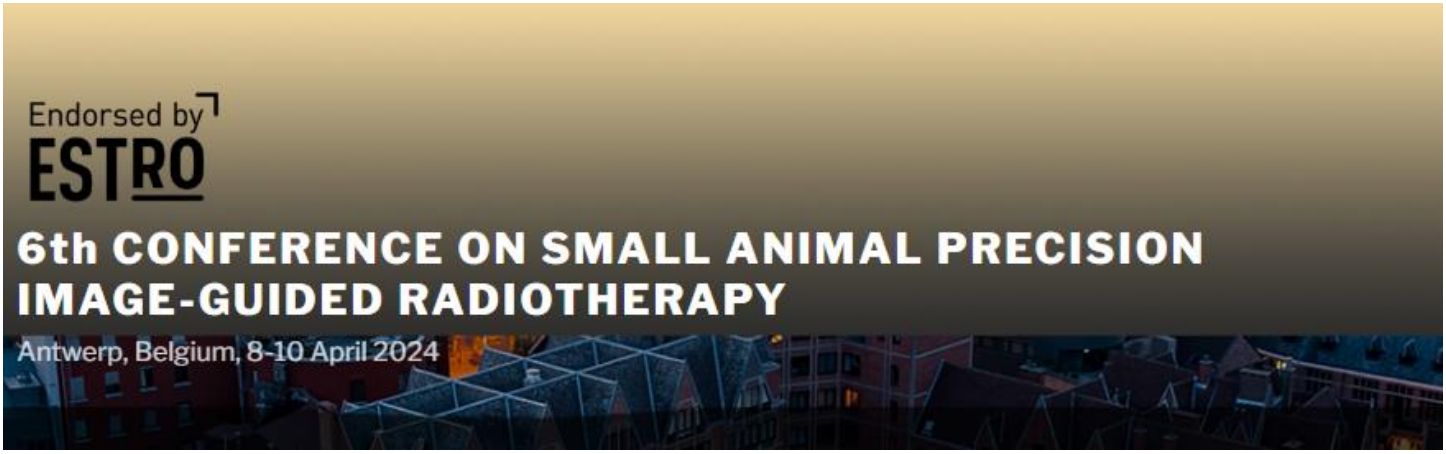

Development of End-to-End Preclinical Treatment Verification Procedures, Traceable to NPL Air Kerma Primary Standard

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Introduction

Modern preclinical radiobiology research involves a complex chain of events which mimic clinical workflows. As a consequence, there is an increasing awareness of the importance of standardising dosimetry procedures. Dosimetry End-to-End (E2E) tests are designed to determine whether the treatment process leads to the accurate delivery of dose to the intended volumes. These verification procedures play a fundamental role in the success of radiotherapy clinical trials. The development of similar tools for multicentre verification of preclinical radiation treatments would improve benchmarking of laboratories engaged in radiobiological research. Ultimately, this will facilitate a more effective intercomparison of experimental outcomes. We developed End-to-End dosimetry audits based on active and passive detectors with calibration directly traceable to the NPL Air Kerma Primary Standard.

Material&Methods

The first dosimetry audit, E2E_Scint, uses an anatomically correct 3D printed mouse phantom that accommodates the Hyperscint plastic scintillator at two different positions (head and abdomen). The scintillator was extensively characterized (linearity, energy dependence, etc.) and subsequently calibrated against a secondary standard ionization chamber-electrometer system. Measured dose

from image guided treatments with different level of complexity, delivered with SARRP, was compared to Muriplan calculated dose. The second developed dosimetry audit (E2E_Ala_Film) combines a 3D printed mouse phantom with alanine at two different positions and EBT3 Gafchromic film, allowing to obtain dose at local points, and 2D dose distributions. NPL alanine dosimetry system is a transfer standard for traceable reference dosimetry. Its energy dependence in medium energy x-rays was previously investigated. Experimental ratios of dose alanine/film were independently validated through Monte Carlo modelling. The system was tested at different beam qualities (Xstrahl 300) for the delivery of non-image-guided treatments.

Results.

The combined standard uncertainty (k=1) of the dose calibration process of the Hyperscint scintillator is 1.5%. The results of applying E2E_Scint over 26 treatment plans (including arcs/obliques-fields/direct/parallel-opposed), showed an average difference between the measured and the Muriplan calculated dose of 1.1%. The maximum difference was 3.3% for a brain plan combining oblique-fields with the 3 mm x 3 mm collimator. While testing E2E_Ala_Film for the verification of total body irradiation treatments to the mouse phantom, the average of the difference between the dose measured with film and alanine was -0.3%. The combined standard uncertainty (k=1) for the determination of the differences among irradiations with beam qualities between 0.5 and 3.5 mm was 3.2%.

Conclusions.

The combination of passive and active detectors with anatomically correct mouse phantoms are adequate for the development of End-to-End dosimetry audits for the independent verification of preclinical radiation treatments. The traceability of the detectors' calibration to primary standards strengthens the dosimetry chain in the validation of preclinical plans, and it is consistent with the current practice for dose traceability of clinical radiotherapy treatments. Dosimetry audits are an important tool to improve quality of reported results and to support standardization of preclinical radiation research. Their implementation at national and regional levels could lead to databases of anonymised records, which will positively impact the dissemination of best practices and sharing of validated results.

REFERENCE: https://easychair.org/smart-program/SmallAnimals2024/2024-04-09.html#talk:245530