

Computerized ECG Mapping and Cardio-Respiratory Motion Management Strategies to Improve Efficiency and Precision of Non-Invasive Radiotherapy for Refractory Ventricular Tachycardia

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INTRODUCTION

- Non-invasive stereotactic radiotherapy (SAbR) is a promising therapy for refractory ventricular tachycardia.
- The current workflow requires many time intensive steps.
- The effect of cardiac and respiratory motion on targeting precision is unknown.

OBJECTIVE

We hypothesized that a strategy combining computerized 12-lead ECG mapping and respiratory-gated therapy may improve the efficiency and precision of SAbR and enable safe therapy in inferior wall targets near the stomach.

METHODS

- Under an IRB-approved protocol, patients with refractory VT were retrospectively studied at 2 hospitals (UC San Diego and Mills-Peninsula Sutter Health medical centers).
- Non-invasive programmed stimulation was performed using the ICD. VT exit sites were localized in 3D using a custom automated computational simulation-based ECG algorithm.
- Respiratory gated therapy was performed at end-expiration when respiratory motion ≥ 0.6 cm, using an external optical surface tracking system to evaluate thoracic motion (AlignRT, Vision RT, London, UK)
- 25 Gy of ionized radiation was delivered in all patients.
- Statistical analysis was performed using Student's and paired t-test for numerical data or Fisher's exact test for proportions analysis using SPSS v27.

RESULTS

Figure 1. An efficient workflow for non-invasive target planning and respiratory-gated delivery was successfully performed in 6 patients.

1. Automated 12-lead ECG mapping was performed in all patients to identify the VT exit site(s) at non-invasive EP study and displayed on a 3D model. **4.2 ± 2.3 VT morphologies/patient were mapped non-invasively; 100% of ECG-mapped sites colocalized to the same cardiac segment when compared with prior available invasive mapping.**
2. The need for respiratory gating was determined if there was ≥ 6 mm respiratory motion during simulation 4DCT.
3. The VT target was planned using both ECG-mapping and substrate imaging and contoured onto the simulation 4DCT.
4. For patients assigned to respiratory gating, therapy was configured to deliver radiation during a pre-specified window at end-expiration using an external optical surface tracking system to evaluate thoracic motion. **Respiratory gating correlated with smaller planning target volumes compared to non-gated patients (71 ± 7 vs 153 ± 35 cc, $p < 0.01$).**

