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## Review Article

# The Role of SPECT-Guided CT for Evaluating Foci of Increased Bone Metabolism Classified as Indeterminate on SPECT in Cancer Patients

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**Abstract :**

Planar and SPECT bone scintigraphy has played a major role in the staging of many cancers such as breast and prostate cancer, as well as in orthopedics. Integrated diagnostic CT combined with SPECT has helped improve localization and characterization of skeletal lesions, improving diagnostic confidence and helping management decisions, over traditional SPECT. A major advantage has been improved characterization of indeterminate bone lesions and differentiation of benign from malignant lesions due to additional CT information. In this treatise the role of SPECT-guided CT for evaluating foci of increased bone metabolism classified as indeterminate of SPECT in cancer patients is reviewed. Using this approach, the diagnostic confidence in differentiating malignant from benign bone lesions should better with the fused SPECT/CT image than with separate sets of bone scintigraphic and CT images.

**Key words:** SPECT, SPECT Guided CT, Differentiating malignant bone lesion.

## Introduction :

Numerous reports emphasize the high sensitivity of bone scintigraphy in the diagnosis of osseous metastases[1]. However, because benign lesions of the bone accumulate the 99m Tc-labeled diphosphonates as well, the specificity of bone scintigraphy is quite low[2]. A particular problem is the enhanced diphosphonate uptake in degenerative processes. In most cases, this enhancement affects the vertebral column and the pelvis. Especially difficult is the differentiation of deforming spondylosis and spondylarthrosis, that is, degenerative disease of the facets, from metastases. In planar scintigraphy, superimposition hampers the exact anatomic localization of lesions. The addition of SPECT allows better distinction of benign from malignant changes because of the more exact localization of increased diphosphonate uptake[3-5]. However, the specificity of SPECT is also not sufficient for a reliable diagnosis[6].

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In daily clinical routine, additional radiologic procedures are recommended for cases of focally enhanced diphosphonate uptake. As a first step, planar radiographs usually are obtained. If these show clear signs of arthrosis, it is concluded that the scintigraphic abnormalities are benign. If osteolysis is clearly shown, CT may be indicated to assess bone stability. However, if the radiographic findings are unremarkable further tests, particularly MRI, are necessary. These may be time consuming and may delay therapeutic procedures; furthermore, they cause considerable stress to the patients waiting for the diagnosis.

In recent years, a hybrid camera combining a dual-head SPECT camera with a low-dose non diagnostic CT scanner has been commercially available[7-9]. However, more recently, hybrid cameras combining SPECT and spiral CT have offered the opportunity of perform diagnostically sufficient CT of scintigraphically suggestive lesions in a single session. These systems allow the field of view of the CT scan to be adapted to the SPECT findings ("SPECT-guided CT")

## SPECT guided CT Acquisition (SPECT/CT):

The SPECT scan was acquired first, with the equivocal finding included in the center of the field of view. When more than one unclear finding was detected on

the planar whole-body scan, the field of view was positioned so as to include all findings. In second, SPECT/CT scan after completion of the first should necessary to visualize all lesions under study. Immediately after the SPECT data had been acquired, the raw data are reconstructed into transaxial, coronal, and sagittal slices using e.soft reconstruction software. The resulting SPECT images are analyzed by a physician not to decide on the necessity of CT but to define the field of view for the CT. Exposure to radiation is reduced by restricting the field of view for CT to the area of the indeterminate SPECT findings. For this aim, a CT topogram is acquired and the scan area for CT is planned using the anatomic information from the SPECT images. Afterward, the CT scan was acquired. Both SPECT and CT are performed during shallow breathing, with the patients stably lying supine. The interval between SPECT and CT is less than 3 minutes.

For the SPECT acquisition, counts from the 15% energy windows at 140 keV are acquired into a 128 x 128 matrix (pixel size, 4.6 x 4.6 mm). Sixty-four 30-s frames are acquired over 360°. The camera heads are equipped with a high-resolution low-energy parallel - hole collimator. Reconstruction is performe STET iteratively using 3-dimensional (3D) ordered-subsets expectation maximization with 4 iterations and 8 subsets. Images are smoothed with a 3D spatial gaussian filter (10 mm in full width at half maximum).

The CT parameters included 130 kV, a 0.8-s rotation time, and a 2 x 2.5mm collimation. Because, only bone structures required analysis, the tube current was reduced to 40 mAs to minimize radiation exposure. A recent study has shown that low-dose CT protocols are appropriate for the diagnosis of lytic bone changes[10]. Image reconstruction using a high-resolution reconstruction algorithm (B80 kernel) resulted in images with a slice thickness of 3 mm for a 1.5-mm reconstruction increment.

