PEDIRHYTHM VII

Pediatric and Congenital Rhythm Congress VII

4 - 7 February 2017 / Grand Hotel Palace - Thessaloniki, GREECE

Utilizing the EGM in ICD Patients Management

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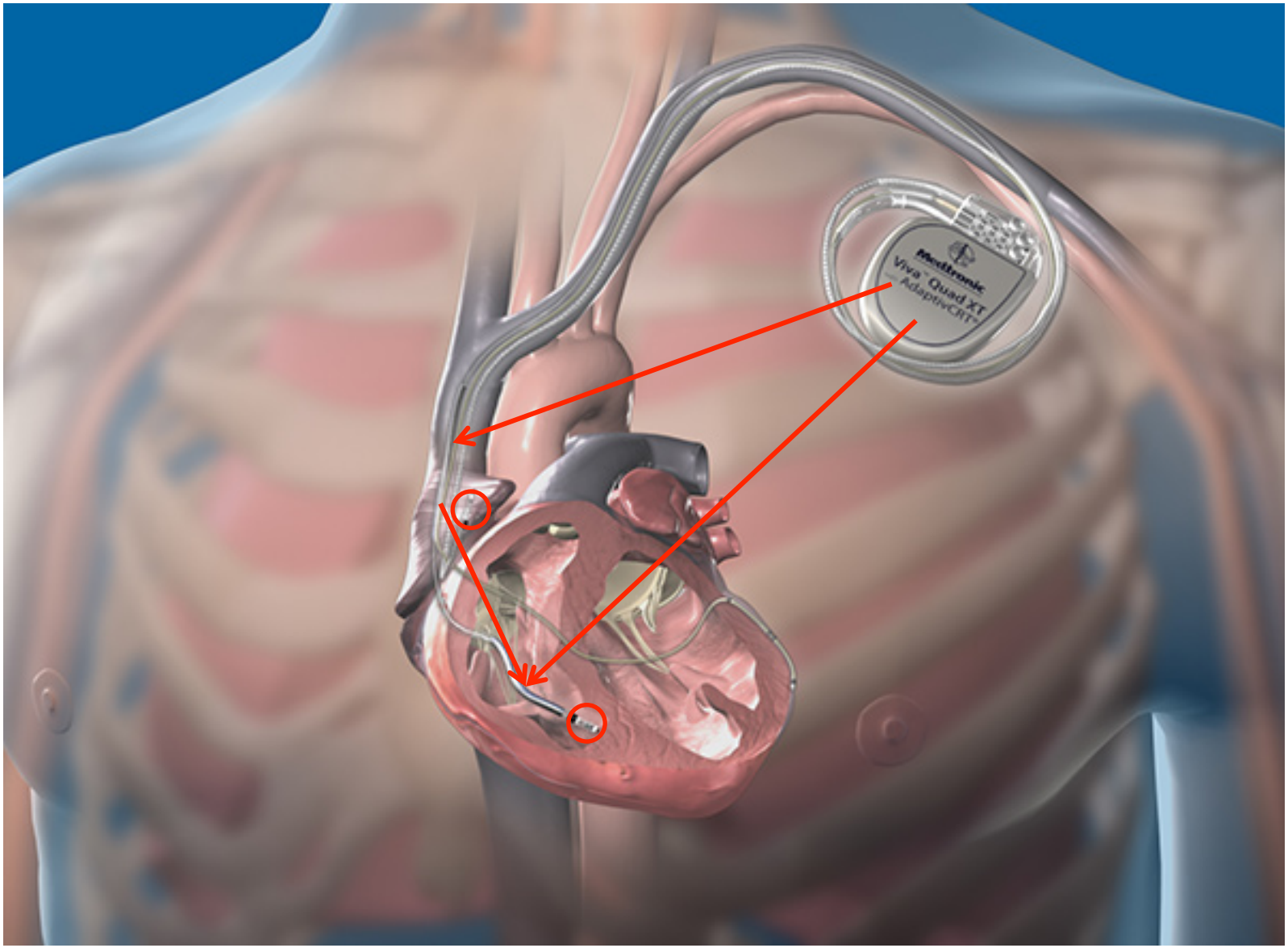
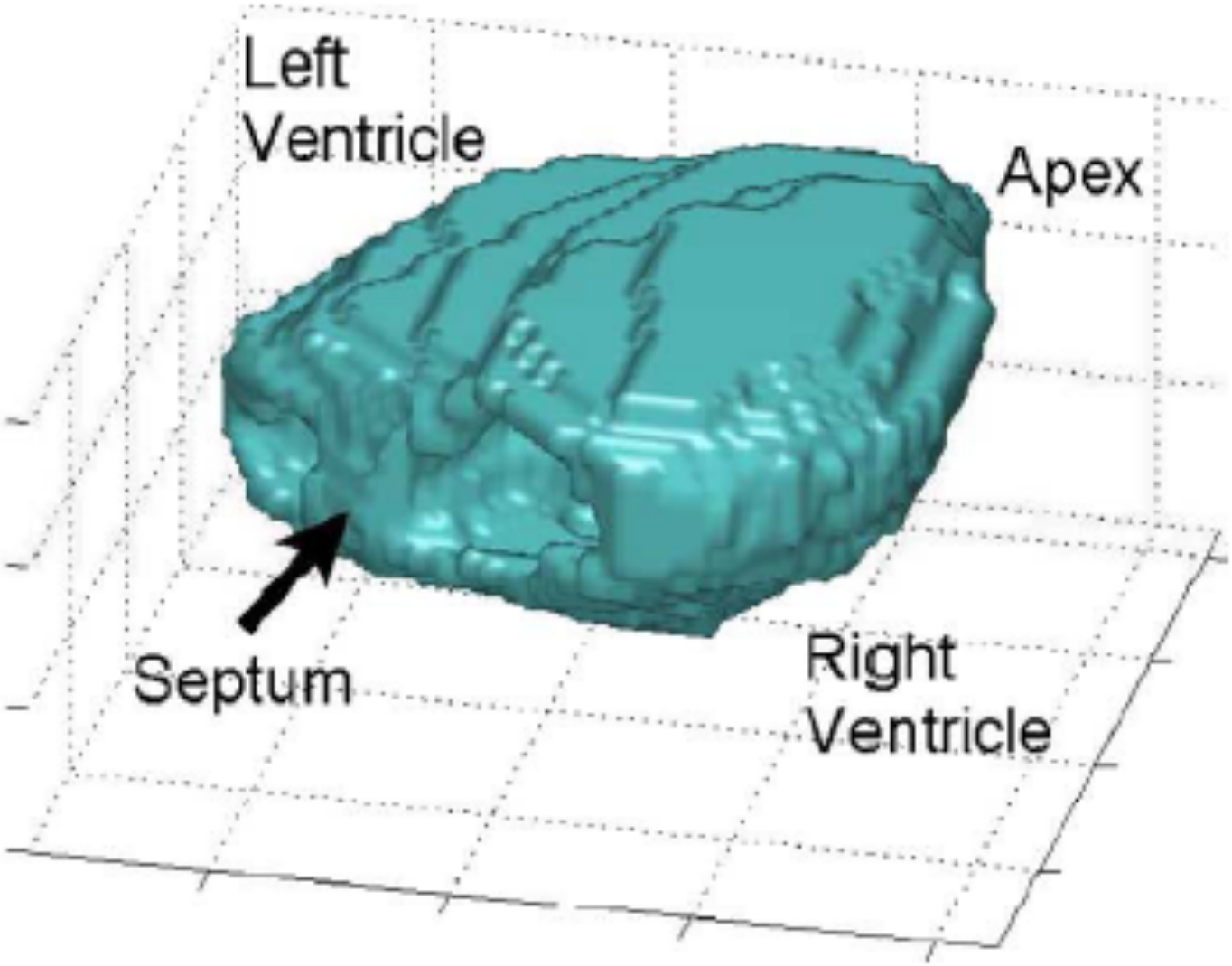
„Near-Field" & „Far-Field" IEGM

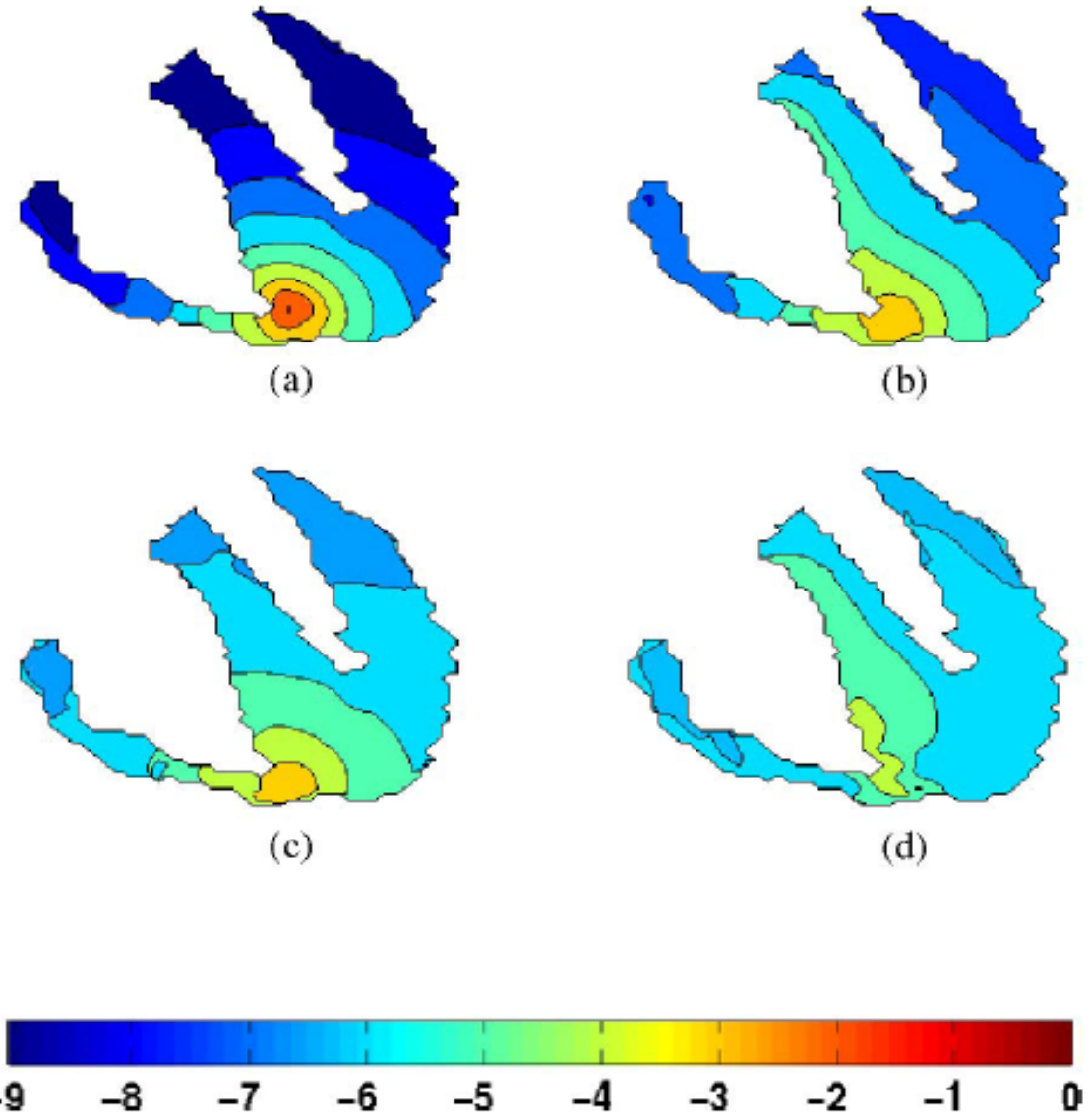


Numerical Model of the Human Heart



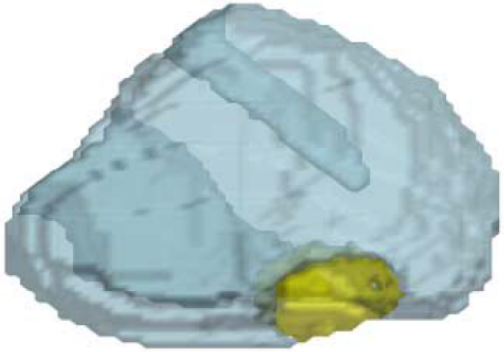
Requena-Carrion et al. Sensitivity and Spatial Resolution of Transvenous Leads in Implantable Cardioverter Defibrillator . IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING, VOL. 56, NO. 12, Dec. 2009

Logarithm of Magnitude of Sensitivity Distribution

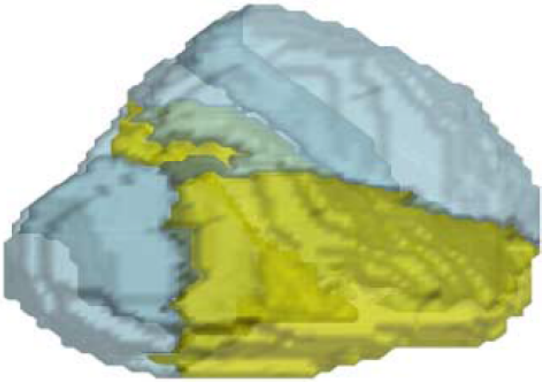


Requena-Carrion et al. Sensitivity and Spatial Resolution of Transvenous Leads in Implantable Cardioverter Defibrillator . IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING, VOL. 56, NO. 12, Dec. 2009

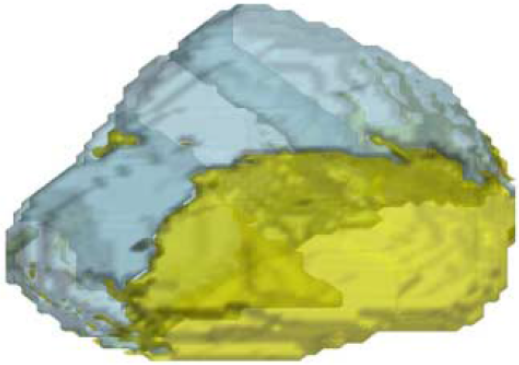
Spatial resolution in the ventricular myocardium



