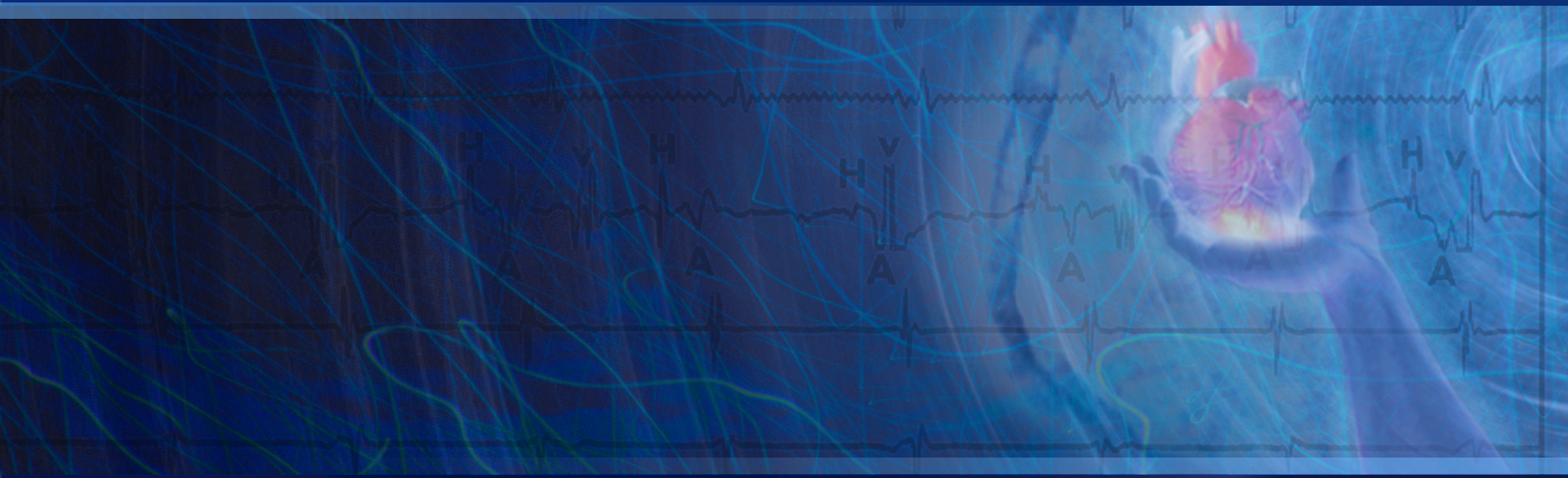
Ventricular Tachycardia Ablation in Patients with Structural Heart Disease



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Disclosure

I receive royalties for work licensed through Mayo Clinic to a privately held company for contributions related to the use of nerve signal modulation to treat central, autonomic, and peripheral nervous system disorders, including pain. Mayo Clinic receives royalties and owns equity in this company. The company does not currently license or manufacture any drug or device in the medical field.

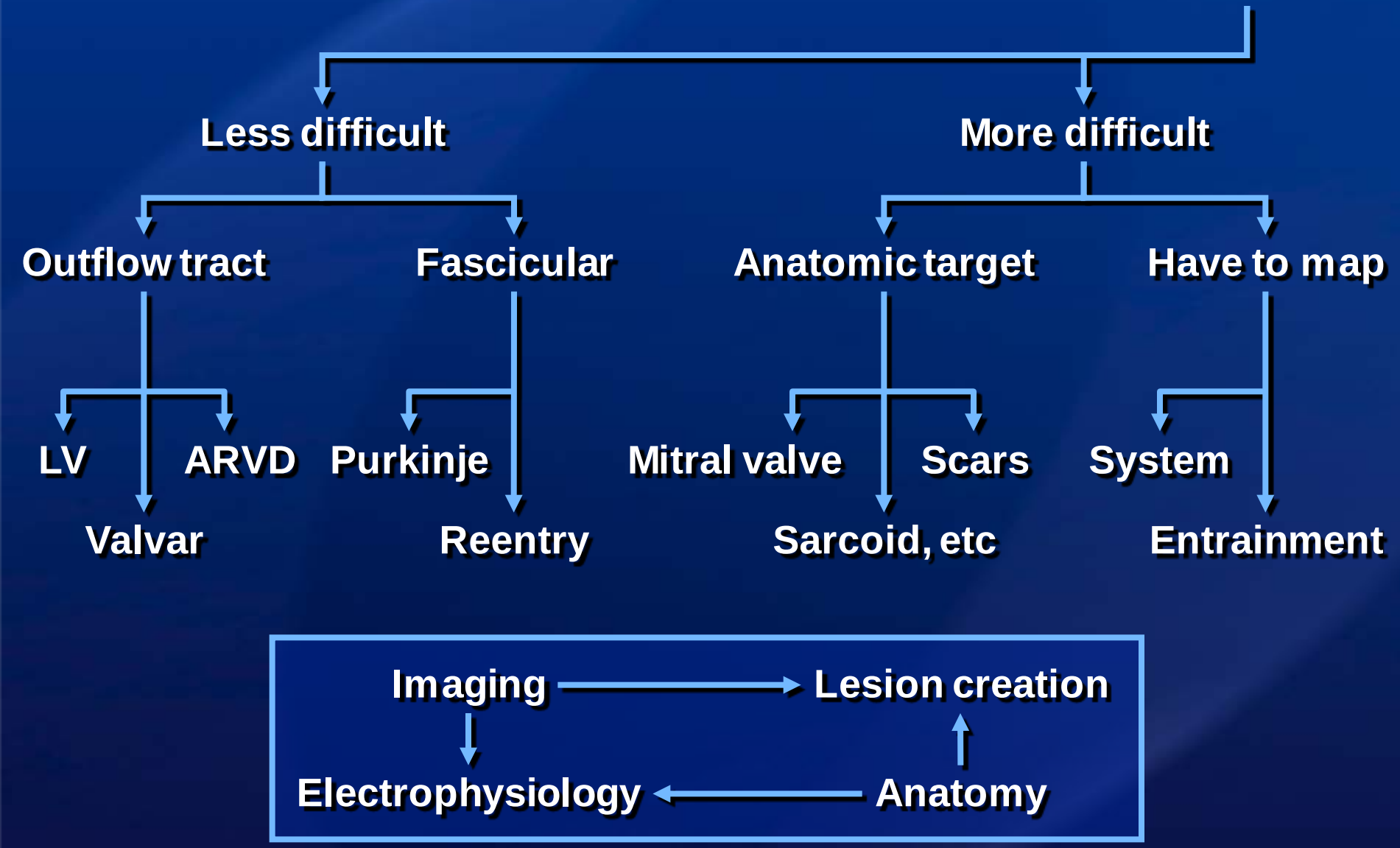
Co-patent holder for technique to minimize coagulum formation during radiofrequency ablation

Products or techniques related to the above disclosures are not being discussed in this presentation.

Pertains to inventions/startup companies that include Nevro, Aegis, and the Phoenix Corp.

Honoraria/Speakers:	**Consulting:**
Abiomed	**Sanofi**
Biotronik	**Stereotaxis**
Blackwell Futura	
Boston Scientific	
Medtronic	
Sanofi-aventis	
Spectranetics	
St. Jude	

VT Ablation



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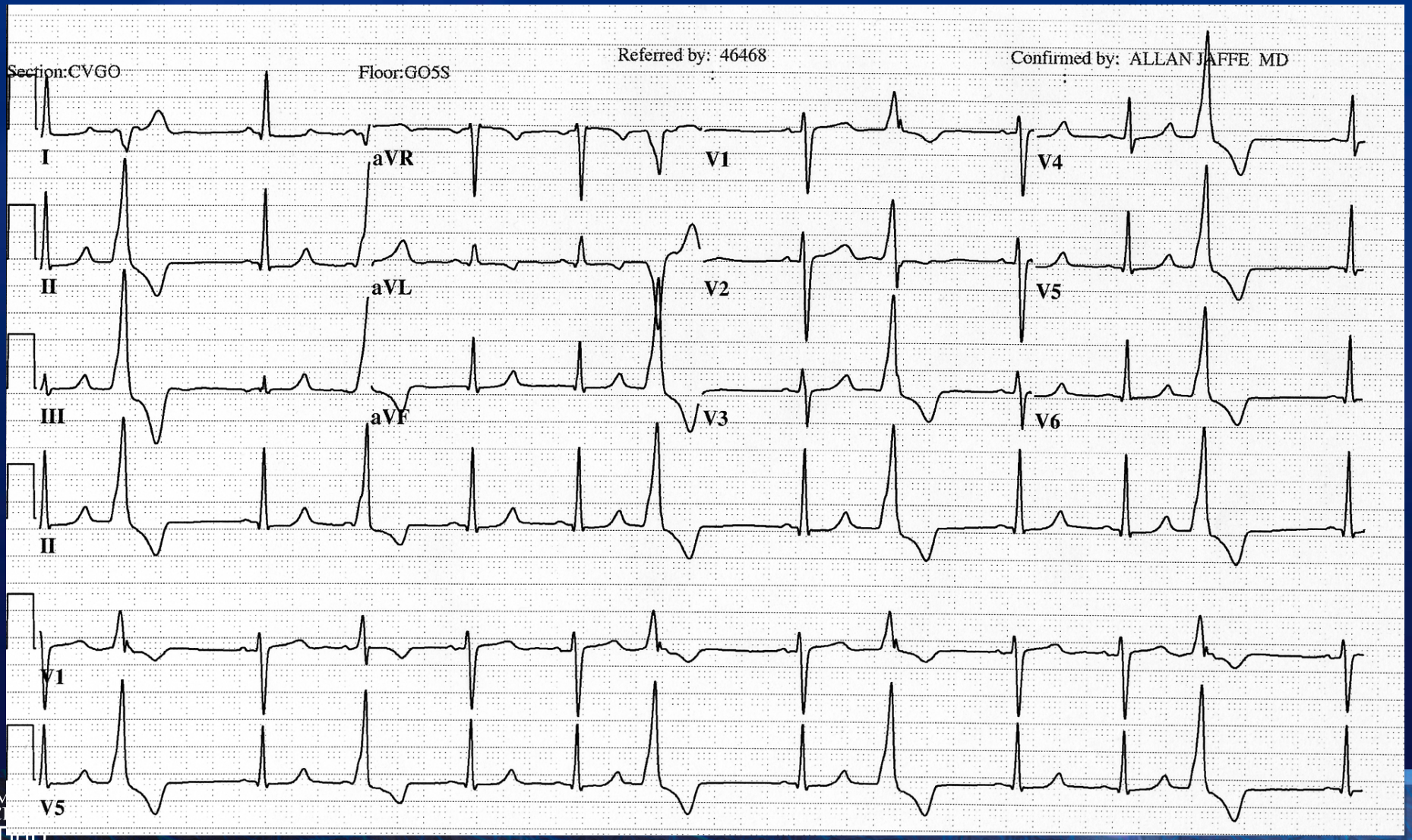
Case #1

19-year-old Student with Fatigue and Exertional Dyspnea

- On evaluation ejection fraction found to be 32%
- No evidence of coronary disease or coronary anomalies
- 24-hour Holter with multiple PVCs
  - 19,000 over 24 hours
- Intolerance and inefficacy of high dose beta blockers
- Fatigue and minimal reduction with sotalol at 120 mg b.i.d.

