

# LEFT VENTRICULAR SUMMIT VT

Kyoung-Min Park, MD PhD

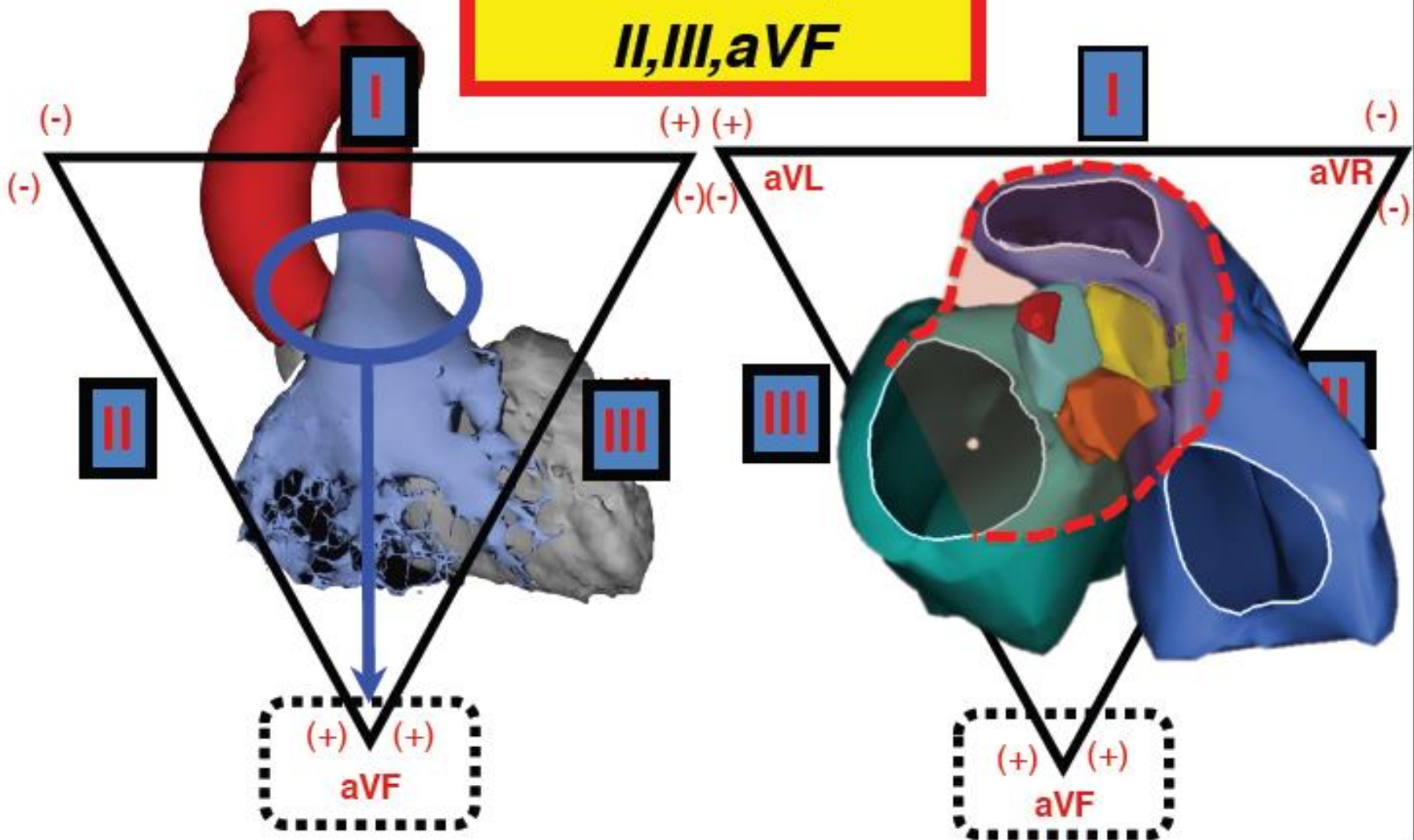
Division of Cardiology, Department of Medicine  
Heart Vascular Stroke Institute

Samsung Medical Center, Sungkyunkwan University School of Medicine

# Outflow Tract Ventricular Arrhythmias

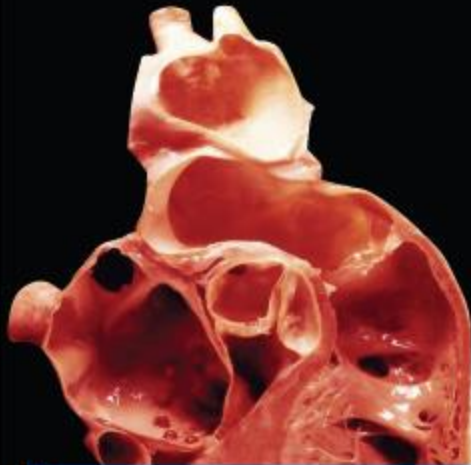
## Definition

**Positive QRS  
II,III,aVF**

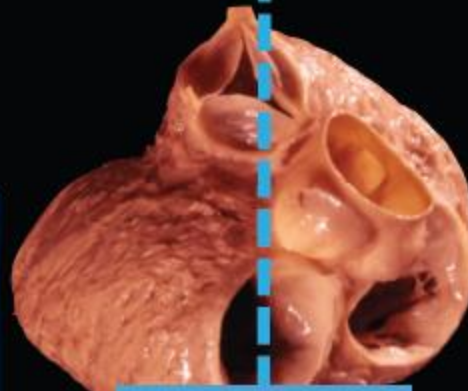
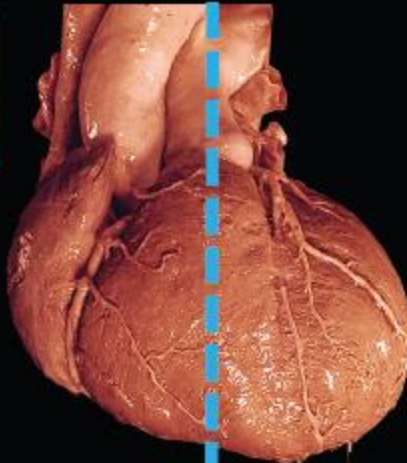


**Right side of midline**

Positive in lead I  
More (-) aVR than aVL



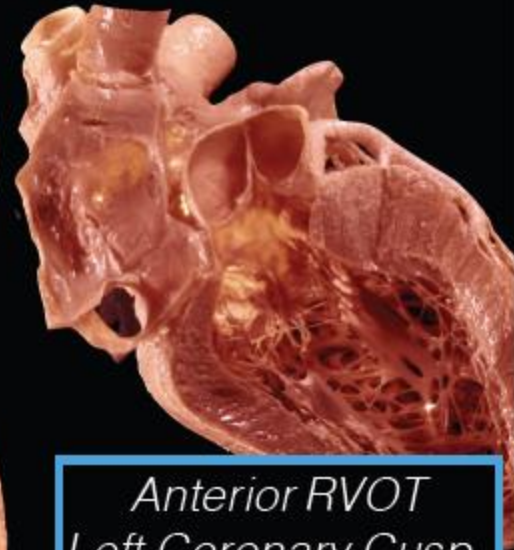
Posterior RVOT  
Parahisian  
Tricuspid Valve  
Right Coronary Cusp  
PSP-LV



R-L Junction

**Left side of midline**

Negative in lead I  
More (-) aVL than aVR



Anterior RVOT  
Left Coronary Cusp  
Mitral valve  
LV summit/Epi  
LV septum

QS V1

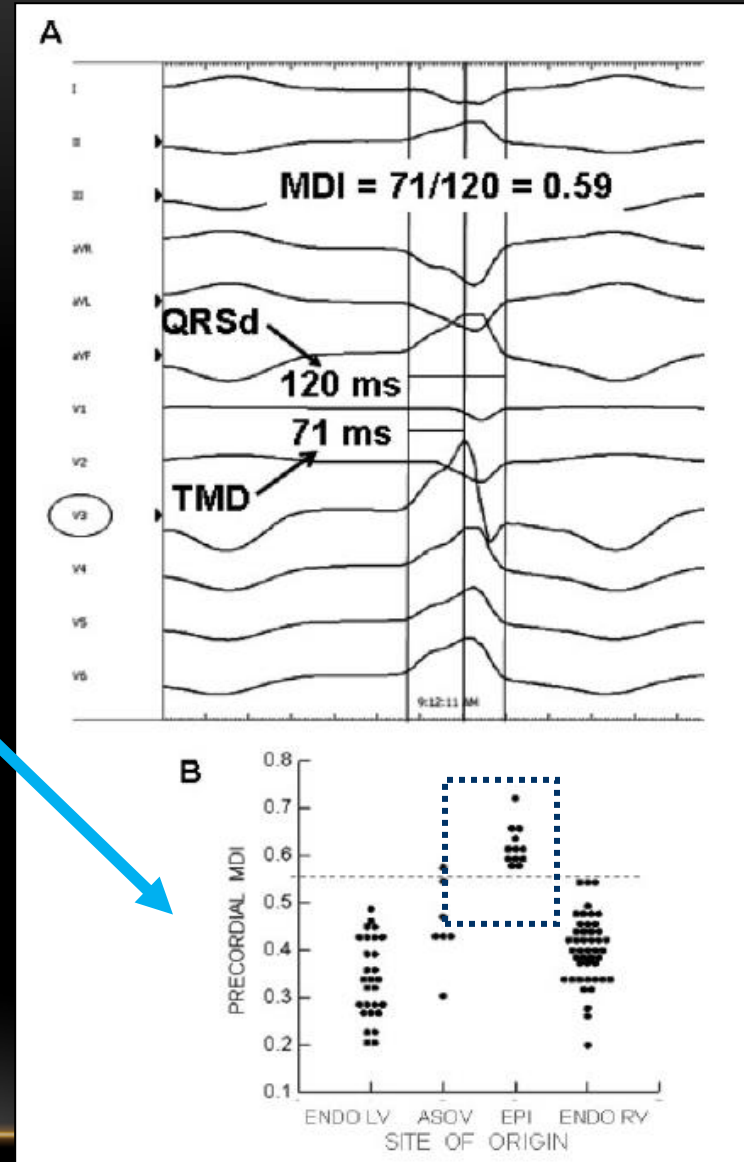
"w" pattern or Notched downstroke

# Epicardial LVOT Patterns

- *Timing - Slow conduction in initial portion of QRS (precordial leads)*
- **Maximum deflection index (MDI) = QRS onset to maximum precordial deflection / QRS duration > .55**

## Morphologic clues – less sensitive but **specific**

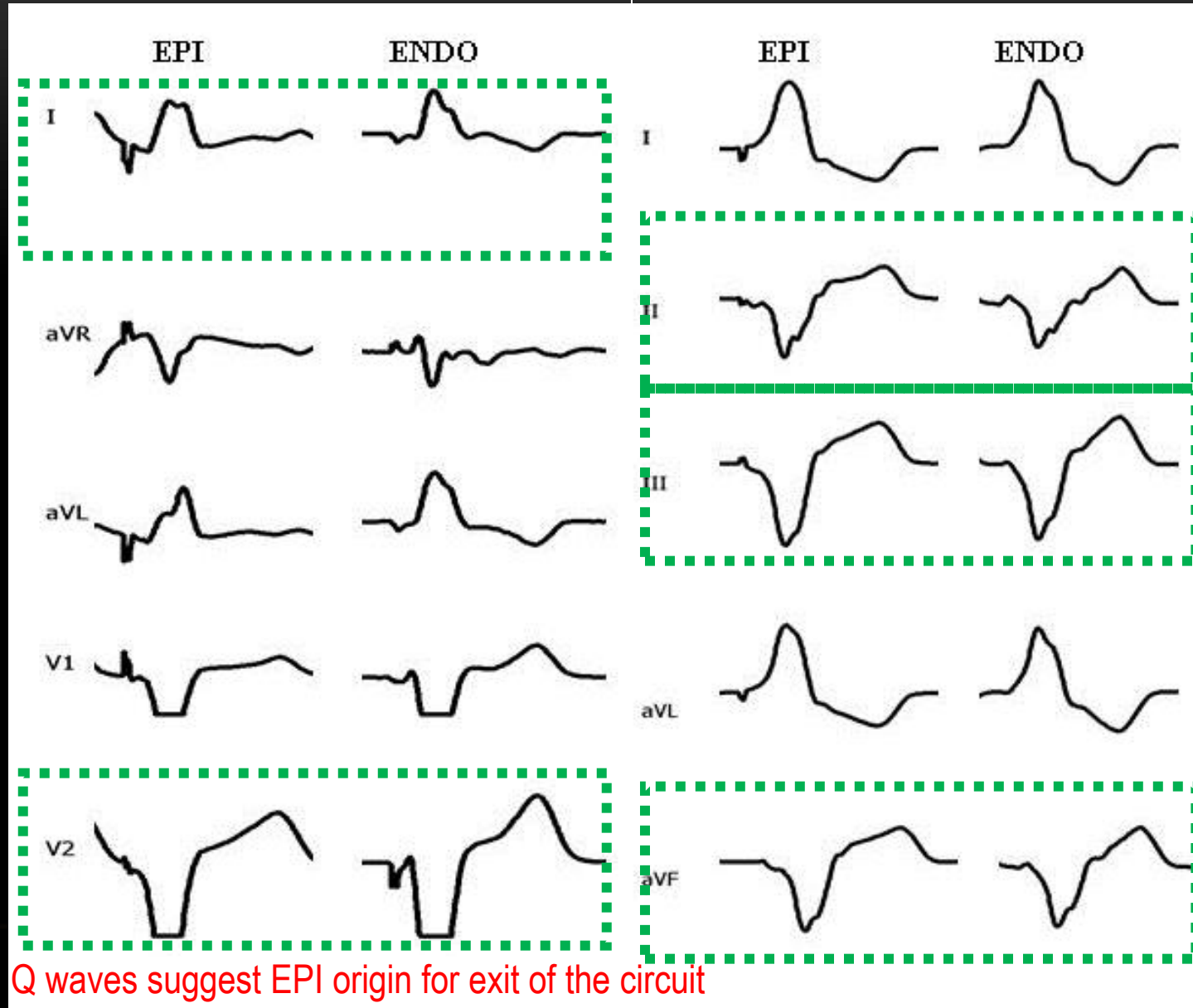
- *QS in lead 1 (anterolat - GCV)*
- *QS in 2,3,avF (Inferior - MCV)*  
(Bazan et al Heart Rhythm 2007; 4(11):1403)
- **Loss of R from V 1 to V2 (QS or rS) with prominent R by V3**
  - *In front of the aortic root - AIV*
  - *Reverse for Inferior (big V2 R) – MCV*



MDI - Adapted from Daniels et al Circulation 2006; 113: 1659-1666

ANTERIOR - Q in V2, 1

INFERIOR - Q in 2,3,avF

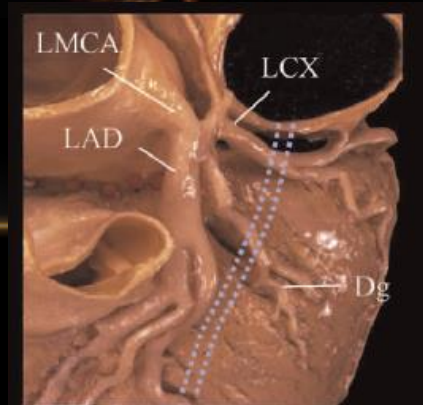
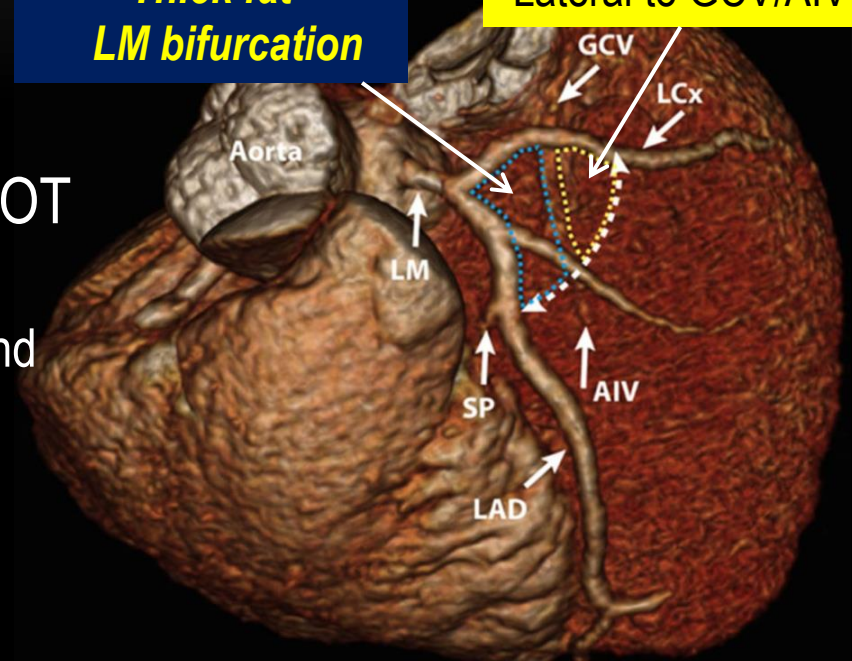


# LV summit: definition

- Highest site of the LV (summit)
- Triangular portion of the epicardial LVOT
- ✓ Bounded by the bifurcation of the LM (LAD and LCx)
- ✓ Transected laterally by the AIV/GCV junction
- ✓ Endocardial LV below LCC represents the opposite aspect of the LV summit