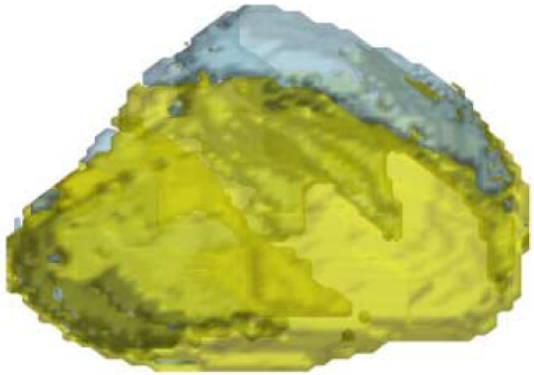
True bipolar 7%



Integrated bipolar 35%



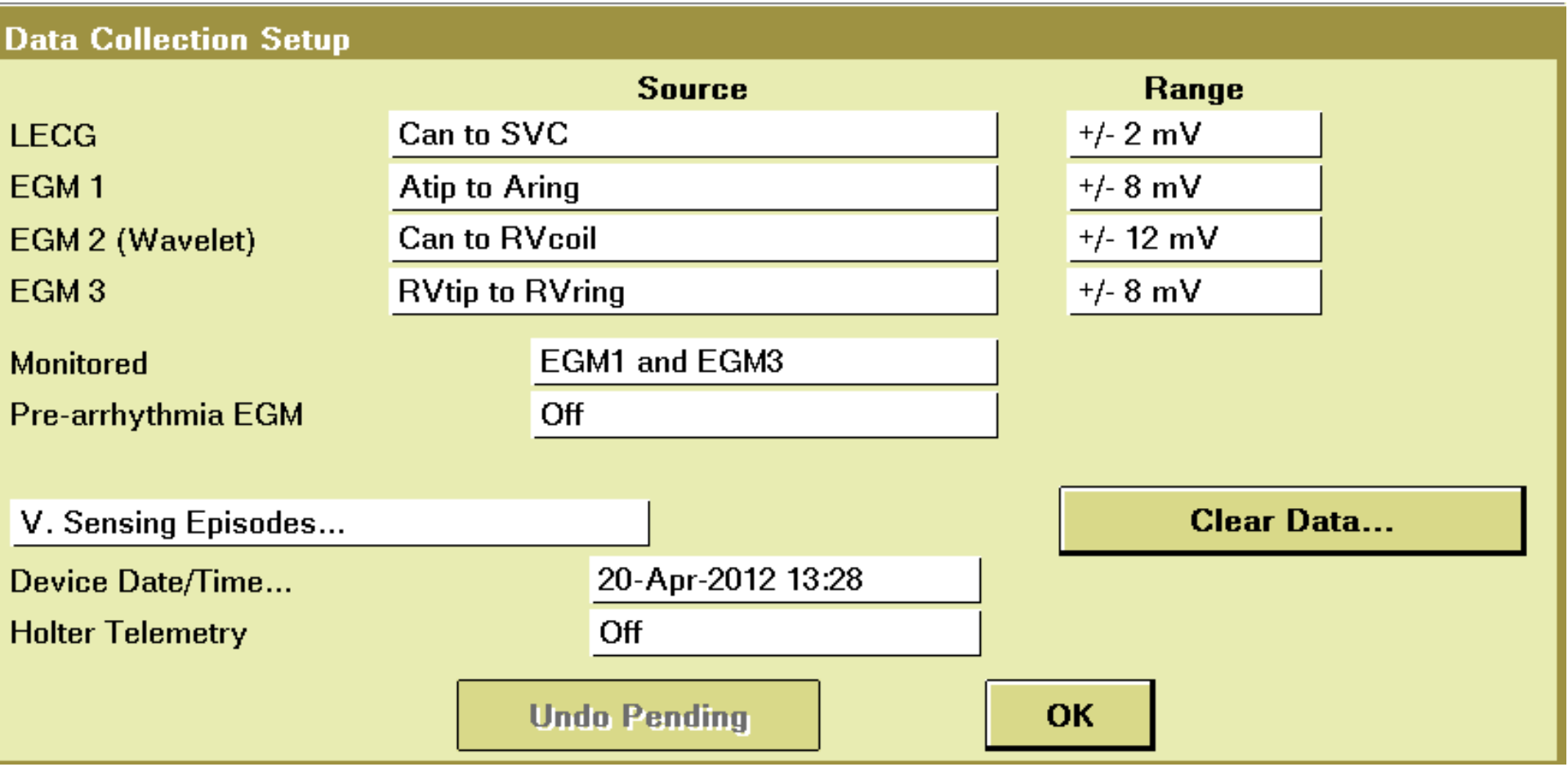
Tip to can 45%



Coil to can 70%

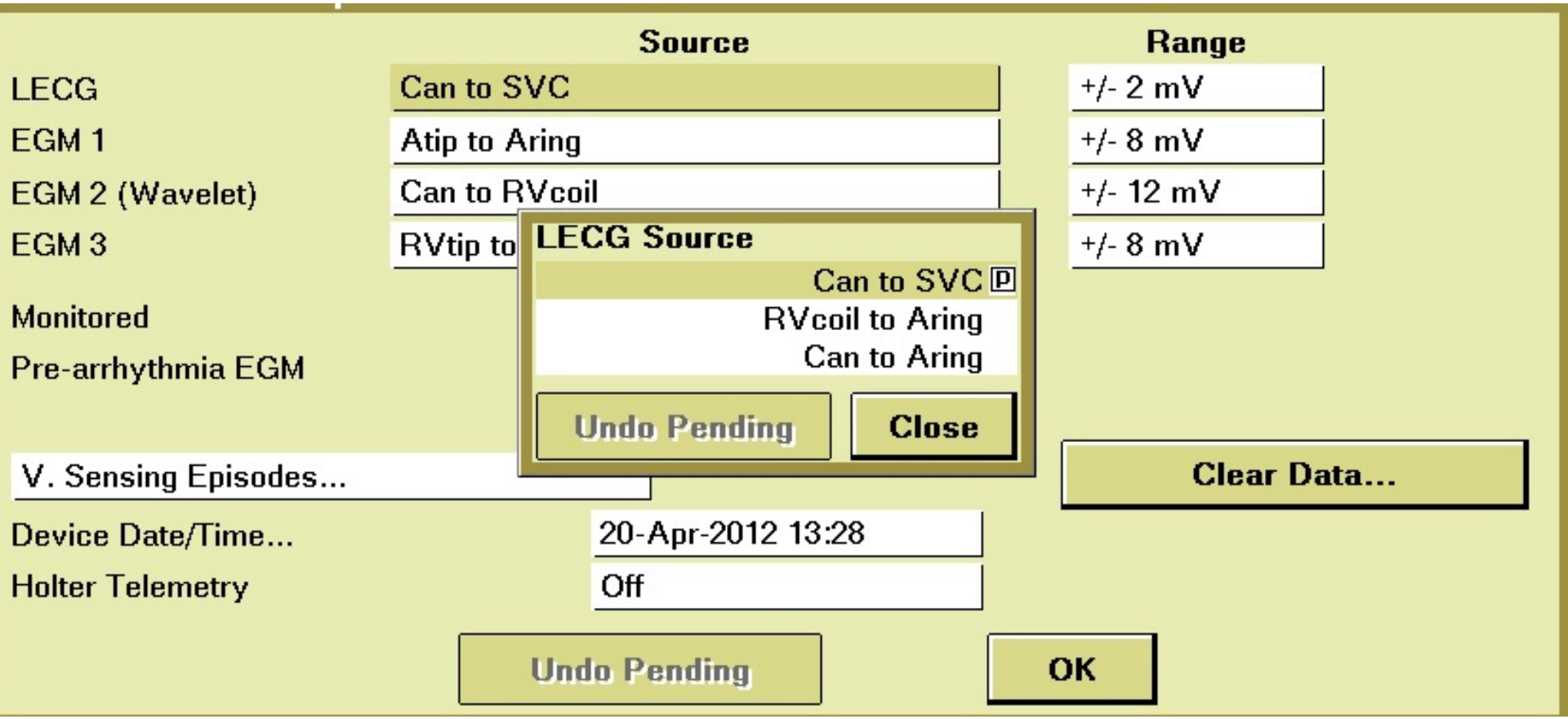
Requena-Carrion et al. Sensitivity and Spatial Resolution of Transvenous Leads in Implantable Cardioverter Defibrillator . IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING, VOL. 56, NO. 12, Dec. 2009

