UT Southwestern Medical Center
Radiation Oncology

A Fast Monte Carlo-based Dose Calculation Platform for Pre-clinical Total Body Irradiation Experiments

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INTRODUCTION

The accuracy of delivered radiation dose is critically important for preclinical radiobiology research studies. Current approach to calculate delivered dose in experiments using an x-ray irradiator is typically based on AAPM-TG61 formalism. However, studies have shown discrepancies between calculated and delivered dose due to lack of sufficient scatter in actual experiments caused by the small animal/phantom sizes. Aiming at achieving experiment-specific dose calculation and improving dosimetric accuracy, we have developed a MC-based dose calculation platform to accurate estimate dose distribution and organ doses for each specific total body irradiation (TBI) experiment conducted on an XRad 320 irradiator (Precision X-ray Inc., North Branford, CT).

METHOD

- We considered the TBI setup for the commercial small animal irradiator XRad 320.
- Animal phantoms were generated based on an openly available Digimouse phantom and user specified animal weight used in experiment.
- A GPU-based fast MC dose engine was employed to ensure computation efficiency.
- The in-air dose calibration for MC simulation was performed to get the absolute organ dose.
- To further validate the simulation dose, we mimic the common radiological experimental scenarios with a mouse radentomorphic phantom.
- A user friendly interface was developed in C++, together with Qt.

RESULTS

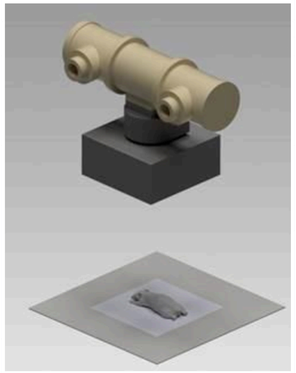

Figure 1. Configuration for radiobiology experimental

Fig. 1, Fig. 2 , Fig. 3 and Fig. 4 show the TBI configuration, rat phantom, dose distribution, user interface, respectively. Tab. 1 show the main organ dose.

- For a rat of 24.8 gram in weight, the average dose rate for heart, lung, brain and kidney were 1.02Gy/min, 1.02Gy/min, 1.178Gy/min, 1.267Gy/min, respectively.
- In a test case with a 28.4 gram rat case, the calculated dose rate to body center was 1.015 Gy/min, in agreement with the actual measured dose rate 1.070 Gy/min.
- The computation time to reach 1% uncertainty was 2.5 seconds using one GPU card.

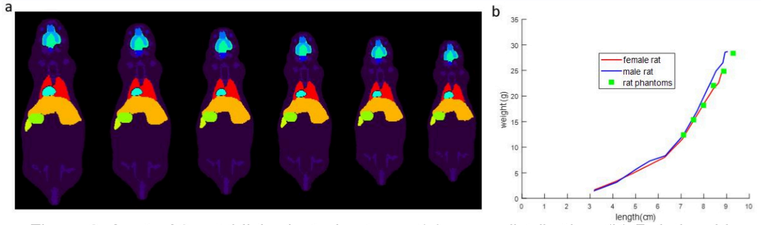

Figure 2. A set of 6 established rat phantoms: (a) organ distribution, (b) Relationship between length and weight

Table 1. *Main organ dose (Gy/min) for six rats with different weight and size*

phantoms name	rat1	rat2	rat3	rat4	rat5	rat6
length(cm)/weight(g)	7.11/12.38	7.55/15.34	7.99/18.18	8.42/22.06	8.88/24.85	9.29/28.35
brain	1.190	1.189	1.184	1.182	1.178	1.178
heart	1.047	1.038	1.033	1.027	1.020	1.015
bladder	0.973	0.963	0.955	0.955	0.943	0.932
stomach	1.206	1.203	1.202	1.198	1.197	1.198
pancreas	1.244	1.244	1.237	1.235	1.239	1.242
liver	1.096	1.091	1.086	1.081	1.075	1.070
kidneys	1.267	1.266	1.268	1.268	1.267	1.265
Adrenal glands	1.238	1.251	1.242	1.253	1.247	1.262
lungs	1.040	1.036	1.030	1.027	1.020	1.016

RESULTS

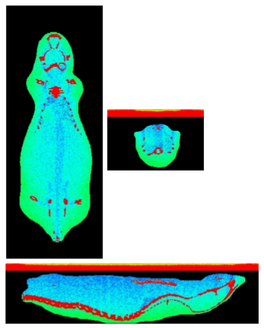

Figure 3. Dose distribution for Digimouse phantom atlas

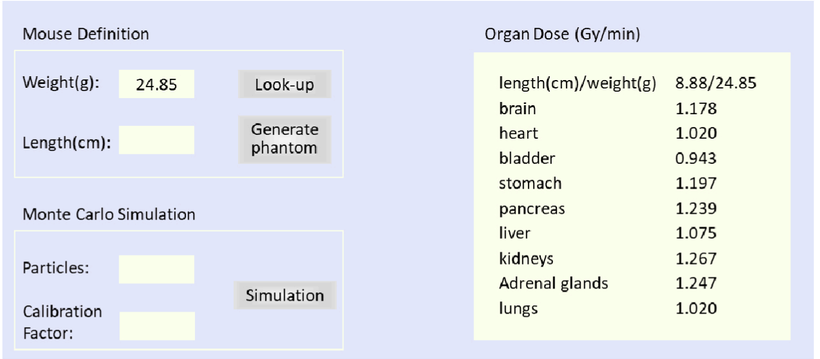

Figure 4. User interface for organ dose calculation of rat phantom

CONCLUSION

We developed a fast case-specific dose calculation platform for pre-clinical radiobiology experiments in the TBI setting, which will facilitate accurate dosimetry of these experiments. A user-friendly interface was developed to help users intuitively configuring the setup and conducting the computation.

CONTACT INFORMATION

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