12-lead ECG

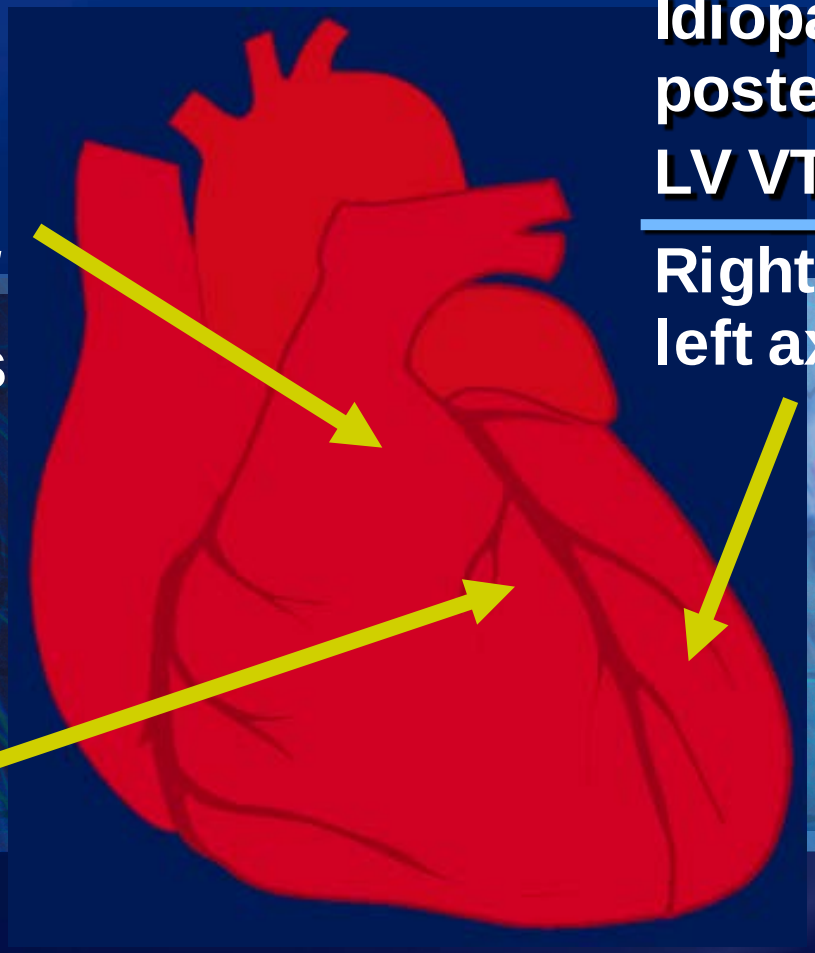


Readily Ablatable Ventricular Tachycardias

MAYO CLINIC

RV outflow tract VT

Left bundle/ inferior axis

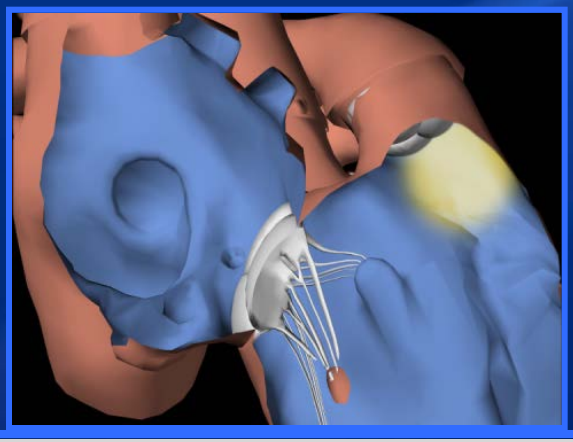


Idiopathic posterior LV VT

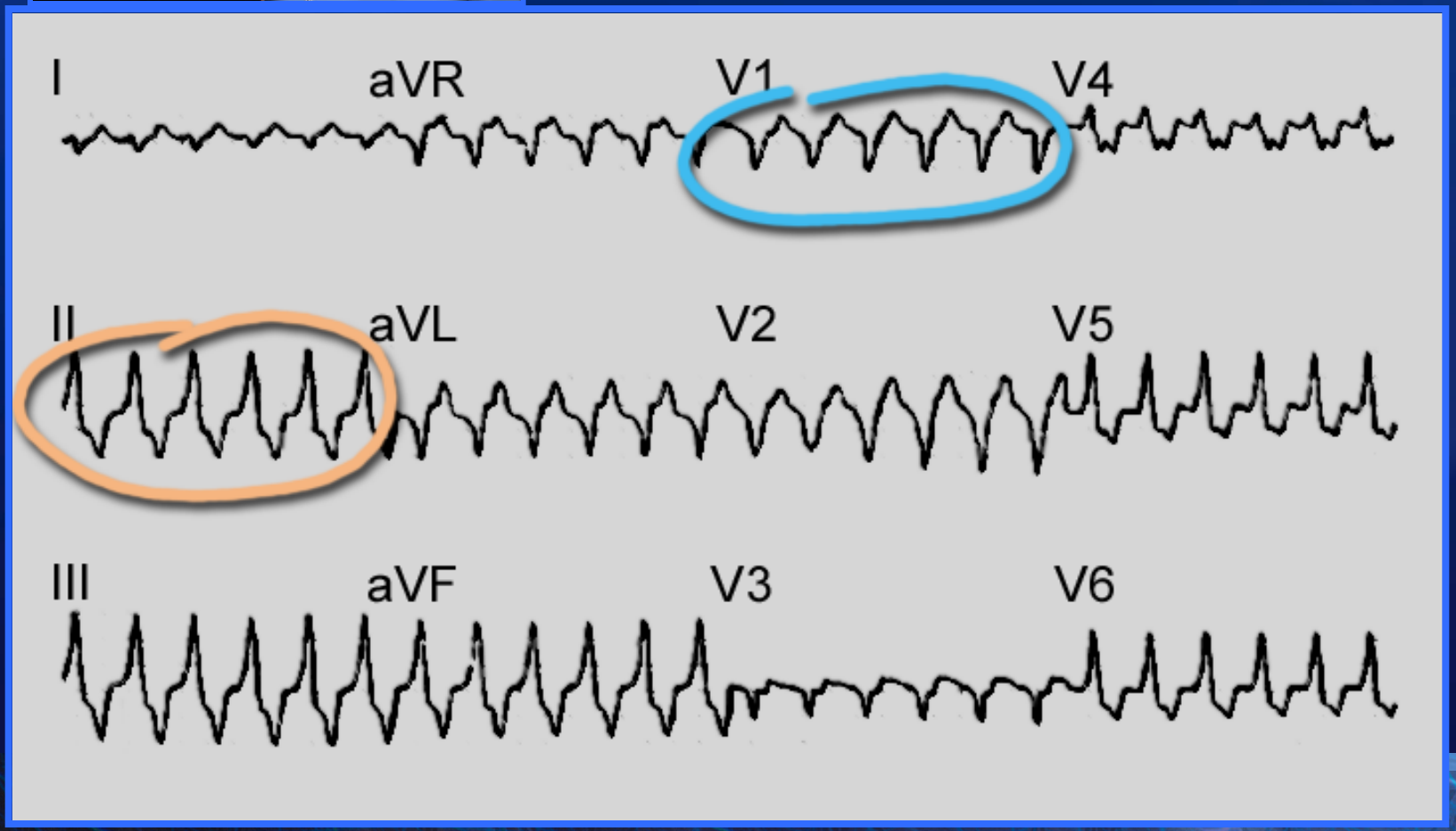
Right bundle/ left axis VT

Bundle branch reentrant VT

Left bundle/ left axis



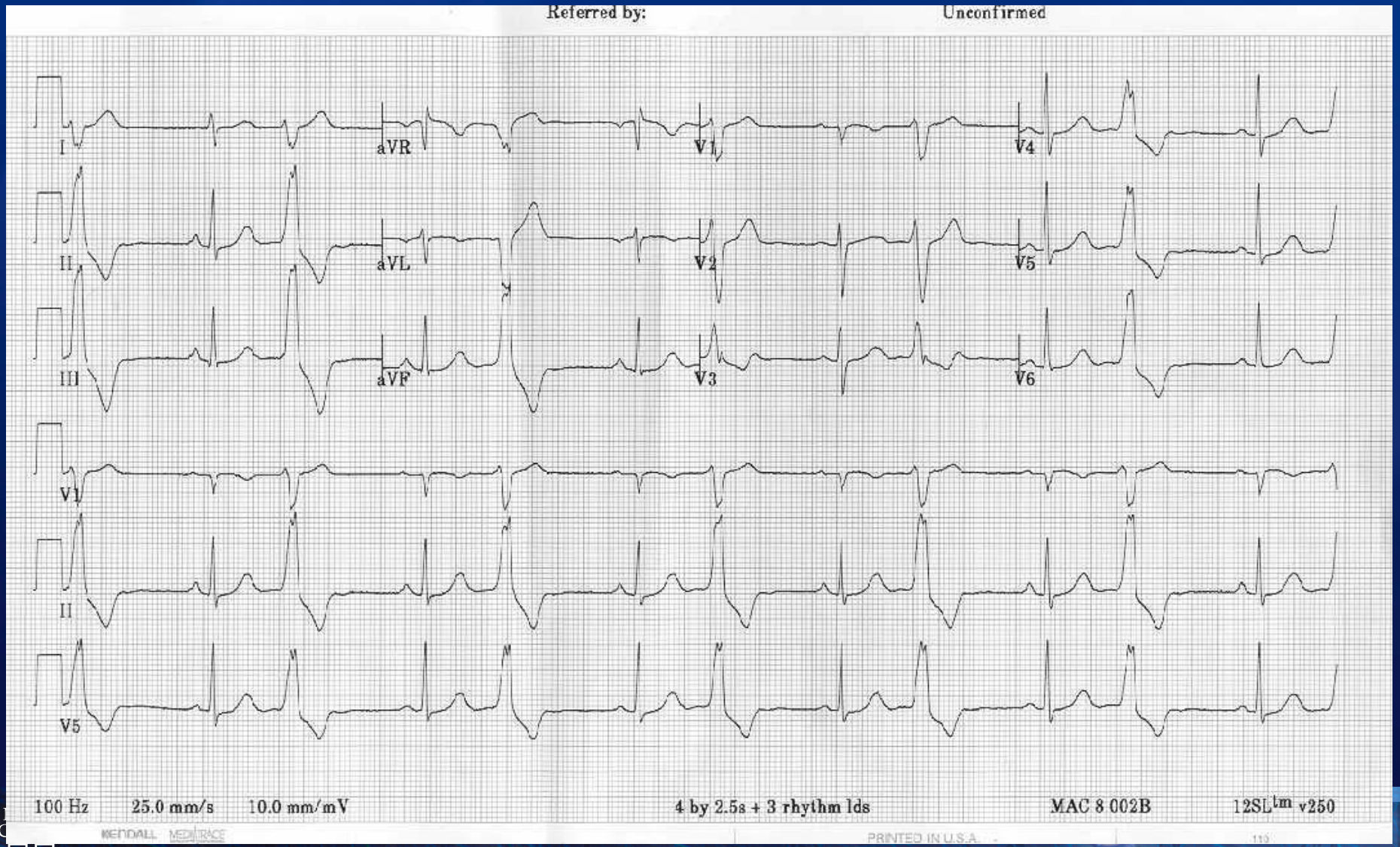
Right Ventricular Outflow Tract VT

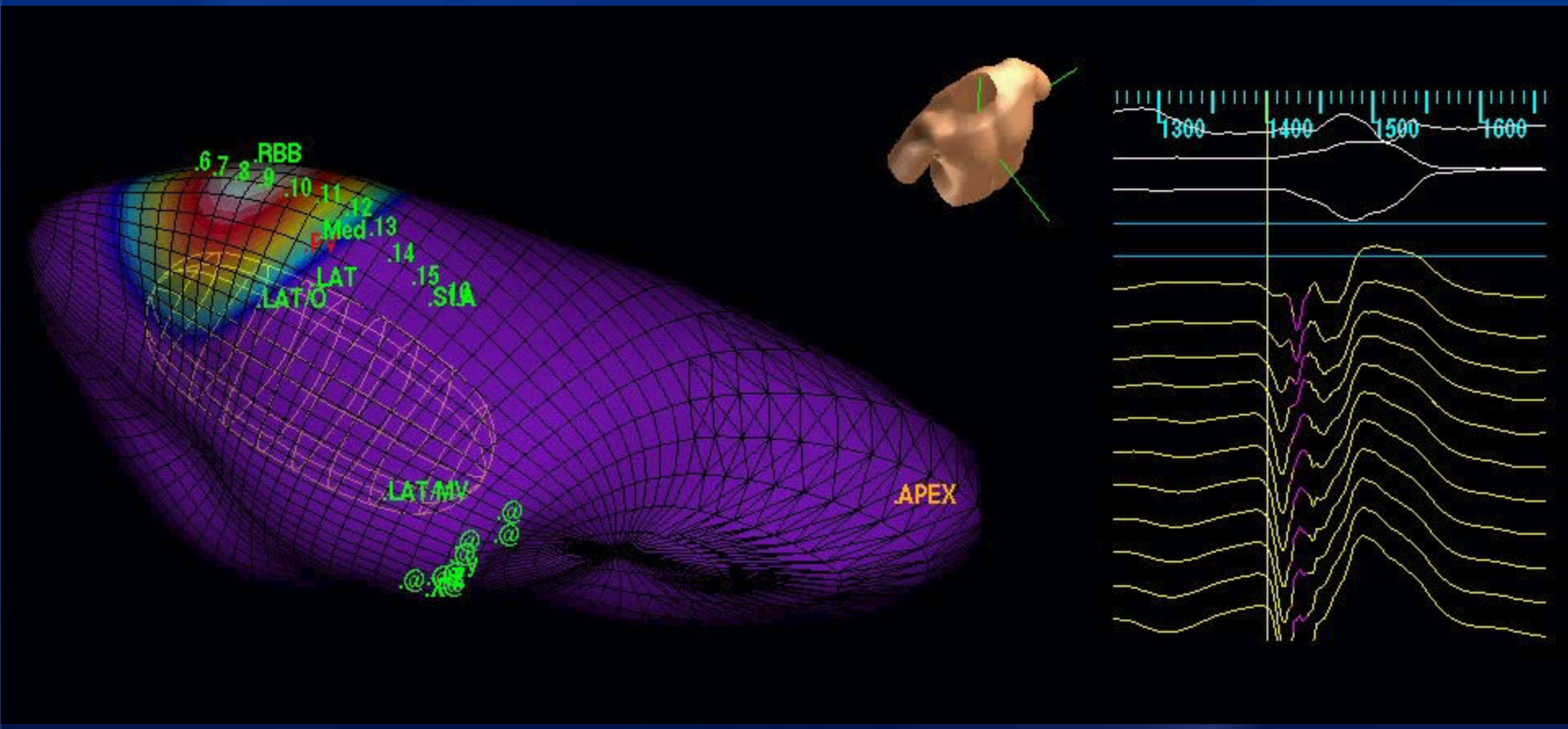


Right Ventricular Outflow Tract VT (RVOT VT)

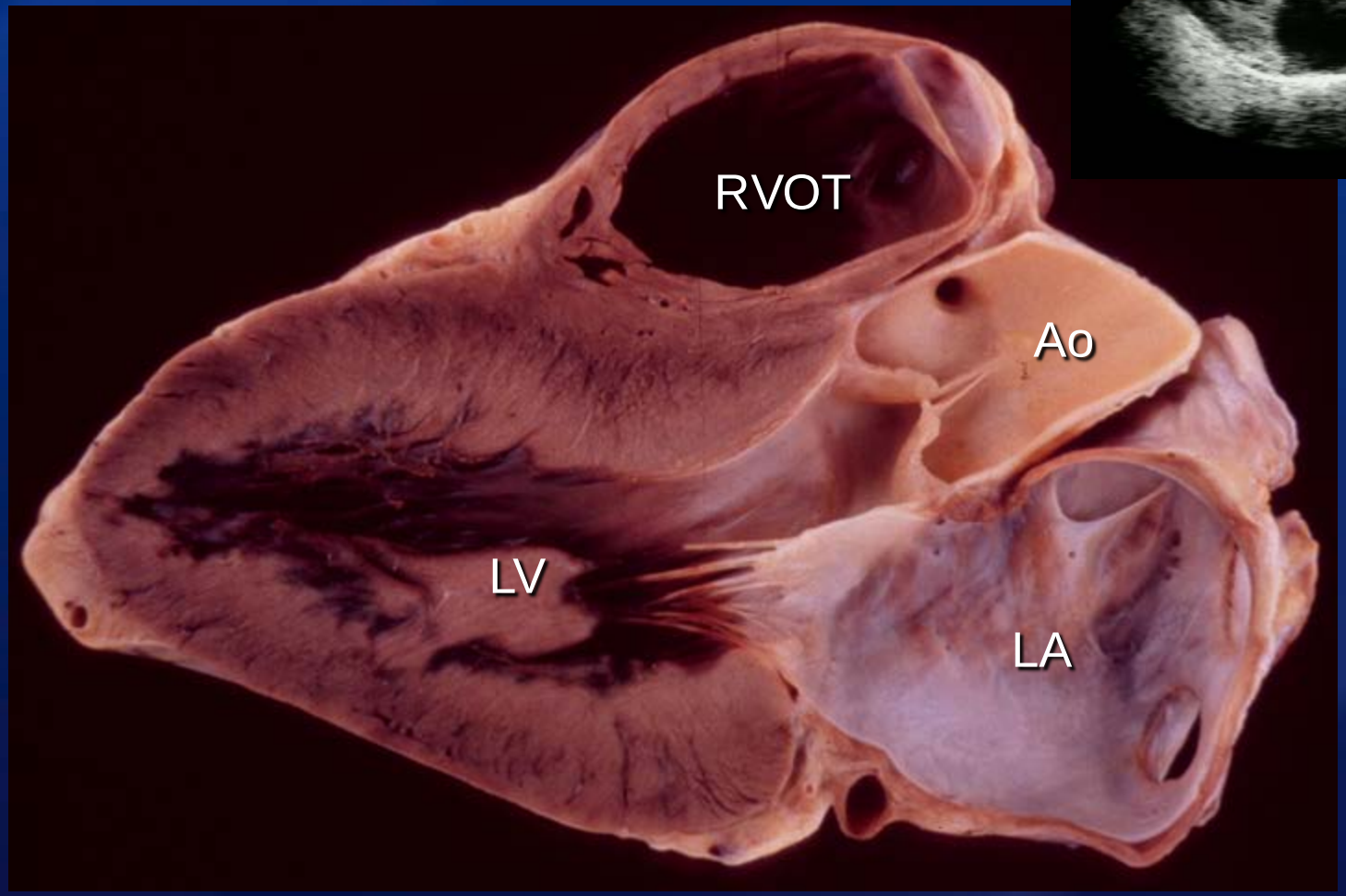
- Left bundle branch block, inferior axis
- Typically exercise provoked
- May be sustained or in salvos
- Prognosis generally excellent
- Some are sensitive to beta blockers or Ca channel blockers
- Mapping based on earliest activation

26 yrs female, 25,000 PVCs on Holter 3 failed ablations





Normal Heart
Ventricles



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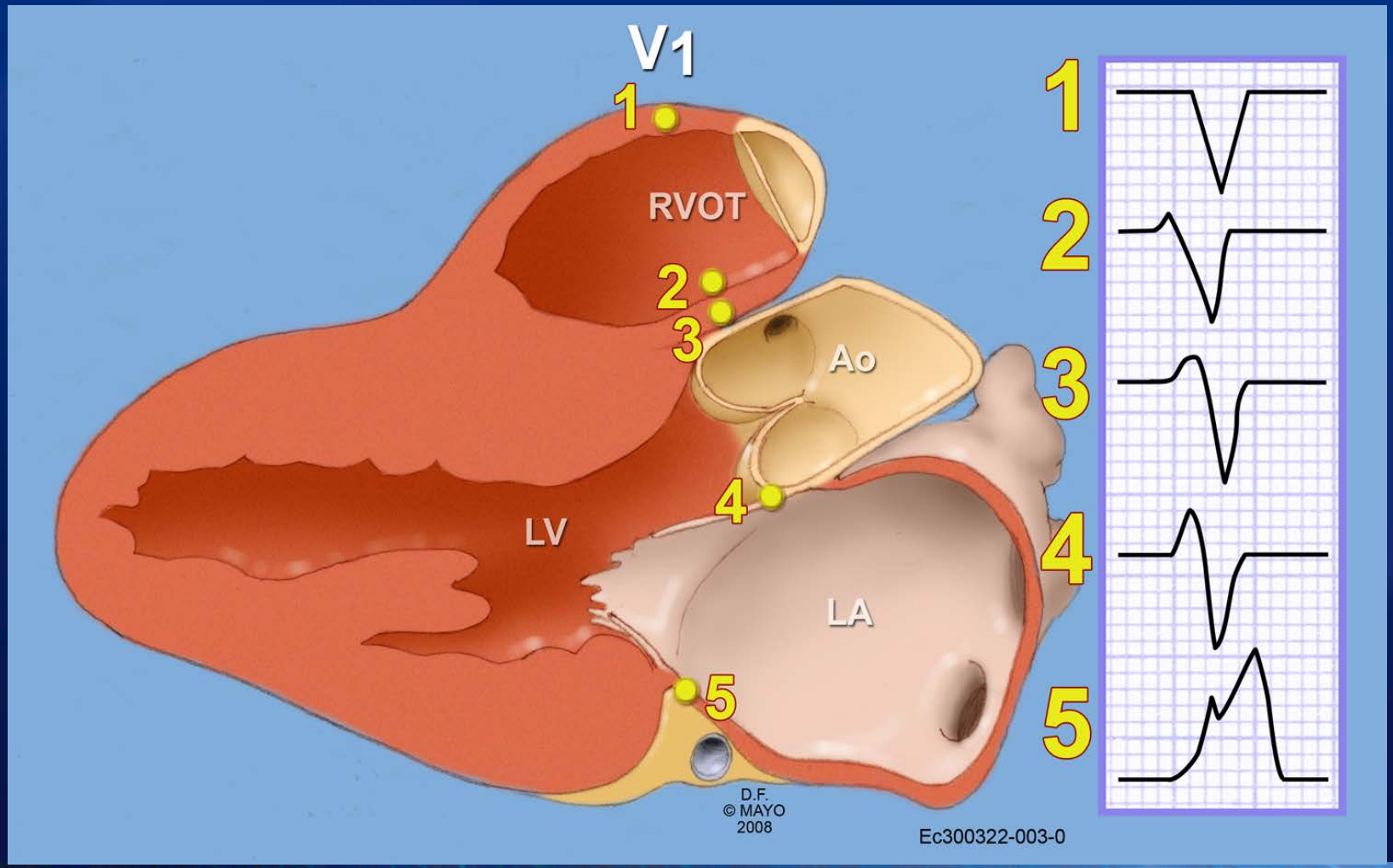
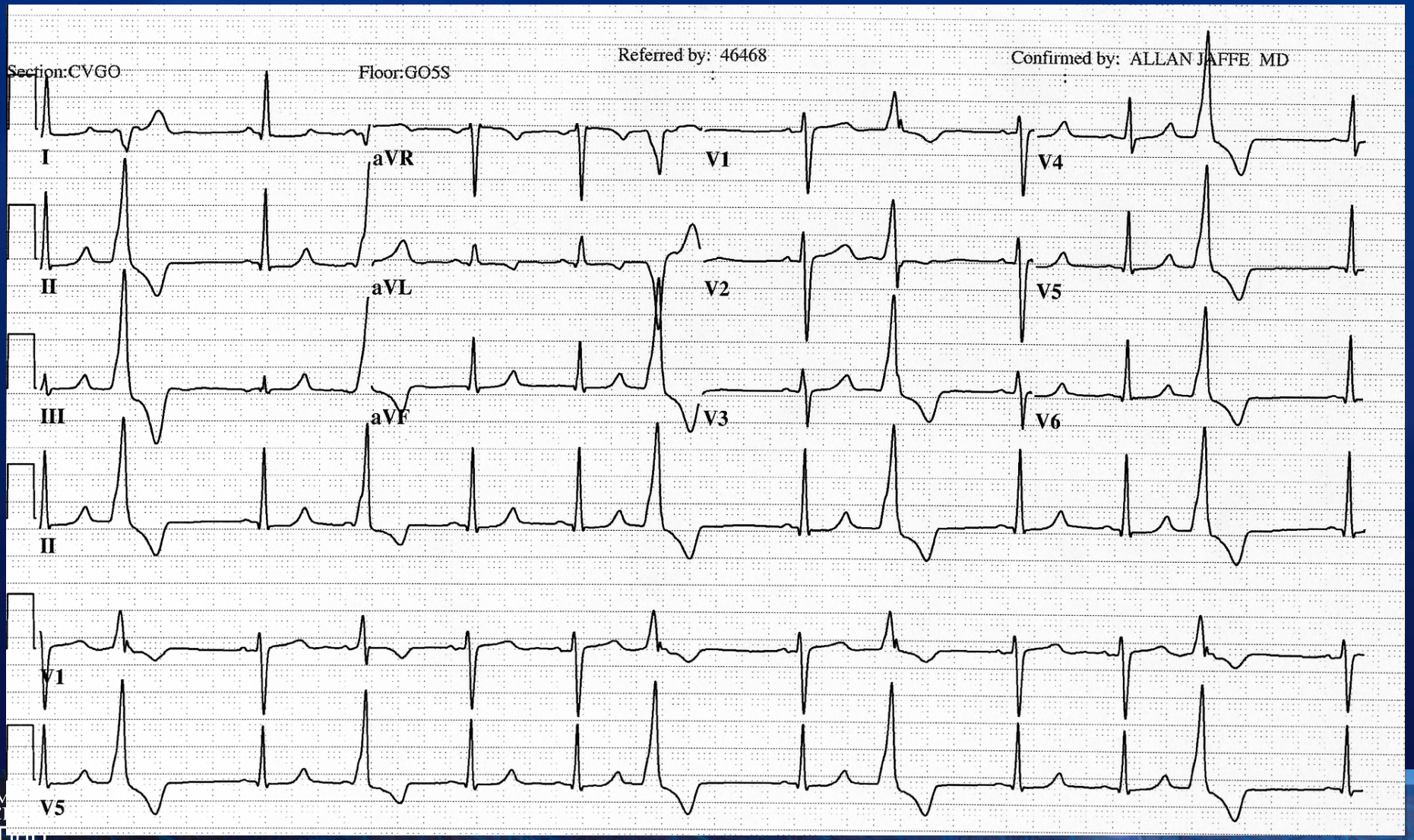
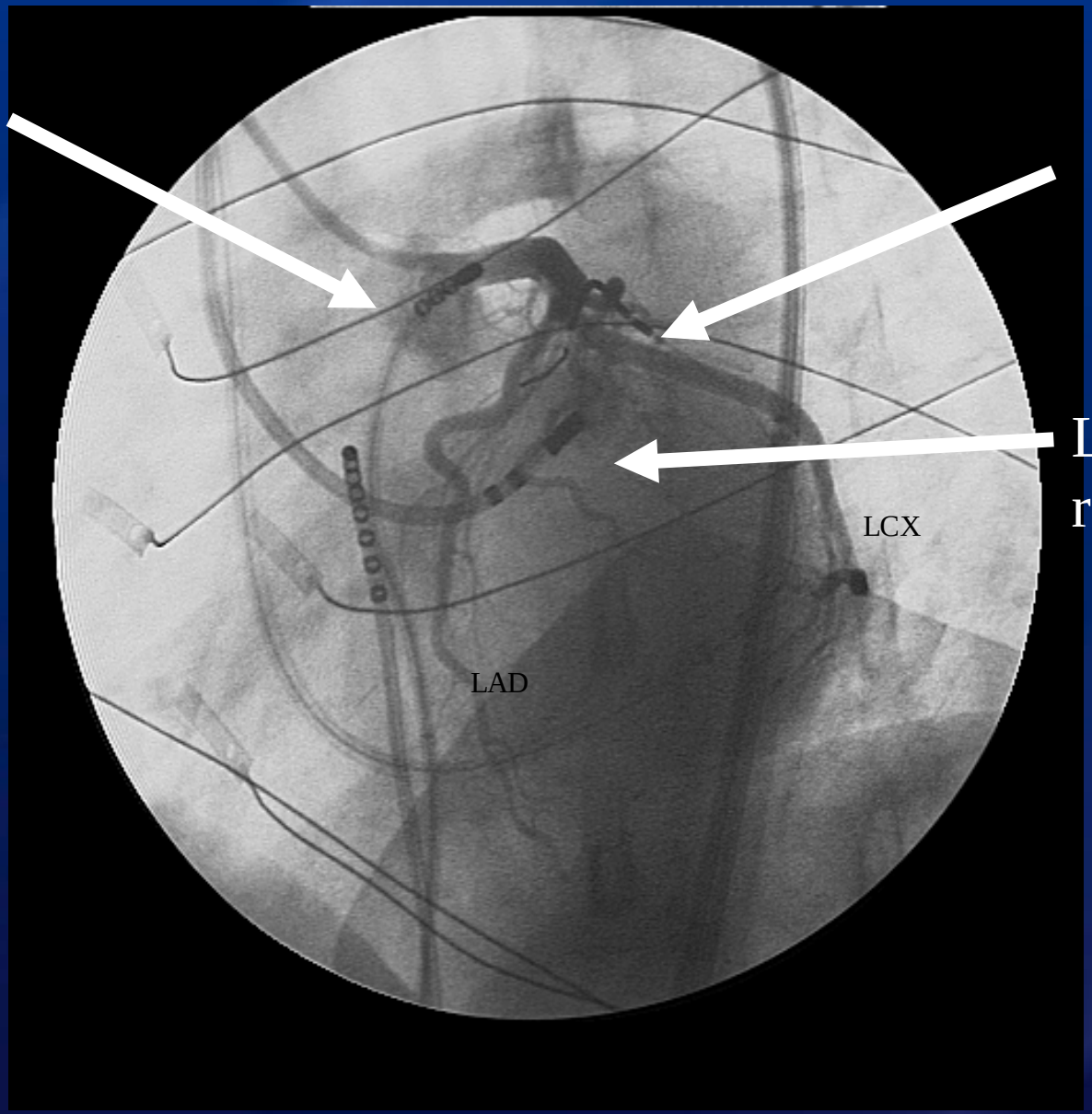
Long-Axis View



