



ORIGINAL ARTICLE

# Non-neoplastic variants of the sternum detected on bone scintigraphy using a hybrid SPECT/CT machine



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## KEYWORDS

Single-photon emission computed tomography/computed tomography, SPECT/CT; Sternum; Variants; Bone scan; MDP

**Abstract** *Purpose:* To identify the non-neoplastic variants of the sternal uptake in patients known to have a primary tumor, referred for detection of metastases elsewhere.

*Materials and methods:* This retrospective study was approved by the Institutional Review Board. Fifty eligible patients (17 males & 33 females) known to have a primary tumor underwent <sup>99m</sup>Tc-MDP-bone scan for detection of metastases. All patients underwent SPECT/CT of the chest region. For each patient, 10 subsites were evaluated (right & left sternoclavicular joints, right and left first costo-sternal articulation, manubrium sterni, manubriosternal junction, body of the sternum, xiphisternal junction, xiphoid process and other sub-sites (e.g. chondro-sternal articulations)). The uptake was described as normal or abnormal. CT findings were categorized as normal/abnormal (arthritis, degenerative, developmental & congenital). Any patient with suspicious metastatic sternal lesion based on CT findings or abnormal tracer uptake was excluded.

*Results:* A total of 500 sub-sites were analyzed. Increased uptake was seen in 189 sub-sites. Of them, 133 showed abnormal CT findings (95 arthritis, 33 degenerative, 3 developmental & 2 congenital) and 56 sites were unremarkable. Of the 311 with normal uptake, only 18 showed abnormal CT findings (8 arthritis & 10 degenerative). The association was statistically significant ( $P < 0.001$ ).

*Conclusion:* Increased sternal uptake is significantly associated with CT structural abnormalities and knowledge of these non-neoplastic variants is essential for correct interpretation of SPECT/CT bone scans especially in patients with known cancers.

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## 1. Introduction

Bone scintigraphy using technetium based phosphonate compounds is the standard method for detection of skeletal metastases from many cancers (1).

Sternum is relatively a frequent site for skeletal metastasis especially in patients with breast cancer (2). The different age-related patterns of normal sternal uptake have been previously described in patients with no malignancy (3,4). Hybrid imaging using SPECT/CT was shown to increase the accuracy of bone scanning and significantly affects the clinical management decisions of cancer patients (5,6).

It is therefore fundamental to recognize the non-neoplastic variants of the sternal uptake and their corresponding CT changes using SPECT/CT.

## 2. Materials and methods

### 2.1. Patients

This retrospective study was approved by the Institutional Review Board. An informed consent was not required. We included patients known to have primary tumor referred for diagnosis/follow-up of bone metastases, in whom SPECT/CT of the chest region was performed with complete inclusion of the sternum and sternoclavicular articulations. Patients with known sternal pathology (pain, trauma, fracture, surgery), or patients with any lesion that is considered suspicious for being metastasis based on bone scan or low-dose CT findings were excluded.

During the period from February 2013 to May 2014, a total of 50 patients were deemed eligible for this study.

### 2.2. Imaging protocol

At first, whole body scans were obtained in the anterior and posterior projections 2 h after the IV injection of about 650–850 MBq of <sup>99m</sup>Tc-MDP. A dual-head  $\gamma$ -camera (Symbia T, Siemens Medical Solutions, USA) equipped with parallel-hole high resolution low-energy collimators using a 20% energy window set at 140 keV was used. The table speed was 12 cm/min, matrix size 256 × 1024.

SPECT/CT images of the chest region were obtained with the sternum and sternoclavicular joints fully included in the scanned field. SPECT procedure was acquired employing a step and-shoot protocol, 25 s/view for a total of 32 views using a noncircular orbit over 360° of rotation (180° per head) and a matrix size of 128 × 128.

Immediately after completing SPECT acquisition, low-dose CT study was acquired using the following parameters: tube current 70 mA s, tube voltage 130 kV, employing a dose-reduction algorithm (CAREdose 4D, Siemens Medical Solutions, USA). The CT dose index per volume (CTDIvol) was on average 7.6 mGy. CT images were reconstructed in 2-mm slices using bone and soft tissue kernels.

After completion of acquisition, the images were reconstructed with attenuation and scatter correction using 3D iterative algorithm (OSEM 3D Flash, Siemens Medical Solutions, USA).

The reconstructed attenuation-corrected SPECT images and CT images were transferred to the viewing stations for reviewing in axial, coronal, and sagittal planes.

### 2.3. Data interpretation

A combined reading of the SPECT/CT data was performed by one nuclear medicine physician (11 years experience) and one radiologist (15 years experience). Both physicians have prior knowledge of the aim of the study and clinical data of the patient (age, gender, primary tumor site and received treatments).

For each patient, 10 sites were evaluated: right and left sternoclavicular joints (SCJs), right and left first costo-sternal junctions, manubrium, manubriosternal junction (MSJ), body of the sternum, xiphisternal junction, xiphoid process and other sub-sites (e.g. lateral borders of the sternum at the sites of cartilaginous rib attachment).

For each site, the intensity of tracer uptake was described as normal or increased. The CT findings were also described as either normal or abnormal. The abnormalities were categorized as follows: arthritic (e.g. joint line irregularity, sclerosis, osteophytes, sub-chondral cysts), degenerative (e.g. calcification, ossification, vacuum phenomenon), developmental (e.g. growth centers), or congenital (e.g. sternal cleft, bony islands). Any other changes (e.g. trauma and bone cysts) were also noted.

### 2.4. Statistical analysis

Qualitative data were expressed as frequencies and percentages. Associations were performed using chi-square. The analyses were carried out using the SPSS 21.0 (SPSS Inc., Chicago, Illinois, USA), (MedCalc, Ostend, Belgium), and Microsoft Excel (Microsoft, USA) softwares.

## 3. Results

A total of 50 patients (17 males & 33 females) with median age 55.5 years (range: 6–86) were eligible for inclusion in that study.

**Table 1** General characteristics of the patients enrolled in this study.

Parameter	N	Percent
Patients	50	100%
Age		
Median (range)	55.5	(6–86) <sup>a</sup>
Age groups		
Age < 35	6	12%
Age 35–60	26	52%
Age > 60	8	36%
Cancer site		
Right breast	14	28%
Left breast	12	24%
Bilateral breast	2	4%
Prostate	4	8%
Kidney	2	4%
Other	16	32%

<sup>a</sup> The numbers in parentheses indicate the range of the data.

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