# A practical approach of organ specific biologically effective dose calculation for Re-irradiation

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## Purpose

Toxicity of organs at risk (OAR) is a great concern for re-irradiation of cancer patients in a region irradiated previously. Biologically effective dose (BED) is needed to consider the effects of different fractionations and gap between the two irradiations in order to create composite dose distributions. Purpose of this study is to develop a practical method for treatment planning of re-irradiation based on organ-specific BED to consider the fact that different OAR may respond to radiation differently.

## Methods and Materials

A linear-quadratic-linear model (LQ-L) considering tissue repair was used to fit published cell survival data of 12 OARs to extract organ-specific BED parameters (e.g., α, β and dt). BED in the LQ-L model is calculated as follows

$$BED = nd\left(1+\frac{d}{\alpha/\beta}\right) \qquad d < d_t$$

$$BED = nd_t\left(1+\frac{d_t}{\alpha/\beta}\right)+n(1+\frac{2d_t}{\alpha/\beta})(d-d_t) \qquad d > d_t$$

The MIM software was used to host these parameters and to calculate BED in each voxel inside an OAR using the organ-specific parameters for both irradiations. The planning images of the first treatment were then registered to the second treatment images using a contour-based deformable image registration algorithm (DIR) in MIM. The composite 3D BED map is obtained by adding the BEDs of the first treatment after warping to the second images to the BEDs of the second treatment. The entire process was implemented in an MIM workflow and demonstrated by generating clinic composite plans for re-irradiations. The summed BEDs can then be converted back to physical doses at a given number of fraction for plan evaluation.

## Conclusion

A practical method to consider organ-specific BED for re-irradiation planning was developed in MIM. The approach would improve composite dose generation and treatment planning for re-irradiation, such as SBRT following an initial conventional RT.

## Results

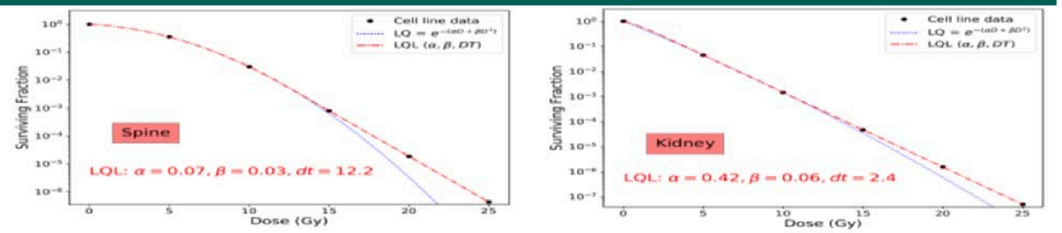


Fig. 1: Example of fitting cell survival data using the LQ-L model to extract model parameters for spine (left panel) and kidney (right panel). The fitting results using the LQ model are also given.

Fig.2: Build-in LQ-L model in MIM with organ-specific model parameters (left panel) for OARs and contour-based deformable registration (right panel), where contours of OARs can be selected to guide the deformable image registration for the dose summation..

Tab.1: The model parameters for each OAR, dose constraints and achieved composite BEDs and physical doses (the last two columns) for a sample patient. The composite physical doses were calculated from the composite BEDs for 28 fx. The physical dose (D) constraints are listed for 28fx. The first radiation therapy was delivered in 28 fx to 50.4 Gy for pancreatic cancer and the second radiation therapy was delivered 2 years later to 45 Gy in 5 fx for liver mets.

| OARs | | | D (Gy) | d (Gy) | dt (Gy) | α/β (Gy) | composite BED (Gy) | Composite Dose (Gy) in 28fx |
|---|---|---|---|---|---|---|---|---|
| SpinalCord | Dmax | < | 43.00 | 1.54 | 12.16 | 2.54 | 49.93 | 33.83 |
| Kidney_L | Mean | < | 18.00 | 0.64 | 2.40 | 7.60 | 17 | 15.82 |
| Kidney_R | mean | < | 18.00 | 0.64 | 2.40 | 7.60 | 18.2 | 16.86 |
| SmallBowel | Dmax | < | 53.00 | 1.89 | 21.54 | 17.90 | 58.72 | 53.10 |
| Stomach | Dmax | < | 53.00 | 1.89 | 21.54 | 17.90 | 57.27 | 51.90 |
| Dudenum | Dmax | < | 53.00 | 1.89 | 21.54 | 17.90 | 59.52 | 53.75 |
| Liver | mean | < | 28.00 | 1.00 | 6.00 | 3.00 | 7.12 | 6.60 |