Papillary Muscle and Moderator Band Ventricular Tachycardia

VT Symposium 2018

Nov 3, 2018

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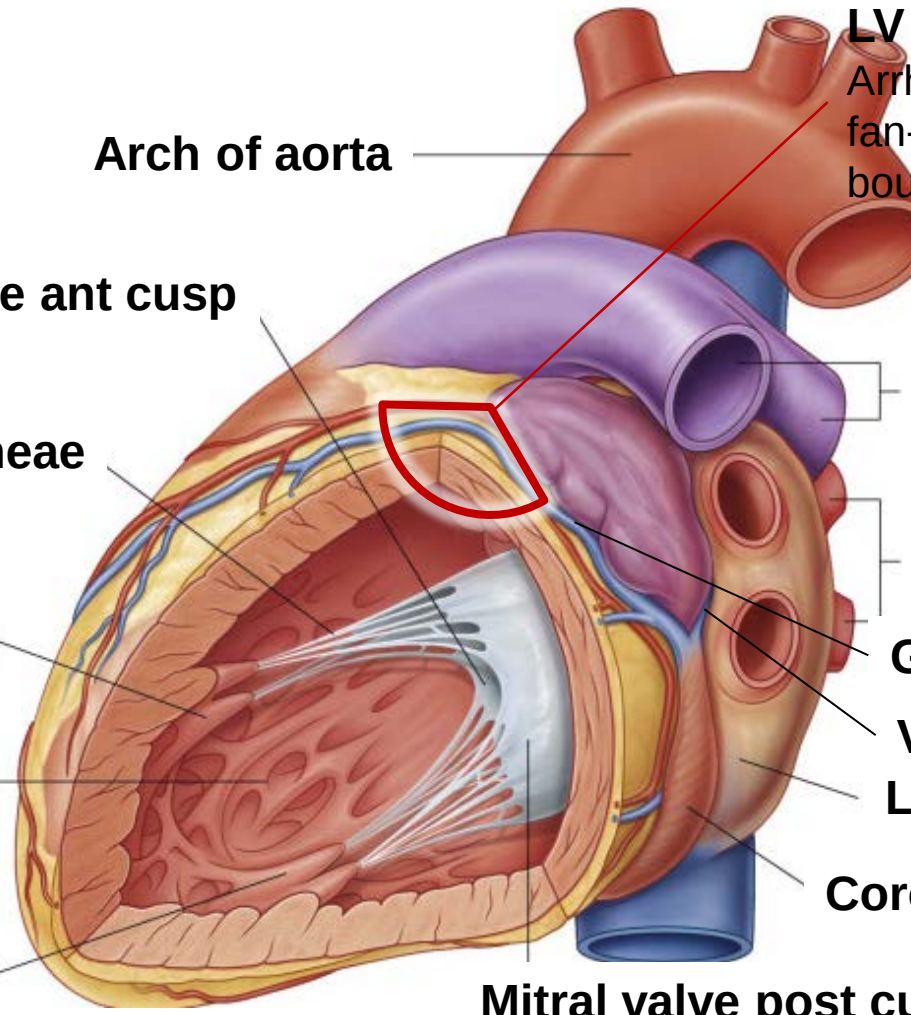
Papillary Muscles (PM) of Left Ventricle



LV summit:
Arrhythmia-prone
fan-shaped epicardial area
bounded by LAD, LCx

Arch of aorta

Mitral valve ant cusp

Chordae tendineae

Ant papillary m

Trabeculae carneae

Post papillary m

Pulmonary a

Pulmonary v

Great cardiac vein

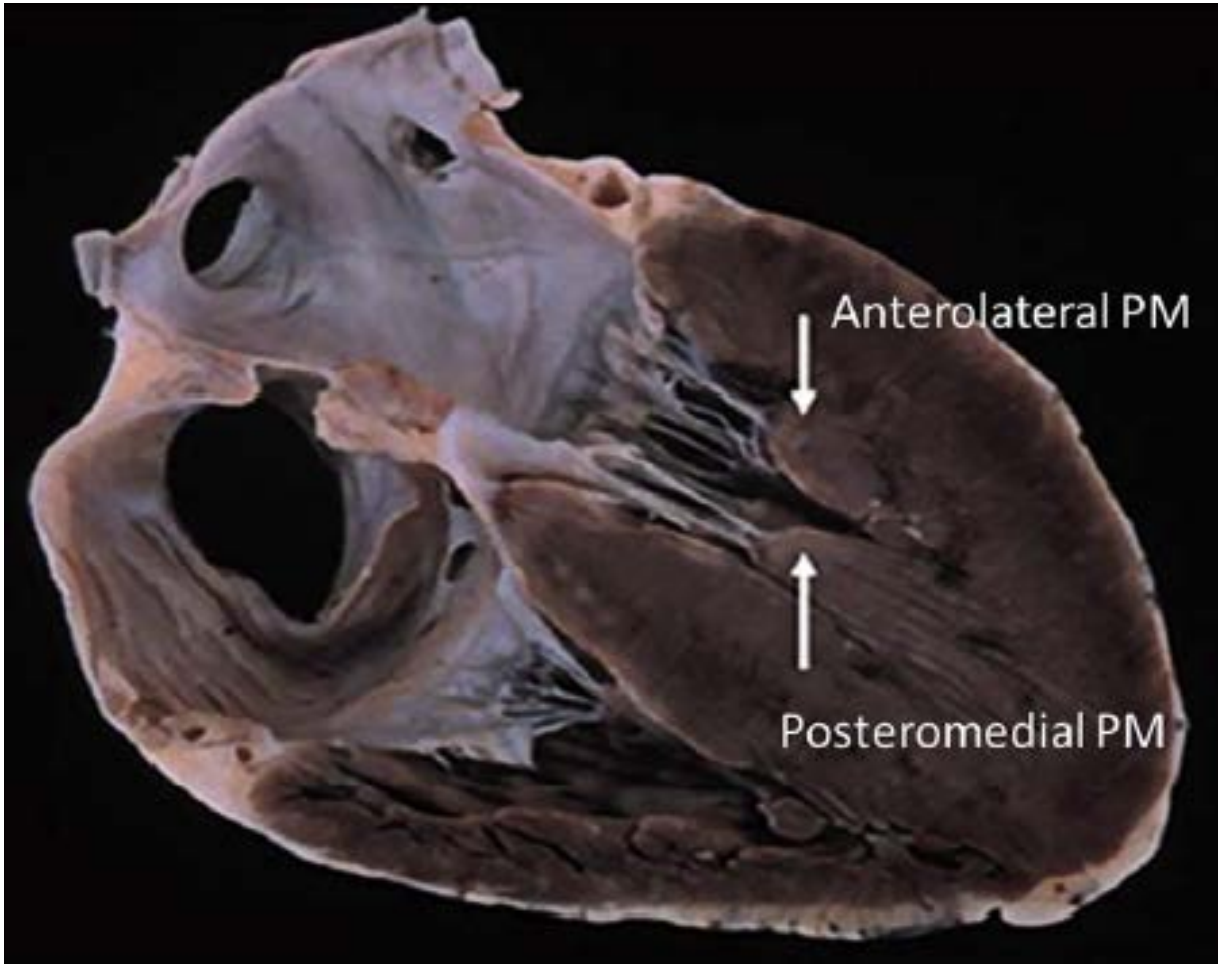
Vein of Marshall

LA

Coronary sinus

Mitral valve post cusp

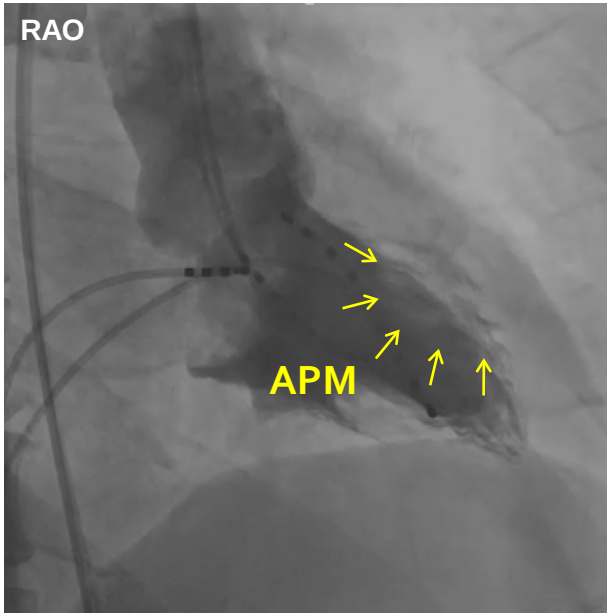
Papillary Muscles (PM) of Left Ventricle

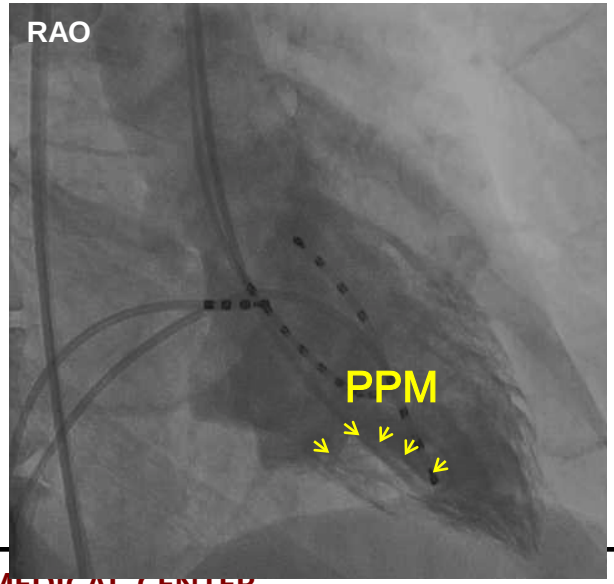


Naksuk N et al. Card Electrophysiol Clin. 2016;8:555-65

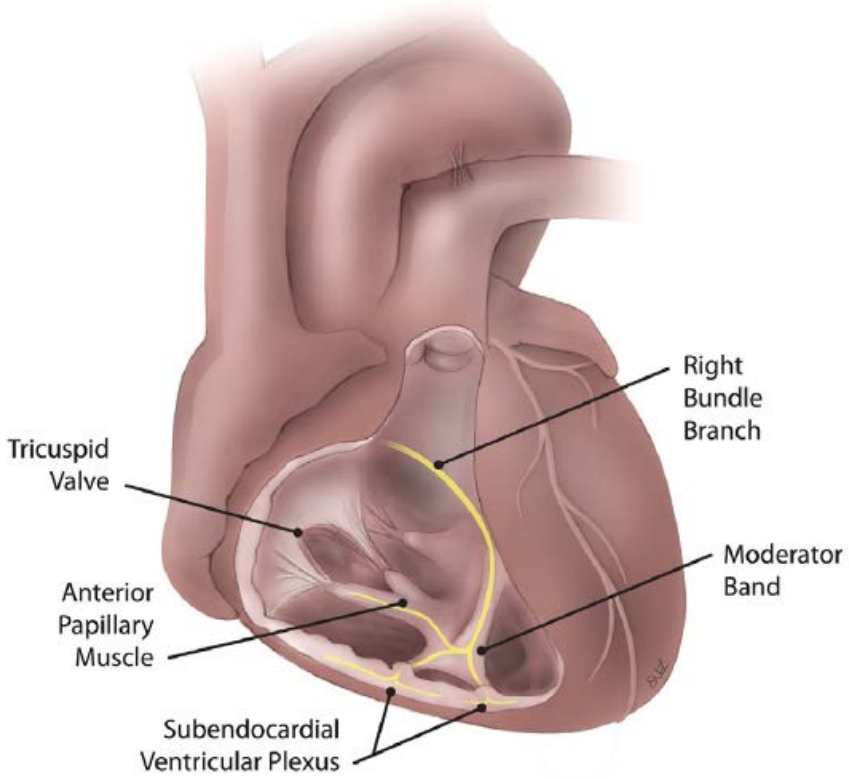
LV Angiography

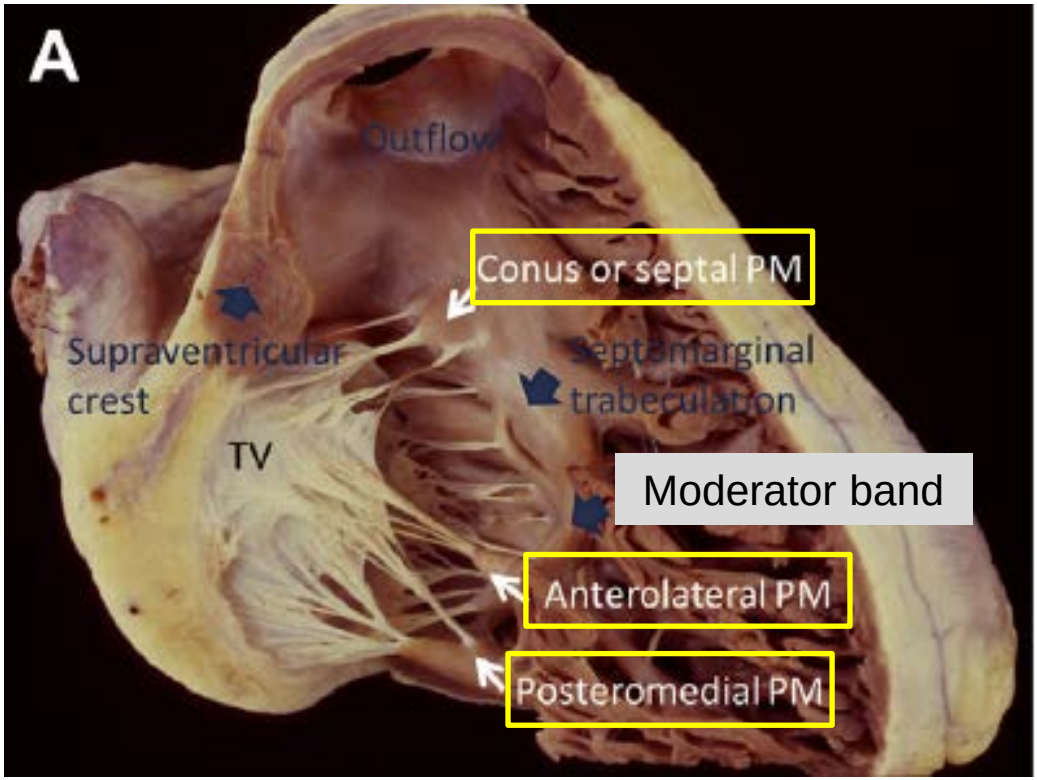
RAO 35º





Papillary Muscles (PM) of Right Ventricle





Naksuk N et al. Card Electrophysiol Clin. 2016;8:555-65

Mechanism

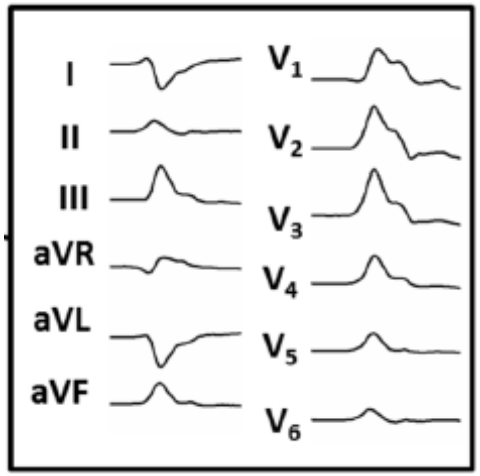
- **Triggered activity or abnormal automaticity**
  - Sensitive to catecholamines
  - Noninducible by programmed stimulation
  - The first beat of tachycardia is typically similar to subsequent beats
  - Non-entrainable
  - Typical lack of low voltage or fractionated potentials at the sites of ablation success

