Implantable Cardioverter Defibrillator Lead Tip as a Surrogate Fiducial for Non-Invasive Cardiac Radioablation of Ventricular Tachycardia

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Background

- Noninvasive cardiac radioablation is increasingly being used for patients with treatment refractory ventricular tachycardia
- Accounting for target motion from both cardiac and respiratory motion is a significant challenge
- The implantable cardioverter defibrillator (ICD) lead tip has been proposed as a surrogate fiducial
- We aimed to quantify motion to evaluate if an ICD lead tip could be a reliable surrogate for target motion

Methods

- Raw CBCT projection data from day of treatment delivery from 6 patients receiving noninvasive cardiac radioablation was acquired
- Right ventricular ICD lead tip was manually segmented for each patient and used to generate a model that could be used to measure lead tip position in each projection and generate a 3D trajectory
- Range of motion and average amplitude (peak to trough) during CBCT acquisition were measured overall motion, and then filtered for respiratory and cardiac motion components individually

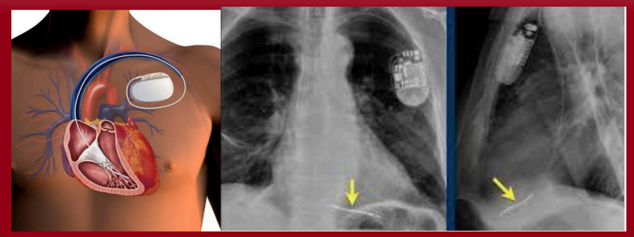

Figure 1: Most patients with a history of ventricular arrhythmias will have an ICD, which may have one or more leads. In this analysis, we examined movement of the right ventricular lead.

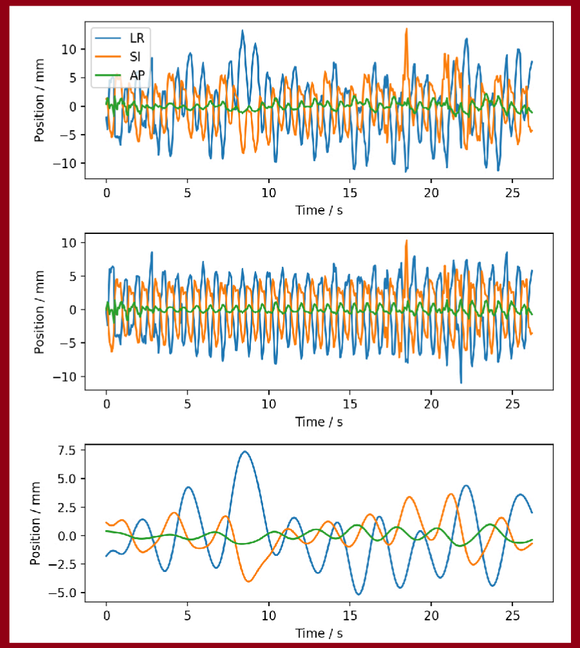

Figure 2: ICD lead tip motion patterns for an example patient: The top row shows combined movement, middle shows cardiac movement, bottom shows respiratory movement

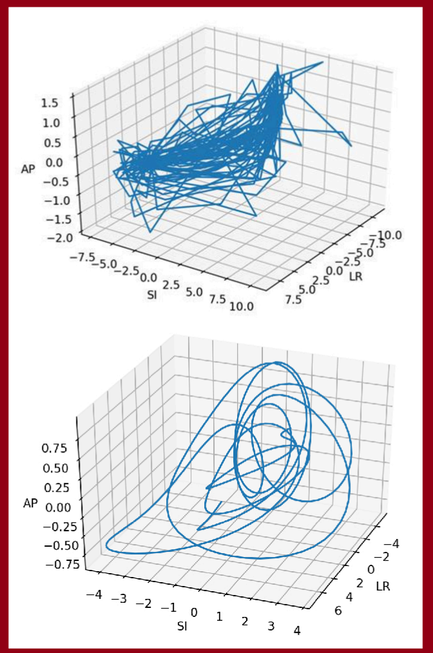

Figure 3: ICD lead tip 3D trajectory for the same patient: the top row shows the cardiac motion component, the bottom shows the respiratory component.

Take a picture to be directed to the **Center for Noninvasive Cardiac Radioablation (CNCR)**

Results: Motion Ranges of ICD Lead Tips

	Left-Right	Anterior-Posterior	Superior-Inferior
Mean Cardiac Motion (in mm, with range)	10.2 (15)	5.8 (7.5)	9.9 (13.9)
Mean Respiratory Motion (in mm, with range)	5.8 (9.1)	3.6 (3.9)	7.3 (9.6)
Overall Mean Motion (in mm, with range)	12.9 (19.4)	7.8 (9.8)	13.9 (13.5)

Results: Amplitude Range of ICD Lead Tips

	Left-Right	Anterior-Posterior	Superior-Inferior
Mean Cardiac Amplitude (in mm, with range)	4.7 (10.7)	2.3 (3.0)	4.5 (6.7)
Mean Respiratory Amplitude (in mm, with range)	3.2 (4.7)	1.4 (1.7)	1.8 (3.9)
Overall Mean Amplitude (in mm, with range)	5.2 (10.4)	2.6 (2.9)	5.2 (5.5)

The mean ejection fraction (EF) was 30% (normal >55%) and there was a negative correlation between increasing EF and cardiac LR range (-0.87, p=0.02).

Conclusions

- Using the ICD lead tip as a surrogate fiducial shows **substantial variations** in range and amplitude in three-dimensions
- This movement may be correlated with a patient's heart function.
- Notably, the hemodynamics of lead tip movement in the right ventricle may **not be an appropriate surrogate** for left ventricular targets

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