Inaccessible area  
Septal to GCV/AIV  
**Thick fat**  
**LM bifurcation**

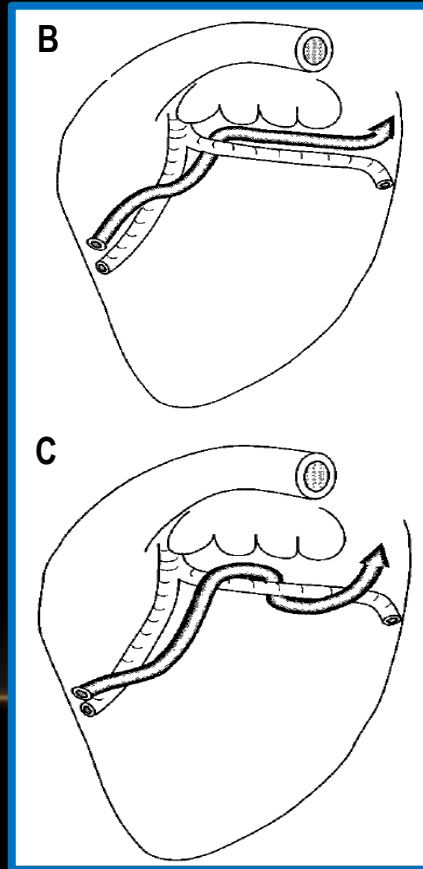
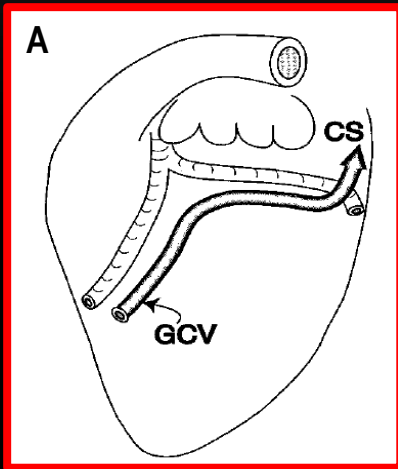
Accessible area  
Lateral to GCV/AIV



Santangei et al. Circulation EP 2015;8:337-43  
Yamada et al. Circulation EP 2010;3:613-23

# GREAT CARDIAC VEIN

## - Anatomical Variations



Relationships of GCV to AIA

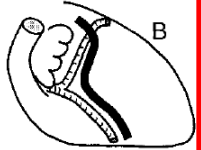
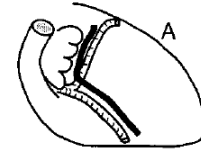
Relationships of GCV to CA

GCV origins left of AIA (no crosses of AIA)

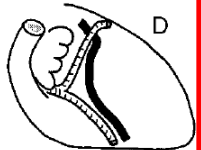
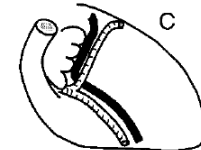
proximal crosses of CA

distal crosses of CA

superficial crosses of CA

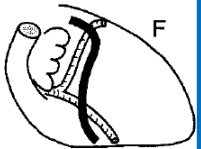
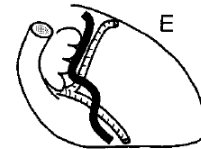


deep crosses of CA



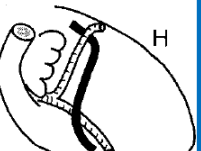
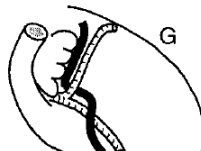
GCV origins right of AIA

superficial crosses of CA

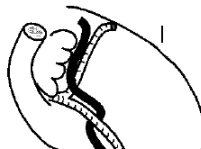


superficial crosses of AIA

deep crosses of CA

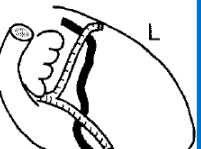
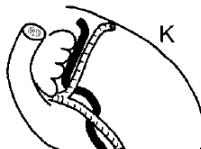


superficial crosses of CA



deep crosses of AIA

deep crosses of CA



**RAO**

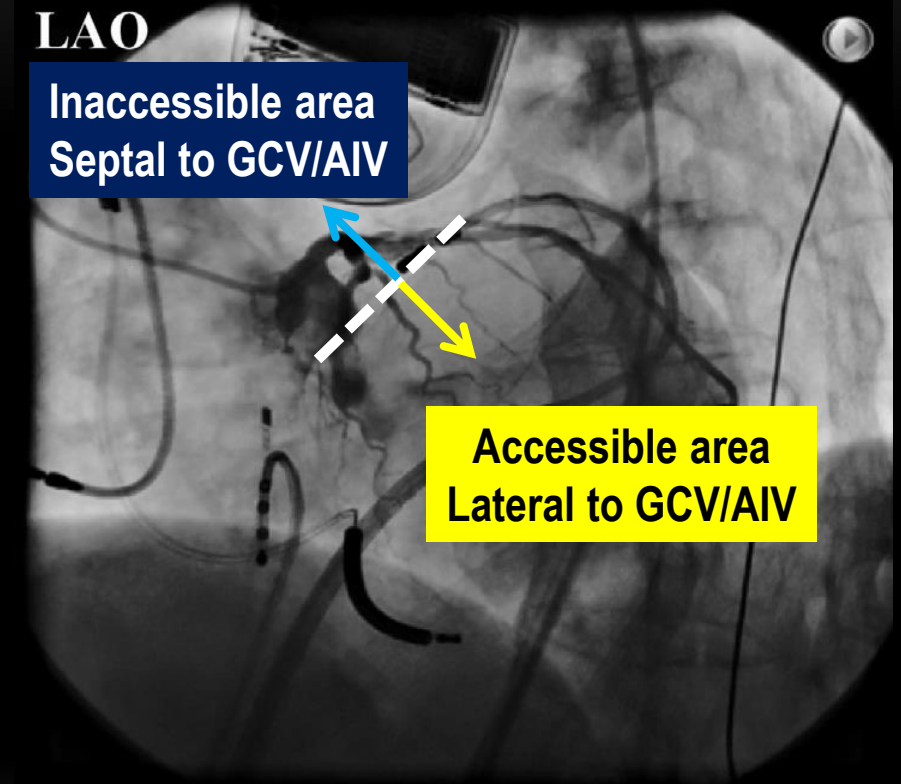
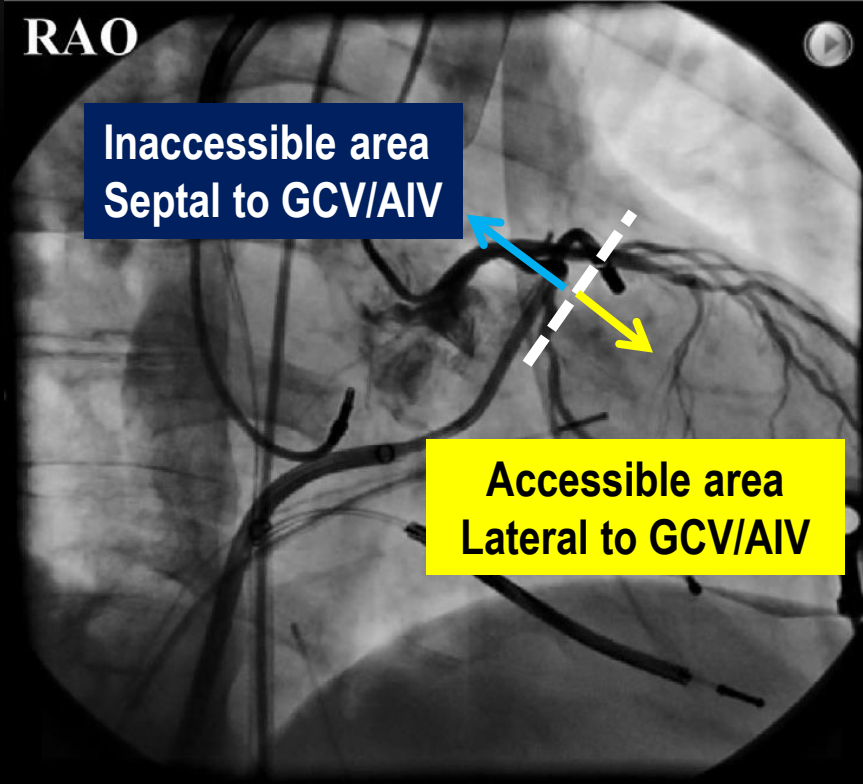
**Inaccessible area  
Septal to GCV/AIV**

**Accessible area  
Lateral to GCV/AIV**

**LAO**

**Inaccessible area  
Septal to GCV/AIV**

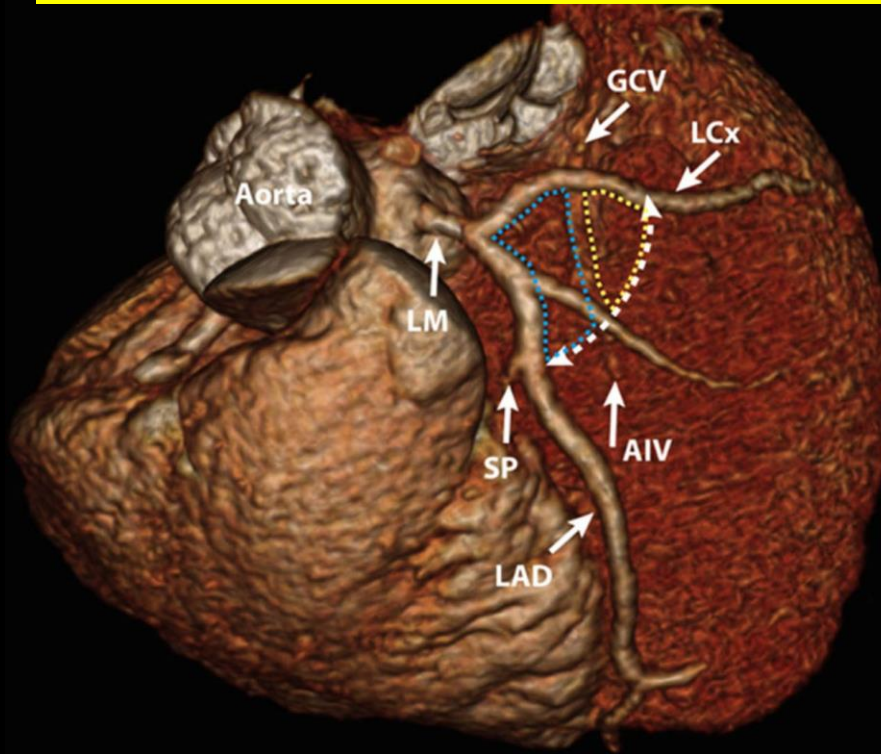
**Accessible area  
Lateral to GCV/AIV**





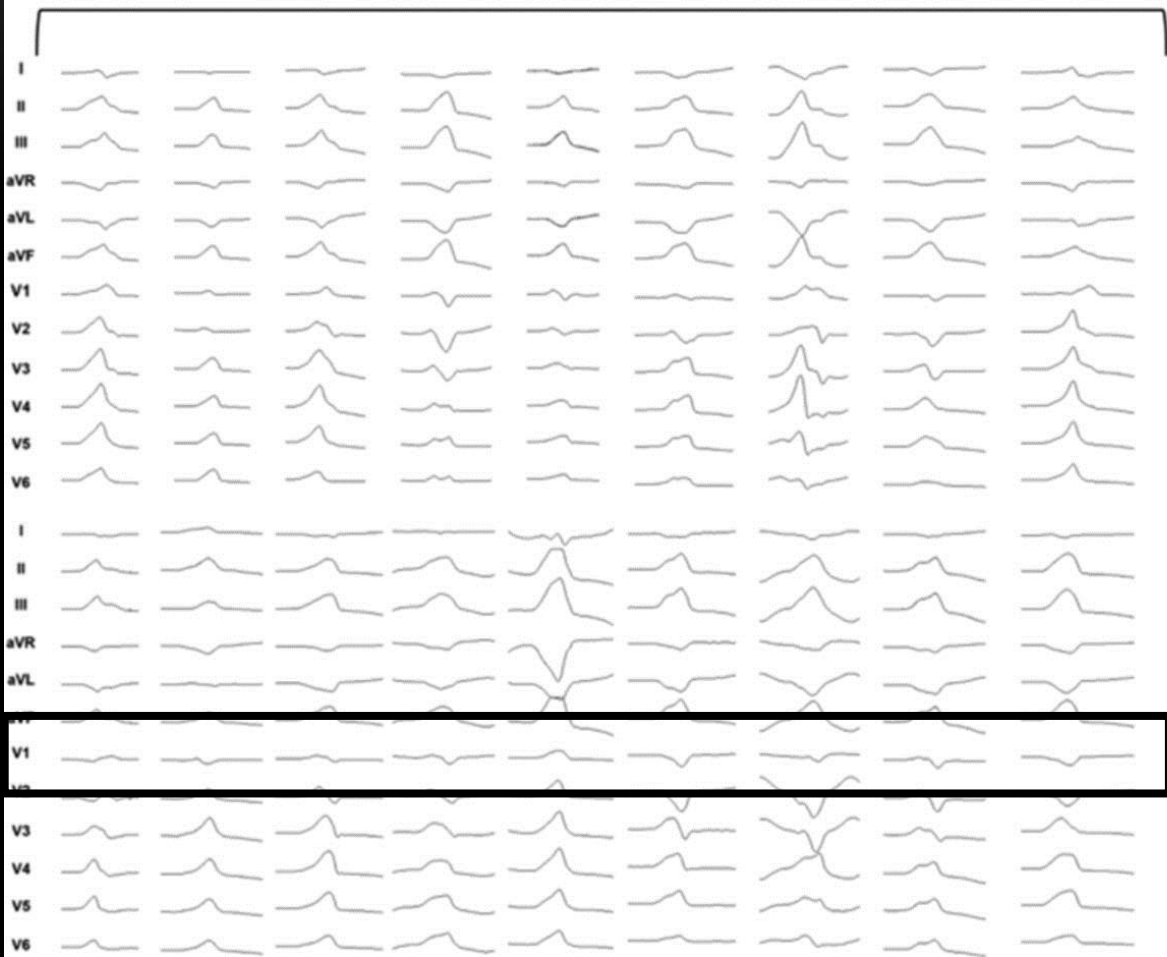
# ECG Features of Successful Epicardial Ablation

**Suggest origin away from LM bifurcation  
*Based of LV summit triangle***

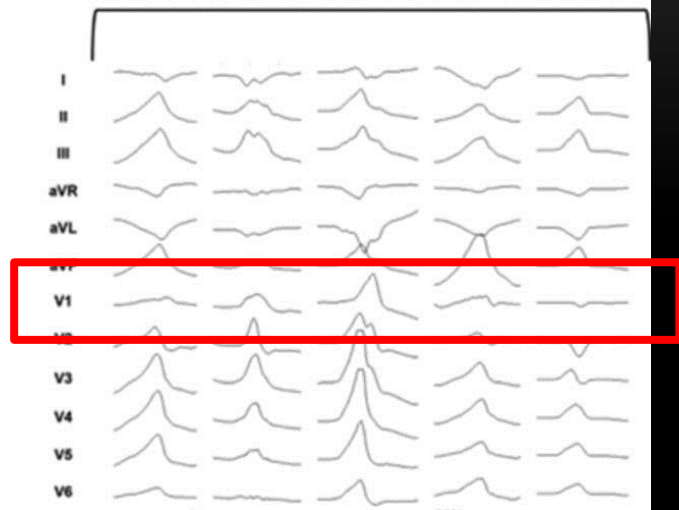


|                     | Successful EPI (n=5) | Unsuccessful EPI (n=18) |
|---------------------|----------------------|-------------------------|
| R/S wave ratio > 2  | 4 (80%)              | 5 (28%)                 |
| Q aVL/ Q aVR > 1.85 | 4 (80%)              | 2 (11%)                 |
| Initial "q" in V1   | 0 (0%)               | 6 (33%)                 |

### UNSUCCESSFUL



### SUCCESSFUL



# ABLATION FROM ADJACENT SITES

: Clues for successful ablation – better PM match with High output pacing  
(Index of anatomical proximity)

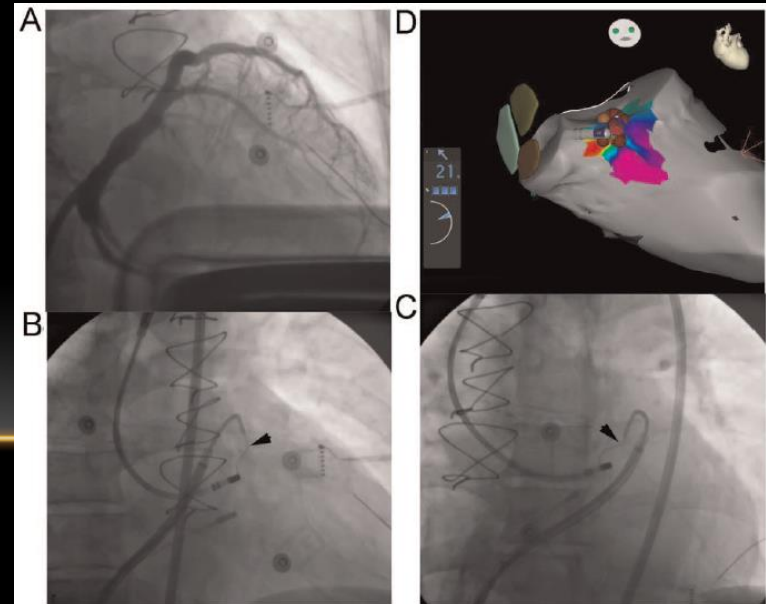
- LA appendage
- Adjacent RVOT (value of ICE)  
*- Frankel et al Circulation EP 2014;7:984-5*
- Ablation from LCC or adjacent endocardium of VT source near the AIV  
*- Abularach et al Heart Rhythm 2012;9:865-873*

# How to map and ablate left ventricular summit arrhythmias

Andres Enriquez, MD,<sup>\*</sup> Federico Malavassi, MD,<sup>†</sup> Luis C. Saenz, MD,<sup>†</sup> Gregory Supple, MD,<sup>\*</sup> Pasquale Santangeli, MD,<sup>\*</sup> Francis E. Marchlinski, MD,<sup>\*</sup> Fermin C. Garcia, MD<sup>\*</sup>

*From the <sup>\*</sup>Section of Cardiac Electrophysiology, Hospital of the University of Pennsylvania, Philadelphia, Pennsylvania, and <sup>†</sup>Centro Internacional de Arritmias Andrea Natale, Fundacion Cardioinfantil, Bogota, Colombia.*

- If the distance from the coronary arteries is not judged to be safe, ablation within the GCV/AIV is not technically feasible, or the earliest activation is recorded at a septal venous perforator, a first ablation attempt is performed from the LCC or LV endocardium, whichever is earliest and/or opposite to the earliest epicardial site marked by the catheters in the venous system.

