

WD4.2 Deliverable: Report on extremity dose distribution from simulations and measurements: comparison of techniques.

The present report corresponds to the second deliverables of the WP4 (Extremity dosimetry in nuclear medicine) of the ORAMED (Optimization of Radiation Protection of Medical Staff) project. This report summarizes the results obtained on extremity dose distribution from the measurement campaign and from the simulations that have been performed.

Results obtained from the measurements

Within WP4 an extensive measurement program has been performed in various hospitals in Europe using the same measurement protocol to evaluate extremity doses and dose distributions across the hands of medical staff working in nuclear medicine departments.

700 measurements in nuclear medicine diagnostics and 155 in nuclear medicine therapy have been performed in 6 different European countries. Appendix 1 is the database of the results collected. All measurement partners have followed the same measurement protocol; therefore the results can be directly compared. All information about the measurements are included in the database: institute collecting the data, hospital identity, technician identity and experience, procedure realized, activity, radiation protection measures, dose obtained for every measuring point (11 per hand, 22 in total).

The evaluation of the results has been shared among all participants. The tasks that have been distributed are: preparation with Tc-99m, administration with Tc-99m, preparation with F-18, administration with F-18 and, finally, preparation and administration with Y-90. Since therapy procedures using Y-90 are more complex to analyze due to high dose gradients and high dose values, one single partner, with large experience in therapy procedures, has done the analysis for both preparation and administration with Y-90.

It has been required that, for diagnostics procedures, a worker performs at least 5 measurements for the same given procedure in order to quantify the intra-worker variability. For therapy, this requirement was not implemented since procedures are not as frequent as diagnostics procedures. Furthermore they are often not performed by the same person.

To extract the maximum information about all data acquired and to be able to compare results obtained for different radionuclides, every partner has to follow the same guidelines when performing the analysis. The guidelines give a detail description of the plots that have to be done and how the data should be treated (see appendix 2).

A multiparameter analysis to test the influence of various factors on the dose and dose distribution across the hand is still under study. Furthermore, uncertainties of all results are being evaluated. A combined analysis with results from measurements and simulations is ongoing to better explain all measurement results.

Results obtained from the simulations

To better understand the experimental data and to analyse the influence of protective devices such as syringe and vial shields, several Monte Carlo simulations have been performed. In particular, 9 typical scenarios have been selected as the most common manipulations performed by technicians when preparing and administering radiopharmaceuticals. These scenarios have been simulated by means of hand wax phantoms modelled in the positions of interest, scanned and introduced as the input geometry of the simulations.

The setting up of the different parameters when using Monte Carlo simulations can be very critical and can easily bias the results. Therefore, some preliminary dedicated studies were

done to determine the parameters to be used when launching the simulations. These have been summarized in dedicated guidelines. These guidelines need to be followed by all simulation partners (see appendix 3).

In order to verify the consistency between measurements and simulations, doses were measured by means of thermoluminescent dosimeters (TLD) in some of the selected scenarios, and also calculated by simulation with MCNPX code. The results of both measurements and simulations have been compared and used to prove the validity of the methodology followed to prepare MCNPX input files for the type of simulations needed. Taking into account the uncertainties in the methodology of the simulations, such as the errors in the position of the bodies, the individual ratios for each position and scenario are considered acceptable ⁽¹⁾. Hence, the methodology of the simulations as proposed to all partners of WP4 is considered good enough to be validated, and is being used in the calculations of the simulation work of WP4.

Numerical simulations have been performed for a set of combinations of the main parameters influencing extremity doses in nuclear medicine. The aim was to determine the effectiveness of different radiation protection measures and to quantify the variation of the dose due to geometrical variations as displacement of the source (vial or syringe), rotation...

Every simulation partner created a simulation plan for the scenario that he had been assigned to (see deliverable 1 for the scenarios chosen). The main parameters that have been studied in the simulation program by all partners are:

- Active volume of source
- Shielding thickness and material
- Rotation of the source
- Displacement of the source along its axis
- Displacement of the source perpendicular to its axis.

All results from the simulations have been compiled in a dedicated database. Consequently, all members are able to access and interpret the results of all other partners (see appendix 3).

Analogous to the measurement campaign, every partner has to follow the same guidelines when performing the analysis of the simulations data. The guidelines give a detail description of the plots that have to be done and how the data should be treated (see appendix 4).

Achievements

The measurement campaign and the simulation program have been successfully performed. The total amount of measurements and simulations that were described in the DOW are finished. All results are now available to all partners on dedicated databases to carry out a detailed analysis.

References

- (1) A Carnicer, M Ginjaume, L Donadille, M Fulop, S Krim, M Sans Merce, G Gualdrini, F Mariotti, M A Duch and F Vanhavere. Monte Carlo simulation of skin dose equivalent to the hand during 18FDG handling. Submitted to *Physics in Medicine and Biology* .