2017년 11월 4일(토) | 세션시간: 10:50~12:05
11:35~11:50 AM

Electrogram Morphology

what can it tell us about myocardial electro-architecture and arrhythmogenicity?

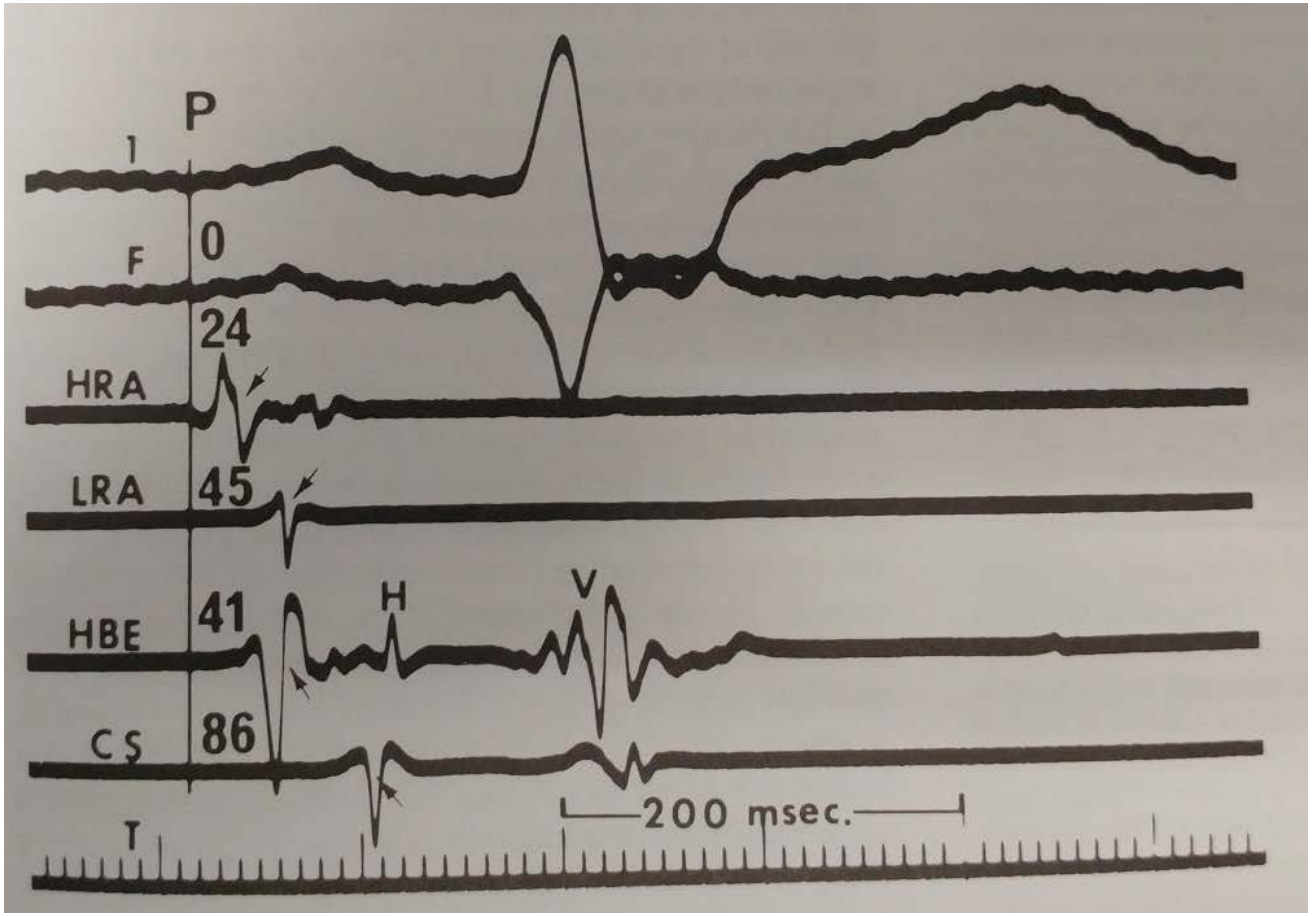
Asan Medical Center

Gi-Byoung Nam MD

Activation sequence
(earliest activation)

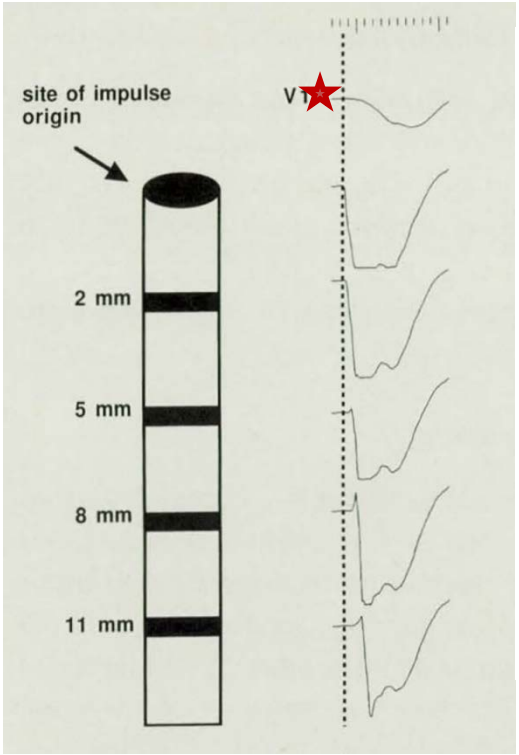
Arrhythmogenic substrate
(scar, channel)

Determination of local activation: bipolar egm

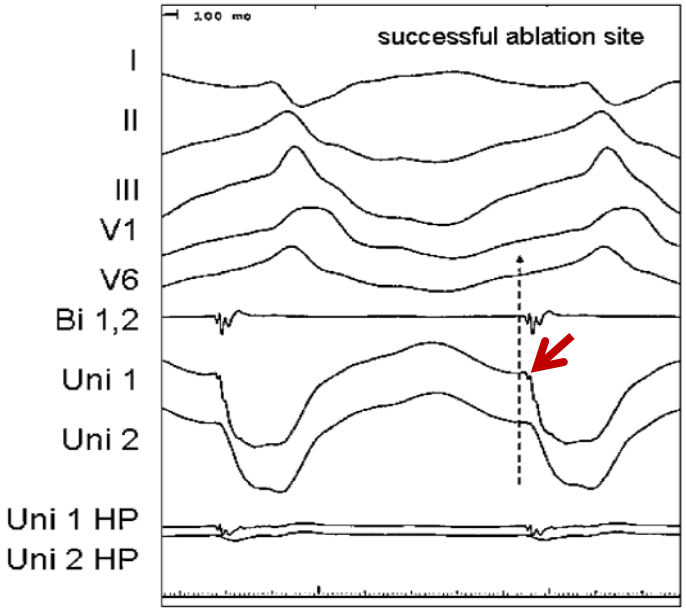


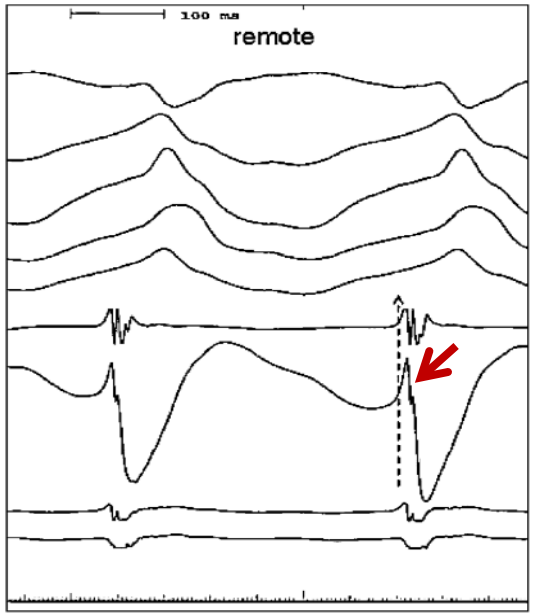
Bipolar—earliest? highest? dV/dT?