Data Collection Setup of the Medtronic 2090 Programmer Screen

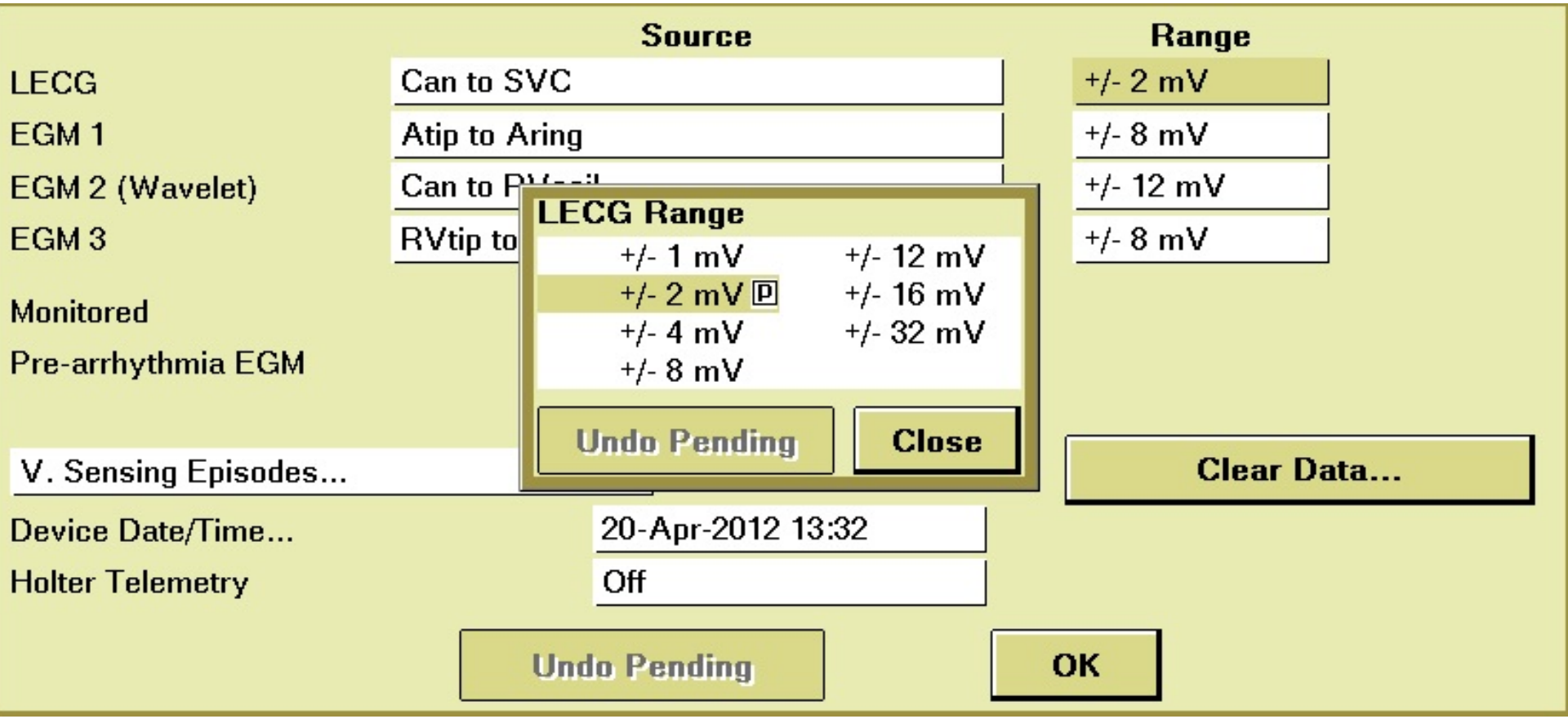


CRT-D with Bipolar LV Lead

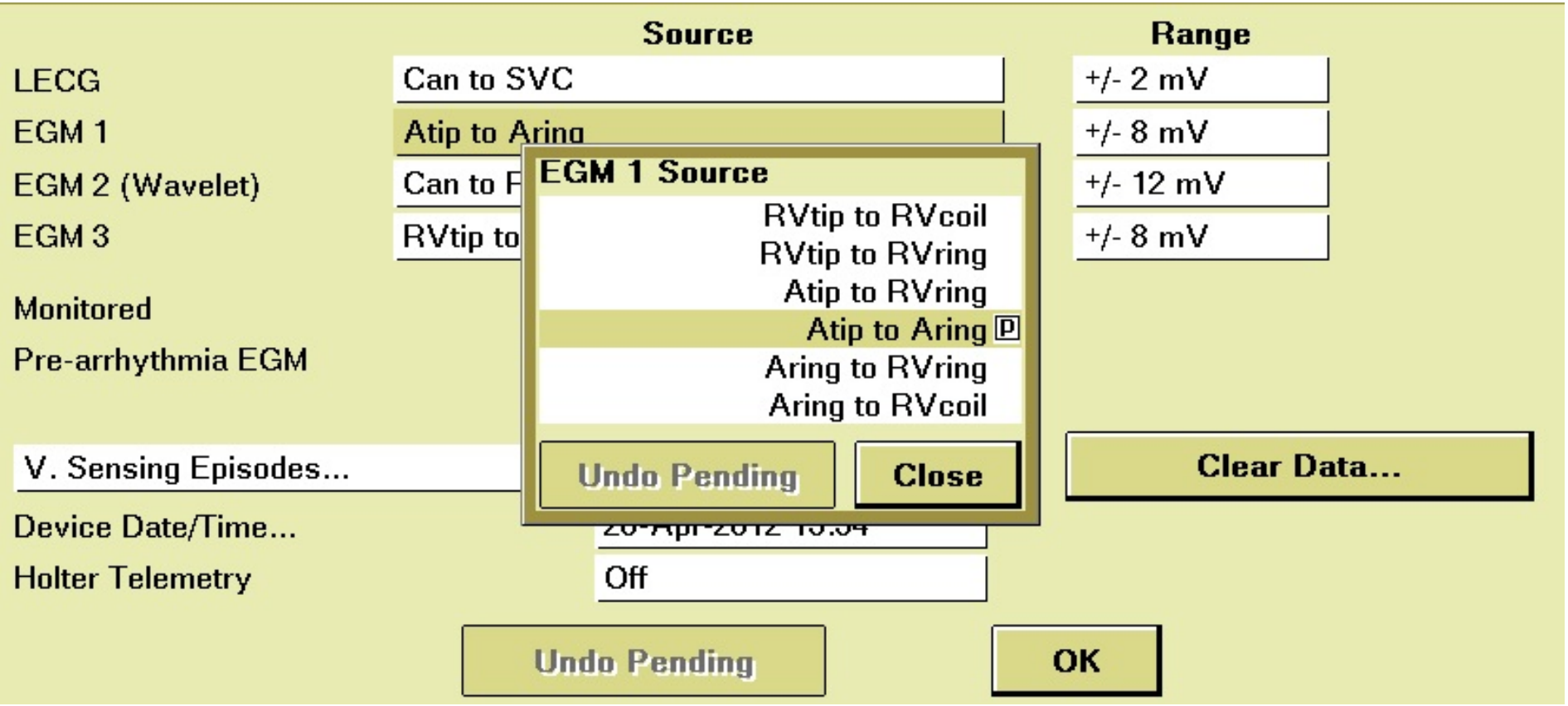
Selection of LECG Vectors



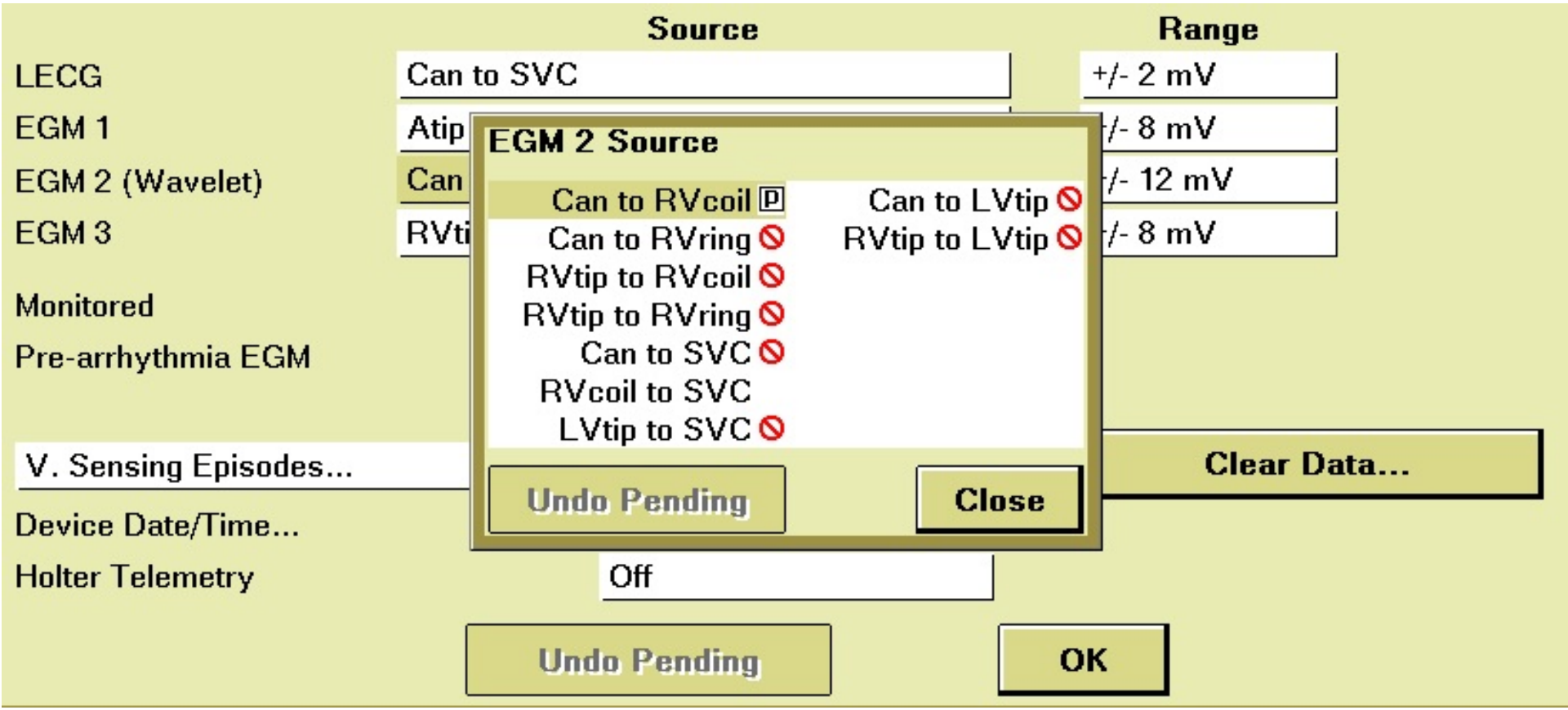
Selection of LECG Gain



Selection of EGM 1 Vectors

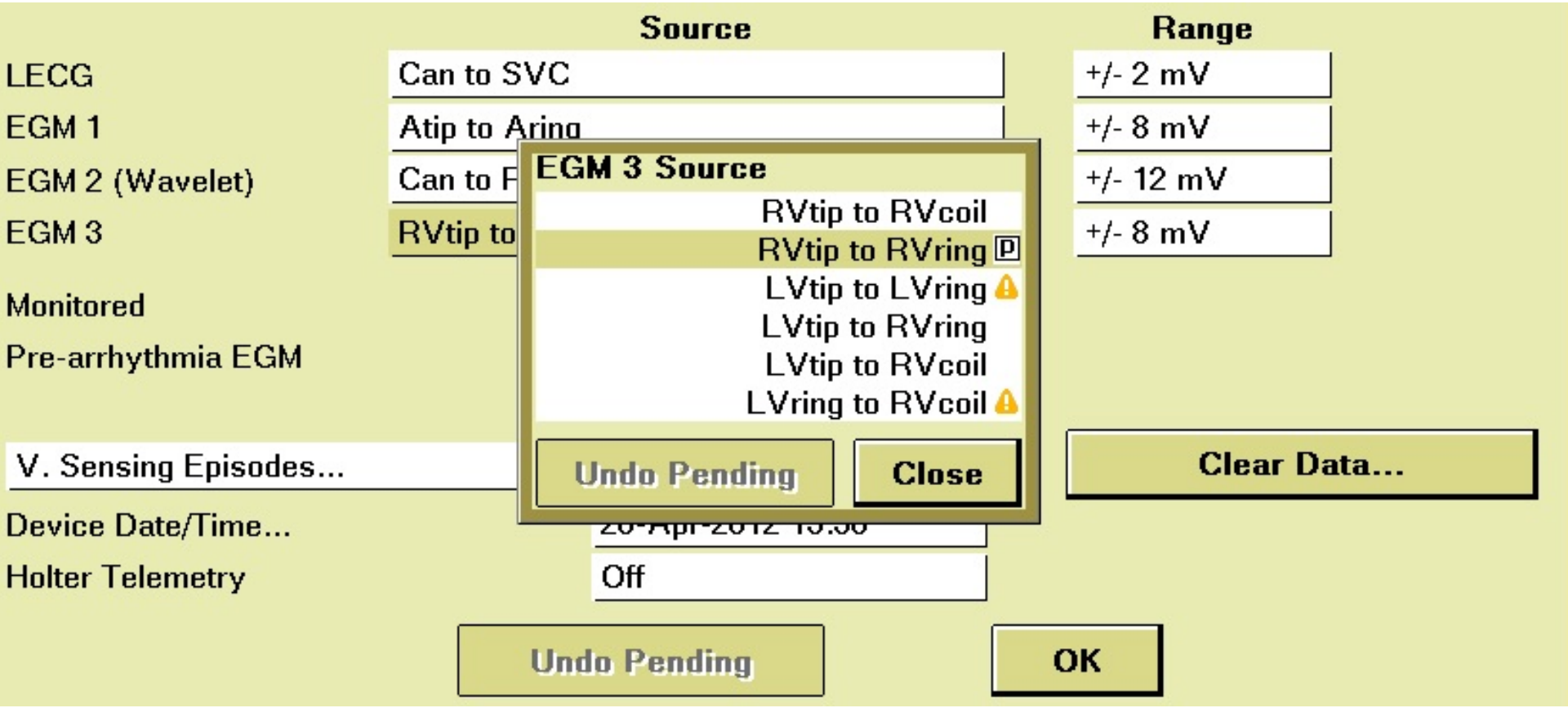


Selection of EGM 2 Vectors (used for Wavelet)

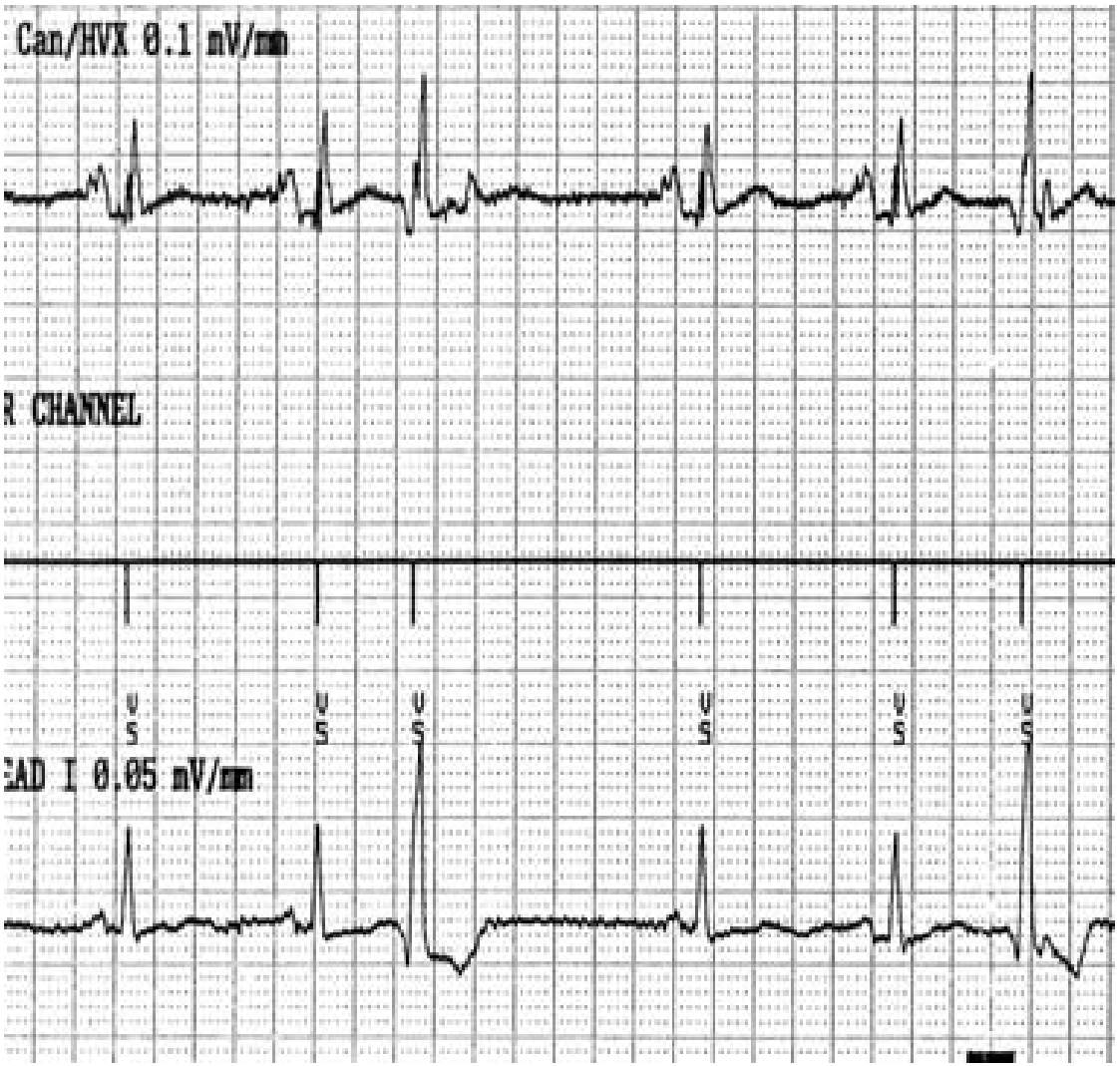


-EGM2 Source must be Can to RVcoil or RVcoil to SVC when RV Lead Noise Enhancement (in V. Detection) is On or On+Timeout.

Selection of EGM 3 Vectors



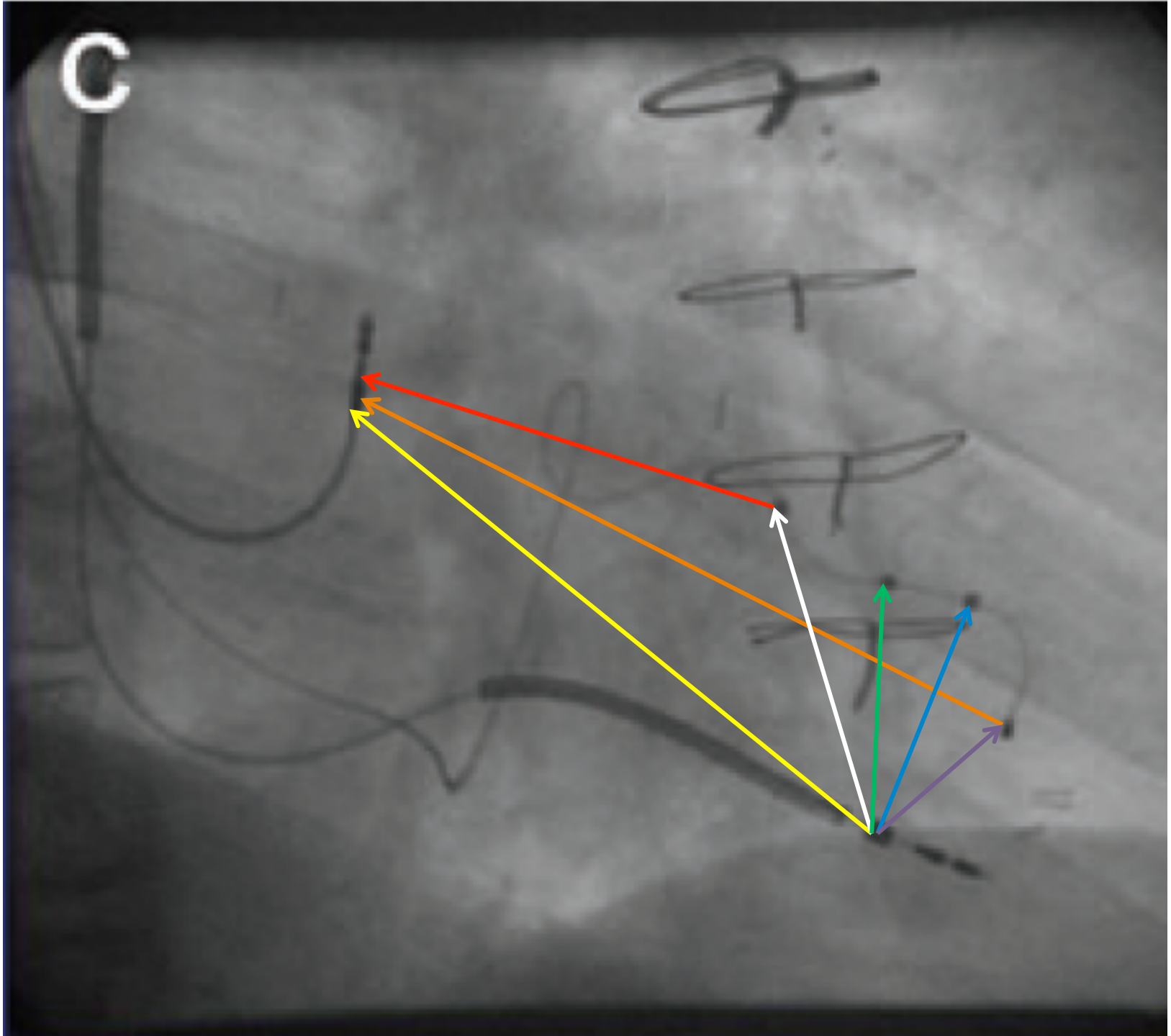
Morphological comparison of the „far-field" IEGM channel (top) compared to Lead I of the ECG (bottom).

