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A Simple HU-Override Strategy to Improve Robustness of Acuros Xb Optimization In Targets Overlapping Air

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ABSTRACT

Introduction: To evaluate whether a low-density HU-override strategy can reduce Acuros XB (AXB) optimizer over-compensation when air volumes overlap the planning target volume (PTV), while maintaining dose coverage and robustness at the air–tissue interface and reducing hotspots when air is replaced by tissue.

Methods: Patients with low-density/air within or adjacent to the PTV were identified across three disease sites: prostate (n=6), HN(n=6), and abdominal/pelvic cases (n=6). An HU-override structure was defined by thresholding HU < −730 in the air cavity within 5mm of PTV. Three plans were generated per patient: AXB optimized without HU override (Plan A) and AXB optimized with the HU-override assigned to the lung and calculated with the HU override removed (Plan B). Evaluation metrics included interface tissue coverage, interface tissue coverage with simulated setup errors shifting air fluence into PTV tissue, and maximum dose after reassigning the HU-override structure to "muscle" to simulate tissue replacing air.

Results: Percent change in PTV_Interface coverage corresponding to V98% for Plan B relative to Plan A: -0.7% +/-1.1% and for the robustness shifted plan for Plan B relative to Plan A: -2.2% +/-2.7%. Change in Dmax in air/tissue replacement for Plan A relative to Plan B: 5.9% +/-7.2% with deviations up to 19.7% higher for Plan A.

Conclusion: Optimized plans achieved high coverage, with PTV_Interface achieving equivalent coverage between Plan A and Plan B. Simulated setup errors showed equivalent coverage of the PTV_Interface. However, robustness testing demonstrated that AXB optimization without override could produce substantial hotspots when air was replaced by tissue, whereas Plan B would minimize this effect due to the reduction of fluence in the air portion of the PTV. The lung-assigned HU-override strategy reduced the magnitude of these hotspots while maintaining interface coverage.

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INTRODUCTION

When air cavities overlap or lie close to the planning target volume, Acuros XB optimization may increase fluence through the low-density region to maintain target coverage. If the air cavity later resolves or is replaced by tissue, this compensation can produce a substantial hotspot.

This study evaluated a simple low-density HU-override strategy designed to reduce this sensitivity while preserving dose coverage at the air–tissue interface.

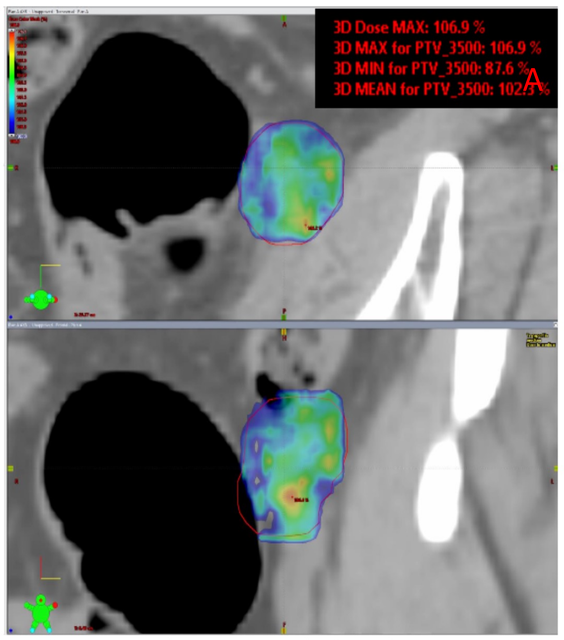
METHODS AND MATERIALS

Eighteen patients with low-density or air regions within or adjacent to the PTV were included: six prostate, six head-and-neck, and six abdominal or pelvic cases. A low-density override structure was generated by thresholding voxels below −730 HU within 5 mm of the PTV.

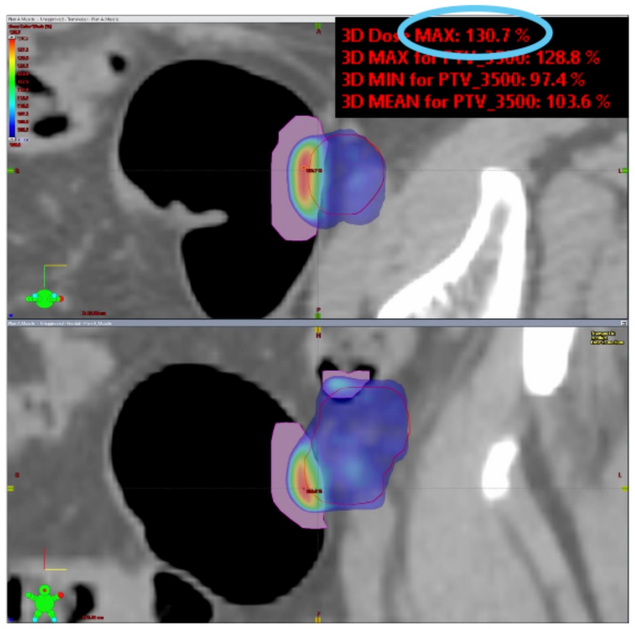
Two Acuros XB planning approaches were compared. **Plan A** was optimized and calculated without an HU override. **Plan B** was optimized with the low-density structure assigned to lung density, then recalculated after removing the override.

