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Effects of Contrast Density Overrides on the Treatment Planning Workflow and Dose Calculations

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ABSTRACT

Purpose. IV and oral contrast are routinely used during CT simulation, and overriding contrast Hounsfield Units (HU) before dose calculation is a common workflow step. This study quantifies the real-world dosimetric impact of contrast on radiation planning.

Methods. Plans across four disease sites were recalculated with and without contrast HU override.

Results. Dose differences from contrast override were negligible at every site — mean-dose changes < 0.3% for all targets and OARs, and uncorrelated with contrast volume.

Conclusion. Contrast HU override has minimal impact on dose calculations and may be unnecessary in the planning workflow.

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INTRODUCTION

CT simulation provides the 3D dataset used for contouring and dose calculation, but its soft-tissue contrast is limited. IV iodinated and oral contrast improve visualization of tumors, nodes, and organs at risk (OARs), and contrast-enhanced simulation is standard practice.

However, contrast artificially elevates CT numbers, which the planning system interprets as increased tissue density — a potential source of dose-calculation error. ASTRO consensus therefore recommends density override of large contrast regions.

Override adds a manual contouring step to an already complex, high-risk workflow — inviting delay and error. Prior studies suggest the dosimetric impact is often clinically insignificant, motivating a systematic multi-site evaluation.

METHODS AND MATERIALS

Cohorts recalculated:

12	**Salvage prostate**	— IV contrast at simulation
10	**Head & neck**	— IV contrast at simulation
10	**Lung**	— IV contrast at simulation
10	**Rectum**	— oral contrast at simulation

Three plans per patient: (1) no HU override, (2) manually-contoured contrast override, (3) whole-bladder override to water (prostate only).

Endpoints: dose to targets (GTV/CTV/ITV/PTV) and OARs (rectum, bladder, sigmoid, small bowel, femoral heads); contouring time for each override method.

RESULTS

All mean-dose differences from contrast override:

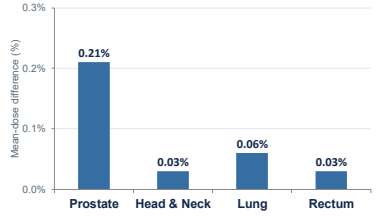
< 0.3%

across every target and OAR, all four sites

RESULTS

For the prostate cohort, minimal dose increase was observed with HU contrast override compared to no contrast override, with mean mean-dose changes for CTV and PTV prostate of 9.85 cGy (0.21%) and 7.84 cGy (0.17%), respectively, and of lymph node 1.48 cGy (0.03%) and 1.73 cGy (0.04%), respectively. Prostate CTV and PTV hotspots were increased 5.47 cGy (0.14%) and 1.22 cGy (0.03%), respectively. Mean mean-dose of exemplar OARs rectum and bladder were increased 2.75 cGy (0.09%) and 9.48 cGy (0.27%), respectively, and hotspot mean increase of 3.32 cGy (0.07%) and 8.63 cGy (0.18%), respectively. Changes were not correlated with volume of contrast and not significantly different with entire bladder override. These results for IV contrast were corroborated across two additional anatomical sites, head and neck and lung, and for oral contrast in rectal cancer plans.

Figure 1. Maximum target mean-dose difference (%) by site



Clinical significance threshold is far above this range. *Even the largest site (prostate CTV, 0.21%) equals only ~10 cGy on a prescription dose.*

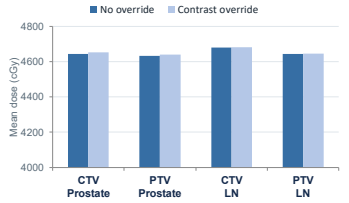
PROSTATE OAR DOSE

Structure	Metric	No Override (cGy)	Override (cGy)	Δ (cGy)	Δ (%)
Bladder	Hotspot	4893	4902	+8.6	0.18
Bladder	Mean	3481	3490	+9.5	0.27
Lt Femoral Head	Hotspot	3973	3978	+5.3	0.13
Lt Femoral Head	Mean	1183	1184	+1.4	0.12
Rectum	Hotspot	4857	4861	+3.3	0.07
Rectum	Mean	3085	3088	+2.8	0.09
Rt Femoral Head	Hotspot	3942	3946	+4.1	0.10
Rt Femoral Head	Mean	1115	1116	+1.0	0.09
Sigmoid	Hotspot	4788	4787	+0.6	0.01
Sigmoid	Mean	3255	3255	+0.2	0.01
Small Bowel	Hotspot	4816	4816	+0.3	0.01
Small Bowel	Mean	1436	1436	+0.0	0.00

Table 1. Bladder & pelvic OAR dose, prostate cohort (n=12). All differences ≤ 9.5 cGy (0.27%).

RESULTS

Figure 2. Prostate cohort — mean dose (cGy): no override vs. override



Bars are visually indistinguishable — override shifts mean dose by ≤ 9.9 cGy.

DISCUSSION

Across 42 patients and four disease sites, contrast HU override produced changes in target and OAR dose that were consistently well below any clinically meaningful threshold (< 0.3% mean dose).

Differences were not correlated with contrast volume, and whole-bladder override yielded results indistinguishable from targeted contrast override.

These findings agree with prior single-site work (Li 2014; Heydarheydari 2016; Shibamoto 2007) and extend it to a consolidated multi-site, multi-target dataset for both IV and oral contrast.

CONCLUSIONS

Negligible dose impact. Contrast override changes mean dose by < 0.3% at all sites which is clinically insignificant.

Workflow simplification. Omitting override removes a manual contouring step, streamlines physics second checks, and reduces needless replanning.

Fewer error opportunities. Eliminating an unnecessary step reduces chances for human error in a high-risk workflow.

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