Experimental study of Radiation induced DNA damage by internal Auger electron cascade compared to external -rays

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and, if needed, a new plan was re-optimized adaptively. Set up was verified with gated orthogonal X rays and non-gated cone beam CT in treatment room. Threshold for gate-on signal was initially set at 10% pressure signal dynamic and qualitatively adjusted in an asymmetric way according to results of plan recalculations in 30% expiration and inspiration. Gating signal was fed to the accelerator to enable beam delivery. Each slice was re-scanned 5 times to smear out possible interplay effects. Acute and early toxicity was scored according to CTCAE 4.0 scale.

Results: GTV and diaphragm excursion between end expiration and adjacent 30% phases was reduced to less than 5 mm. GTV (D95%) and critical OAR (D1%) DVH in 30% inspiration and expiration phases showed on average minimal (less than 3%) differences as compared to planning end expiration plan. Toxicity was minimal with no G3 event; 15% acute G2 and 10% G2 toxicity at 3 months was observed.

Median follow up was rather short (3 months) nevertheless in 23 patients the dose limiting OAR was either stomach or small bowel or esophagus, therefore early toxicity data are informative.

Conclusion: Active scanning with carbon ion beams for the treatment of moving target using abdominal compression, 4D simulation, robust planning gating and rescanning is feasible and safe. Longer follow up is needed to evaluate oncological outcome.

Keywords: organ motion, active scanning

86 Carbon ion radiotherapy: do we understand each other?

How to compare different RBE-weighted dose systems in the clinical setting?

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In carbon ion radiotherapy (CIRT), mainly two calculation models are adopted to define relative biological effectiveness (RBE)-weighted doses (D_{RBE}): the Japanese Kanai model and the Local Effect Model (LEM). Taken the Japanese longest-term clinical data as a reference, the use of a different RBE model, with no correction for the Gy (RBE) scale, leads to deviations in target absorbed dose (D_{abs}) with no correction for the Gy (RBE) delivered at NIRS were exported in DICOM format, for comparison between simulated and measured pristine and position, size and composition. Validation went through code, according to design information about elements imported in a LEM-based commercial TPS where plans were optimized prescribing the non-converted and converted D_{RBE} systems, confirming D_{RBE} prescription dose values.

Purpose: The aim of this study is to compare the radiation induced DNA damage by internal Auger electron cascade compared to external γ-rays.

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Material/Methods: In order to compare the radiation effects by the Auger emitter to that of external γ-rays we need to be able to estimate the dose delivered. As Auger cascade electrons have a very short range the precise spatial distribution of the decays is of high importance.

We are currently working with two Auger emitters, Cs-131 and La-135. First experiments have been performed using HeLa cells, which were incubated with either Cs-131 or La-
135 for internal exposure. Theses ions seem to be taken up by the cells. However more knowledge about the bio-kinetics of these auger emitters is needed to estimate the dose rates and the dose distribution in the cell. As the cells take up the Auger emitter, the dose rate by the internal Auger decays are continuously changing as a function of cellular accumulation and half-life of the isotope.

Uptake curves are therefore produced by incubating HeLa cells with Auger-electron emitters for various amounts of time and with different levels of radioactivity to calculate the changing dose rate and accumulated dose. These conditions will be mimicked as closely as possible with external γ-rays, by moving the cells closer to the source (Cs-137). DNA damage will be assessed by flow cytometry measurements (MUSE) of phosphorylated histone H2AX (γH2AX) and/or the clonogenic cell survival assay.

Keywords: Auger, RBE, Internal Radiotherapy

References:

Fig1: Deformed 2D dose distribution at the Bragg peak area for a 250MeV proton beam in a 3T field

Conclusion: Beam deflections in magnetic fields could be described by a numerical algorithm. The observed change in dose distribution in the Bragg-peak region has to be taken into account in future dose calculations. However, local dose changes due to boundary effects seem to be negligible for clinical applications. Current work in progress deals with the inclusion of magnetic field effects in a dose calculation algorithm for particles.

Keywords: particle therapy, Monte Carlo, Magnetic Resonance Imaging

References:
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The Biology of Single Dose Radiotherapy
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The mechanism of tumor cure by ionizing radiation is regarded tumor cell autonomous, effected by misrepair of radiation-induced DNA double strand breaks (DSBs), to a large extent via the function of error prone non-homologous end joining (NHEJ). This model prevails at the low dose range, with cure depending on tumor phenotypic propensity for NHEJ misrepair, and requires repeated exposures for tumor ablation. Here we report high (>10Gy) single dose radiotherapy (SDRT) employs an alternative dual target model, inducing in addition to DSBs also an early wave of acid sphingomyelinase (ASMase)-mediated microcirculatory ischemia/reperfusion (I/R) injury. Reactive oxygen species (ROS) induced therein in parenchymal tumor cells disrupt activation of homology-directed repair (HDR), leading to catastrophic reprogramming of DSB repair. We show Ku- and 53BP1-mediated NHEJ are not affected, although MDC1/53BP1 resolution is delayed, while engagement of the HDR mediator cluster in DSB repair is aborted, promoting a divergent DSB repair pathway, generation of massive chromosomal alteration and reproductive tumor clonogen demise. Scavenging of ROS with the SOD-mimetic tempol reversed the loss-of-function HDR and tumor cell lethality, aborting tumor cure by SDRT. We define I/R-mediated loss-of-function HDR as the detrimental SDRT damage response.