Role of the Unipolar Egm for Identification of SOO



JCE, 8-974, 1997



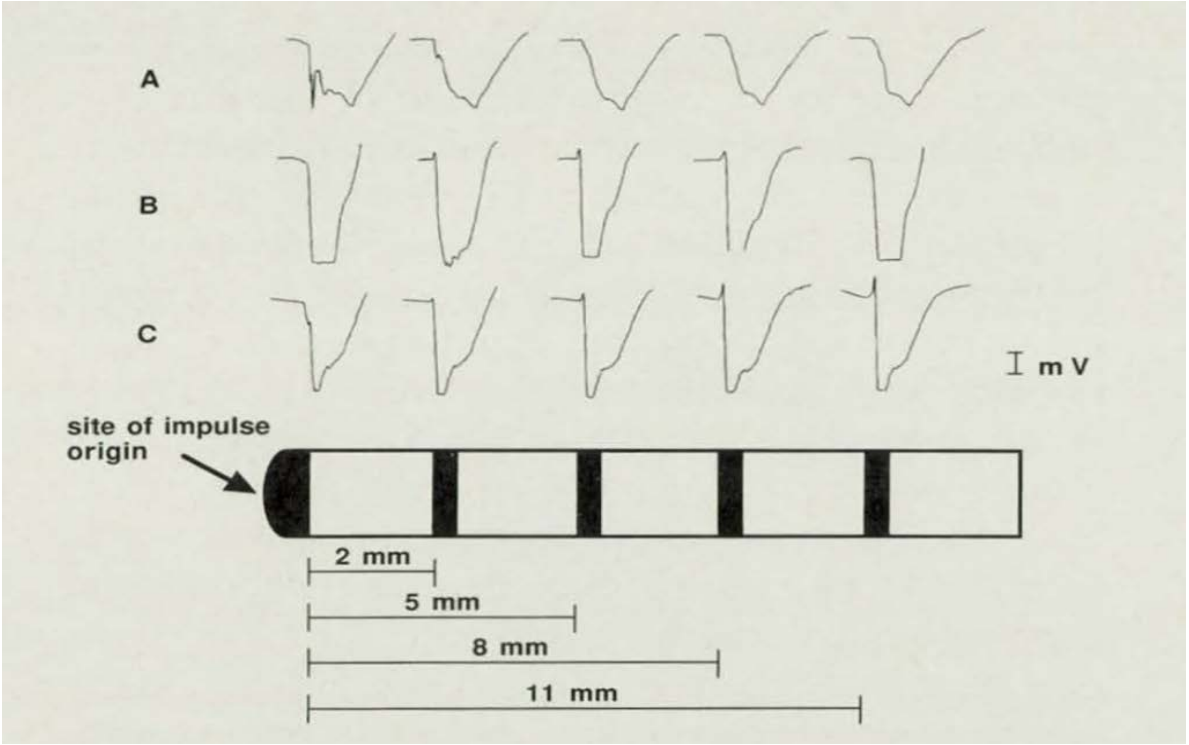


SOO: site of origin

JCE, 16-1017, 2005

Accuracy of the Unipolar Egm for Identification of SOO

20 patients
(3 w CAD, 2 w VHD)



JCE, 8-974, 1997

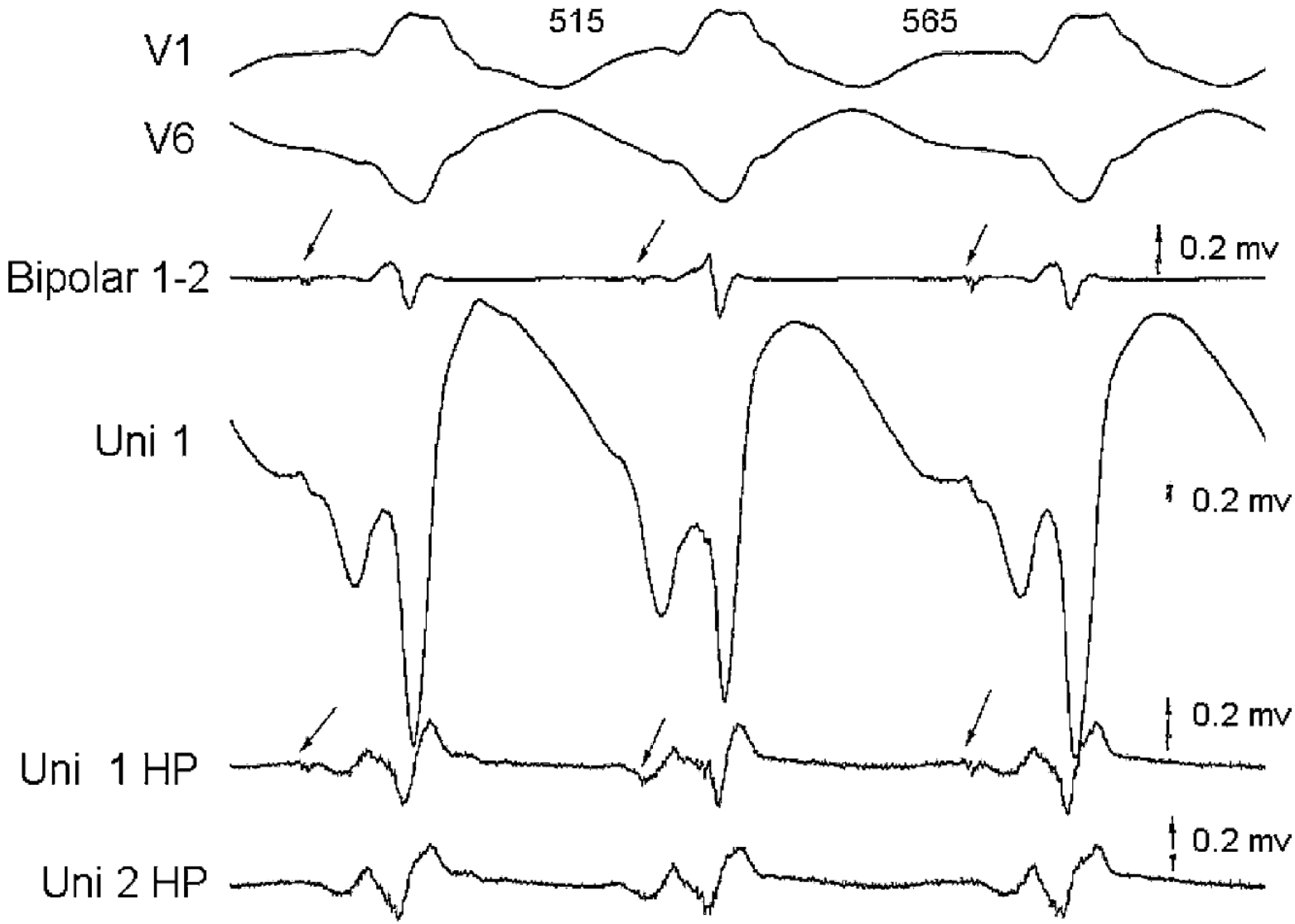
- **No R waves at the site of origin.**
- **No R wave at distances < 11 mm from the origin in 13 of 20 pts (65%)**
  - *** Absence of R wave in Uni egm, <u>inadequate guide</u> for identification of an effective target site for ablation**

Limitation of Unipolar, Bipolar mapping

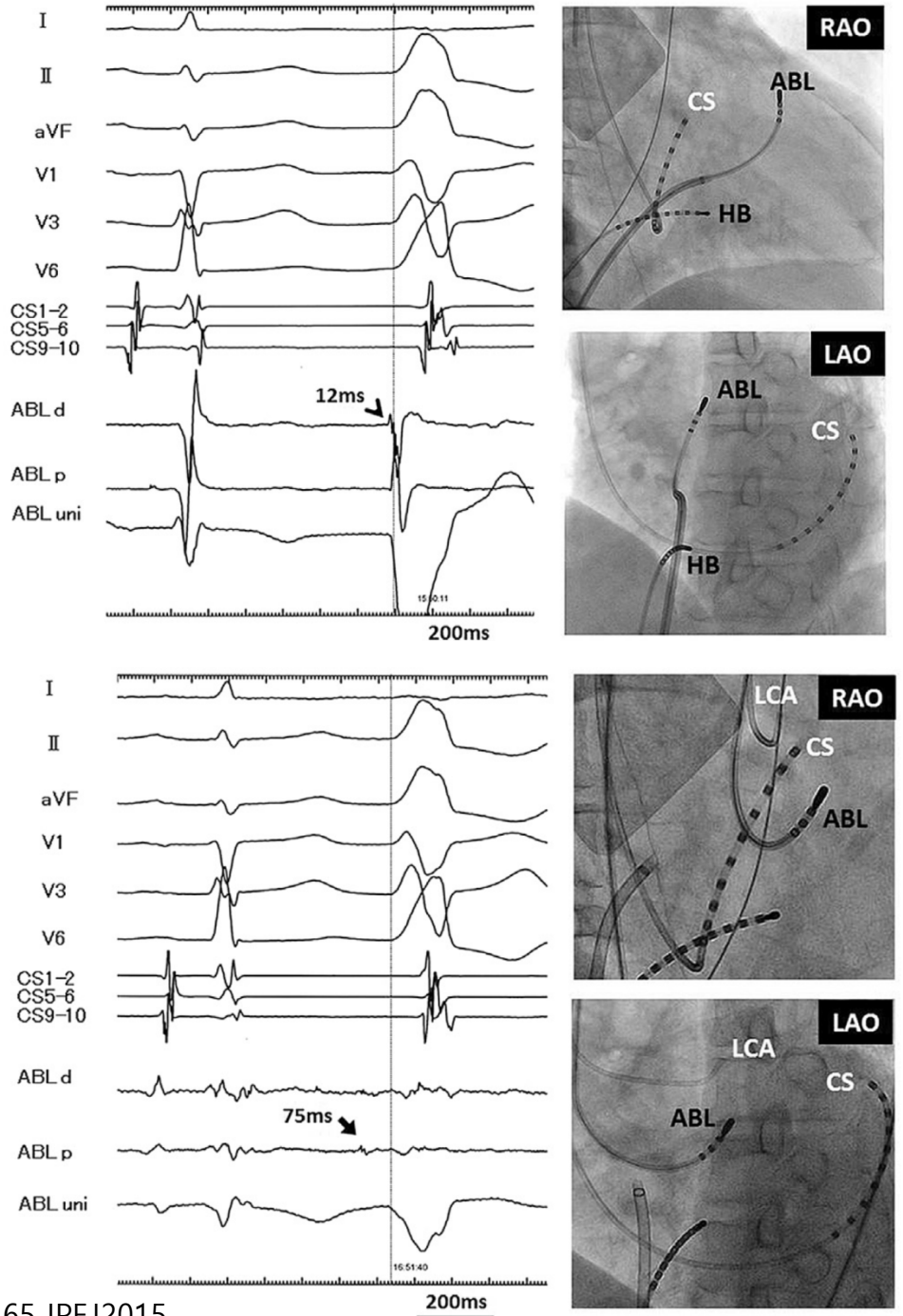
Bipolar – useful in activation mapping,
identification of precise AT?

