To apply the treatment plan to clinic, beam delivery efficiency should also be considered. In the future, the plan delivery time will be evaluated with the features of carbon ion synchrotron beam extraction time structure. Further, it will be explored to improve the delivery efficiency of carbon ion arc radiotherapy in the treatment plan optimization.

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5 - 72 Sensitivity Study of the Logistic Nanodosimetry Model for Carbon Ion Radiotherapy

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With the development of ion beam radiotherapy, nanodosimetry is considered a more suitable tool for track structure description. In logistic nanodosimetry model, the coefficient parameters in the linear-quadratic(LQ) relation of cell survival curve are derived as follows [1]:

$$\alpha = \frac{\rho V}{wM_1} F_2 P\left(M_1^{C2}\right) - \frac{\rho V P_{S-l}}{wM_1}\left[1 - F_2 P\left(M_1^{C2}\right)\right] + \frac{\rho V P_{S-l}}{wM_1}\left[1 - F_2 P\left(M_1^{C2}\right)\right]^2, \tag{1}$$

$$\beta = \frac{\rho^2 V^2 P_{S-l}}{w^2 {M_1}^2}\left[1 - F_2 P\left(M_1^{C2}\right)\right]^2, \tag{2}$$

where,

$$P\left(M_1^{C2}\right) = \frac{k}{1 + \exp\left(-r\left(\left(M_1^{C2} - m_0\right)\right)\right.} \tag{3}$$

Therefore, this model introduces four free parameters: P_{s-1}, r, m_0, k.

Sensitivity analysis of model parameters is a necessary work for a model to move from proposal to clinical practice. To study the parameter sensitivity of the model, $\alpha\beta$ values were recalculated by varying the parameters separately by $\pm\{5, 25, 50\}\%$ of the nominal values[2]. This work is based on the parameters of HSG cells in normoxic state, which are 2.0×10^{-11}, 3.602, 3.296 and 9.3×10^{-5} for P_{S-1}, r, m_0, k, respectively. Nanodosimetric quantities were obtained with condensed-history Monte Carlo simulation (Gate) and the pre-calculated nanodosimetric database[3] at the depth of 0, 24, 52, 83, 86, 87, 92, 100 mm of a carbon-ion pencil beam with initial energy of 200 MeV/u.

Figure 1 shows the variation of $\alpha\beta$ values at different depths. As shown in Fig. 1, β is proportional to P_{S-l}, but the changes of other parameters have no effect on β or can be negligible (not shown). As for α, it is proportional to k, the effect ofP_{S-l} can be negligible. The effect of variations in r m_0 on α exhibits different behavior at different depths. The reason for this is P_{S-l} and k are very small. So, equation 1 and 2 can be simplified as the following equations.

$$\alpha = \frac{\rho V}{wM_1} F_2 P\left(M_1^{C2}\right), \tag{4}$$

$$\beta = \frac{\rho^2 V^2 P_{S-l}}{w^2 {M_1}^2}. \tag{5}$$

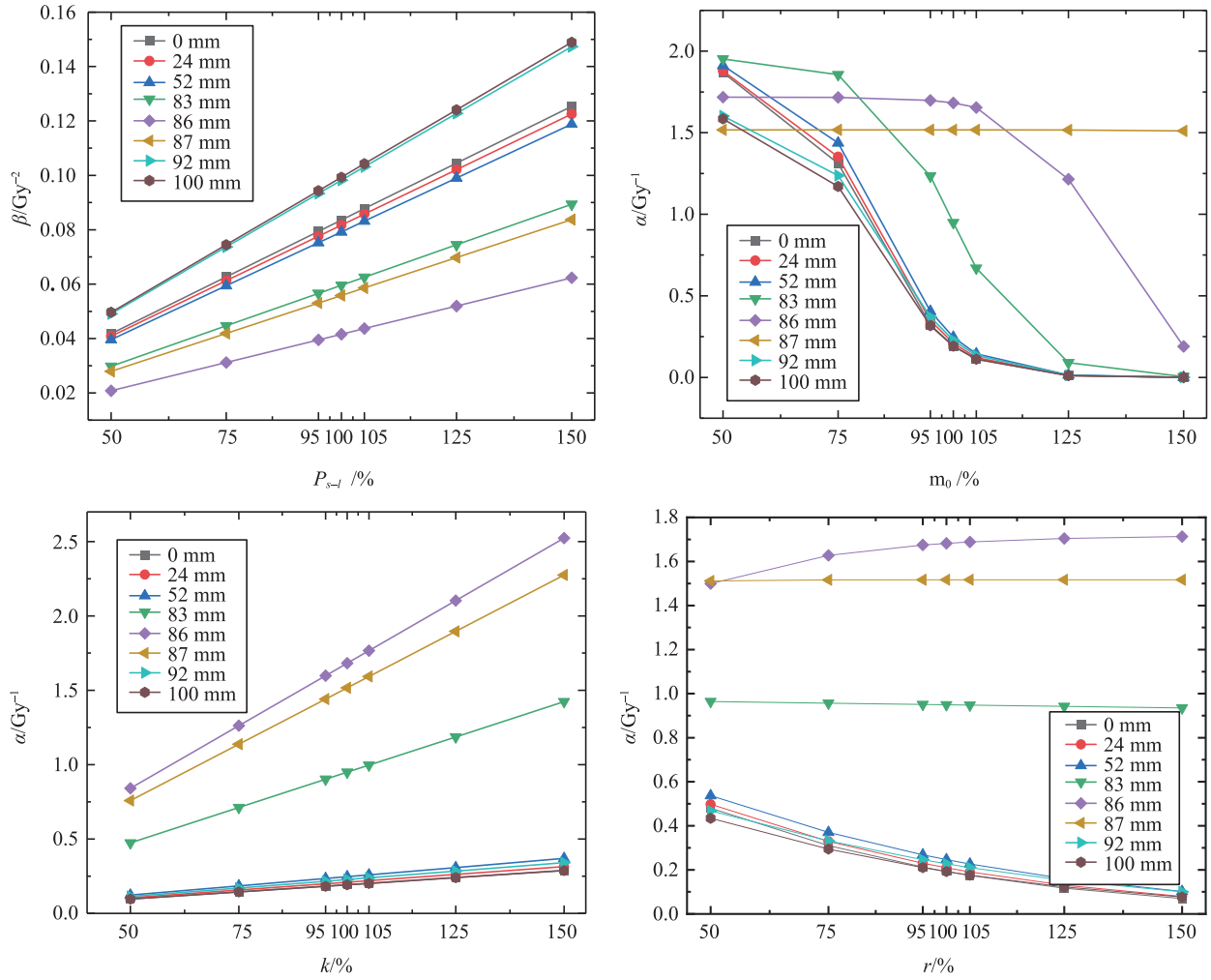

Fig. 1 (color online) α and β values calculated by the logistic nanodosimetric model at different depths of carbon ion beam with initial energy of 200 MeV/u by varying the parameters separately by ±{5, 25, 50}% of the nominal values.

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