Optimization of Yttrium-90 Bremsstrahlung imaging for evaluation of microspheres post-therapeutic liver radioembolization distribution

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ABSTRACT

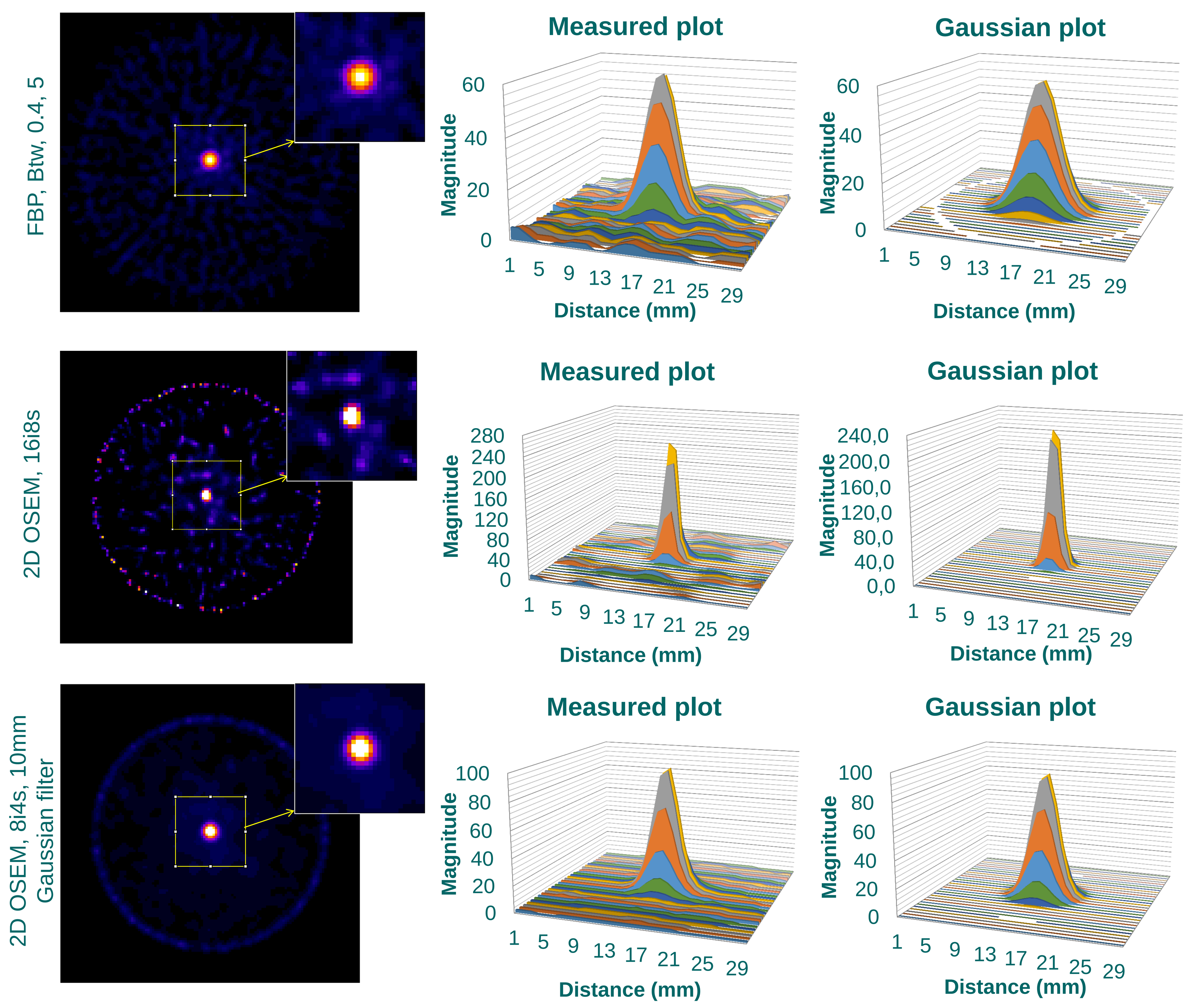
Post-therapy imaging of ^{90}Y-Bremsstrahlung x-rays using SPECT, although ^{90}Y is not the best isotope for imaging, has the potential of providing a reliable activity distribution of the ^{90}Y-microspheres inside the liver. Quantitative Bremsstrahlung imaging is very difficult to obtain due scatter, septal penetration, the continuous nature of the Bremsstrahlung energy spectrum, and inefficient Bremsstrahlung production. In literature, several image acquisition parameters and subsequent different reconstruction protocols can be found. With the aim of obtaining an optimized ^{90}Y-Bremsstrahlung SPECT image, two reconstruction methods, Filtered-Backprojection (FBP) and Ordered-Subsets-Expectation-Maximization (OSEM), were applied both to phantoms and post-therapeutic images using several reconstruction parameters.