12 Lead ECG

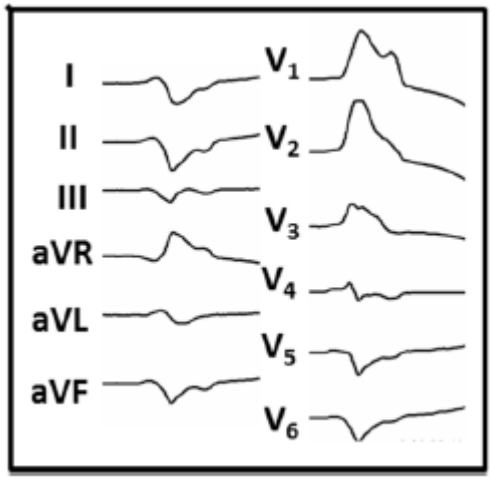
- **LV Anterior PM**
  - RBBB, right inferior axis
  - Transition at leads V3-V5
  - Inferior lead discordance (lead II (-), lead III (+))
- **LV Posterior PM**
  - RBBB, superior axis
  - Transition at leads V3-V5

PM VT vs. Fascicular VT

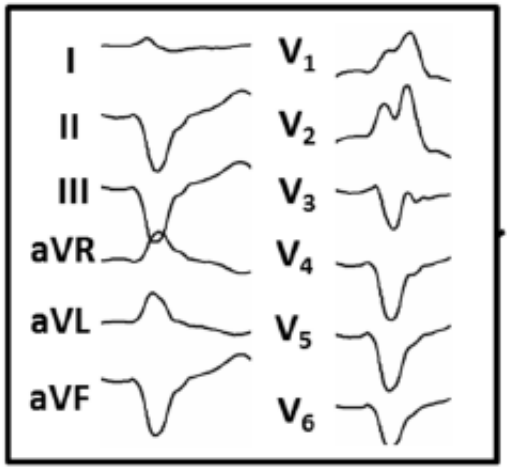
APM



PPM



Fascicular



	PM VT	Fascicular VT
QRS duration	150±15	127±11
V1	qR or R	rsR’
Q waves I, aVL	No	Yes

Good E et al. Heart Rhythm 2008;5:1530–1537
Al'Aref SJ et al. Circ Arrhythm Electrophysiol. 2015;8:616-24

Differentiation of PM VT vs. Fascicular VT

	PM VT	Fascicular VT
Age	Older	Younger
Manifestation	Sustained VT < PVC or NSVT	Sustained VT > PVC or NSVT
Response to verapamil	(-)	(+)
Mechanism	Abnormal automaticity or triggered activity	Re-entry
ECG		
V1 QRS morphology	RBBB, qR or R	RBBB, rsR'
QRS duration	Longer	Shorter
Q wave in I and aVL	(-)	(+)
Mode of induction	Isoproterenol or epinephrine infusion and burst pacing	Programmed electrical stimulation
Fractionated potentials at the successful sites	(-)	(+)
Recurrence after RFCA	Relatively high	Low

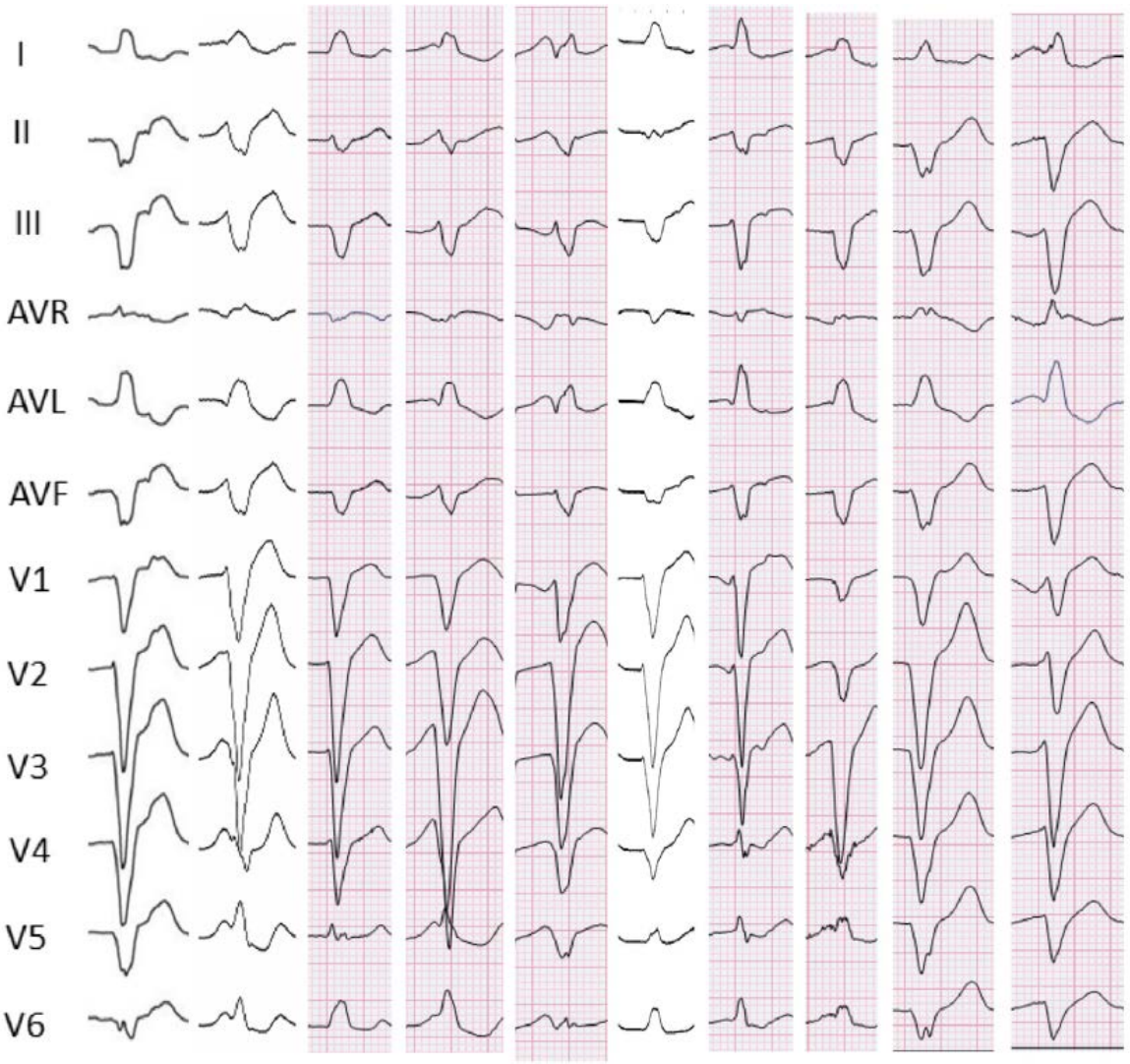
Modified from Park YM. Int J Arrhythm 2015;16:219-223

12 Lead ECG

- **Moderator band (MB)**
  - LBBB, left superior axis
  - Late transition (≥V4)
- **RV PM**
  - LBBB
  - Anterior or posterior PM: late transition (≥V4), superior axis > inferior axis
  - Septal PM: early transition and inferior axis, similar to RVOT VT, but wider QRS and notching in precordial leads

12 Lead ECG

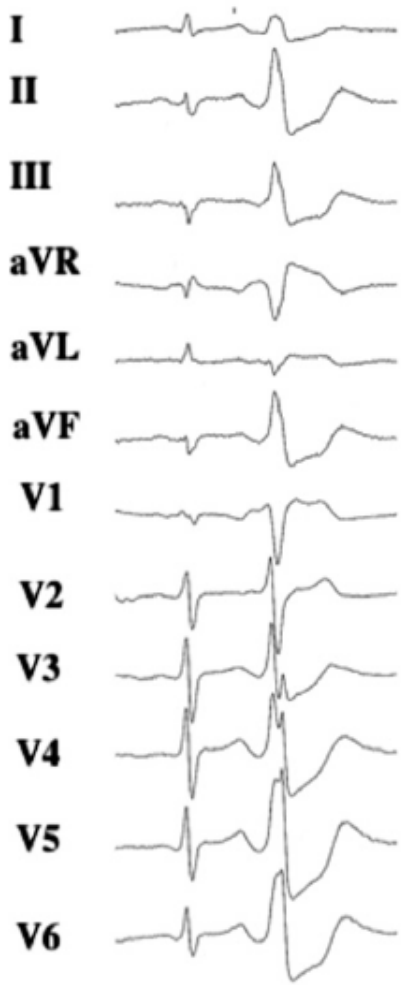
Moderator Band



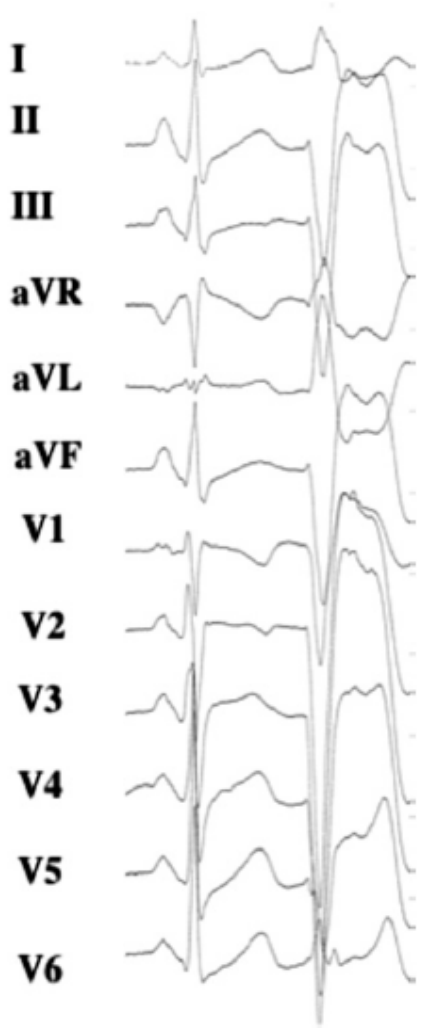
Sadek MM et al. Heart Rhythm. 2015;12:67-75.