12-lead ECG



RVOT

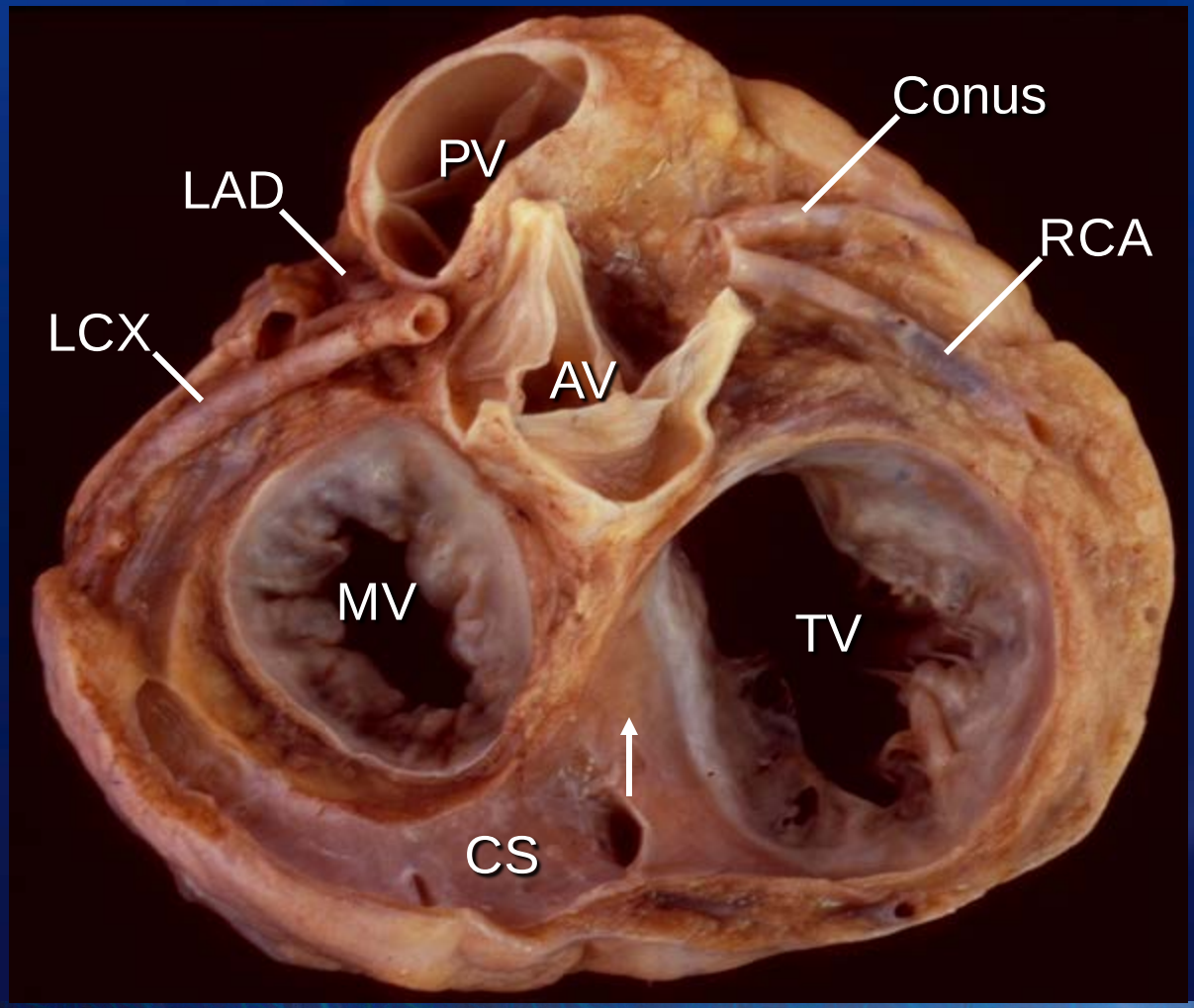


Cardiac Vein

LVOT
retrograde approach

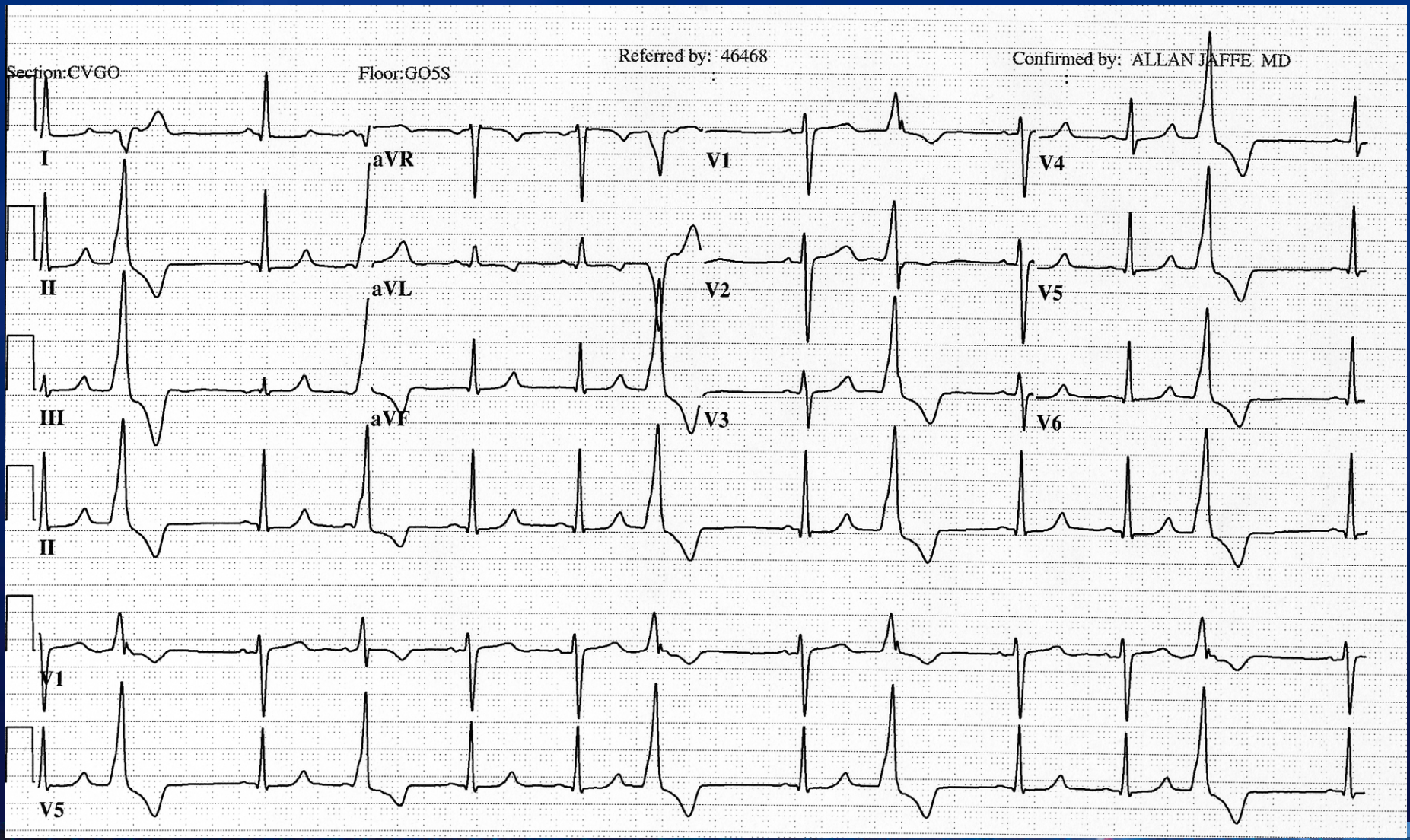
LAO

Normal Heart
Valves & Coronary Arteries

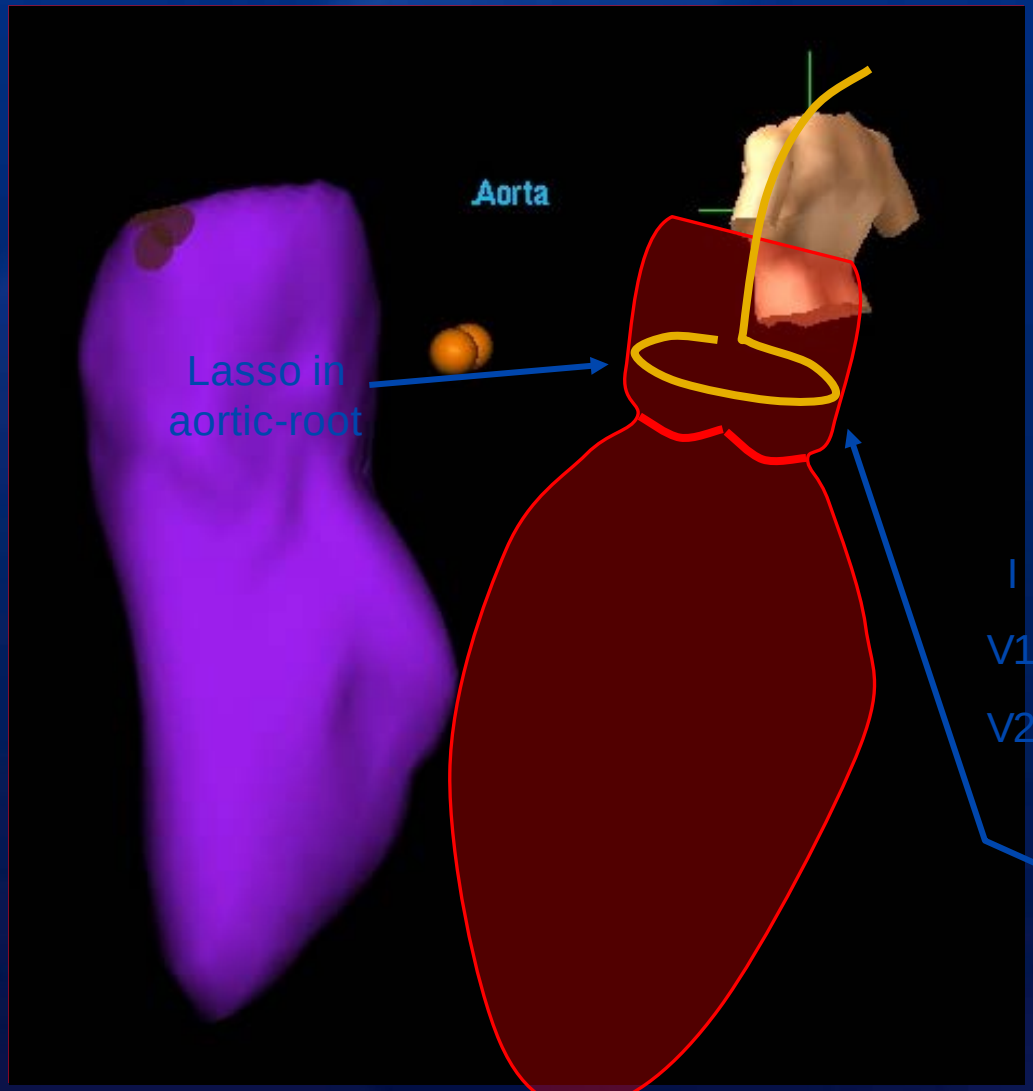


Cardiac Base

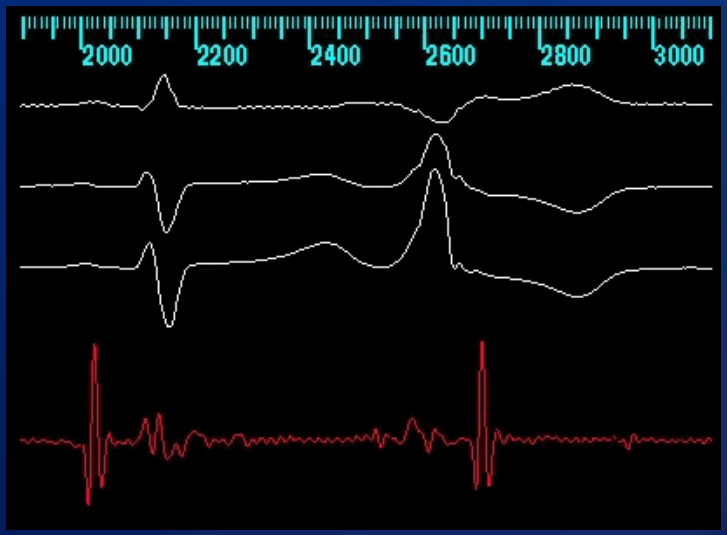
12-lead ECG



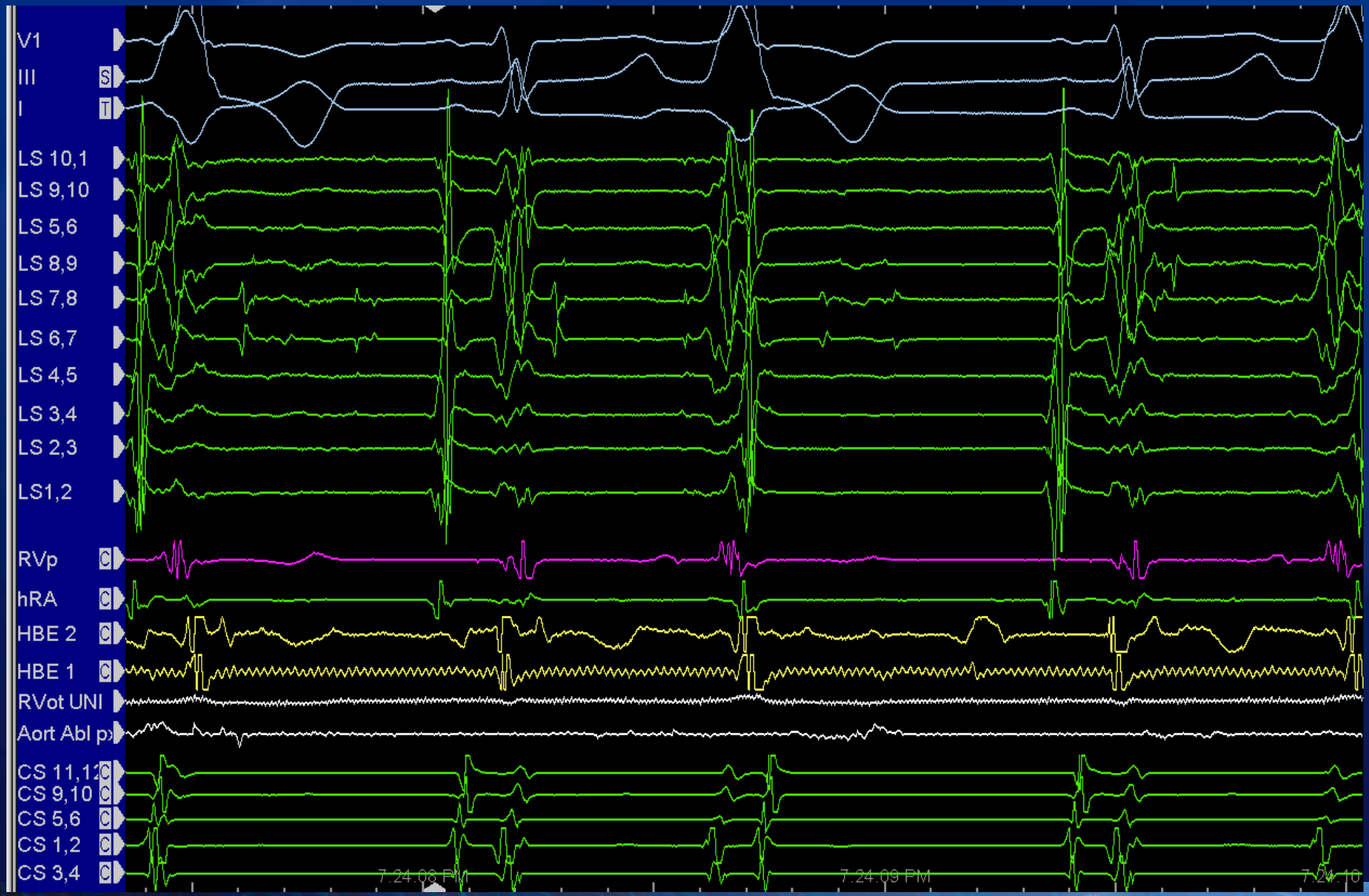
RVOT Anatomy



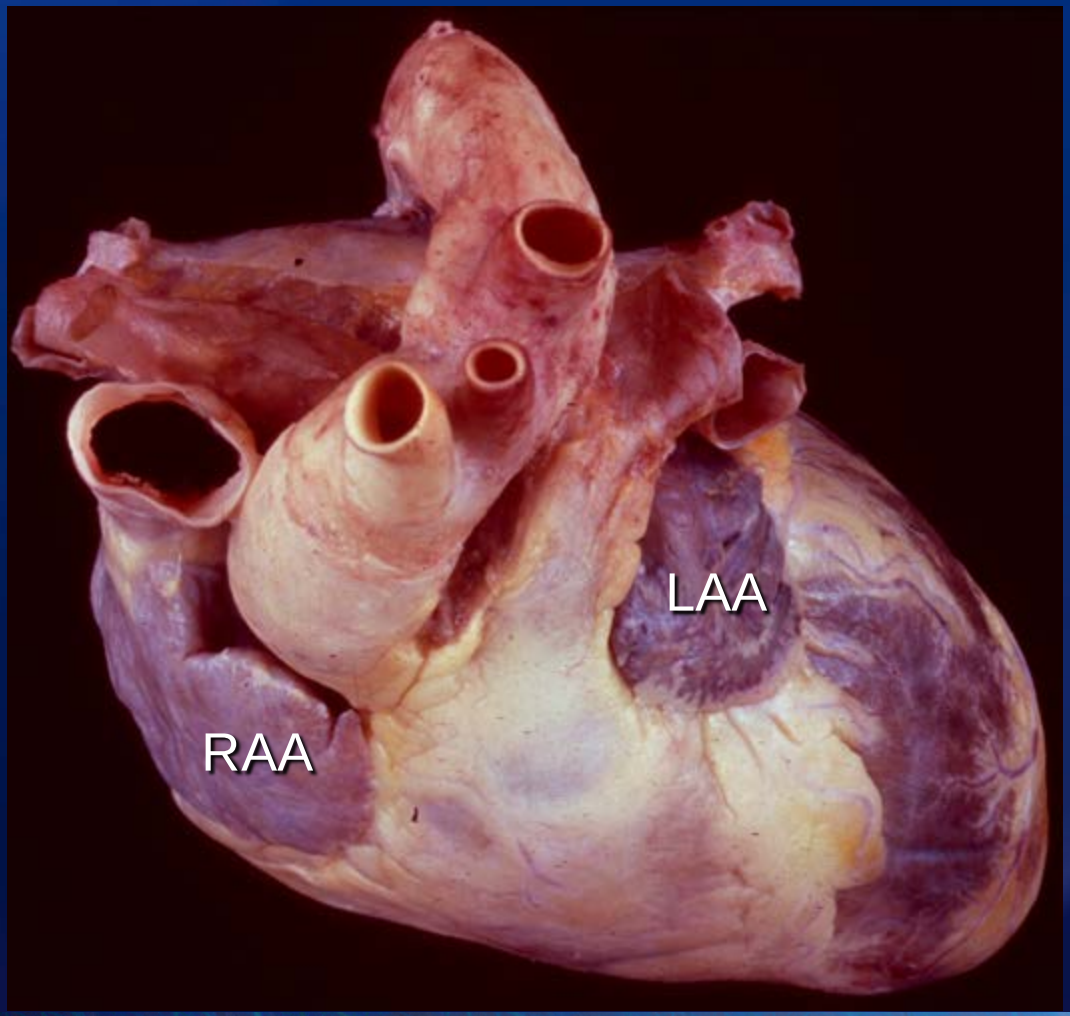
LPO



Lasso at aortic Sinus of Valsava

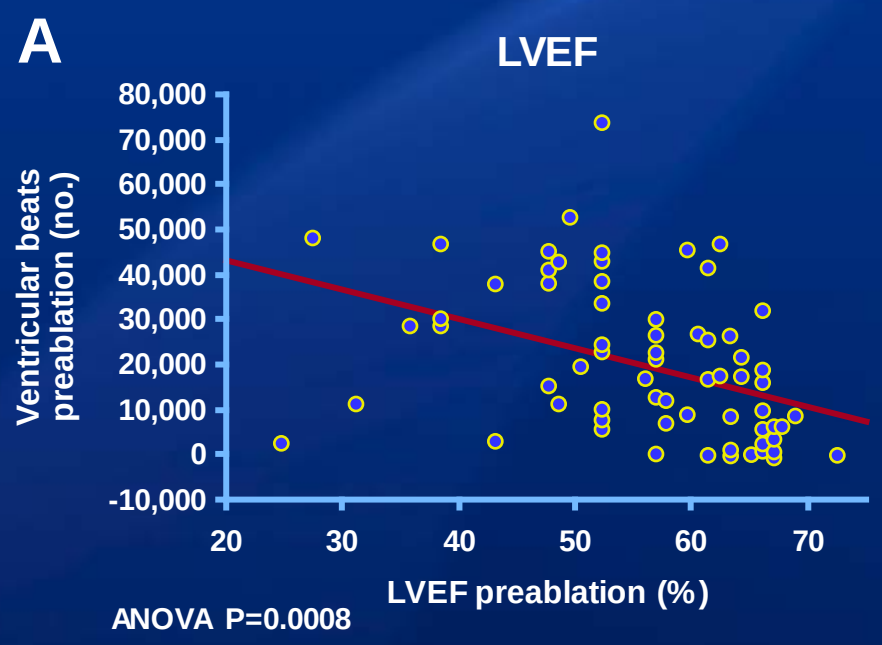


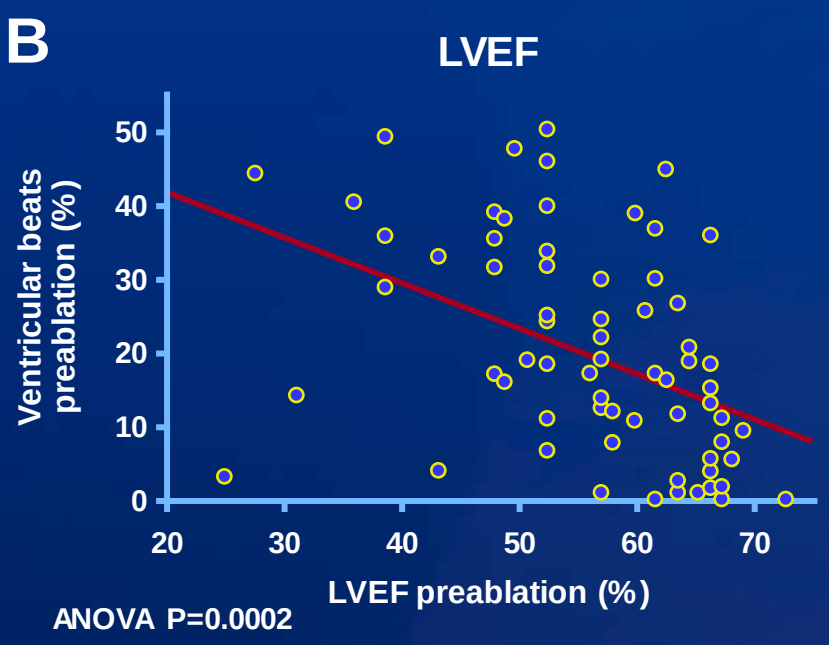