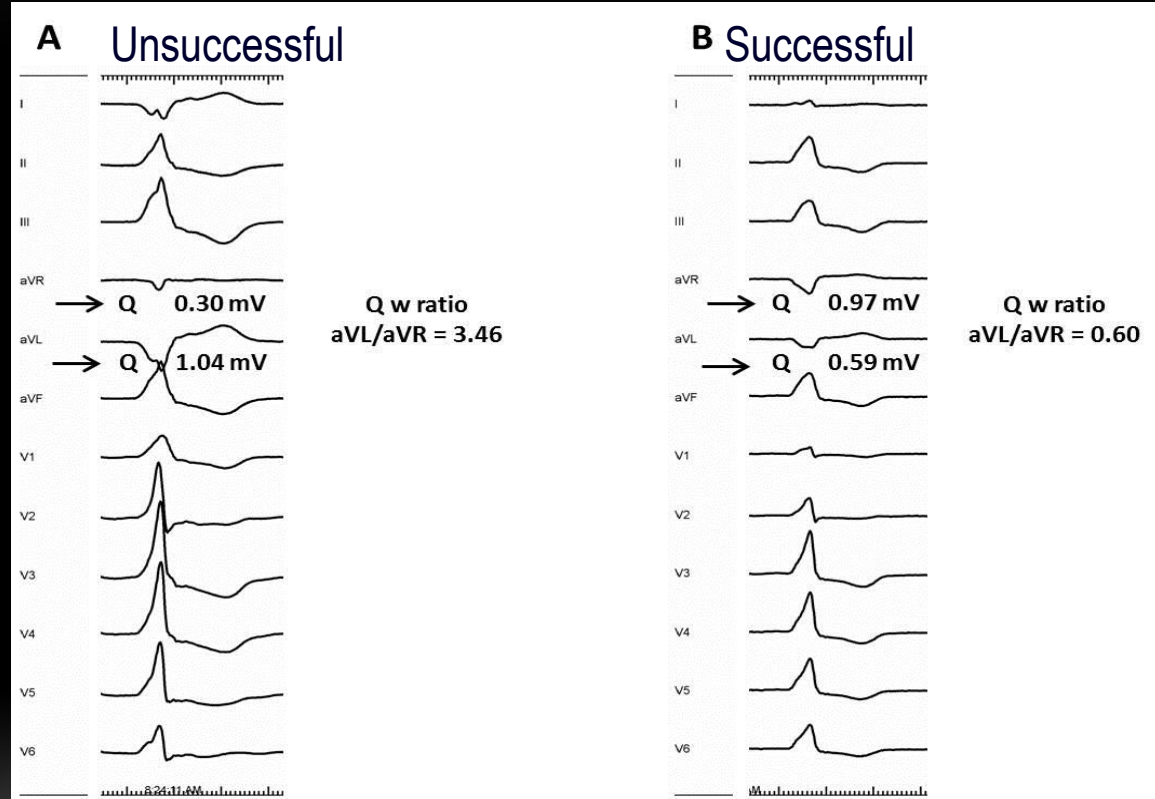
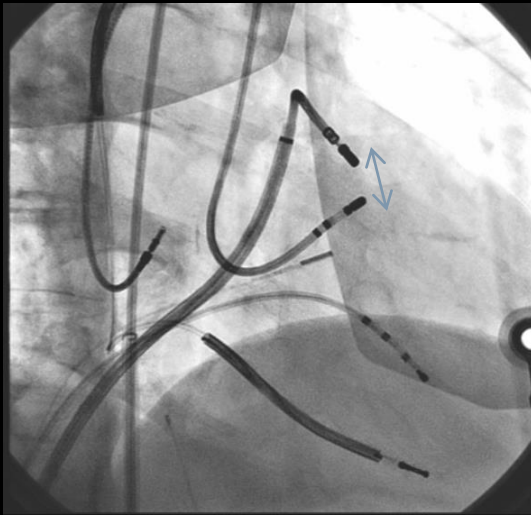
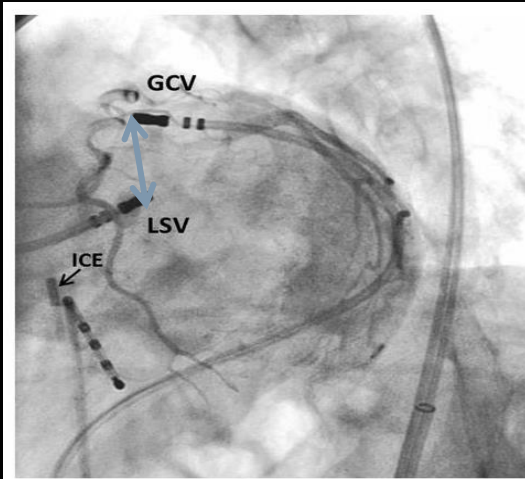


# ABLATION FROM LCC OR ADJACENT ENDOCARDIUM OF VT SOURCE NEAR THE AIV (EARLIEST SITE/BEST PM)

RATIONALE: AVOID CORONARIES/ EPI DIFFICULT

Anatomic Distance <13.5mm

Q wave ratio aVL/aVR - <1.45



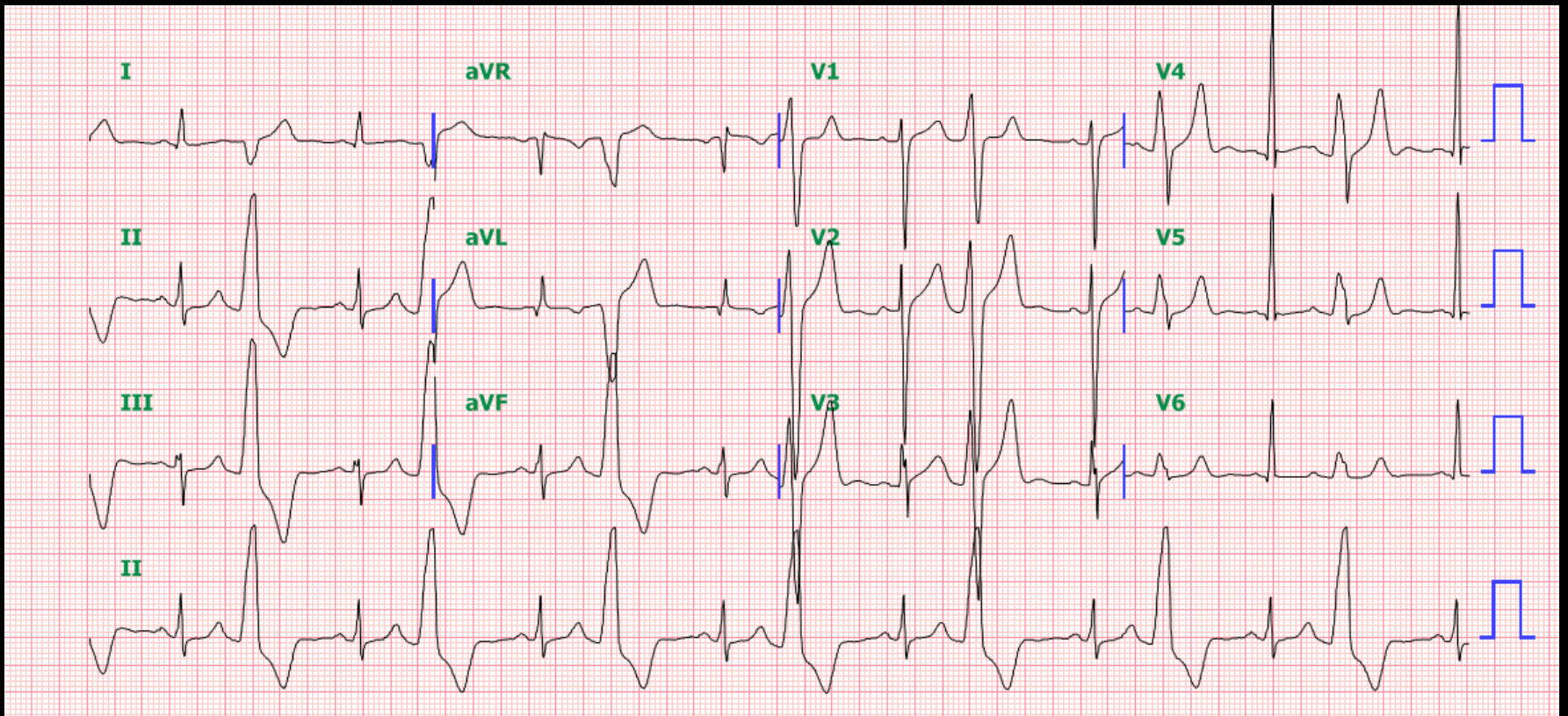
# Case

## BRIEF HISTORY

- 40 year-old male
- Dec 2014 Follow up every 3 month for symptomatic VPC (palpitation) in local hospital
- Mar 2016 Referred to SMC complaining of dyspnea & palpitation; VPC bigeminy and normal echoCG
- Jun 2016 VPC 34% in 24hr holter (36686 isolated, 42 couplets, 11 triplets, 15397 bigeminies), moderate LV systolic dysfunction (LVEF 35%)

- Jul 2016 1<sup>st</sup> RFCA was done
  - Sep 2016 Slightly improved symptom, but still large burden of VPC (26%, 28138 isolated, 1 couplet, 5 triplets, 15754 bigeminies) in 24hr holter
  - Oct 2016 Admission for 2<sup>nd</sup> RFCA; improved LV systolic function (LVEF 47.2%) in follow-up echoCG
-

# PRE-1<sup>ST</sup> RFCA ECG



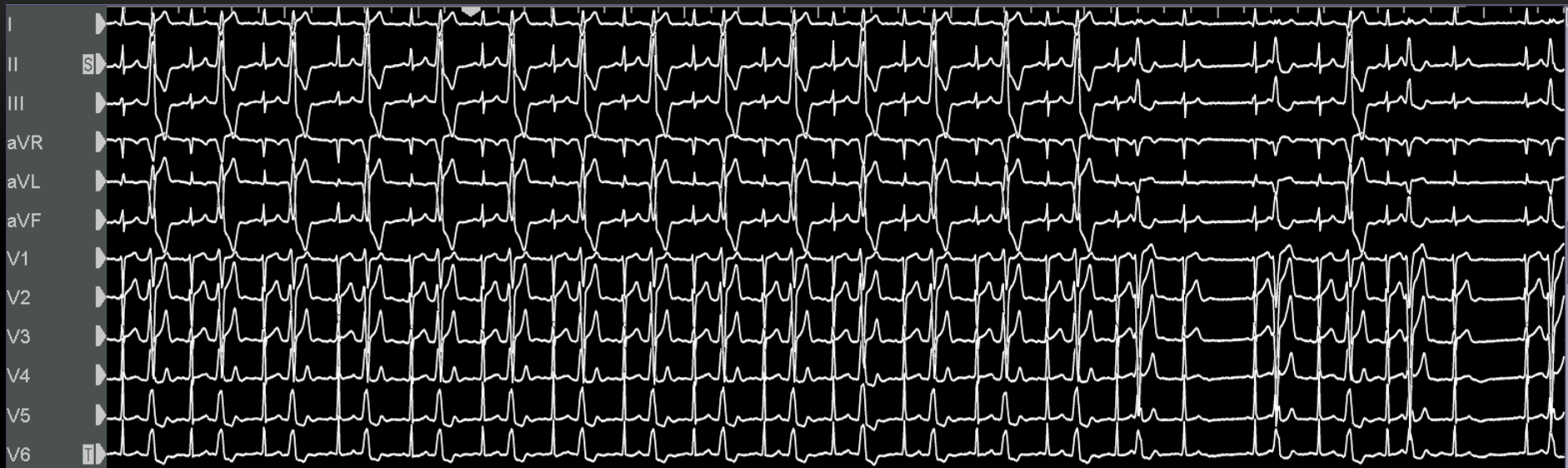


# 1<sup>ST</sup> RFCA

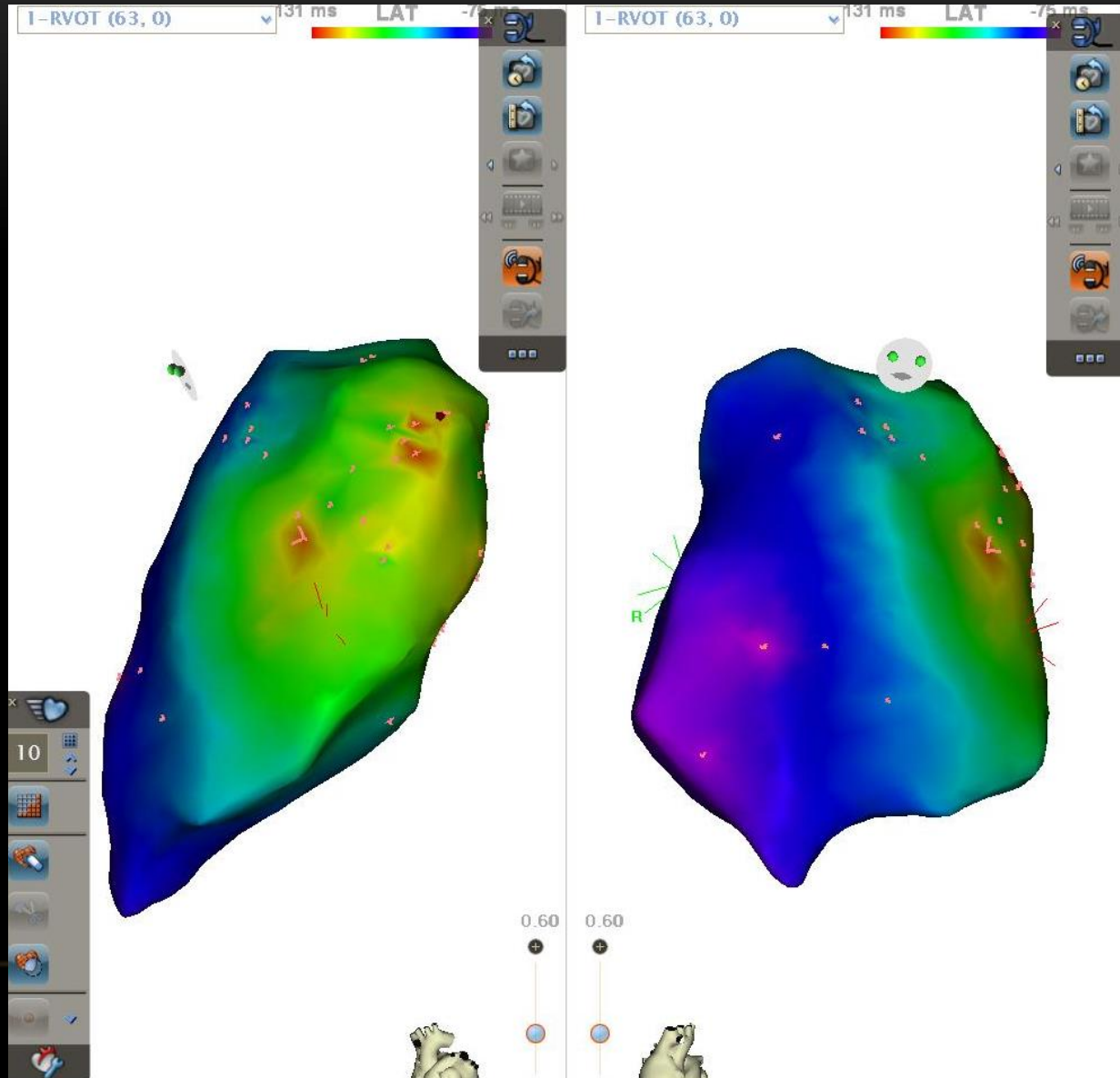
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2016-07-11

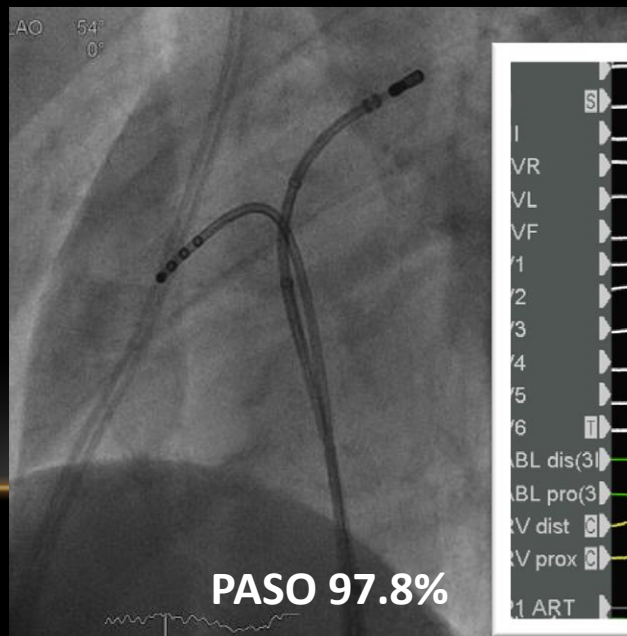
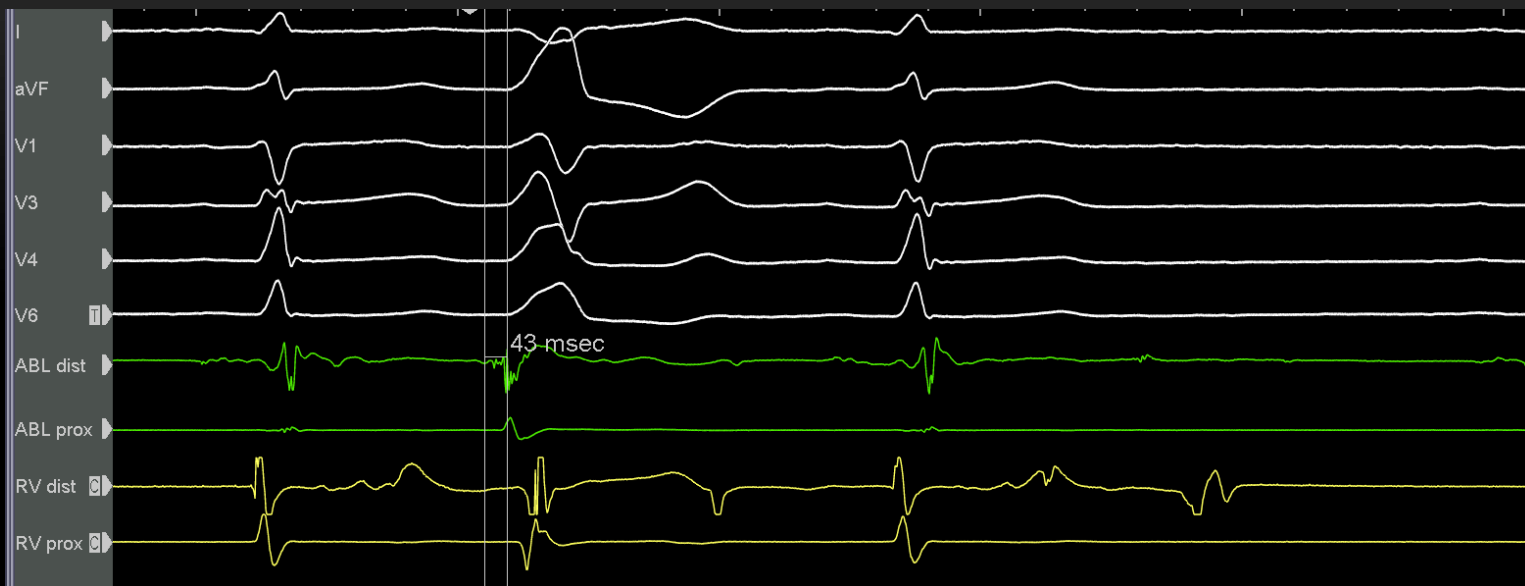
# PRE-RFCA 12 LEADS