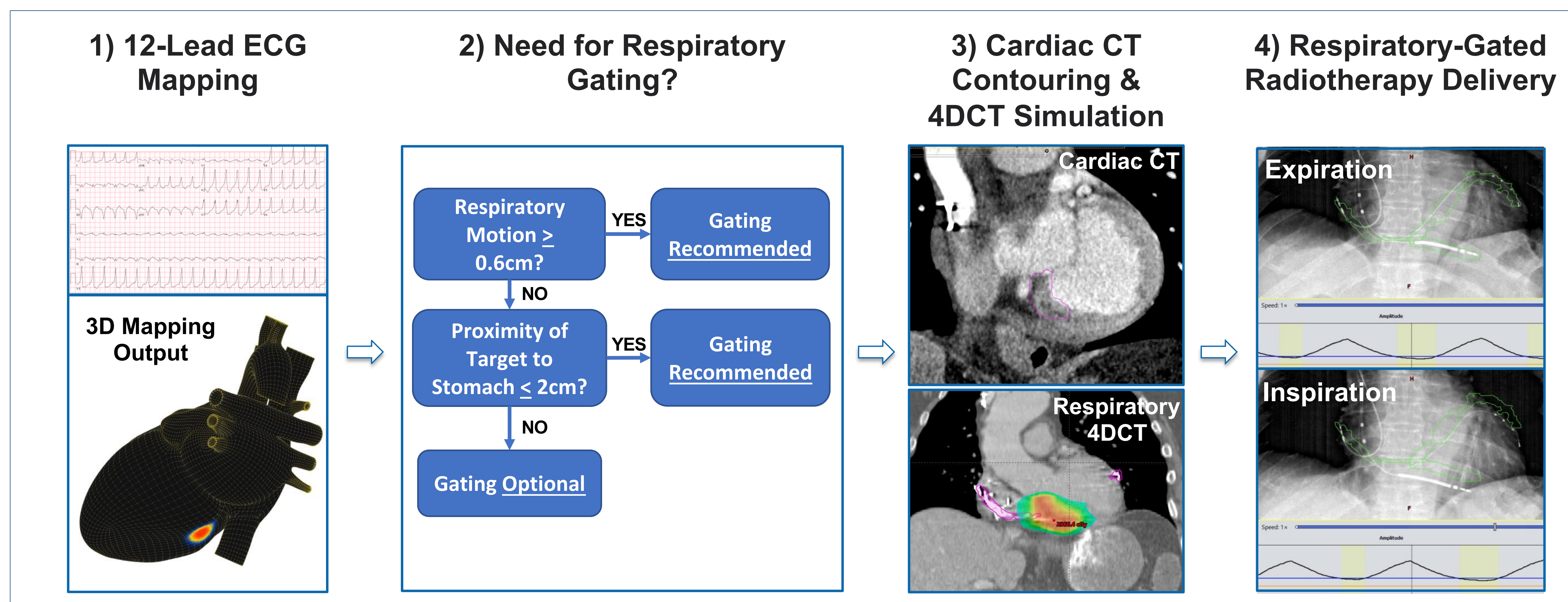
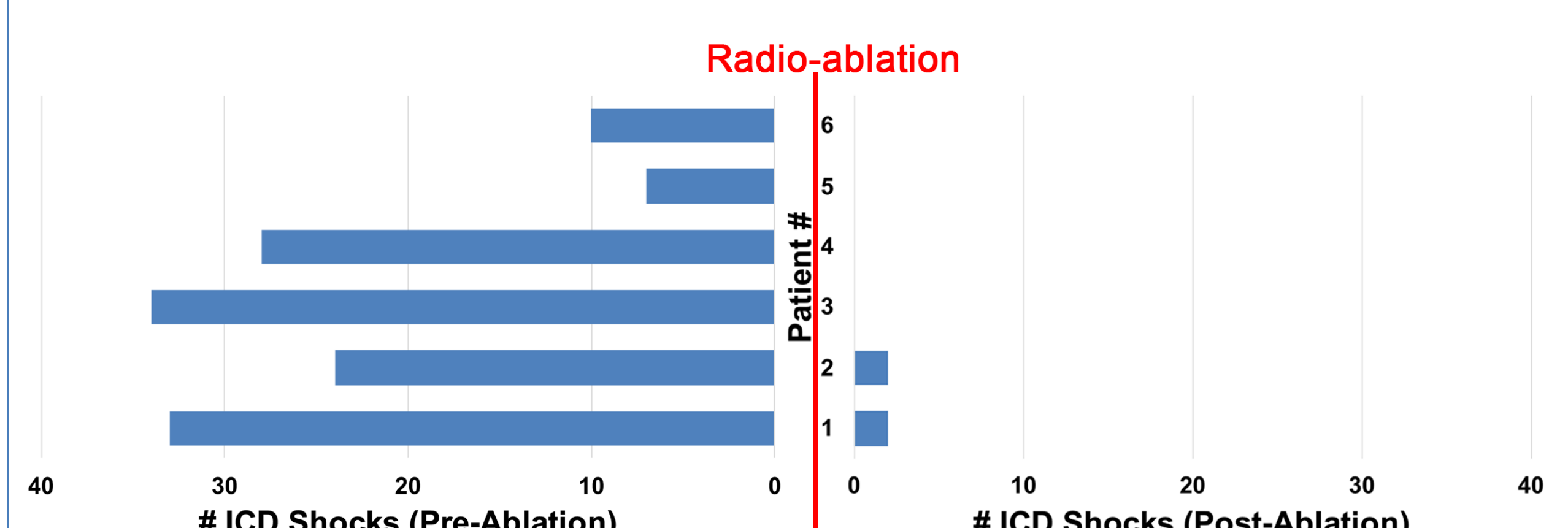


Table 1. Study patient characteristics

Subject #	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6
Age	76	77	69	81	66	64
Gender	M	M	M	M	M	M
LV EF	23	40	46	27	10	25
Cardiomyopathy Type	NICM	ICM	NICM	NICM	ICM	NICM
NYHA Class	IV	III	III	IV	IV	IV
Failed AAD	4	2	2	2	1	5
Failed Catheter Ablations	3	3	3	1	1	2
Pre-Ablation ICD Shocks	33	24	34	28	7	10
VTs Induced	6	4	2	1	5	7
VT Locations	Basal septum, LV summit, anterior mitral annulus	Epicardial basal inferoseptal RV and LV (crux)	Mid-septum	Mid anterolateral LV	Inferior mid and apical LV	LV summit, anterior mitral annulus
VT Cardiac Segment*	1, 2, 6	3, 4, 23	8, 9	12	15, 17	1, 2, 6
Scar Location	Basal septum, perimitral	Inferior basal RV and LV	Septum	Inferolateral, anterolateral LV	Inferior wall	Basal septum, anterolateral LV

Figure 2. ICD shocks before and after therapy

ICD shocks decreased from 23 ± 12 shocks/patient to 0.67 ± 1.0 post-SAbR at 6 \pm 5 months follow-up ($p < 0.001$, 97% relative reduction).



CONCLUSIONS

- A novel non-invasive mapping and gating strategy improved workflow efficiency and significantly reduced ICD shocks.
- Protocol-guided use of respiratory gating delivered precise and safe therapy in patients with targets close to the stomach.

DISCLOSURES

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