A ^{90}Y-Bremsstrahlung image of a water filled Jaszczak phantom was acquired. A line source containing 222 MBq of ^{90}Y and uniformly distributed activity was placed inside, along the longitudinal axis. The image was acquired using a gamma camera (e.cam, Siemens) equipped with a MEGP parallel-hole collimator and an energy window of 136-184 keV. By modifying the order and critical frequency (FBP) and number of iterations, subsets and Gaussian-filter FWHM (OSEM), SPECT resolution, image contrast, noise and counts per voxel (C_{voxel}) were obtained from the phantom images. 24 different reconstruction protocols (10 FBP and 14 OSEM) were used and compared.

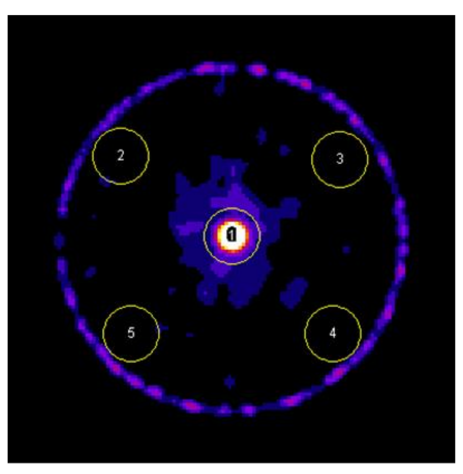
MODEL DESCRIPTION

Measurements

For each reconstruction parameters was fitted a 2D Gaussian function to create simulated data in order to explore the SPECT resolution (FWHM) . A square ROI was delineated on SPECT slice and the data collected to show the 2D plot of the experimental data. The figures below show a transaxial 2D profile from different reconstruction parameters.



For each reconstructed SPECT volume, contrast recovery coefficients, noise and activity per voxel (A_{voxel}) were calculated using the following equations:



$$Contrast\ (\%) = \left|\frac{C_p - \overline{C_b}}{C_p + \overline{C_b}}\right| \times 100$$

$$Noise\ (\%) = \frac{STD_b}{C_b} \times 100$$

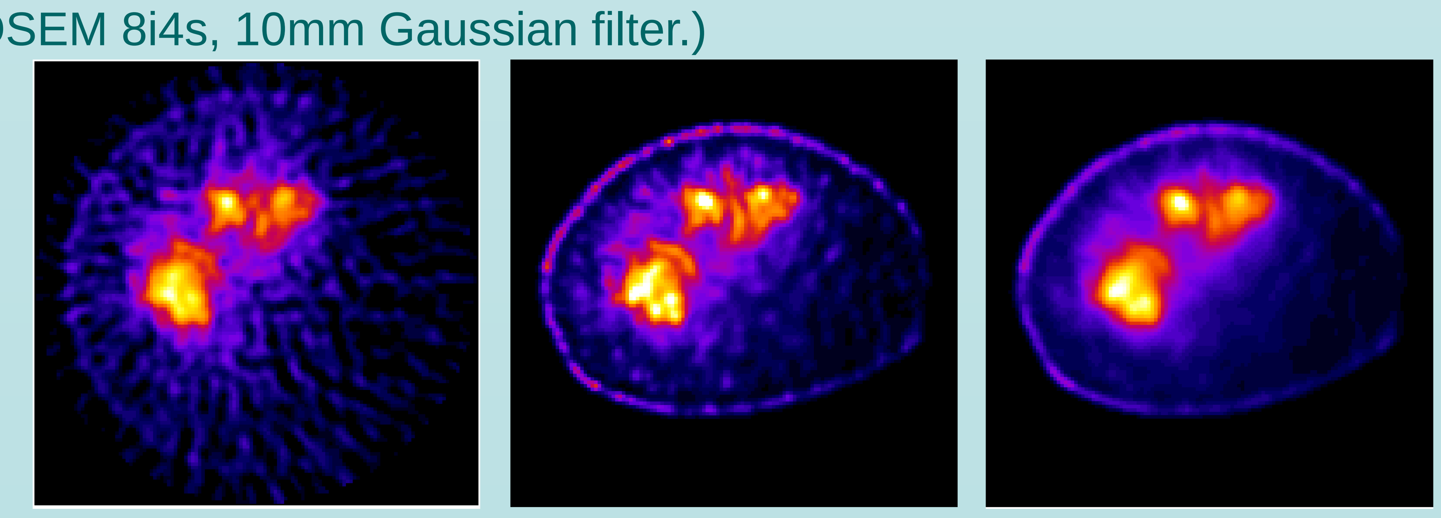
$$A_{voxel} = A_{total} \times \frac{C_{voxel}}{C_{total} + C_b}$$

