AbstractID: 7926 Title: A Radiobiological Model for the Relative Biological Effectiveness of High Dose Rate Cf-252 Brachytherapy

A radiobiological model was developed to determine dependence of ^{252}Cf neutron relative biological effectiveness (RBE) on a variety of radiobiological parameters. The purpose for developing this model was to advance our current program towards treating patients with high dose rate ^{252}Cf brachytherapy. Since this type of radiation has dose and dose rate dependencies that significantly differ from low-LET radiation, it is necessary to supplement existing animal experiments and clinical results with a sound radiobiological model. Parameters used in this model include both neutron and photon alpha and beta ratios, and neutron and photon doses and dose rates. We used the LQ-model, and equated total equivalent dose as $D_{T\text{-}EQ} = RBE_\gamma D_\gamma + RBE_N D_N$ with gamma- and neutron-components. While the proportion of gamma:neutron dose varies as a function of distance from the source and as a function of the material, we can start off with $D_\gamma = ½ D_N$ for clinical applications. This leads to: $D_{T-EQ} = D_\gamma + \frac{D_N}{2}$. Since RBE is the ratio of doses needed to achieve a given biologic effect, we define the effect as identical cell survival: $S_\gamma = S_N \Rightarrow e^{-n(\alpha_\gamma D_\gamma + \beta_\gamma D_\gamma^2)} = e^{-n(\alpha_N D_N + \beta_N D_N^2)}$ which can be simplified, $\alpha_\gamma D_\gamma + \beta_\gamma D_\gamma^2 = \alpha_N D_N + \beta_N D_N^2$, and rearranged to give $\beta_\gamma D_\gamma^2 + \alpha_\gamma D_\gamma - \left(\alpha_N D_N + \beta_N D_N^2\right) = 0$. Applying the quadratic equation ($ax^2+bx+c=0$), the total equivalent dose may now be expressed as a function of neutron dose with high- and low-LET radiobiological parameters, $D_{T-EQ} = \frac{\sqrt{\alpha_\gamma^2 + 4\beta_N\left(\alpha_N D_N + \beta_N D_N^2\right)} - \alpha_\gamma}{2\beta_\gamma} + \frac{D_N}{2}$, which permits direct derivation of the neutron RBE: $RBE_N = \frac{\sqrt{\alpha_\gamma^2 + 4\beta_N\left(\alpha_N D_N + \beta_N D_N^2\right)} - \alpha_\gamma}{2\beta_\gamma D_N}$. Using α_γ=0.21, β_γ=0.0.35, α_N=0.71, β_N=0.078, and D_N=1.5 Gy established from pre-clinical HDR^{252}Cf studies and teletherapy neutron sources, an RBE_N of ~ 3 was obtained.