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Numerical Simulation and Optimization of Radiotherapy Cancer Treatments Using the Caputo Fractional Derivative

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Abstract

This paper presents an improved numerical simulation and optimization of radiotherapy cancer treatments. The model used was obtained by integrating the Caputo fractional derivative and the linear-quadratic with the repopulation model into the previous radiotherapy cancer treatment model. Taking advantage of the existing model factors and parameters, especially the clinical data of six cancer patients treated with radiotherapy, the resulting model equations were simulated in MATLAB. The Caputo fractional derivatives were evaluated by using the fractional differential equation code (FDE12.m). The biologically effective dose formula was used to obtain six regression equations that were used for determining the appropriate fractional-order for each radiation protocol. Thereafter, the simulations were done in four cases. First, the fractionated doses of six patients were varied from 1.0 Gy to 6.0 Gy. Secondly, the fractionated doses were also varied from 1.0 Gy and 6.0 Gy but with 20 fractions. Thirdly, the doses of the six patients were unaltered but the number of fractions was varied from 25 to 35 fractions. Finally, a single regression equation was used to simulate the six patients' cancer treatment. The simulations had minimal errors and it was concluded that the simulated results are better predictions of the different radiation protocols.

Keywords: Radiotherapy; caputo fractional derivative; radiation protocols; optimal cancer treatment.