Knowledge-Based Planning for Ventricular Tachycardia SBRT

Tavia Keys[2], Kirk Luca[1], Vanessa Wildman[1], Jie Ding[1], Aparna Kesarwala[1], Pretesh Patel[1], Matthew Case[1], Trisha Jones[1], Braylon Madison[1], Alex Stanforth[1], Keyur Shah[1], Justin Roper[1], Eduard Schreibman[1], Xiaofeng Yang[1], Shadab Momin[1]

[1]Department of Radiation Oncology, Emory University, Atlanta, GA, USA

[2]Medical Dosimetry Program, Southern Illinois University, Carbondale, IL, USA

INTRODUCTION

Purpose: Stereotactic Body Radiation Therapy (SBRT) is an emergent treatment option for refractory ventricular tachycardia (VT), a condition characterized by complex, arrhythmogenic cardiac substrates requiring urgent intervention. Treatment planning can be variable due to planner experience differences, time constraints, and target complexities. This study aimed to develop VT treatments through the development of a knowledge-based planning model (VT-KBP) for evaluation across diverse VT cases.

METHODS

- 48 heterogeneous VT cases queried
  - 33 training/model development
  - 15 model validation
- The VT-KBP model included cardiac substructures, including the coronary arteries and great vessels
- Planning was performed per the RAVENTA protocol and institutional constraints
- Validation cases were replanned with VT-KBP model using the original clinical beam geometry to 25 Gy in 1 fraction
- All plans were normalized such that 95% of the PTV received the prescription dose
- Plan quality was assessed relative to the original clinical plans using the RAVENTA protocol and conformity metrics (CI100% and CI50%)
- In parallel, four planners with limited experience each replanned the same three randomly selected cases of varying complexity
- Dosimetric endpoints including planning time were evaluated for comparison between the manually optimized plans vs. the VT-KBP model

RESULTS

Plan Quality:

- OAR dose metrics were comparable, with VT-KBP yielding slightly lower doses overall
- Overall coronary artery dose, and coronary arteries, such as the LAD and RCA exhibited a lower mean maximum dose (Dmax) with the VT-KBP approach, along with various cardiac substructures
- VT-KBP produced a lower CI100% with a slightly higher CI50% (not statistically significant) in comparison to the original clinical plan