12 Lead ECG

RV Septal PM



RV Posterior PM

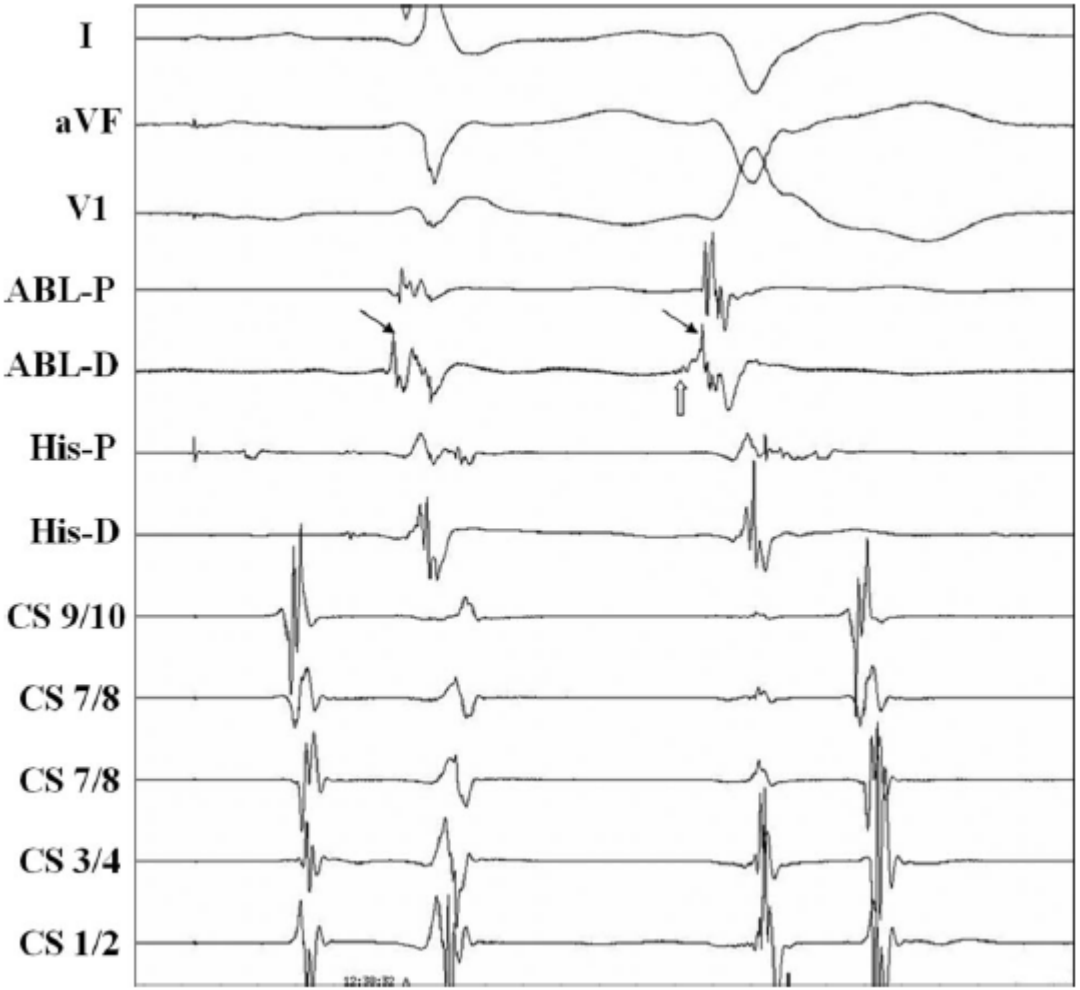


Crawford T et al. Heart Rhythm. 2010;7:725-30

Mapping Technique

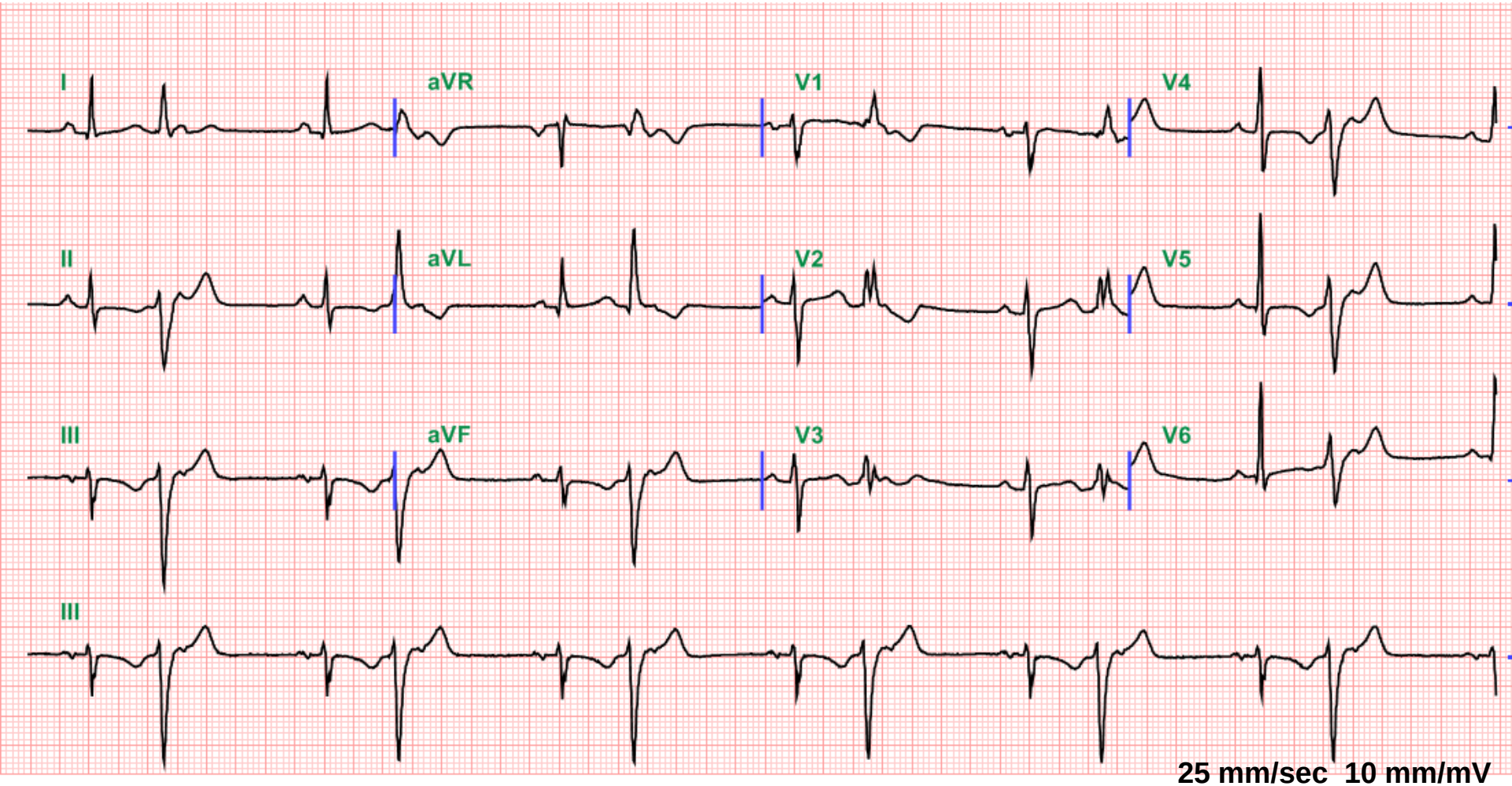
- **Transaortic vs.Transseptal**
  - Transaortic: PPM or medial aspect of APM
  - Transseptal: lateral APM, steerable sheath
- **Activation mapping**
  - Most commonly used
  - ≥-30 ms earlier than QRS
  - QS pattern in unipolar recording
  - Sharp early signals: a more superficial location
  - Far-field signals: a deeper location
  - Sharp Purkinje potential (~40%)

Purkinje Potential during Mapping



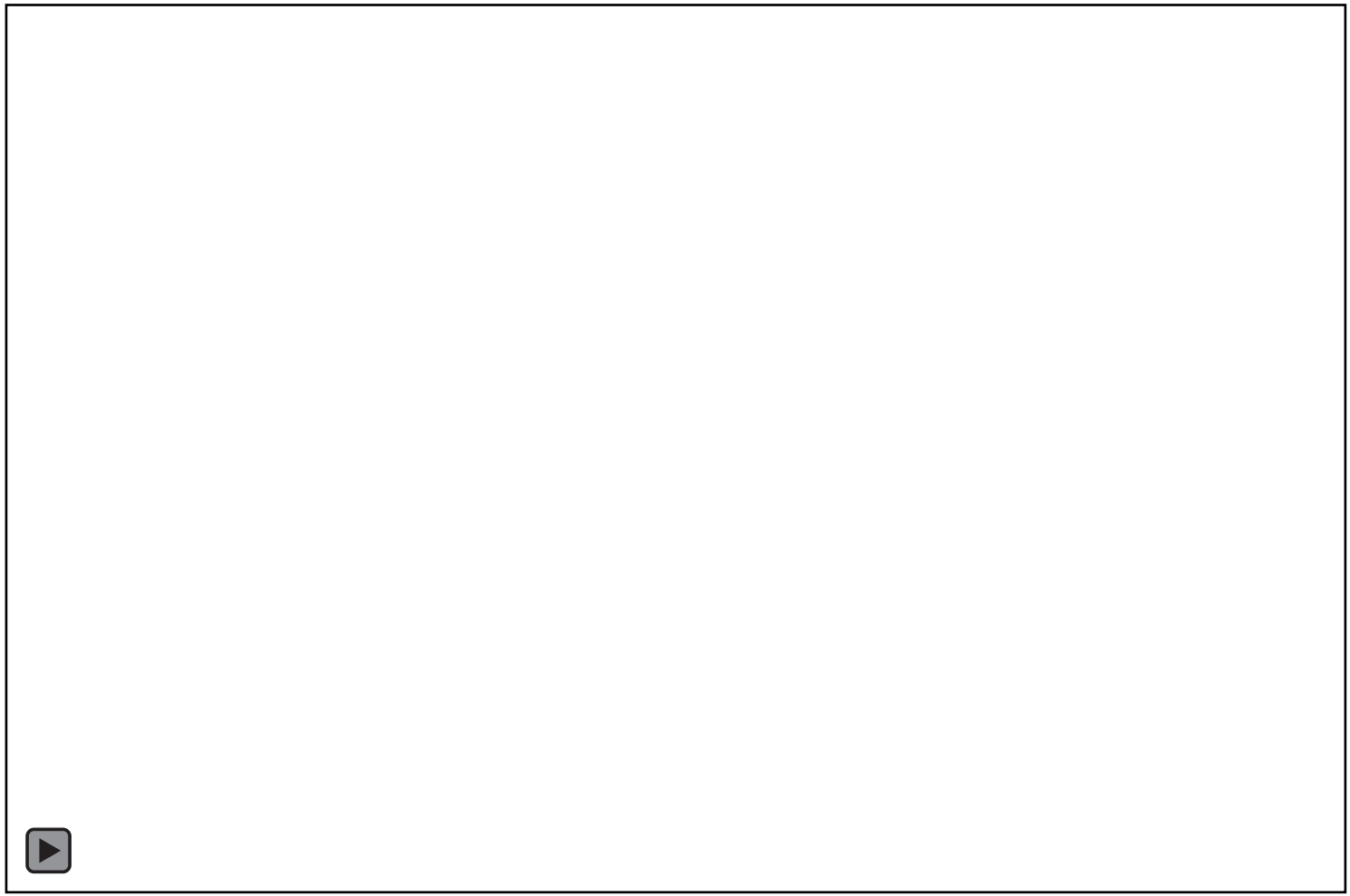
Doppalapudi H et al. Circ Arrhythm Electrophysiol. 2008;1:23-9

- **F/54, palpitation**



- **Purkinje potential, -35ms earlier than QRS**

- ICE



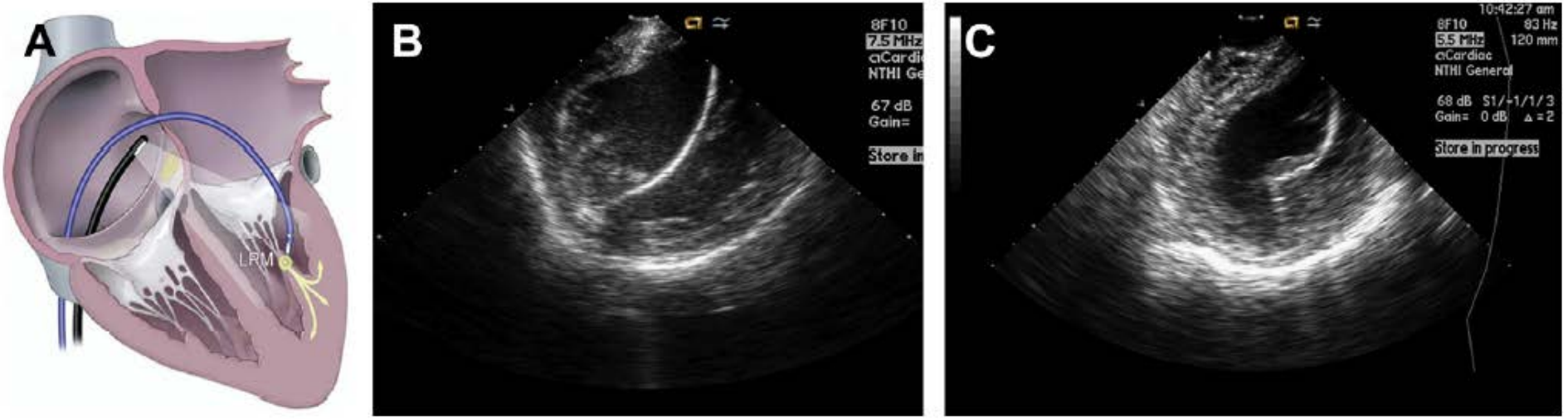
Mapping Technique

- **Pace mapping**
  - Useful, but not sufficient by itself
  - Possibility of capturing adjacent tissue
  - Sites of successful ablation usually exhibit an excellent pace map (≥11/12)
  - Ablation at sites with perfect pace maps may fail to terminate the arrhythmia (exit site vs. origin)
- ICE is fundamental to allow real-time visualization of PM and ensure proper catheter-tissue contact

Mapping Technique

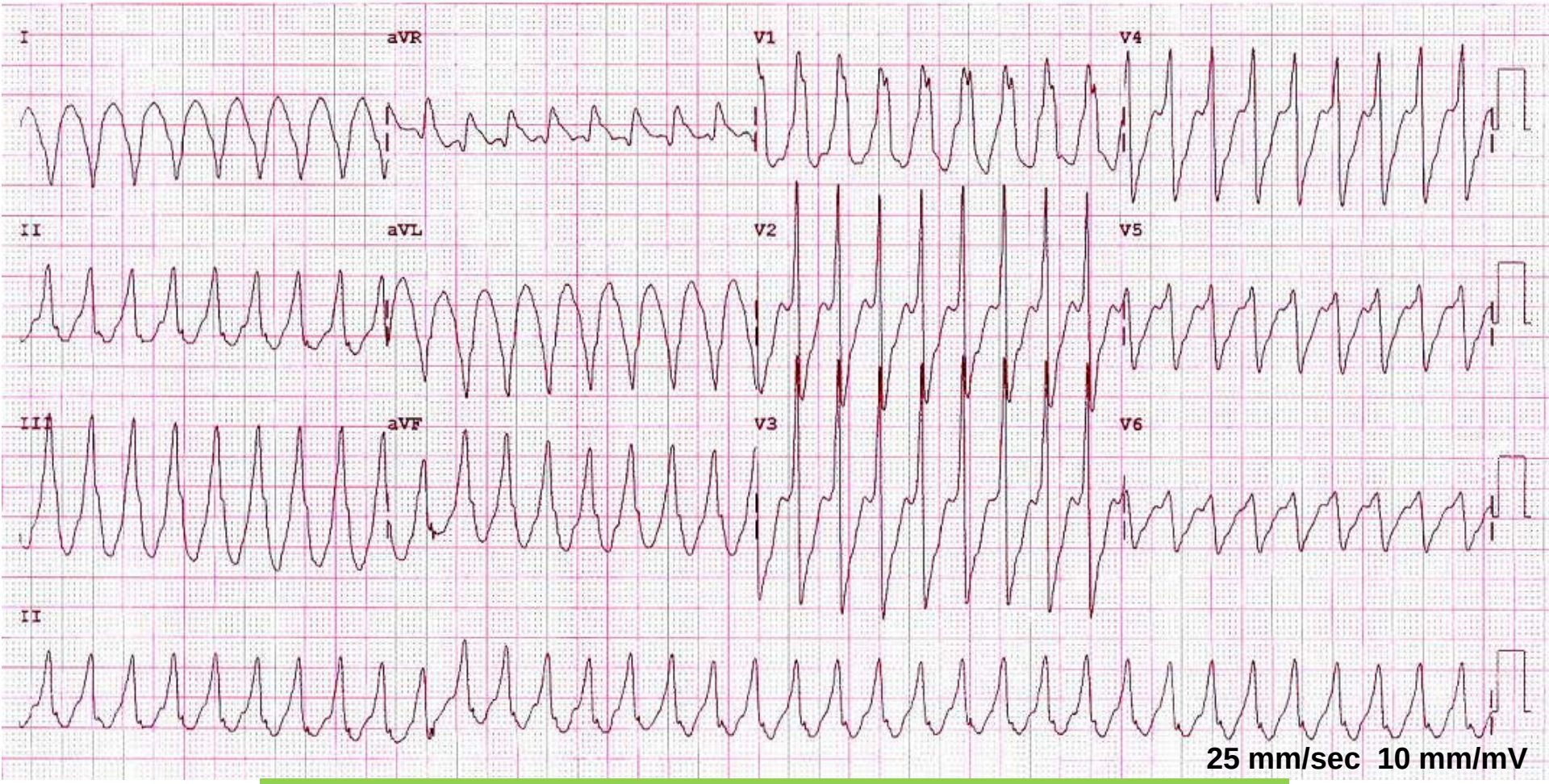
- ICE allows clear visualization and confirmation of contact