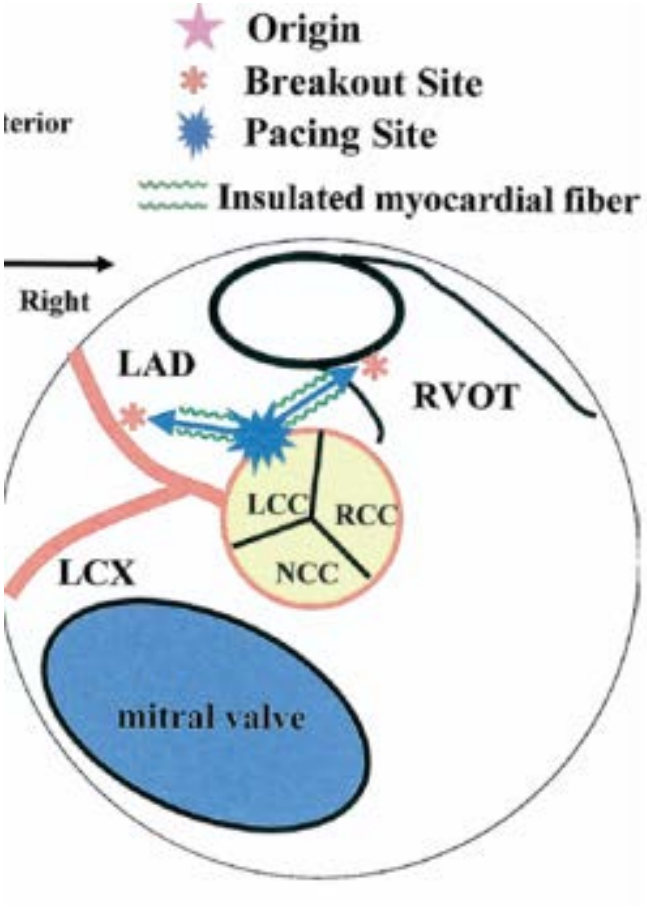
Unipolar – QS pattern and dV/dT
QS, not specific
local, obscured by far-field signal

- scar tissue
- endo-cavitary structure (papillary m)
- overlapping structure (RVOT, ASC)



J Cardiovasc Electrophysiol, 16-1017, 2005





J Am Coll Cardiol 2007;50:884–91
Takumi Yamada et al.

Summary

Determination of local activation time

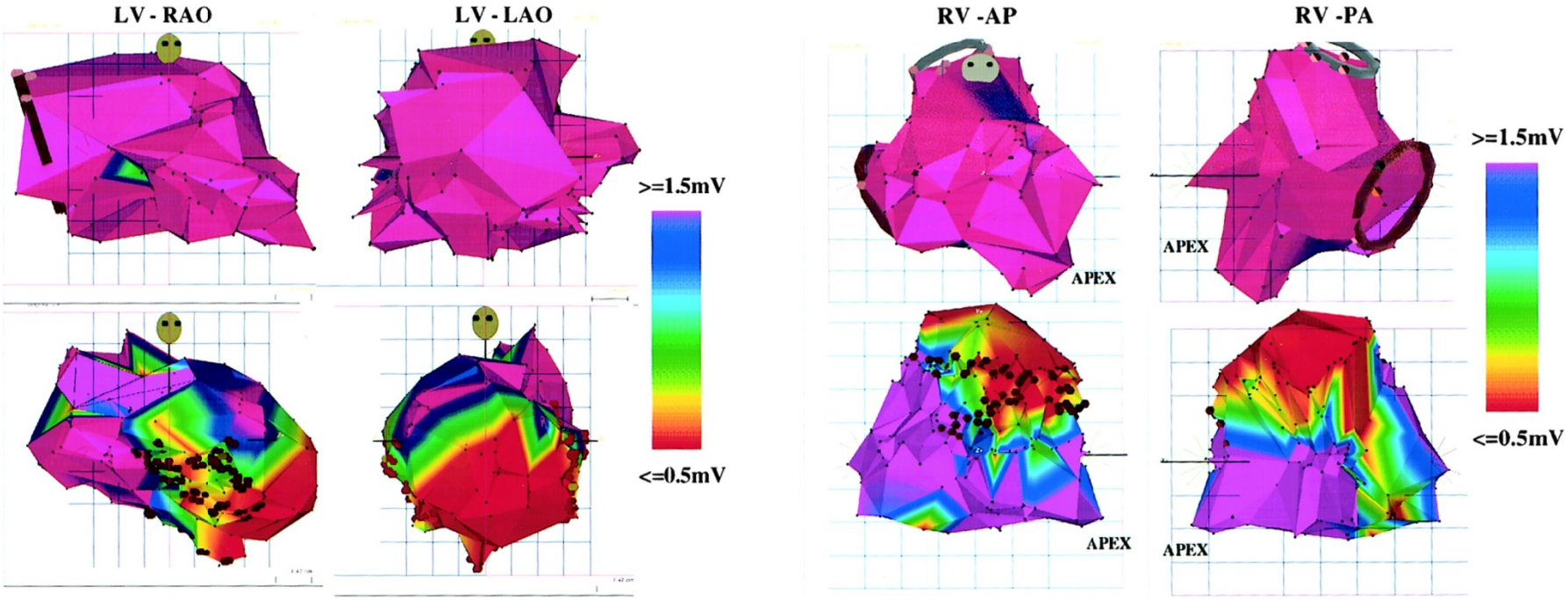
Bipolar – distinct, m/c recording modality in clinical EP
*** difficult to pinpoint the true local activation time**

Unipolar – QS and max dV/dT, marker of origin
*** large electrical view (may reflect far-field activ.)**
eg. endo-cavitary structure (pap m),
overlapping structures (ASC+RVOT),
diseased myocardium or scar

Activation sequence
(earliest activation)

Arrhythmogenic substrate
(scar, channel)

Voltage criteria for normal vs. scar area



Endo (LV, RV)

