Application of Radiotherapeutic Fixation Tools to Achieve Patient Setup Reproducibility during in vivo Gamma Spectrometry Investigation

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Introduction

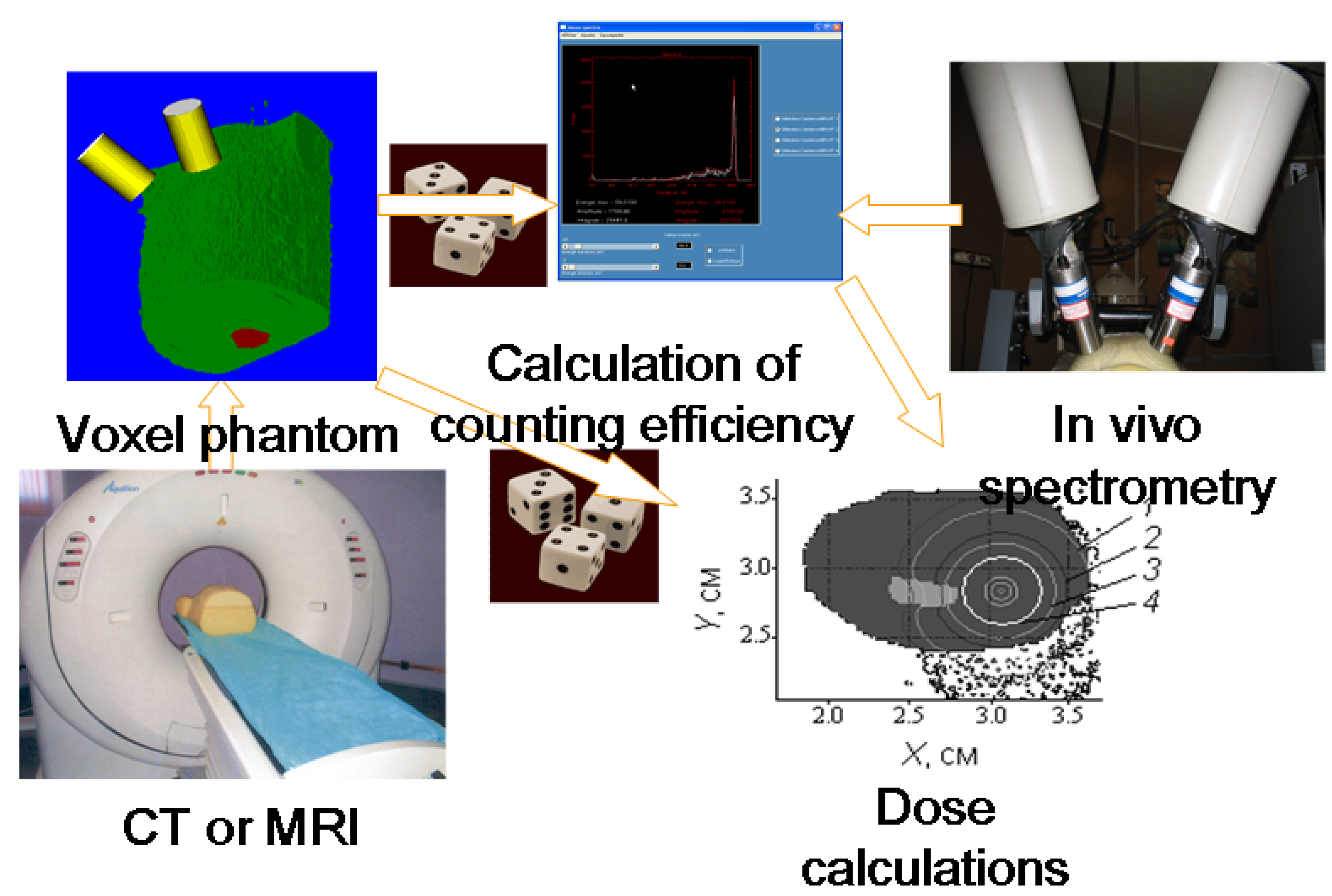
During the past two decades, individual voxel phantoms and radiation transport calculations were applied for the calibration of *in vivo* gamma spectrometers that, which are used to assess the radionuclide content in patients' organs and tissues. According to this approach, the counting rate of gamma spectrometers is recalculated in terms of radionuclide content using *in silico* simulation of gamma ray transport from inside the body of a patient into the sensitive volume of a detector, which is typically placed near the patient.However, voxel phantom calibration of *in vivo* gamma spectrometers is not free of numerous uncertain factors. One of the biggest uncertainty factor is related with unsatisfactory reproducibility of the patient setup from the CT scanner table (where the data for individual voxel phantom creation are obtained) to the table of the *in vivo* gamma spectrometer. The new approach to reduce the uncertainties is illustrated on the example of the project "Definition of principal parameters of the biokinetic model for actinide distribution during contamination through wound surfaces".

