Purpose: To implement and evaluate a functional mean dose-based objective in a well-established IMRT system, using lung perfusion images and direct machine parameter optimization (DMPO).

Methods: Nineteen patients underwent SPECT perfusion imaging prior to treatment. In this retrospective study, plans were generated using Pinnacle³ DMPO (Philips Healthcare, Andover, MA) with the aim of minimizing either the mean lung dose (MLD) or the lung functional mean dose (FMD). A seven equidistant beam configuration was used in all plans. Two levels of dose were prescribed: 50 Gy to the PTV1 (clinical target volume with margins) and 66 Gy to the PTV2 (gross tumor volume with margins). The MLD or FMD objective was decreased by steps of 1 Gy until dose to target volumes or organs at risk was deemed unacceptable. Plans were compared in terms of dose-volume and dose-function parameters. Statistical significance was assessed with a Wilcoxon matched pairs test.

Results: While keeping PTV coverage similar (volumes receiving 93% of the prescribed dose were all over 98%), differences in MLD between both types of plans for a given patient ranged from -1.0 to +1.5 Gy ($p = 0.2050$), while FMD decreased significantly with a range of -2.1 to 0.0 Gy ($p = 0.0003$). The net improvement (FMD difference - MLD difference) ranged between -2.2 and 0.0 Gy. Dose to other organs at risk were similar and below widely-accepted tolerances.

Conclusions: The use of SPECT perfusion images in conjunction with DMPO allowed a significant decrease of FMD while keeping dose to other structures at an acceptable level. Functionality-aware dose redistribution could prove useful for dose escalation to improve tumor control with similar or lower lung complication probabilities. The approach can also be easily ported to arc therapy treatment planning using SmartArc.

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