<0.5 mV

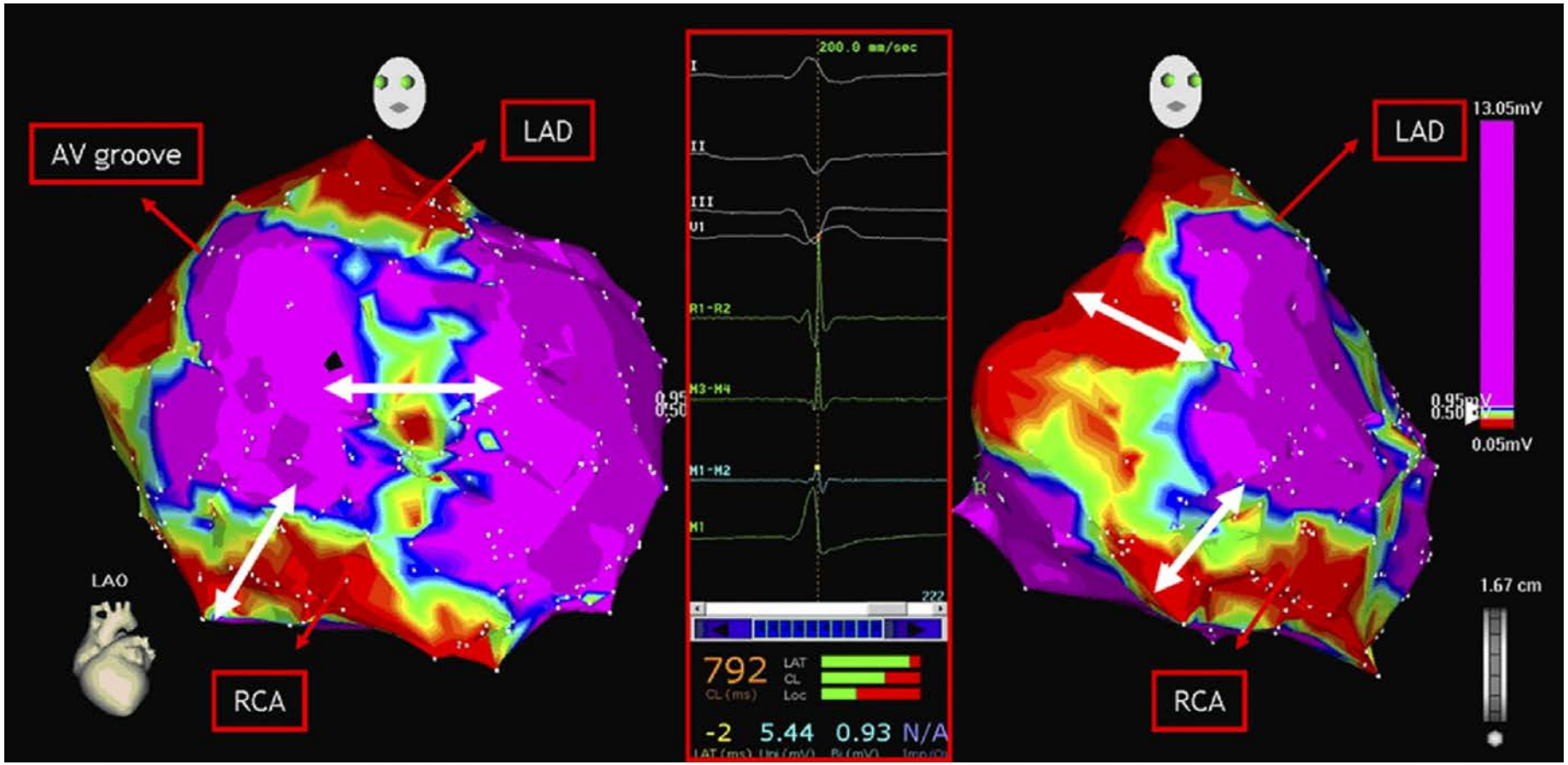
0.5-1.5 mV

>1.5mV

Linear Ablation Lesions for Control of Unmappable VT in Patients w. ICM and NICM
Circulation. 2000;101:1288-1296

Epicardial bipolar egm voltage

: perivascular fat tissue in inter-ventricular, AV groove



Epi

<0.5 mV

0.5-1.0mV

>1.0 mV

1. Wide egm (> 80ms)
2. Split egm (≥2 distinct components w 20ms isoelectric segment)
3. Late potentials (egm w a distinct onset after the QRS

J Am Coll Cardiol 2009;54:799–808

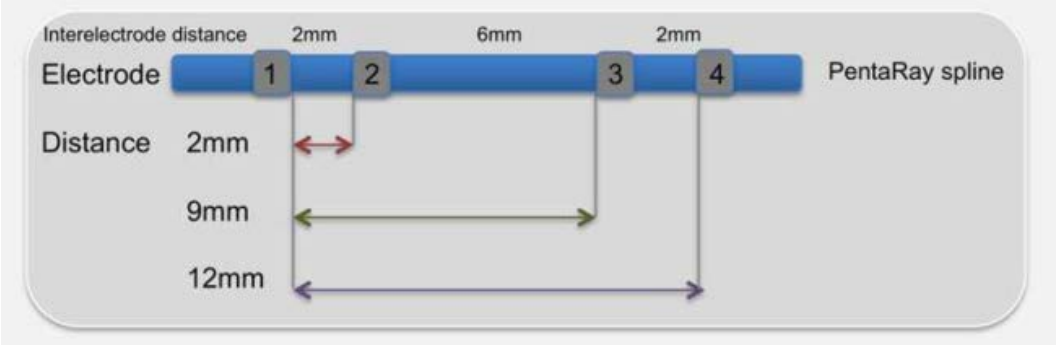
Limitation of bipolar egm defining scar

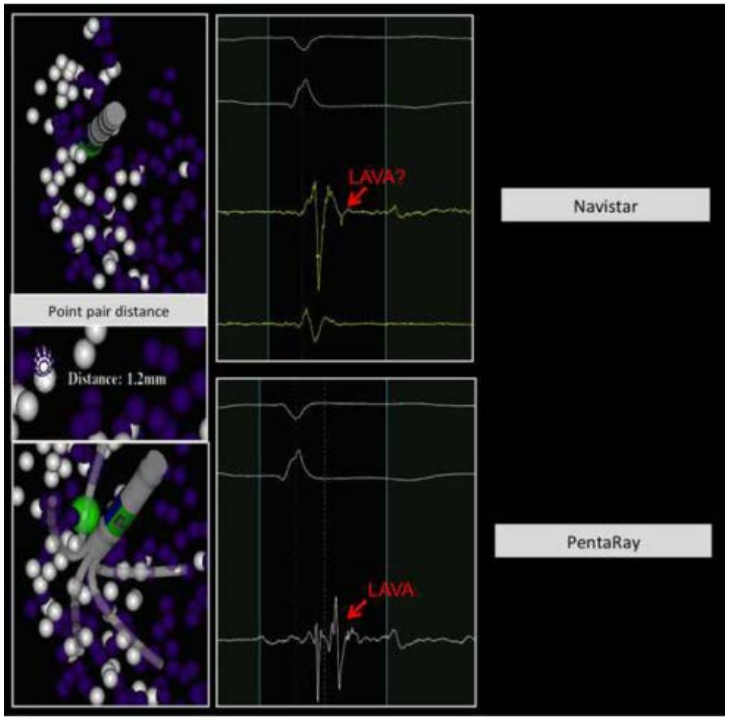
1. Scar voltage criteria, arbiturary

2. Dependent on configuration of recording electrode,
   & Directional change

3. Mid-myocardial or epicardial scar

Impact of Electrode Type on Mapping of Scar-Related VT

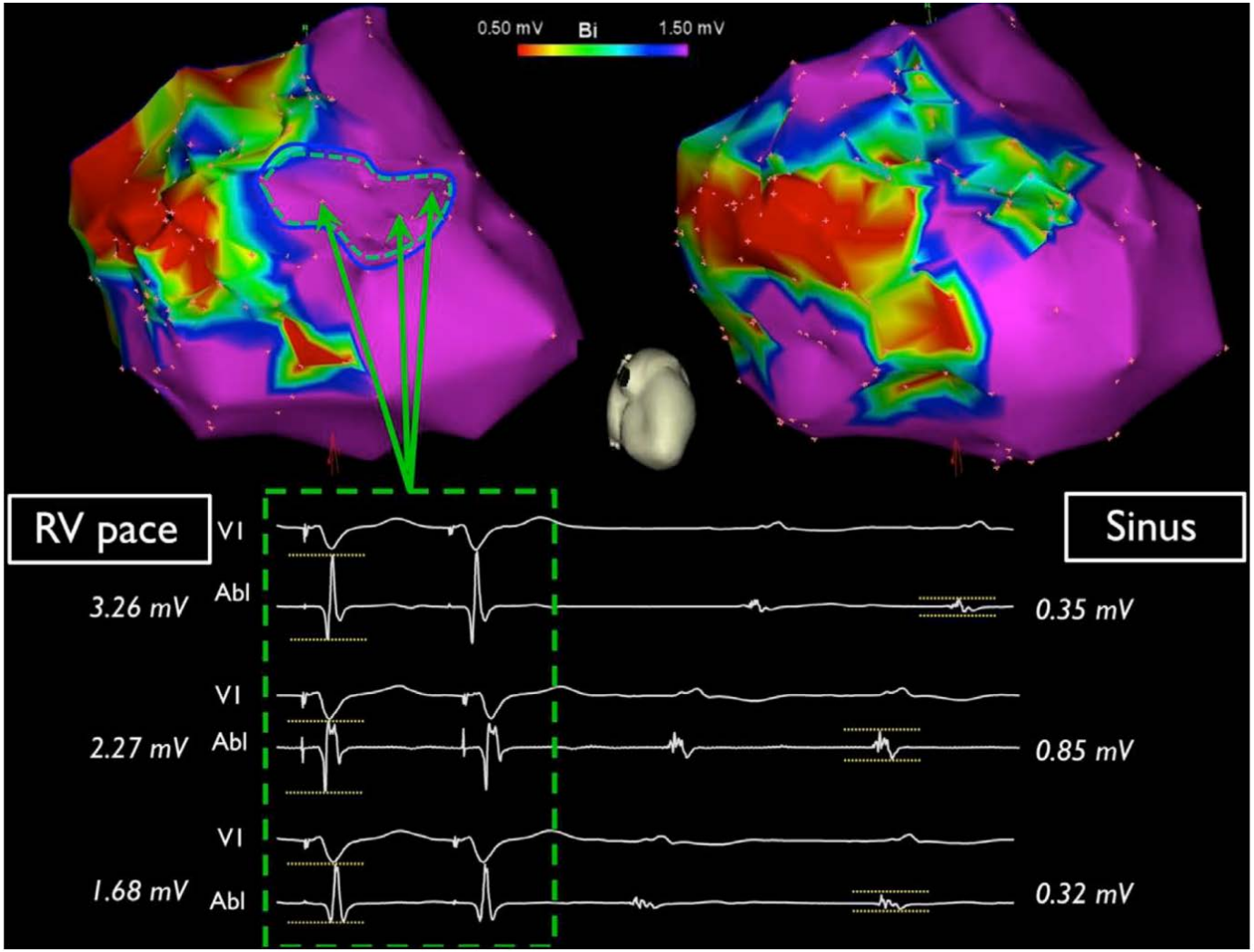




Conclusion: **Multipolar mapping catheters with small electrodes provide more accurate and higher density maps, with a higher sensitivity to near-field signals. Agreement between Pent-Ray and Navistar is low.**