Normal Heart
External Topography

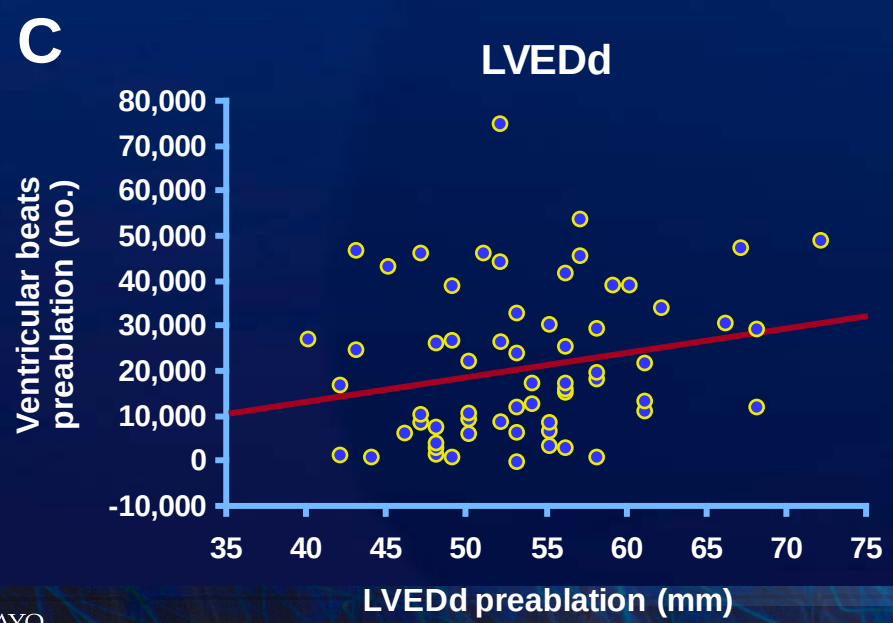


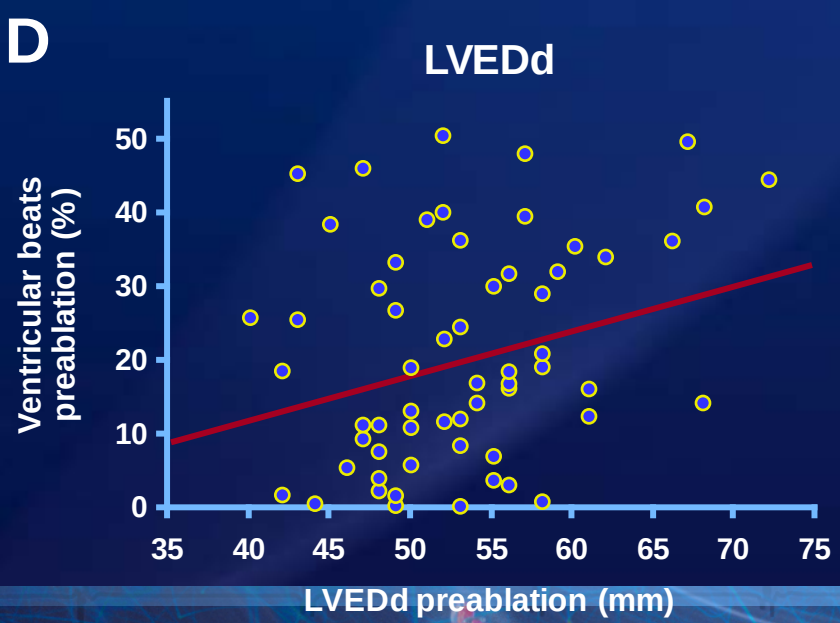
Superior View


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
V1
II
V5
100 Hz
25.0 mm/s
10.0 mm/mV
4 by 2.5s + 3 rhythm lds
MAC 8 002B
12SL tm v250
©2012 MEMER | 3208966-21



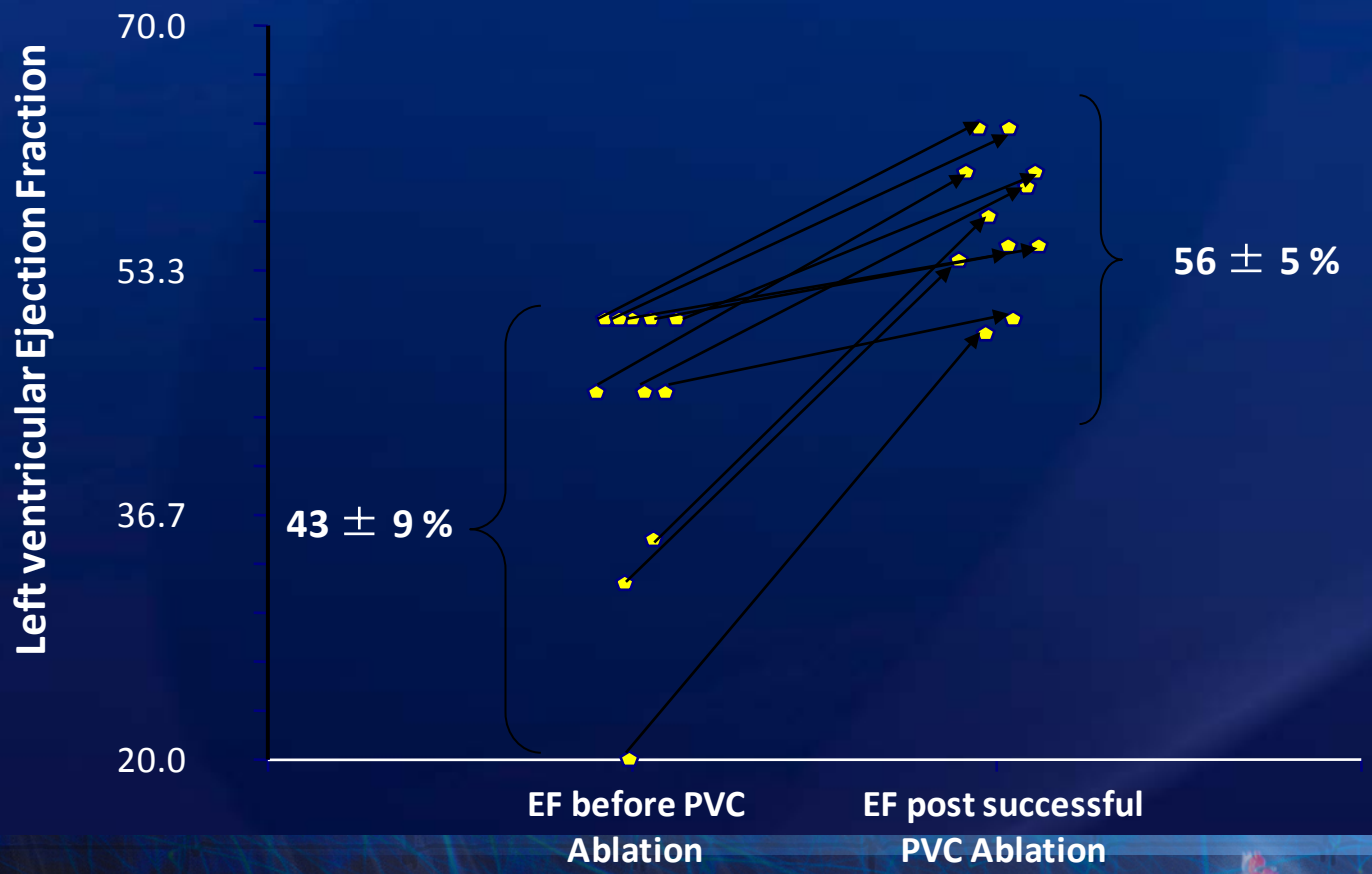


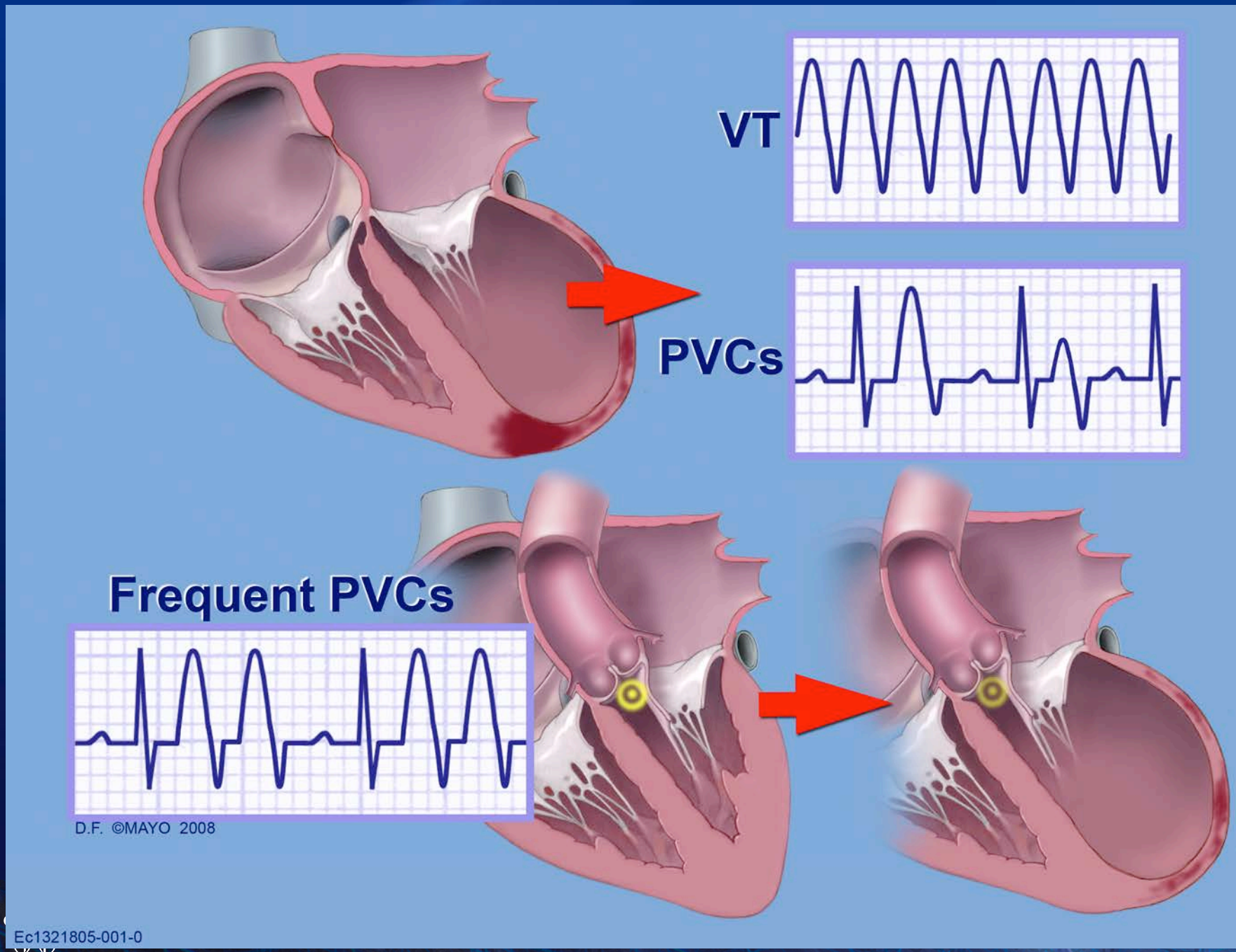




MAYO CLINIC

Improvement in LV ejection fraction in patients with low EF after ablation of frequent PVCs.





