“A Generalized Concept of Equivalent Uniform Dose”.

Dose distributions are inherently non-uniform, especially for normal structures. Although IMRT is capable of delivering superior dose distributions tailored to the geometry of irradiated structures; it often produces inhomogeneous target dose distributions. To quantitatively evaluate a treatment plan one needs to know the consequences of dose inhomogeneity for all structures of interest. A concept of Equivalent Uniform Dose (EUD) for tumors, based on models of clonogen survival, has recently been developed and investigated in several clinical settings. Here we report on generalization of the EUD concept that applies to both tumors and normal tissues. Based on the analysis of outcomes for several clinical studies providing volumetric information for tumors and normal organs we propose that EUD for a structure of interest be estimated as:

$EUD=\left(\frac{1}{N}\sum_{i=1}^{N} D_i{}^{a}\right)^{\frac{1}{a}}$ or, using a differential dose-volume histogram $EUD=\left(\sum_{i=1}^{N} n_i D_i{}^{a}\right)^{\frac{1}{a}}$,

where $\{v_i, D_i\}$ are bins of the histogram and “a” is a tissue-specific parameter. It is easy to see that EUD is bounded by the minimum and by the maximum dose, and is equal to the mean dose for “a” equal to one. The parameter “a” is negative for all tumors and it is positive for all normal structures. We estimated the maximum likelihood values of the parameter “a” for several tumors and normal structures and they range from –13.1 for local control of chordoma tumors to 17.7 for perforation of esophagus. We will discuss the rationale for this generalized EUD concept and we will discuss the estimates of the parameter “a” for several important structures and end-points.