Radioablation for Refractory Ventricular Tachycardia

Matthew Susen M.B.A, MS CMD (R)(T), Nathan Yu MD, Hicham El Masry MD, Jennifer Swartz BSRT (R) (M) (T) CMD, Quan Chen PhD
Division of Radiation Oncology, Mayo Clinic Arizona

BACKGROUND

Refractory ventricular tachycardia (RVT) is a rapid heart rhythm that originates in the ventricles. This is a potentially life-threatening cardiac condition with risk of fainting, heart failure, or sudden cardiac arrest if left untreated. Invasive surgical ablation has historically been the primary method to treat for this condition, but surgery isn't always successful in eliminating the issue of cardiac arrhythmias and further attempts are necessary.

ABSTRACT

The risks of invasive surgery become increased with multiple attempts to ablate an RVT. This in turn had cardiologists looking to radiation for noninvasive alternative treatment options.
Mayo Clinic Radiation Oncology and Cardiology have collaborated to develop an alternative option for RVT patients. Utilizing photon stereotactic body radiation therapy, a one fraction dose may eliminate the arrythmia. However, radiation as a treatment option should be considered with caution over surgical procedures due to similar associated cardiac risks and radiation side effects.

FIGURE 1.0 CT Simulation Immobilization Devices

METHODS

Both a 10 phase 4DCT and DIBH scan were obtained during simulation with the patient laying in treatment position. These were evaluated for reproducibility (repeated 5 times). A specialty physics consult was performed creating an average and MIP scan from 10 phase 4DCT.

The GTV is determined by mapping the arrythmia from electrocardiogram imaging and matching desired area to our simulation scan to develop a target volume.

The gross target volume in combination with the 4D imaging helps develop an expansion to create an internal target volume. Lastly, a planning target volume expansion to account for set up error to create the PTV designated PTVHeart. No additional cardiac substructures were drawn by dosimetry for this case. The heart, stomach, liver, spinal cord, lungs, esophagus, and great vessels were contoured as organs at risk with clinical goals for dose constraints.

For treatment planning, the 0%-80% phases used in the eclipse planning DIBH Gating scan. Two partial coplanar arcs; one clockwise and with opposing counter crosswise with collimators set to 0^0 and 90^o. Beam energy set to 10x FFF (flattening filter free) for VMAT optimization.

Treatment matched the simulation with the patient laying supine with legs under gray sponge in a mask over thorax with arms above head facing forward. The immobilization devices are depicted in Figure 1.0 to the bottom left. Image guidance using cone beam CT aided in accurately treating target to 25 Gy in a single fx patient while the patient was NPO for 6hr prior to treatment.

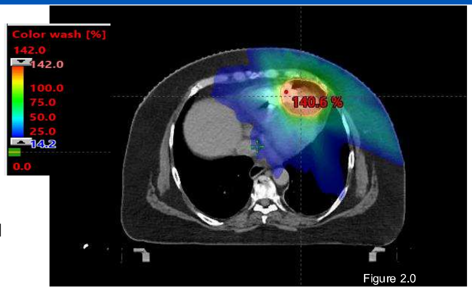


Figure 2.0

Figure 3.0

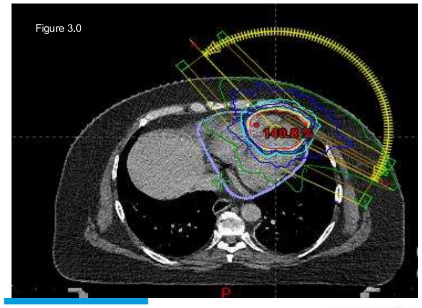
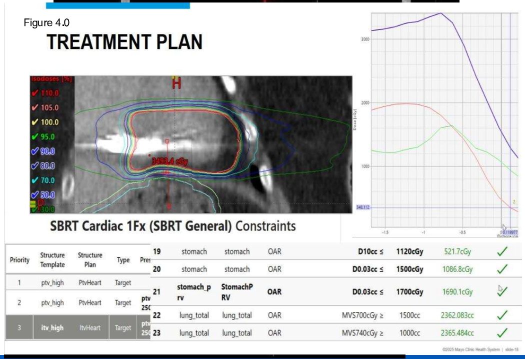


Figure 4.0



RESULTS

Running VMAT optimization, the dosimetrist achieved rapid dose fall off due to a hot spot over 140% noted in color wash in figure 2.0. Clockwise arc one gantry 320-120º delivered 3804 MU and counterclockwise 120-320º arc delivered 4028MU gantry (figure 3.0) The partial arc therapy avoids dose to the contralateral lung and spinal cord with minimal dose to the ipsilateral lung. Images of beam orientation are Minimal number of arcs used to achieve dose constraints surrounding the target. (Figure 4.0)

DISCUSSION

Patient was successfully treated in single fraction SBRT using image guidance of fluoroscopy to check correct phases in sync with the gated window. Gated CBCT aligning to Itv and Ptv, and soft tissue/bony anatomy. Therapists fluoro to confirm target in sync with the gate window

The 10x flattening filter free beam allows for faster treatment delivery for significant number of MUs per arc. Collimator set to 0 and 90 in this case to aid in sharper penumbra to achieve sharp dose fall off to lung and stomach prv OARS. This was a primary goal for treatment planning provided from radiation oncologist.

No cardiac substructures drawn by dosimetry. However, additional cardiac structures would be beneficial for observing radiation side effects such as the ventricles and atria.

Reduced refractory ventricular events at 2 months post treatment. These events are recorded by an implanted cardioverter-defibrillator. ICD which is contoured and monitored in treatment planning

CONCLUSIONS

Efficacy of this procedure are reviewed from counting ventricular tachycardia via implanted cardioverter-defibrillator [(1)]

This treatment is novel in Arizona and studies are currently being performed to investigate proper targeting and dose there is the potential for patient harm and should be cautiously considered until further studies have provided evidence for

Limiting radiation dose to other heart structures is critical for safety and surgery should be considered at this point due to limit patient numbers for this procedure. This patient previously had two failed surgical ablations and SBRT Radioablation was a last resort unless heart transplant became[2)] available.

REFERENCES

1. Noninvasive cardiac radiation for ablation of ventricular tachycardia

N Engl J Med, 337(2017), pp 23225-2336

Phillip S. Cuculich, M.D., Matthew R. Schill, M.D., Rojano Kashani, Ph.D., Sasa Mutic, Ph.D., Adam Lang, M.D., Daniel Cooper, M.D., Mitchell Faddis, M.D., Ph.D., Marye Gleva, M.D., Amit Noheria, M.B., B.S., Timothy W. Smith, M.D., D.Phil., Dennis Hallahan, M.D., Yoram Rudy, Ph.D., and Clifford G. Robinson, M.D

2. **Radiation Therapy Workflow and Dosimetric Analysis from a Phase 1/2 Trial of Noninvasive Cardiac Radioablation for Ventricular Tachycardia**

International Journal of Radiation Oncology Biology Physics Vol 104 issue 5, Aug 2019 pp 1114-1123

Nels C. Knutson PhD [a], Pamela P Sampson, MPHS, Geoffrey D. Hugo PhD, S. Murty Goddu PhD [a], Francisco J. Reynoso PhD, James A. Kavanaugh MS, Sasa Mutic PhD, Kaitlin Moore BS, Jessica Hilliard MS · Phillip S. Cuculich MD , Clifford G. Robinson MD