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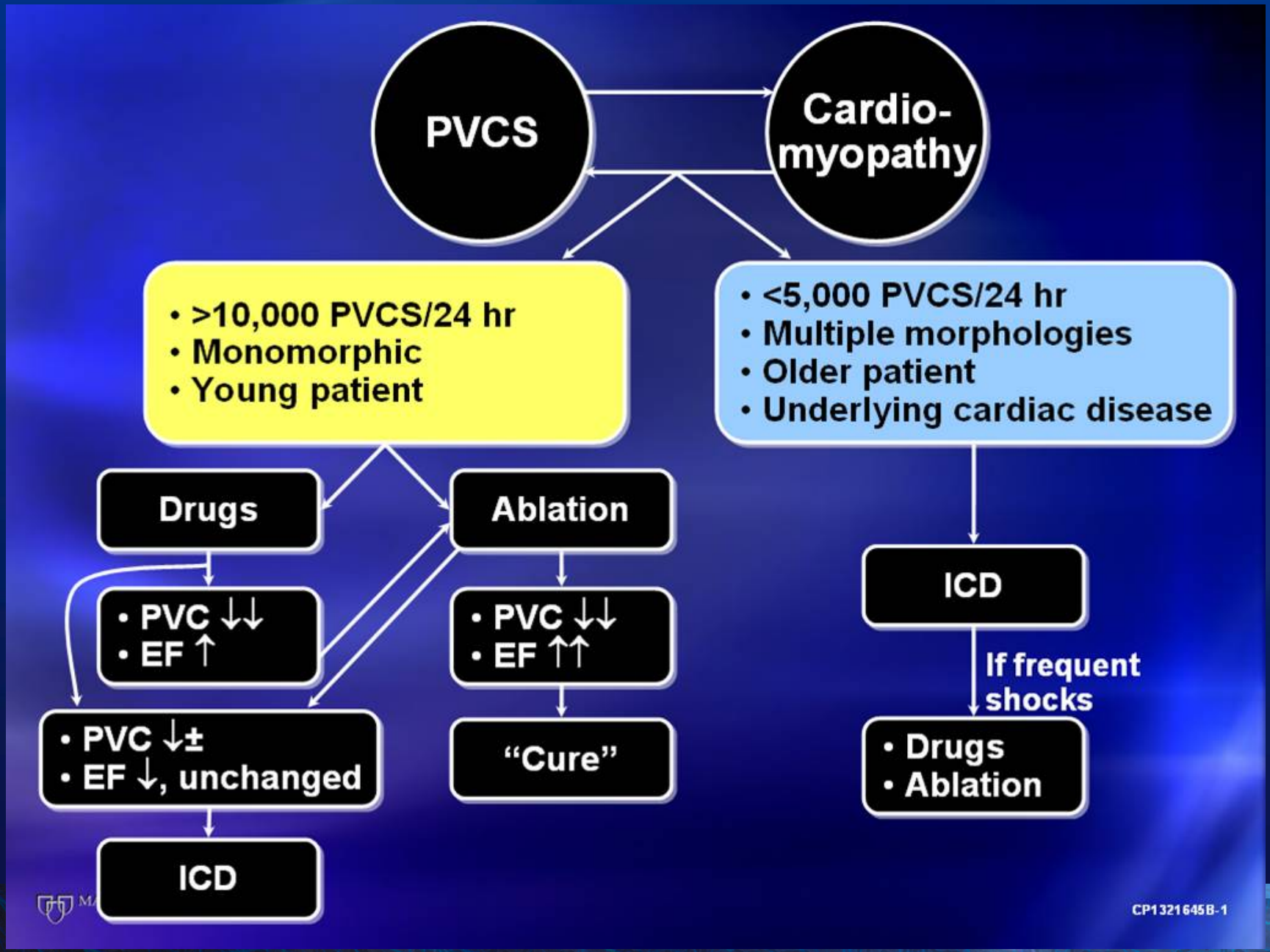
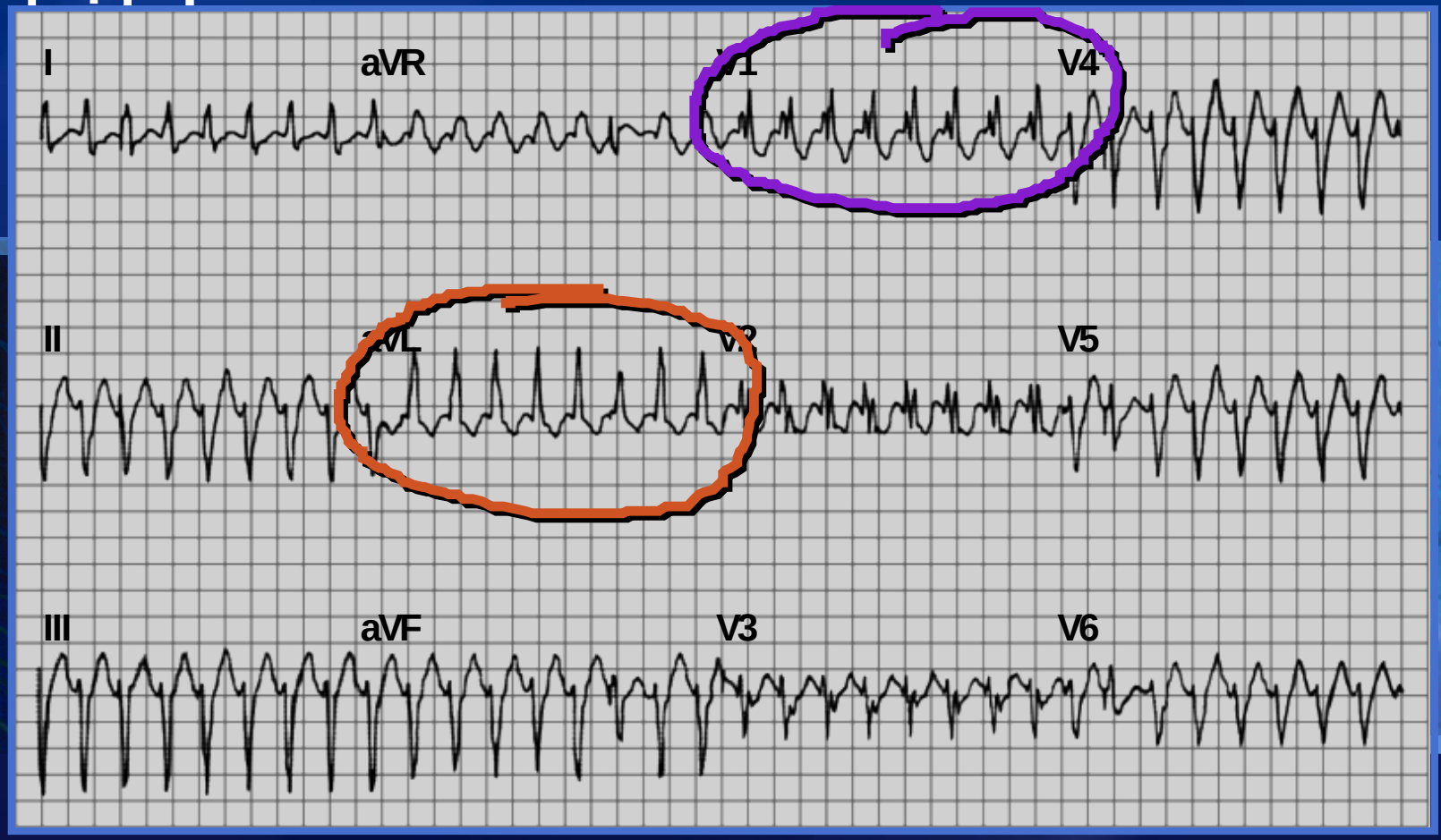


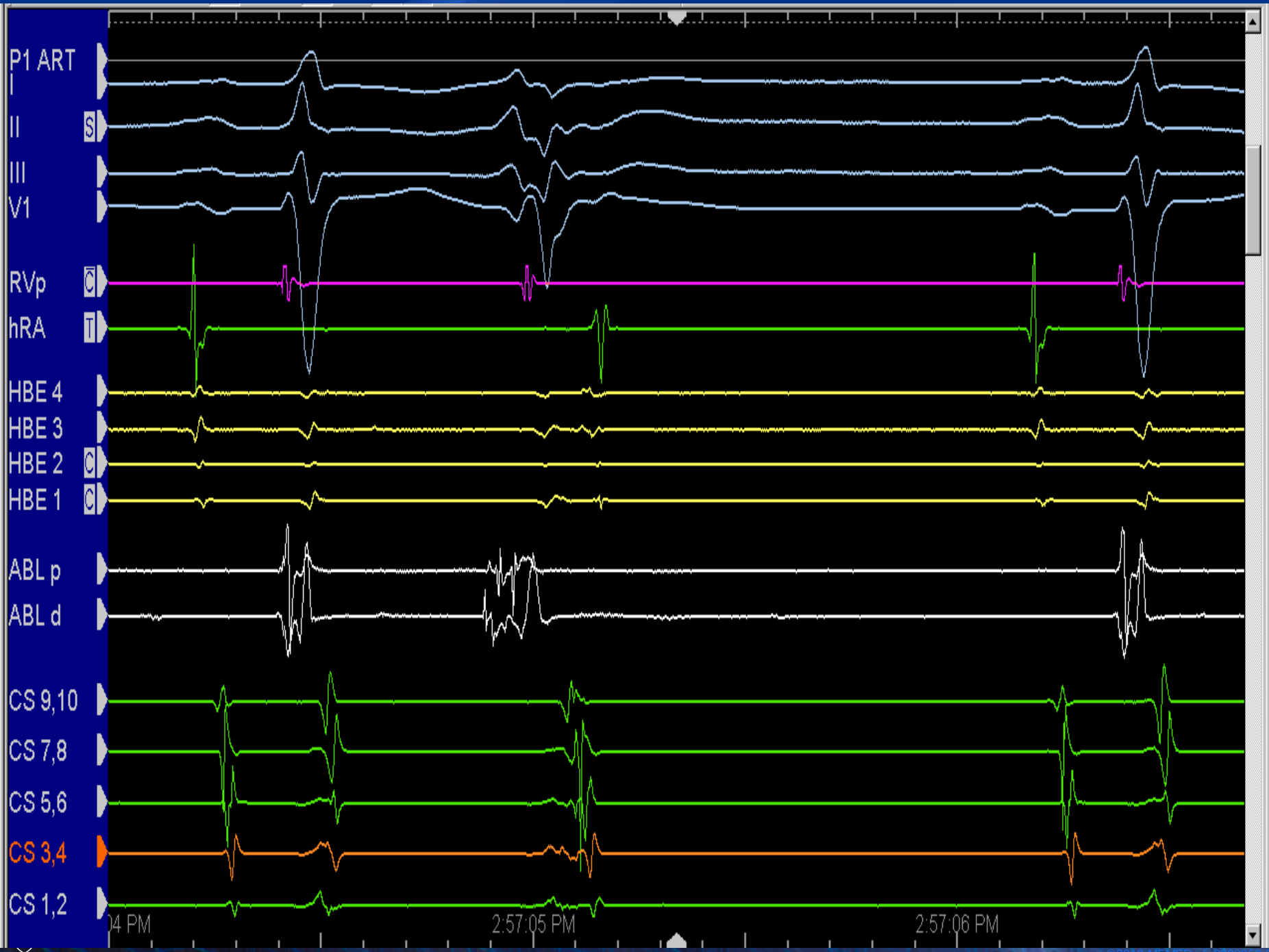
Case #2

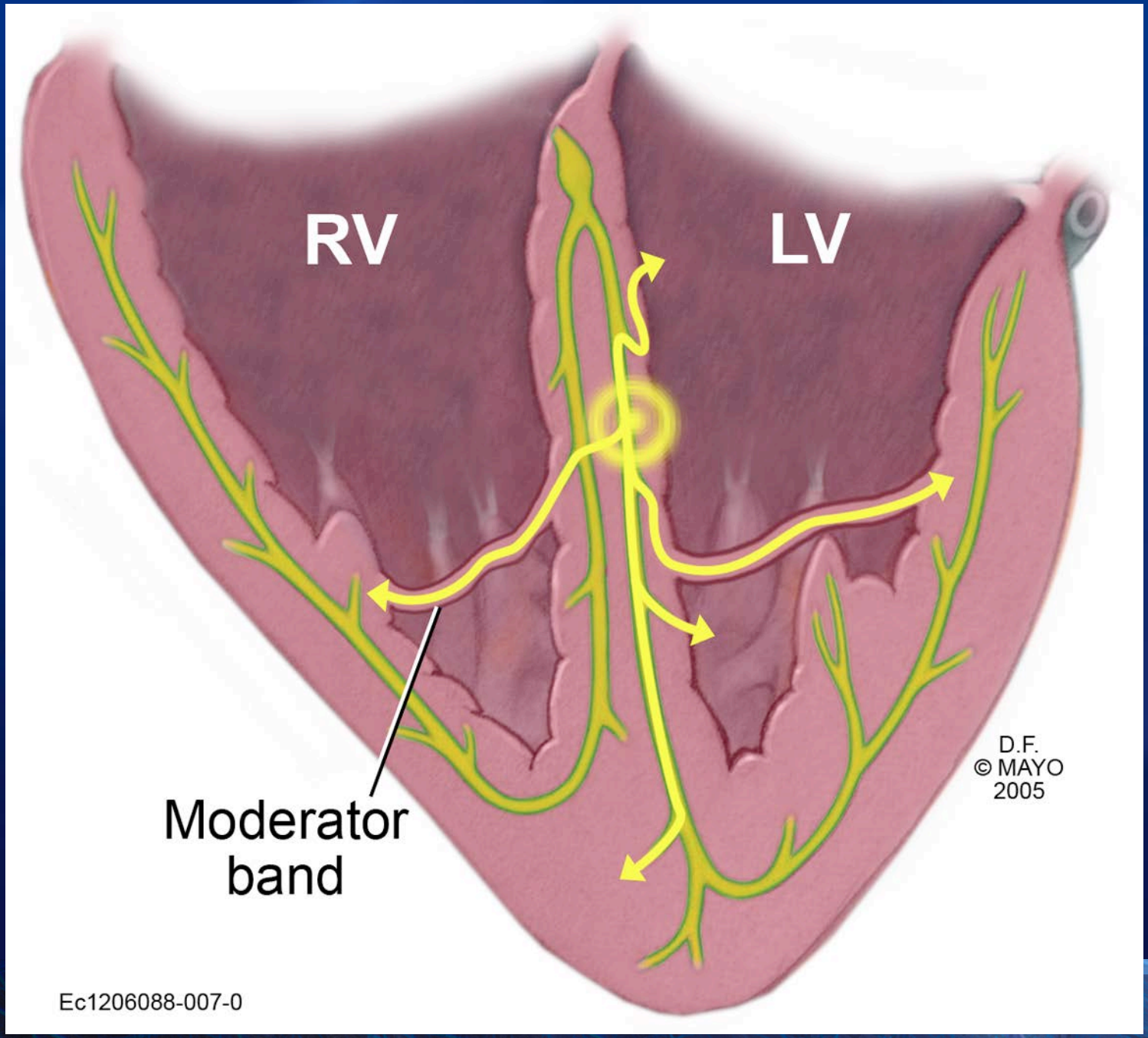
17-year-old ice hockey player who has near syncope from onset rapid tachypalpitations.

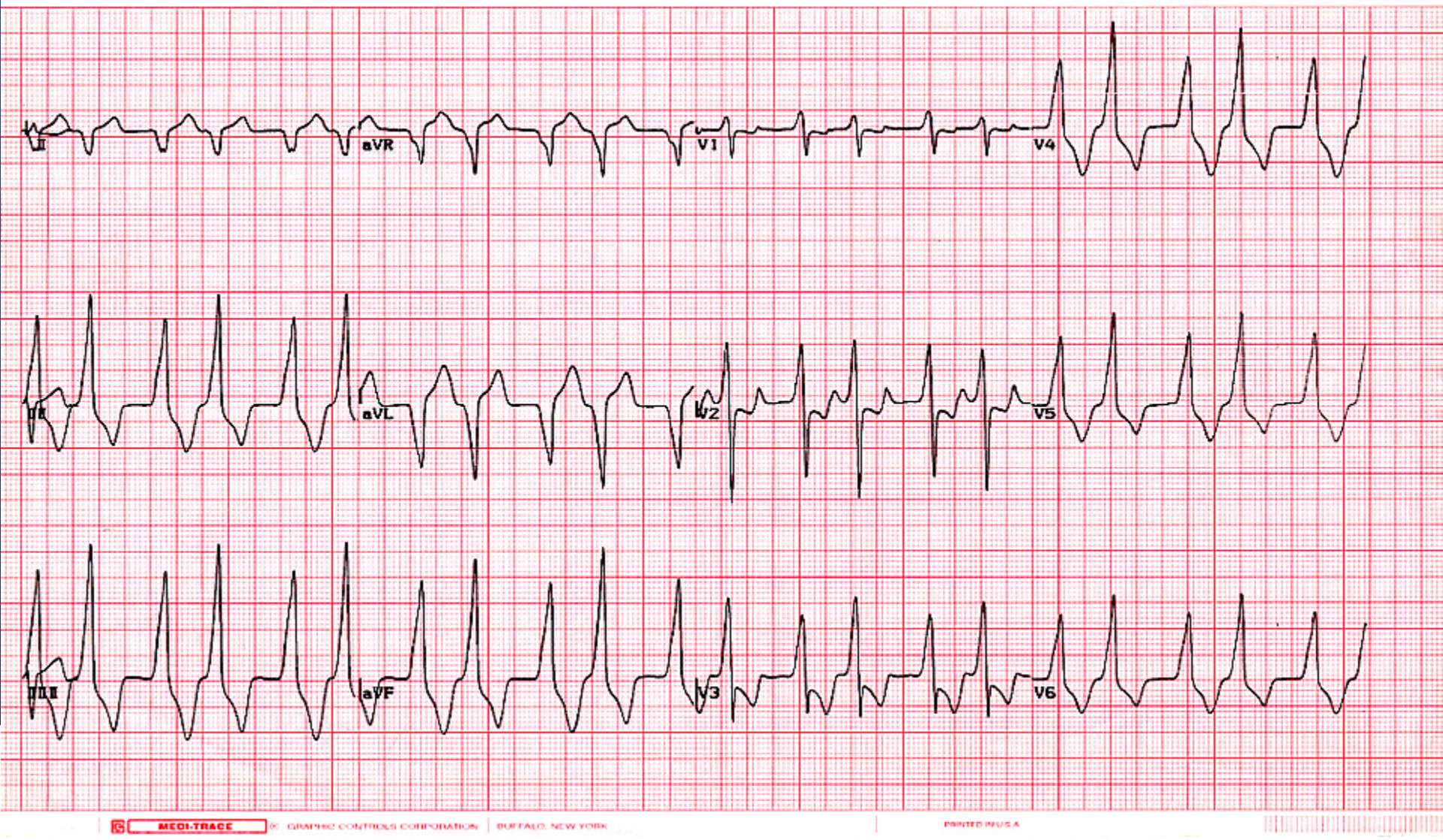
With the electrocardiogram shown, what is the likely diagnosis and what is your treatment approach?

MAYO CLINIC

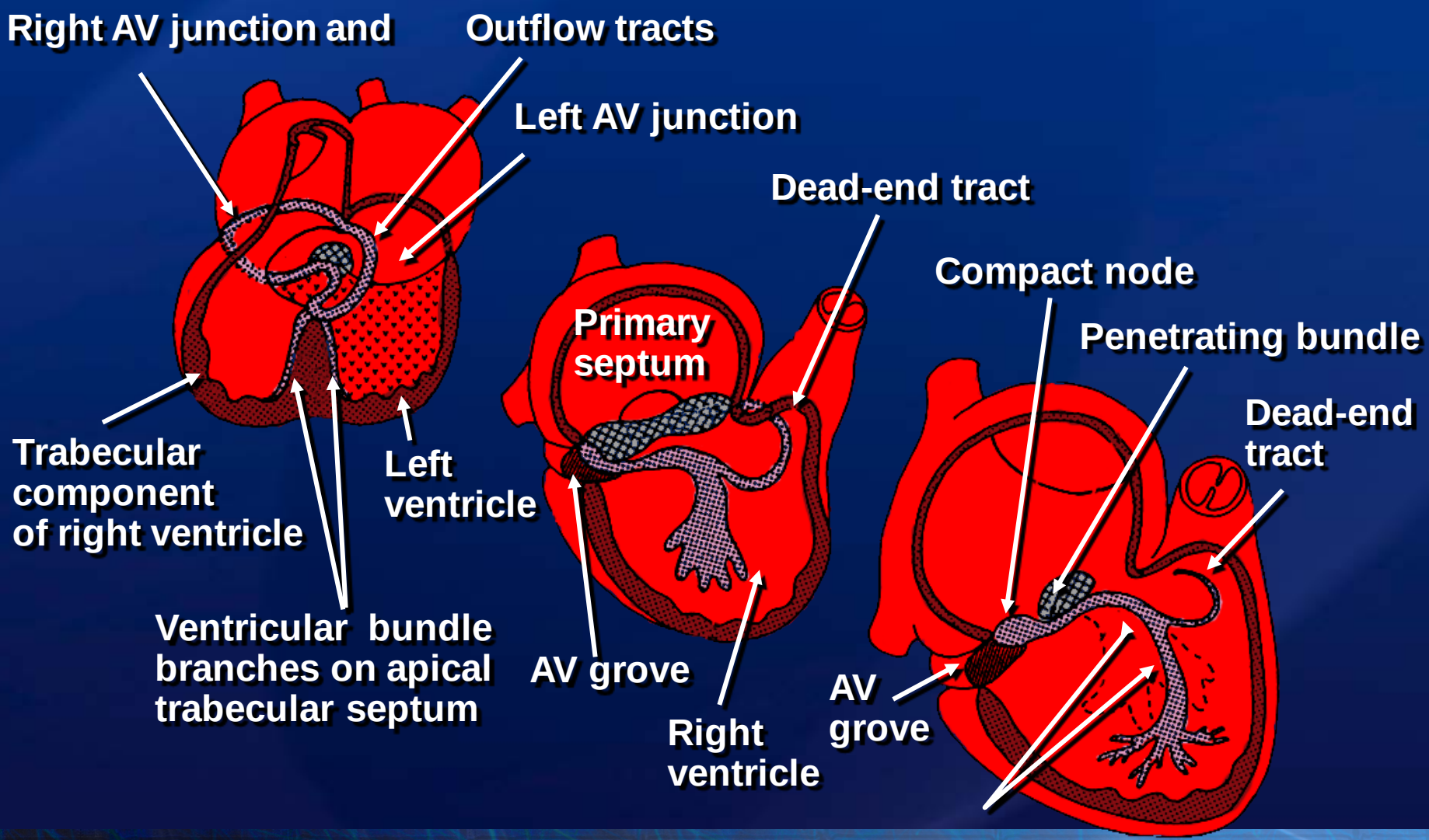







I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
MEDI-TRACE
GRAPHIC CONTROLS CORPORATION
BUFFALO, NEW YORK
PRINTED IN U.S.A.