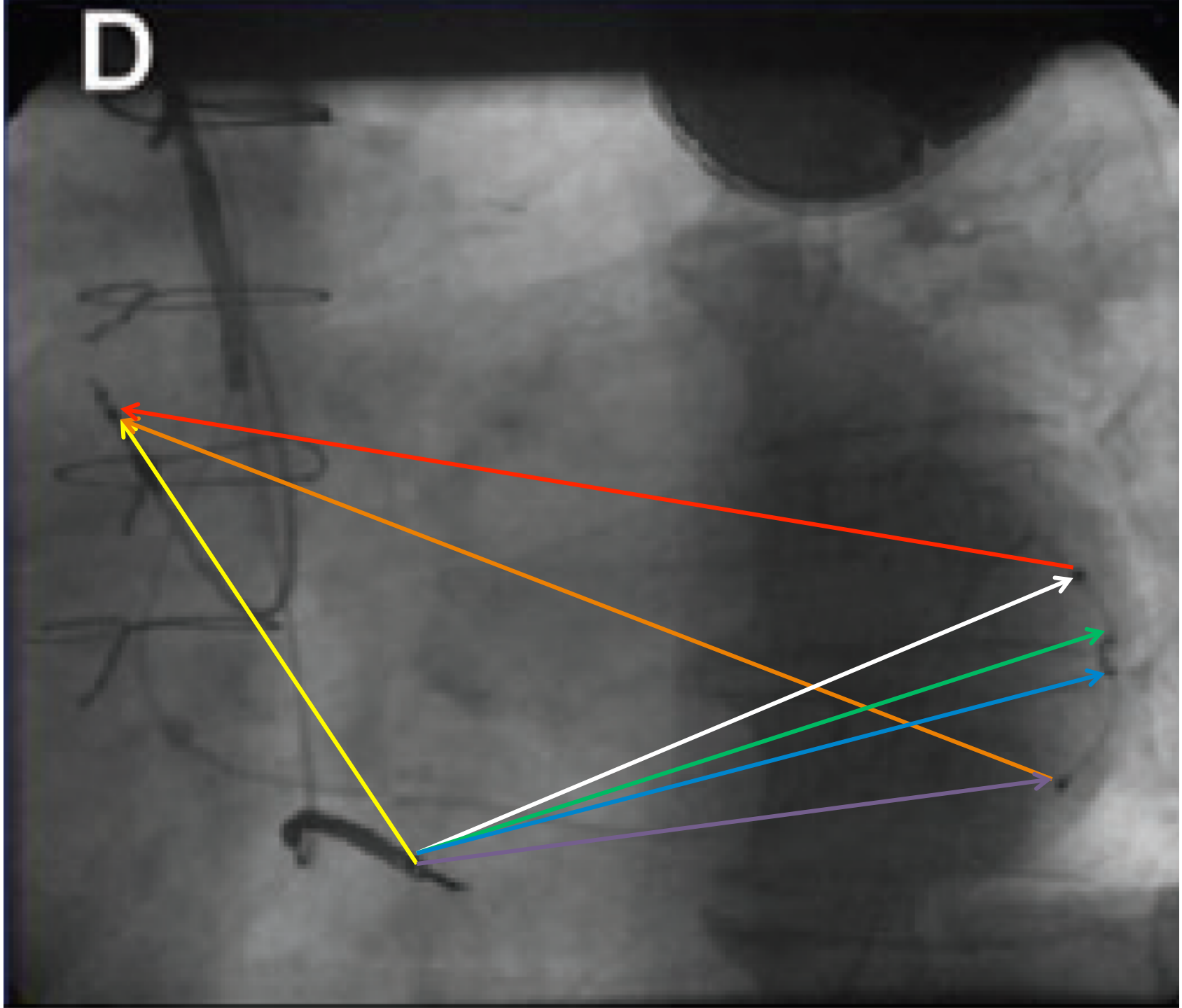


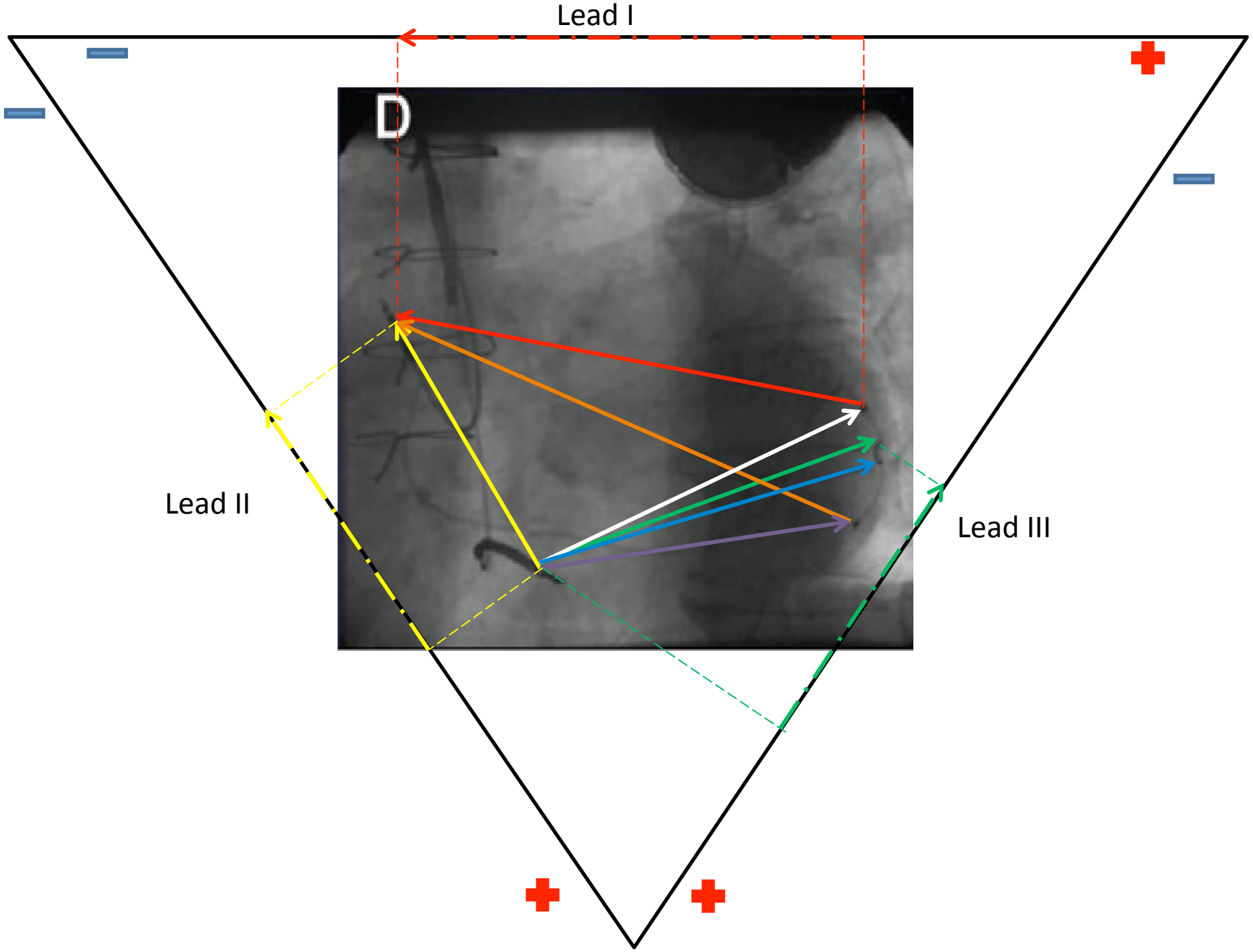
Michael et al. Use of an Intracardiac Electrogram Eliminates the Need for a Surface ECG during Implantable Cardioverter-Defibrillator Follow-Up. PACE 2007; 30:1432–1437

Quadripolar Lead in CRTD System

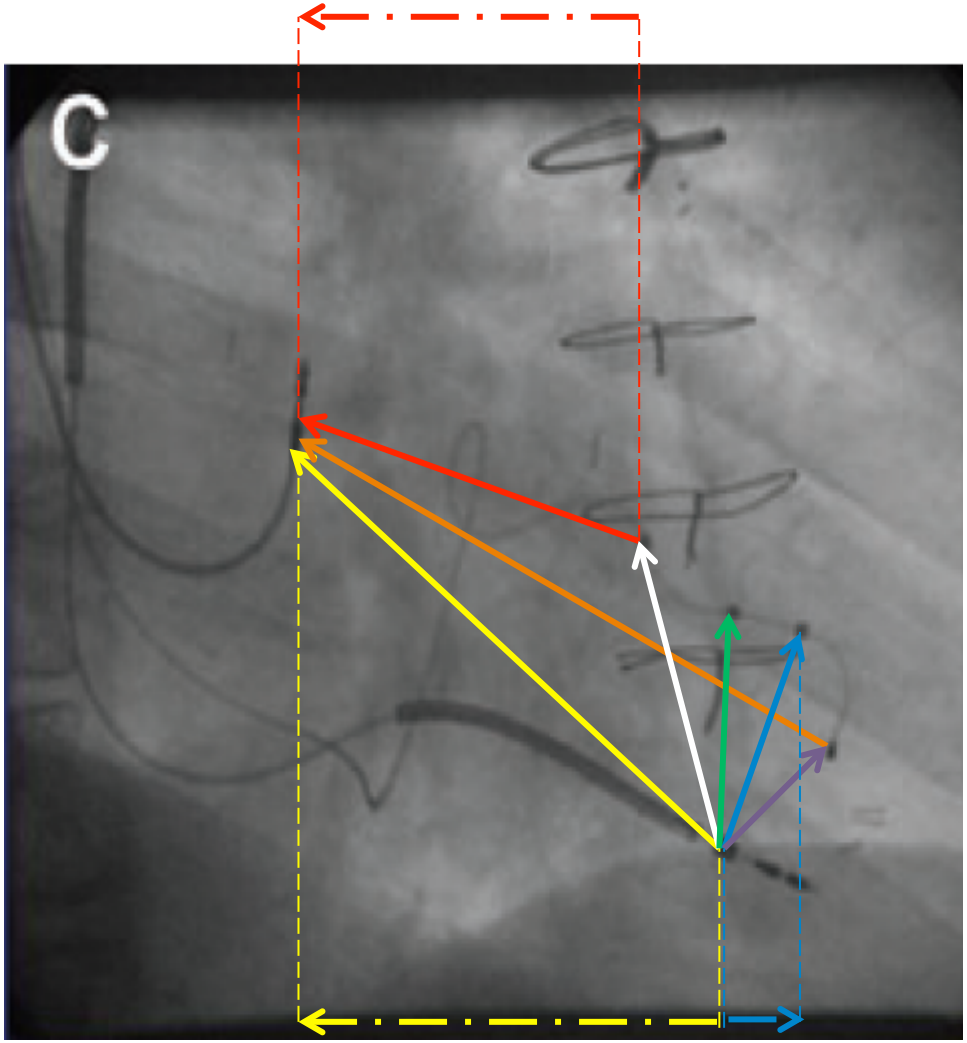
What kind of far-field EGM recordings we could do with such a system?


