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Meeting Report | Dosimetry & Image Analysis

Precision in dosimetric analysis and generation of a benchmark dosimetry dataset - An IAEA study

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Abstract

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Introduction: Nuclear medicine dosimetry implementation varies depending on the clinical application, dosimetry protocol, software, and ultimately the operator. Assessing clinical dosimetry accuracy & precision in MRT is therefore a challenging task. This work illustrates some pitfalls encountered even during a very structured analysis, performed on a single patient dataset by various participants using one standard protocol and clinically approved (CE) software. The study required the development of specific dosimetry checkpoints and led to a comprehensive benchmark dataset that can be used by individuals to assess their expertise in MRT clinical dosimetry.

Methods: The clinical dataset was derived from the dosimetric study of a patient administered with Lutathera® at Tygerberg Hospital, South Africa, as a part of an IAEA-CRP E23005. SPECT/CT images were acquired at five time points post injection on a GE Infinia Hawkeye 4 (3/8" NaI crystal thickness and medium energy collimator). A calibration phantom was imaged using the same acquisition settings. Patient and calibration images were reconstructed on a HermesTM workstation, and a calibration factor of 122.6 Bq/cts was derived.

A standard dosimetric protocol was defined and PLANET® Dose (v3.1.1) from DOSIsoft SA was installed in nine participating centers to perform the dosimetric analysis of 3 (out of 4) treatment cycles on the reconstructed patient image dataset. The protocol included rigid image registration, segmentation (semi-manual for organs, activity threshold for tumors), dose point kernel convolution of activity followed by absorbed dose rates (ADR) integration to obtain the absorbed doses (AD). Iterations of the protocol were conducted with training and brainstorming sessions, to analyze dosimetric result variability. Intermediary checkpoints were developed to understand the sources of variation and to differentiate user error from legitimate user variability. Eventually, a 'real-time' clinical dosimetry session was conducted for one cycle at IAEA headquarters with 8 participants in order to reduce the sources of identifiable error.

Results: Initial dosimetric results (AD, ADR) for organs (liver & kidneys) and liver lesions showed considerable inter-operator variability (as high as 161%). This necessitated the generation of intermediate checkpoints like total counts, volumes, activity, but also activity-to-counts ratio, activity concentration (AC), and ADR/AC ratio to analyze most variable steps. For the 'real-time' analysis, absorbed doses for normal organs were within 5%, while for lesions, up to 25% variation was observed, mostly due to the choice of the fitting model. Volume differences across organs were reduced to 9.4% (except for right kidney with 14%) and among

lesions to 5%. Activity in organs and lesions varied by 10% (excluding 11.5% in right kidneys) and 4.2% respectively, whereas AC and ADR variations dropped below 5%.

Conclusions: Even in a simplified situation where the same patient dataset was analyzed using the same dosimetry procedure and software, significant disparities were observed in the results obtained. The results of the 'real-time' multi-centric dosimetry analysis were striking, with most variation sources identified as either error or permissible. Variations owing to human error may be minimized or avoided by performing intensive training sessions, establishing intermediate checkpoints, conducting sanity checks, and cross-validating results across physicists. This promotes the development of quality assurance in clinical dosimetry. This study produced a 'benchmark dataset' that includes expected dosimetry results for the considered dosimetry procedure and software that will be made available freely. The work should be extended to various dosimetry softwares. Simulated datasets should provide ground truth for accuracy assessment. This will allow individuals to train themselves and increase their proficiency in clinical dosimetry procedures.

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