Non-Invasive Mapping and Radio-ablation of Refractory Ventricular Tachycardia

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Introduction

Refractory ventricular tachycardia (VT) is a challenging clinical scenario, particularly when unresponsive to catheter ablation1. Fortunately, novel technologies are available to map arrhythmia sources and deliver targeted therapy using non-invasive methods1-3. Here we present a case of a patient with refractory VT originating from the interventricular septum who continued to have arrhythmia episodes despite aggressive catheter ablation and antiarrhythmic drug therapy who was successfully treated with stereotactic ablative radiotherapy (SAbR), with effective arrhythmia suppression out to 11 months.

Case Presentation

The patient is a 69-year-old male who noted the onset of ventricular tachycardia and was diagnosed with congestive heart failure with a left ventricular ejection fraction of 35%. He underwent biventricular implantable cardioverter-defibrillator (Bi-V ICD) implantation and was started on guideline-directed medical therapy. He presented 1 month later with 3 ICD shocks and was started on sotalol. He underwent VT ablation and was transitioned to amiodarone. ICD shocks continued, and he was transferred to UCSD for management.

At UCSD he underwent electrophysiology study and catheter ablation, which localized the source of the arrhythmia to the interventricular septum. Aggressive bipolar ablation from both sides of the interventricular septum was attempted but was unsuccessful. He continued to experience frequent ICD shocks despite treatment with amiodarone, sotalol, and mexiletine, resulting in a low quality of life.

At this point, it was decided to attempt noninvasive mapping and ablation. A 12-lead ECG of the clinical VT was analyzed using a novel arrhythmia-mapping algorithm (vMap, Vektor Medical, Carlsbad, CA), which localized the arrhythmia substrate in a 3-dimensional computational model of the heart (figure, panel A, red area). This information was transferred to the SAbR planning software (Varian, Palo Alto, CA) and contoured onto a free-breathing computed tomography (CT) scan. A total of 25 Gy of ionizing gamma radiotherapy was delivered to the target volume (figure, panel B, orange region) at end-expiration, guided by ICD lead movement during respiration. The stereotactic ablation procedure was completed in just 30 minutes, and the patient was discharged home after the procedure.

The patient's shock burden decreased from 34 ICD shocks in the 6 months preceding SAbR therapy to 0 ICD shocks in the 11 months after treatment. His quality of life improved significantly, and he has resumed an active lifestyle.

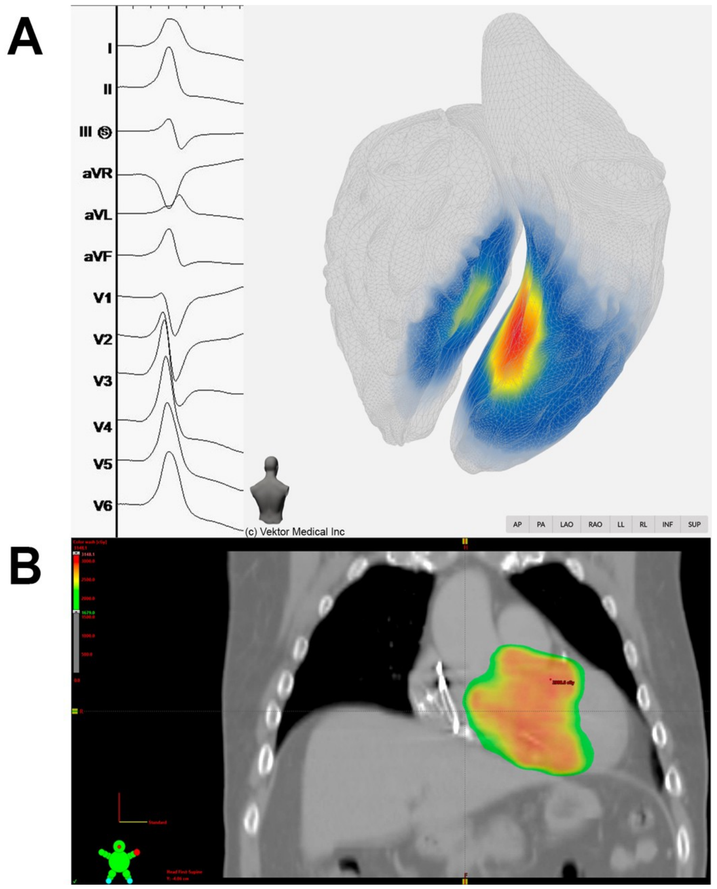

Figure 1. Imaging from novel noninvasive mapping and ablation procedure
(A) 3D computational heart model using the novel arrhythmia mapping algorithm vMAP (Vektor Medical, Carlsbad, CA). The origin of the arrhythmia was mapped to the interventricular septum (red region) (B) SAbR planning software (Varian, Palo Alto, CA) correlated the arrhythmia mapping onto a CT scan. With the CT scan, a total of 25 Gy ionizing gamma radiotherapy was delivered to the targeted area (orange region).

Discussion

While percutaneous catheter ablation remain a core treatment option for ventricular arrhythmias, acute and long-term procedural success rate range widely from 38%-77%1.

Sub-optimal ablation response can occur for a variety of reasons including if the arrhythmia is unable to be induced for mapping, the arrhythmia originating close to critical structures, or if the arrhythmia comes from mid-myocardial or cardiac summit regions.

Stereotactic radioablation has shown tremendous promise in recent years, allowing non-invasive ablation of VT. Short term radioablation therapies have demonstrated significant reduction in total VT burden in several studies2.

However, the long-term effects of radiotherapy and its potential side effects require further investigation. One of the limitations of radiotherapy is the radiation exposure of adjacent structures to the targeted site such as the normal myocardium, coronary arteries, cardiac valves, esophagus, and stomach. Given that radiation side effects to normal myocardium, coronary arteries, and valves may take months or years to manifest, clinicians need to weigh the risks and benefits of the procedure including accounting for patient's overall clinical situation and risk-to-benefit ratio2.

Conclusion

In select cases, VT may be refractory to guideline-directed catheter ablation and antiarrhythmic drug therapy. Non-invasive computational mapping based upon the 12-lead ECG and respiratory-gated stereotactic radiotherapy offer an alternative approach for such patients. Larger, multicenter studies are required to validate these findings in larger populations.

References

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