Improving Target Coverage in Abdominal Adaptive Radiotherapy Using Distance-Based OAR Cropping in Ethos 2.0

Nur Izzati Huda Zulkarnain-Lemke, PhD, Beatriz Guevara, MS, Christian E. Petersen, BS, Kenneth W. Gregg, MS, Theodore H. Arsenault, MS, Meiying Xing, PhD, Gisele Castro Pereira, PhD, Rojano Kashani, PhD, Lauren E Henke, MD and Alex T. Price, PhD
University Hospitals Seidman Cancer Center, Cleveland OH

ABSTRACT

PURPOSE:
This study investigated the efficacy of selective distance-based OAR cropping on improving target coverage and plan robustness in abdominal adaptive SBRT planned with Ethos 2.0. Eleven patients with abdominal malignancies treated on Ethos 2.0 were included.

METHOD:
Twenty clinical adaptive fractions requiring plan normalization due to OAR constraint violations were selected for offline replanning. The small bowel, large bowel, duodenum, and stomach were cropped within a 3 cm axial and 1.2 cm longitudinal expansion from the PTV. Each fraction was reoptimized by applying the same planning template with the only modification being the application of cropped OAR objectives rather than full organ volumes to reduce the computational burden imposed by the Ethos optimization algorithm. Target coverage metrics, normalization factors, and monitor units were compared between clinical adaptive plans and cropped offline replans using paired t-tests.

RESULTS:
Distance-based OAR cropping significantly improved target coverage, with mean PTV_Eval D98% increasing from 88.9%Rx to 93.4%Rx (mean increase = 4.5%, $p < 0.001$). Normalization factors also increased significantly with OAR cropping (0.998 ± 0.008 vs. 0.953 ± 0.031, $p < 0.001$), with substantially fewer replans requiring normalization. Analysis of monitor units demonstrated no significant difference between cropped and original plans (4378 vs. 4375, $p = 0.97$), indicating no systematic increase in plan complexity.

CONCLUSION
These findings suggest that selective distance-based OAR cropping in Ethos 2.0 improves target coverage and plan robustness without increasing OAR dose or overall modulation, supporting its use as an effective optimization strategy for abdominal adaptive radiation therapy.

CONTACT

Nur Izzati Huda Zulkarnain-Lemke
UH Seidman Cancer Center
nurizzatihuda.zulkarnainlemke@uhhospitals.org

INTRODUCTION

Abdominal SBRT presents significant planning challenges because target volumes are frequently located near gastrointestinal (GI) organs at risk (OARs). The Ethos™ 2.0 platform allows online adaptive radiation therapy (ART) through automated replanning using predefined clinical templates that integrate target coverage goals and OAR dose constraints.

However, target coverage can be reduced when adaptive plans require normalization to satisfy OAR constraints, since OAR objectives are intentionally assigned higher importance within the optimizer. It was hypothesized that intrinsic Ethos optimization objectives, such as full OAR mean dose minimization, may overburden the optimizer by continuously reducing dose in OAR regions distant from the target, diverting optimization effort from target-adjacent regions where increased modulation complexity is required.

To address this challenge, this study evaluated whether a selective distance-based OAR cropping strategy could improve target coverage and plan robustness in Ethos 2.0 abdominal adaptive radiation therapy. This strategy preserve existing clinical templates while reducing the volume of OARs included in optimization, to improve target coverage and plan robustness.

METHODS

Twenty adaptive fractions from eleven patients treated with abdominal SBRT (renal, pancreas and pelvic nodal sites) on the Ethos 2.0 platform were retrospectively replanned. Fractions were selected when the clinical adaptive plan underwent automatic normalization to satisfy priority 1 GI OAR constraints. Prescription doses ranged from 40–50 Gy delivered in 3–5 fractions.

For each fraction, the daily CBCT and adapted contours were used to generate a cropped offline replan. As shown in Figure 1, a contour ring was created by expanding the PTV by 3.0 cm axially and 1.2 cm superior–inferiorly. The stomach, duodenum, small bowel, and large bowel were intersected with this ring to generate OAR subvolumes, which replaced the corresponding full organ volumes for priority 1 GI OAR optimization.

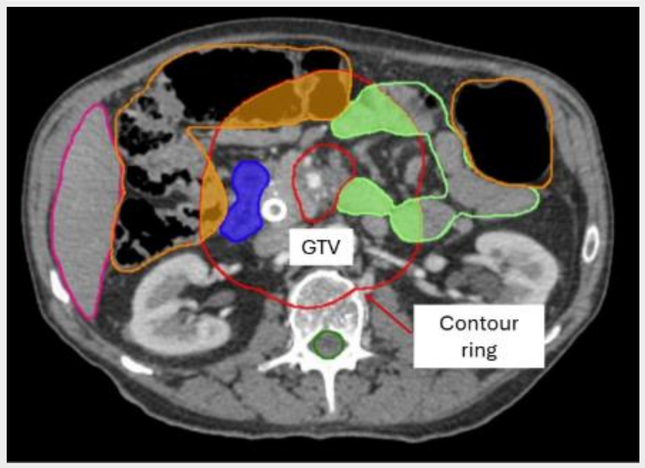

Figure 1. Axial CT slice showing the target and OARs: duodenum (blue), stomach (yellow), large bowel (orange), and small bowel (green). A contour ring (red) was generated from a PTV expansion, to define a proximity region. Only OAR subvolumes intersecting it were used for cropped plan optimization, whereas the original clinical adaptive plan used the full OAR volumes.

