

Pencil Beam Scanning Proton vs Photon Stereotactic Body Radiotherapy for Ventricular Tachycardia: A Comparative Planning Study

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Purpose:

Cardiac radiotherapy is used to treat refractory ventricular tachycardia after pharmacologic and/or surgical treatment failure. Photons are primarily used since the advantages of protons are not well defined. A comparative planning study was done to assess the viability of Pencil Beam Scanning (PBS) protons as a treatment modality for ventricular tachycardia.

Methods:

Pencil beam scanning (PBS) proton plans were created for ten patients with ventricular tachycardia previously treated with photon stereotactic body radiotherapy (SBRT). Four proton plans with three fields were created for each patient to evaluate the effectiveness of multifield (MFO) vs single field optimization (SFO) and robust vs non-robust optimization. The dose volume histograms (DVH) of all four plans were individually compared to the clinically delivered photon SBRT plan to gauge each method's effectiveness in meeting the target coverage and organ at risk (OAR) objectives. The dose differences between photon and proton plans per clinical objective were measured for individual optimization methods and averaged for an overall comparison. Robust optimization uncertainty parameters for isocenter shift and calibration curve error were 0.5cm and 3.5% respectively, for all patients. The effectiveness of robust optimization was evaluated by comparing the 2nd worst [PTV 2500cGy D95% >=95] perturbation for each proton plan. Patients (n=9) were planned to PTV 2500cGy and (n=1) PTV 3000cGy in a single fraction.

Results:

Average target coverage on [PTV 2500cGy, D95% >=95] was $-2.37 \pm 0.98\%$ for non-robustly optimized and $+3.24 \pm 0.81\%$ for robustly optimized proton plans. Robust-multifield optimization target coverage [PTV 2500cGy, D95% >=95] was $+3.26 \pm 0.78\%$ and $+3.22 \pm 0.87\%$ for robust single field optimization.

The average 2nd worst perturbation [PTV 2500cGy, D95% >=95] for non-robustly optimized plans was $87.4371 \pm 1.4712\%$, and $100.0069 \pm 0.2722\%$ for robustly optimized plans.

Figure 1 below, plots the average dose differences between PBS proton and photon SBRT plans across all PTV 2500cGy patients, per clinical objective.

Conclusion:

Robustly optimized PBS proton plans provide better target coverage than cardiac photon SBRT plans and can significantly decrease OAR dose in the mediastinum. With limited motion management techniques for PBS proton therapy, evenly weighted, robustly optimized SFO plans present a viable alternative to photon SBRT for the treatment of ventricular tachycardia.

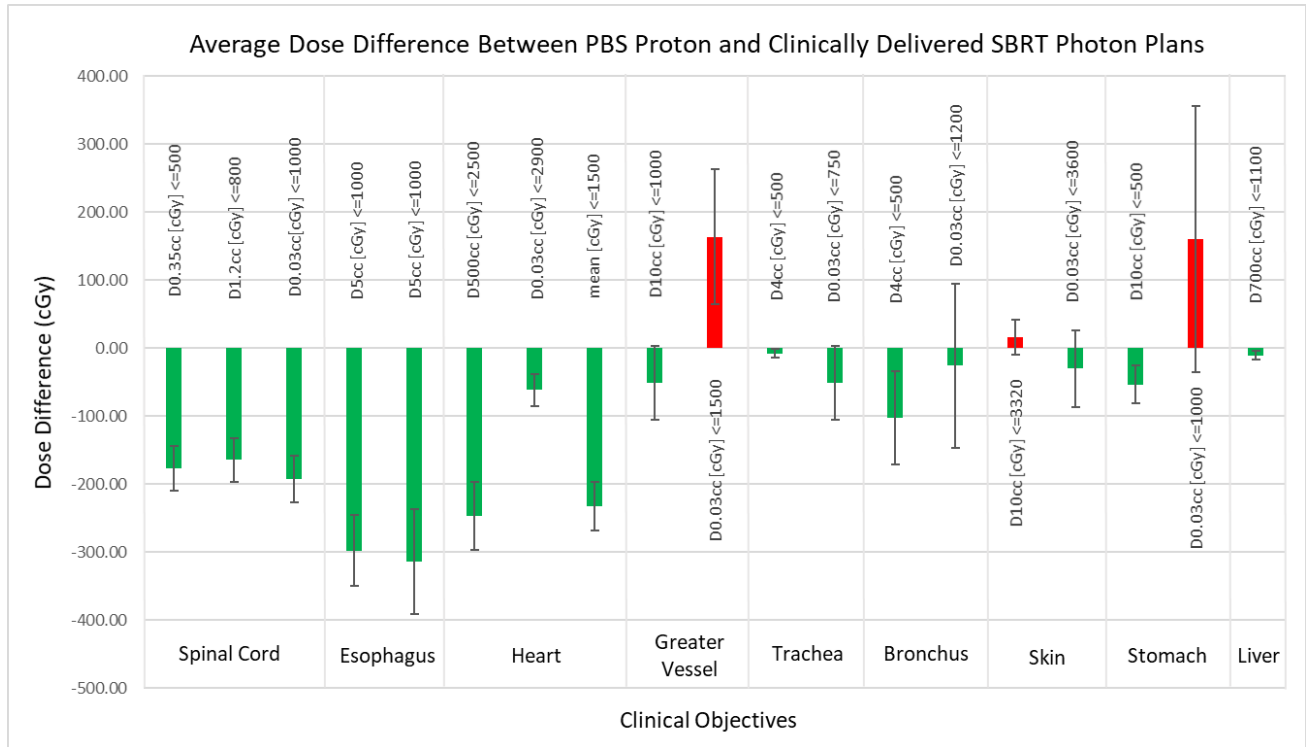


Figure 1. Average dose difference between PBS proton and photon SBRT plans for PTV 2500cGy ventricular tachycardia patients (n=9) per clinical objective.