PPM **APM**



Naksuk N et al. Card Electrophysiol Clin. 2016;8:555-65

- **M/65, Palpitation and dyspnea, DM, HTN**



HR 213/min, QRSD=171ms, RBBB, Right inferior axis

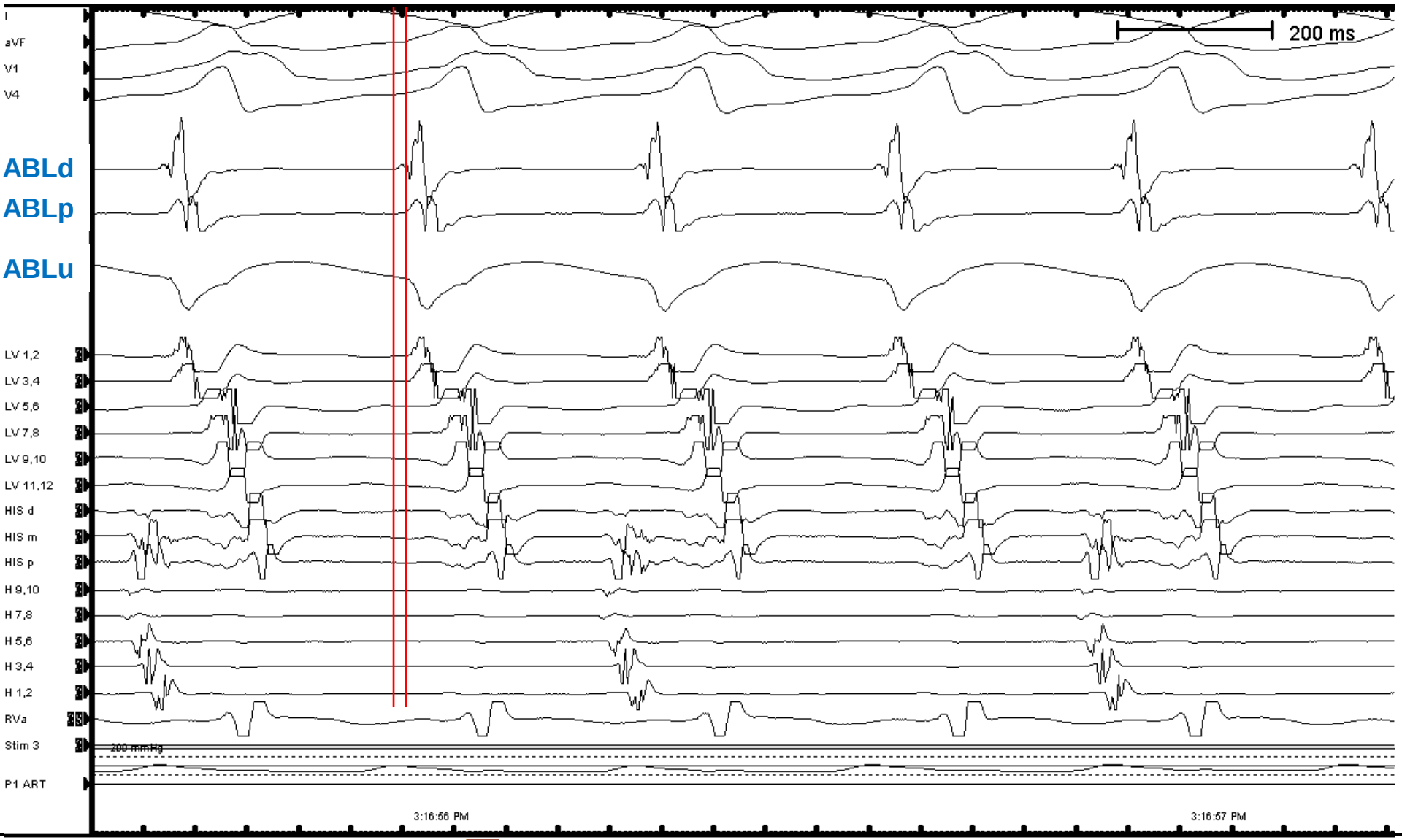
VEST 400/300/290/220 – VT Induction

VT – TCL 300ms

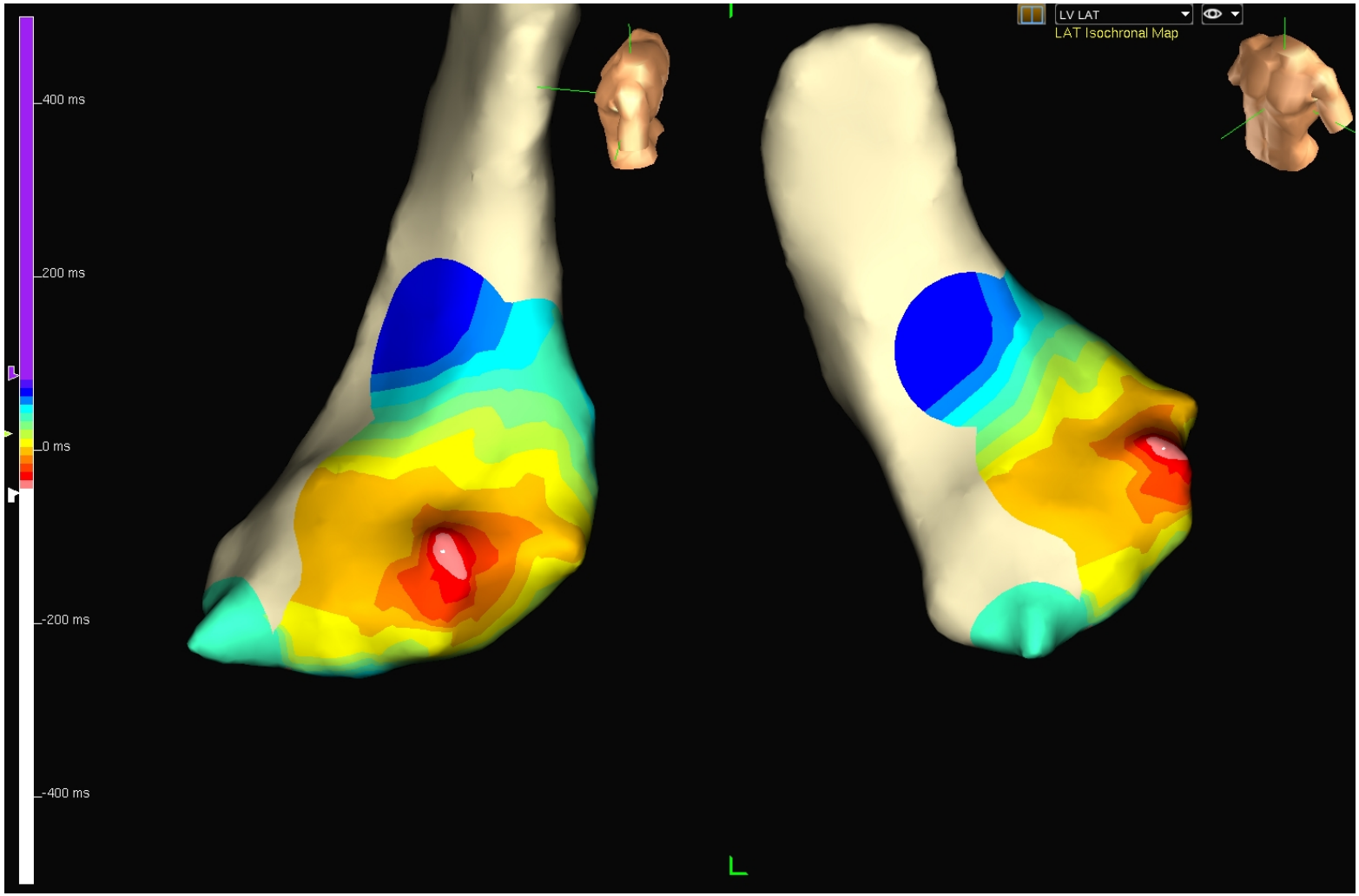

I
aVF
V1
V4
H 19,20
H 17,18
H 15,16
H 13,14
H 11,12
HIS d
HIS m
HIS p
H 9,10
H 7,8
H 5,6
H 3,4
H 1,2
RVa
Stim 2
200 ms
200 mmHg
1:12:66 PM
1:12:66 PM

Comparison of induced VT vs. clinical VT

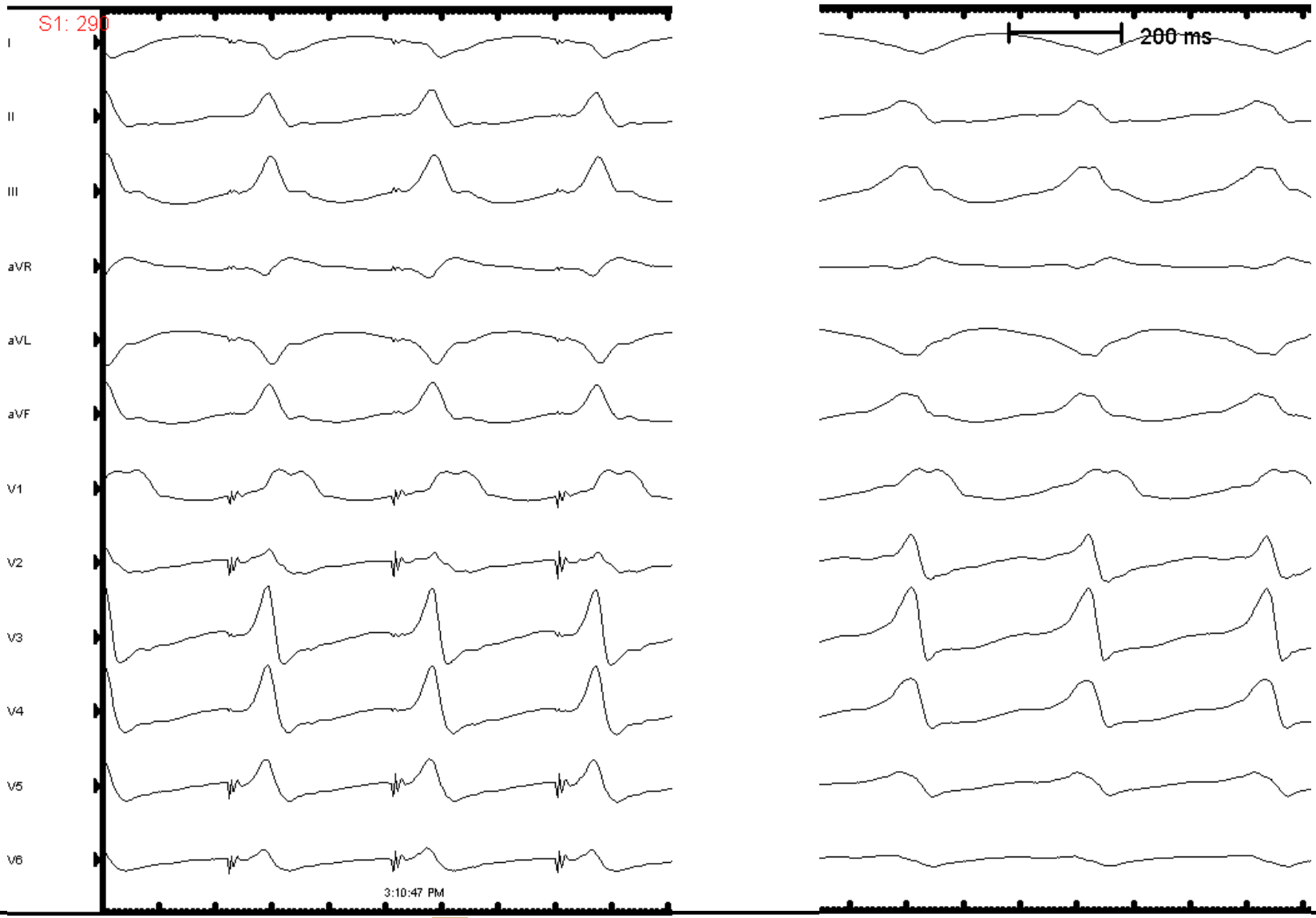
- **Activation mapping, -25ms earlier than QRS**