C

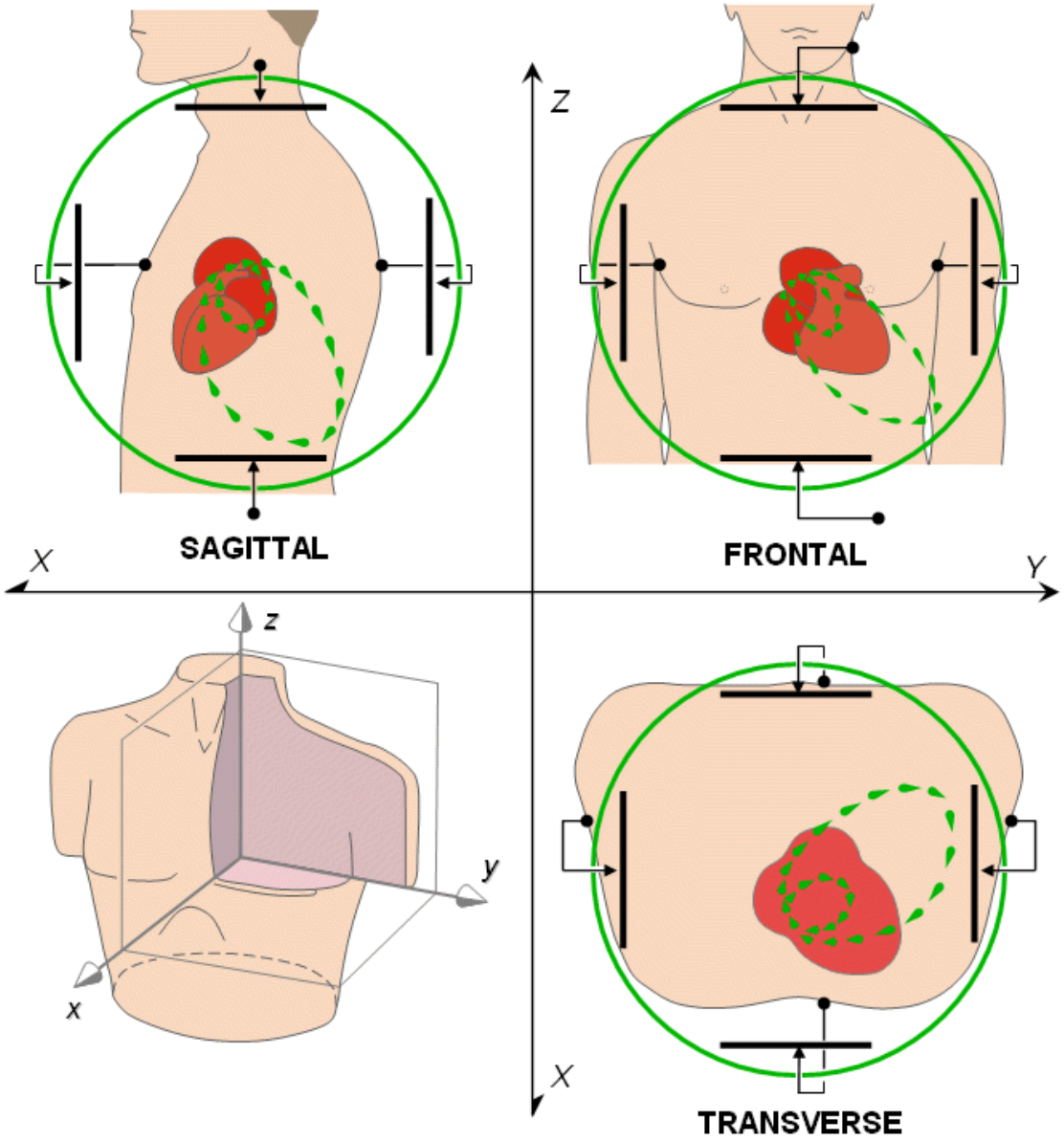

D


Lead I
D
Lead II
Lead III

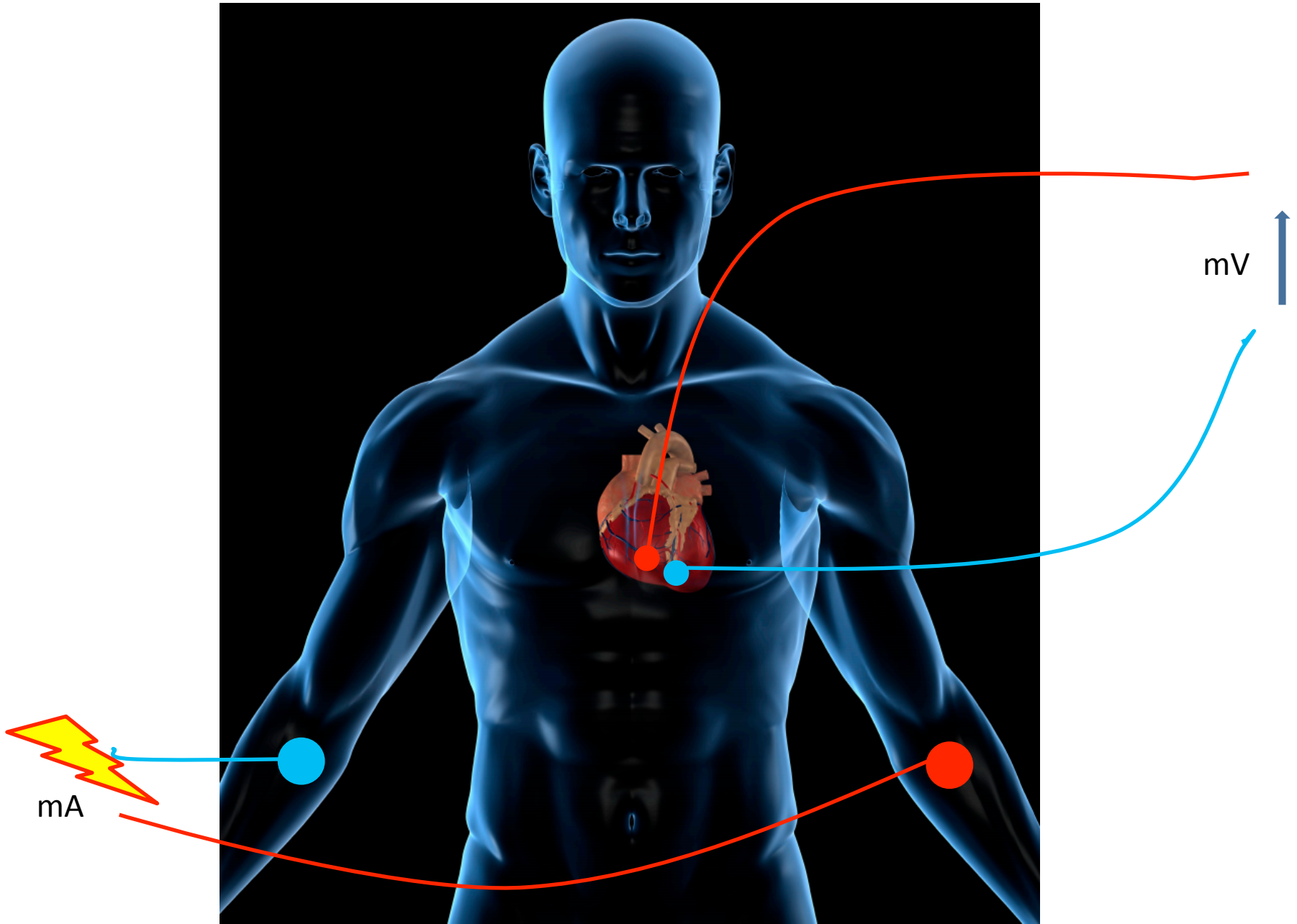
Sagittal plane



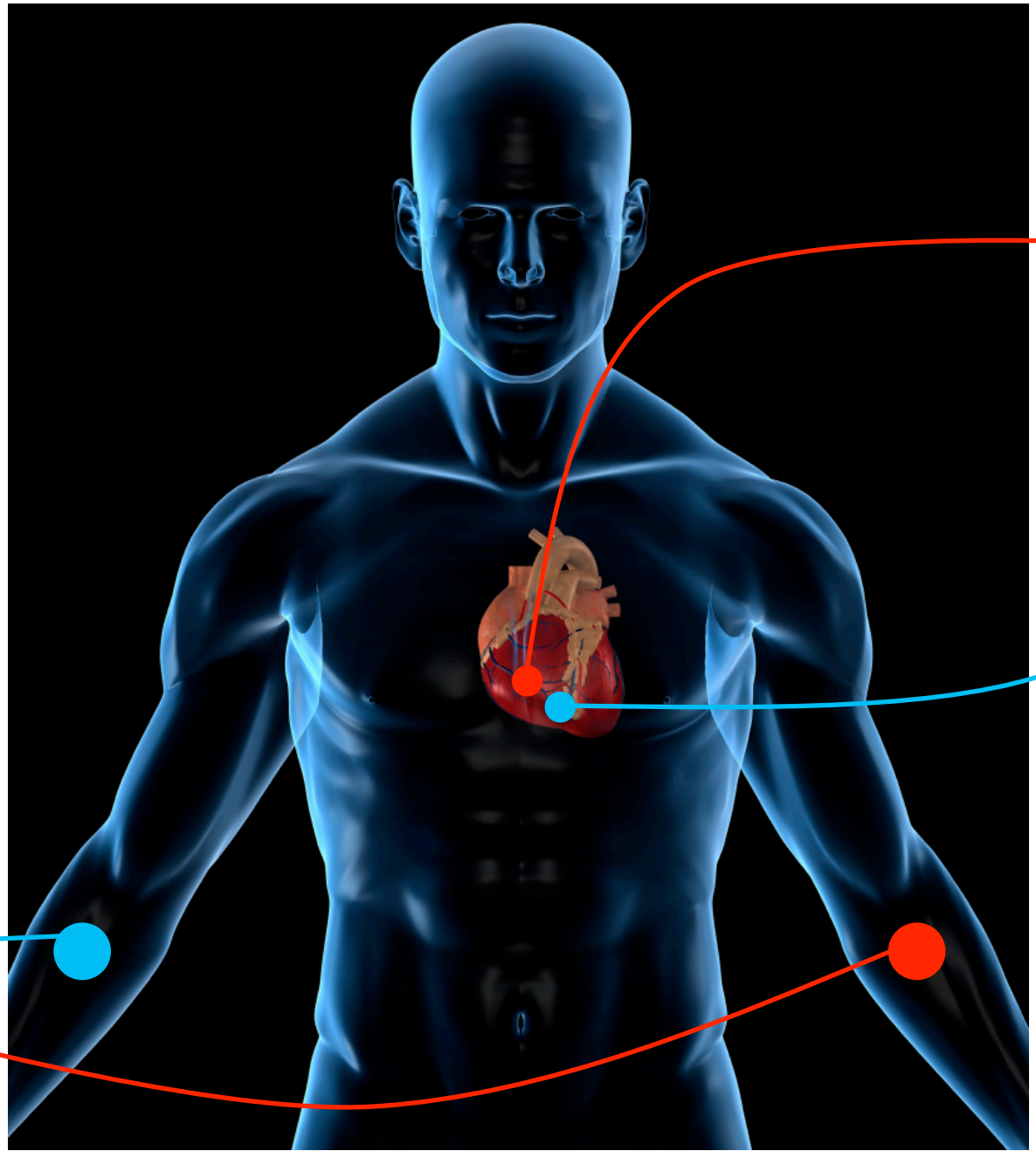
Frank Leads



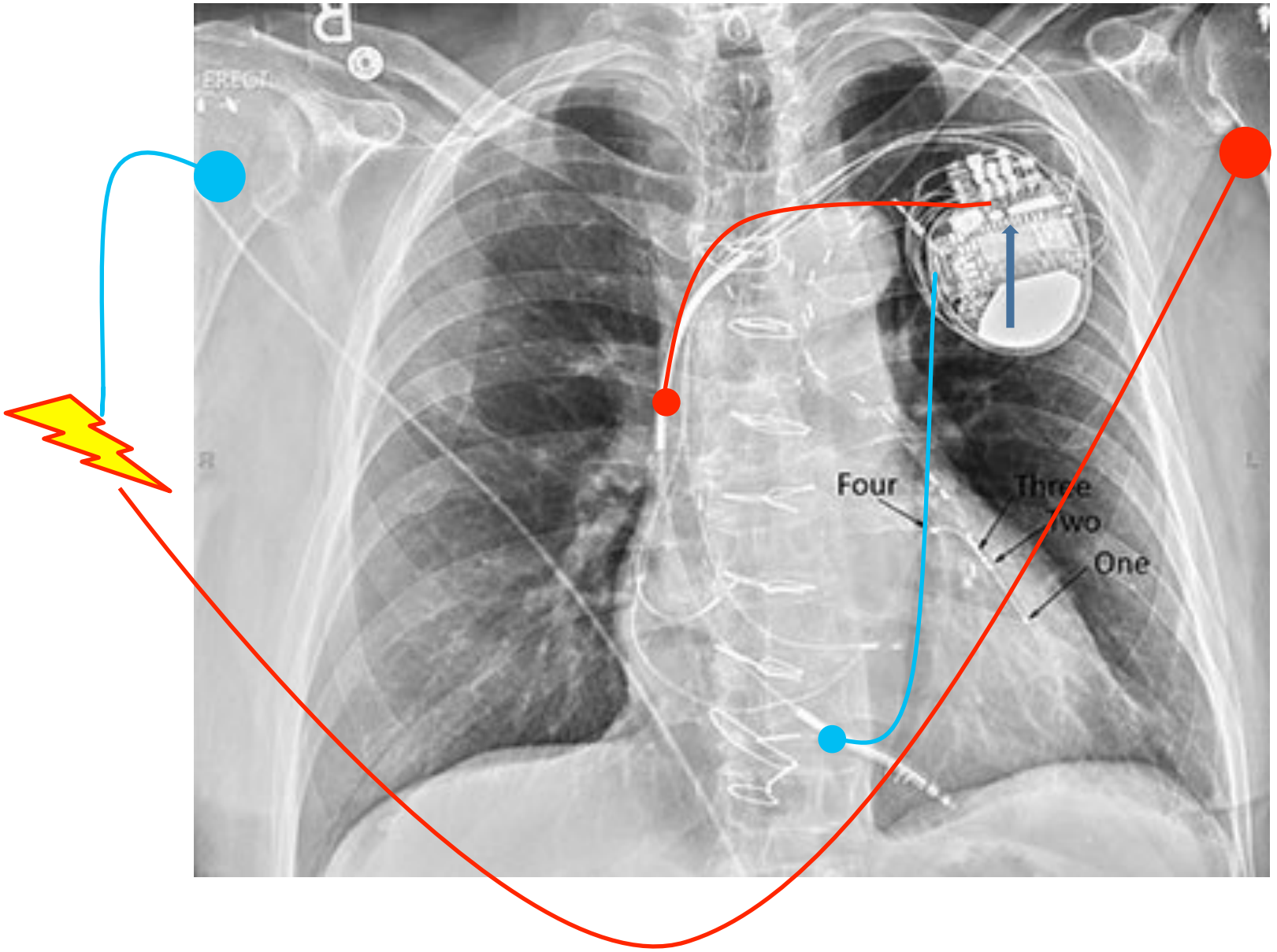
Electric Field Inversion Theorem



The equal current amplitude yields equal measured potential



Simple Calibration Method



Clinical Applications of the ICD IEGM Leads

Ischaemia

Occlusion of the LAD at a distal site

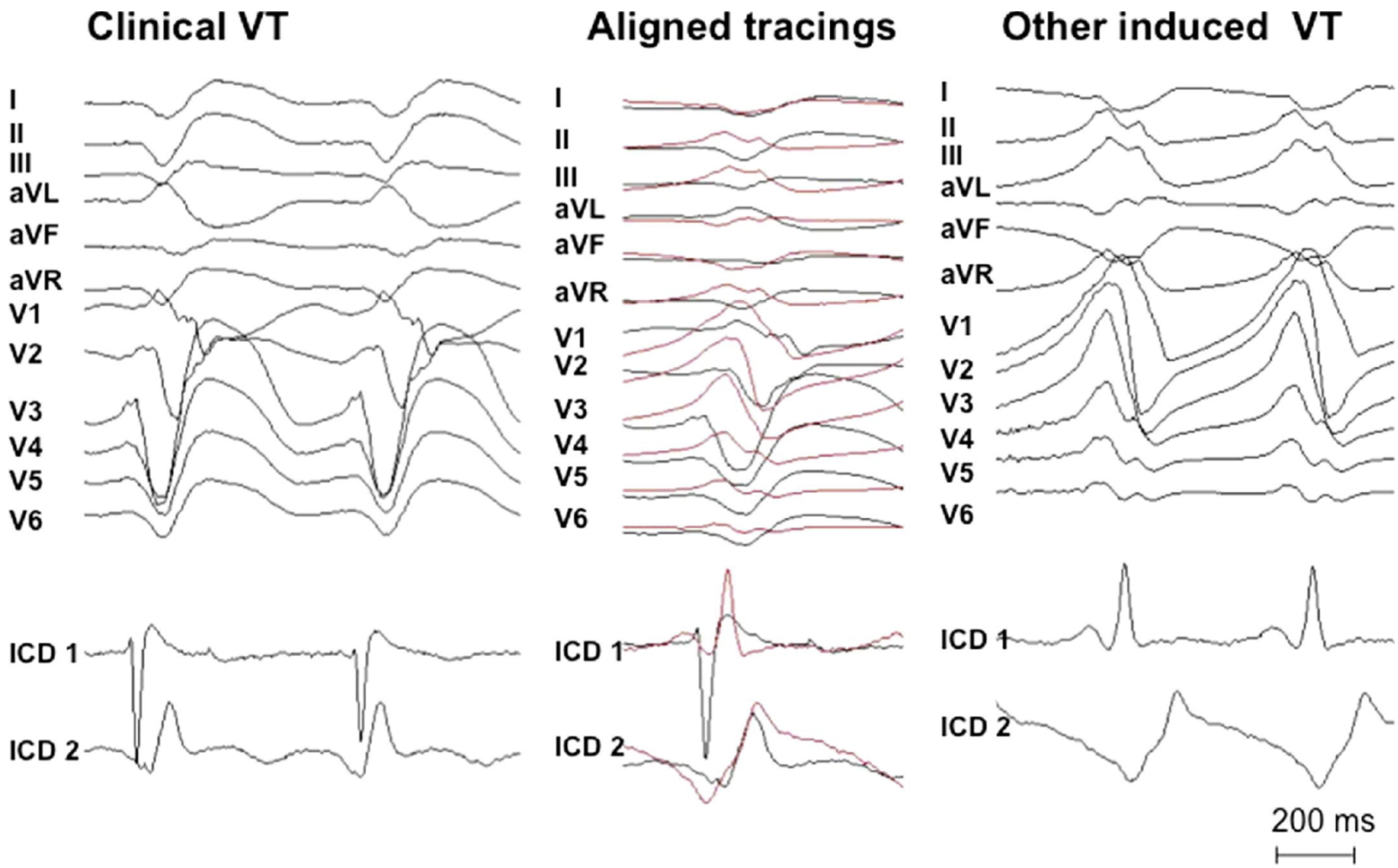
Asbach et al. Intrathoracic Far-Field Electrocardiogram Allows Continuous Monitoring of Ischemia After Total Coronary Occlusion. *PACE 2006; 29: 1334–1340*

Problem for electrophysiologists

12-lead ECG of the spontaneous post-infarction VT referred for catheter ablation is often not documented

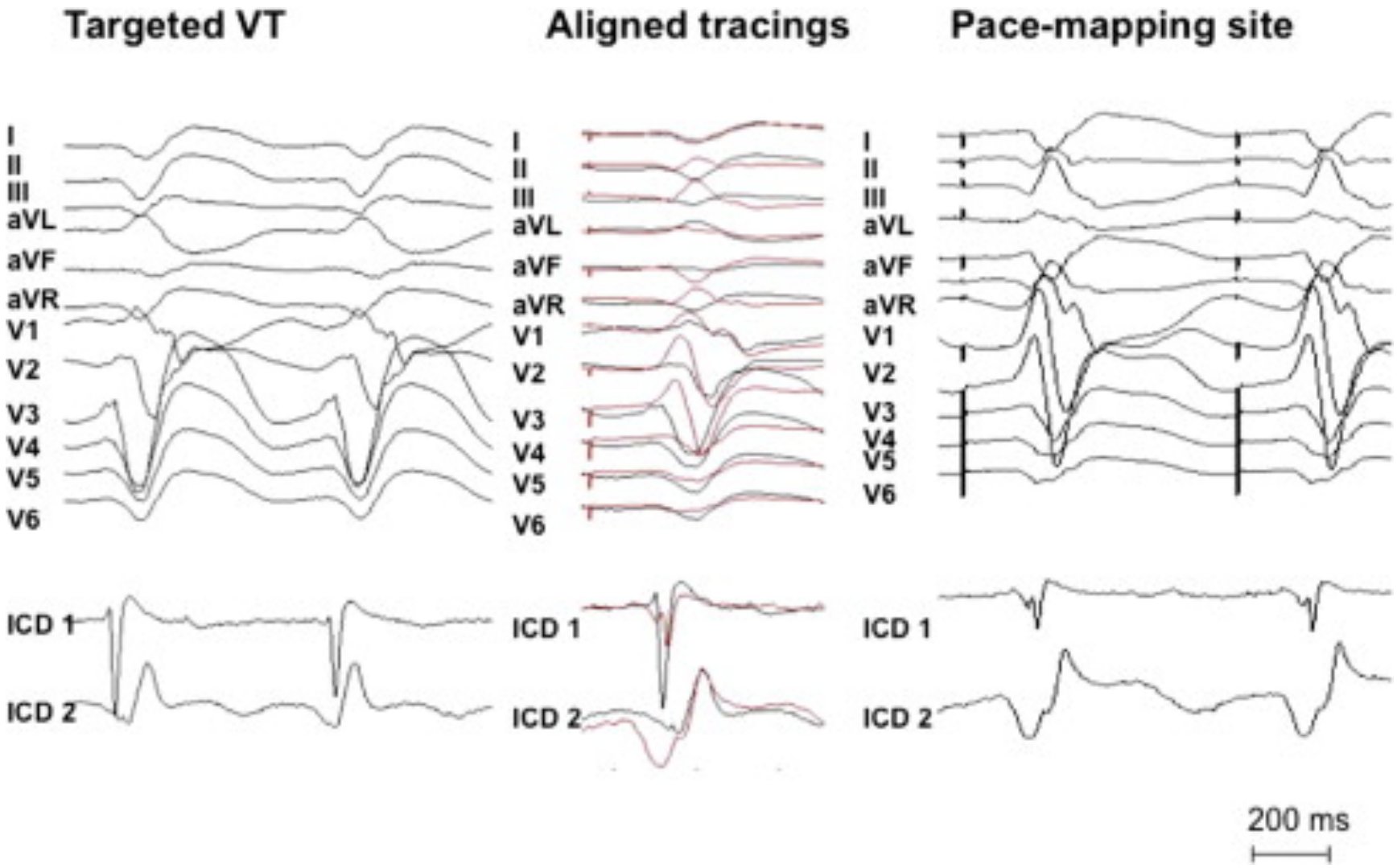
Many of these patients have ICD !

