INVITED COMMUNICATION

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EARLY SOLUTIONS TILL THE DEVELOPMENT OF PET/IRM

U. Pietrzyk. *Research Center Juelich, University of Wuppertal, Germany*

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ORAL COMMUNICATIONS

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A NEW RESPIRATORY GATING DEVICE TO IMPROVE 4D PET/CT

C. Jaudet, D. Didierlaurent, F. Courbon, O. Caselles. *Institut Claudius Regaud, Service de Médecine Nucléaire, Toulouse, France, SIMAD, LU50, Université Paul Sabatier, Toulouse III, France*

Purpose: Respiratory motion creates artifacts in position emission tomography with computed tomography (PET/CT) images especially for lung tumors, and can alter diagnosis. To account for motion effects, respiratory gating techniques have been developed. However, the lack of measures strongly correlated with tumor motion limits their accuracy. The authors developed a real-time pneumotachograph device (SPI) allowing to sort PET and CT images depending on lung volumes.

Methods: The performance of this innovative respiratory tracking system was characterized and compared to a standard system. Our experimental setup consisted in a movable platform and a thorax phantom with six fillable spheres simulating lung tumors. The accuracy of SPI to detect inhalation peaks was also determined on volunteers. A comparison with the real-time position management (RPM) device, that relies on abdominal height measurement, was then investigated.

Results: Experiments showed a high accuracy of the measured signal compared to the input signal ($R = 0.88$ to 0.99), and of the detection of the inhalation peaks (error of 0.1 ± 5.8 ms) necessary for prospective binning mode. Activity recovery coefficient was improved (until +39%) and the smearing effect was reduced (until 2.74 times lower) with SPI compared to ungated PET/CT acquisition. The spatial distribution of activity in spheres was similar for 4D PET gated with SPI and RPM. Significant improvement of the binning stability and matching between PET and CT were highlighted for irregular breathing patterns with SPI.

Conclusions: SPI is an innovative device that provides better binning performance than the current gating device on phantom experiments. Future works will focus on patients where the authors expect a significant improvement of specificity and sensitivity of PET/CT examinations.

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INTEGRATION OF THE LUNG MOTION INTO 3D PHANTOMS

R. Laurent, P.-E. Leni, M. Salomon, J. Henriet, R. Gschwind. *Université de Franche-Comté, Equipe IRMA/LCPR-AC/Chrono-Environnement, UMR 6249 CNRS, Montbéliard, France, Université de Franche-Comté, Equipe AND/DISC/FEMTO-ST, Belfort, France*

Introduction: Currently, S factor computations in internal radiation therapy or TPS quality controls in external radiation therapy are only performed in 3D, i.e. without taking into account physiological or metabolic movements. That is why we propose to add a dimension representing time to the IRSN phantoms and thus enable these protocols in 4D.

Materials and methods: The NEMOSIS platform (based on an Artificial Neural Network – ANN) has already been presented and validated in previous works, which were dedicated to the customized simulation of internal lung motions. To adapt it to phantoms that were determined according to anthroporadiametric data, new entries (perimeter and height of a cylinder representing the lungs) were added to the ANN.

The IRSN phantoms (12 phantoms of heights varying between 165 and 185 cm) only account for the organ contours. To make NEMOSIS able to proceed these contours, we have elaborated an algorithm that automatically tracks the evolutions of the lung contours of each patient on every 4DCT.

After the learning step of the patient data, our platform is used to simulate the motion of phantoms.

Results: Thanks to this approach, 32,480 points were computed and added to our dataset, which is constituted of 16 patients over 10 respiratory phases.

The similarity index, calculated between the simulated volumes and 4D, is strictly greater than 0.94 and thus allow the validation of our approach applied to a test patient.

The motion of the phantoms computed by NEMOSIS is consistent and represents realistic variations according to the lung localization and phase. The hysteresis is also depicted, but measured variation of the lung volume for this phantom is of only 0.185 l.

Conclusion: Perspectives: Despite very promising results, the quality of the motion simulation can still be improved by taking into account the deformation of the diaphragm. However, our 4D simulation of the lung motion of phantoms can already be validated.

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3D PERSONALIZED MONTE CARLO DOSIMETRY FOR TREATMENT PLANNING IN 90Y-MICROSPHERES THERAPIES OF HEPATIC CANCERS

A. Petitguillaume, M. Bernardini, C. de Labriolle-Vaylet, D. Franck, A. Desbrée. *Laboratoire d'Evaluation de la Dose Interne (LEDI), Institut de Radioprotection et de Sûreté Nucléaire (IRSN), Fontenay-Aux-Roses, France, Service de Médecine Nucléaire, Hôpital Européen Georges Pompidou (HEGP), Paris, France, UPMC, Univ Paris 06 Biophysics et Service de Médecine Nucléaire, Hôpital Trousseau, Paris, France*

Introduction: For targeted radiation therapies, treatment planning is a real challenge. In fact, the activity that can be injected to the patient is limited by the dose to organs at risk (OARs) which has to be kept below the tolerance threshold. Therefore, a 3D dosimetric method (PMCD), based on Monte Carlo calculations, has been developed in order to personalize and optimize the activity prescription for Selective Internal Radiotherapy (SIRT) treatments.

Methods: The PMCD method was used with data from 10 patients treated for hepatic metastases. Using the OEDIPE software, regions of interest outlines, drawn on CT images, were used to create patient-specific voxel phantoms and 99mTc-MAA SPECT data were used to generate 3D-matrices of cumulated activity. The absorbed dose and biological effective dose (BED) were calculated at the voxel scale using the MCNPX Monte Carlo transport code and OEDIPE. The maximum injectable activity (MIA) was then calculated using