For all fused images, the accuracy of the matching of internal anatomic landmarks visible on both CT and SPECT should be checked; no misregistration exceeding 3 mm should be noticed. Because the SPECT and CT data are optimally registered, Hounsfield units could easily be used to calculate attenuation coefficients, and attenuation-corrected images are reconstructed as described recently[11]. On CT, malignant lesions are suggested by the presence of lytic, sclerotic, or mixed lytic-sclerotic changes. Furthermore, the presence of osteophytes, spondylophytes, subchondral sclerosis, or narrowing of the joint space is regarded as a clear sign of benignity[12]. CT -Expo software (Hannover Medical School) should be used to determine the additional radiation exposure caused by the CT scan[13,14].

**Discussion:**

The development of SPECT/CT has been popularized by the recent implementation of spiral CT scanners. These systems can adapt the field of view of the CT scan to the SPECT findings. Romer et al[9] shows, SPECT-guided CT allowed for a definite diagnosis in 92% of axial skeleton lesions classified as indeterminate on SPECT alone, thus considerably shortening the diagnostic process. Up to now, the next step in the diagnostic workup of indeterminate findings on bone scintigraphy has been planar radiography, the least expensive and most widely available morphologic imaging modality[1]. However, the drawbacks of planar radiography in the identification of osteolysis, especially in the spine, are well known[15]. Clear evidence exists that destruction of more than 50% of trabecular bone is a prerequisite for metastases to be visible on planar radiography studies[16]. Therefore, additional MRI or CT will be necessary to clarify enhanced bone metabolism in a considerable number of patients. A further problem is the difficulty and potential inaccuracy of correlating skeletal SPECT scans and planar radiographs through side-by side viewing. Accuracy might be improved by using CT or MR images for side by side viewing or even by using retrospective registration with SPECT. In a recent publication, Utsunomiya et al[17] compared SPECT/ CT fusion and side by side reading of SPECT/ and CT data.

A gantry free SPECT scanner and an 8-detector row CT scanner were juxtaposed such that the CT table could move with the patient directly from the CT scanner into the SPECT scanner. Afterward, both image datasets were retrospectively registered on a separate workstation. Using this approach, the authors found that diagnostic confidence in differentiating malignant from benign bone lesions was better with the fused SPECT/CT image than with separate sets of bone scintigraphic and CT images. At least in some patients, the exact match provided only by SPECT/CT might be necessary to exactly localize that area of increased tracer uptake, especially in small anatomic structures.

Hybrid cameras combining SPECT with low dose CT (140 kV, 2.5 mA) were introduced 5 years ago[7,18]. This method, called transmission emission tomography[19], readily acquires data for attenuation correction and for identifying anatomic landmarks. However, because of the technical shortcomings of low dose CT, morphology cannot be visualized in greater detail with this technology. Nevertheless, Horger et al[8]

could correctly classify 85% of unclear foci of diphosphonate uptake with transmission emission tomography, compared with only 36% using SPECT alone. They reported that the highest diagnostic gain was in the spine, the thorax, and the pelvis. However, they also considered that, because of the limited resolution of the low-dose CT scan, small osteolytic lesions could be missed by transmission emission tomography.

This shortcoming apparently does not apply to hybrid cameras equipped with spiral CT scanners, which achieve significantly higher resolution of morphologic detail.

CT should be performed after SPECT. The SPECT images are evaluated while the patient is still in the scanner. The information from both SPECT and planar scintigraphy is used to determine the area (limited to the suggestive focus of diphosphonate uptake) to be scanned additionally with CT. With this approach, the additional radiation exposure to the patient could be kept as low as possible. The mean radiation exposure caused by the SPECT -guided CT was 2.3 mSv, which is about one third the radiation exposure caused by the bone scintigraphy alone. The concept is in contrast to SPET/CT, for which the fields of view of the PET and CT scans are identical in order to use CT data for attenuation correction[20]. However, in PET, attenuation correction is mandatory. In SPECT, attenuation correction by the use of CT data is possible[11,21], but the clinical benefit of attenuation correction has not yet been sufficiently evaluated.

**Conclusion:**

Hybrid cameras combining SPECT and spiral CT offer the opportunity to obtain a diagnostic quality of CT image on scintigraphically suggestive lesions that directly correlates with the SPECT image. The field of view of the CT scan can be adapted on the basis of the SPECT findings ("SPECT - guided CT"). So, using this approach, diagnostic confidence in differentiating malignant from benign bone lesions is better with the fused SPECT/CT image than with separate sets of bone scintigraphic and CT images.

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