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HyperSight Slow-Scan CBCT Supports Reliable Target Delineation and Dosimetric Improvement in Online Lung Adaptive Radiotherapy

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INTRODUCTION

Online adaptive lung radiotherapy has not been widely reported due to challenges in respiratory motion management and reliable ITV delineation on on-couch imaging. This work demonstrates the feasibility of daily online lung adaptive radiotherapy using slow-scan CBCT to capture tumor motion and support adaptive planning. By enabling daily online adaptive hypofractionated or stereotactic lung radiotherapy, this approach has potential to reduce dose to critical thoracic organs-at-risk, including the proximal bronchial tree, great vessels, aorta, and brachial plexus. Dose reduction to these structures has the potential to decrease clinically relevant toxicities such as bronchial injury, esophagitis, and brachial plexopathy, while maintaining target coverage.

METHODS AND MATERIALS

A retrospective analysis was performed on six patients treated with daily online adaptive lung SBRT using the CBCT-based Ethos platform. Two patients received 60 Gy in 8 fractions and four received 50 Gy in 5 fractions. A planning structure was created to boost the ITV center to 120% of the prescription.

ITV volumes contoured on slow-scan CBCT were compared with 4DCT maximum intensity projection to assess equivalence in target motion representation. Inter-physician contouring variability was evaluated by comparing primary and covering physician contours.

For dose calculation validation, treated adaptive plans were recalculated on slow-scan CBCT and simulation CT and evaluated using gamma analysis (3%/2 mm, 10% threshold). Dosimetric benefits were assessed by comparing target and organ-at-risk (OAR) dose metrics between adaptive and non-adaptive plans.

RESULTS

The mean ITV volume difference between slow-scan CBCT and 4DCT was 0.7 ± 0.94 cc. Inclusion of covering physician contours increased the difference to 3.3 ± 2.61 cc. Dose comparison resulted in a mean gamma passing rate of 98.9%, with all cases exceeding 97%. Across patients, adaptive planning was associated with reductions in maximum OAR dose (D0.03cc) relative to non-adaptive plans.

All patients treated with daily online adaptive radiotherapy demonstrated dosimetric improvement, with summary statistics shown in Figure 1. **Observed reductions included up to 23% for the proximal bronchial tree, 5.8% for the aorta, and 6.2% for the great vessels (Figure 2).** For a patient with a target adjacent to the brachial plexus, a 22% reduction in D0.03cc was observed. Target coverage increased by 4–8%. Adaptive plans met OAR constraints, whereas corresponding non-adaptive plans failed.

DISCUSSION

Respiratory motion has limited online adaptive lung SBRT. The close ITV agreement between slow-scan CBCT and 4DCT supports reliable treatment-day target delineation, while the larger variation among physicians highlights the need for standardized contouring. High gamma agreement supports CBCT-based dose calculation. Adaptive planning improved target coverage and reduced critical OAR dose, suggesting the greatest benefit for central or high-risk tumors near dose-limiting structures.

CONCLUSIONS

HyperSight slow-scan enables reliable ITV delineation, dose calculation, and dosimetric improvements in online adaptive lung SBRT.

Figure 1. Comparison of adaptive and non-adaptive plans across six hypofractionated or stereotactic lung adaptive patients. (a) PTV coverage (%) and (b) organ-at-risk (OAR) dose per fraction (D0.03cc, cGy) are shown as box plots for each patient. Adaptive plans (gray, hatched) are compared with corresponding non-adaptive plans (white). The OARs shown include proximal bronchial tree (PBT), great vessels, aorta, and brachial plexus, depending on tumor location. Boxes indicate interquartile range, center lines denote medians, and whiskers represent the data range.

