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Early Clinical Experience of Cardiac Stereotactic Body Radiation Therapy (SBRT) for Recurrent Ventricular Tachycardia (VT): A Case Study

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INTRODUCTION

A phase I/II trial has been initiated at Washington University (St Luis, USA) for delivering ablative dose to patients with recurrent VT. The initial published results have been promising. Our institution treated our first VT SBRT patient, and we combined our experience from simulation to treatment.

AIM

Ventricular tachycardia is a heart rhythm disorder (arrhythmia) caused by abnormal electrical signals in the lower chambers of the heart (ventricles). The traditional treatment options have high recurrent rate for even optimally selected patients. The pioneered study from Washington University to treat VT patients with SBRT showed promising results. This case study shares our experiences for treating our first VT patient and also provide us a foundation for future research direction to improve treatment accuracy and normal tissue sparing.

METHOD

The patient is a 58-year-old with non-ischemic cardiomyopathy s/p prior ICD and LVAD device placement. He has a history of multiple recurrent symptomatic VTs with multiple failed ablations. Cardiology determined that the patient did not have further ablative treatment options. As a result, the patient was referred for cardiac SBRT, which was prescribed to a dose of 25Gy in a single fraction. The simulation was performed with compression belt (10mmHg) for motion management, and both free-breathing and 4DCT were acquired. Electrophysiological voltage map was used to assist in target delineation and contouring. ITV was contoured based on the largest motion range on 4DCT and a 5mm-margin was used for PTV. Treatment planning was done in Eclipse (V15.6, Varian) with one coplanar full arc and two non-coplanar partial arcs. Average scan was generated from 4DCT and was the reference CT for patient alignment. ICD and LVAD dose were constrained and in-vivo dosimetry was performed for ICD.

RESULTS

GTV, ITV, and PTV volumes were 14.95cc, 27.59cc and 73.22cc respectively. All OAR dose constraints were compliant with the guideline published by Washington University. The plan quality measures were as follows – conformity index(CI): 0.974, gradient index(GI): 2.7, homogeneity index(HI): 1.2, gradient measures: 2.1cm, mean heart – PTV dose: 4.56Gy, and MU ratio: 4.53. These parameters showed our plan quality is comparable with the sixteen cases investigated in their published results. ICD and LVAD maximum dose estimated in Eclipse were 0.25Gy and 5.26Gy respectively and the in-vivo ICD dose was measured 0.17cGy.

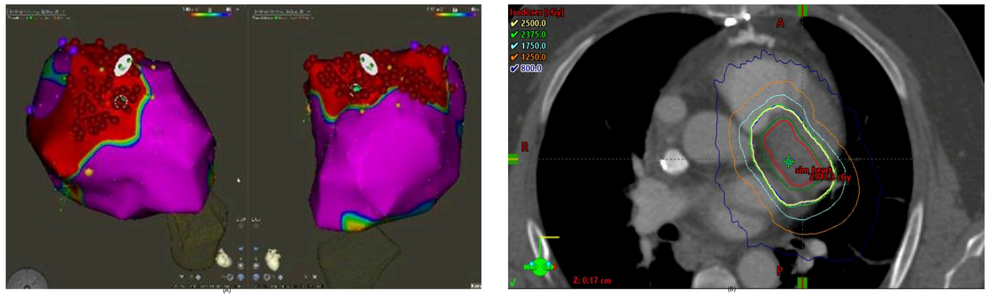

Figure 1. (A) Electroanatomical voltage map which identified the abnormal electrical signal that causing VT was used to guide the SBRT contouring process. (B) Isodose distribution showed a very conformal prescription dose (25Gy) with quick dose fall off outside the PTV. (Red - GTV, Green - ITV, Blue - GTV).

Parameters	Value
MU Ratio	4.53
Gradient Index (R50)	2.7
Gradient Measure	2.1cm
Conformity Index (CI)	0.974
Homogeneity Index	1.20
Mean Heart-PTV Dose	4.56Gy

Table 1. Plan quality measures. MU Ratio – total MU/Rx dose, Gradient Index – volume of 50% isodose/PTV volume, Gradient Measure – the average distance between 50% dose equivalent spherical volume and 100% dose equivalent spherical volume, Conformity Index – volume of 100% isodose/PTV volume,

Structure	Criteria	MSH Plan
PTV	D95 > 95%	D95 – 100%
ITV	Hotspot < 135%	120.1%
GTV	Hotspot < 135%	120.1%
Cord	V10Gy < 0.35cc	0 cc
	V8Gy < 1.2cc	0 cc
	Dmax < 14Gy	4.54Gy
Esophagus	V11.9Gy < 5cc	0 cc
	Dmax < 15.4Gy	5.79Gy
Stomach	V17.4Gy < 5cc	0 cc
	Dmax <22Gy	0.46Gy
Total Lung	<1500cc received 7Gy	2621.9cc <7Gy
Liver	<700cc received 11Gy	1954cc < 11Gy

Table 2. Target and organ-at-risk dose constraints for cardiac SBRT listed in Phase I/II Trial of Electrophysiology-Guided Noninvasive Cardiac Radioablation for Ventricular Tachycardia initiated at Washington University. The MSH treatment plan shows well complaint with all the dose constraints.

CONCLUSIONS

SBRT for VT is a relatively new procedure and has great potential in treating cardiac patients with limited alternative treatment options. Future work will be focused on fusion of simulation scan with the cardiac voltage map and motion management for treatment.

CONTACT INFORMATION

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