Ra-223 planar whole body scan and SPECT of surgically removed bone

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Introduction

Recently, radionuclide therapy with Ra-223 dichloride (Xofigo™, Bayer Healthcare) has been initiated in many countries for the treatment of patients with castration-resistant prostate cancer with symptomatic bone metastases and no known visceral metastatic disease. Typical prescribed activity is 50 kBq/kg body weight given 6 times at 4 weeks interval.

The half-life of Ra-223 is 11.43 d, and the decay chain of Ra-223 to stable Pb-207 involves 6 stages, all with shorter half-lives (ms to minutes) than Ra-223. Four of the stages are by alfa, two by beta emission. The total emitted energy in the decay is 28 MeV, and a number of X-ray and gamma lines (1% of total energy) in the interval 80-400 keV allows external detection with photon counting devices and gamma-cameras.

Methods and Materials

The possibility of imaging Ra-223 treated patients and bone was investigated. We acquired a SPECT scan 27 days after the last treatment of ex-vivo bone, that was removed during hip surgery. The hip bone was stored in a plastic container in a formaldehyde solution. A planar whole body scan of a patient (in-vivo), who was administered 4.4 MBq Ra-223 one hour before scanning, was also acquired.

A dual head Philips Precedence SPECT-CT with MEGP collimators was used. A one hour planar whole body scan was acquired with 40 mm/min scan speed and 2.78 mm pixel size.

SPECT acquisition was performed in step and shoot mode with a 128x128 matrix size, 4.66 mm pixels and 128 angles. Data was acquired 600 s per angle resulting in a total acquisition time of almost 11 hours. Reconstruction was performed with a resolution recovery OSEM method (Astonish) with 3 iterations and 8 subsets. Attenuation Correction was performed with a 140 kVp low dose CT.

We compared a set-up with two 20% width energy windows. One at 269 keV overlapping the two most intense gamma-lines (14% and 11% yield) and another one at 84 keV overlapping the two most intense X-ray emissions at 84 and 81 keV (25% and 15% yield), see table 1.

***Table 1**: Gamma and X-ray emissions with yield >10%.*

Nuclide	Energy in keV	Yield in %	Type
Ra-223	81.1	15.2	X-ray
Ra-223	83.8	25.2	X-ray
Ra-223	269.5	13.7	gamma
Rn-219	271.2	10.8	gamma
Bi-211	351.1	12.9	gamma

http://www.nndc.bnl.gov

A whole body planar patient scan

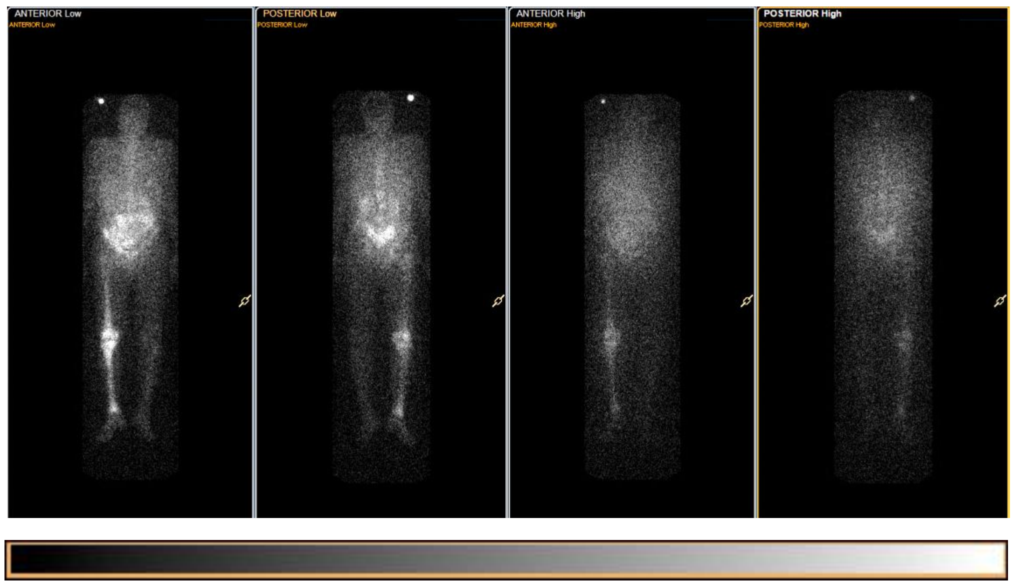

***Figure 1**: From left to right, 84 keV 20% width energy windows anterior and posterior view, 269 keV 20% width energy windows anterior and posterior view.*

