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WIDMApp (Wearable Individual Dose Monitoring Apparatus): an innovative approach for individual dose monitoring in Targeted Radionuclide Therapy

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In Targeted Radionuclide Therapy (TRT), radio tracers having specificity for the tumor to treat are administered to the patient in order to selectively damage diseased cells via the decay radiation of the isotope. However, given their systemic administration, these molecules not only concentrate on the tumor, but also diffuse to healthy tissues which thus receive an unavoidable dose of radiation.
A high level of personalization in TRT could bring advantages in terms of treatment effectiveness and toxicity reduction. Individual organ-level dosimetry is crucial to describe the radiopharmaceutical biodistribution expressed by the patient, to estimate absorbed doses to normal organs and target tissue(s).

A new approach for individual radioagent biokinetics determination is proposed with the Wearable Individual Dose Monitoring Apparatus (WIDMApp).
WIDMApp has been conceived as a multi-channel radiation detector associated with data processing system for in vivo patient measurement and collection of radiopharmaceutical biokinetic data (i.e., time-activity data) [1]. This system could provide an effective tool to characterize more accurately the radiopharmaceutical biokinetics in TRT patients, reducing the need of resources of nuclear medicine departments, such as technologist and scanner time, to perform individualized biokinetics studies.
A diagram of the WIDMApp paradigm is presented in Figure 1. The multi-channel detector system is composed by sensors that will be stably positioned within compartment of a wearable garment. Each sensor is placed to maximize its sensitivity to an organ of interest, even though it will generally detect radiations emanating from positions throughout the body as shown in Figure 1. The sensors can be used individually or grouped in any number to cover, as a unique subsystem, a wider area. Data are acquired at a fixed or variable sampling frequency during the entire MRT treatment and even continuously over 24 hours per day.

An experimental proof-of-principle of WIDMApp was realized using a NEMA phantom. A first prototype of the WIDMApp detecting element was developed based on a plastic scintillating crystal and silicon photomultiplier technology. It was used to detect the gamma radiation emitted from radionuclides with different decay time: 18F, 99mTc and 64Cu. Solution of these radionuclides with 54, 53 and 28 MBq respectively were injected in three spheres of the NEMA phantom to mimic organs with different time-activity trend - i.e. different radioagent biokinetics. The WIDMApp sensor was placed in three positions on the phantom surface, and used to measure the time evolution of the counts due to the gamma emitted by the three radionuclides. Data was collected over four days with a frequency of 24 minutes at each measurement point. The decay times of the three sources were estimated by fitting the data and were compared with the proper radionuclide decay constants.
The results obtained from this firse feasibility studies and from a Monte Carlo simulation of the system justify the development of an actual prototype system to characterize this technique under realistic clinical conditions.
In this contribution an overview of WIDMApp, as well as the first experimental feasibility study, are presented. Particular attention will be paid to the description of the brand-new multi-channel detector system design, the front-end electronics and its characterization.

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