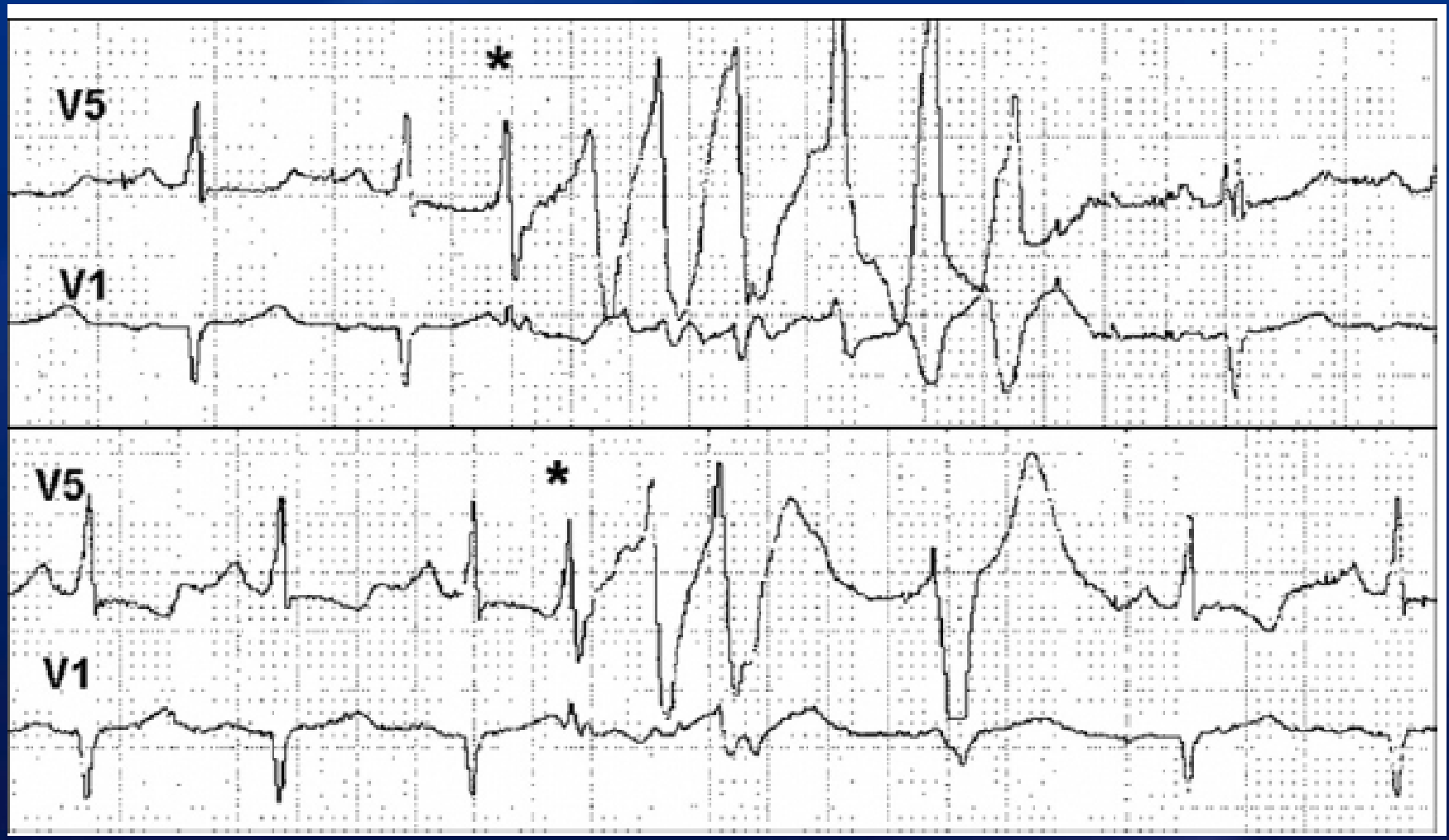
Inlet-outlet ring around



Case #3

11-year-old Hispanic female with sudden collapse soon after completing exercise. A second episode occurs while shopping and polymorphic ventricular tachycardia/ventricular fibrillation is diagnosed.

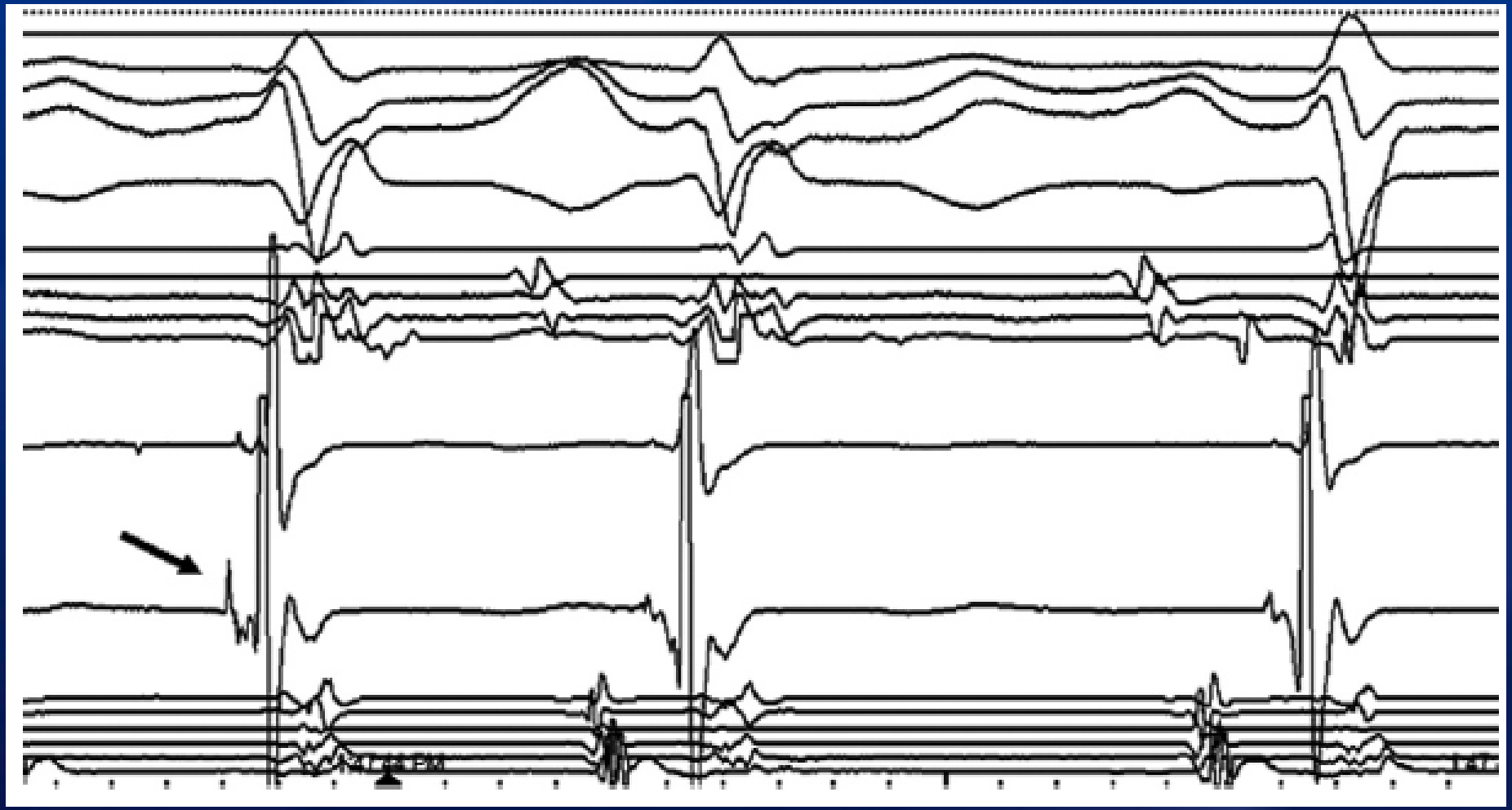
By echocardiography there is no evidence of structural heart disease and coronary angiography is normal. The QT interval is felt to be “borderline” an exercise test is normal with no evidence of arrhythmia.



Srivathsan K, AS G, Ackerman M, Asirvatham S: Treatment of ventricular fibrillation in a patient with prior diagnosis of long QT syndrome: importance of precise electrophysiologic diagnosis to successfully ablate the trigger. . Heart Rhythm 2007; 4:1090-1093.

Ventricular Fibrillation Ablation

- Role of the conduction system
- Role of the supravalvar myocardium
- The papillary muscles
- Substrate versus trigger
- Causes of difficulty with ablation
  - Hemodynamic compromise
  - How do you trigger the triggers?



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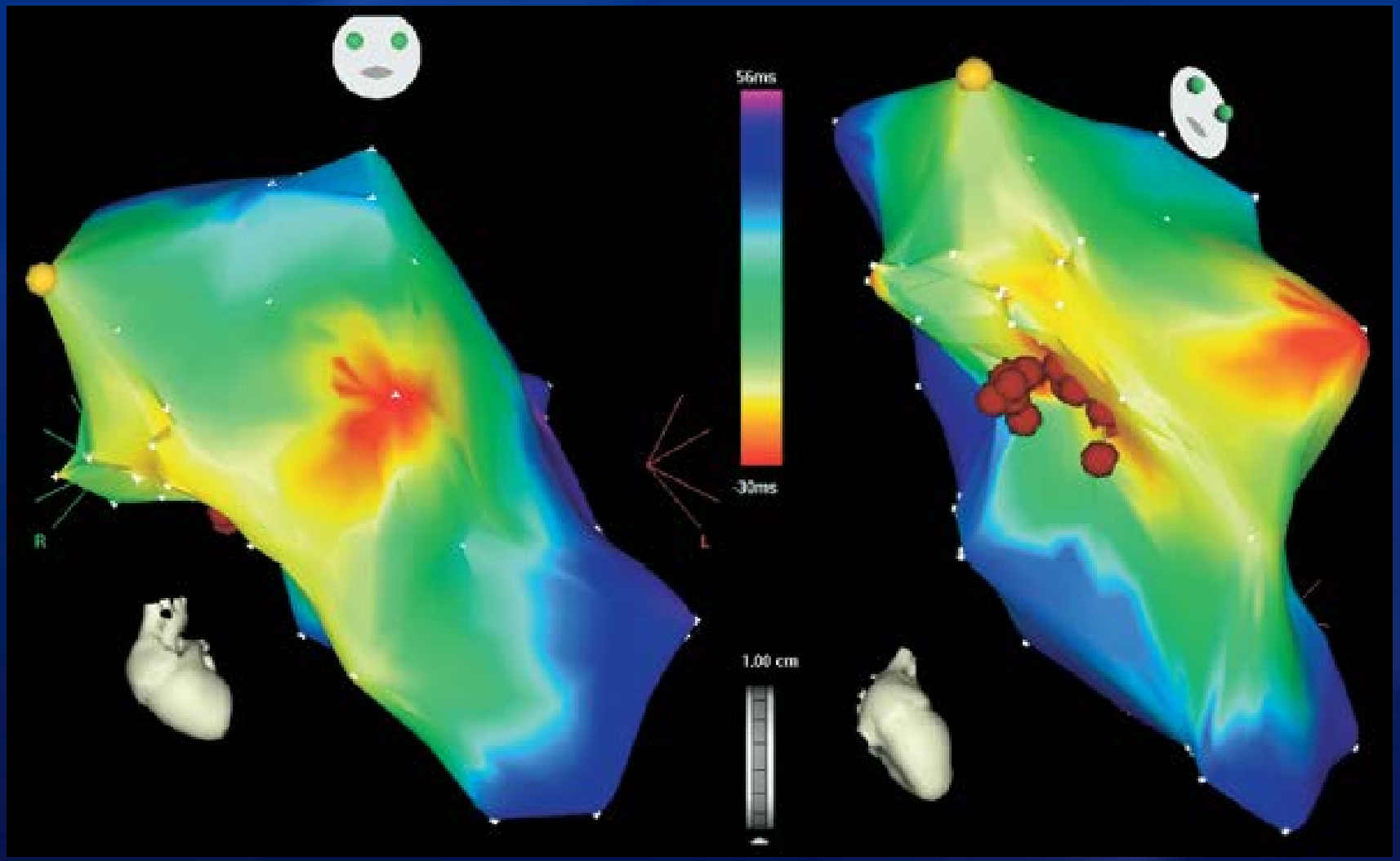