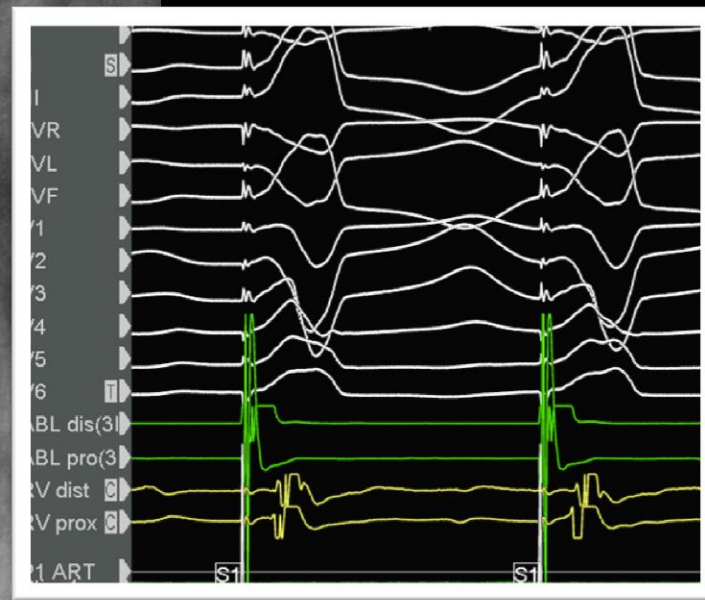
# ACTIVATION MAP BY CARTOUNIVU (RVOT)



# EARLIEST ACTIVATION SITE IN RVOT



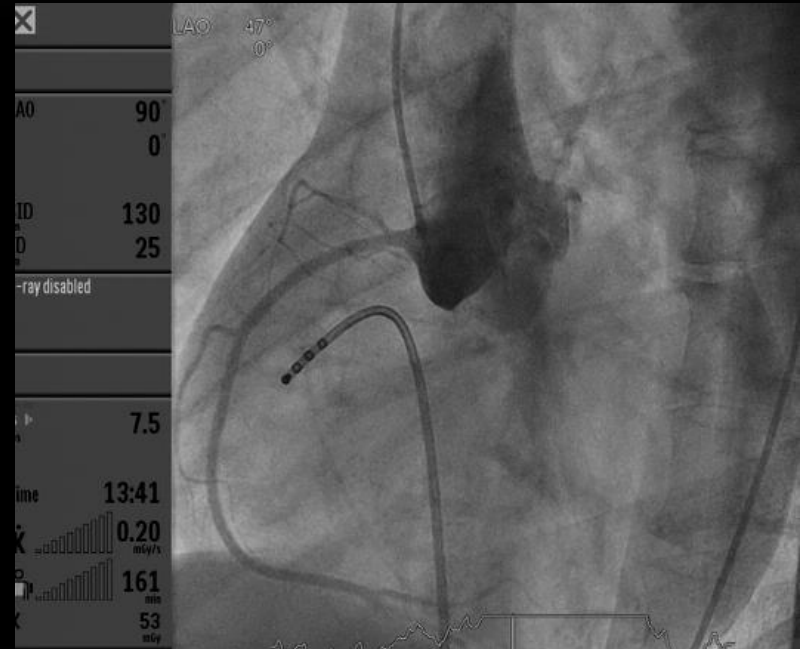
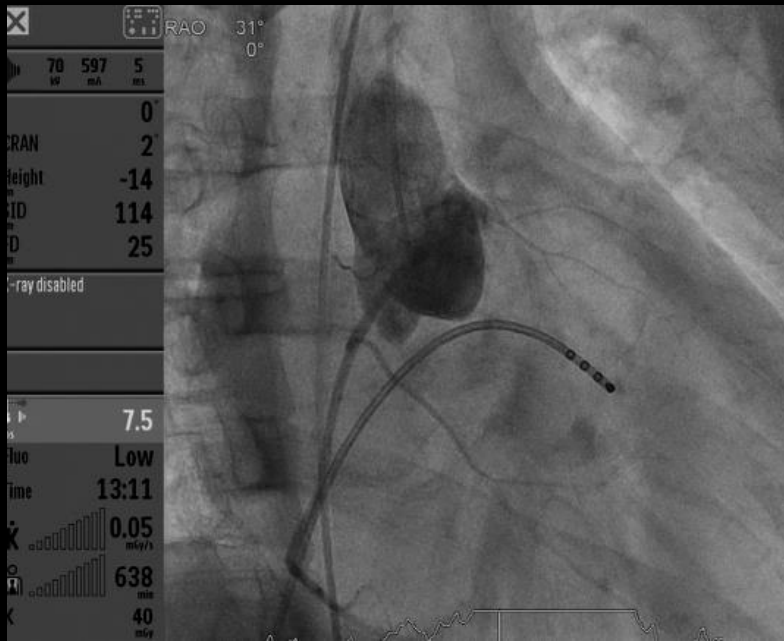
PASO 97.8%



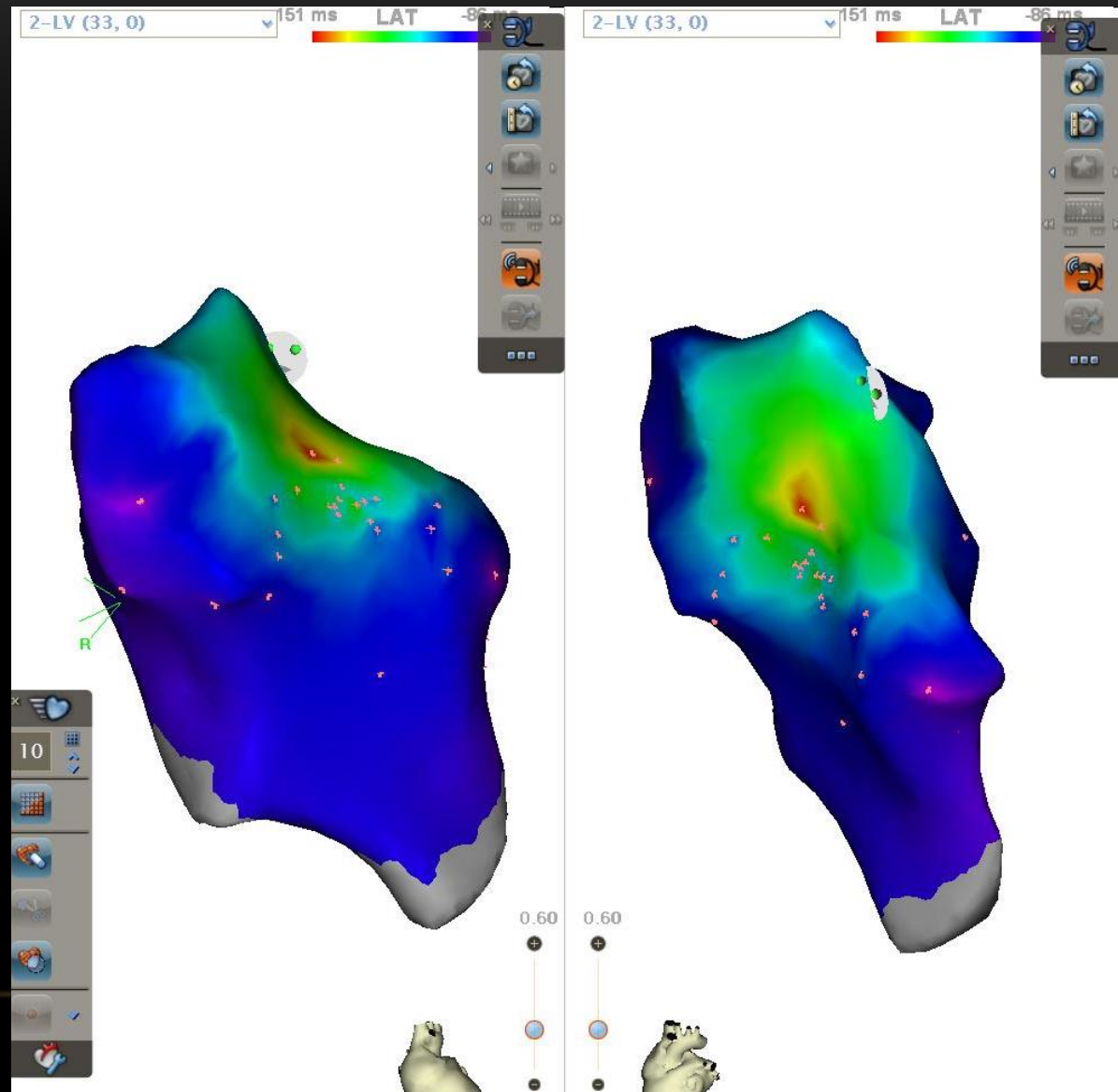
# ABLATION IN RVOT (ANTERIOR SEPTUM) #2



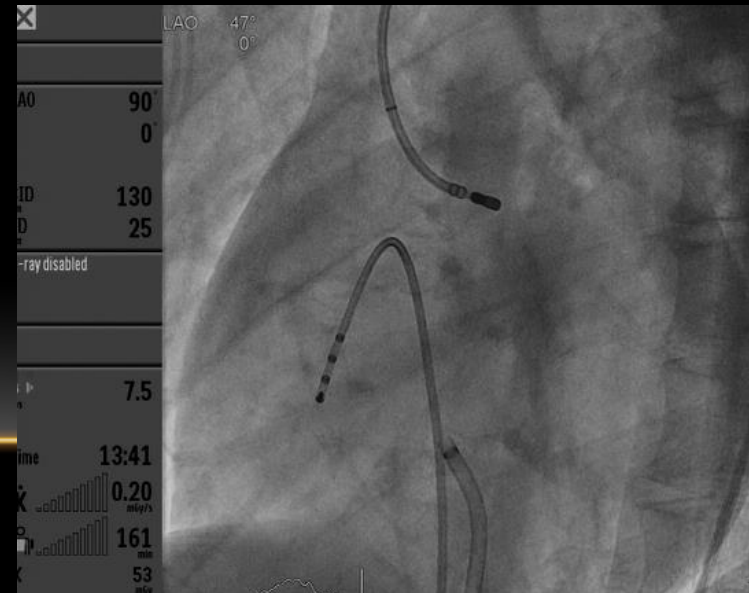
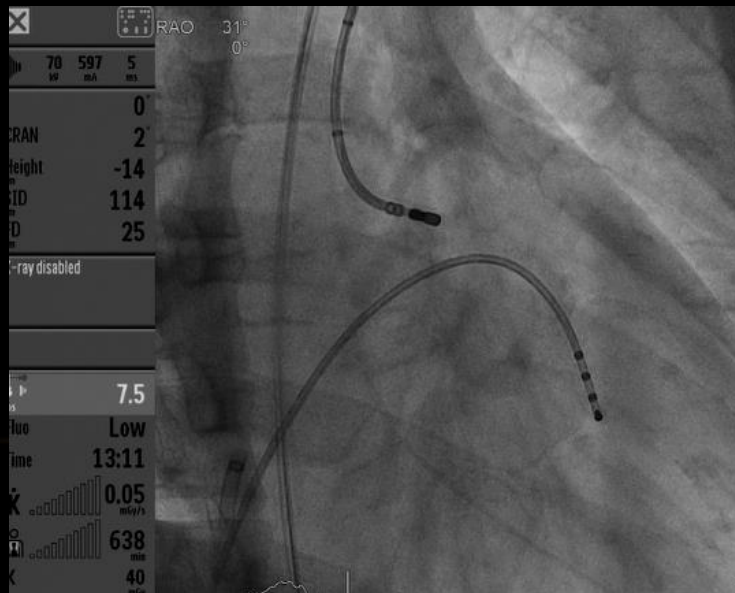
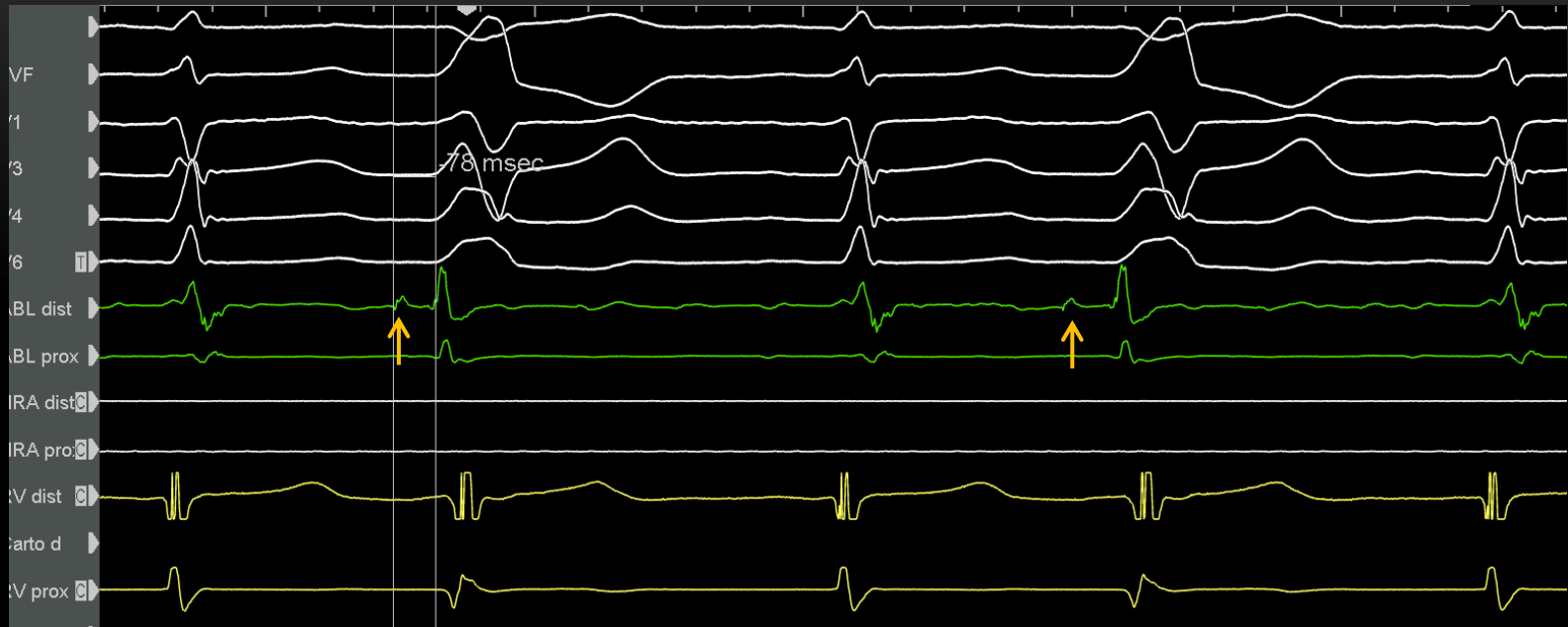
# AORTOGRAM