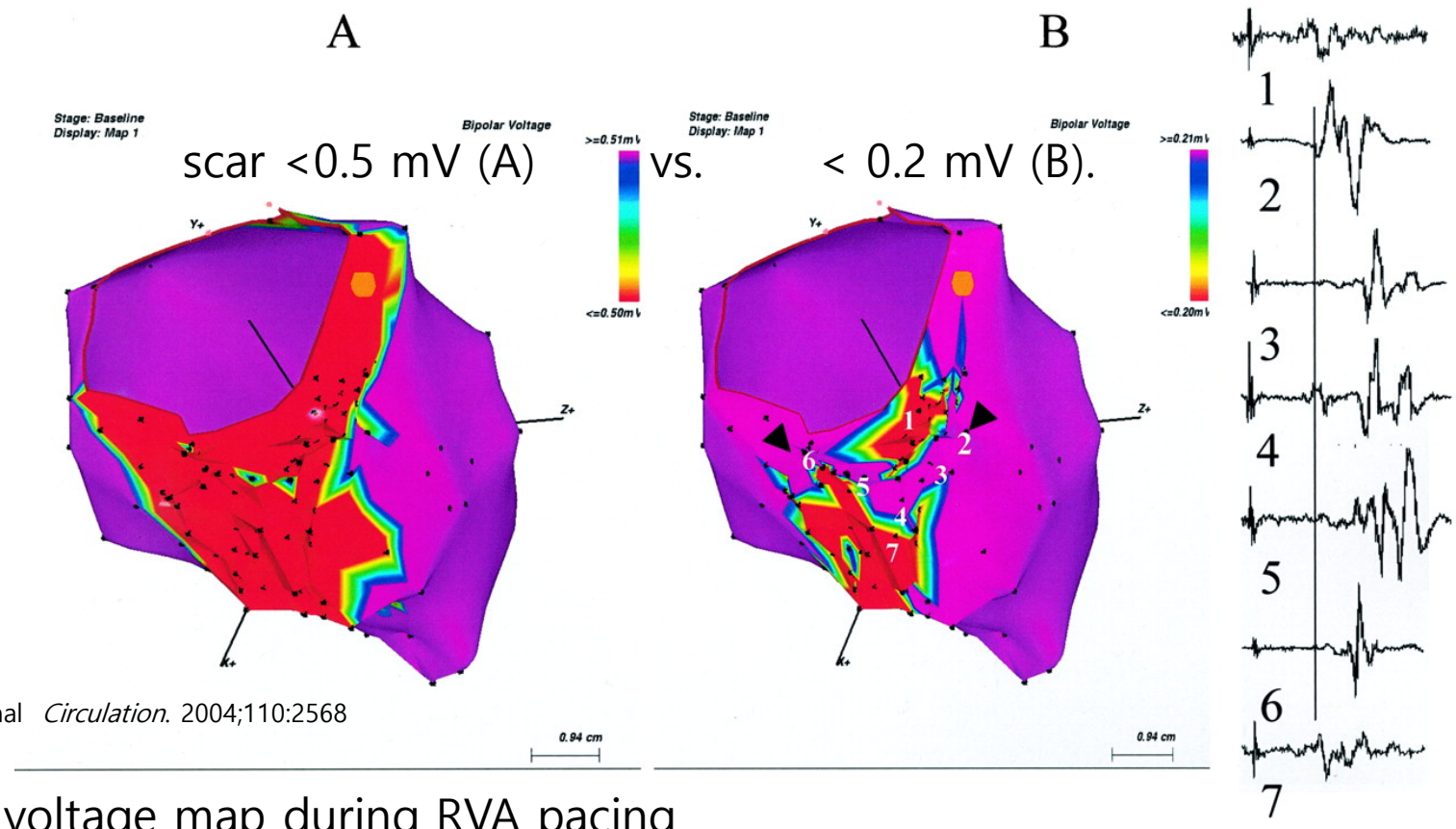
J Cardiovasc Electrophysiol, 26;1213, 2015

Directional Influences of Ventricular Activation on Myocardial Scar Characterization Voltage Mapping With Multiple Wavefronts During VT Ablation



CircEP 2016;9:e004155

Mapping during RV pacing, adjustment of voltage scar definition



Angel Arenal *Circulation*. 2004;110:2568

a voltage map during RVA pacing
scar definition was set at 0.5 mV (A) and at 0.2 mV (B).
Single-component electrograms only at entrances;
multiple-component electrograms at inner part.
Activation time seems to follow from both entrances to inner part.
Pacing from these CCs - a long-stimulus QRS interval.
RF lesion applied to CCs - suppressed VT in 88% of CC-related VT

Voltage adjustment- limitation

Scar areas might be too narrow to be detected by EAM

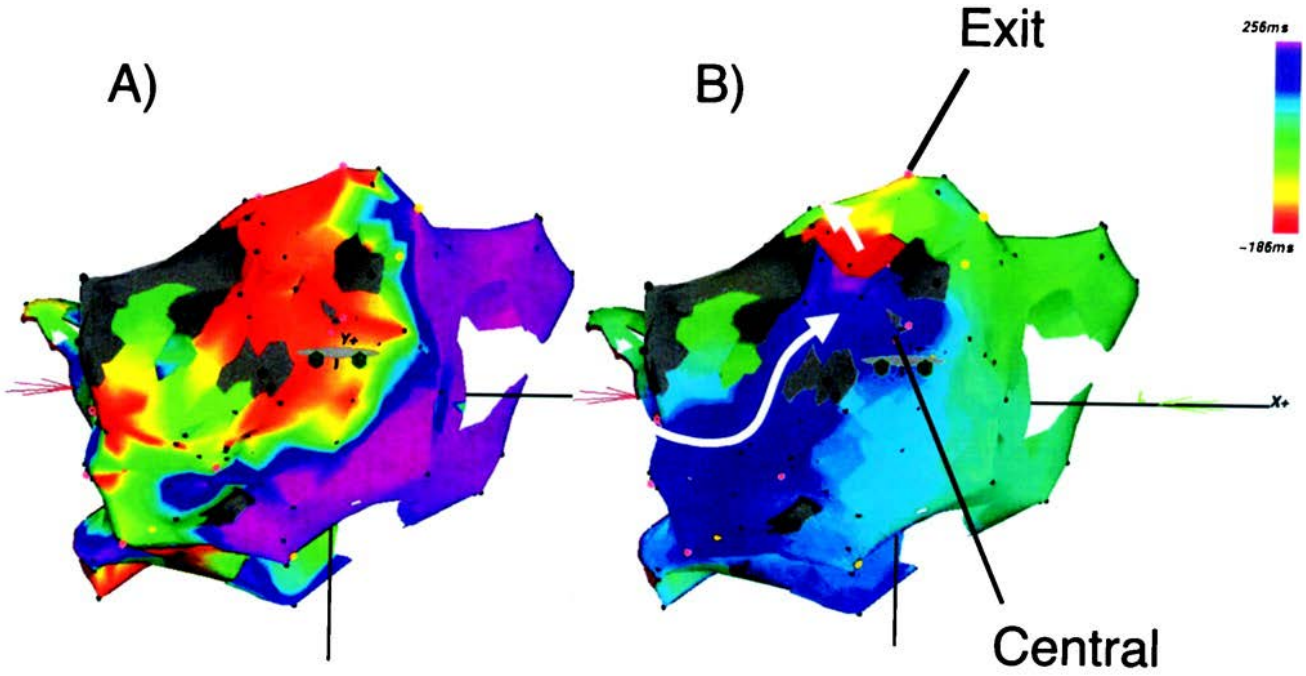
Many sites in reentry circuit isthmuses have very low amplitudes (0.1mV). Plots of electrogram amplitude alone do not adequately identify VT circuit isthmuses.

