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Implementation of Single Alpha-Particle Traversal Microdosimetric Model

Background:
Radiotherapy is one of the commonly used approaches to treat cancer. Current research trend and breakthroughs in radiotherapy are focusing on high linear energy transfer (LET) radiation such as alpha particles. Targeted Alpha Therapy (TAT) is the most important application of alpha particles in the development of radiotherapy in the past decade. This paper highlights the research work done on computational modelling of TAT at Canadian Nuclear Laboratories (CNL).

Methods:
• Develop a single-event, computational alpha-particle traversal microdosimetric model based on commercial spreadsheet developed by Roseke [1] using Monte Carlo method.
• Modify the single event alpha-particle traversal microdosimetric model to calculate the energy deposited within the cellular nucleus with known location of alpha particle (provided by the CFD simulation), and
• Integrate the single event alpha-particle traversal microdosimetric model and CFD model to calculate the energy deposited on cellular nucleus of an alpha particle in blood flow.

Results:
A coupled model based on the Monte Carlo micro-dosimetry technique and Computational Fluid Dynamics analysis was established. Transient drug delivery process and background dose to the cells along the pathway were investigated. A mesoscale numerical simulation in a simplified 2D capillary was performed to determine the transient toxicity of the Alpha-Immuno-Conjugate to the targeted cell.

Conclusions:
The paper demonstrates the feasibility of coupling CFD simulations and microdosimetic modeling to evaluate the efficacy of the TAT methodology realistically and accurately.

Reference:
[1] John C Roeske and Mark Hoggarth, "Alpha-particle Monte Carlo simulation for microdosimetric calculations using a commercial spreadsheet", Phys. Med. Biol. 52 (2007) 1909–1922.

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