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Assessing the Interplay Effect Based on a Precise Machine-Specific Delivery Sequence and Time for Cyclotron Accelerator Proton Therapy System.

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Purpose: To assess acute GI and GU toxicities of IMPT targeting prostate/seminal vesicles and pelvic lymph nodes for prostate cancer

Methods: A prospective study (ClinicalTrials.gov: NCT02874014) evaluating moderately hypo-fractionated IMPT for high-risk (HR) or unfavorable intermediate-risk (UIR) prostate cancer accrued 56 patients. Prostate/seminal vesicles and pelvic lymph nodes were treated simultaneously with 6750 and 4500 cGy RBE, respectively, in 25 daily fractions. All received androgen deprivation therapy. Acute GI and GU toxicities were prospectively assessed, using 7 GI and 9 GU categories of CTCAEv.4, at baseline, weekly during radiotherapy, and 3-month post-radiotherapy. Fisher exact tests were used for comparisons of categorical data.

Results: Median age: 75 years. Median follow-up: 25 months. 55 patients (52: HR; 3: UIR) were available for acute toxicity assessment. 62% and 2% experienced acute grade 1 and 2 GI toxicity, respectively. 65% and 35% had acute grade 1 and 2 GU toxicity, respectively. None had acute grade $\geq$ 3 GI or GU toxicity. The presence of baseline GI and GU symptoms was associated with a greater likelihood of experiencing acute GI and GU toxicity, respectively (Table 1 and 2). Of 45 patients with baseline GU symptoms, 44% experienced acute grade 2 GU toxicity, compared to only 10% among 10 with no baseline GU symptoms (p=0.07). Although acute grade 1 and 2 GI and GU toxicities were common during radiotherapy, most resolved at 3 months post-radiotherapy.

Conclusions: A moderately hypo-fractionated regimen of IMPT targeting prostate/seminal vesicles and pelvic lymph nodes yielded very acceptable acute GI and GU toxicity.

Physics 2: Delivery Technics including FLASH and Spot-Scanning Proton Arc (SPARC)

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Assessing the interplay effect based on a precise machine-specific delivery sequence and time for cyclotron accelerator proton therapy system

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Purpose: We proposed an experimental approach to build a precise machine-specific model for standard, volumetric, and layer repainting delivery based on a cyclotron accelerator system. Then, we assessed the interplay effect using a 4D mobile lung target phantom compared to a generic delivery sequence model from West German Proton Therapy Essen (WPE).

Methods: The machine delivery log files, from an IBA ProteusPLUS® system, were retrospectively analyzed to quantitatively model energy layer switching time, spot switching time, and spot drill time for standard and volumetric repainting delivery. To quantitatively evaluate the interplay effect, a series of digital thoracic 4DCT image sets were used. The interplay effect was assessed based on the 4D dynamic dose accumulation method. Different delivery technique such as standard delivery (n=1), volumetric repainting delivery (n=2,3,4) and layer repainting delivery (n=2,3,5,25) were simulated based on the machine-specific delivery sequence model and WPE model.

Results: The results showed that the WPE model's spot delivery sequence deviated from the log file significantly compared to the machine-specific model. Based on the treatment delivery calculation of a lung treatment plan with target size (65 mm^3) and layer repainting 25 times (n=25), the difference is about 21.01%. Such a difference also resulted in different interplay effects estimation between the two models even though both institutions used the same proton system from IBA and calculated using the same 4DCT imaging set.

Conclusion: A precise machine-specific delivery sequence is highly recommended to ensure an accurate estimation of mobile target treatment's interplay effect.