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

Shang Haijiao 1,2, Pu Yuehu 1,2, Chenbin Liu1, Wang Yuenan 4

1. Shanghai Institute of Applied Physics, Chinese Academy of Sciences, 201800, Shanghai, China.
2. University of Chinese Academy of Sciences, 100049, Beijing, China.
3. Mayo Clinic Arizona, 85054, Phoenix, USA.
4. Chinese Academy of medical Science (CAMS) Shenzhen Cancer Hospital, 518000, Shenzhen, China.

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 robustly optimized plans on average CTs to ITV, 4D robustly optimized plans on 4D CTs to CTV and 4D robustly optimized plans with a series of layers repainting. All plans with same beam angles and beam numbers. Regular fractionation (60Gy[RBE] in 30 fractions) were considered and 3D robustly optimized plan was normalized to have the same ITV D95% as the 4D robustly optimized 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 (V20). The formulation as follows: Interplay effect = (4DS-4DD)/4DS. Fig. 1 shows the process of 4D robustly optimized plans and interplay evaluation.

Results

In terms of tumor coverage, 4D robustly optimized plans can reduced interplay compared to 3D robustly optimized plans. After the optimal number layers of repainting, the interplay can be further reduced as show from Fig. 2. In regards to Lung V20, 4D robustly optimized plans may not necessarily reduce interplay within the lung compared to 3D robustly optimized plans, as show from Fig. 3.

Conclusions

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

Fig. 1 3D robustly optimized plans had been extended to 4D robustly Optimized plans by incorporating the 4D CT images from parts of breathing phase. A scripting for repainting tools developed by RaySearch staff was used to get a series of layers plan. Another scripting for interplay evaluation was used to calculate the 4D dynamic dose for all plans.

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 V20 with interplay effects considered was not obviously changed for all patients by 4D robust optimization or layer repainting technique.

Copyright © 2019 Haijiao Shang, shanghaijiao@sinap.ac.cn