# ACTIVATION MAP BY CARTOUNIVU (LVOT)

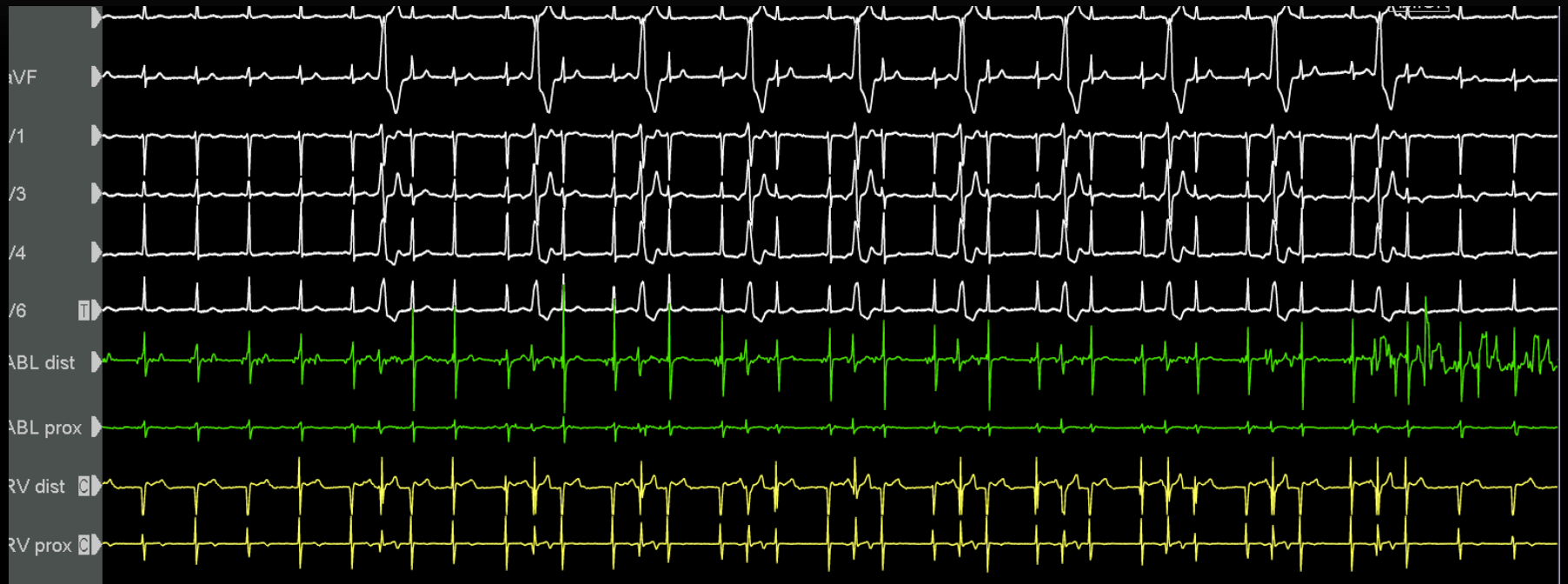


# DISCRETE POTENTIAL LCC

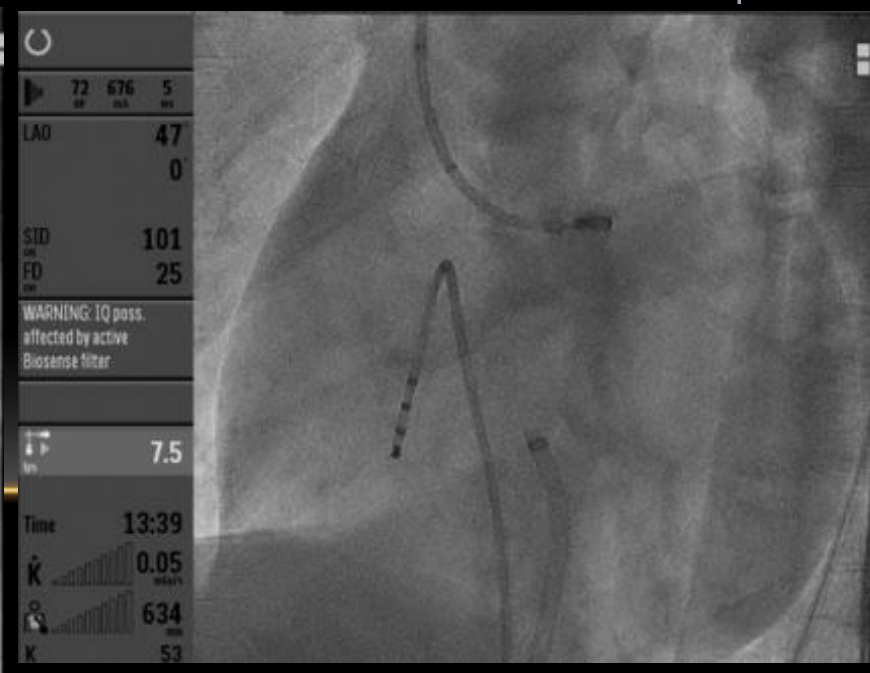
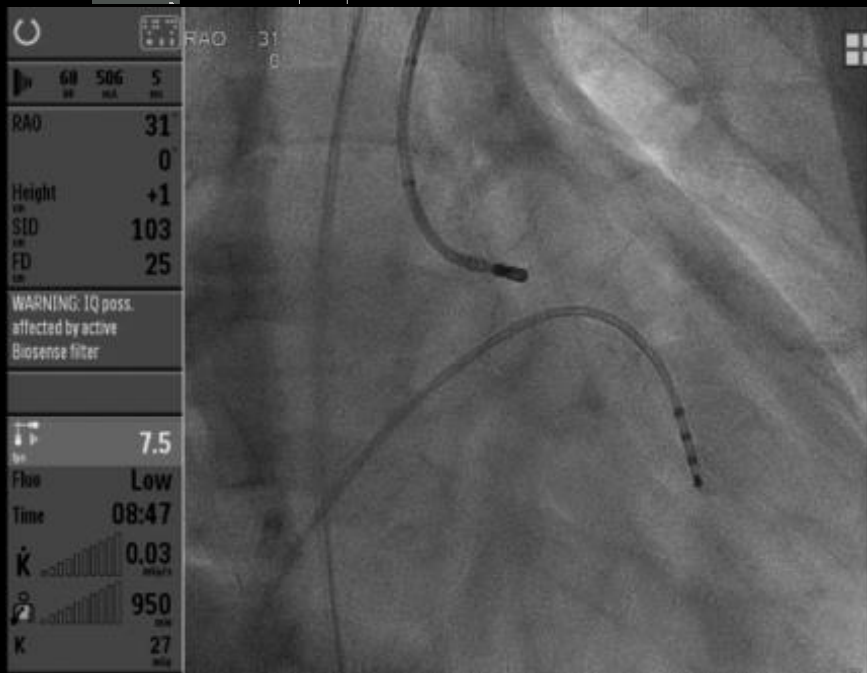
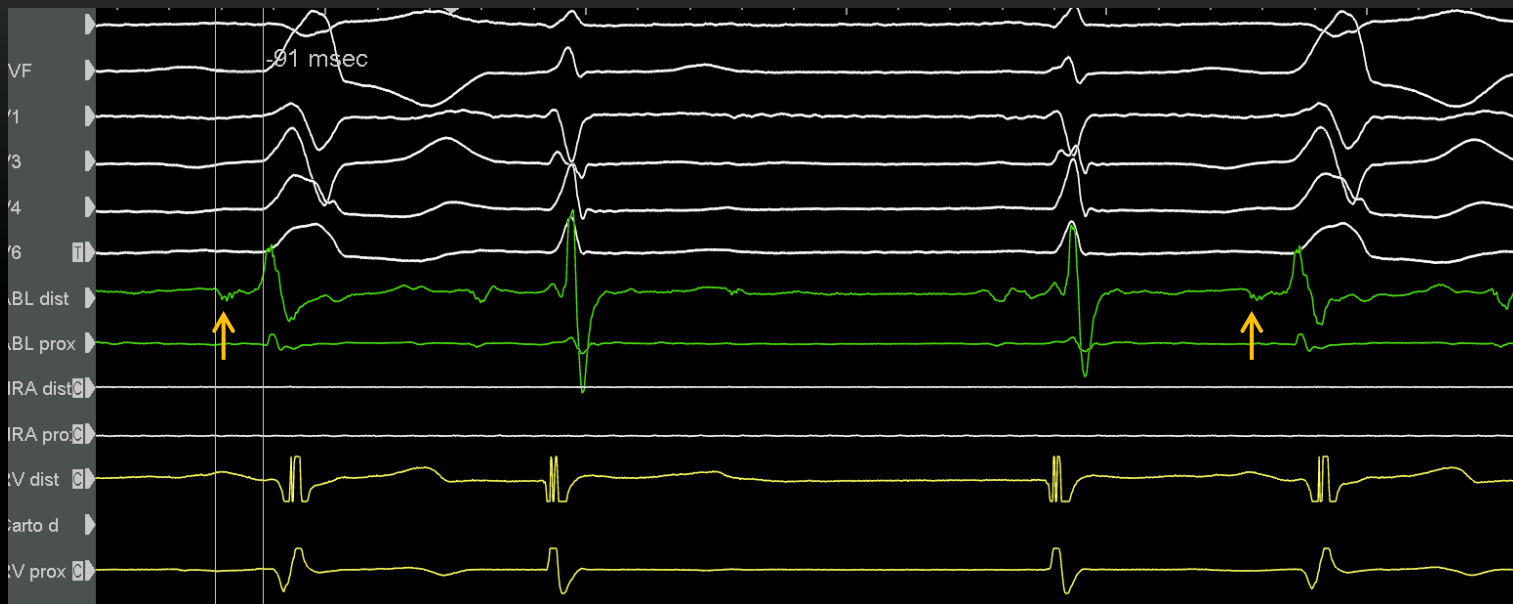




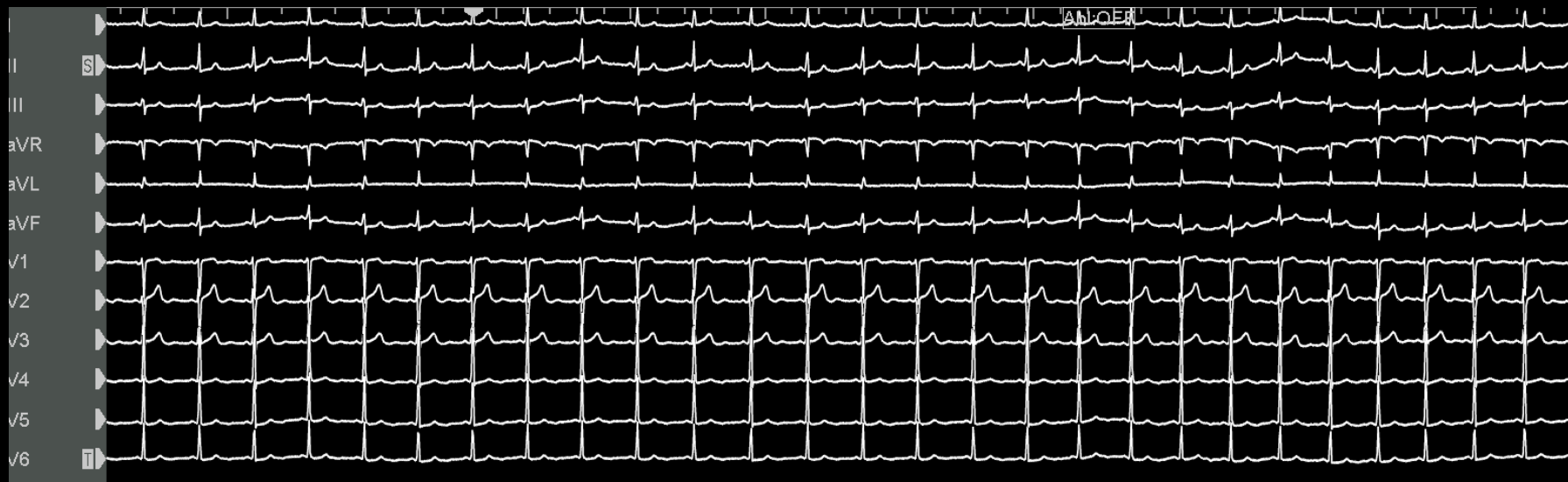
# POST-ABLATION #8 LCC



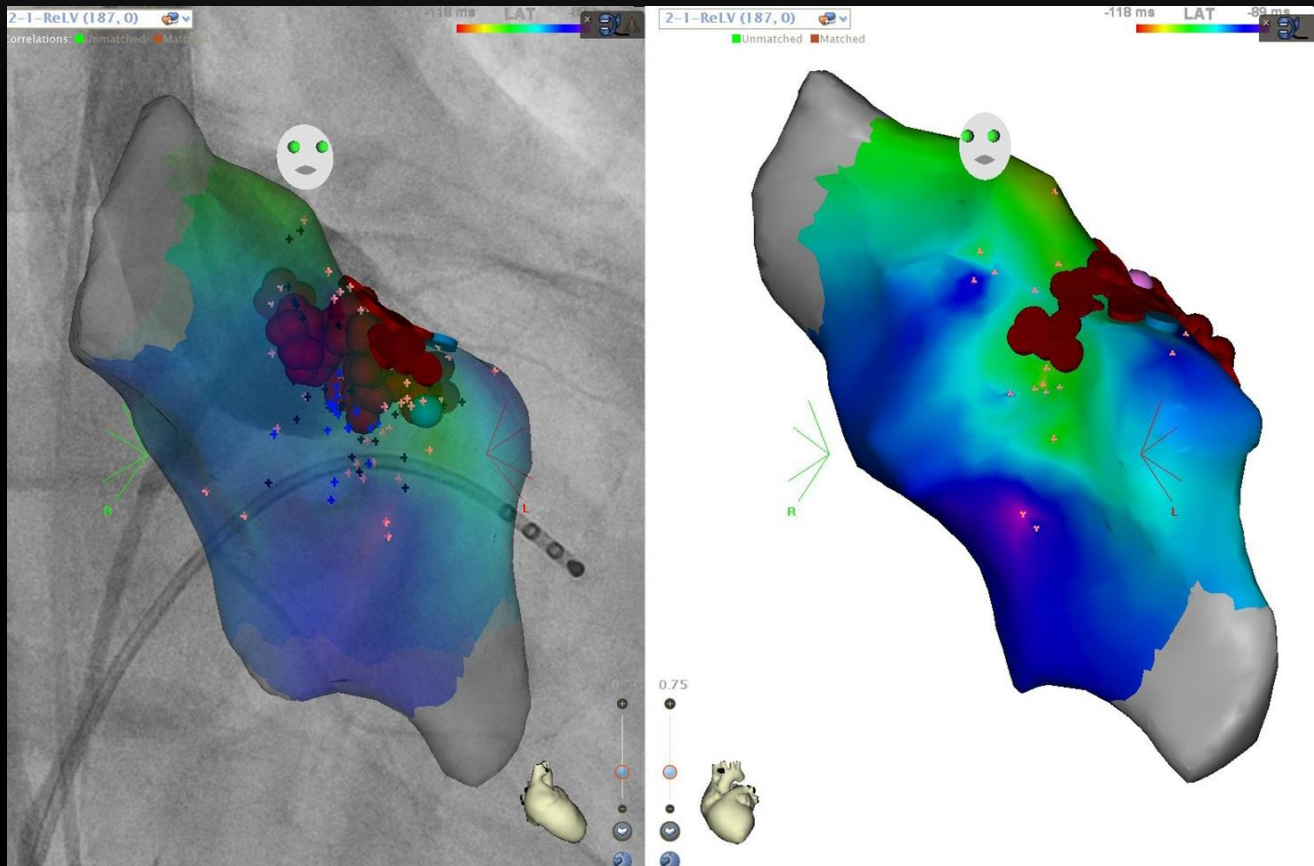
# DISCRETE POTENTIAL BELOW LCC



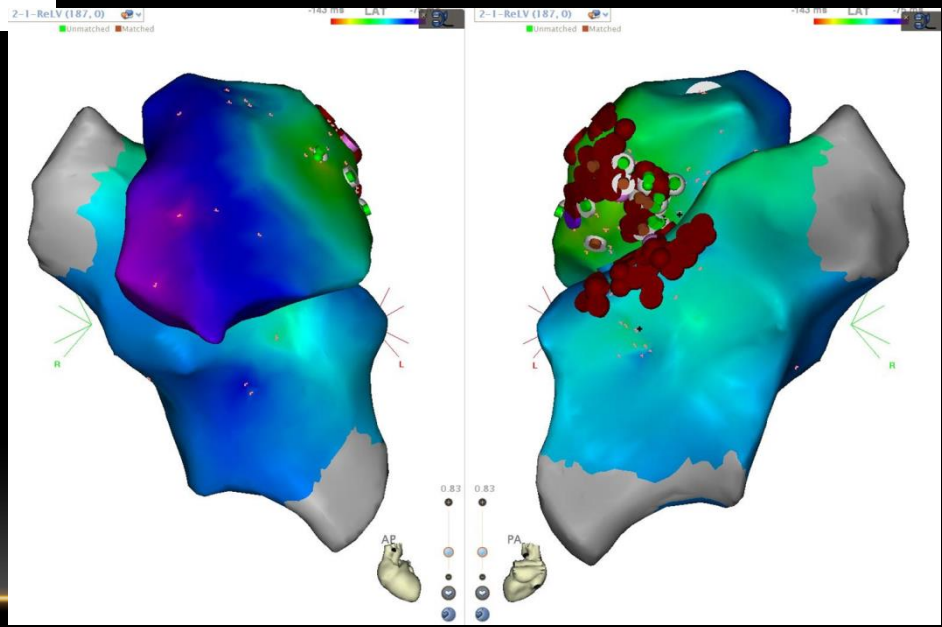
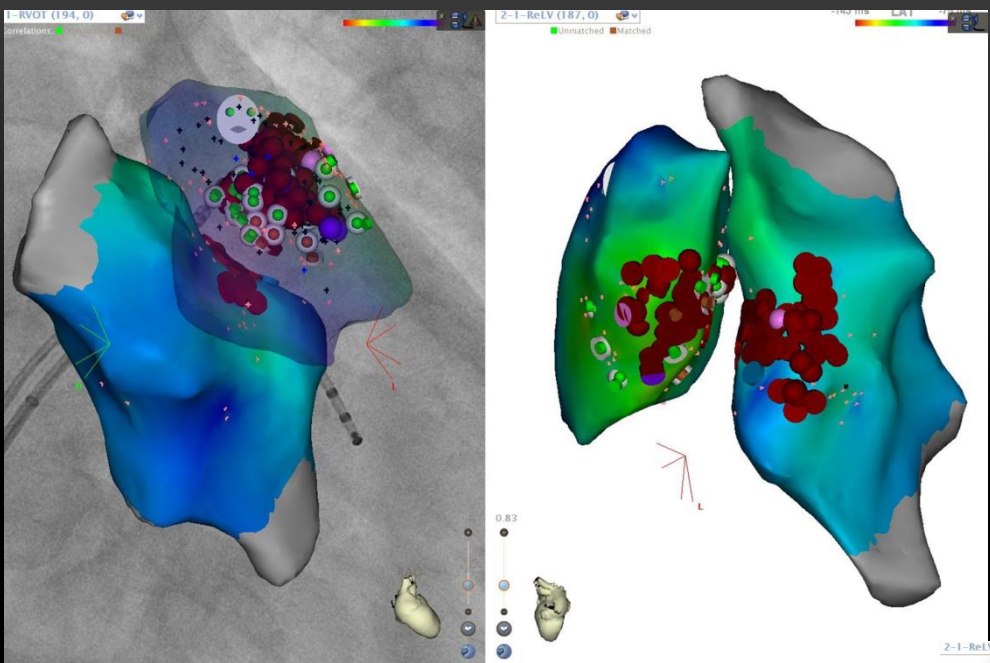
# ABLATION IN EARLIEST ACTIVATION SITE