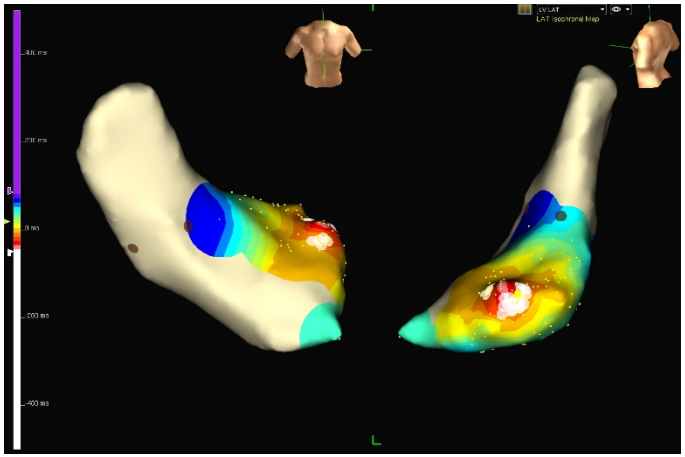
- **Activation mapping**

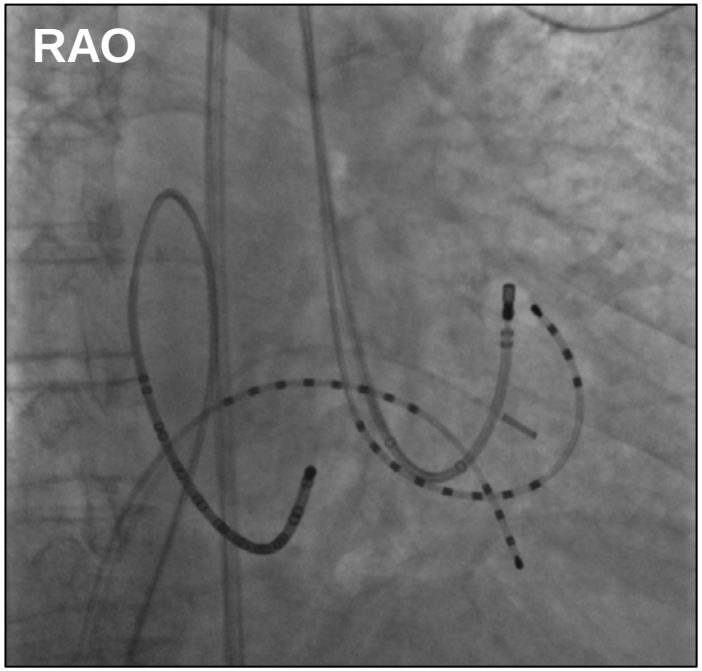


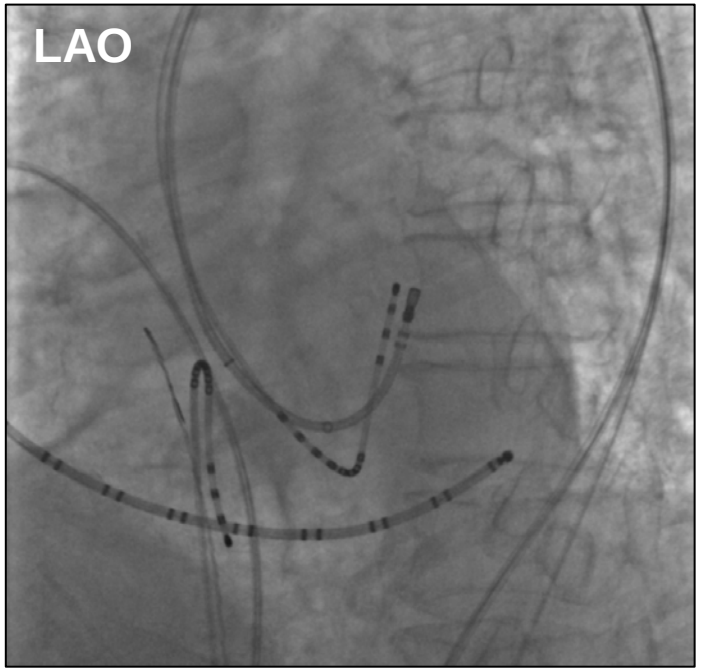
Pace mapping



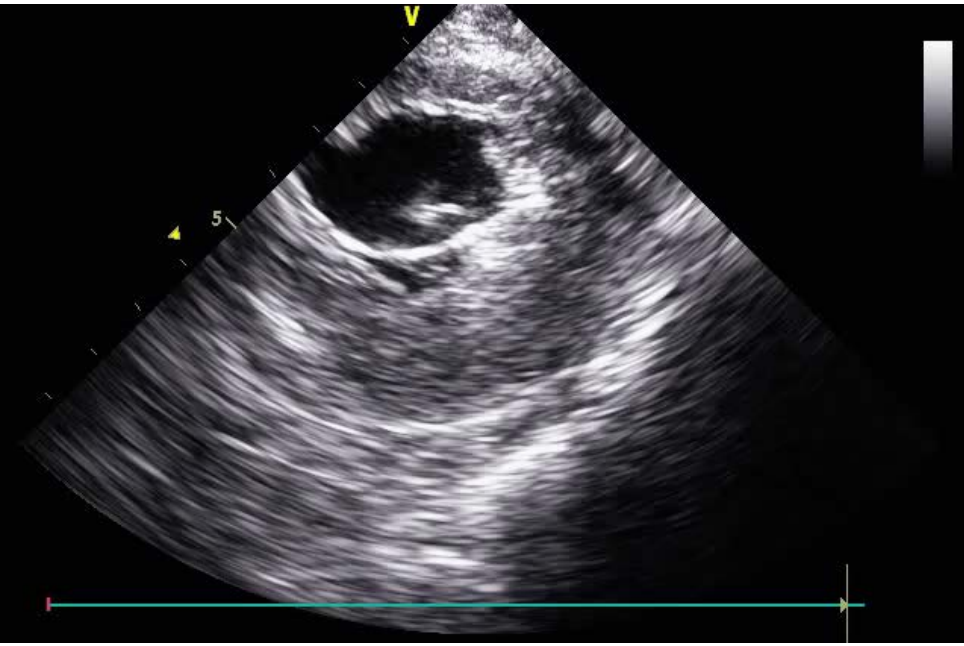
- **Successful ablation site**

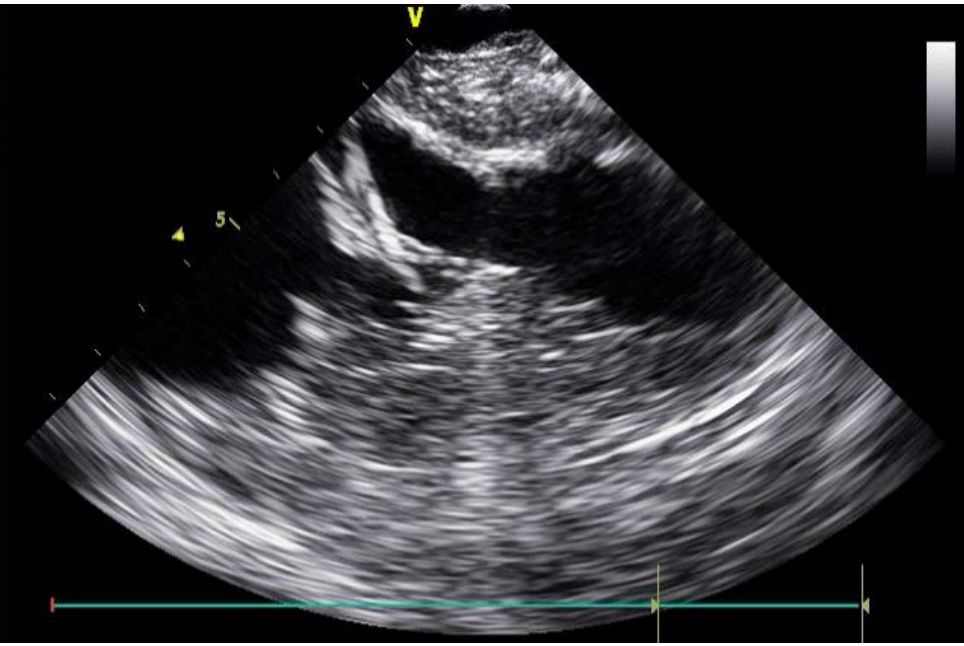




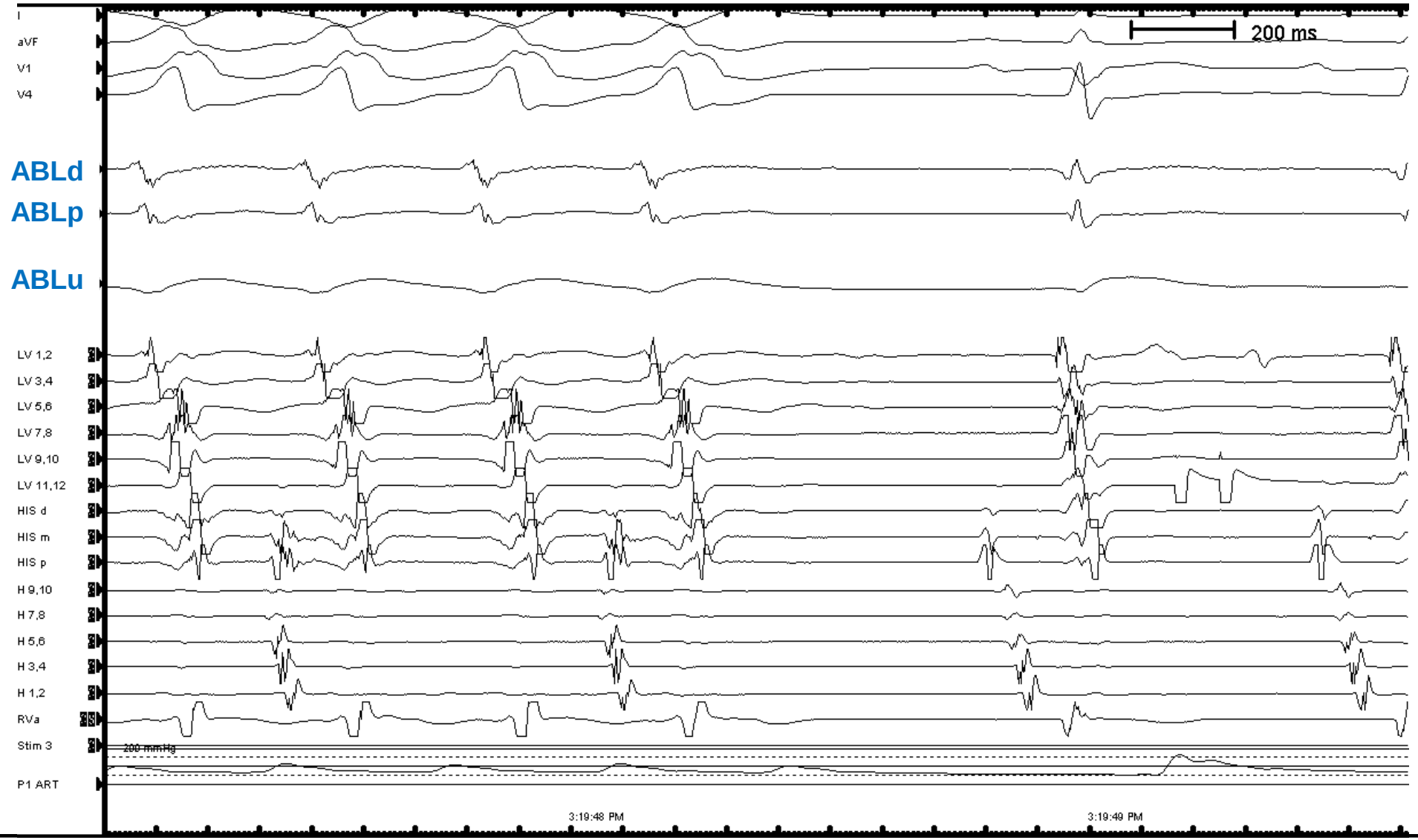


- **Ablation site on ICE**

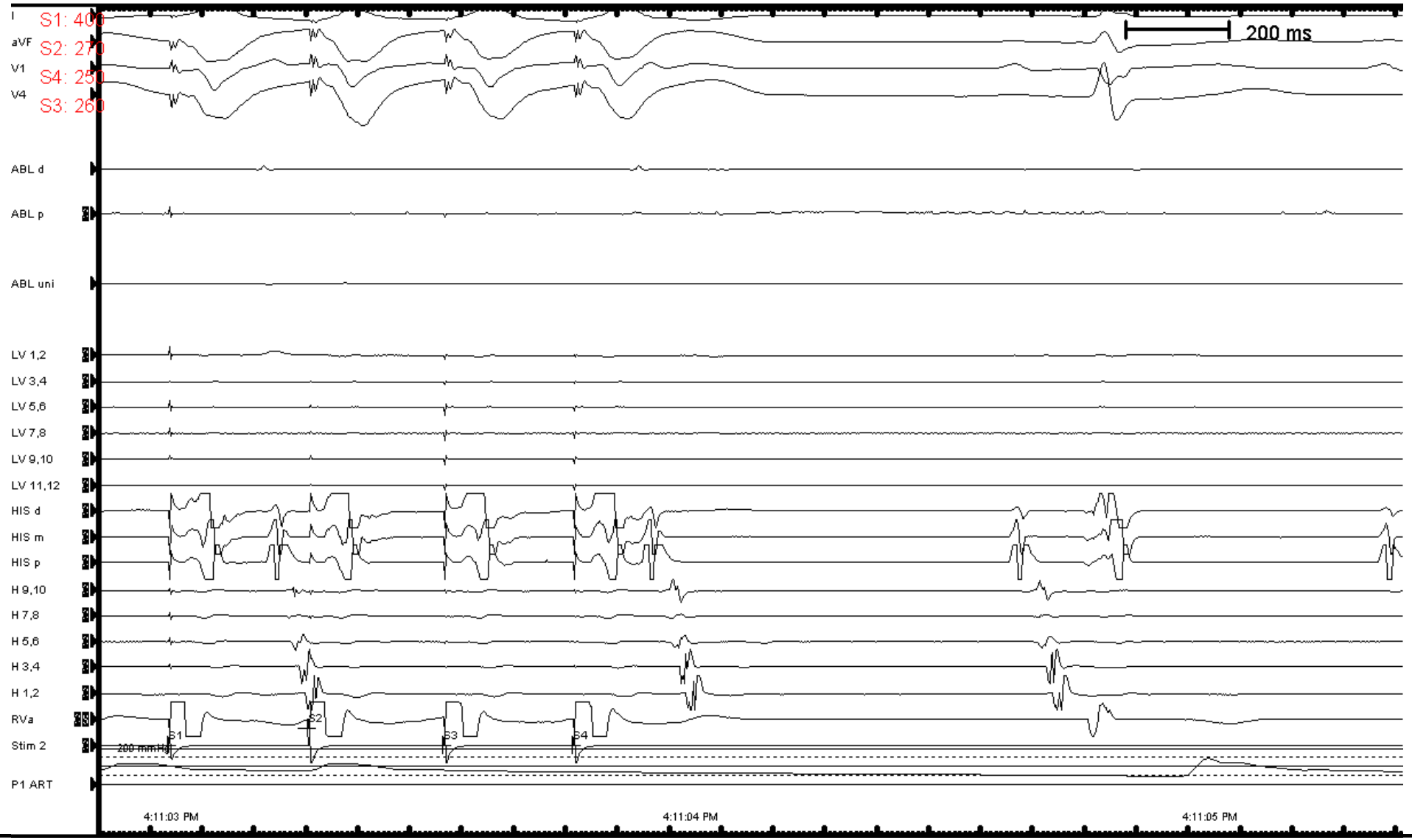




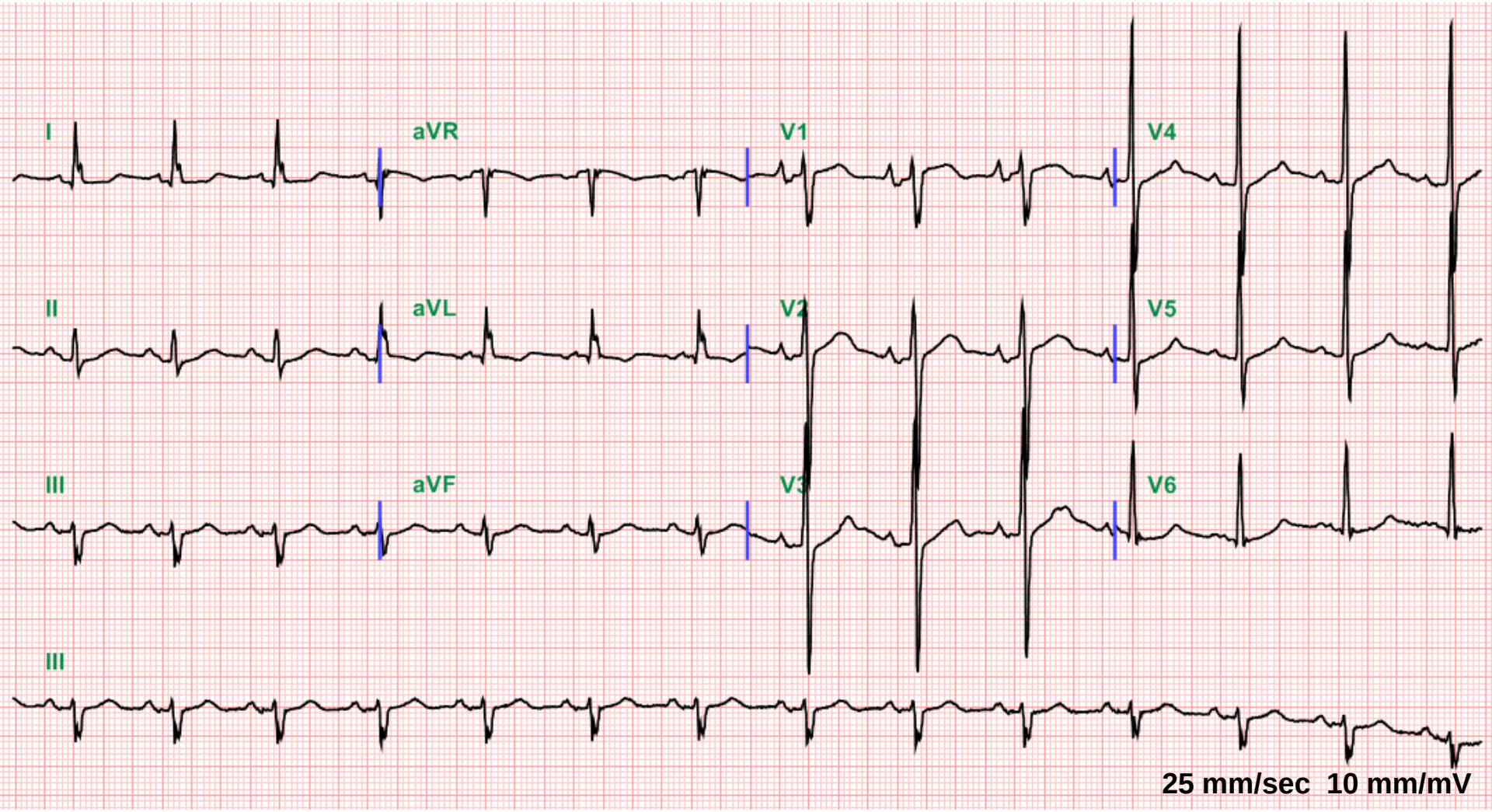
VT termination during ablation