Robustness was evaluated using three endpoints: PTV–air interface coverage, interface coverage after simulated setup shifts that moved air-directed fluence into tissue, and maximum dose after assigning the low-density structure to muscle to simulate replacement of air by tissue.

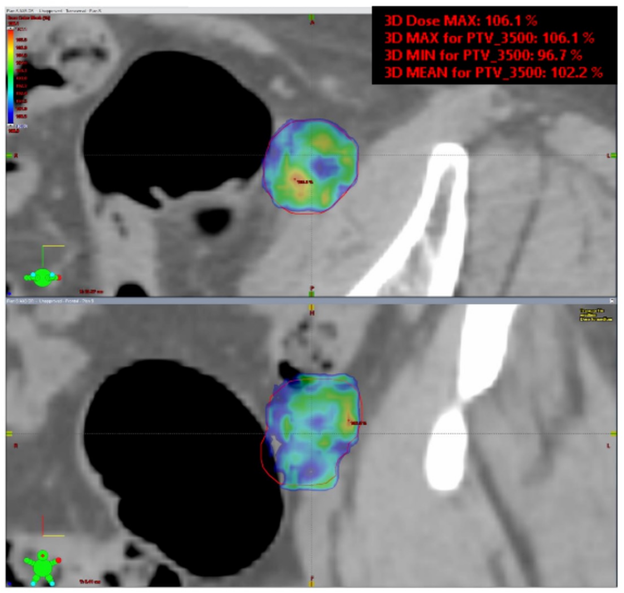
PLAN A – AXB



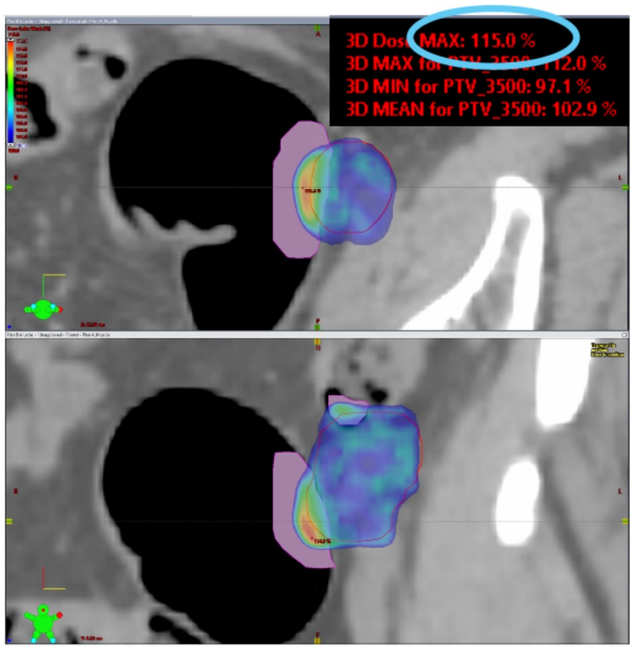
PLAN A – AXB – Override w/ Muscle B



PLAN B – AXB w/ -730HU C



PLAN B – AXB – Override w/ Muscle D



RESULTS

A, B: Acuros XB optimization without low-density override. When the air region is simulated as tissue (muscle), the hotspot increases markedly (example shown: maximum dose rises from ~106.9% to 130.7% of prescription).

C, D: Acuros XB optimization with HU < -730 override assigned to lung. Under the same tissue-replacement simulation, the hotspot is reduced (example shown: maximum dose rises from ~106% to 115% of prescription).

PTV–air interface coverage was comparable between the two planning approaches. Relative to Plan A, Plan B showed a mean change in PTV_Interface V98% of −0.7% ± 1.1% under nominal conditions and −2.2% ± 2.7% after the simulated setup shift.

The main difference appeared when air was replaced by tissue. Plan A produced higher maximum doses than Plan B, with a mean Dmax difference of 5.9% ± 7.2% and case-specific differences as high as 19.7%.

In the representative case, maximum dose increased from approximately 106.9% to 130.7% without the override, compared with an increase from approximately 106% to 115% when the −730 HU lung override was used during optimization. These findings indicate that the override reduced hotspot sensitivity while preserving interface coverage.

DISCUSSION

The HU-override strategy preserved PTV–air interface coverage while reducing sensitivity to air-to-tissue changes. Without the override, AXB optimization could place excessive fluence through the low-density region to maintain coverage. When that air was replaced by tissue, the same fluence produced larger hotspots.

Assigning the low-density region to lung density during optimization reduced this overcompensation. The approach was simple to implement and provided a practical robustness check for cases in which air cavities may change during treatment.

CONCLUSIONS

The −730 HU lung-density override reduced the risk of large hotspots from air-to-tissue changes without compromising PTV–air interface coverage.

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