Evaluation of the interplay effects in IMPT of patients with early stage NSCLC

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Objective

Proton therapy has been proposed for lung cancer. However, interplay effect may degrade plan quality. The purpose of this study to evaluate the interplay effect quantitatively and to reduce the interplay effect using 4D robust optimization and layer repainting.

Methods and Materials

The study was approved by the local ethics committee. 5 patients with NSCLC IA/IB selected retrospectively. Three groups of IMPT plans were created for each patient: 3D robust plans on average CTs to ITV(3D Robust), 4D robust plans on 4D CTs to CTV(4D Robust) and 4D robust with a series of layers repainting(4D Robust Repainting). All plans with same beam angles and beam numbers. Regular fractionation (60Gy[RBE] in 30 fractions) were considered and 3D Robust plans were normalized to have the same ITV D95% as 4D Robust plan for fair comparison. Interplay effect can be quantified as the dose difference between 4D dynamic dose(4DD) and 4D static dose(4DS) in ITV coverage (D95%, HI, CI) as well as normal Lung (V_{20}), The formulation as follows : Interplay effect = (4DS-4DD)/4DS. The process of 4D Robust plans and interplay evaluation as showed from Fig.1.

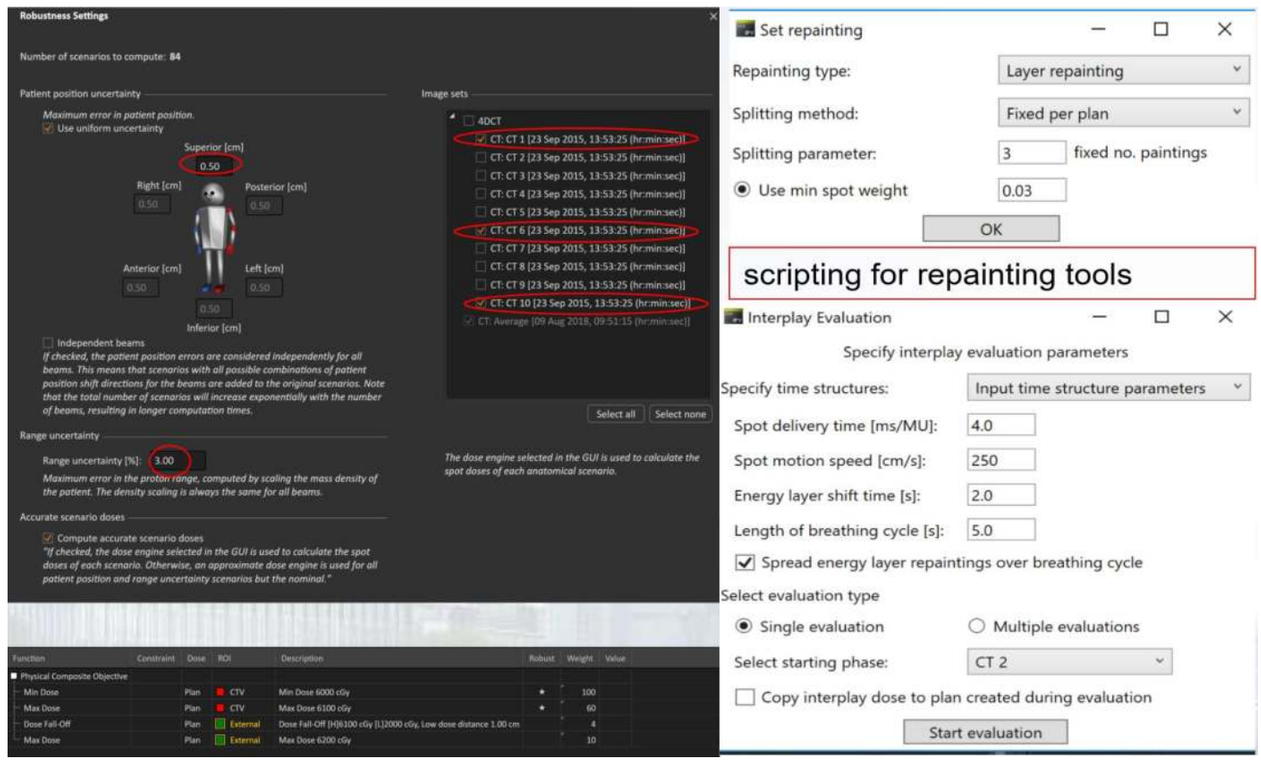

Fig.1 3D Robust plans had been extended to 4D Robust plans by incorporating the 4D CT images from parts of breathing phase. A scripting for repainting tool developed by RaySearch staff was used to get layer repainting plans. Another scripting for interplay evaluation was used to calculate the 4DD for all plans.

