

Theme: **Clinical / Biology**

Abstract No.: **PTCOG-AO2025-ABS-0127**

Abstract Title: **Tissue-Specific Biological Responses in Carbon Ion Radiotherapy (CIRT) Based on the Particle Irradiation Data Ensemble (PIDE) Database**

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Backgrounds / Aims:

- CIRT has relied on a fixed RBE model based on the human salivary gland (HSG) cell line.
- To investigate the inter-tissue variability in radiobiological responses leveraging PIDE.

Subjects and Methods:

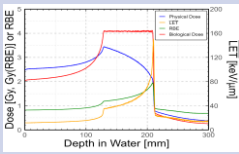
LQ Parameter Fitting

- Extracted C-ion irradiation data for 13 human tissue groups from the PIDE.
- Empirically fitted α and β as a function of LET for each tissue.

$$\alpha(\text{Gy}^{-1}) \text{ or } \beta(\text{Gy}^{-2}) = \frac{a+b \cdot \text{LET}}{1+c \cdot \text{LET}+d \cdot \text{LET}^2} \quad (\text{LET in keV}/\mu\text{m})$$

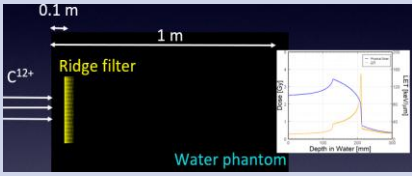
SOBP Design

Ridge filter based on the fitted parameters of the HSG cell line



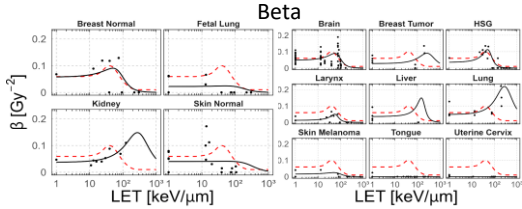
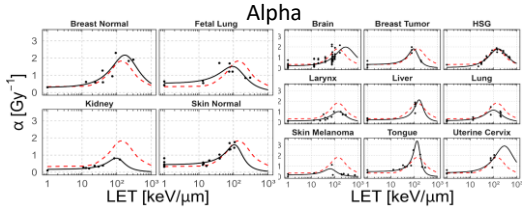
Tissue-Specific Simulation

Applied identical SOBP beam to all tissue models

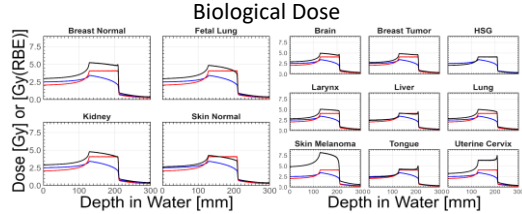
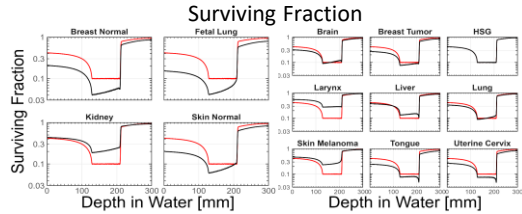


Results:

- LQ Parameter Fitting** (● : PIDE data, — : Empirical fitting, - - - : NIRS RBE model (HSG))

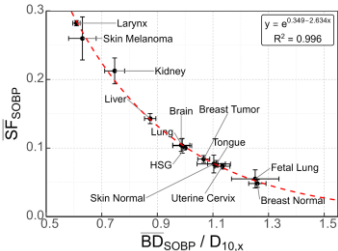


- Tissue-Specific Simulation** (— : Physical dose of SOBP, — : Each tissue, — : HSG)



- Biological dose deviated by -20% to +30% from the HSG reference across most tissue, except for skin melanoma and uterine cervix.

Framework for Dose Adjustment



- Clear exponential correlation between two metrics:
 - $\overline{BD}_{SOBP} / D_{10,x}$: Ratio of the delivered mean biological dose to the target photon reference dose
 - $\overline{SF}_{SOBP}$: Mean surviving fraction across the SOBP
- This relationship allows for the estimation of dose adjustments required to achieve a uniform biological outcome.