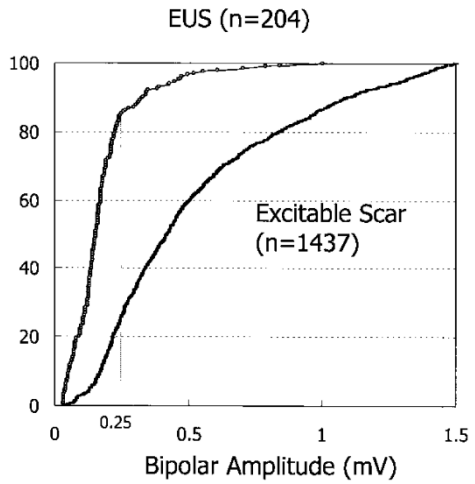
Boundaries of the isthmus could be functional lines of block not detected during RVA pacing or SR

The dispersion of voltage in some scar areas may appear only when activated at the VT rate.

Electrically Unexcitable Scar Mapping Based on Pacing Threshold for Identification of the Reentry Circuit Isthmus

unipolar pacing threshold > 10 mA at pulse width 2 ms





Although electrogram amplitude correlated with pacing threshold, many isthmuses had very low-amplitude electrograms, and EUS could not be identified from electrogram amplitude alone.

RF ablation lines connecting selected EUS regions abolished all inducible VTs in 10 patients (71%).

Soejima et al. Circulation. **2002;106: 1678-1683**

Electrically Unexcitable Scar (EUS)- limitation

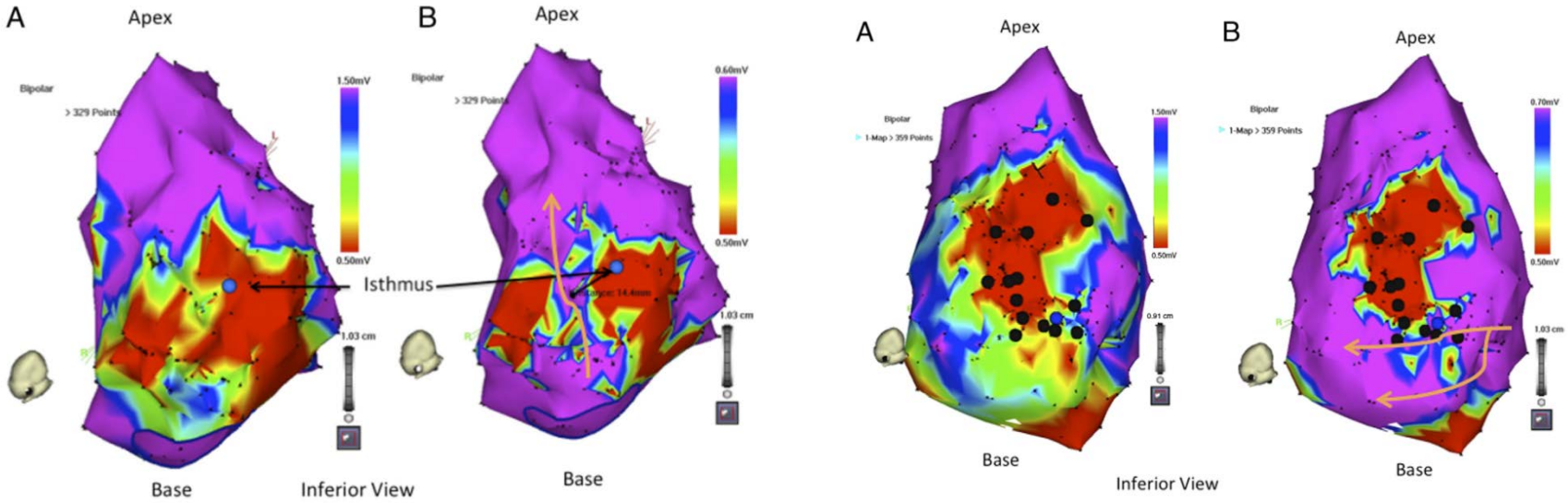
Although pacing likely identifies large unexcitable areas of scar, small strands of fibrosis, which may still create important conduction block, would likely escape detection. (fiber<0.1mm vs. catheter tip 3.5mm)

Large sheets of surviving endocardial myocardium may occur in some pt with circuits created by functional block during VT and no endocardial EUS.

Virtual electrode may excite normal/viable tissue

Relationship btw Voltage Map Channels and Location of Critical Isthmus Sites in Pts w Post-MI Cardiomyopathy & VT

24 patients with post-MI cardiomyopathy and "tolerated" VT



Channels were identified in **88% of patients** with VT by adjusting the voltage limits; however, the specificity of them predicting the location of VT isthmus sites was only 30%. (The majority of channels are **"bystanders"** or are artifacts.) A strategy of empiric ablation of all identified channels, **not likely to be useful**.

The presence of ILPs inside the voltage channel significantly increases the specificity for identifying the clinical VT isthmus. A corroborative finding of a **functional measure of slow conduction (isolated late potential, ILP)** within a channel, can increase the specificity of predicting a clinical channel.

J Am Coll Cardiol 2013;61:2088

Isolated, delayed potential - limitation

Late potentials may represent ‘bystander’ or dead end pathways.

Late potentials may not be seen in sinus rhythm. (manifest only with functional block).

Very small (i.e. <0.1 mV) late potentials may be missed.

Limitation of bipolar egm defining scar

1. Scar voltage criteria, arbiturary

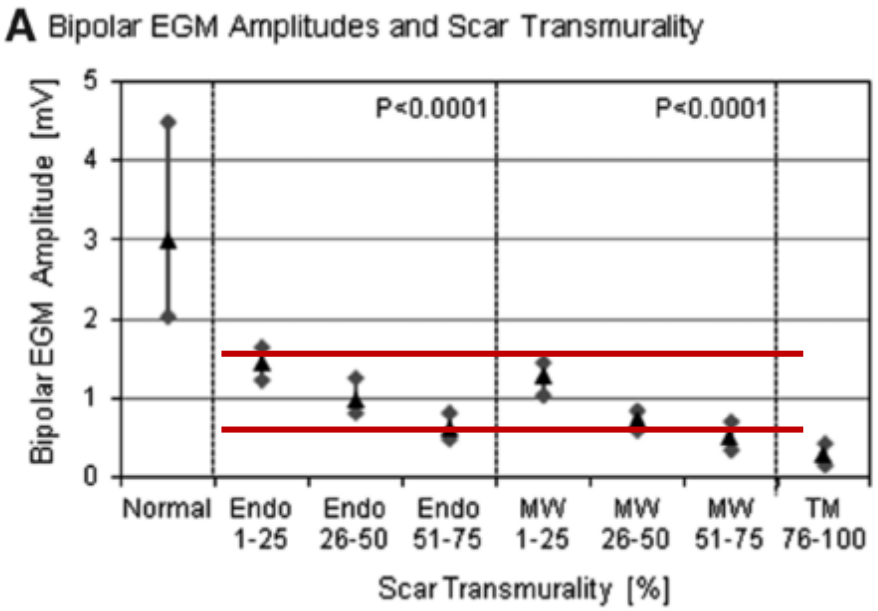
2. Dependent on configuration of recording electrode,
   & Directional change
   ⇒ pacing, voltage adjustment, isolated LP

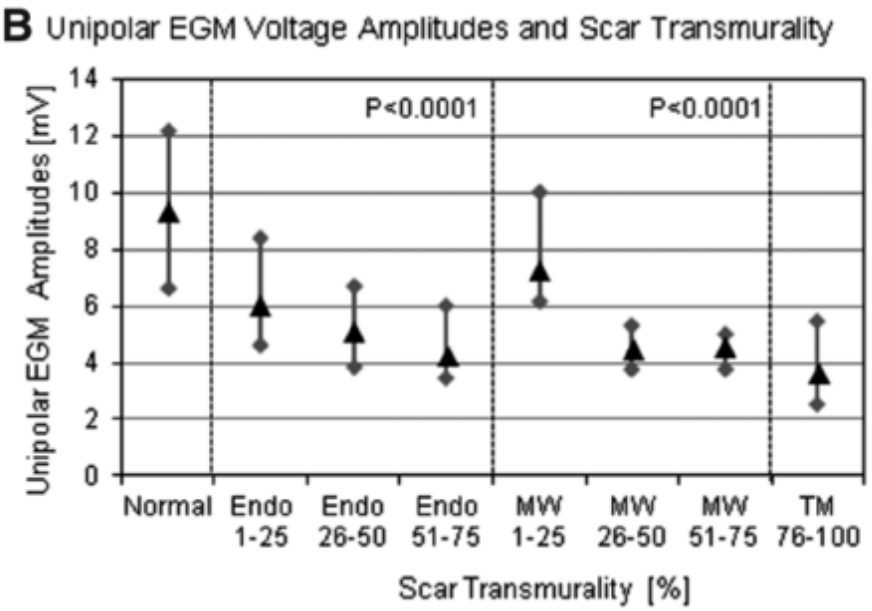
3. Distribution of scar (Mid-myocardial or epicardial)


epi
endo
epi
endo

Myocardial Structural Associations with Local Electrograms

A Study of Post-MI VT Pathophysiology and Magnetic Resonance–Based Noninvasive Mapping