# ABLATION SITES IN CARTOUNIV IMAGES

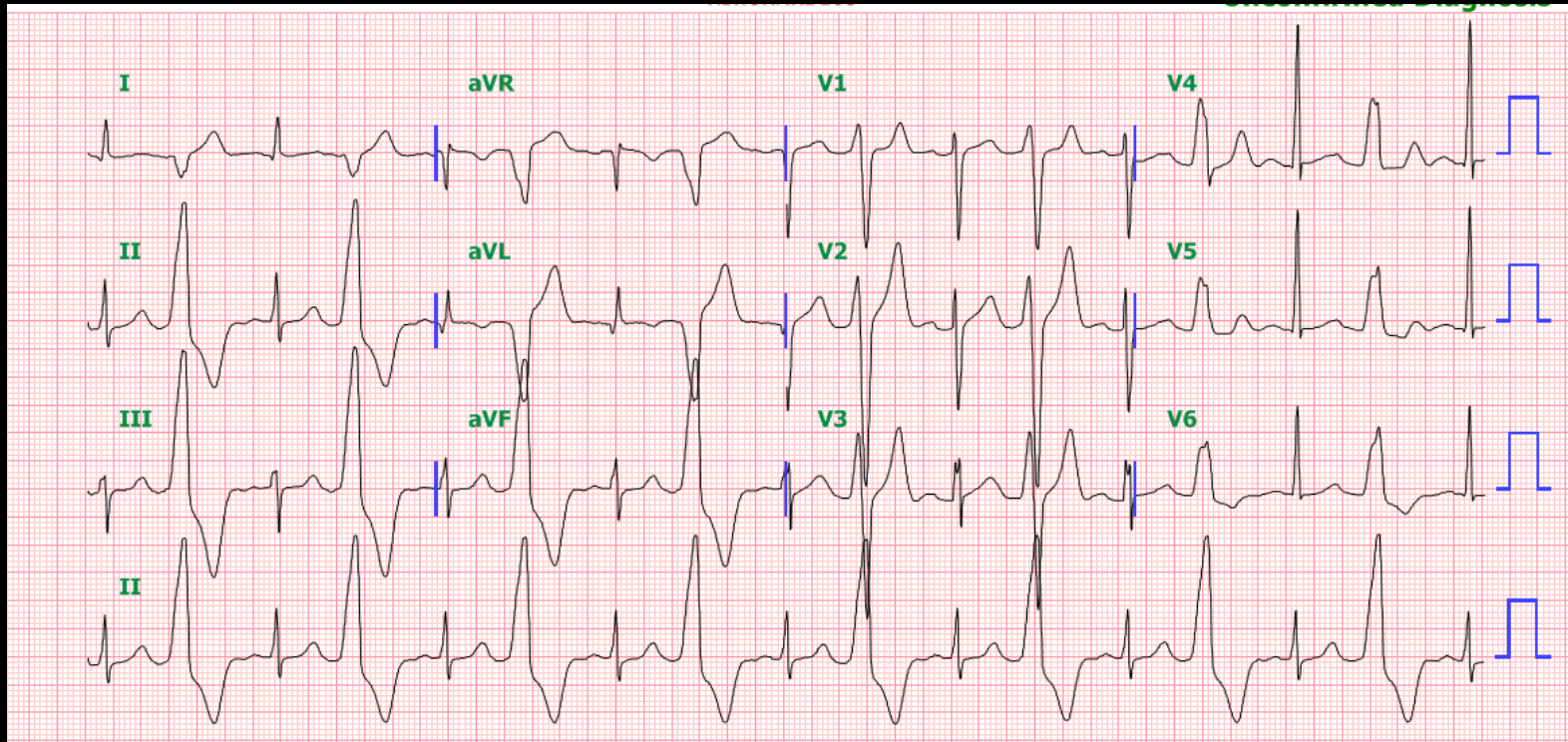


RVOT anterior septum



RVOT anterior septum and opposing LVOT septum

# 1 MONTH AFTER RFCA



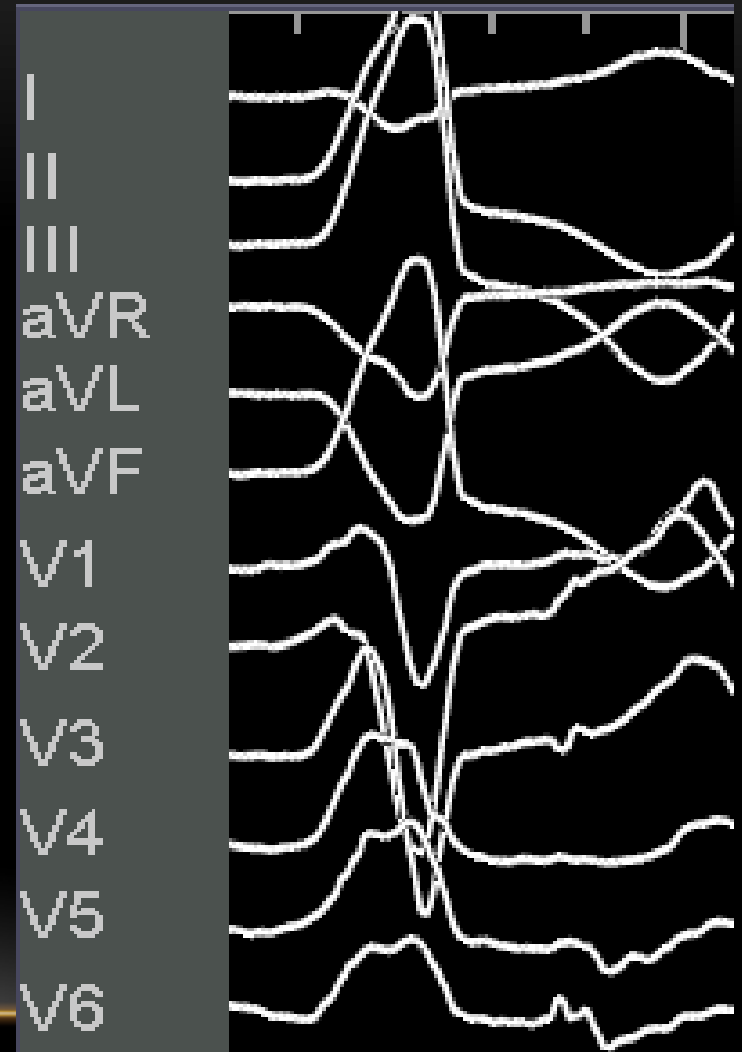
# 2<sup>ND</sup> RFCA

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Recurred VPCs

**Q.** WHICH LOCATION  
WOULD YOU PREFER TO  
MAP FIRST IN THIS PATIENT?

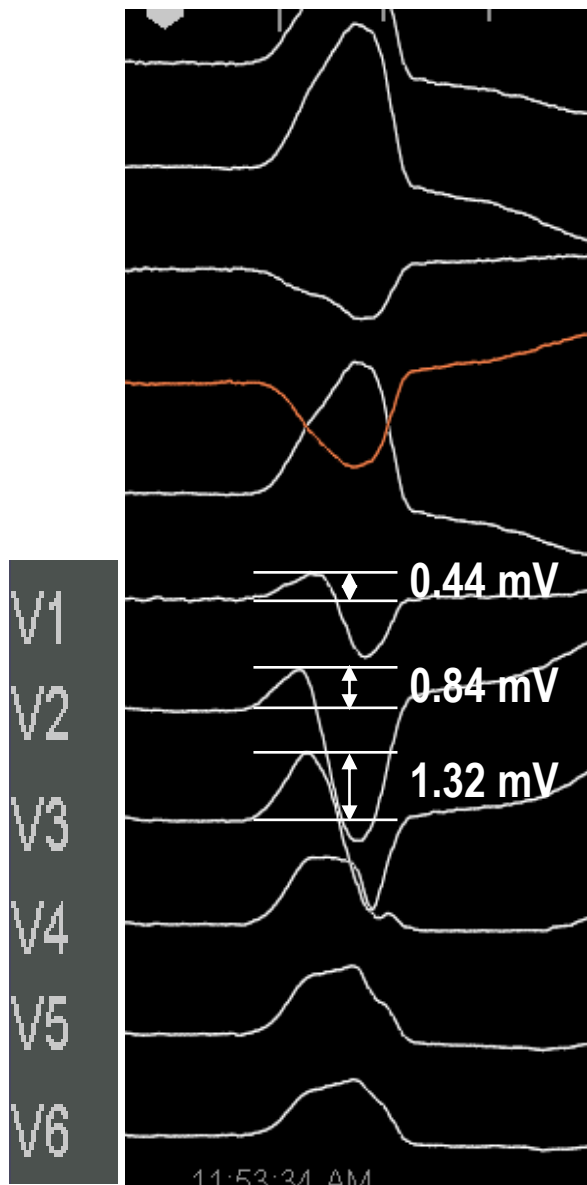
1. RVOT
2. LVOT
3. Epicardial side



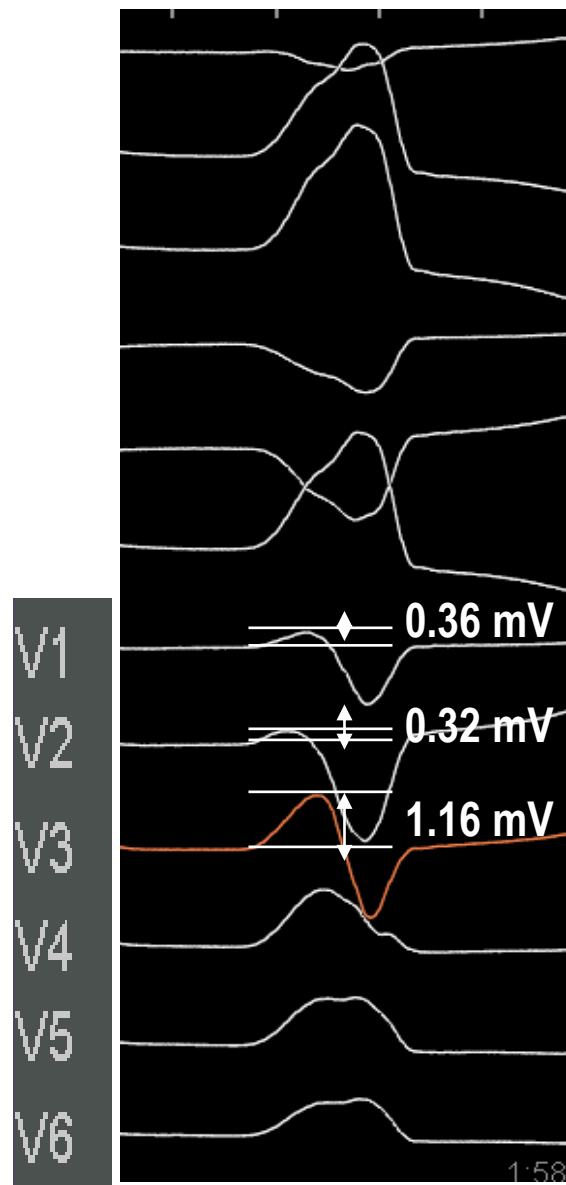
Before redo RFCA



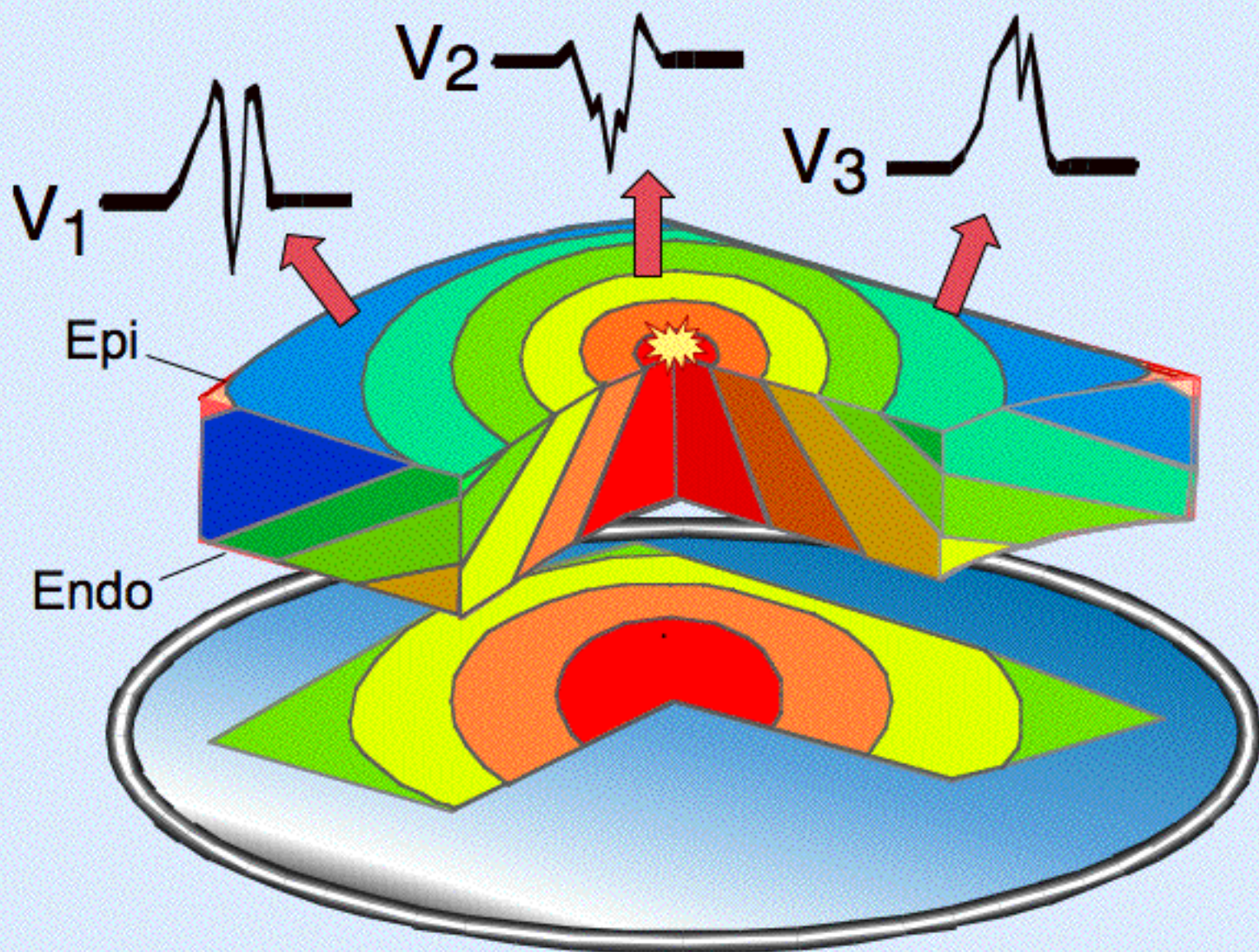
### 1st RFCA



### 2nd RFCA



# Epicardial VT Origin: Specific Contours

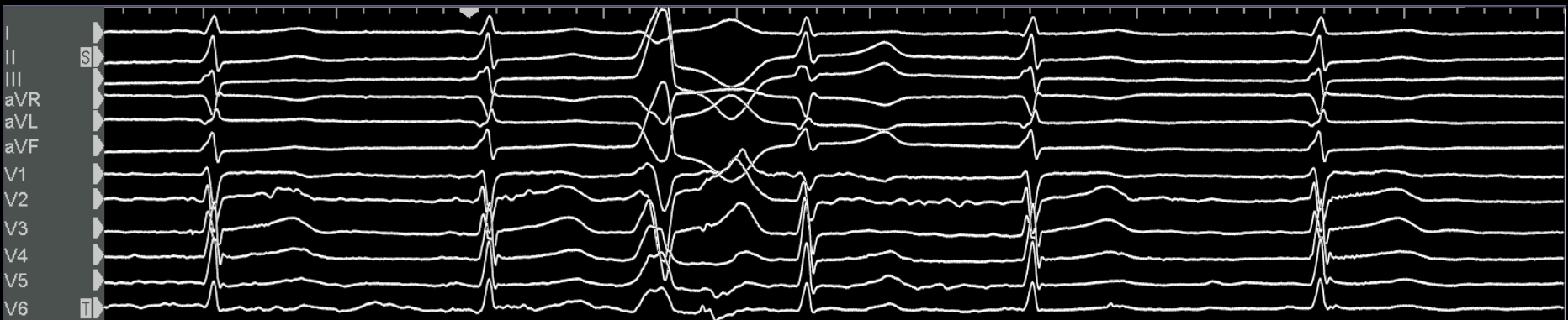
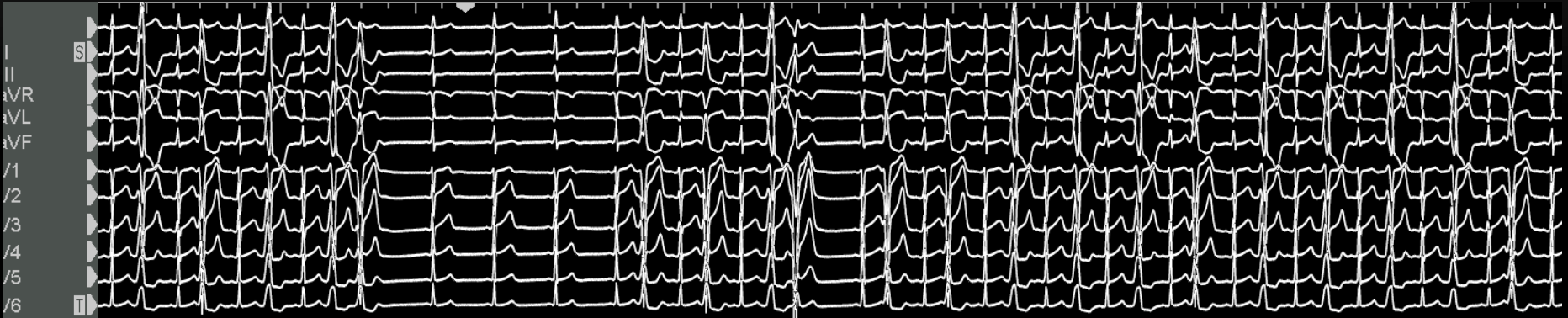


**Outflow Tract VT With Pattern Break in Lead V2.** *Introduction:* In outflow tract ventricular arrhythmias (OT-VAs), an abrupt loss of the R wave in lead V2 compared to V1 and V3 (pattern break in V2–PBV2) suggests an origin close to the anterior interventricular sulcus (anatomically opposite to lead V2) and adjacent to proximal coronaries. We studied the outcome of catheter ablation of OT-VAs with a PBV2.