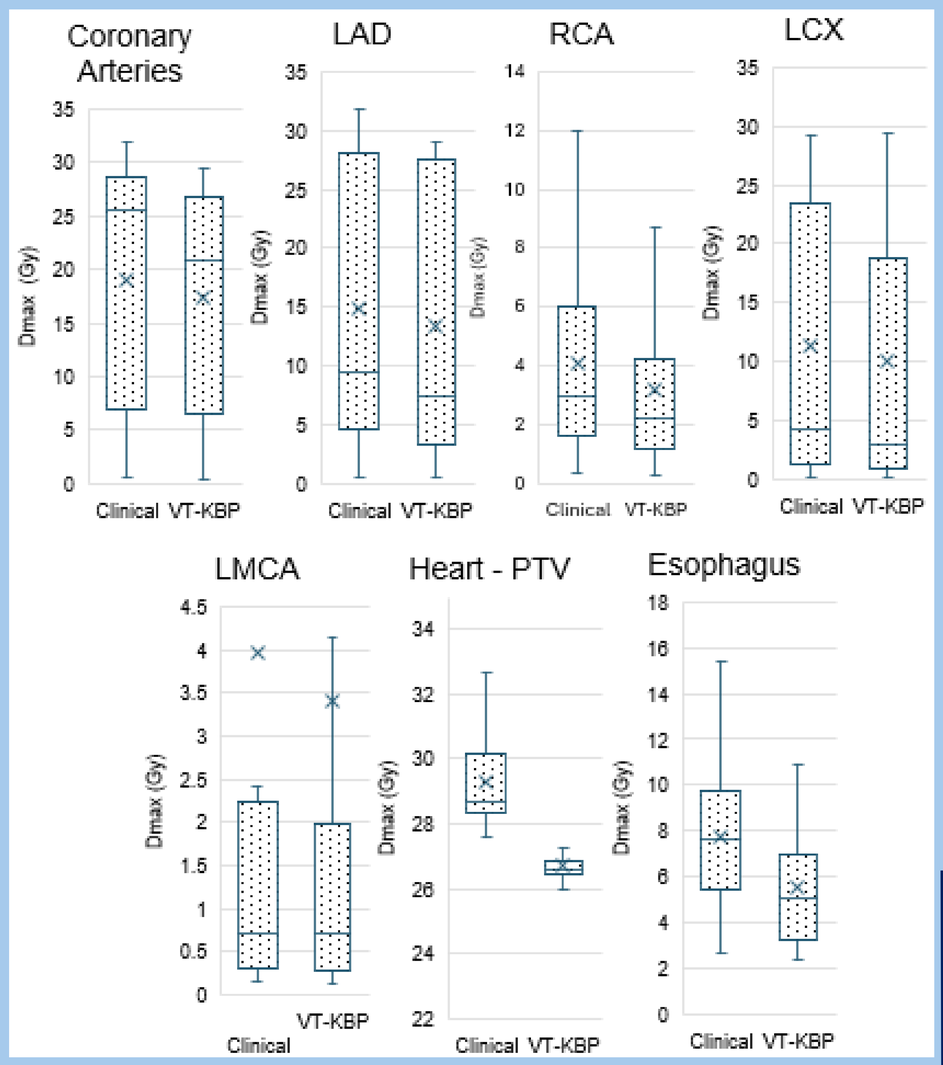

Figure 1. Box plots of key OARs

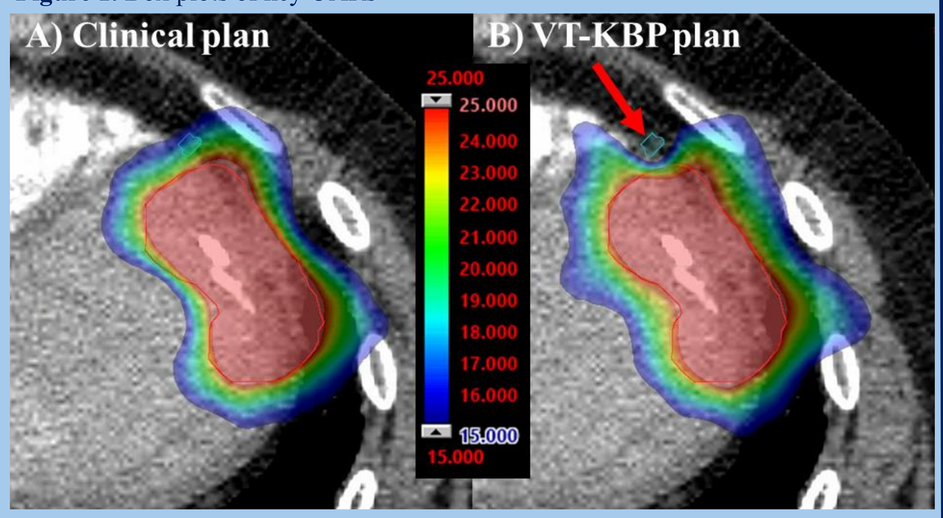

Figure 2. Plan comparison showing LAD sparing with VT-KBP

Planning Efficiency:

- Across Cases 1–3, VT-KBP improved planning efficiency relative to treatment planners with limited experience (31.33 ± 5.69 min vs 40.92 ± 17.61 min)
- The largest benefit was observed in the most challenging case, Case #3, where VT-KBP reduced planning time from 59 to 25 minutes
- VT-KBP demonstrated tighter high-dose conformity and intermediate-dose spillage, reflected by improved CI100% and CI50% values relative to the manual plans (CI100%: 0.97 ± 0.03 vs 0.99 ± 0.04; CI50%: 3.66 ± 0.73 vs 3.72 ± 0.62).

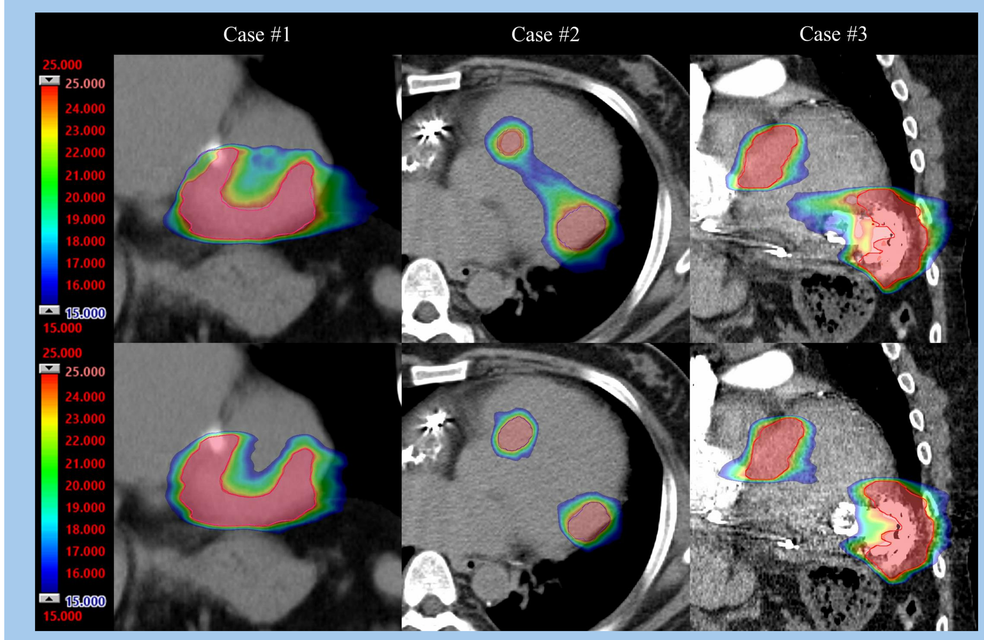

Figure 3. Treatment plan comparison for three randomly selected cases replanned by four manual planners. Top row: manual replans; bottom row: corresponding VT-KBP plans.

CONCLUSIONS

- The VT-KBP model consistently generated clinically acceptable treatment plans across heterogenous targets
- VT-KBP improved OAR sparing while reducing planning time and interplanner variability
- These results support KBP as a promising approach for improving plan quality, consistency, and workflow efficiency
- Additional validation and clinical integration are warranted to support broader adoption

REFERENCES