Results

In terms of tumor coverage, 4D Robust plans could reduced interplay compared to 3D Robust plans. The interplay could be further reduced after 4D robust with optimal layers repainting (Fig.2). In regards to Lung V_{20}, 4D robust plans may not necessarily reduce interplay within the lung compared to 3D robustly optimized plans, as show from Fig.3.

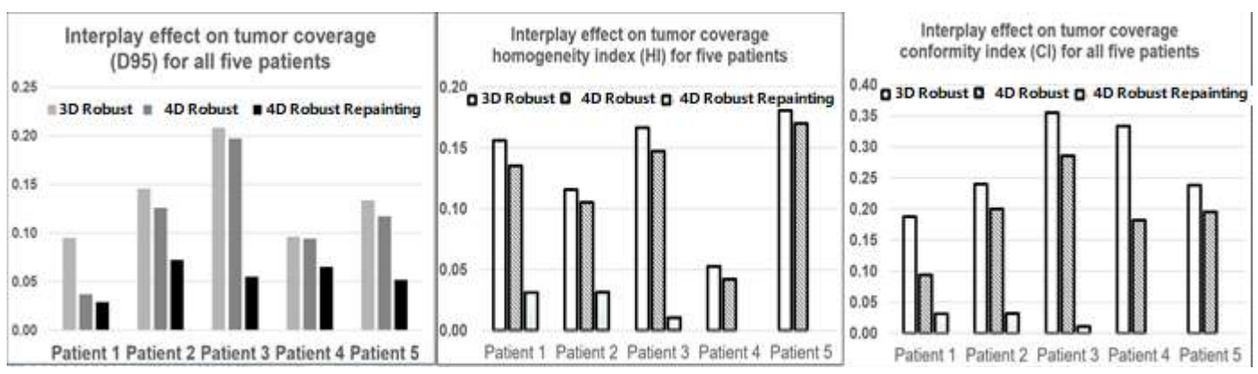

Fig.2 Comparison of 5 patients' ITV coverage (D95%, HI, CI) of the interplay effects in 3D Robust、4D Robust and 4D Robust repainting plans. 4D robust optimization produced significantly more interplay-effect resistant plans for targets, which can be further reduced by layer repainting based on 4D robust optimization.

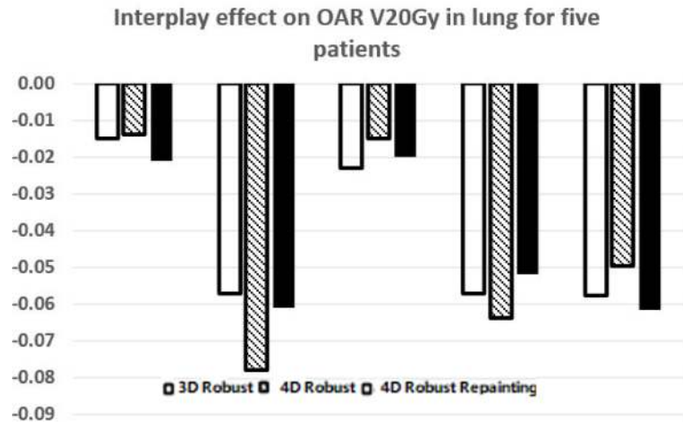

Fig.3 The normal lung tissue V_{20} with interplay effects considered was not obviously changed for all patients by 4D robust optimization or layer repainting technique.

Conclusions

Interplay effect on the tumor coverage had been reduced using 4D robust optimization and layer-repainting technique. The optimal number of layer repainting has clinical potential to mitigate the interplay effect of tumor coverage for IMPT.

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