A SPECT-slice of surgically removed bone

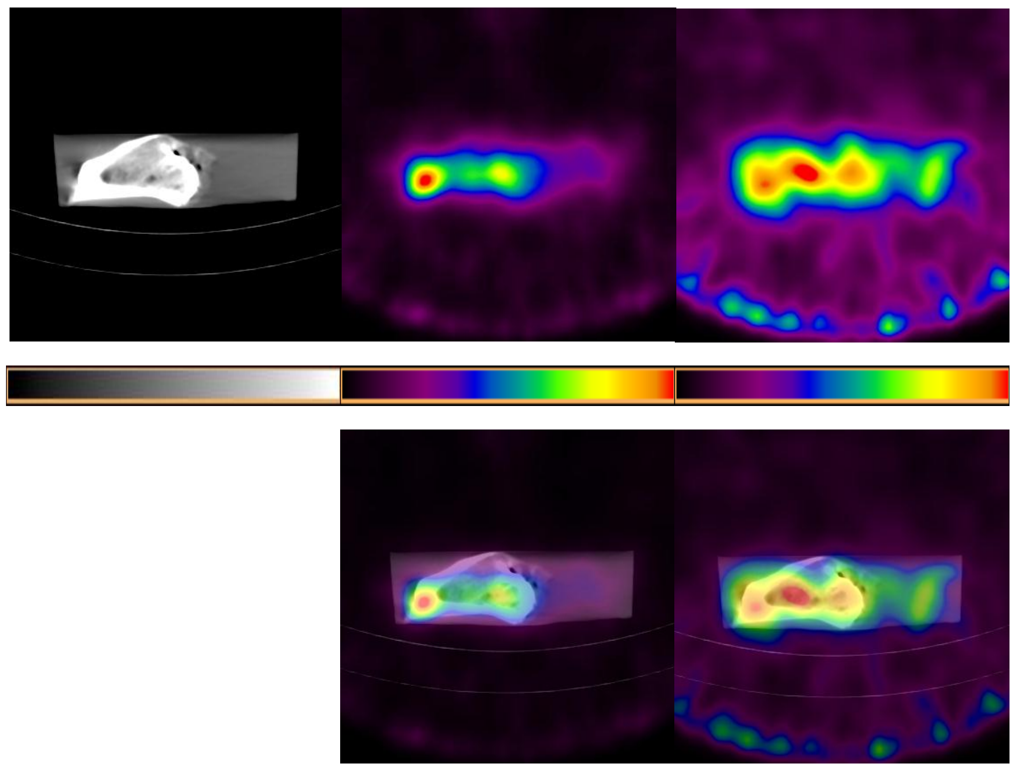

***Figure 2**: Top row, from left to right: 140 kVp low dose CT, 84 keV 20% width energy window and 269 keV 20% width energy window SPECT reconstructions. Bottom row: the SPECT reconstructions fused with the low dose CT.*

Results

The lower energy window resulted in visually better images than the higher energy window in both cases, see figure 1 and 2. The SPECT of the bone revealed that spatial allocation of the counts is best in the 84 keV window. The 269 keV SPECT showed a significant amount of counts in areas without bone indicating a bigger influence of scatter.

Conclusions

LEGP collimators might improve the quality for the 84 keV SPECT, as long as downscatter from higher energy photons does not become a problem. We have showed that it is possible to image patients treated with Ra-223 and that it is best done with the 84 keV window.

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