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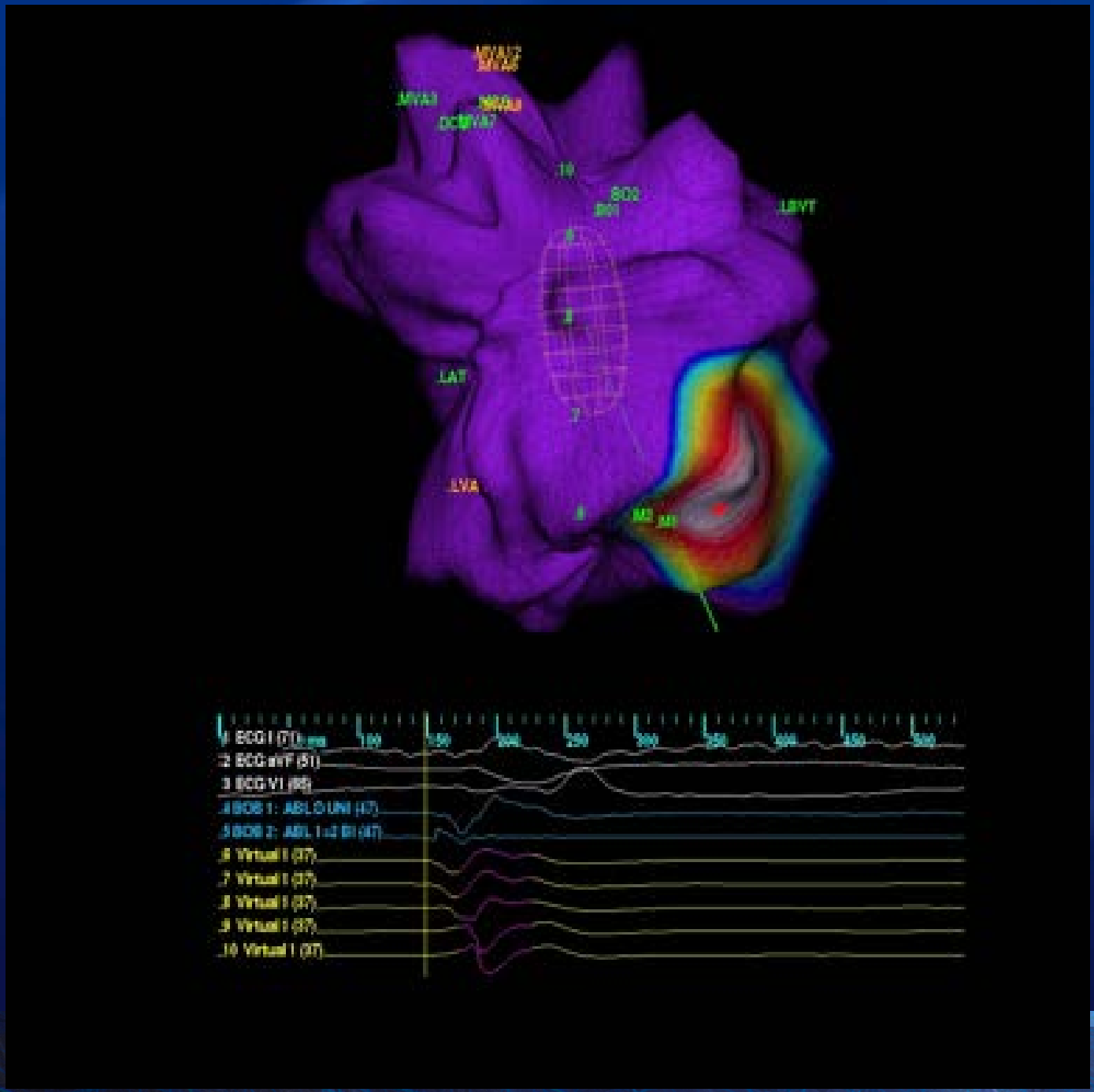
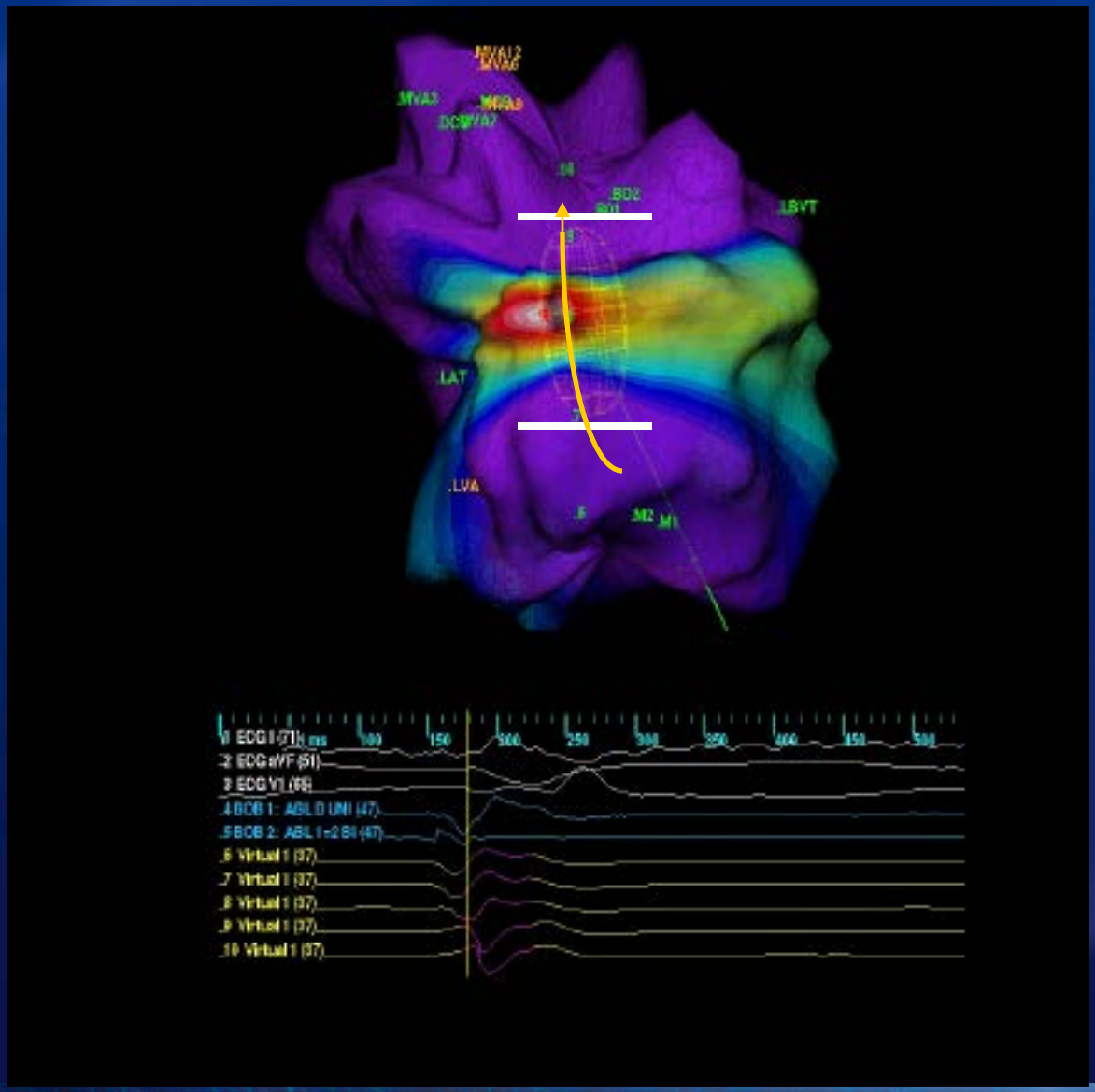
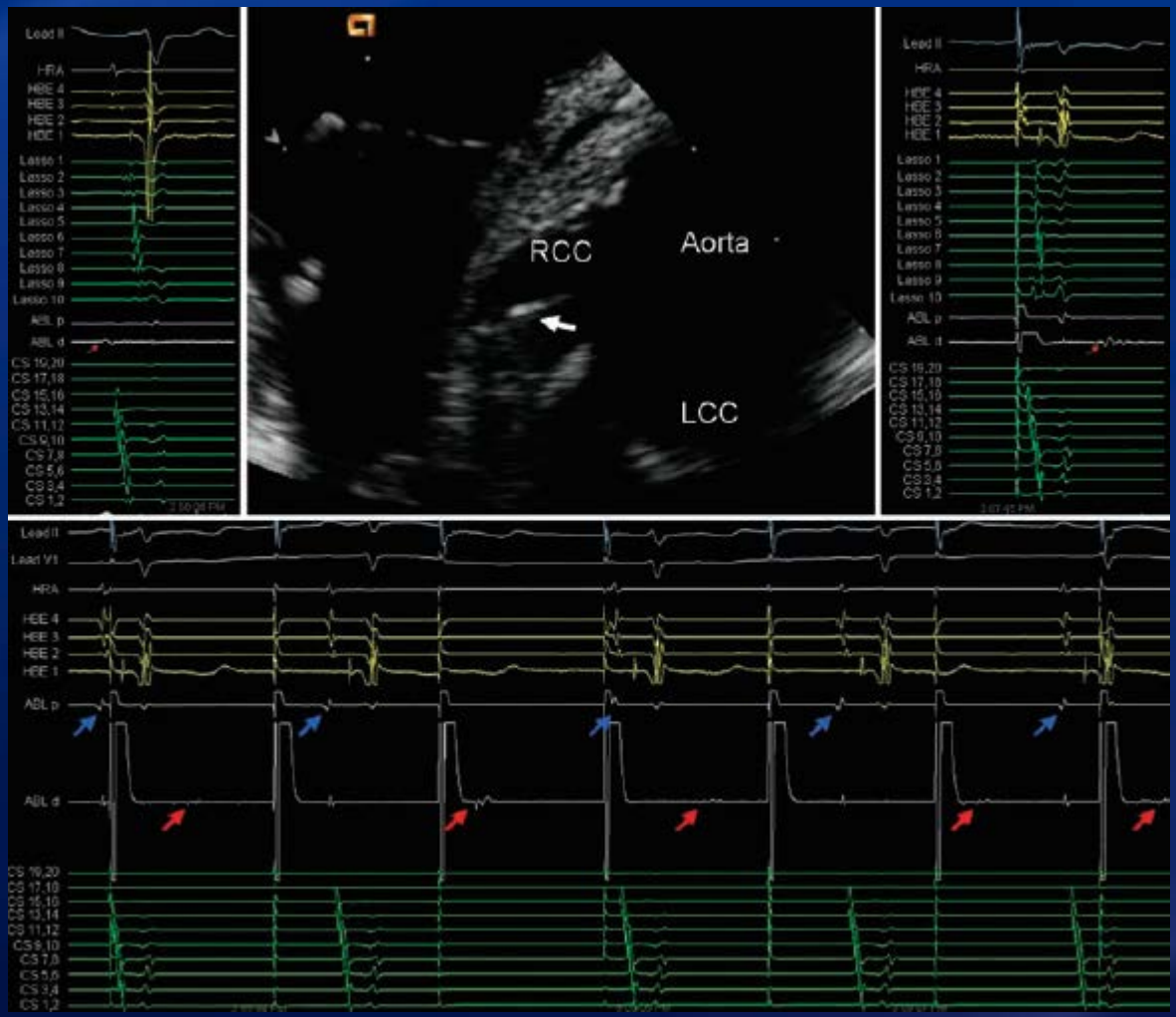
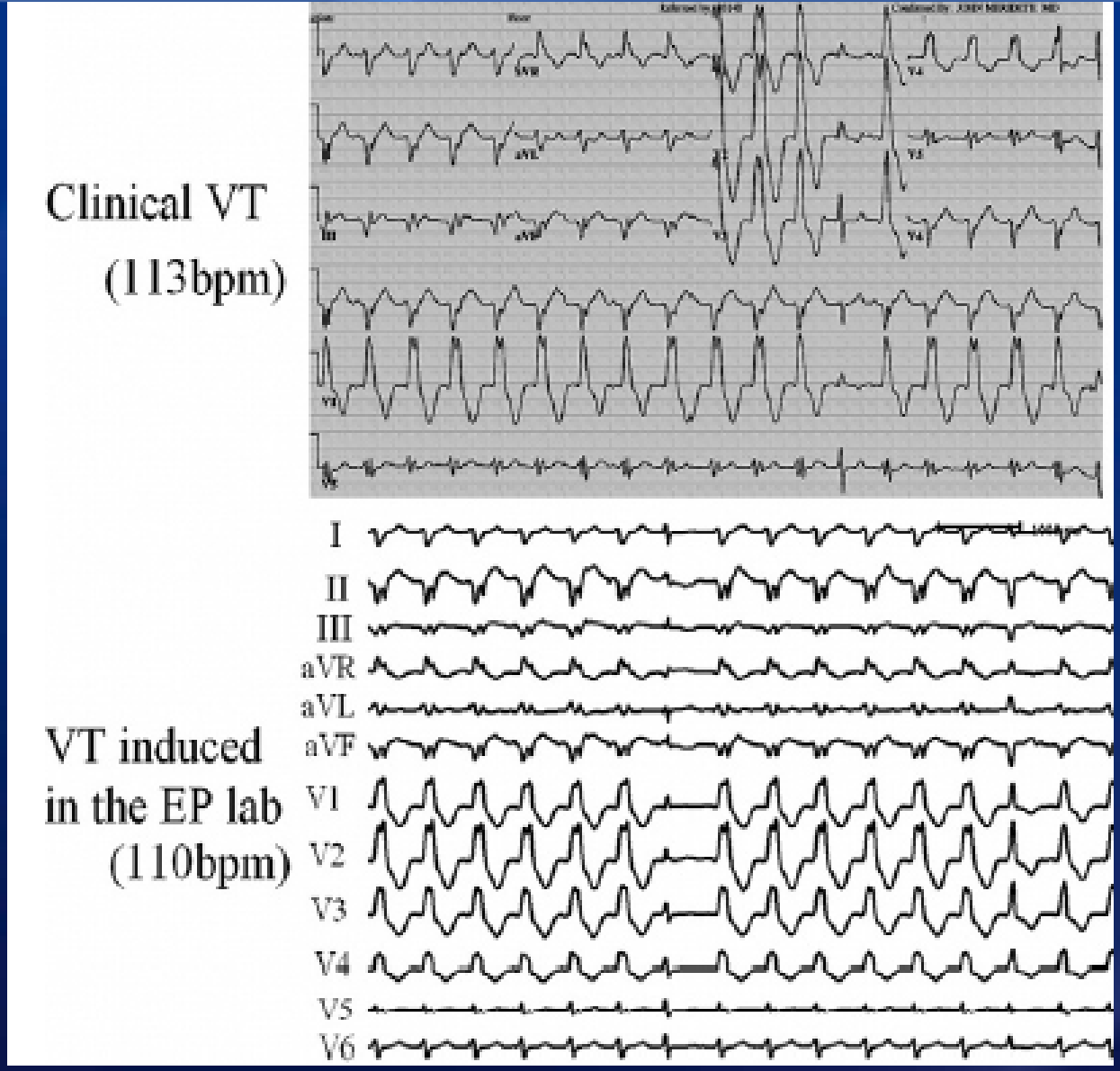
Right Bundle Left Axis VT



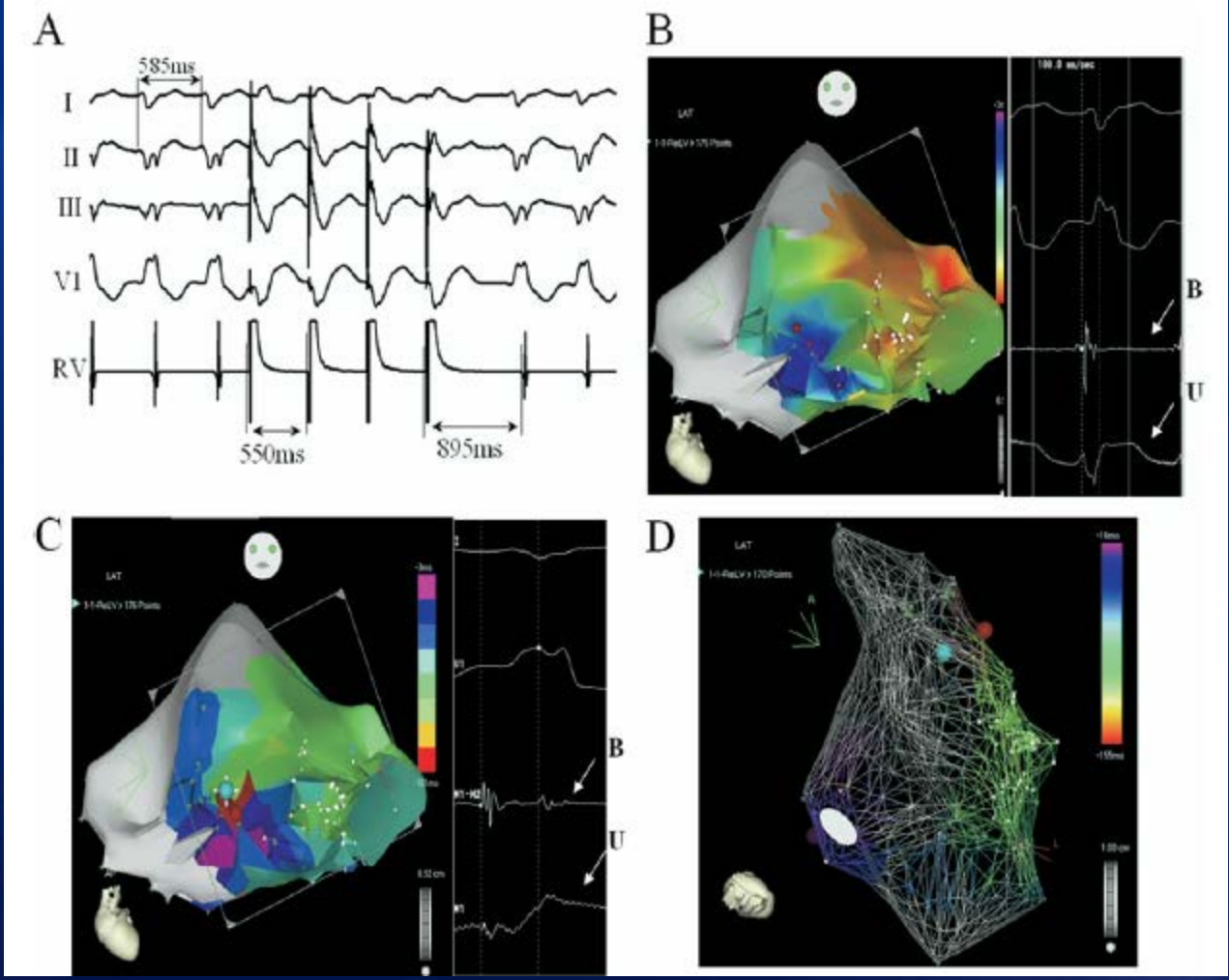




Gami AS, Venkatachalam KL, Friedman PA, Asirvatham SJ: Successful ablation in the right coronary cusp of the aortic valve in a patient with atrial fibrillation: what is the substrate? J Cardiovasc Electrophysiol 2008; 19:982-986.



Liu XK, Barrett R, Packer DL, Asirvatham SJ: Successful management of recurrent ventricular tachycardia by electrical isolation of anterolateral papillary muscle. Heart Rhythm 2008; 5:479-482.



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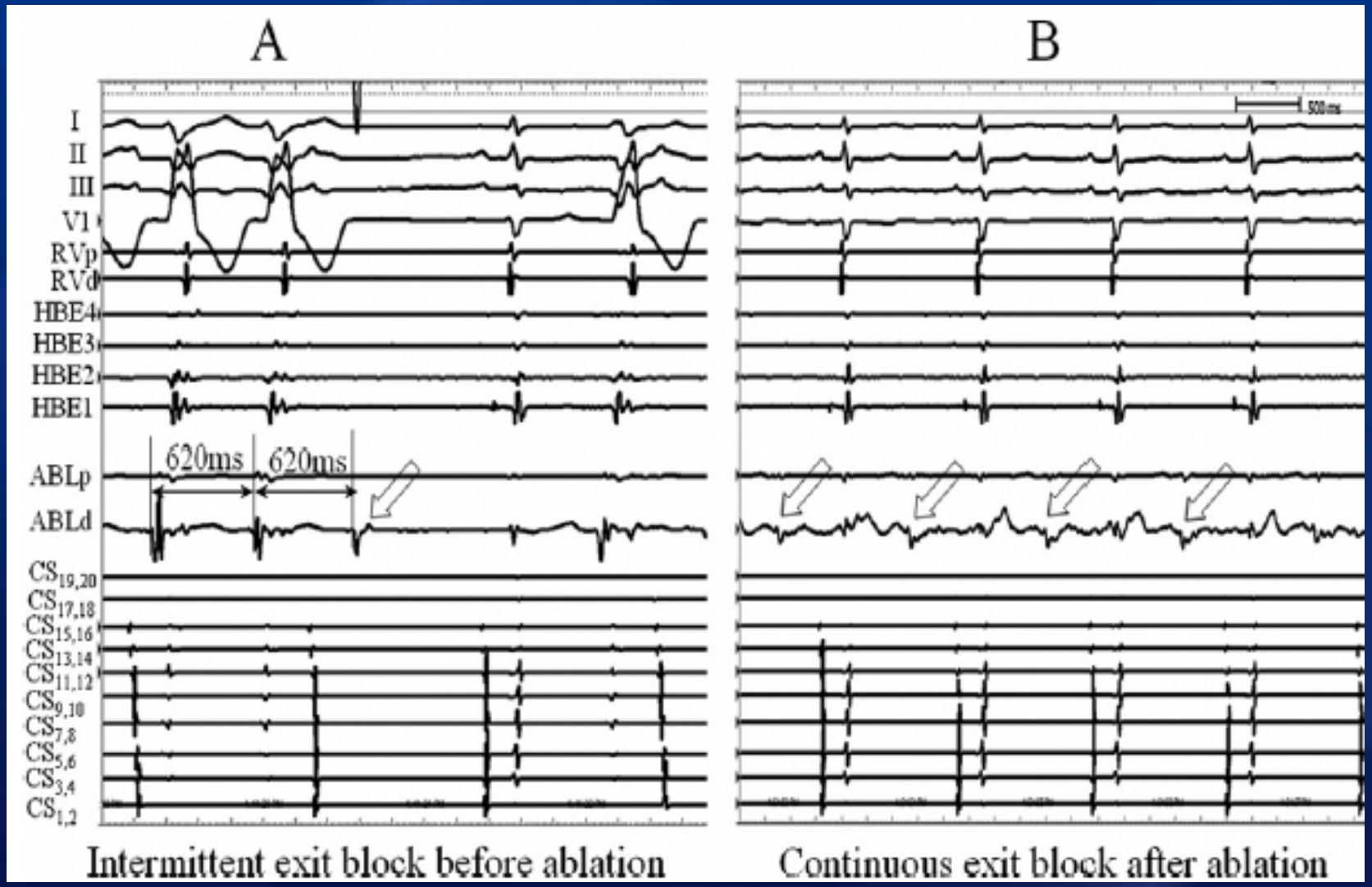

