Purpose:

The repair rate conventionally assumed to be constant during the entire radiation course. However, increasing evidences from animal studies show that the repair process may slow down with time and the experimental data does not fit an exponential pattern. To address this enigma, we presented a generalized linear-quadratic (gLQ) model incorporating reciprocal time repair pattern of sublethal damage and fit the model to published experimental data.

Methods:

In the gLQ model, the parameter G in the surviving fraction represents the repair process of sublethal damage with Tr as the repair half-time. When a reciprocal time pattern of repair process was adopted, a generalized form of G was derived analytically for arbitrary radiation schemes \( I(t) = I_i, t_{i-1} < t < t_i, \) where \( i=1 \) to \( N, \) \( I_i \) is the dose rate of the \( i \)th segment to the voxel in question, and \( N \) is the total number of segments for the entire treatment course). The published animal data was used to test the reciprocal formulas.

Results:

The gLQ model incorporating a reciprocal time pattern to describe the repair process was used to fit the experimental data. The reciprocal model showed better fit to the animal data than the exponential model, particularly for the ED50 data, resulting in the following parameters: the reduced chi-square of 1.52, \( a/\beta=0.9 \) Gy, \( Tr=1.0 \) h for the reciprocal model and reduced chi-square of 3.39, \( a/\beta=1.6 \) Gy, \( Tr=3.5 \) h for the exponential model.

Conclusions:

The modeling results suggest that the gLQ model incorporating the reciprocal time pattern of sublethal damage repair facilitates the interpretation of complex experimental designs, especially for irregular dose delivery schedules. These formulas can be used to analyze experimental and clinical data, where a slowing-down of the repair process occurs during the radiation therapy course.