Clinical VT and Other Induced VT

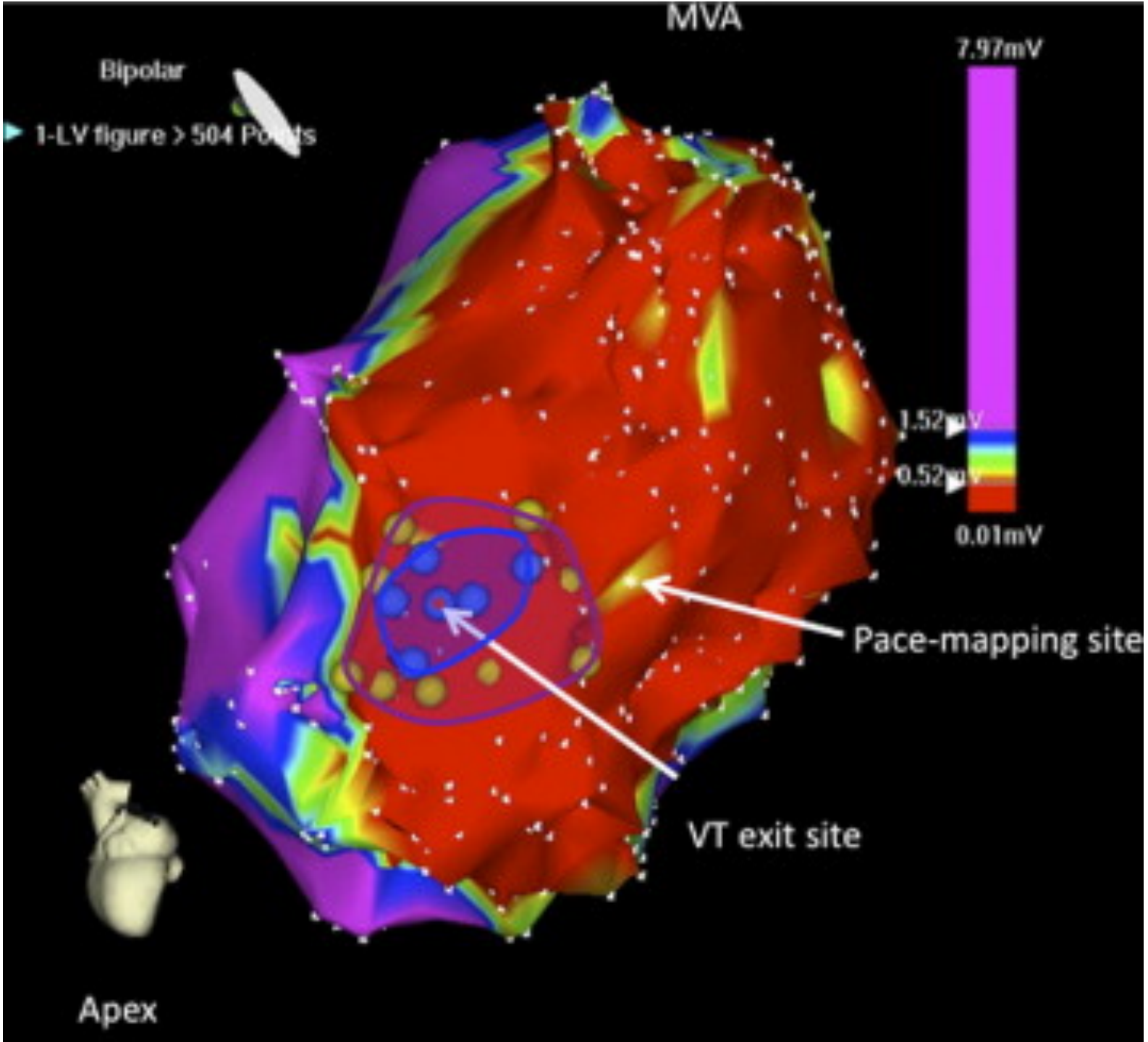


Yoshida et al. The Value of Defibrillator Electrograms for Recognition of Clinical Ventricular Tachycardias and for Pace Mapping of Post-Infarction Ventricular Tachycardia. Journal of the American College of Cardiology Vol. 56, No. 12, 2010

Targeted VT and Pace Mapping at Exit Site



Yoshida et al. The Value of Defibrillator Electrograms for Recognition of Clinical Ventricular Tachycardias and for Pace Mapping of Post-Infarction Ventricular Tachycardia. Journal of the American College of Cardiology Vol. 56, No. 12, 2010


MVA
Bipolar
1-LV figure > 504 Points
7.97mV
1.52mV
0.52mV
0.01mV
Pace-mapping site
VT exit site
Apex

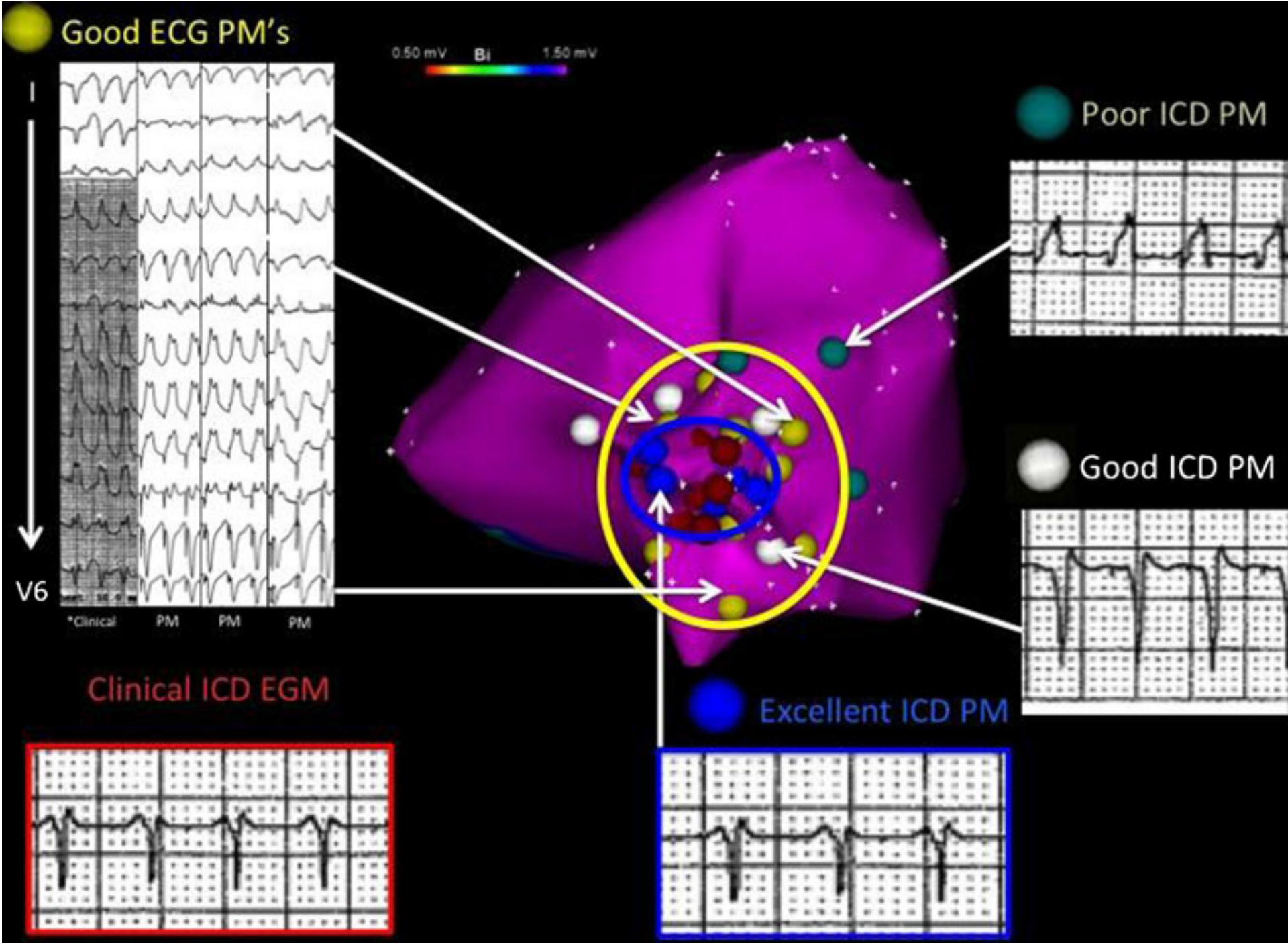
Clinical Relevance

- In post-infarction patients with VT, ICD EGMs can be used to differentiate clinical VTs from inducible VTs of uncertain clinical relevance.
- Spatial resolution of pace mapping based on ICD EGMs is inferior to the spatial resolution of 12-lead ECGs
- ICD EGMs may be useful for determining whether an ablation catheter is located at a VT exit site.
- ICD EGMs was found to be as accurate as computerized analysis for differentiating clinical VTs from previously undocumented VTs.
- Visual comparisons of stored and real-time ICD EGMs provides a simple and practical technique for identifying clinical VTs.

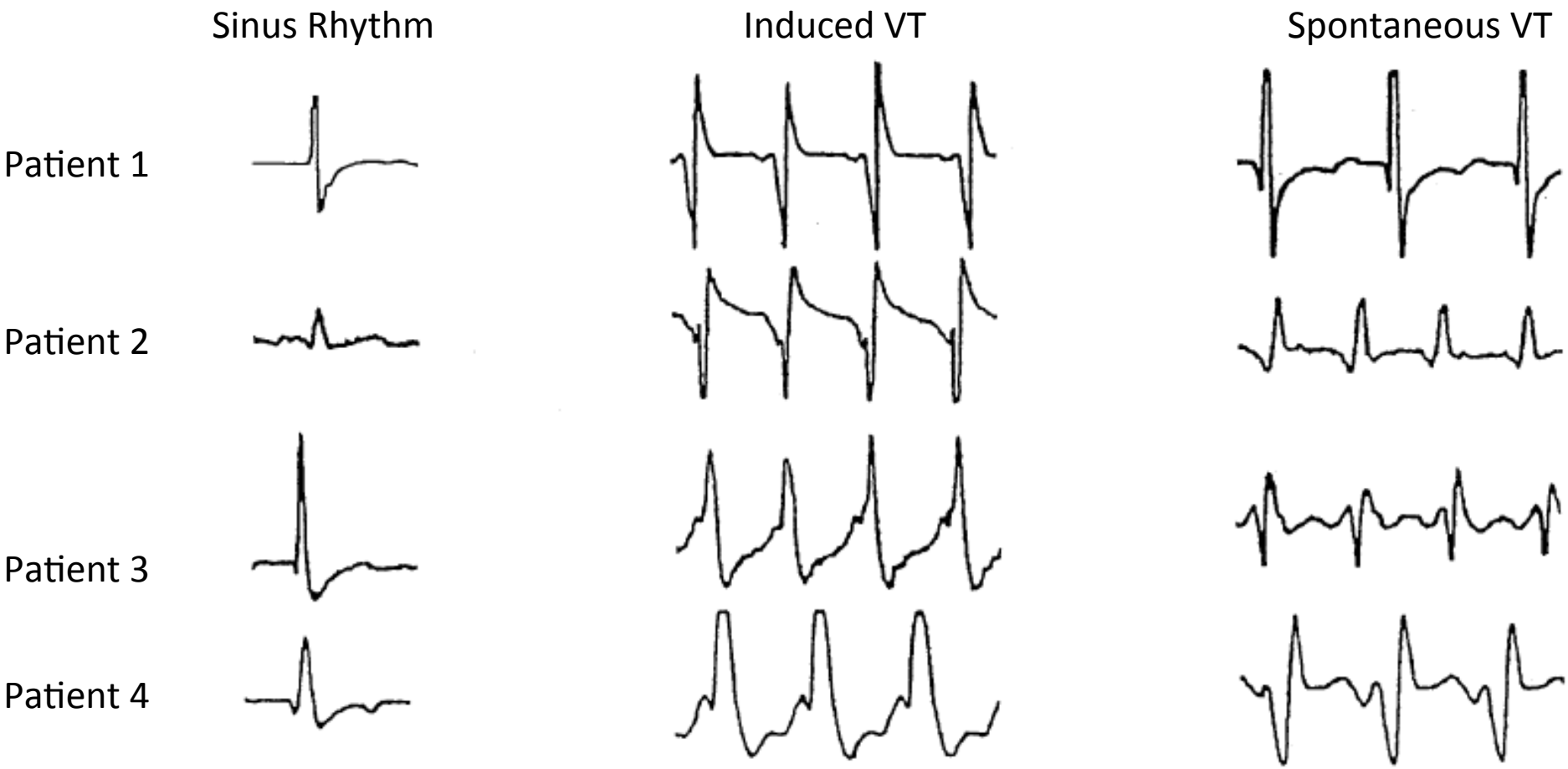
Developing an ablation strategy when the clinical arrhythmia cannot be induced is a challenge

Pacemapping of the VT and EGM

Tschabrunn C.M., Anter E. and Marchlinski F.E. **Identifying non-inducible ventricular tachycardia origin utilizing defibrillator electrograms.** J Interv Card Electrophysiol (2013) 36:243–246

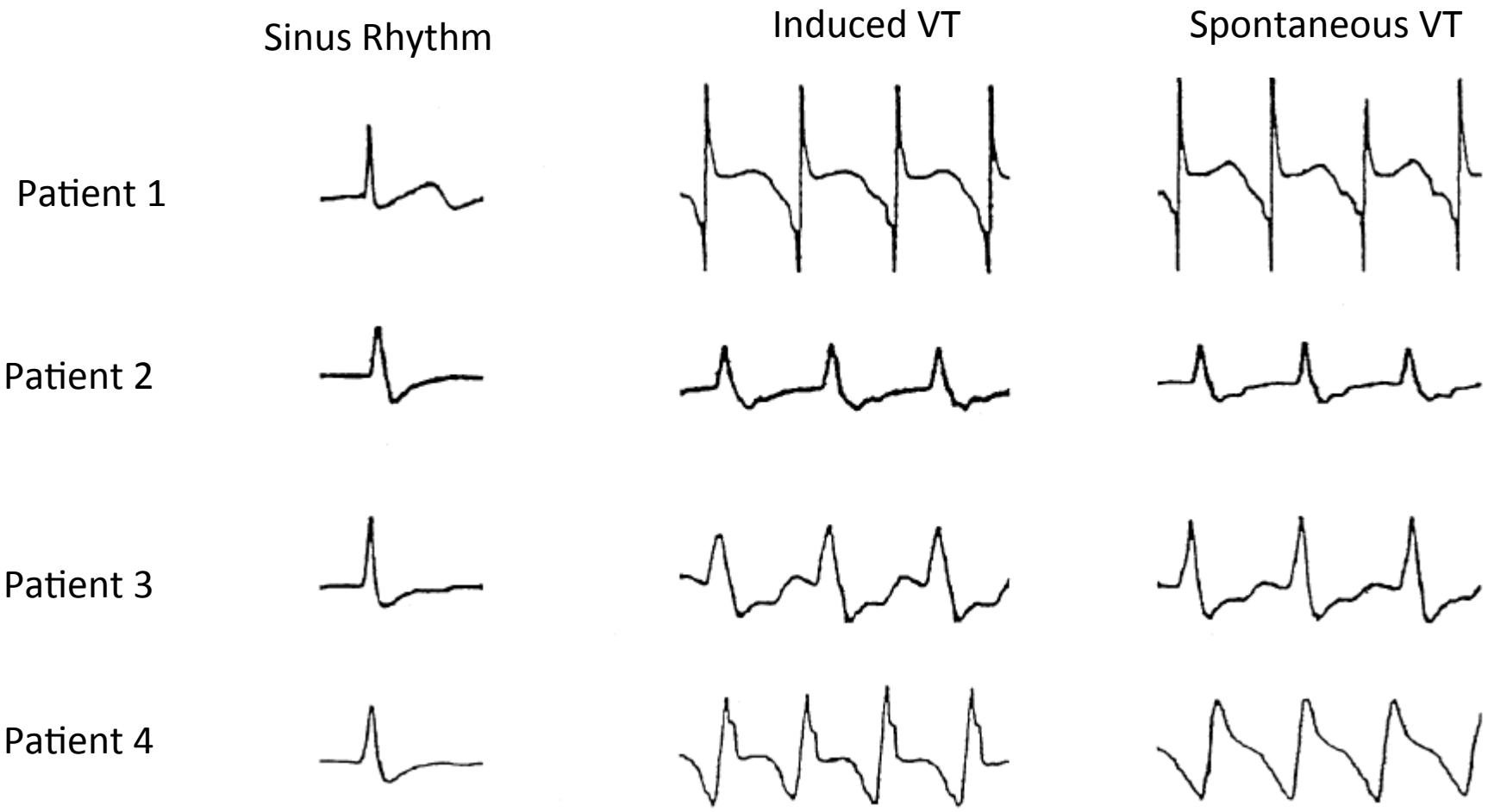

Good ECG PM's
I
V6
*Clinical
PM
PM
PM
0.50 mV
Bi
1.50 mV
Poor ICD PM
Good ICD PM
Excellent ICD PM
Clinical ICD EGM

