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SCIENTIFIC POSTER

Do Rectal Proton Therapy Plans Require Adaptation for Rectal Gas Variability?

Anthony Austin Kassaee, MS · Melissa Vila MS · Alireza Kassaee, PhD
Department of Radiation Oncology, University of Pennsylvania, Philadelphia, PA

Penn Medicine
Roberts Proton Therapy Center

−1.98% CTV D98% coverage under large rectal gas

+11.3% CTV D2% hot-spot escalation

+255% Homogeneity Index degradation

r = 0.84 gas extent ↔ hot-spot rise (p = 0.003)

Background & Purpose

Rectal gas varies substantially between fractions, introducing density heterogeneities that can perturb the sharp distal falloff of proton beams and compromise dose robustness in rectal proton therapy.

This study evaluates how interfraction rectal-gas variability affects target coverage, dose homogeneity, and small-bowel and bladder dose in robustly optimized pencil-beam scanning (PBS) plans, and whether static robustness assumptions are sufficient.

Methods

1. 10 rectal cancer patients, each with a single planning CT, retrospectively analyzed.
2. 4500 cGy / 25 fx (180 cGy/fx) to CTV via IMPT, two posterior-oblique beams, robust multifield optimization (setup + range uncertainty).
3. All 10 rectal patients planning CTs are synthetically modified to create larger air gabs representative of moderate gas and large case
4. Dosimetric indicators characterize coverage, homogeneity, and small-bowel & bladder dose across all scenarios.

WORKFLOW

Planning CT + robust IMPT → Deformable gas / bladder mapping → 2 synthetic CTs / patient →

Forward dose recompute & DVH analysis

Synthetic Rectal-Gas Scenarios

representative axial CT · same patient, escalating rectal gas · presacral gas expands and displaces the target

Nominal planning anatomy · **Moderate gas** interfraction · **Large gas** worst case

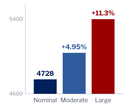
Results — Target Coverage & Homogeneity

CTV D98% — coverage

cGy · Rx 4500

CTV D2% — hot spot

cGy · rising with gas



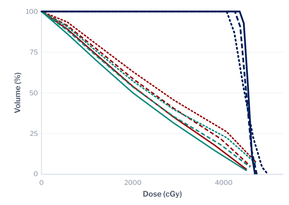
Homogeneity Index (D2%−D98%)

cGy · lower is more homogeneous

+255% vs nominal

DVH of a Representative Case

Single patient, forward-calculated · nominal vs. moderate vs. large gas



CTV · Small bowel · Bladder · Nominal · Moderate · Large gas

OAR Behavior & Per-Patient Variability

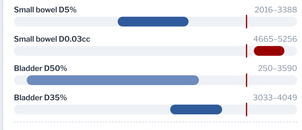
Per-Patient % Change — Large Gas vs Nominal

every patient loses coverage and gains hot-spot & inhomogeneity

	ΔD98%	ΔD2%	ΔHI%
P1	-0.7	+12.7	+249
P2	-2.2	+8.5	+132
P3	-2.2	+9.9	+205
P4	-4.6	+13.8	+409
P5	-2.6	+12.5	+211
P6	-1.7	+14.7	+319
P7	-4.2	+9.4	+237
P8	-1.9	+12.9	+377
P9	-2.5	+13.5	+312
P10	-2.6	+13.1	+255

OAR Dose Redistribution — Cohort Range

min–max across synthetic scenarios · cGy scale 0–5500



Small bowel V1500 cGy spans 97–209 cc · Rx 4500

r = −0.76
p = 0.010
Greater rectal-gas extent → **more coverage loss** (CTV D98%)

r = +0.84
p = 0.003
Greater rectal-gas extent → **higher hot spot** (CTV D2%)

Conclusions

Robust IMPT absorbs modest rectal-gas perturbations, but under large gas, target homogeneity degrades sharply and small-bowel & bladder dose redistribute substantially.

Coverage loss and hot-spot escalation both scale with gas extent, exposing the limits of static robustness assumptions.

Department of Radiation Oncology · University of Pennsylvania · Roberts Proton Therapy Center
Contact: anthony.kassaee@pennmedicine.upenn.edu