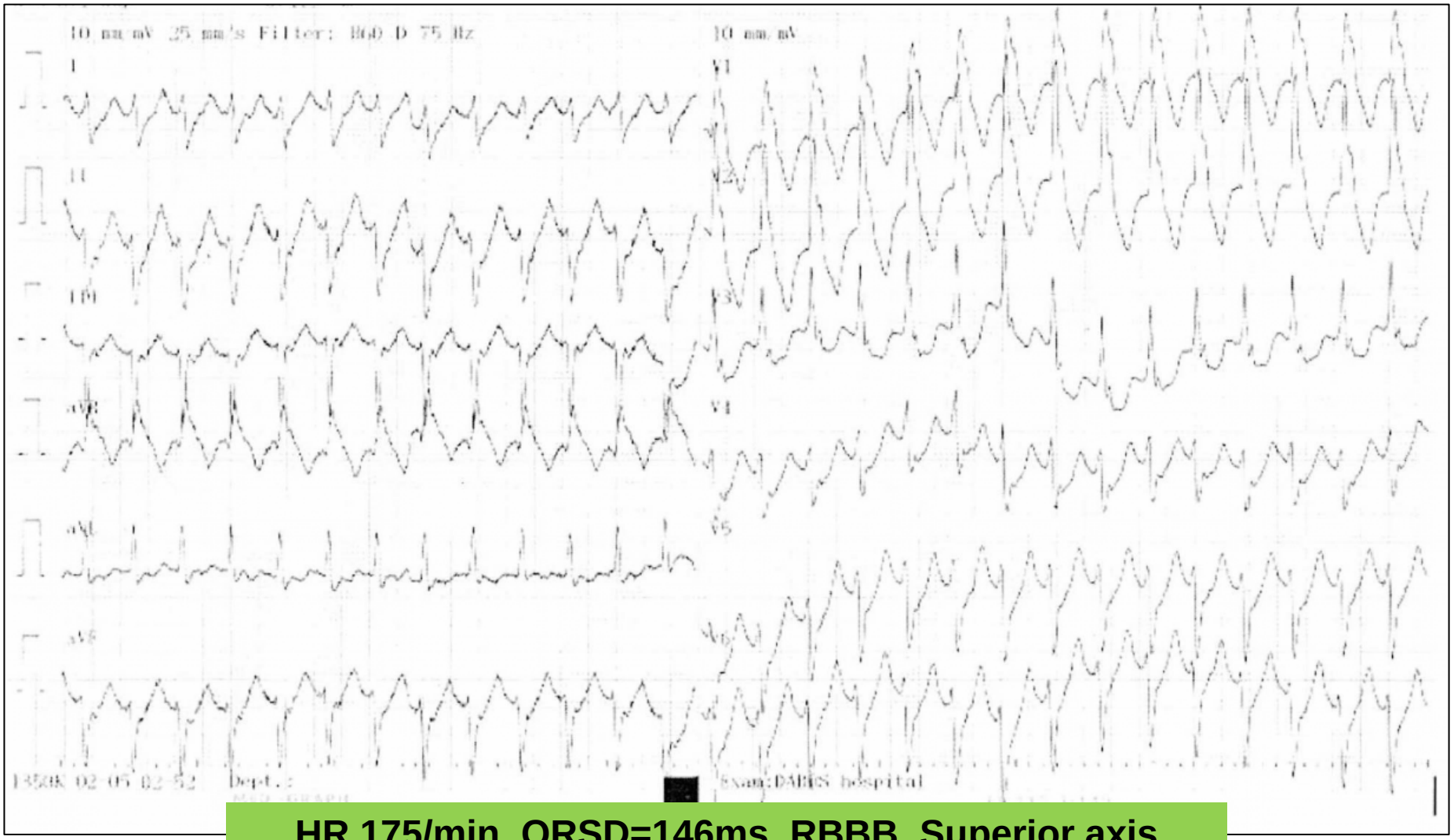
VEST 400/260/250/240 – No VT Induction



- **Post ablation**

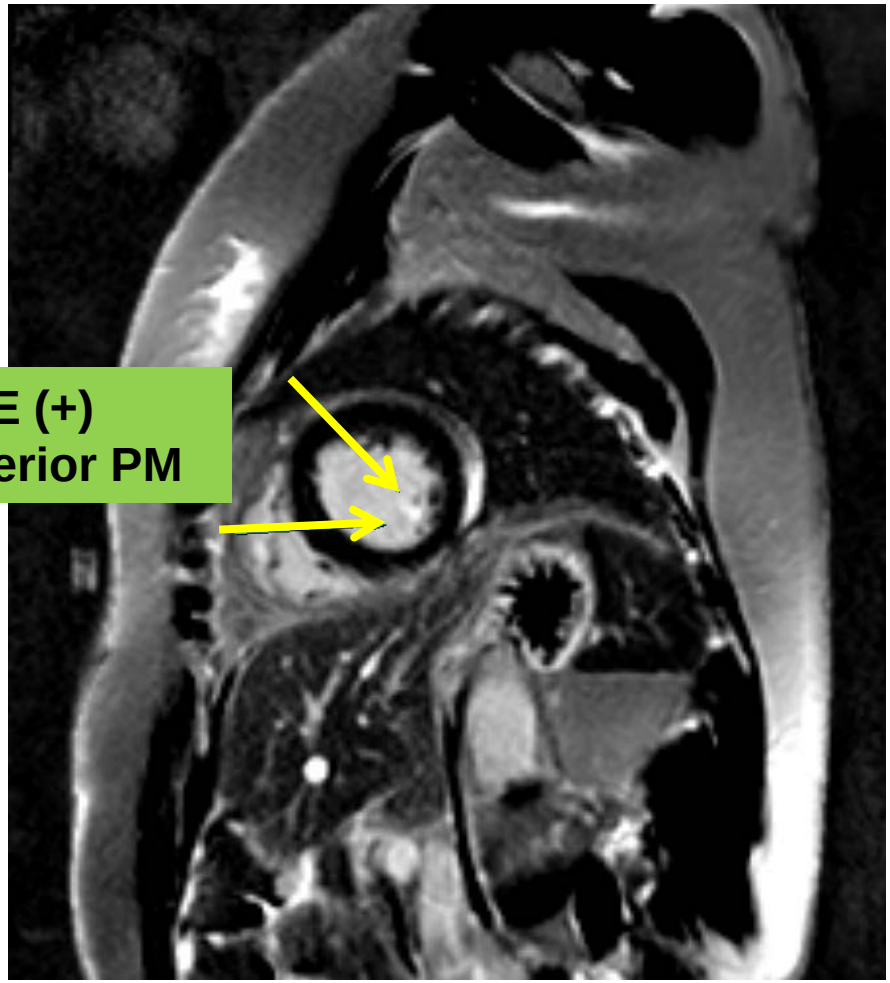


- **F/58, Palpitation and chest pain**

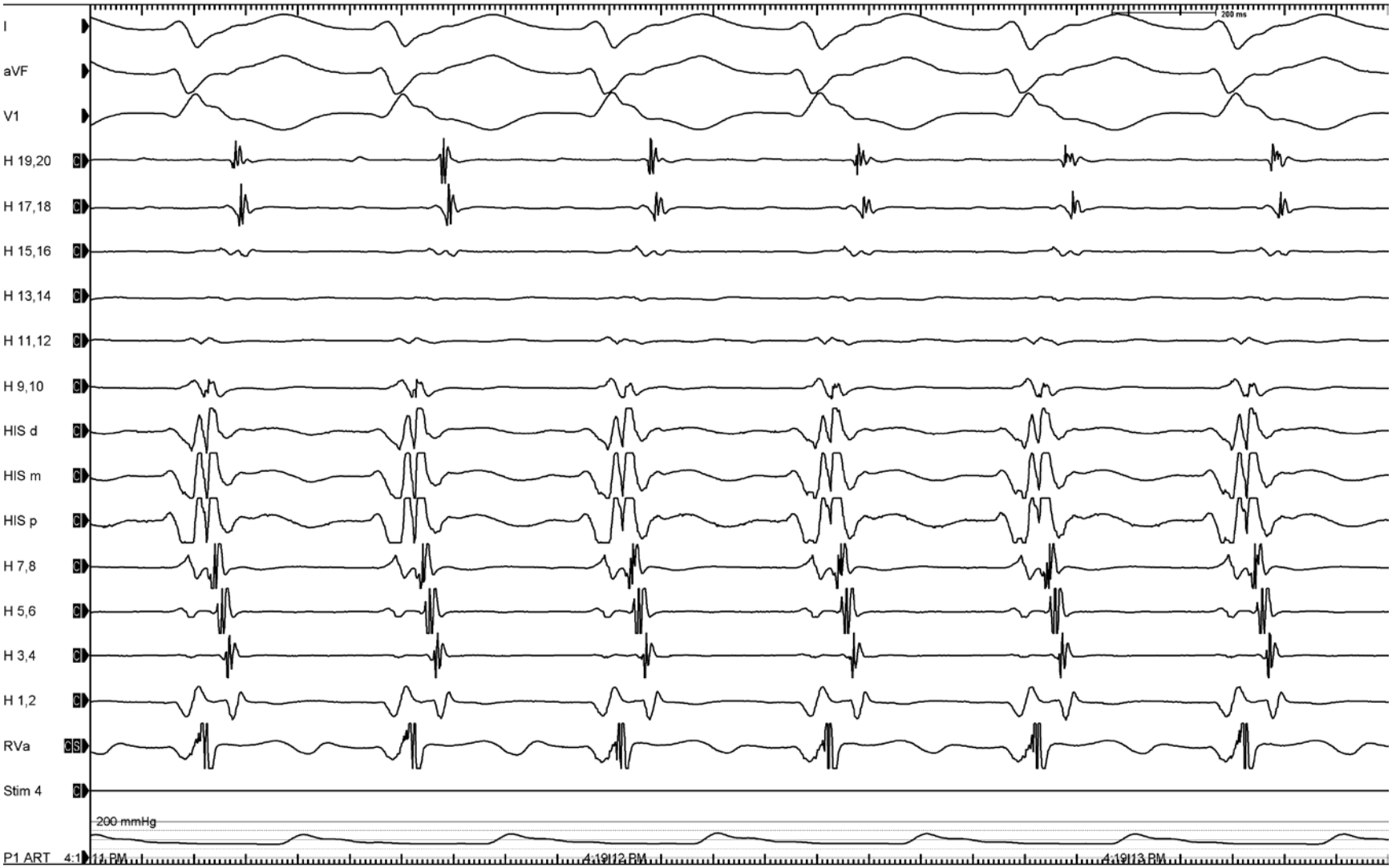


HR 175/min, QRSD=146ms, RBBB, Superior axis

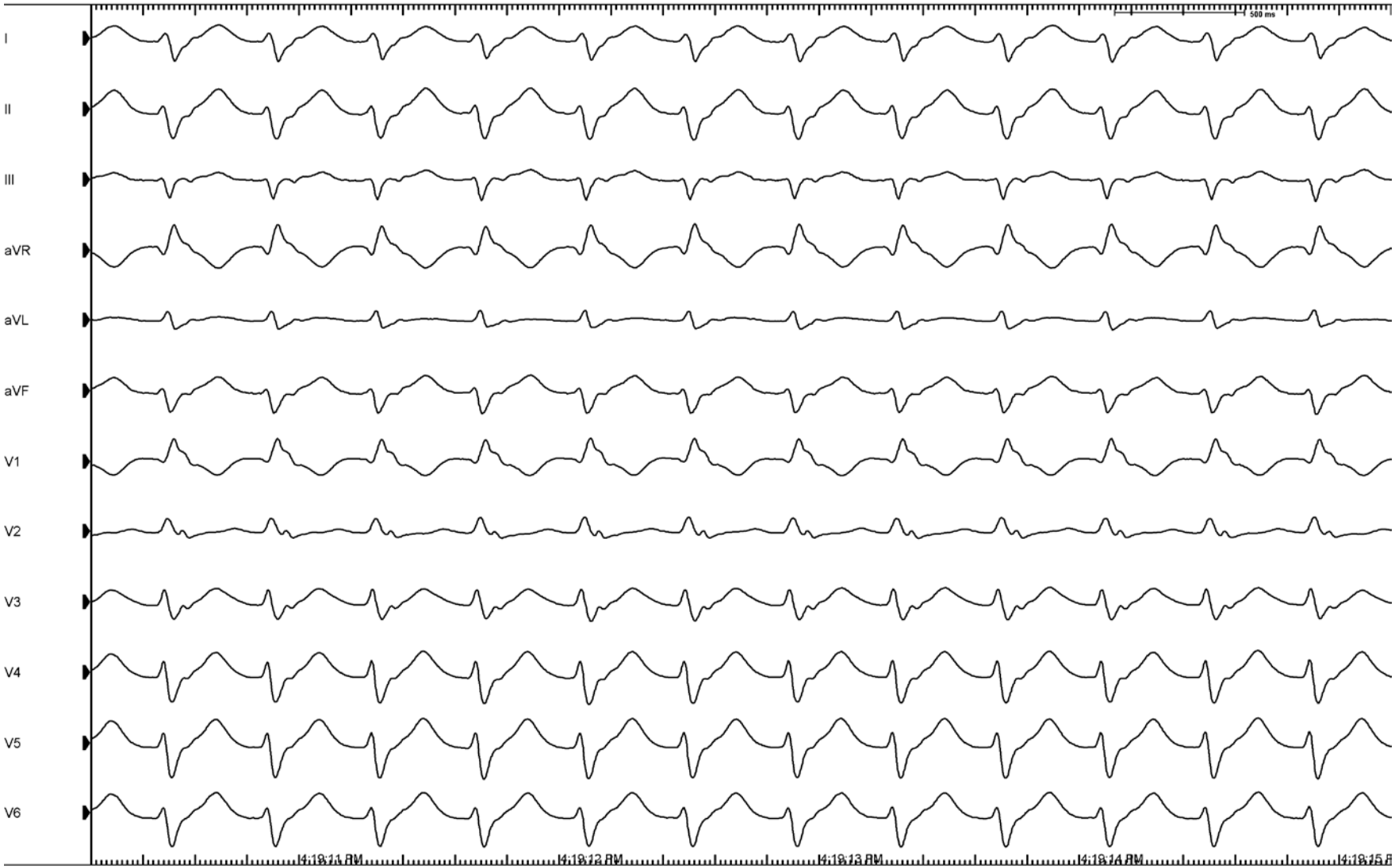
- **Cardiac MRI**



VT induction



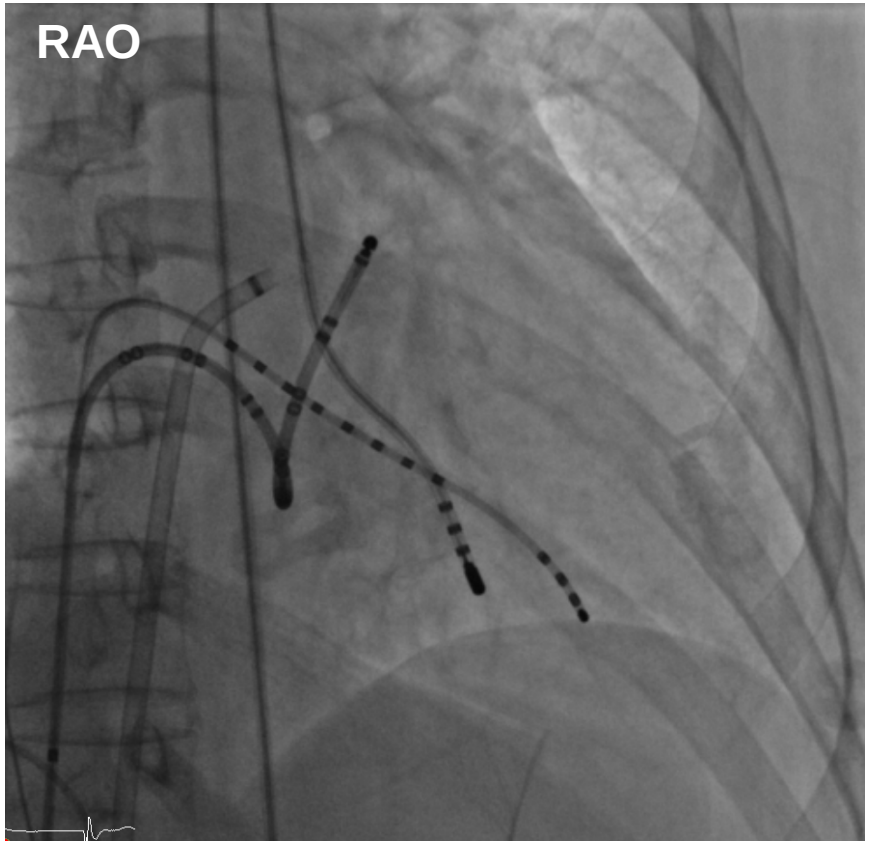
- **VT, 12 lead ECG**

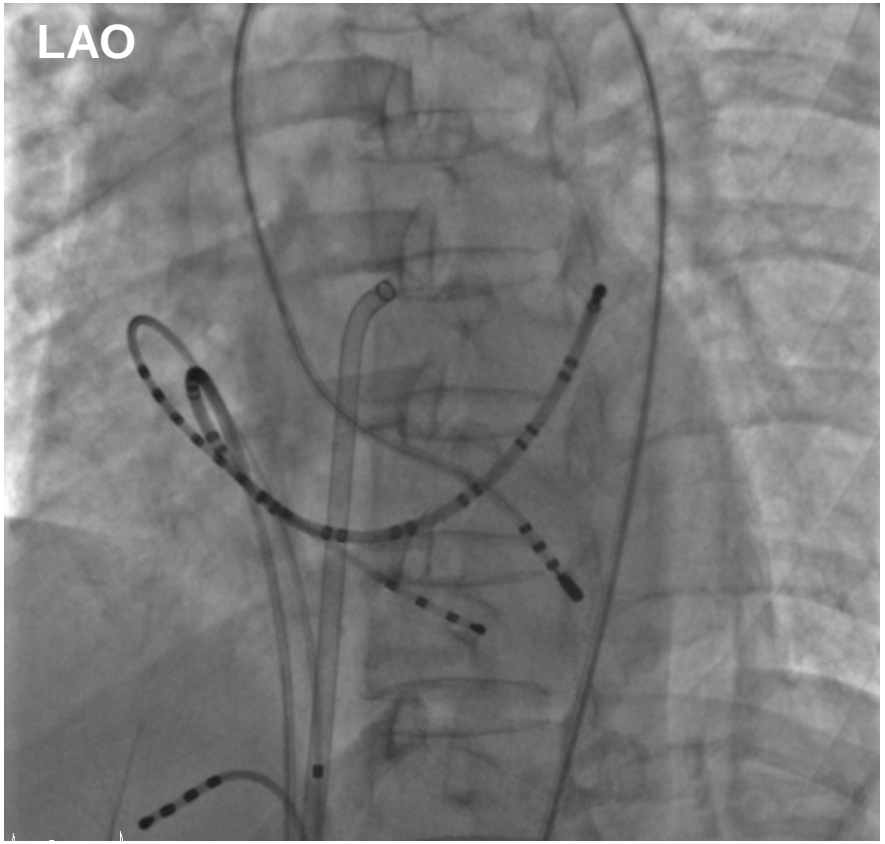


