Heavy Ion Therapy Research Integration

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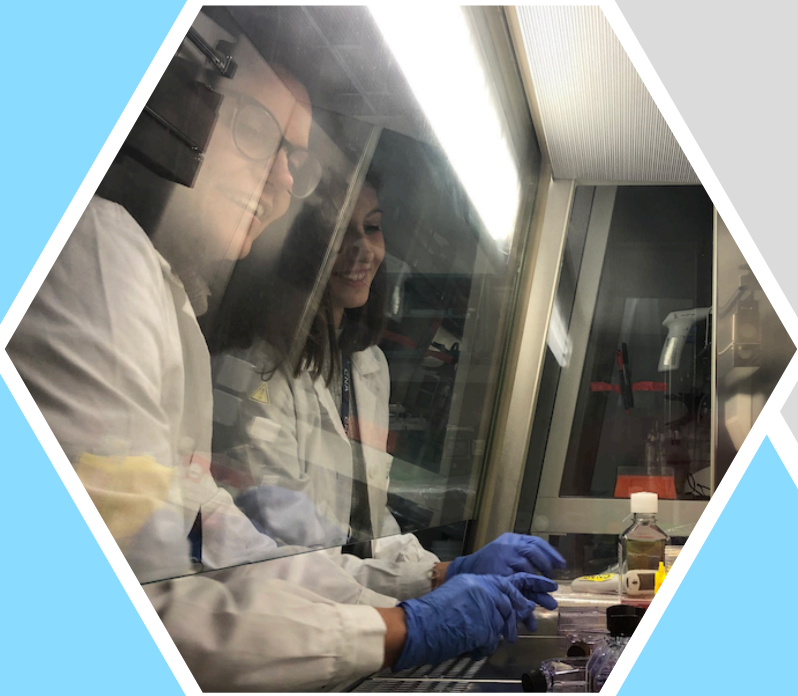
STANDARDISATION OF RADIOBIOLOGICAL EXPERIMENTS

LEVERAGING DECADES OF EXPERIENCE TO HARMONISE ION-THERAPY TREATMENTS FOR ENHANCED PRECISION, EFFICACY AND SAFETY

ILLUMINATING VARIATIONS IN BEAM QUALITY BY EXPLORING HOW CELL SURVIVAL RATES DIVERGE ACROSS CENTRES UNDER IDENTICAL DOSES



DESCRIPTION

Protocols for a standardised radiobiological experiment were set in the INSPIRE project, which established a comparable radiobiological dosimetry for proton beam irradiation.

These protocols were then used in the framework of HITRI*plus* for a series of irradiations with carbon-ion beams , performed at the research and ion therapy centres CNAO, MIT, MedAustron, GSI and HIT.

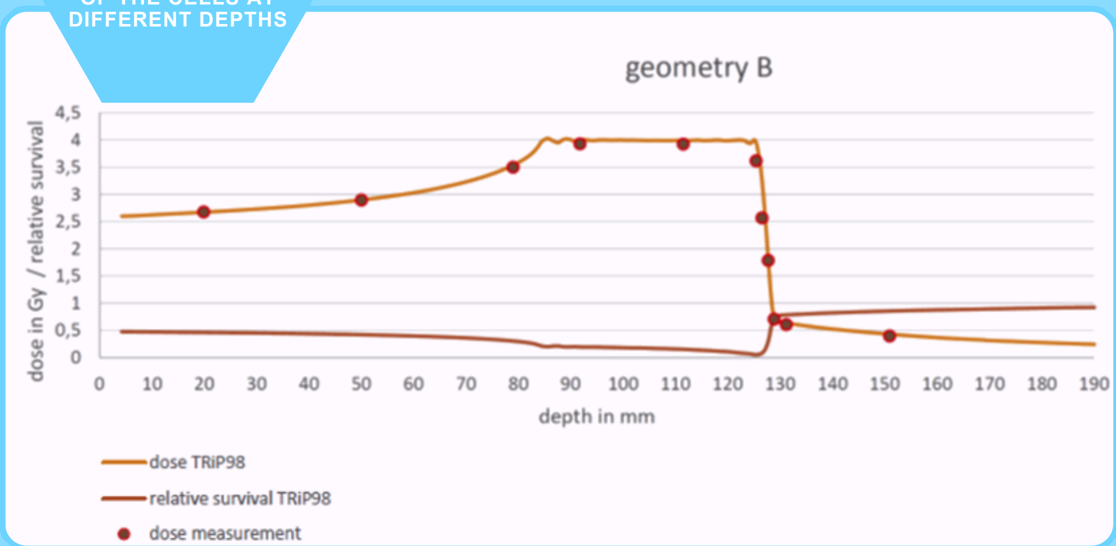
A survey was used to establish a standard operating procedure, followed by distributing protocols and treatment planning parameters at the different centres.

A COMMON CELL LINE (V79) WAS USED FOR THE EXPERIMENTS, ALONG WITH A SHARED PHANTOM PROVIDED BY GSI.

The experiment’s results could then be used to investigate the cell survival curves and calculate radiobiological effectiveness, while also comparing cell survival when applying an identical dose, thus revealing differences in beam quality between the ion therapy centres.

Hypoxic conditions and oxygen environments could also be evaluated.

DEPTH DOSE DISTRIBUTION AND EXPECTED SURVIVAL OF THE CELLS AT DIFFERENT DEPTHS



After completion, a biological database for treatment planning systems was compiled, focusing on carbon ions and the specific cell line. Despite being limited to the specific cell-line, the results are invaluable for discerning differences between carbon-ion centres and testing the validity of local models predicting relative biological effectiveness. The primary aim is to address uncertainties in local models, fostering advancements in ion-therapy practices.

CHALLENGE

In carbon-ion and proton irradiation, measuring physical dose as energy deposition presents a formidable challenge in clinical routines.
This challenge is exacerbated by the inherent variability in beam qualities, often resulting in diverse biological outcomes.

Understanding the intricate relationship between physical dose, clinical measurements, and biological outcomes is crucial yet complex. While existing models aim to estimate biological effectiveness, they rely on elusive factors that are difficult to measure accurately.

Measurements are typically conducted once during accelerator setup and then applied to models for estimating biological effectiveness. However, for carbon ions, accurately modelling relative biological effectiveness requires depth-dependent spectral fluences of secondary particles, such as alpha particles, simulated using Monte-Carlo codes.

The use of different models across carbon ion centres introduces variability in results, stemming from differences in application methods and particle spectra.
This discrepancy creates an unknown clinical uncertainty that remains to be fully characterized.

SOLUTION

The radiobiological experiment showcases the differing biological effects of a standardised physical dose across five distinct centres.

As it characterises the effectiveness of local models in ion therapy, it can be used to reduce uncertainty and improve precision for treatment, in established and next generation ion therapy centres.

VALUE

The activities enable comparison of biological differences in treatments across centres, clarifying clinical uncertainty in model usage.

Key parameters of beam quality influencing biological effect become apparent, enhancing treatment precision.

Assessment of beam scattering methods uncovers which techniques are more straightforward for deriving the biological effectiveness which could be particularly beneficial for centres using passive scattering.

Results improve comparability of treatment modalities, standardizing procedures and creating a shared database for enhanced collaboration.