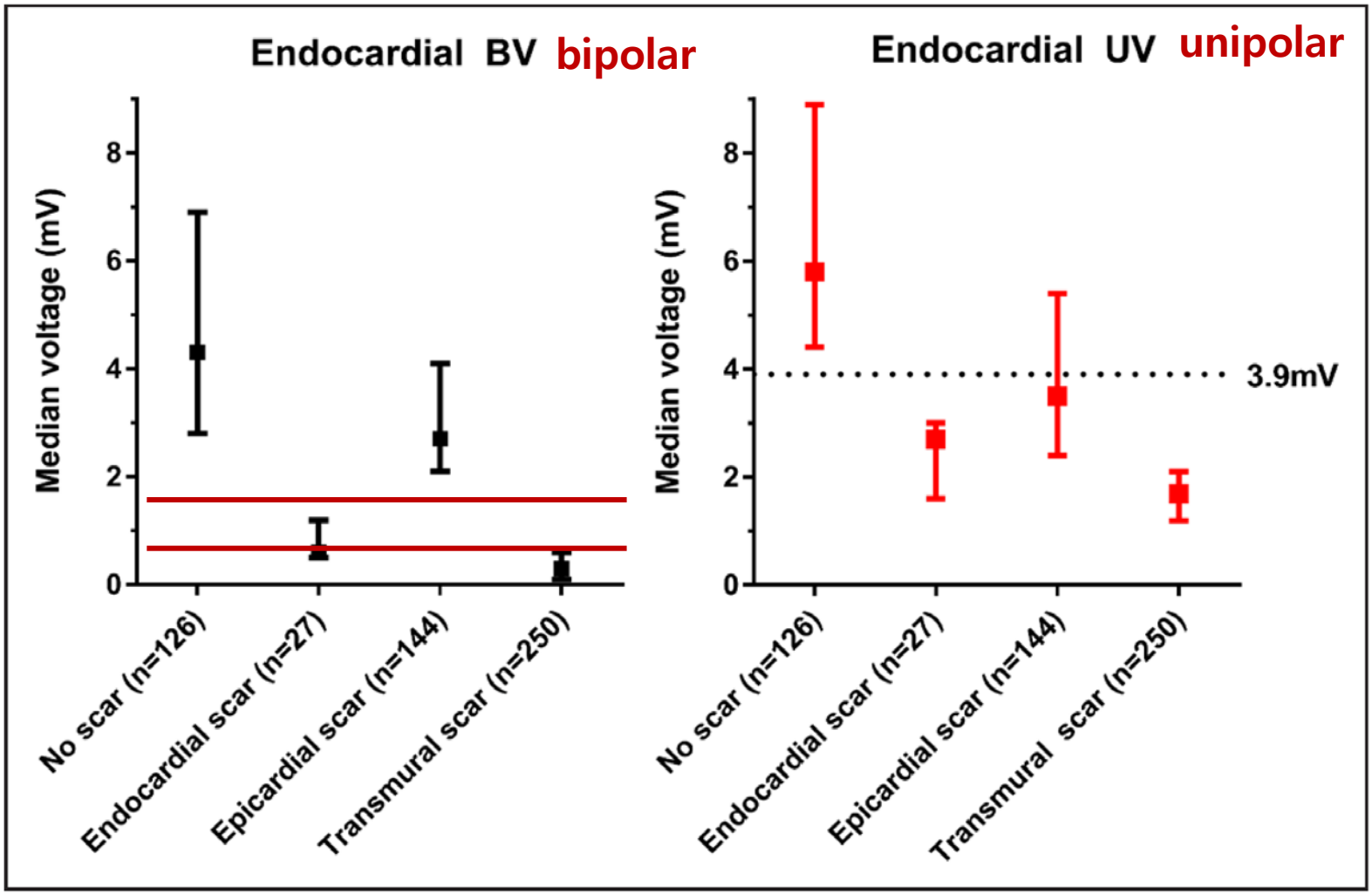
bipolar

unipolar

Circ Arrhythm Electrophysiol. **2012;5:1081-1090**

Unipolar Endocardial Voltage Mapping in the RV

Optimal Cutoff Values Correcting for CT–Derived Epicardial Fat Thickness and Their Clinical Value for Substrate Delineation

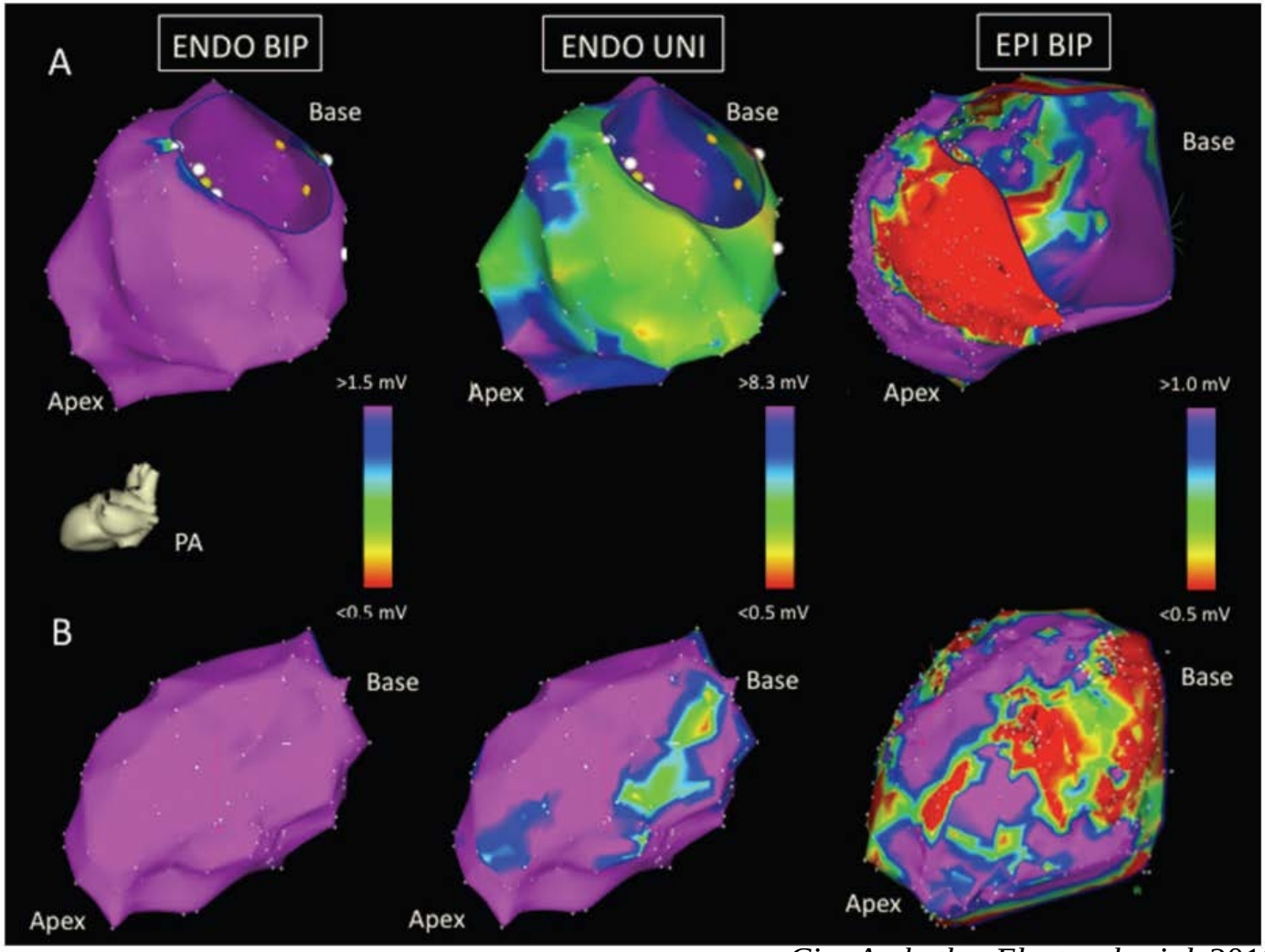


Circculation AE. **2017;10:e005175**

Endocardial Unipolar Voltage Mapping to Detect Epicardial Ventricular Tachycardia Substrate in Patients With Nonischemic Left Ventricular Cardiomyopathy

Mathew D. Hutchinson, MD; Edward P. Gerstenfeld, MD; Benoit Desjardins, MD, PhD; Rupa Bala, MD; Michael P. Riley, MD, PhD; Fermin C. Garcia, MD; Sanjay Dixit, MD; David Lin, MD; Wendy S. Tzou, MD; Joshua M. Cooper, MD; Ralph J. Verdino, MD; David J. Callans, MD; Francis E. Marchlinski, MD

Unipolar Reference Values
95% of LV ENDO unipolar signals > 8.27 mV (mean, 19.6±6.9 mV), defined as the value of normal LV ENDO UNI signal amplitude.

