Multi-modality imaging of treatment response after stage III non-small cell lung cancer radiotherapy

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INTRODUCTION

- Radiation therapy for non-small cell lung cancer is known to cause cardiac and lung toxicity in many patients[1,2]
- Multi-modality imaging can be used to assess the response of both the tumour and surrounding healthy tissue after radiation therapy (RT)
- Imaging may also be used to develop patient-specific strategies for minimizing toxicity risk, such as ventilation-guided treatment[3]

PURPOSE

To perform comprehensive functional imaging assessments of the lungs, heart, and tumour before and after radiation therapy for non-small cell lung cancer (NSCLC) in 2 patients

METHODS

- Two Stage III NSCLC patients with primary tumours in the left upper lobe were enrolled; Patient 1 has coronary artery stents, and Patient 2 has no previous cardiac history

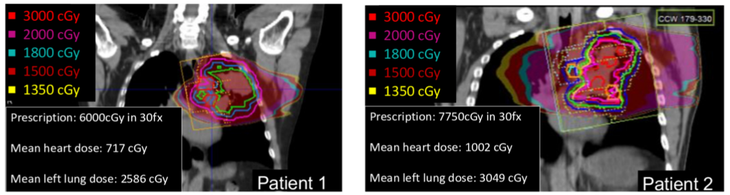

Figure 1. The radiation dose distribution delivered to each patient

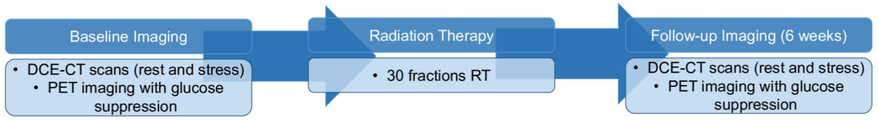

Figure 2. Study timeline for imaging at baseline and after radiation therapy

Image Acquisition

- Two dynamic contrast-enhanced (DCE) scans were performed on the GE Revolution CT scanner: one at rest and one under adenosine-induced stress
- PET images were acquired on a Siemens 3T hybrid PET/MR scanner using glucose suppression

Image Analysis

- Perfusion analysis of the heart and tumour was completed using CT-Perfusion5 software (GEHC). Myocardial perfusion reserve was calculated as the ratio of blood flow of stress/rest scans.
- End-inspiration and end-expiration CT images were non-rigidly registered using Elastix[4], and ventilation was calculated using an established density-based method[5]
- Myocardial FDG increase factor was determined as the ratio of mean SUV_{bw} follow-up/baseline using the standard six-segment model, tumour mean SUV_{bw} was computed in MIM software.

RESULTS

Table 1. Measurements of PET uptake in the heart and tumour before and after treatment

FDG Uptake (SUVbw)		Left Circumflex		Left Anterior Descending			Right Coronary	Tumour mean SUVbw
		basal lateral	mid lateral	apical lateral	apical septal	mid septal	basal septal	
Patient 1	baseline	1.92	1.56	1.02	1.33	1.46	1.63	11.74
	Follow-up	3.45	3.28	2.6	3.25	4.11	3.44	4.75
FDG increase factor		1.8	2.1	2.55	2.44	2.82	2.11	
Patient 2	baseline	1	0.56	0.21	0.73	1.03	1.21	13.1
	Follow-up	1.78	1.52	1.02	1.41	1.92	1.97	4.37
FDG increase factor		1.78	2.71	4.86	1.93	1.86	1.63	

Table 2. CT measurements of specific ventilation and perfusion in the irradiated lobe before and after treatment

		Specific Ventilation (mean)	Lung Perfusion (mean +/- SD)
Patient1	Baseline	0.338	264.9 +/- 365
	Follow-up	0.156	373.65 +/-347
Patient2	Baseline	0.300	277.9 +/- 249
	Follow-up	0.229	470.8 +/- 364

Table 3. DCE-CT measurements of myocardial perfusion reserve before and after treatment

Myocardial perfusion reserve		Left Circumflex		Left Anterior Descending			Right Coronary
		basal lateral	mid lateral	apical lateral	apical septal	mid septal	basal septal
Patient1	Baseline	1.2	1.55	1.34	1.58	1.74	2.07
	Follow-up	**1.77**	2.28	**1.07**	1.65	2.1	**1.74**
Patient2	Baseline	2.61	2.27	2.39	2.43	2.78	2.81
	Follow-up	**1.37**	**1.71**	**1.8**	**1.66**	**1.63**	**1.41**

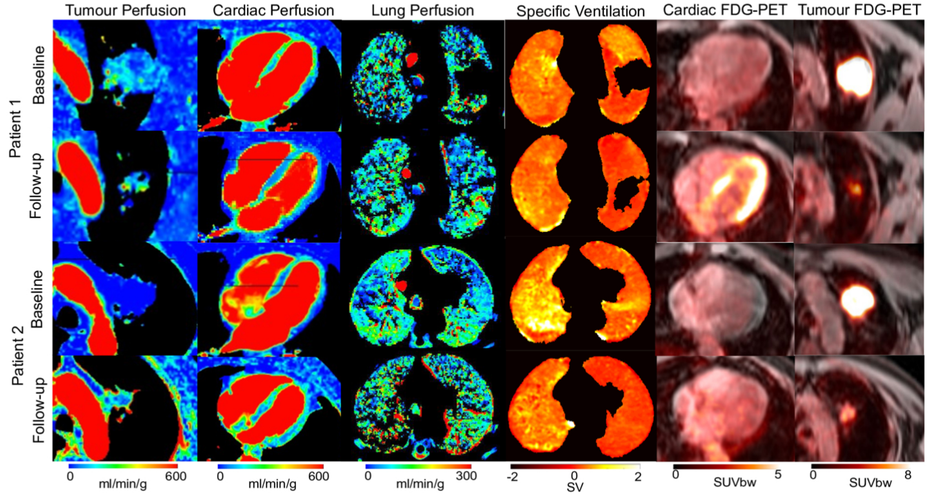

Figure 2. Representative slices from the multi-modality functional imaging acquired for patient 1 (top 2 lines) and patient 2 (bottom 2 lines). Tumour perfusion (column 1), cardiac perfusion (column 2), lung perfusion (column 3), specific ventilation (column 4), cardiac FDG uptake (column 5) and tumour FDG uptake (column 6) are shown.

DISCUSSION

- This study established a protocol for early assessment of radiation toxicity, tumour response, and heart and lung function simultaneously using multimodality imaging, including FDG-PET and volumetric CT
- The CT myocardial perfusion reserve measurements suggest a different response in the patient with previous coronary artery disease compared to the patient with no cardiac history
- These results suggest that these methods are sensitive to changes 6 weeks after treatment and may suggest an acute inflammatory response in both the lungs and heart
- This data will aid in the design and evaluation of radiation techniques that better spare the heart and functional lung in patients with thoracic malignancy.

CONCLUSIONS

- This study demonstrated the feasibility of collecting extensive functional imaging data with two imaging sessions before and after RT for Stage III NSCLC
- This protocol may be used to provide important patient-specific information for clinical decision making

REFERENCES

1. Atkins et al. J Am Coll Cardiol. 2019 2. Bradley et al. Oncol. 2015, 3. Yamamoto et al. Radiother Oncol 2016; 4 Klein et al, IEEE Trans Med Imaging 2010; 5 Guerrero et al, Phys Med Bio 2006

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