Diagnostic Imaging-based Radiation Planning without Adaptation for Non-Small Cell Lung Cancer (NSCLC) Patients

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Background

Planning a patient's RT course using pre-existing diagnostic CT (dCT), aka diagnostic scan-based planning (DSBP), allows for starting treatment sooner, requires less visits for the patient, and helps to decongest crowded simulator resources. Currently, DSBP is a well-established practice in many clinics for palliative cases, using simple 3D planning.[1,2]
Recent studies have examined the potential role DSBP (aka simulation-free planning) could have in the definitive setting, including NSCLC.[3] Other studies have focused on utilizing DSBP to create a base plan, typically for SBRT, with the intention to adapt.[4]

Objectives

The intention of this study is to:
- Consider a potential DSBP workflow for our hospital's NSCLC service
- Model the differences in doses to targets and OARs when the DSBP workflow is used
- Consider the effects of planning and treating VMAT technique with the DSBP workflow

Methods

For this retrospective study, the department REDCap database was used to find patients meeting these criteria:
- NSCLC patients who were prescribed definitive RT (66Gy/30 or 60/20-25) within the last five years;
- Had diagnostic PET/CT within six weeks before the simulation CT (sCT), with fusion performed for the original treatment planning.
- Received and completed a conventional course of VMAT treatment

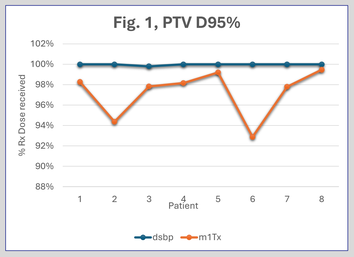
For treatment planning volumes, the dCT images were autosegmented using Limbus (for OARs). In Eclipse, target volumes were rigidly copied from the sCT structure set. The planner reviewed OARs and modified the opti structures according to anatomy changes between the scans.

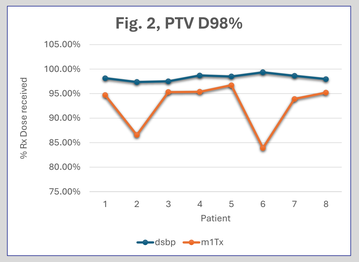
The original plan was copied onto the dCT structure set and optimization was performed until the plan quality matched that of the original plan. Dose was calculated for Truebeams, using Acuros. VMAT technique generally used two hemi+10-30 degree arcs, 6X energy; although variations included three arcs (n=1), full arcs (n=2), and beam energy (10X, 10XFFF). This diagnostic scan plan is referred to as *<Site>_dsbp* (e.g. Lung R_dsbp).

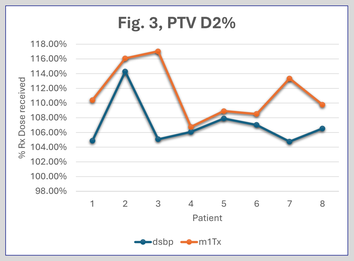
In order to assess acceptability, a robustness evaluation was performed by recalculating unscaled dose back onto the sCT structure set. This "mock first treatment" plan is referred to as *<Site>_m1Tx*.

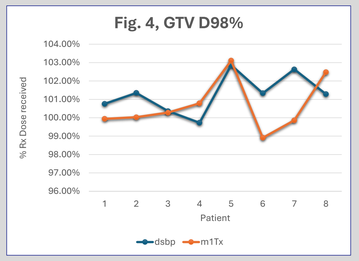
Results

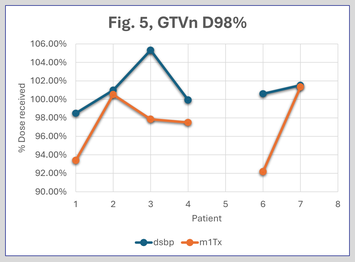
TARGETS & HOMOGENEITY

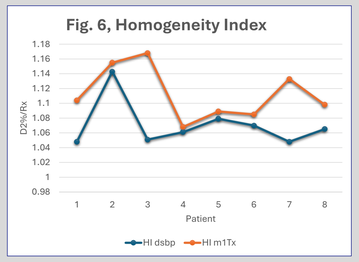












Figures 1-6. Pairwise comparison of dose to targets, HI, between the DSBP and the mock treatment. The trend towards lower coverage and higher hot spots/HI for the mock treatment were found to be significant for all metrics, with a threshold alpha=0.05.