RESULTS

Reconstruction parameters	$FWHM_x$ (mm)	$FWHM_y$ (mm)	Contrast (%)	Noise (%)	A_{voxel} (MBq)
FBP, btw, 0.2, 4	20.22	19.98	90.49	0.33	0.74
FBP, btw, 0.4, 5	13.34	12.89	88.96	0.49	1.20
FBP, btw, 0.4, 10	13.13	13,02	87.22	0.48	1.03
FBP, btw, 0.4, 20	12.58	13.45	86.89	0.50	1.04
FBP, btw, 0.5, 10	12.39	13.46	83.80	0.55	0.92
FBP, btw, 0.5, 20	12.39	13.46	83.52	0.55	0.91
FBP, btw, 0.6, 6	13.05	12.51	82.86	0.57	0.93
FBP, G Han, 0.5, 0.5	17.66	17.79	88.32	0,35	0.79
FBP, G Han, 0.5, 1.0	12.32	13.37	83.72	0.55	0.72
FBP, G Han, 1.0, 0.5	13.81	14.10	84.64	0.53	0.85
2D OSEM, 4i2s	14.45	13.90	89.62	0.26	1.45
2D OSEM, 8i4s	8.59	8.36	93.74	0.69	3.54
2D OSEM, 16i8s	5.81	5.98	92.91	1.53	5.62
2D OSEM, 4i2s, 6mm Gaussian filter	15.45	14.90	88.35	0.20	1.31
2D OSEM, 8i4s, 6mm Gaussian filter	9.15	9.10	93.02	0.55	3.04
2D OSEM, 16i8s, 6mm Gaussian filter	6.65	6.76	92.74	0.95	4.60
2D OSEM, 4i16s, 10mm Gaussian filter	9.05	9.10	91.10	0.48	2.83
2D OSEM, 5i8s, 10mm Gaussian filter	9.99	9.96	91.20	0.43	2.45
2D OSEM, 8i4s, 10mm Gaussian filter	10.22	10.34	91.40	0.42	2.33
2D OSEM, 10i16s, 10mm Gaussian filter	7.87	8.10	92.19	0.62	2.97
2D OSEM, 15i16s, 10mm Gaussian filter	7.53	1.98	91.30	0.61	3.57
2D OSEM, 4i2s, 12mm Gaussian filter	17.40	18.12	85.80	0.03	1.01
2D OSEM, 8i4s, 12mm Gaussian filter	11.25	12.08	91.45	0.42	2.03
2D OSEM, 16i8s, 12mm Gaussian filter	8.95	9.14	91.34	0.49	2.72

Table 1 – The results presented were obtained from Jaszczak phantom data.

The images below represent three examples of reconstruction applied to a clinical case (I – FBP, Btw, 0.4, 5; II – 2D OSEM 16i8s, 6mm Gaussian filter; III - 2D OSEM 8i4s, 10mm Gaussian filter.)



I II III

CONCLUSIONS

Although in the past FBP algorithms were thoroughly used as standard methods for SPECT reconstruction, nowadays, iterative methods can be used in an acceptable reconstruction time due to an increase in computer performance and, often, present better quantitative and qualitative results. Still, optimization is required to provide the best trade-off between noise/contrast and image resolution. Nevertheless, the availability of FBP reconstruction algorithms is still desirable due to the higher number of parameters (e.g. different filters).