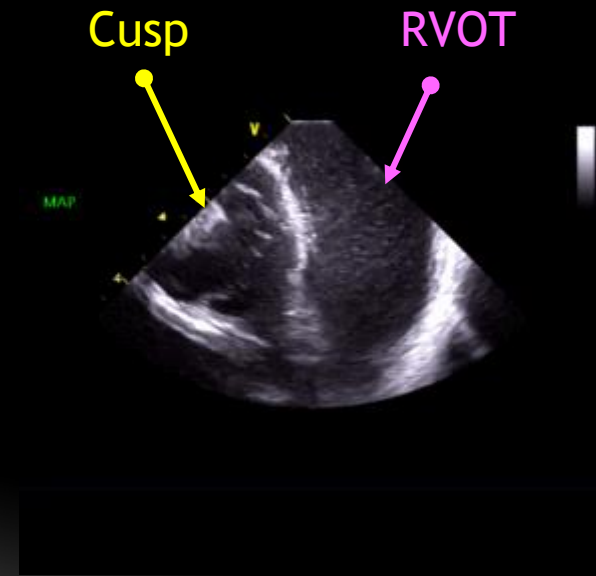
*Methods and Results:* Of 130 consecutive patients with idiopathic left bundle block morphology OT-VAs and transition  $\leq$ V4, 12 (9%) had PBV2. Outcomes in this group were compared to the remaining 118 patients. Patients with PBV2 were more likely to be younger ( $41 \pm 18$  vs.  $50 \pm 14$  years,  $P = 0.0384$ ) and women (11 [92%] vs. 70 [59%],  $P = 0.0302$ ). The earliest activation was at the RVOT in seven, left coronary cusp (LCC) in one, anterior interventricular vein (AIV) in two and the epicardium in two. In five (42%) cases (earliest activation in the AIV in two, epicardium in two, and RVOT below the valve level in one), ablation was aborted due to proximity to the left anterior descending (LAD) coronary artery. After  $36 \pm 17$  months and  $1.3 \pm 0.5$  procedures, VAs elimination was achieved in 58% of patients with PBV2 compared to 89% of the reference population ( $P = 0.0125$ ) with effective site in five of seven at the most anterior and leftward RVOT adjacent to the pulmonic valve (PV).

*Conclusions:* OT-VAs with PBV2 demonstrate a unique ECG pattern and challenging catheter ablation. Proximity to LAD precludes ablation in about half. Long-term VA suppression could be achieved in only 58% of cases most commonly when the earliest site is at the anterior and leftward RVOT just under the PV. (*J Cardiovasc Electrophysiol*, Vol. pp. 1-11)

# PRE-2<sup>ND</sup> RFCA 12 LEAD



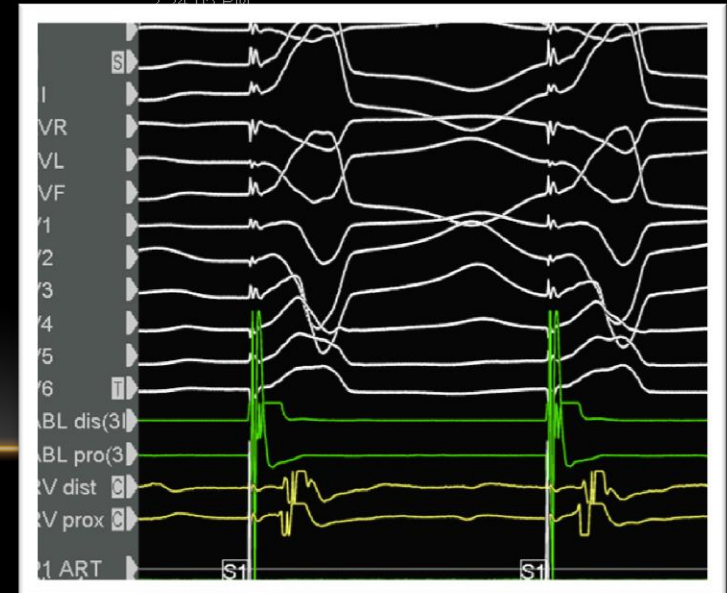
# ANATOMICAL MAPPING USING THE SOUNDSTAR™ CATHETER



# ACTIVATION MAP BY CARTOSOUND (RV)

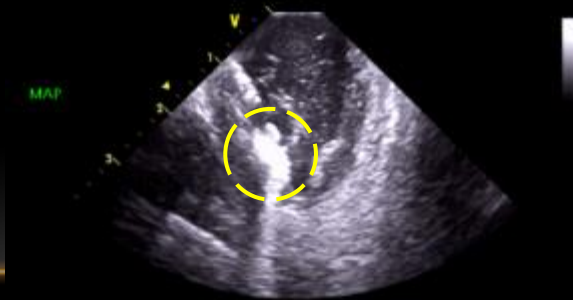
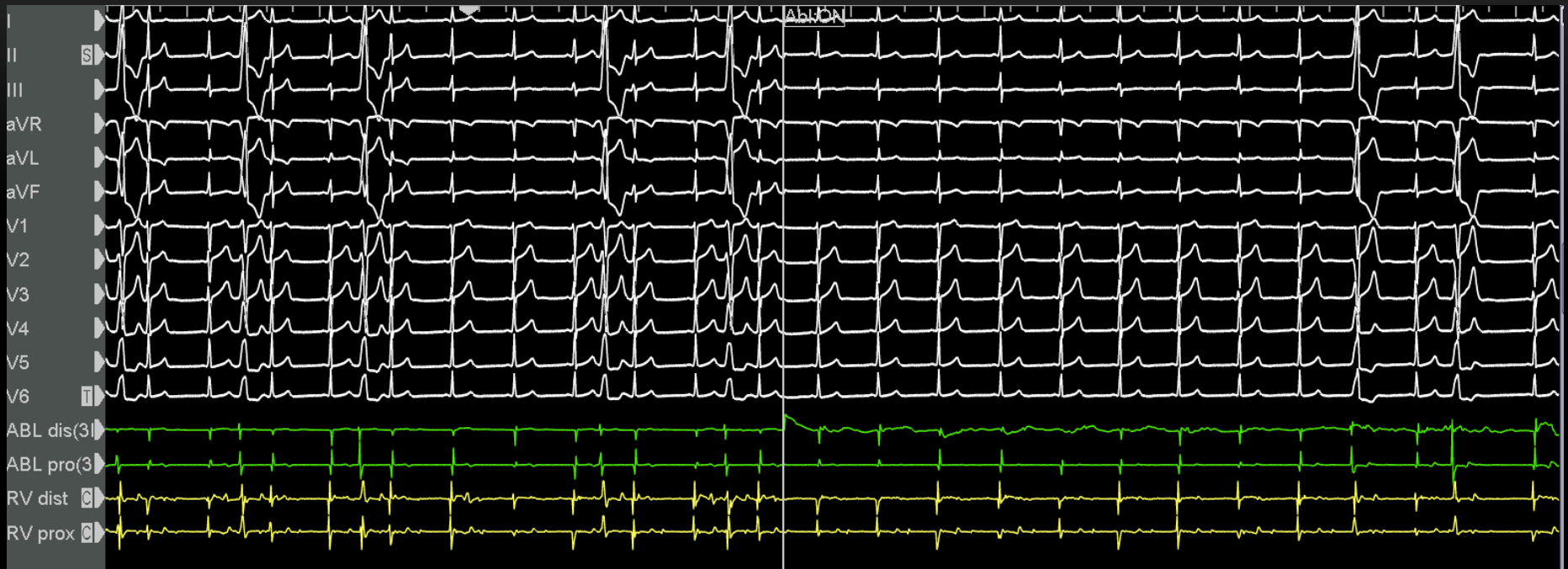


# EARLIEST ACTIVATION SITE IN RVOT



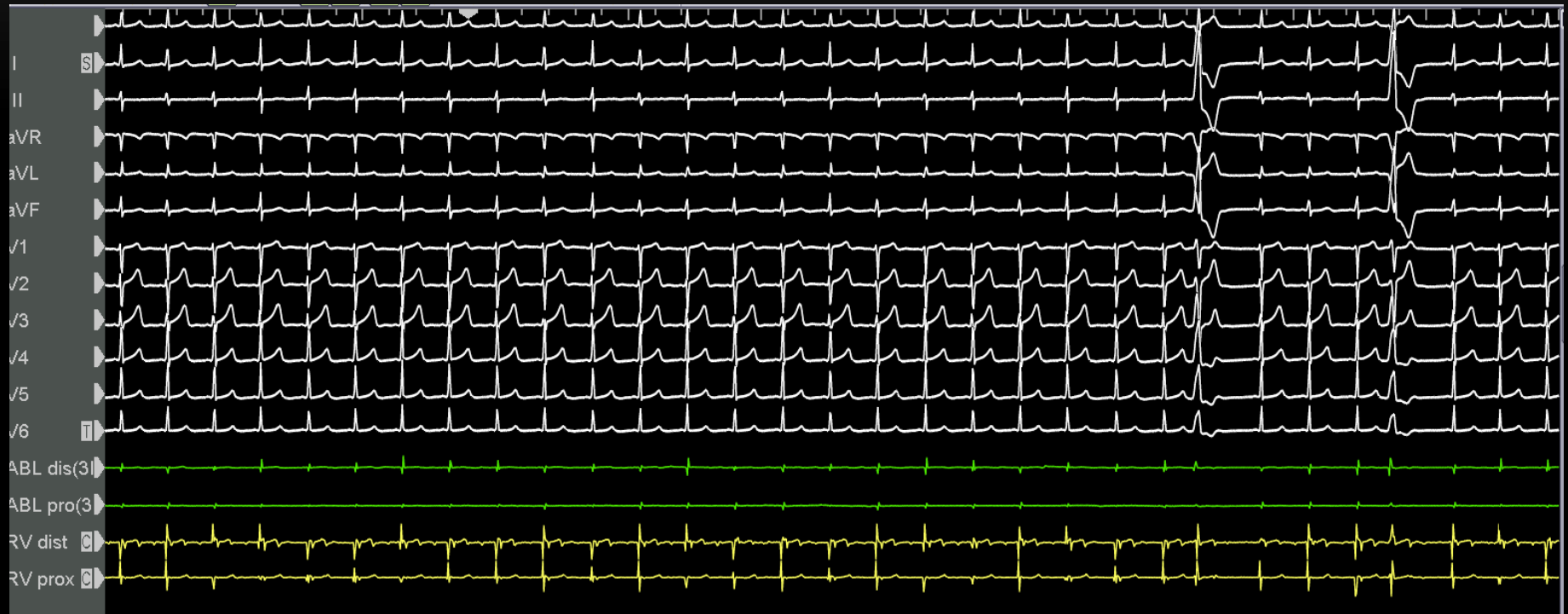
PASO 98.7%

# ABLATION IN RVOT (ANTERIOR SEPTUM)

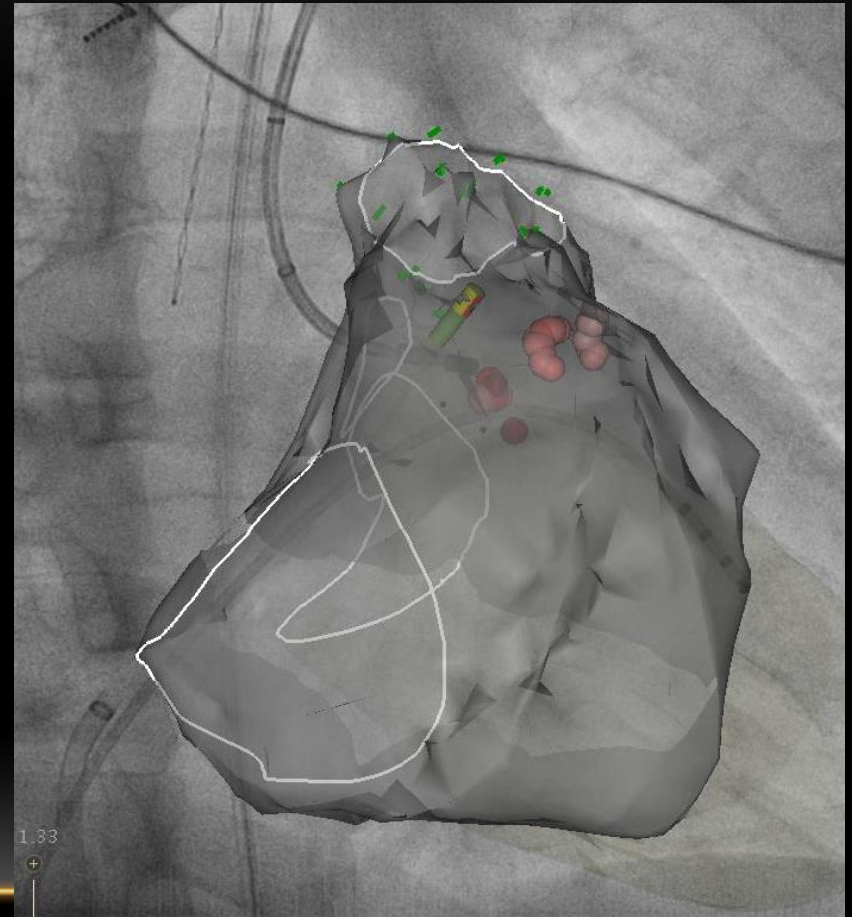




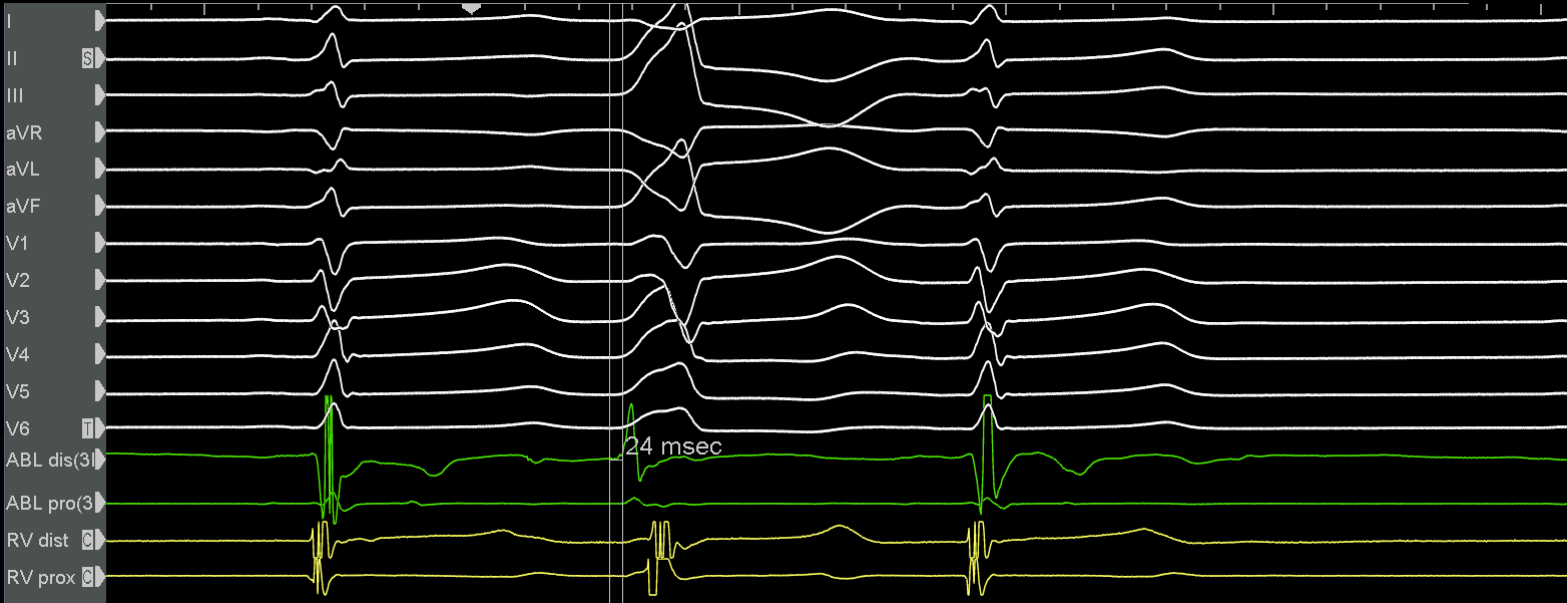
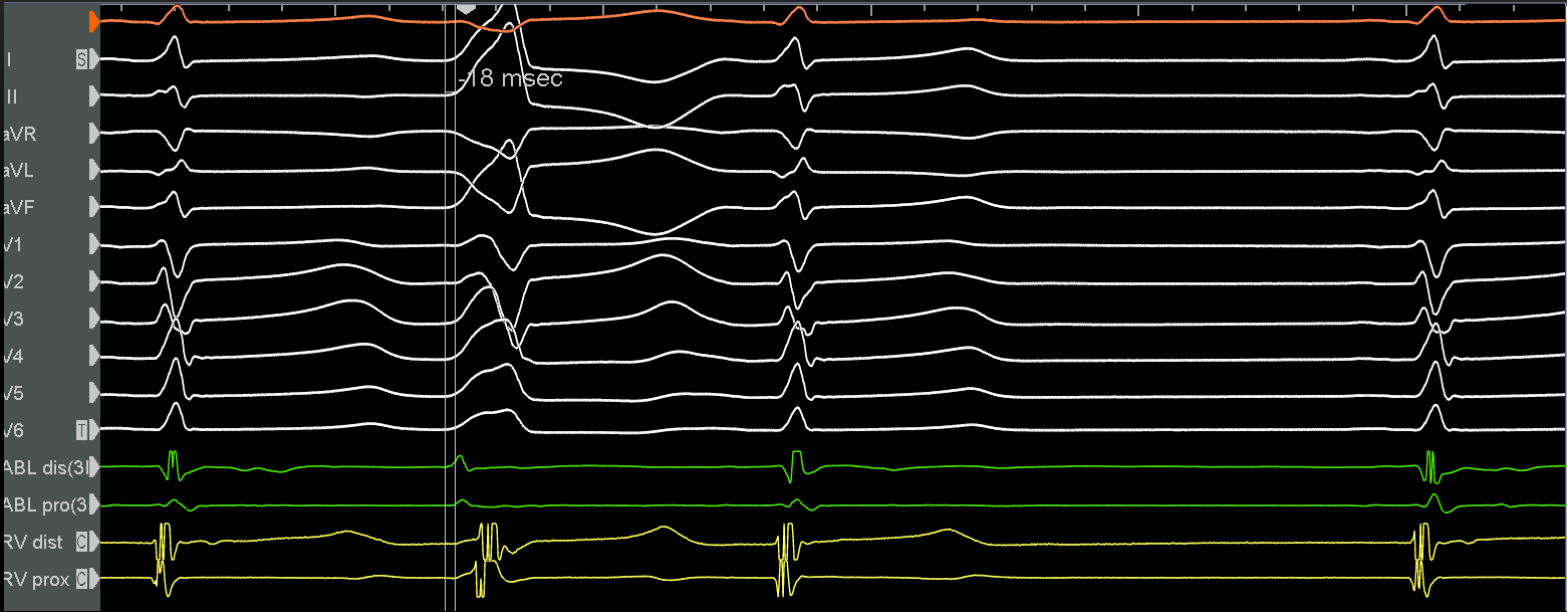
# POST-RFCA #14 IN RVOT