Methods: A mixture of three transuranium radionuclides (^{239}Pu + ^{241}Am + ^{237}Pu) was administered to the animals (four pigs). The use of ^{237}Pu privides an option of direct plutonium measurements including *in vivo* spectrometry, because of well detectable gamma rays of 100 keV, whereas direct *in vivo* measurements for ^{239}Pu are almost impossible due to low gamma ray that are emitted by this radionuclide. During two months of observation, the pigs were investigated using skull and liver with the germanium gamma ray detector Canberra-Packard. The detector was calibrated using the Monte Carlo (MCNP5) calculations in voxel phantom geometry retrieved using the software OEDIPE according to the MRI scans.

MRI scanner

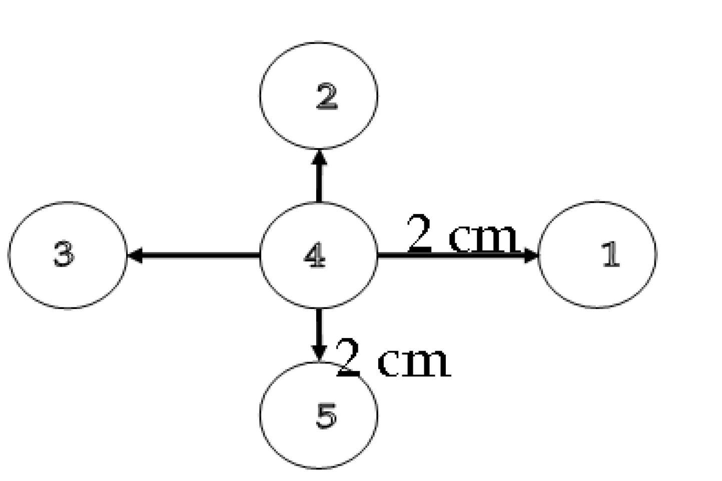
Whole body/organ counter

In vivo investigation of the pigs



OEDIPE, an MCNP-based software complex
for individualized *in vivo* spectrometry
(Borisov et al., Health Physics, 2002, v. 83, p. 272-289)

Results



Five detector positions for MCNP5 calculations. Counting efficiencies were averaged these positions, in order to estimate the influence of uncertainties of detector placement next to the organ

Detector position	Counting efficiency, counts for decayed nucleus, 10^{-3}			
	^{241}Am	ε,%	^{237}Pu	ε,%
1	0,32	7	0,64	10
2	0,29	8	0,59	3
3	0,34	9	0,70	10
4	0,30	5	0,59	6
5	0,34	8	0,72	6

Uncertainty for the ^{237}Pu and ^{241}Am activity assessment.

Time after administration	30 min	3 h
^{241}Am	13%	14%
^{237}Pu	17%	16%

Discussion

On the other hand, radiotherapy has accumulated much experience in obtaining patient's setup reproducibility. To achieve these goals, several fixation devices, such as thermoplastic masks and vacuum bags are used. These masks are typically shaped to fit the patient's face and (optionally) shoulders at the moment of diagnostic CT scans. The bags are filled with silica gel that hardens upon pumping the air our during the sirst setup of the patient.

We suggest the use of these masks to reduce uncertainties in the patient setup for *in vivo* gamma spectrometry. Calculated results for the examined pigs show that such devices can eliminate the bias of the radioactive actinide assessment in bones by tens of percents.