Diagnostic scan-based plan — Mock 1st treatment (robustness test)

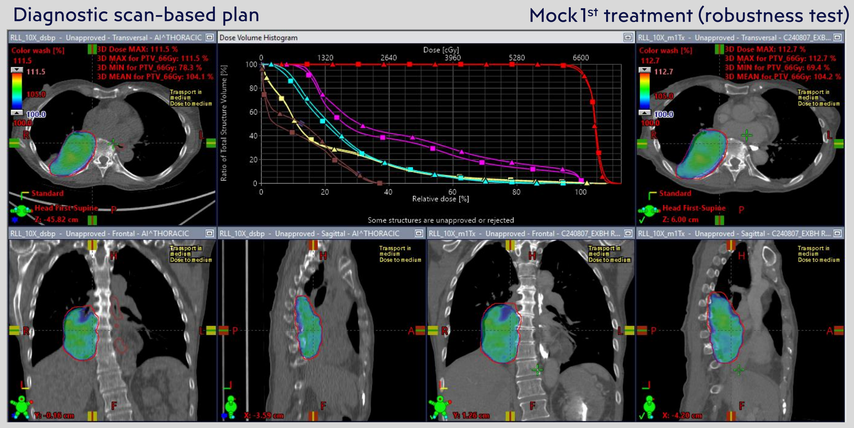
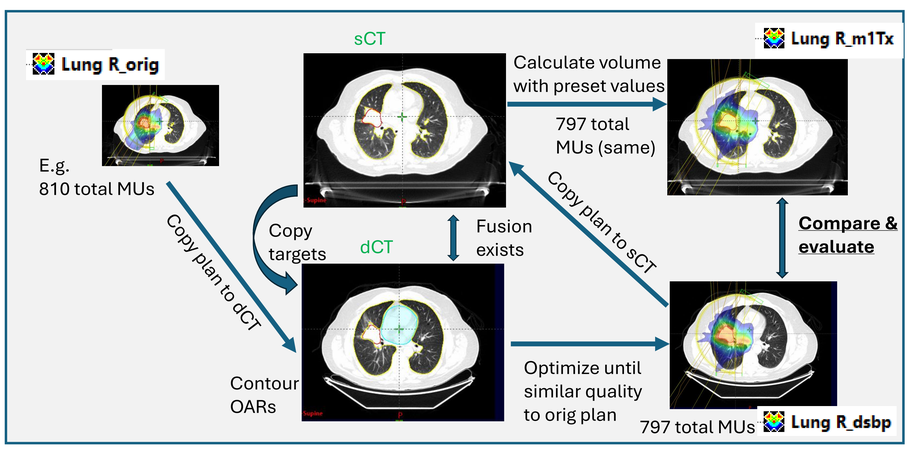


Fig. 8. Plan comparison of Patient #5's DSBP with the dose as delivered in a mock treatment. The patient's original simulation CT scan was used to back test the DSBP. DVH: ▲DSBP, ■ m1Tx, red=PTV, magenta=bronchiole tree; aqua=heart; yellow=combined lungs; brown=esophagus

Methods



Results

OARS

Fig. 7		mean		avg. diff.	Sign test
		dsbp	m1Tx		*p-value*
Lungs - GTV	*V20Gy<30%*	17.5%	18.5	1%	0.4975
Lungs - GTV	*V30Gy<20%*	10%	10.8	0.7%	1.0000
Lungs - GTV	*Dmean<15 Gy*	1062.5 cGy	1138	75 cGy	0.4975
Esophagus	*Dmean<15 Gy*	0.3 cGy	0.7	0.44 cGy	0.5637
Esophagus	*D0.03cc<70 Gy*	4523 cGy	4368	-155 cGy	0.4795
Heart	*V30Gy<50%*	7.3%	7.1	-0.2%	1.0000
Heart	*V45Gy<35%*	2.4%	2.7	-0.4%	1.0000
Heart	*Dmean<10 Gy*	981 cGy	930	-50 cGy	0.4795
Spinal cord	*D0.03cc<45 Gy*	2722 cGy	2937	215 cGy	0.1573
LAD	*V15Gy<10%*	7%	15.2	-8.2%	0.0800
Bronchial tree	*D0.03cc<70 Gy*	6012 cGy	6074	62 cGy	0.1573
Brachial plexus	*D0.03cc<70 Gy*	3938 cGy	5166	1228 cGy	n/a

Figures 7. Dose statistics in key metrics for our institution were compared. Sign test analysis (α=0.05) did not show significant differences in dose to OARs.

PATIENTS

# of patients	8
Avg # days, dCT to sCT	33
Diagnosis	NSCLC, stage IB-IIIB
Prescribed dose	66Gy/30 (4), 60Gy/20 (3), 66 Gy/25 (1)
Sim (sCT) breathing	EBH (4), 50% bin (3), free breathing (1)
PET/CT (dCT) breathing	free breathing

Conclusion

- Coverage and homogeneity trended lower when the diagnostic scan-based plan was back-tested on the simulation CT structure set.
- PTV D95% was generally observed to be >96% Rx dose. PTVD2% was generally <115% Rx dose.
- No significant differences were observed in doses to OARs.

LIMITATIONS
- Low n required nonparametric statistical tests.
- The study design did not account for changes in tumor anatomy between dCT and sCT.
- Differences in lung anatomy (due to differences between dCT and sCT protocol) were not analyzed as part of the study.

References

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