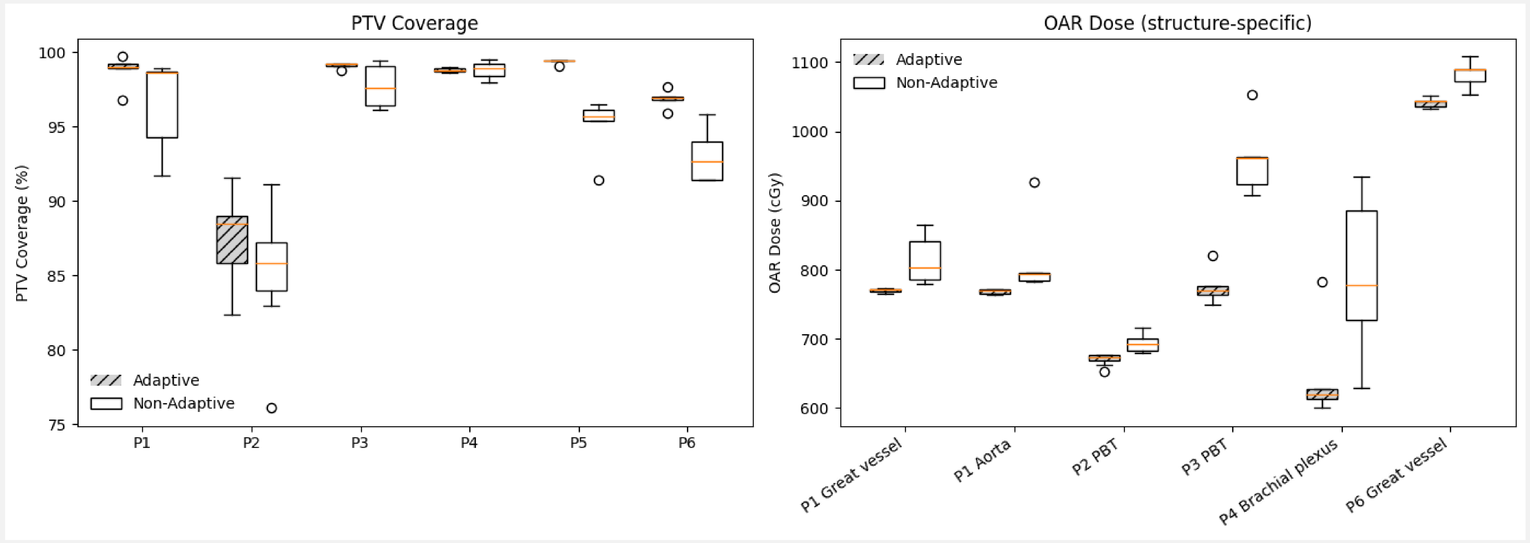
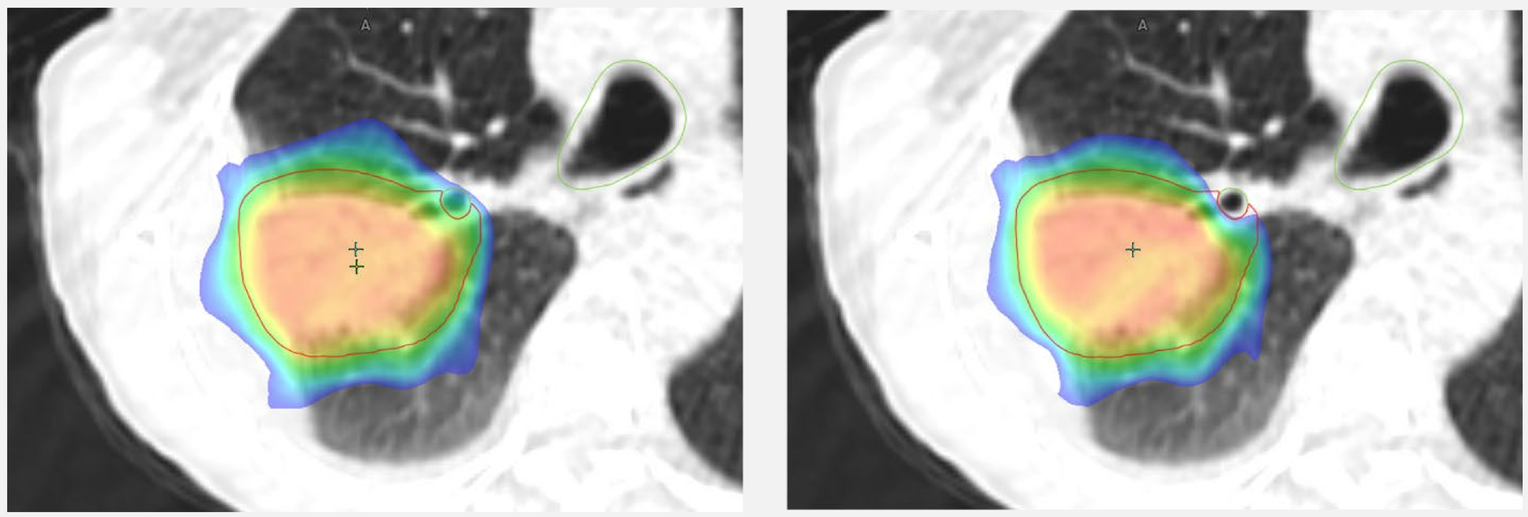


Figure 2. Representative axial dose distribution for an 8 Gy fraction illustrating proximal bronchial tree (PBT) sparing with online adaptive planning. The non-adaptive plan (left) shows the 8 Gy isodose encompassing the PBT, resulting in a maximum dose (D0.03cc) of 1053 cGy, exceeding the clinical constraint of 800 cGy. The adaptive plan (right) reduces dose to the PBT, achieving a D0.03cc of 750 cGy while maintaining target coverage. The 8 Gy isodose is displayed as a color wash.



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