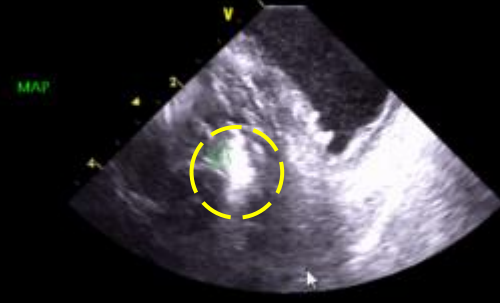
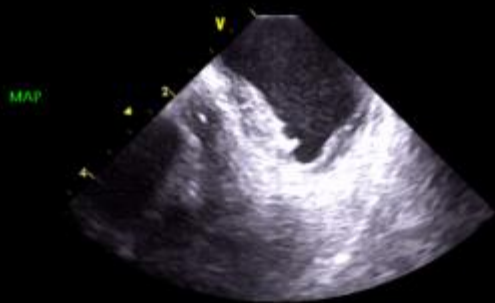
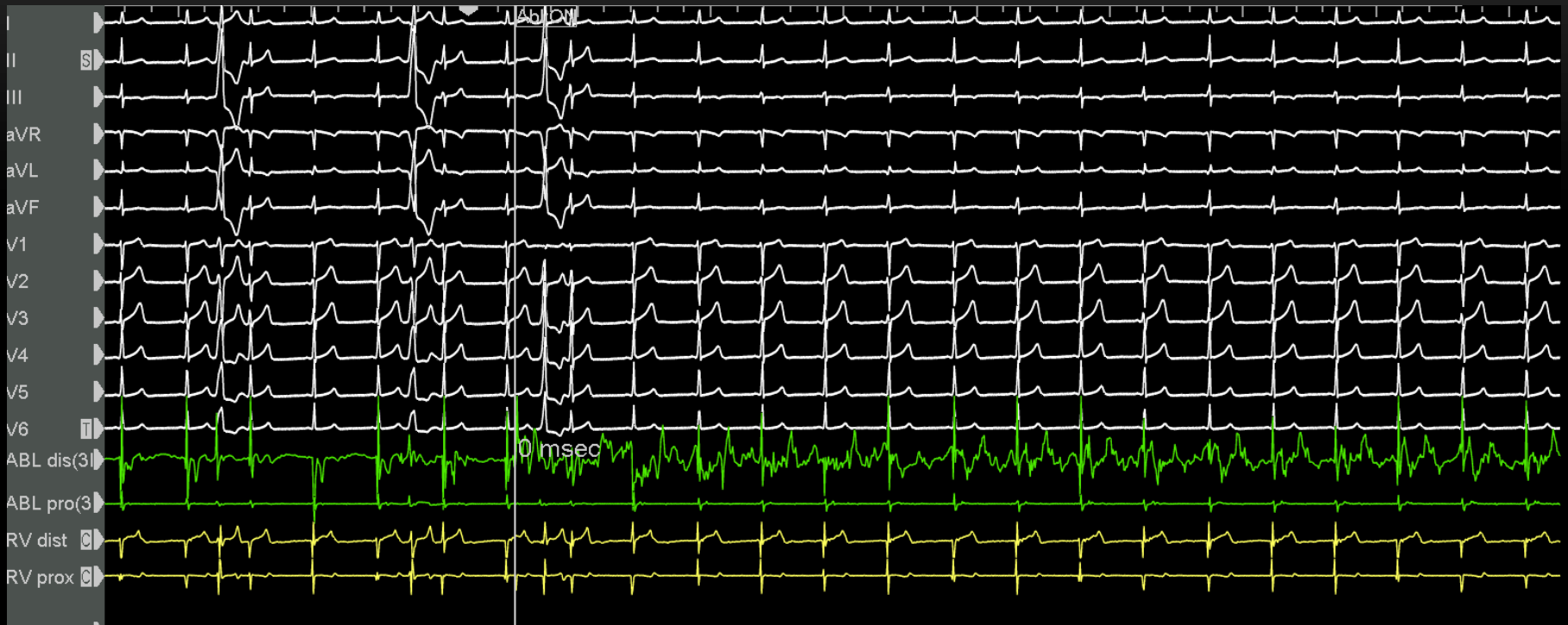
# ACTIVATION MAP BY CARTOSOUND (LV)



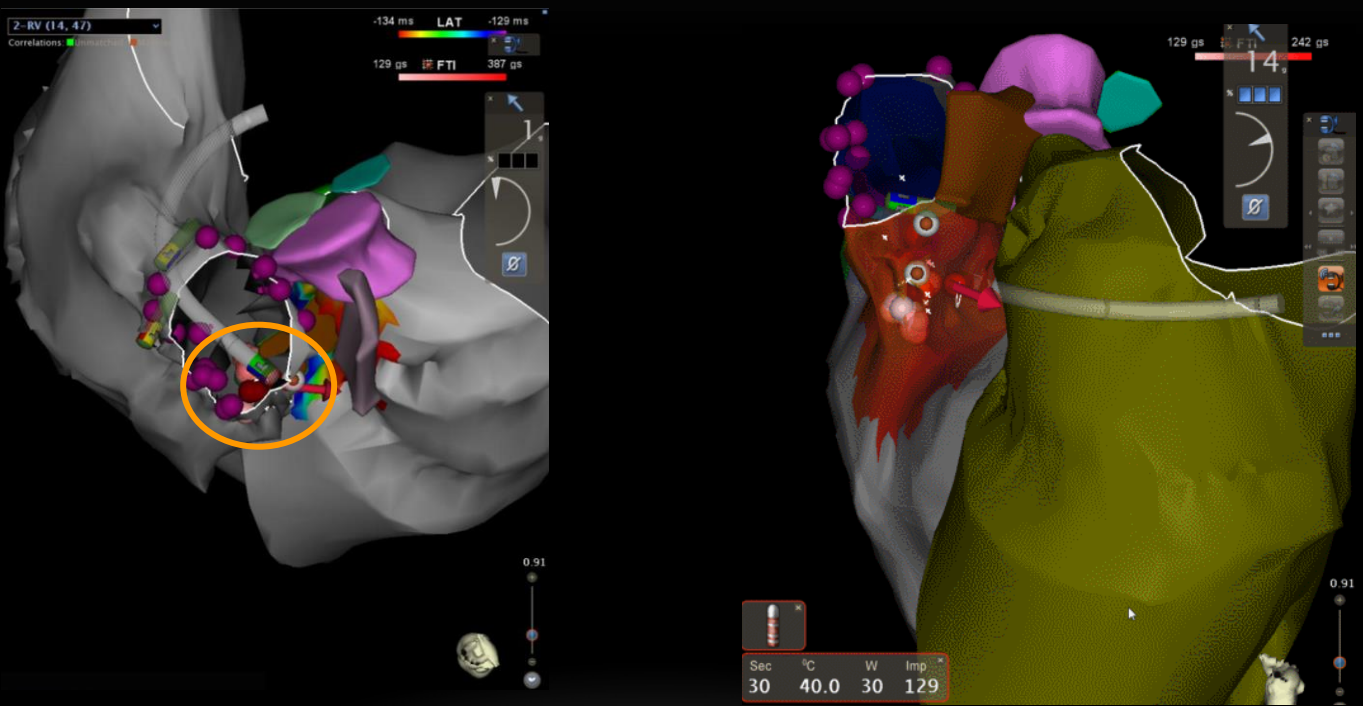
# EARLIEST ACTIVATION SITE IN LVOT



# SUCCESSFUL ABLATION IN LVOT (BELOW LCC)

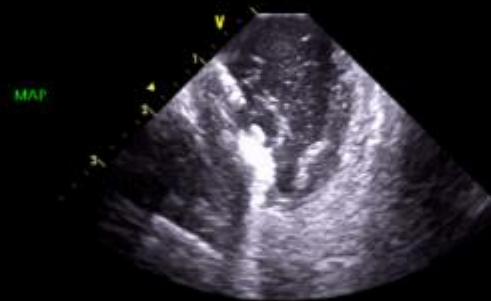
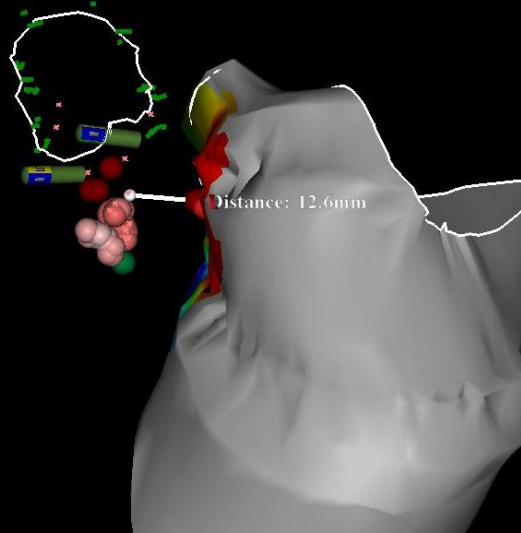


# ABLATION WITH SMARTTOUCH CATHETER



Maximal power 40W, duration 160s

# LESION FORMATION VISUALIZED BY ICE



RVOT Lesion Formation

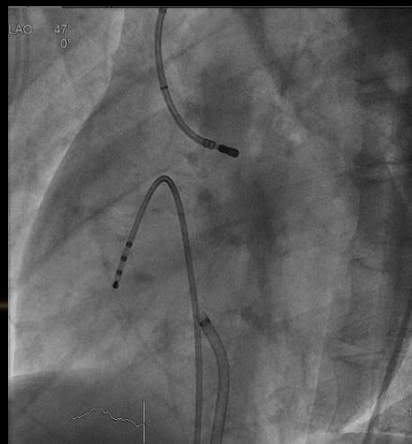
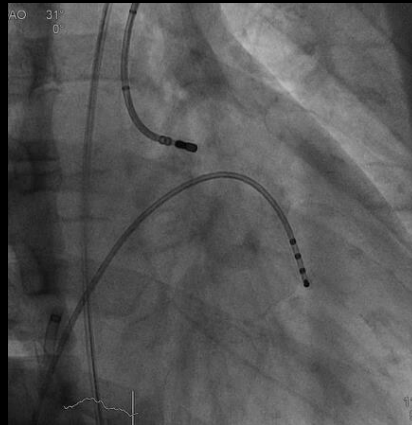


LV Lesion Formation

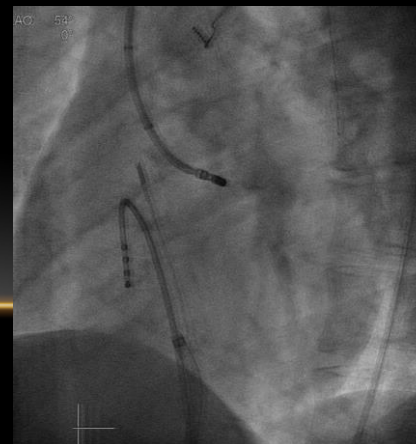
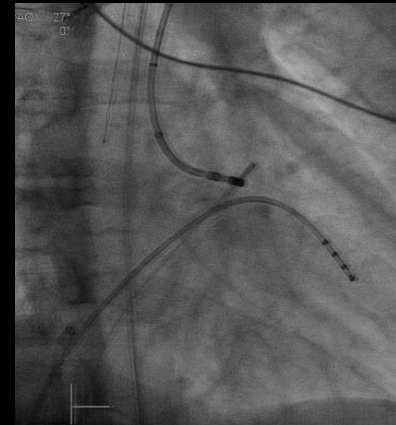
# COMPARISON OF THE TWO PROCEDURES

## Location by fluoroscopy

- 1<sup>st</sup> procedure

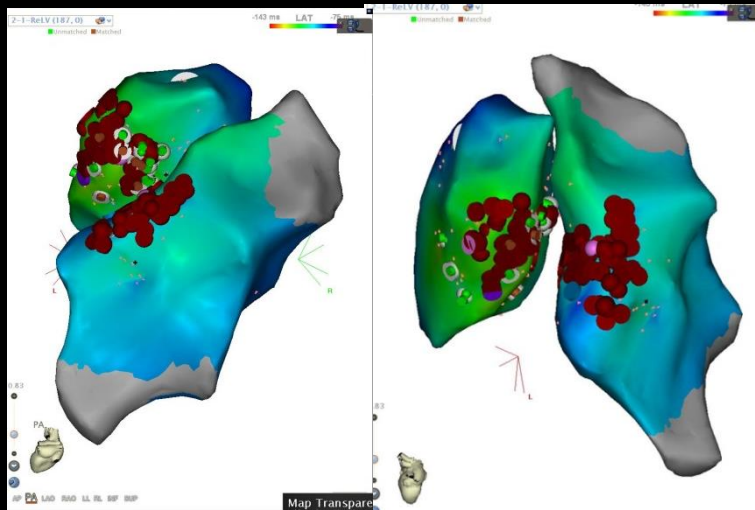


- Redo procedure

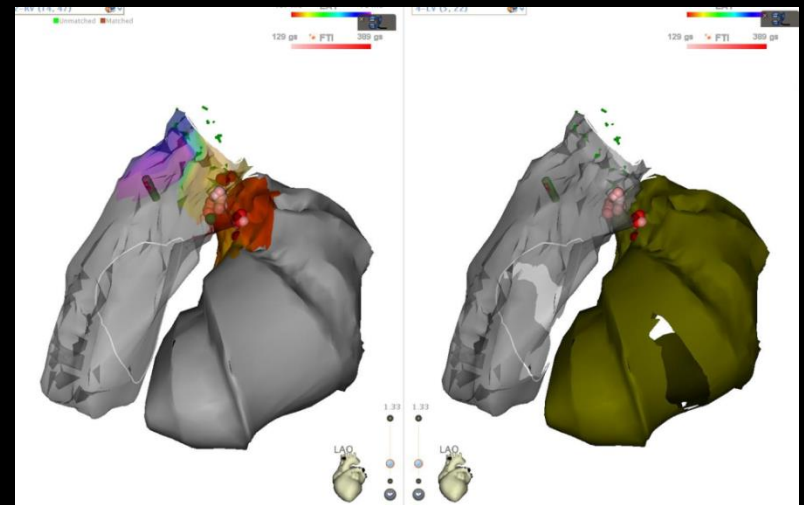


# Location by 3D mapping

- 1<sup>st</sup> procedure



- Redo procedure





## Mapping and ablation

|          | 1st            | Redo       |
|----------|----------------|------------|
| System   | CartoUnivu     | CartoSound |
| Catheter | J&J Thermocool | SmartTouch |

## RF energy

|           | 1st                 | Redo                |
|-----------|---------------------|---------------------|
| Max power | 30W                 | 40W                 |
| Duration  | 60s                 | 160s                |
| Number    | RVOT #6<br>LVOT #11 | RVOT #14<br>LVOT #4 |

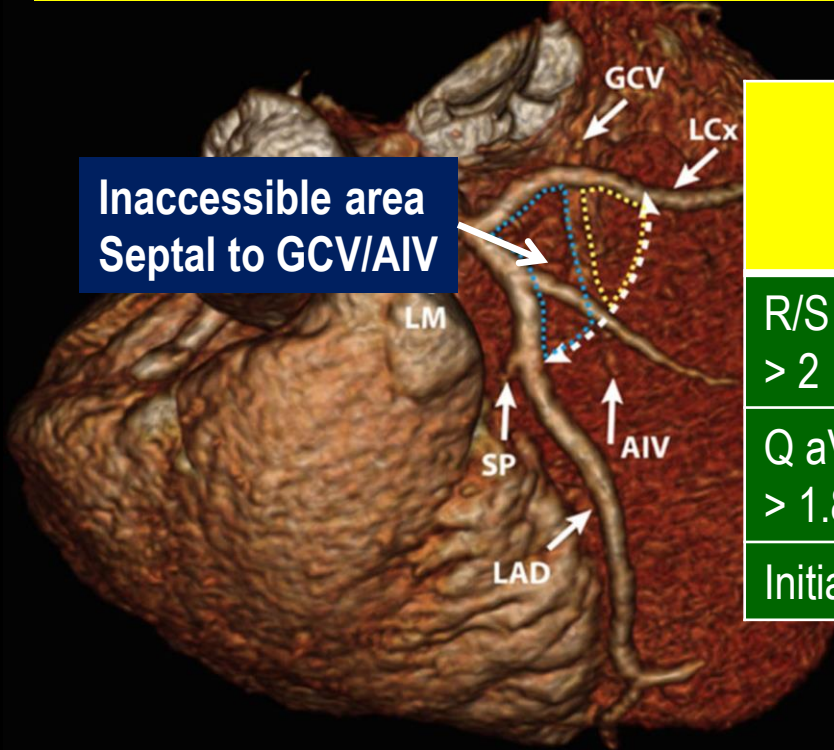
**Deep lesion** could be made with higher power, longer duration, and stable contact by assistance of ICE and SmartTouch catheter.

## Earliest activation by EGM

|      | 1st                | Redo     |
|------|--------------------|----------|
| RVOT | -24 msec           | -24 msec |
| LVOT | Discrete potential | -24 msec |

# ECG Features of Successful Epicardial Ablation

**Suggest origin away from LM bifurcation  
Based of LV summit triangle**



|                     | Successful EPI (n=5) | Unsuccessful EPI (n=18) | Case |
|---------------------|----------------------|-------------------------|------|
| R/S wave ratio > 2  | 4 (80%)              | 5 (28%)                 | 0.42 |
| Q aVL/ Q aVR > 1.85 | 4 (80%)              | 2 (11%)                 | 1.43 |
| Initial "q" in V1   | 0 (0%)               | 6 (33%)                 | no   |

# LV Summit VT

- Anatomical definitions
  - ECG clues to recognize epicardial origin
  - Common sites of origin/link to venous system
  - How to ablate (direct vs. adjacent sites)
-

THANK YOU!

A thin, horizontal, glowing orange line is positioned below the text, extending across the width of the slide.