The same planning template, beam geometry, and optimization settings were preserved for all replans. Plans generated in Ethos were selected without manual modification. The normalization goal was set to satisfy all priority 1 OAR objectives. Dosimetric evaluation was performed using the original full OAR contours.

RESULTS

Distance-based OAR cropping resulted in consistent improvements in target coverage across all evaluated target metrics (Figure 2). Significant increases were observed in PTV_Eval D98%, with corresponding improvements in PTV D98%, PTV D50%, and V98%, indicating enhanced dose coverage throughout the target volume. These findings suggest that restricting optimization to OAR subvolumes in close proximity to the target allows optimization effort to be concentrated on the anatomically relevant region where target coverage and OAR sparing compete most directly.

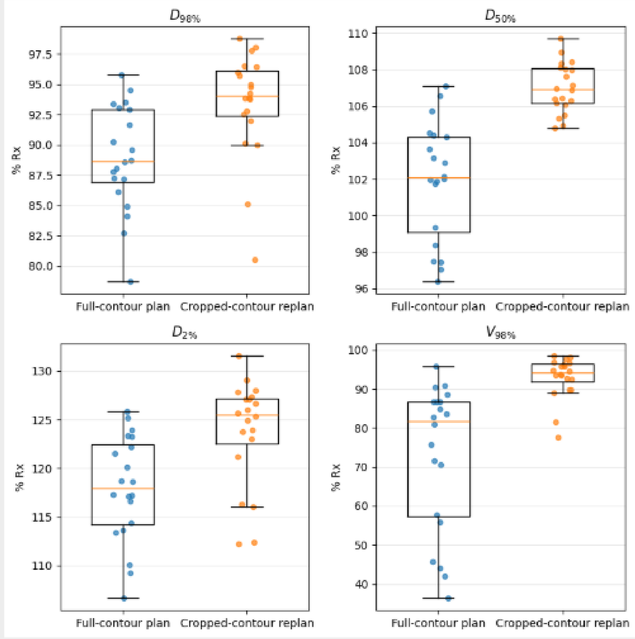

Figure 2. Comparison of target coverage metrics between full-contour clinical adaptive plans and cropped-contour replans. Cropped-contour replans demonstrated improved target coverage and dose distribution, with significant increases in PTV_Eval D98%, PTV D50%, and V98%.

Importantly, no systematic increase in GI OAR dose was observed following OAR cropping (Figure 3). GI OAR dose metrics remained comparable between the clinical adaptive plans and cropped replans, with statistically significant reductions observed for small bowel D2cc (1.31 Gy, $p = 0.014$) and large bowel D2cc (0.67 Gy, $p = 0.031$). These findings indicate that the improvements in target coverage were achieved without compromising GI OAR sparing.

Normalization factors improved significantly (0.998 ± 0.008 vs. 0.953 ± 0.031, $p < 0.001$), with substantially fewer plans requiring normalization to meet OAR constraints. Only two cropped replans required normalization factors below 1.0 (0.97 and 0.98). Notably, these values remained comparable to the highest normalization factors observed in the original clinical adaptive plans (0.99). Despite these improvements, no significant difference in monitor units was observed between cropped and original plans (4378 vs. 4375 MU, $p = 0.97$).

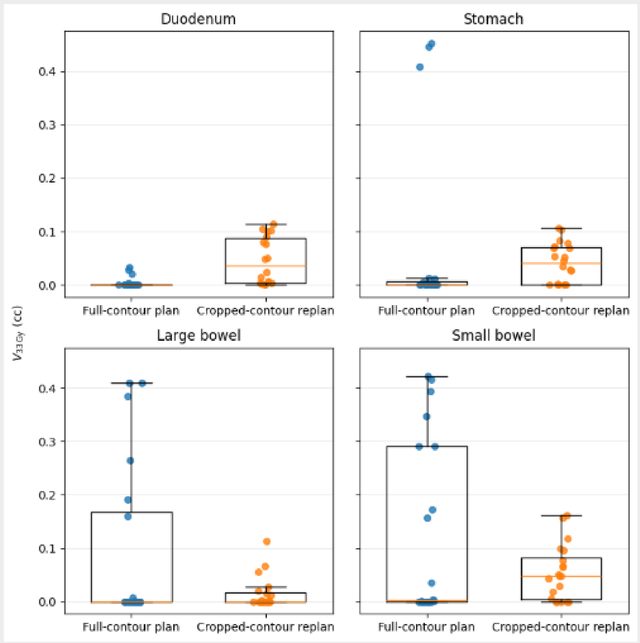

Figure 3. Comparison of GI OAR dose (V33Gy) between full-contour adaptive plans and cropped-contour replans. GI OAR doses were maintained or reduced following distance-based OAR cropping, despite improved target coverage.

DISCUSSION AND CONCLUSION

This study presents a practical optimization strategy developed specifically for the Ethos 2.0 adaptive RT platform, addressing a current need for guidance on generating high-quality adaptive plans in anatomically complex abdominal treatments. By applying a selective distance-based OAR cropping approach that preserves existing clinical templates without increasing GI OAR dose or plan complexity, optimization was focused on anatomically relevant structures near the target while reducing competing optimization demands from more distant OAR regions.

Because the method integrates seamlessly into existing Ethos workflows and requires minimal modification to current planning practices, it offers a simple and reproducible strategy for improving adaptive plan quality. As clinical experience with Ethos 2.0 continues to grow, these results provide practical insight into optimization techniques that may support more consistent and higher-quality abdominal adaptive treatments. Future work will include analysis of the dosimetric impact of this optimization strategy in a larger patient cohort to further evaluate its reproducibility and applicability across a broader range of abdominal adaptive treatment scenarios.

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