Induced vs Spontaneous VT



Monahan K.M. Et al. **Relation of Induced to Spontaneous Ventricular Tachycardia from Analysis of Stored Far-Field Implantable Defibrillator Electrograms.** Am J Cardiol 1999;83:349–353)

Induced vs Spontaneous VT

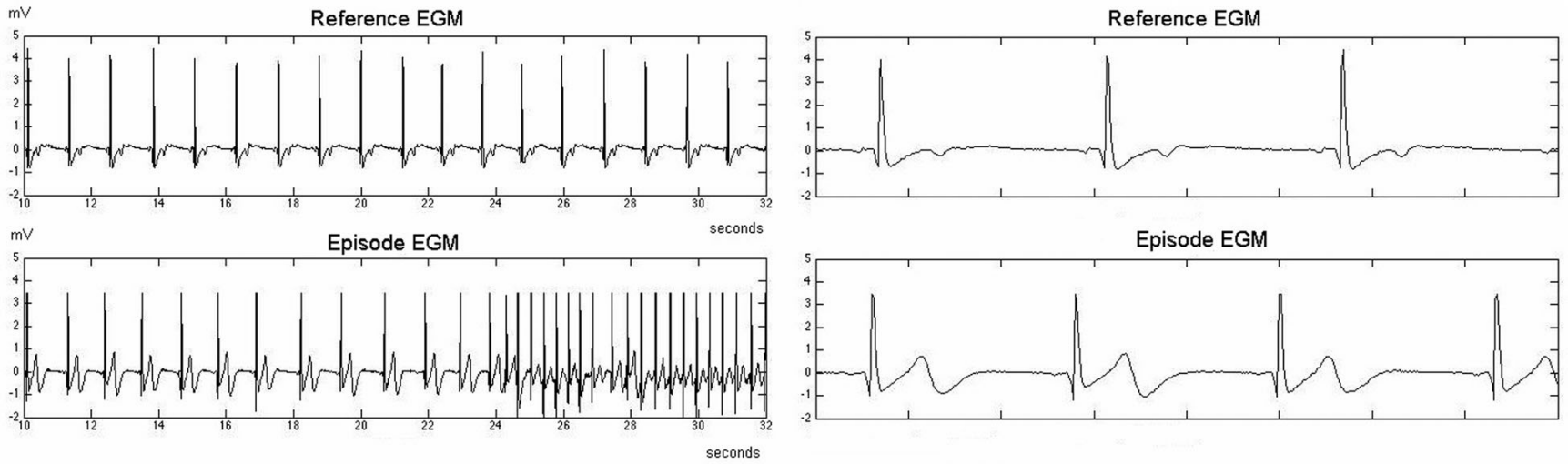


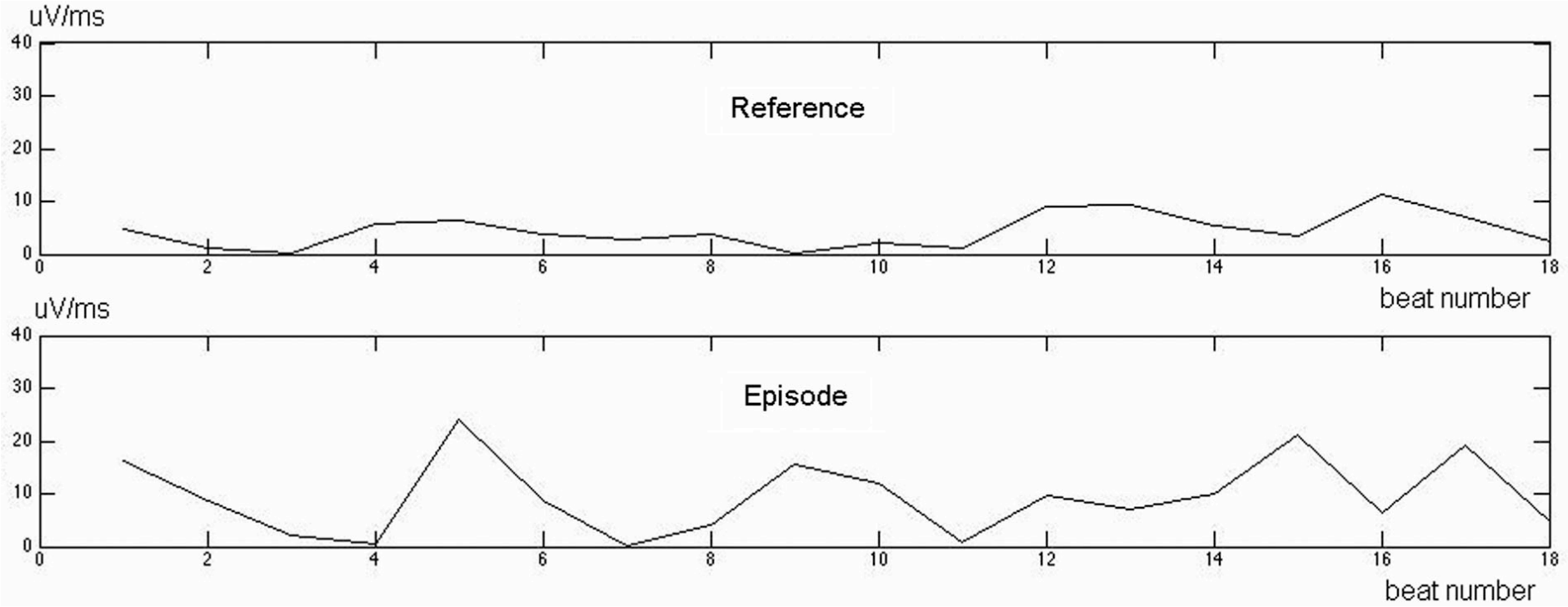
Monahan K.M. Et al. **Relation of Induced to Spontaneous Ventricular Tachycardia from Analysis of Stored Far-Field Implantable Defibrillator Electrograms.** Am J Cardiol 1999;83:349–353)

ETWAS: The Endocardial T-Wave Alternans Study *PACE 2014; 37:1510–1519*

The aim: to prospectively assess the presence of T-wave alternans or beat-to-beat repolarization changes on ICD-stored electrograms immediately preceding the onset of spontaneous VT or VF

Beat-to-beat variations in T-wave maximal descending slope drawn from the baseline and pre-trigger EGM



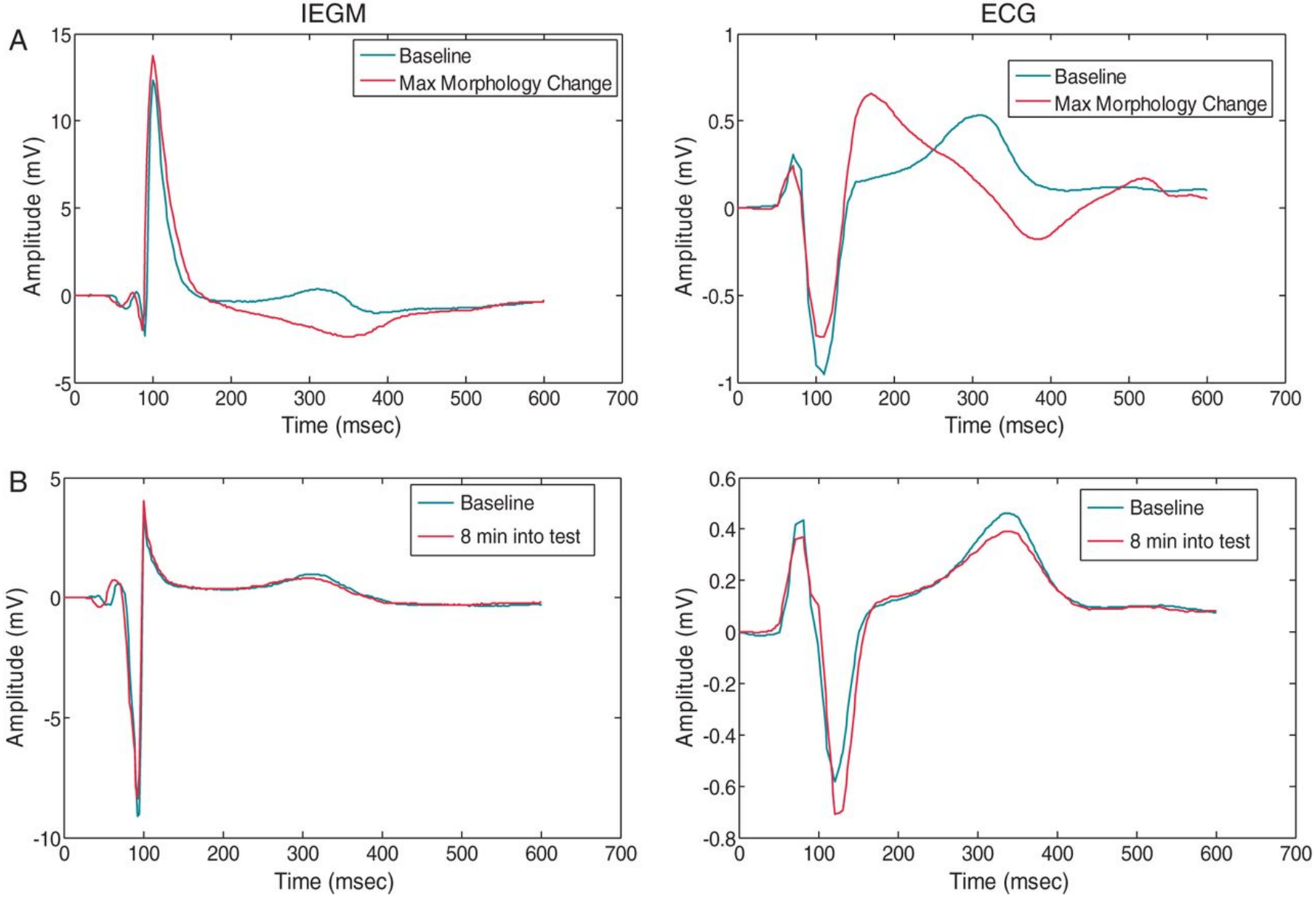


ETWAS: The Endocardial T-Wave Alternans Study *PACE 2014; 37:1510–1519*

Conclusions: *Detection of beat-by-beat repolarization variations in ICD-stored EGMs is feasible in a significant subset of cases and may be used for predicting the onset of ventricular arrhythmias.*

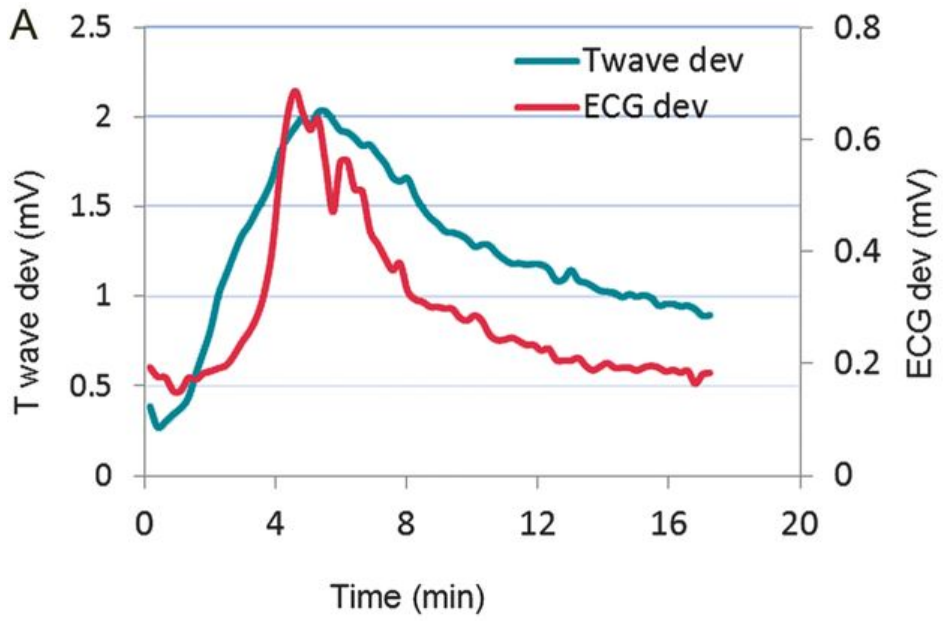
Brugada-Brugada Syndrome

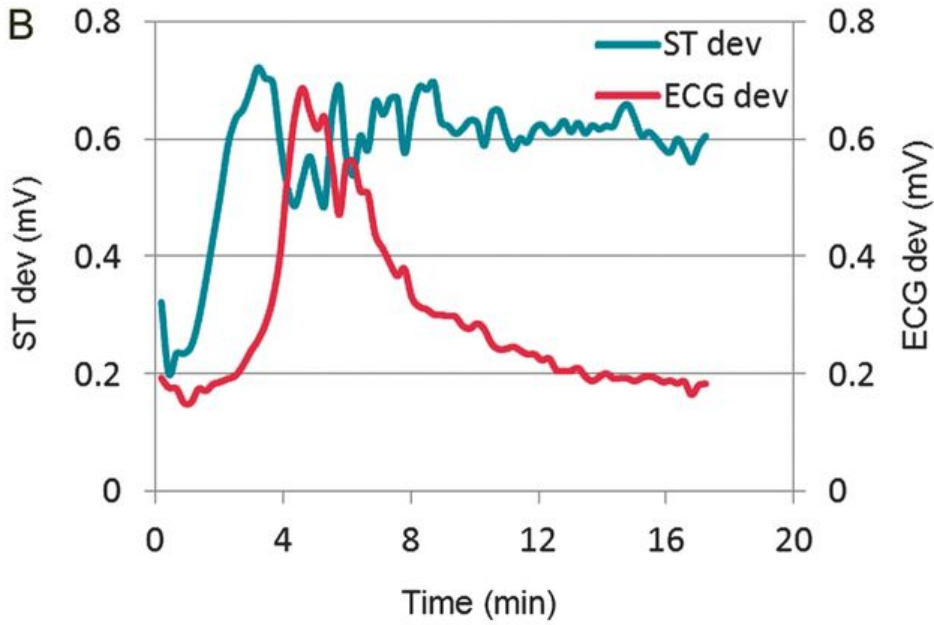
Is there a correlation between surface ECG and IEGM during ajmaline challenge in ICD recipients ?



