;
gl.andries@yahoo.com
References