- **Activation mapping, -29ms earlier than QRS**

VT termination during ablation

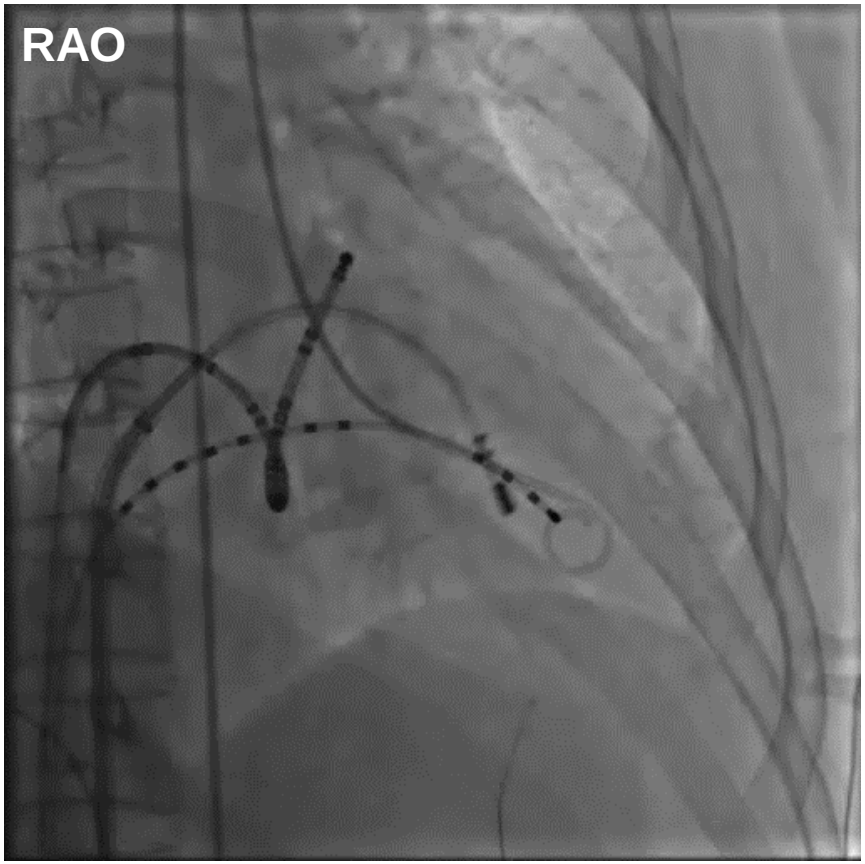
- **Ablation site, retrograde transaortic approach**

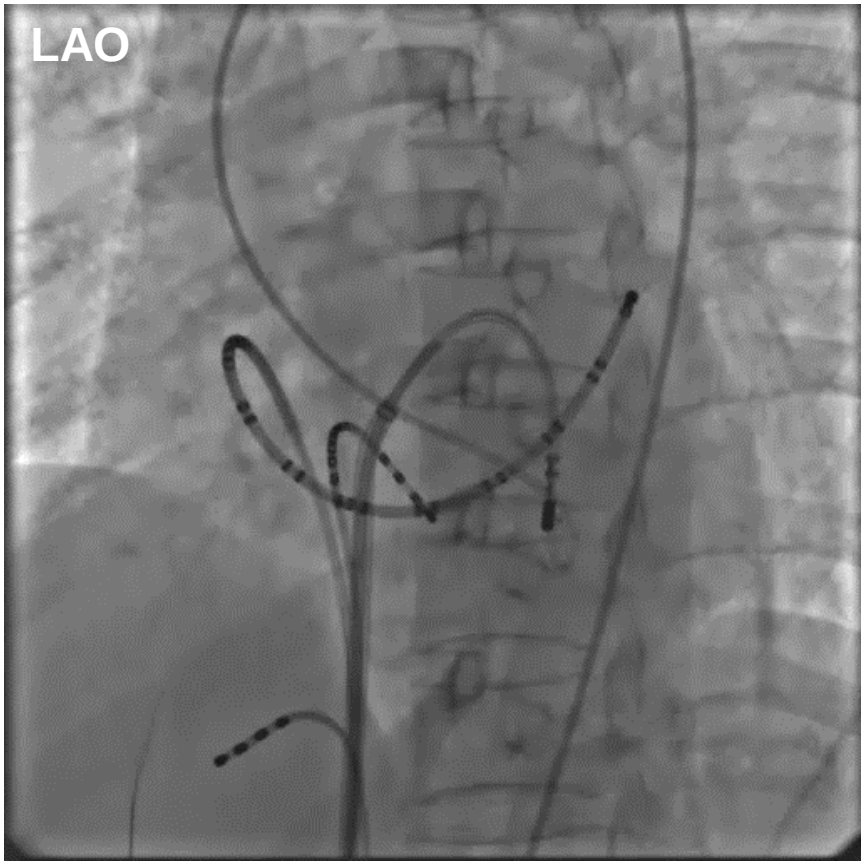




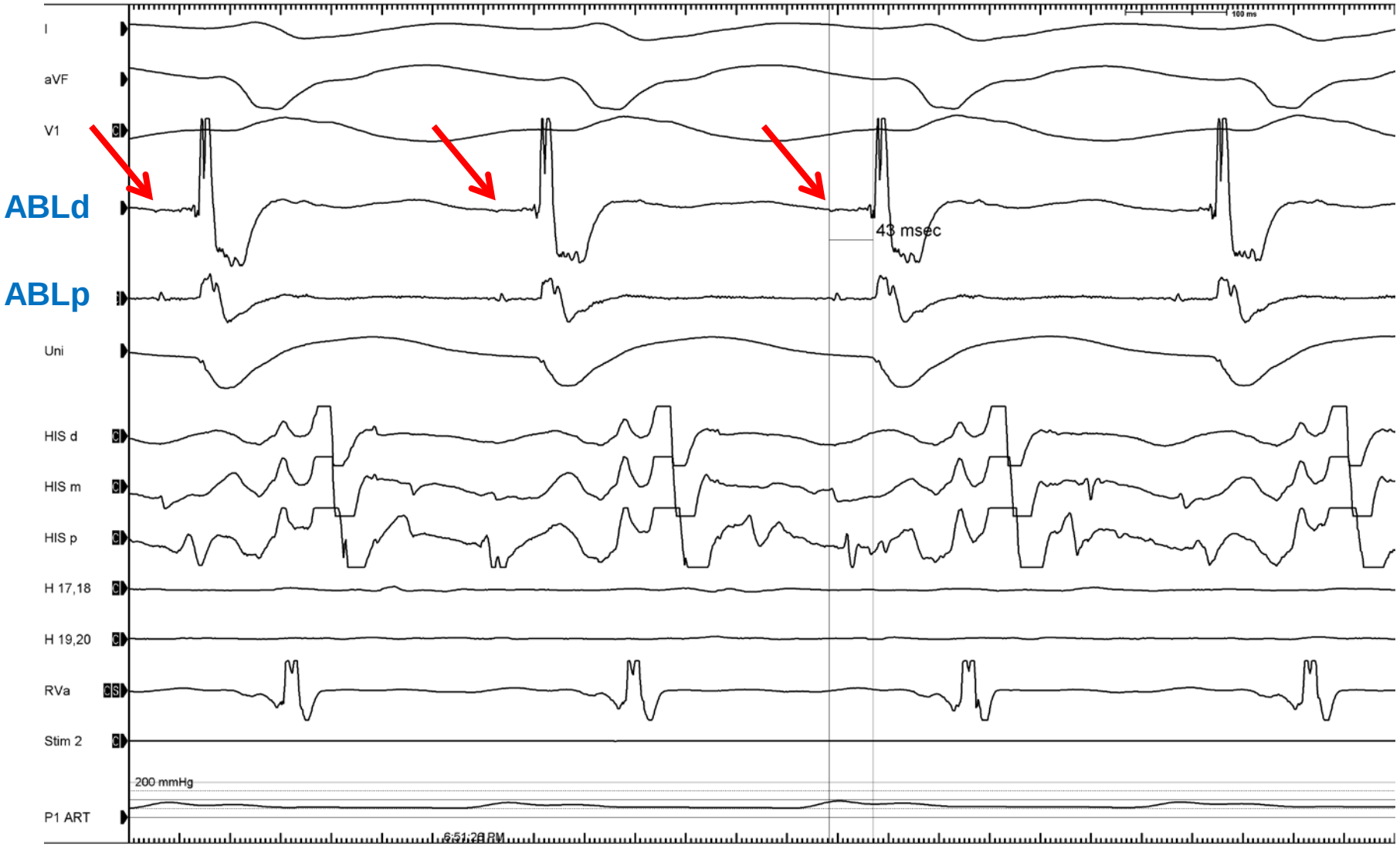
However, VT was still inducible despite repeated ablation…

- **Transseptal approach, LV angiogram**



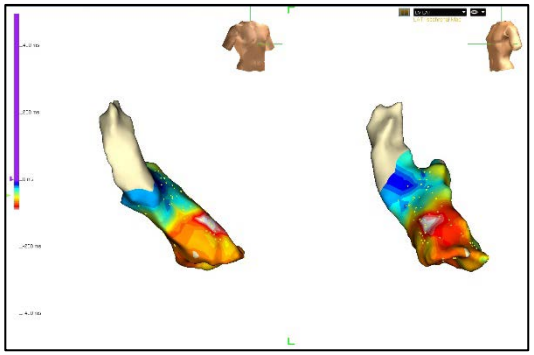


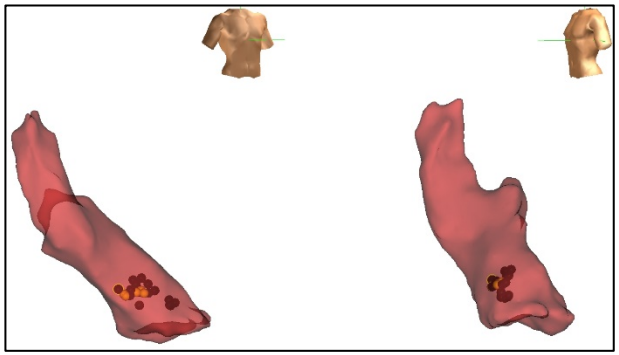
VT induction, activation map, -43ms earlier than QRS