Probst et al. Correlation of intracardiac electrogram with surface electrocardiogram in Brugada syndrome patients. Europace (2014) 16, 908–913

Comparison of the ST and T wave deviations of the IEGM vs. the ST deviation of the ECG





Time course of the ajmaline challenge

Probst et al. Correlation of intracardiac electrogram with surface electrocardiogram in Brugada syndrome patients. Europace (2014) 16, 908–913

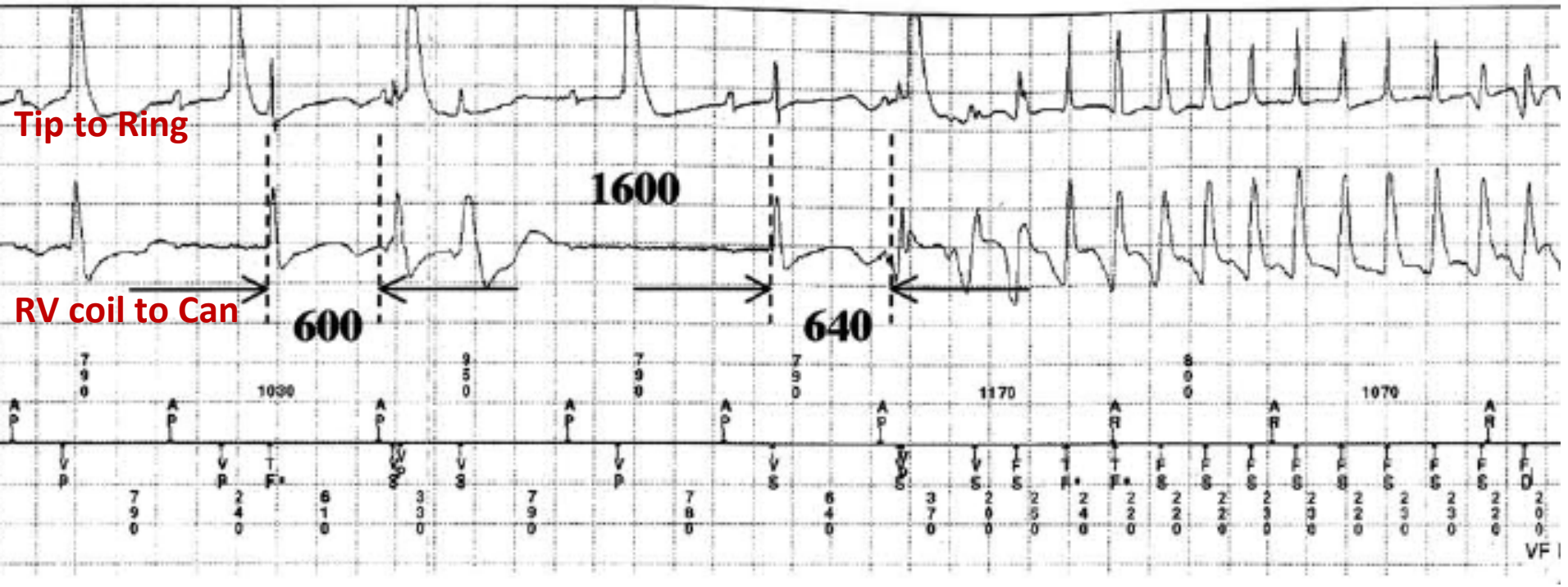
Opening the New Therapeutic Strategies

† First demonstration of the modification induced by the type I Brugada syndrome aspect on the IEGM.

† modifications of IEGM due to the type I Brugada syndrome are localized on the T wave.

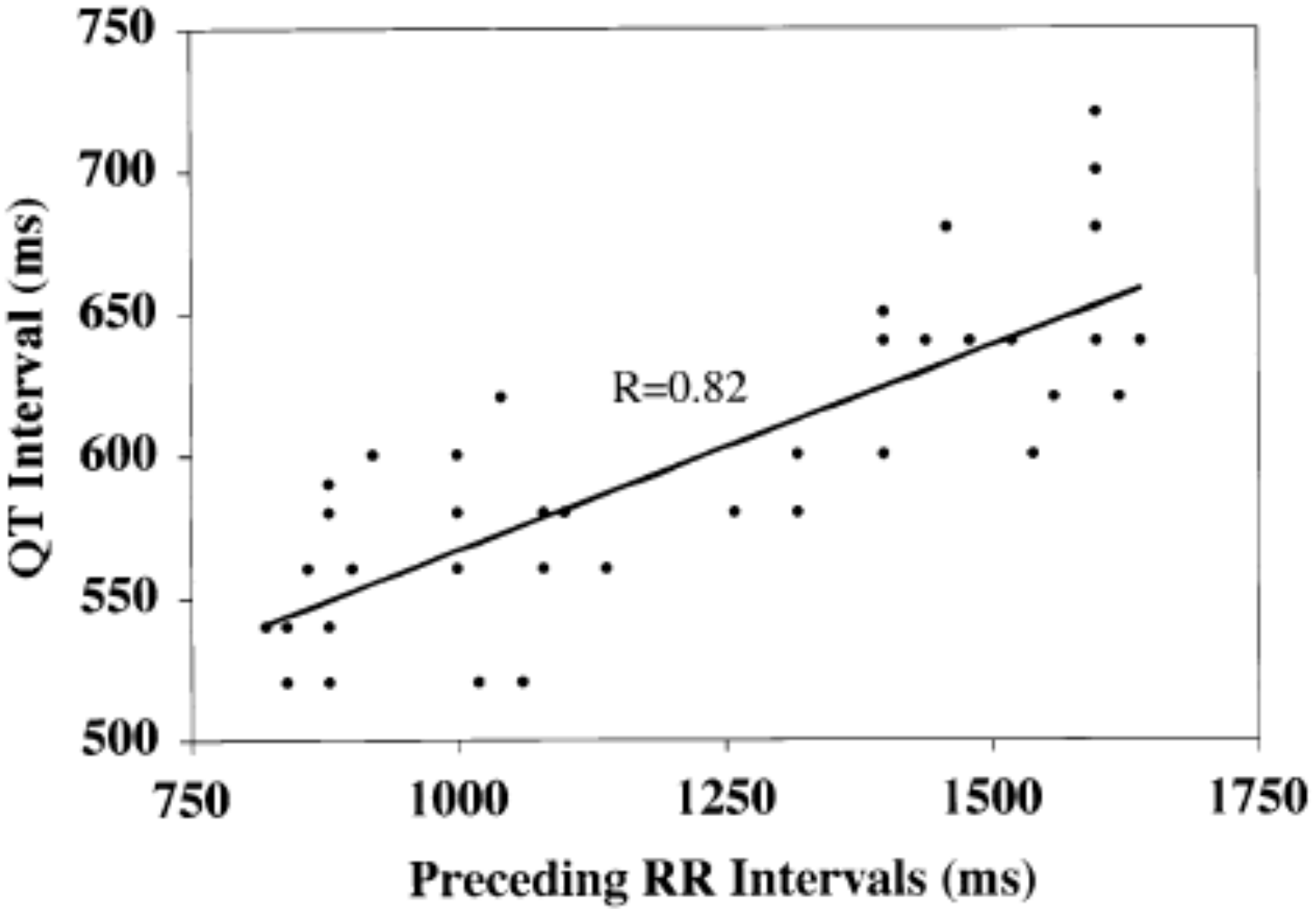
† first step towards ICD-based continuous monitoring of Brugada syndrome to enable therapeutic strategies reducing the risk of arrhythmia secondary to Brugada syndrome.

Episode of Torsades in Long QT Syndrome

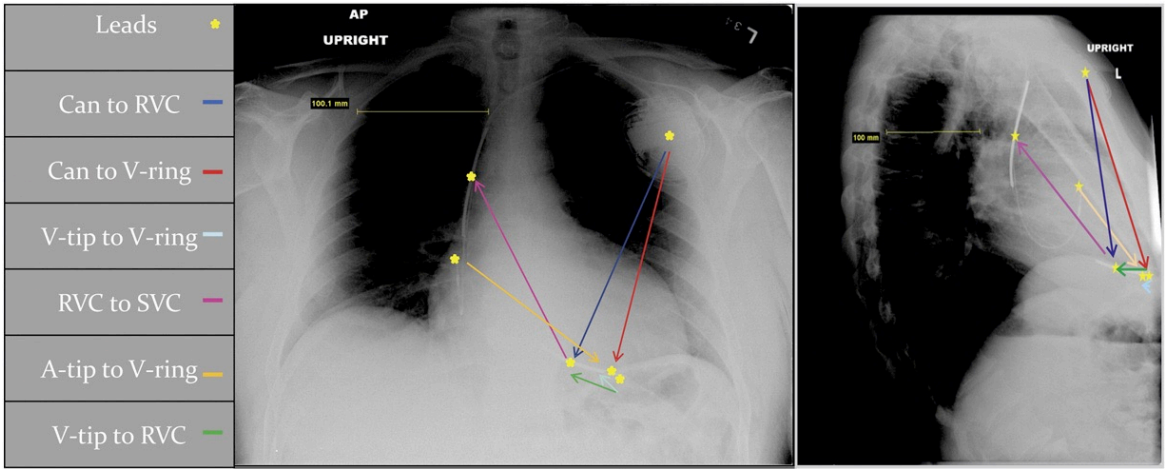


Frank Bogun and Subramaniam C. Krishnan. **Retrospective Diagnosis of Prolonged QT interval and Torsades de Pointes Made by Analysis of ICD Electrograms.** Journal of Electrocardiology Vol. 37 No. 3 2004

QT Intervals Analysis

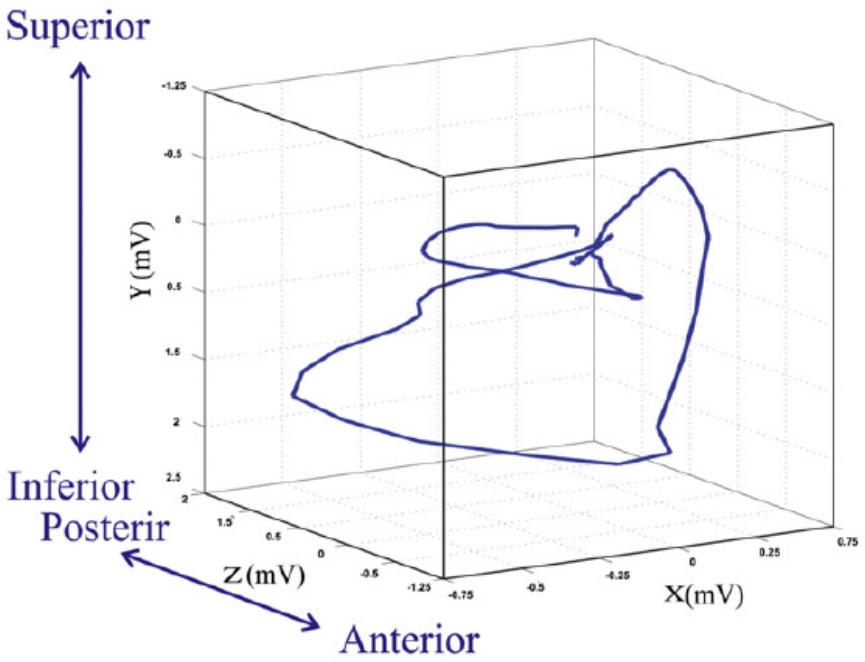


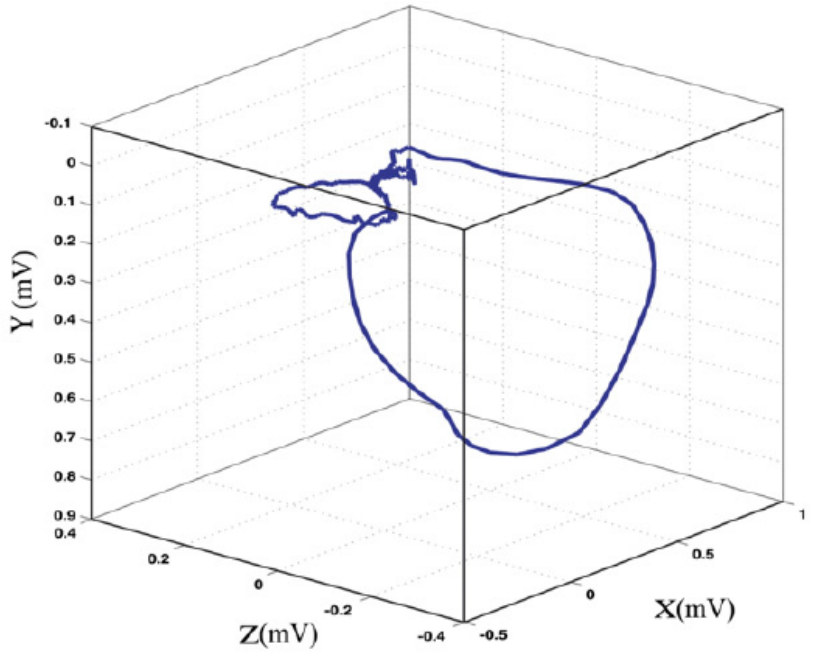
Frank Bogun and Subramaniam C. Krishnan. **Retrospective Diagnosis of Prolonged QT interval and Torsades de Pointes Made by Analysis of ICD Electrograms.** Journal of Electrocardiology Vol. 37 No. 3 2004



iVCG (Median)

VCG





Ghafoori et al. Construction of intracardiac vectorcardiogram from implantable cardioverter-defibrillator intracardiac electrograms. Journal of Electrocardiology 48 (2015) 669 – 671

(12) **United States Patent**
Ferek-Petric

(10) **Patent No.: US 6,766,190 B2**
(45) **Date of Patent: Jul. 20, 2004**

(54) **METHOD AND APPARATUS FOR DEVELOPING A VECTORCARDIOGRAPH IN AN IMPLANTABLE MEDICAL DEVICE**

(75) Inventor: **Bozidar Ferek-Petric**, Zagreb (HR)

(73) Assignee: **Medtronic, Inc.**, Minneapolis, MN (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 279 days.

(21) Appl. No.: **10/003,547**

(22) Filed: **Oct. 31, 2001**

(65) **Prior Publication Data**

US 2003/0083587 A1 May 1, 2003

(51) **Int. Cl.**[7] **A61B 5/0402**; A61B 5/0452
(52) **U.S. Cl.** **600/512**; 600/509; 607/4
(58) **Field of Search** 600/509, 512, 600/515–518; 607/9, 14, 25

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WO	WO 02/089901 A2 *	11/2002	

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Frank, Ernest, "An Accurate, Clinically Practical System For Spatial Vectorcardiography," *Circulation*, vol. XIII, p. 737–49 (May, 1956).

* cited by examiner

Primary Examiner—Carl Layno
(74) *Attorney, Agent, or Firm*—Girma Wolde-Michael

(57) **ABSTRACT**

Implantable medical devices (IMDS) are adapted for developing a vectorcardiograph (VCG) from signals across pairs of electrodes. Sense amplifiers of the IMD are calibrated to correlate the signals to reference sagittal, horizontal and frontal planes of the body. Polar coordinate data is plotted over the time of occurrence of the sensed PQRST electrogram as at least one of an x-axis vector projected into the reference sagittal plane as a sagittal VCG, a y-axis vector projected into the reference horizontal plane as a horizontal VCG, a z-axis vector projected into the reference frontal plane as a frontal VCG, and an xyz-vector in 3-D space. The VCG loops plotted by each of the vectors can also be derived. Thresholding and template matching techniques determine one or more of the maximum vector magnitude and orientation, average axis vector magnitude and orientation, the loop shape, and the loop area representing a particular heart rhythm.

46 Claims, 16 Drawing Sheets

Is there a storm out there?