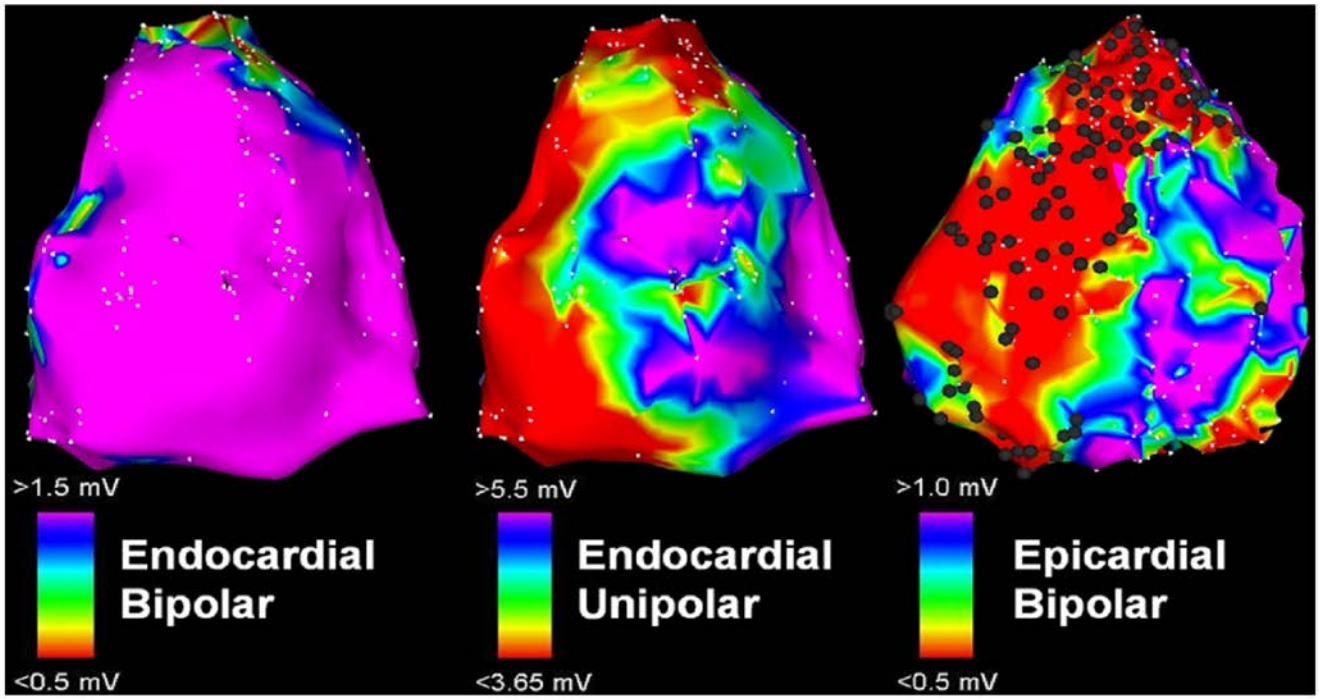


Circ Arrhythm Electrophysiol. 2011;4:49-55

Unipolar voltage mapping in RV

Endocardial unipolar voltage mapping to identify epicardial substrate in arrhythmogenic right ventricular cardiomyopathy/dysplasia

Glenn M. Polin, MD, Haris Haqqani, MBBS, PhD, Wendy Tzou, MD, Mathew D. Hutchinson, MD, Fermin C. Garcia, MD, David J. Callans, MD, FHRS, Erica S. Zado, PA-C, FHRS, Francis E. Marchlinski, MD, FHRS

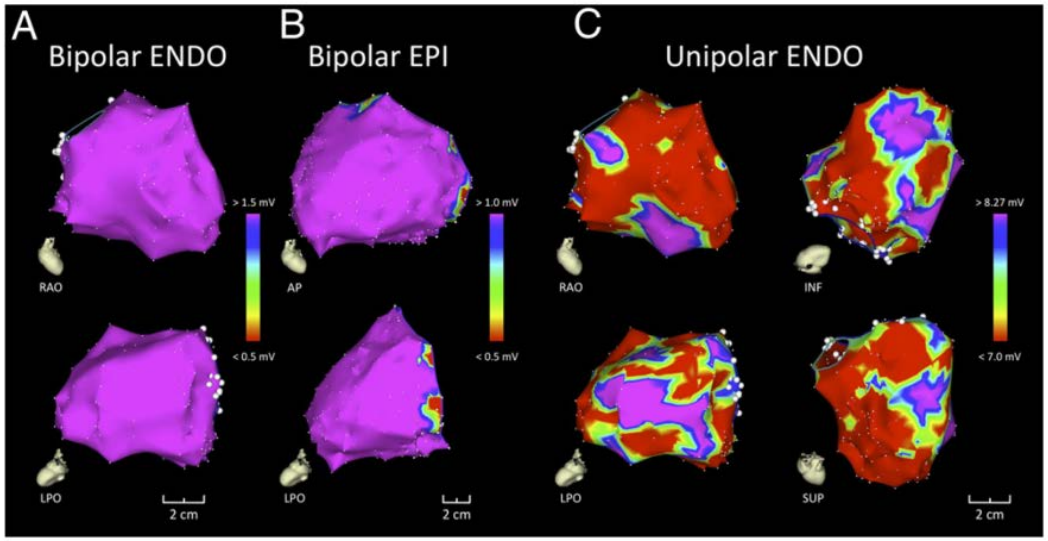


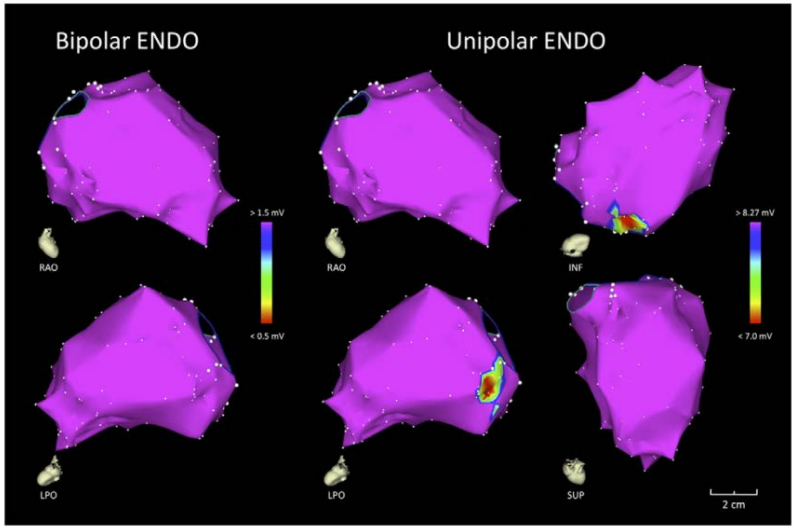
Normal unipolar electrogram
95% of unipolar signals had an amplitude >5.5 mV and defined a normal unipolar electrogram amplitude.

Heart Rhythm 2011;8:76–83

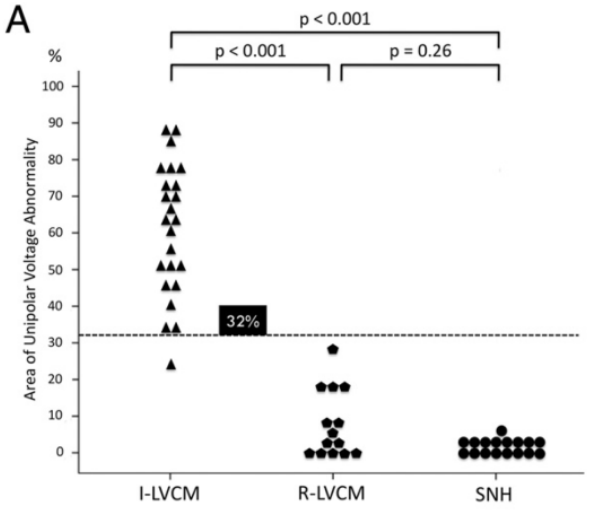
Reversibility of PVC-induced CM

Role of unipolar electrogram





Detailed unipolar voltage mapping can identify irreversible myocardial dysfunction consistent with fibrosis, even in the absence of bipolar EAM or cardiac magnetic resonance abnormalities, and may serve as valuable prognostic tool in patients presenting with LVCM to facilitate clinical decision making.



JACC 2012;60: 2194–204

Summary

1. Propagation or Activation map – uni vs. biplar map

    * Limitation in SHD, overlapping structure,

      cavitary structure

2. Detection of scar. Identification of channel

    * voltage definition

      -- voltage adjustment/pacing/isolated P

    * scar distribution (epicardial scar)

      ...reversibility of PVC-cardiomyopathy