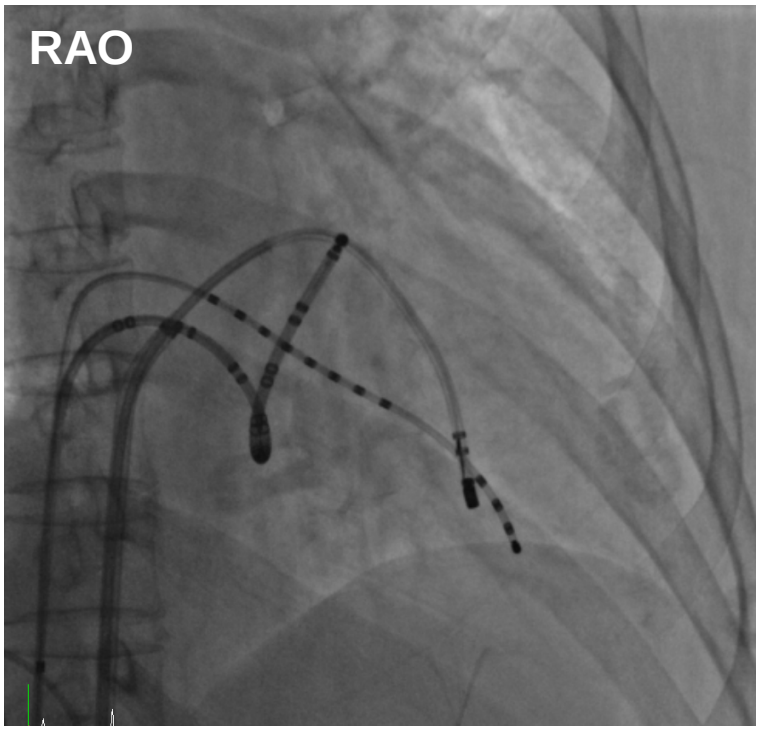


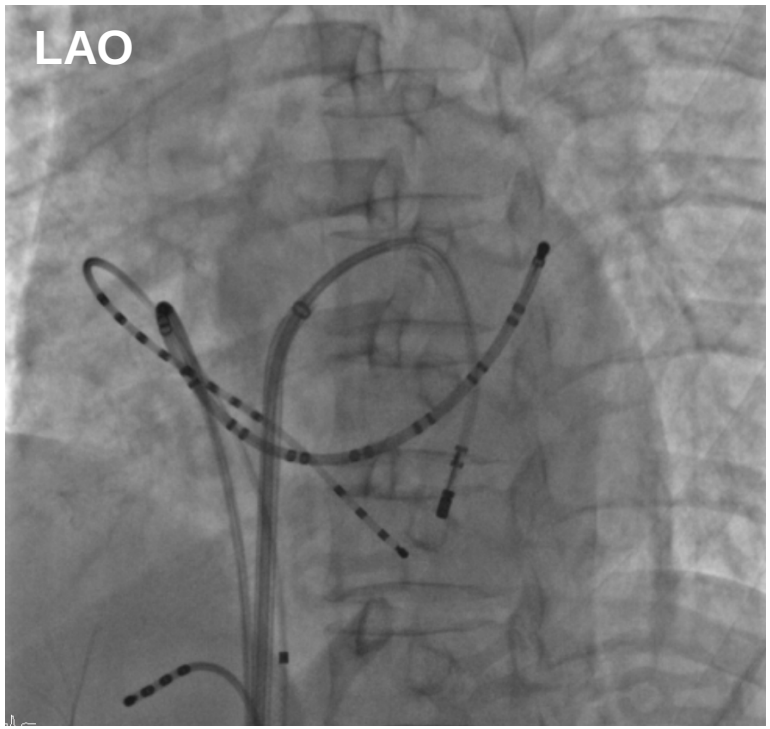
VT termination during ablation

- **Successful ablation site**









Catheter Ablation

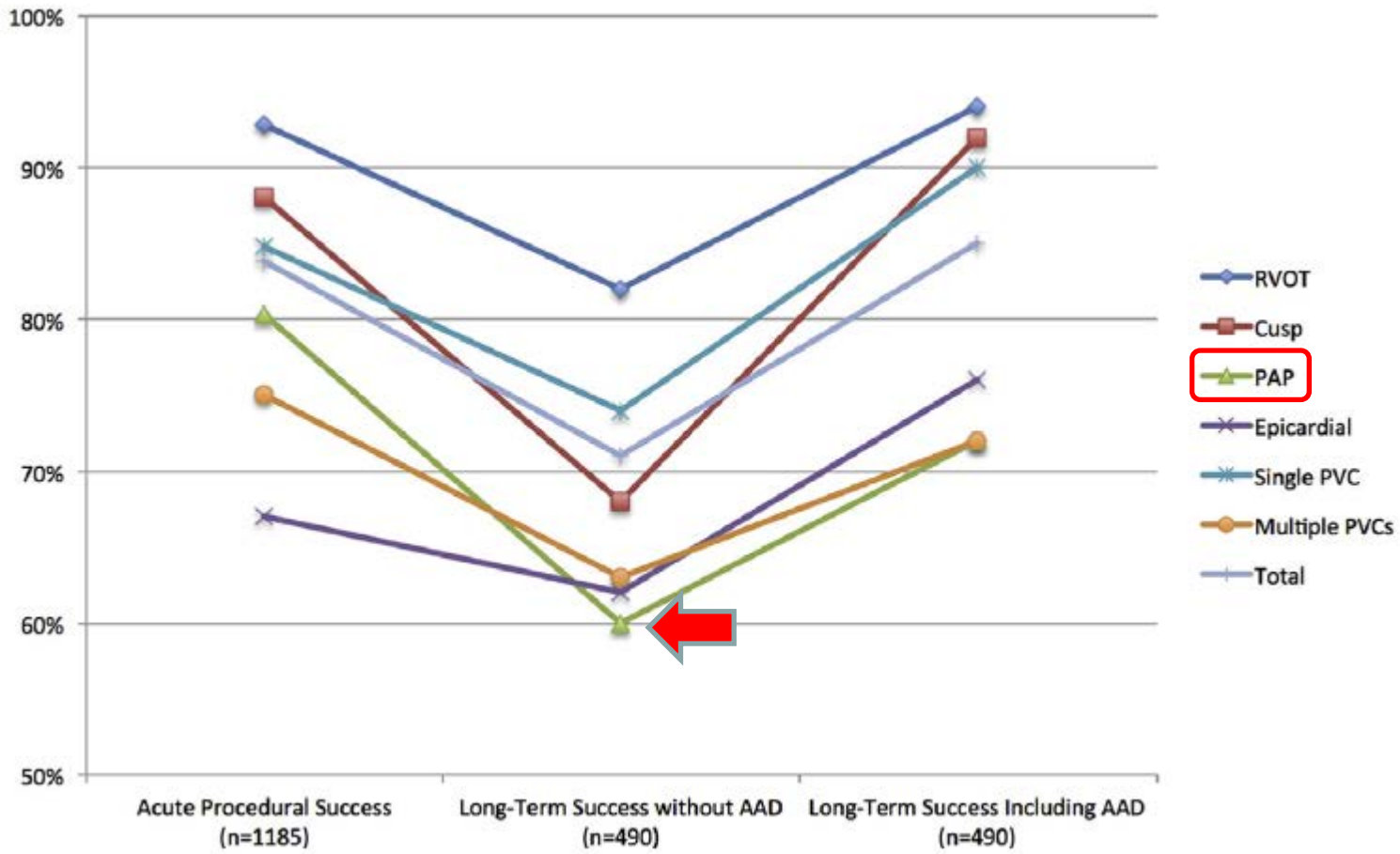
- **Challenging issues**
  - Complexity and variability of PM anatomy
  - Potentially deep intramural site of origin
  - Catheter stability
- **Deep intramural origin**
  - Best site of activation is ≤20 ms pre-QRS
  - The signal appears farfield looking
  - QRS morphology changes with an RF application
  - Surround the base of the PM with lesions aiming for exit block

Catheter Ablation

- **Techniques to improve procedural success**
  - Irrigated-tip, 8mm tip catheter
  - RV pacing
  - ICE to evaluate catheter contact
  - Carto-sound or MDCT image integration with electroanatomical mapping
  - Contact force sensing catheter
  - Cryoablation

Outcome of Catheter Ablation

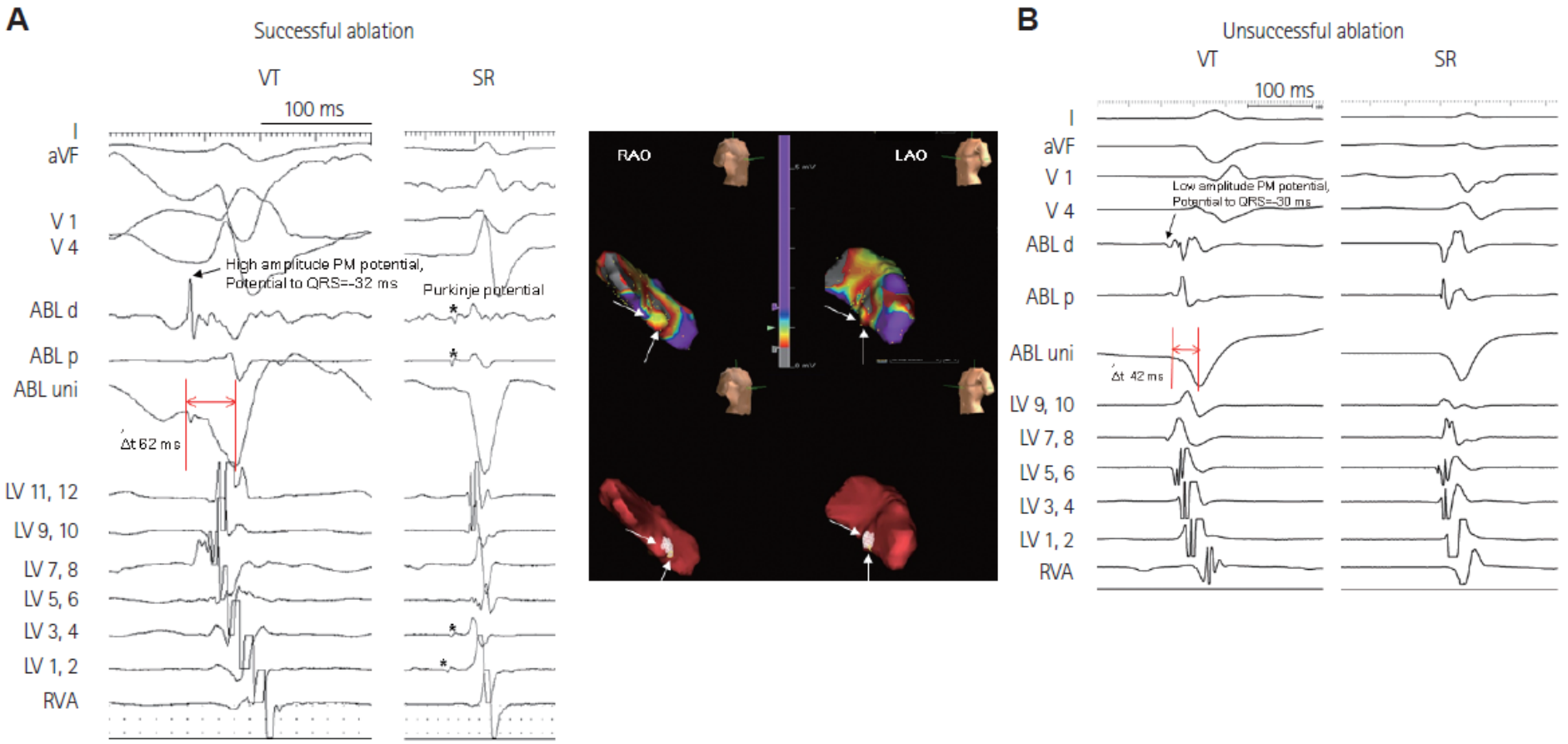
- N=1,185 (55% female; mean age 52 ±15 years)
- at 8 centers between 2004 and 2013



Latchamsetty R et al. JACC Clin Electrophysiol. 2015;1:116-123.

Predictors of Outcome

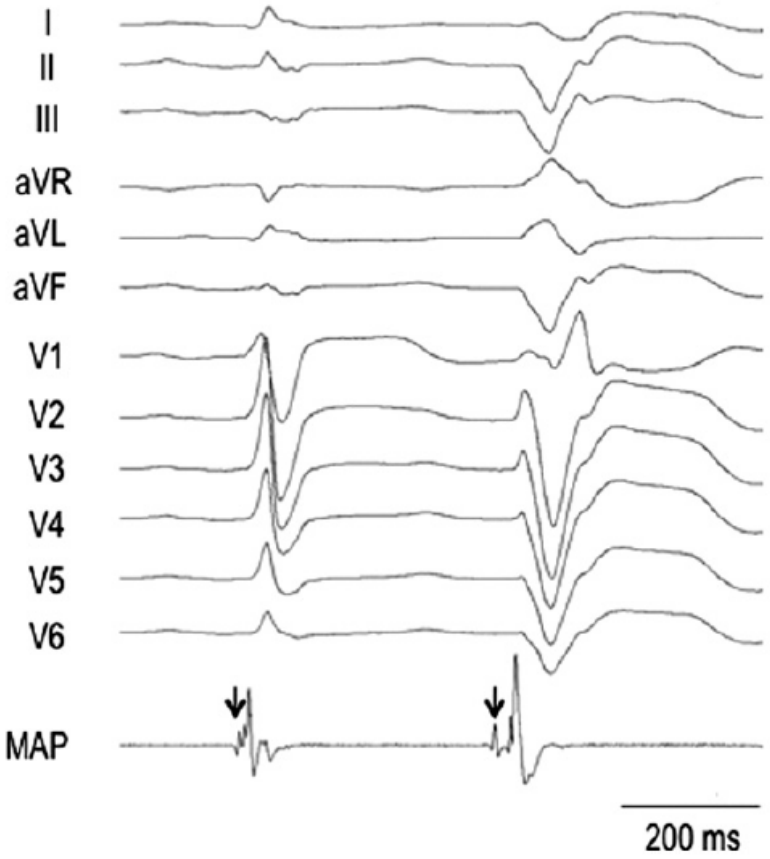
- High-amplitude discrete potentials before QRS and slow downstroke of the initial Q wave on the unipolar egm were related to favorable outcome



Ban JE et al. Korean Circ J. 2013;43:811-8.

Predictors of Outcome

- The presence of Purkinje potentials at the site of origin and a smaller size of the PAP are associated with successful ablation of PAP arrhythmias.



	Effective (n=31)	Ineffective (n=9)	P-value
N of PVC morphologies	4±3	4±5	0.6
P-potential at ablation site	15 (48%)	0 (0%)	0.02
Activation time (ms)	-31± 18	-28±7	0.66
Pacemapping	22(71%)	2 (22%)	0.02
Total PM mass	5.3±1.8	9.1± 4.8	<0.01
Arrhythmogenic PM mass	2.3±0.6	4.7±2.2	<0.01

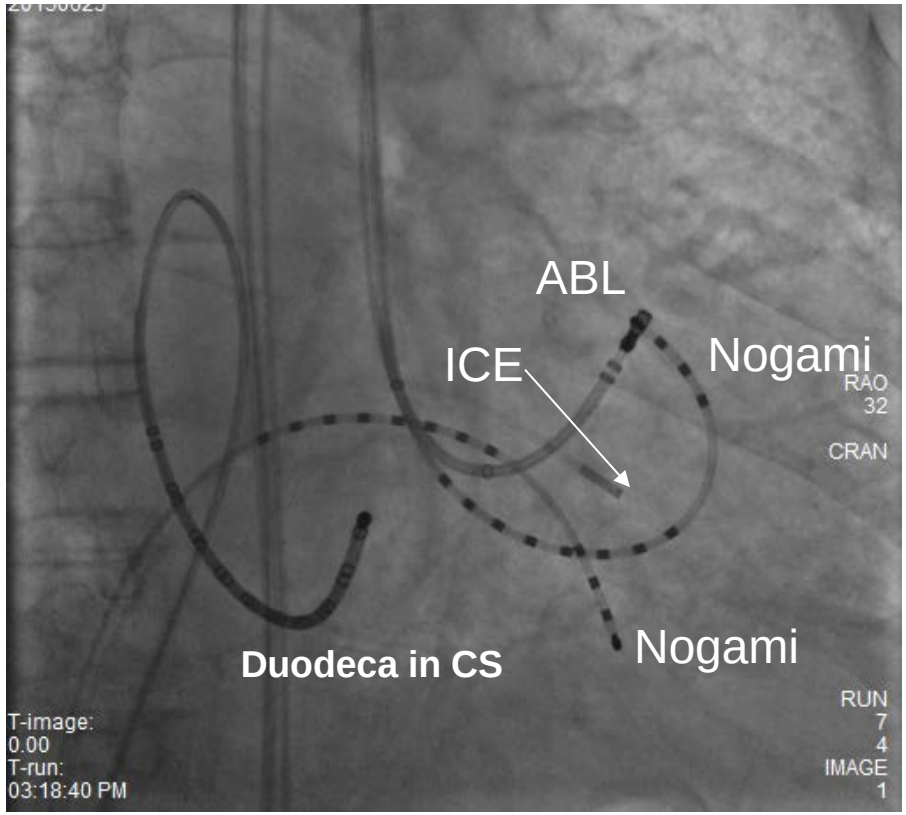
Yokokawa M et al. Heart Rhythm 2010;7:1654 –1659.

Summary

- **Mechanism**: focal (non-reentry)
- **ECG characteristics**: differential diagnosis and preprocedural planning
- **Mapping**: activation mapping complemented with pace mapping
- **Catheter ablation**: effective but challenging
  - Complex anatomy and stability issue
  - Often deep site of origin with multiple exits
  - Multiple ablation lesions frequently required
- **Use of ICE**: help localization and good contact

- **EP study, catheter position**

RAO



LAO