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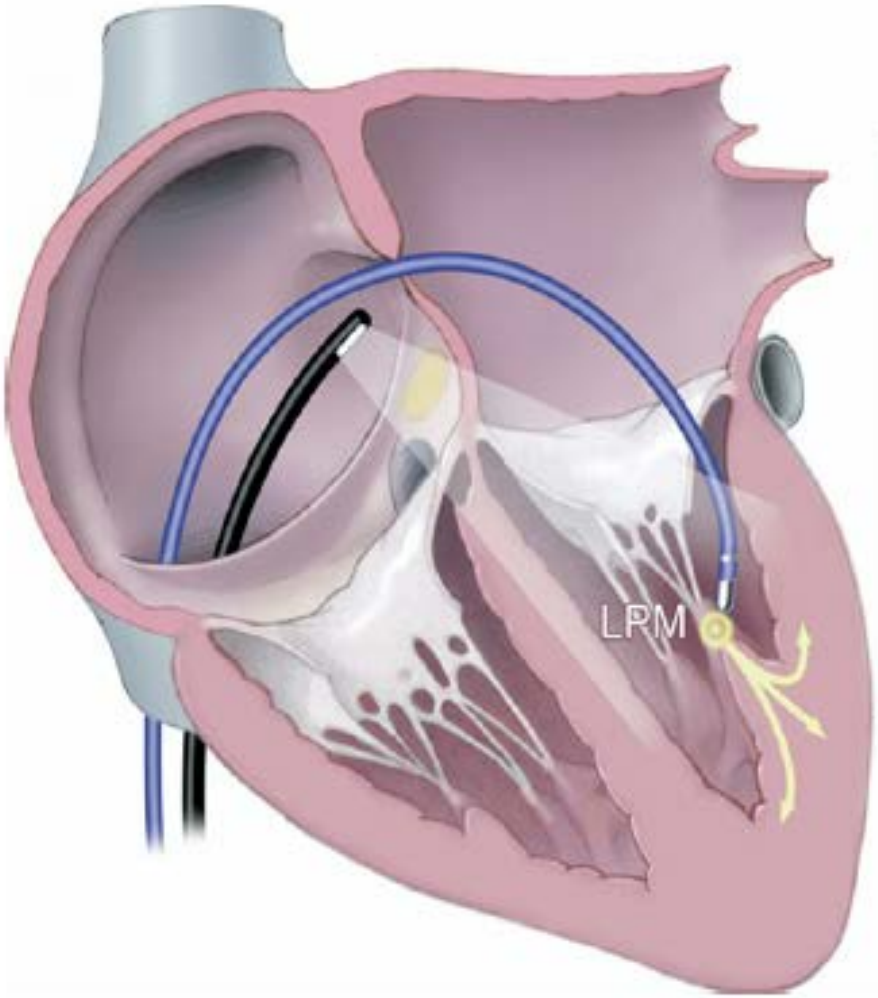
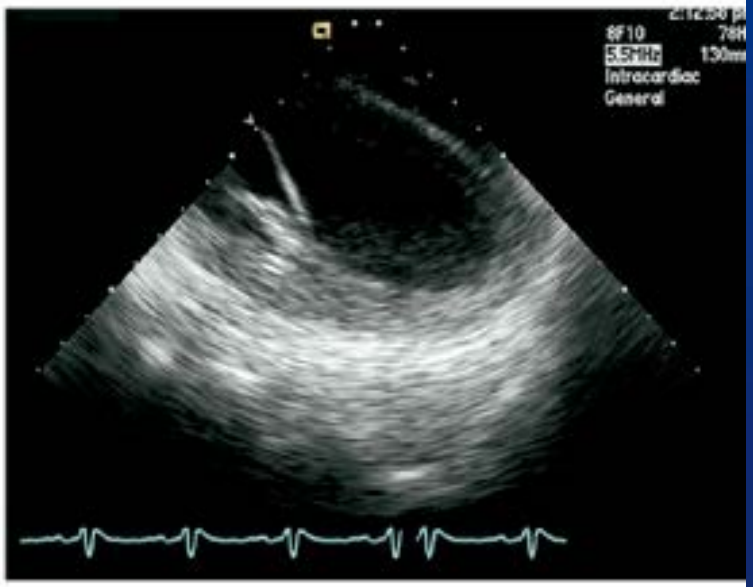
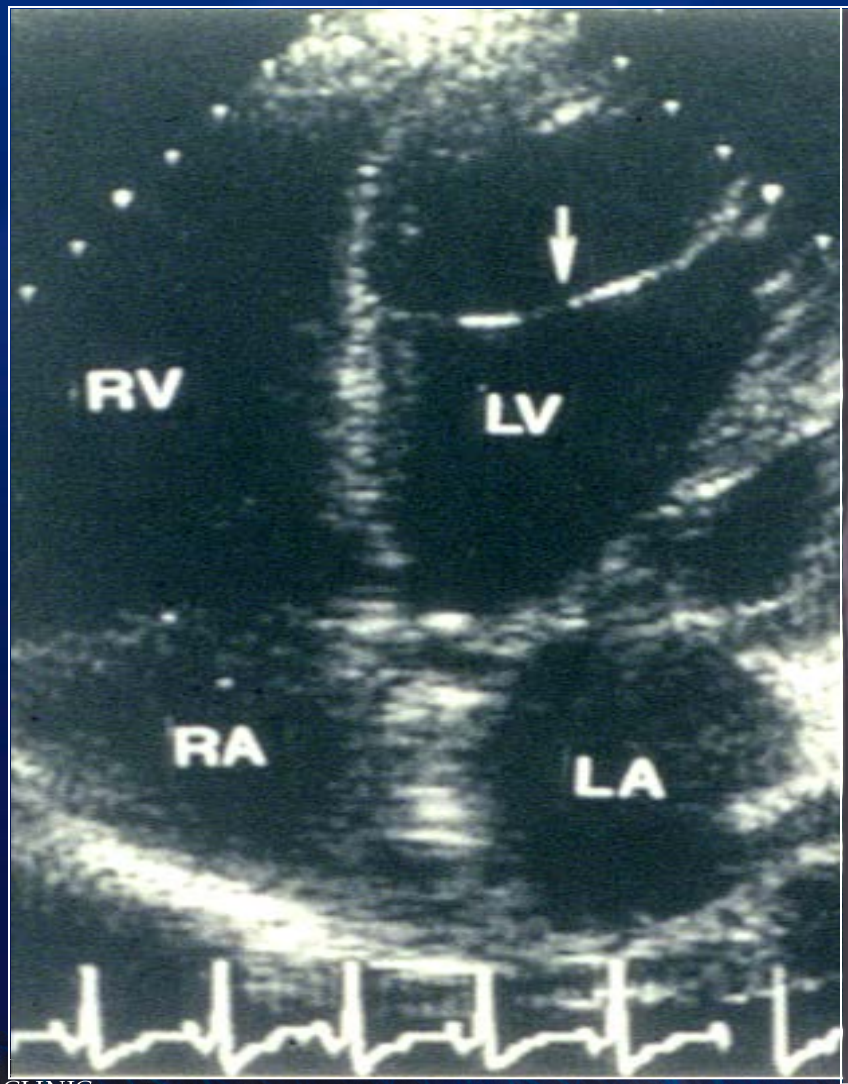
MAYO CLINIC

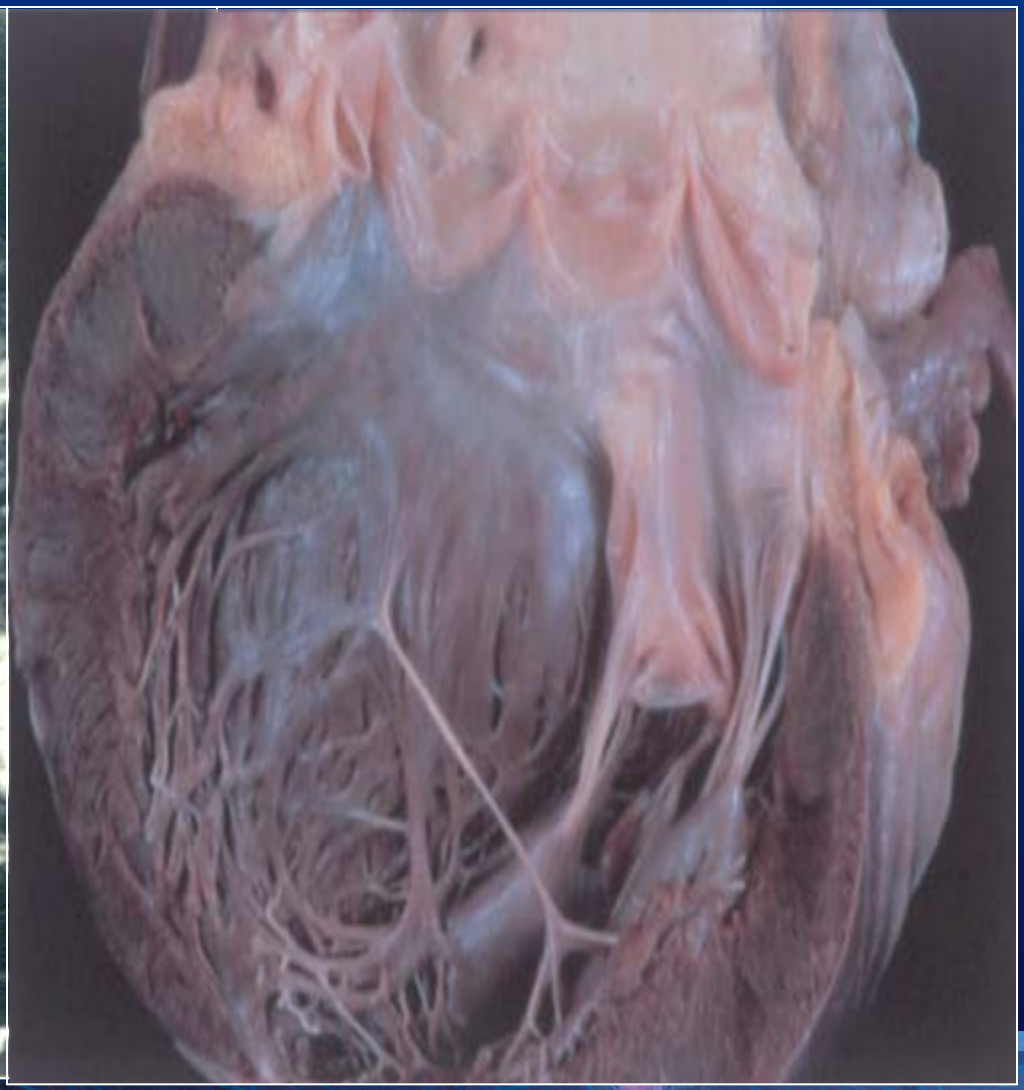




Liu XK, Barrett R, Packer DL, Asirvatham SJ: Successful management of recurrent ventricular tachycardia by electrical isolation of anterolateral papillary muscle. Heart Rhythm 2008; 5:479-482.

Echo: EPS and Ablation





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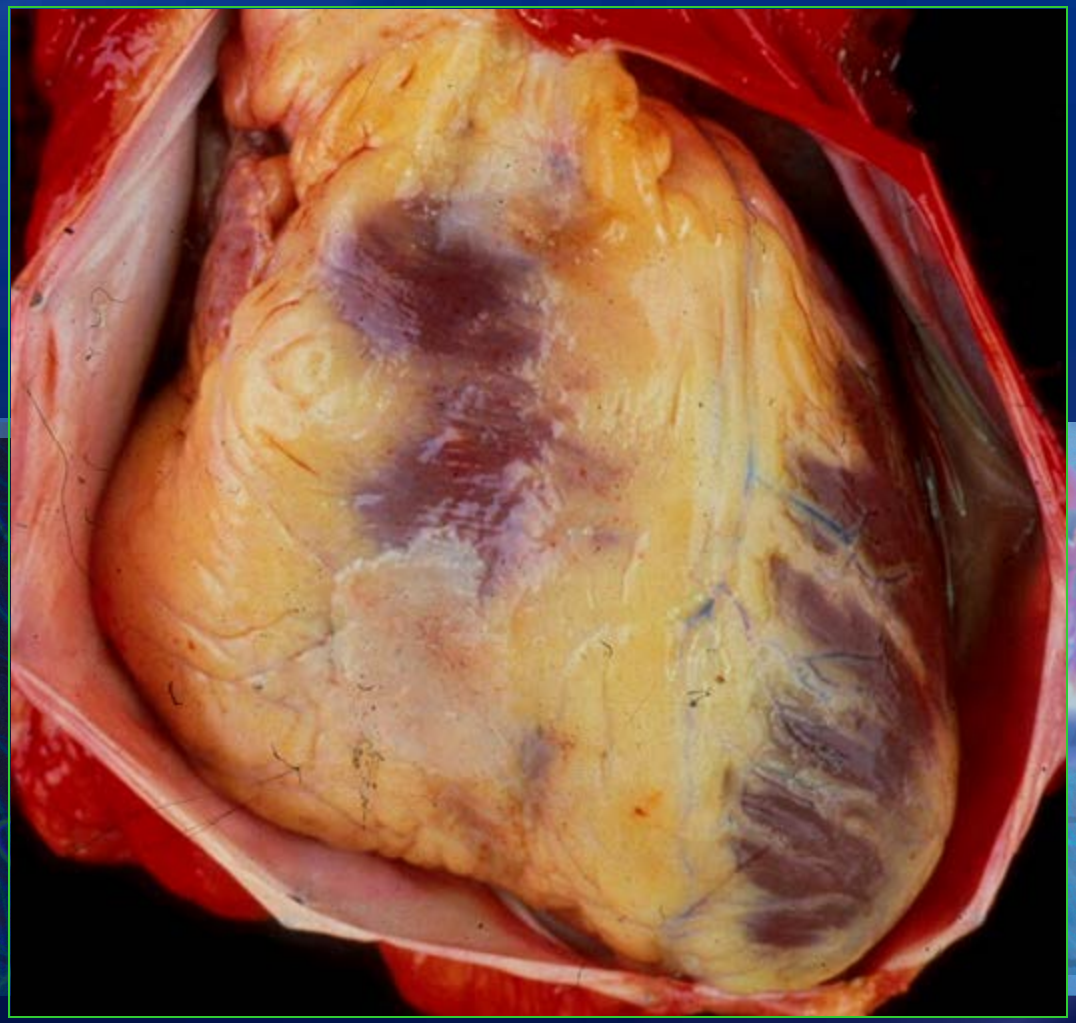
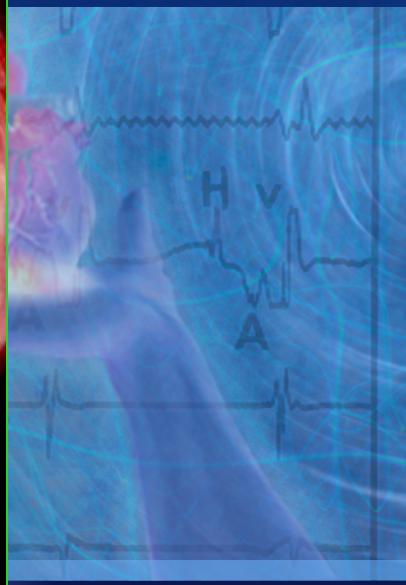
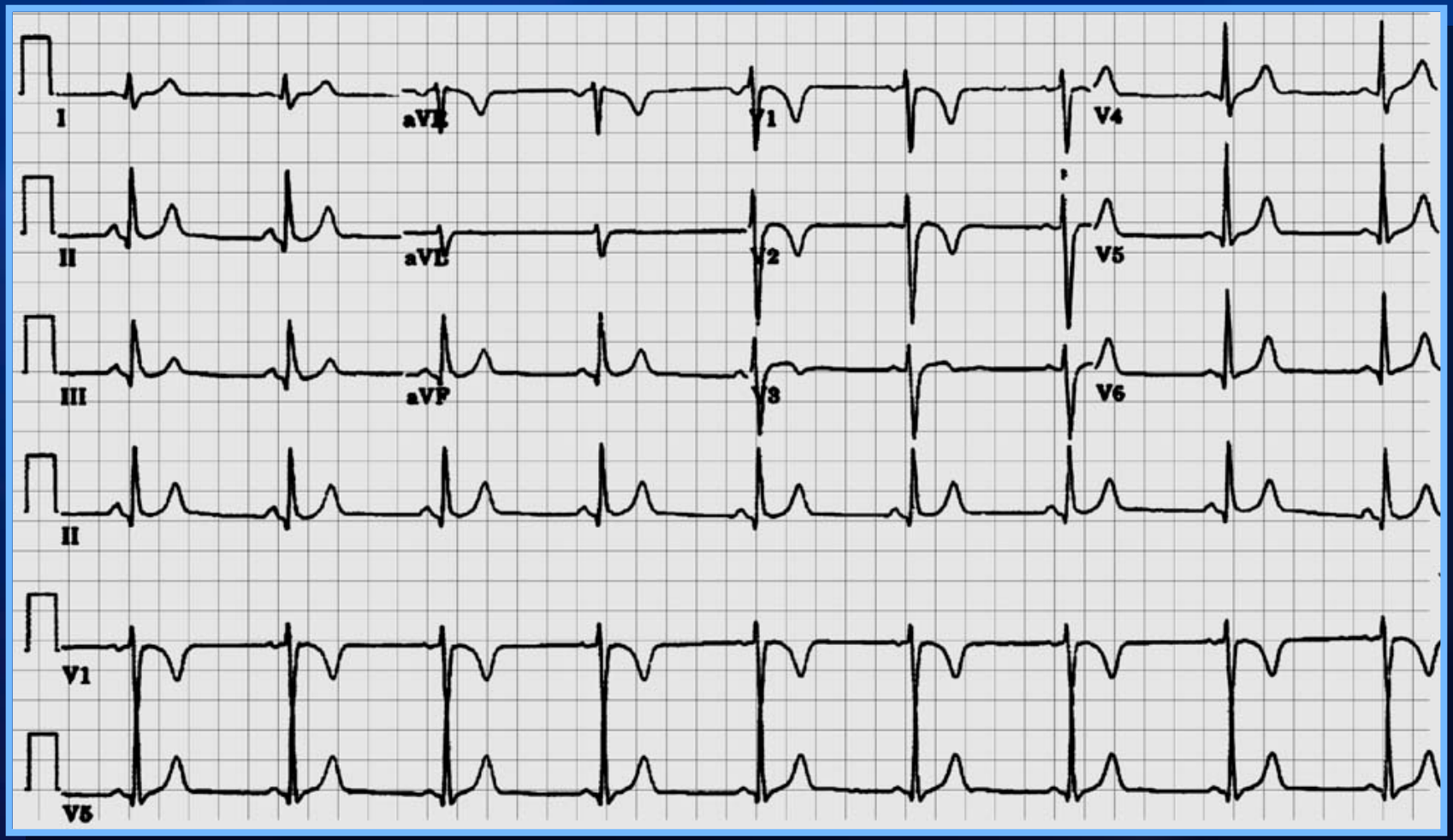
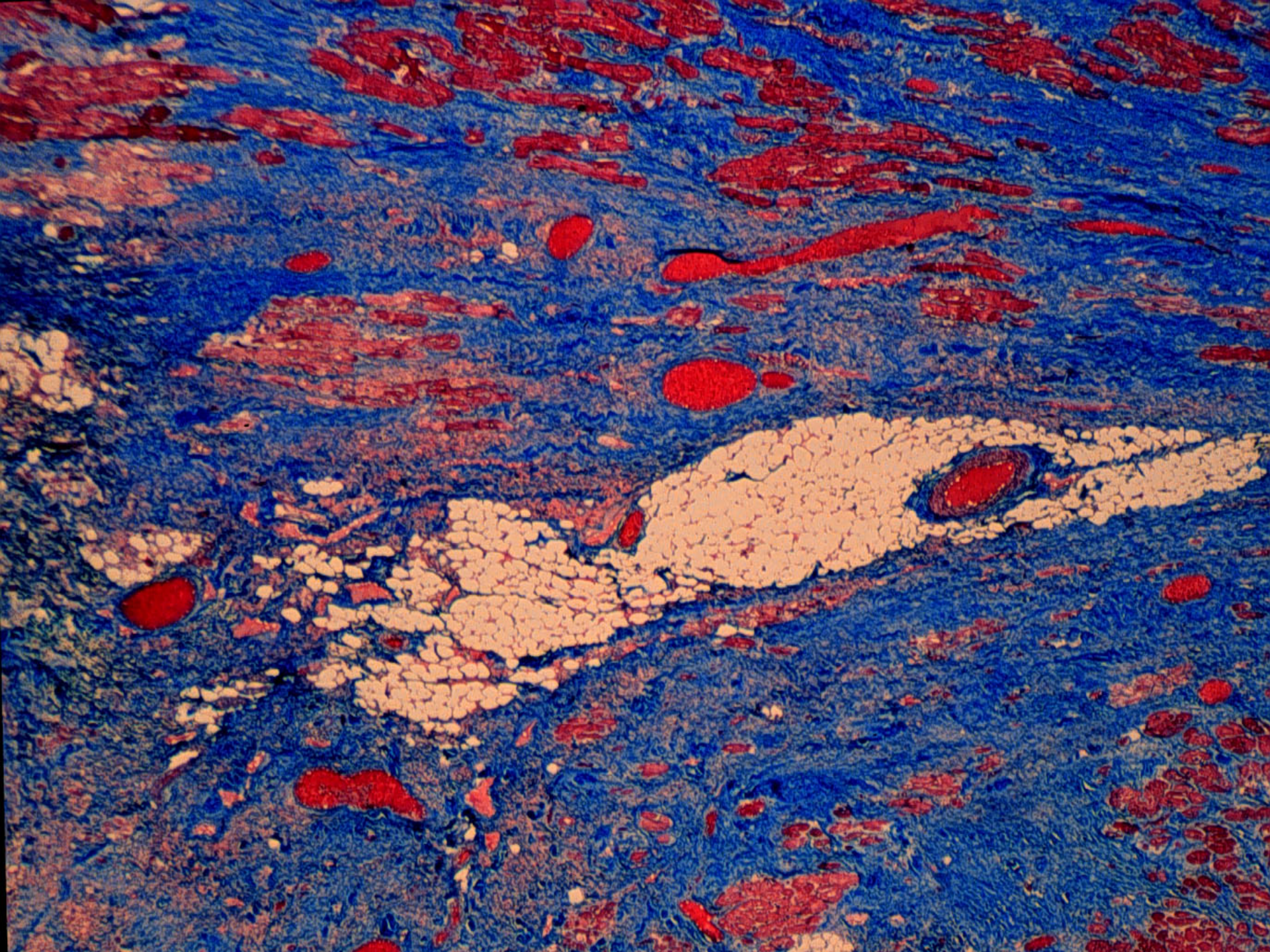
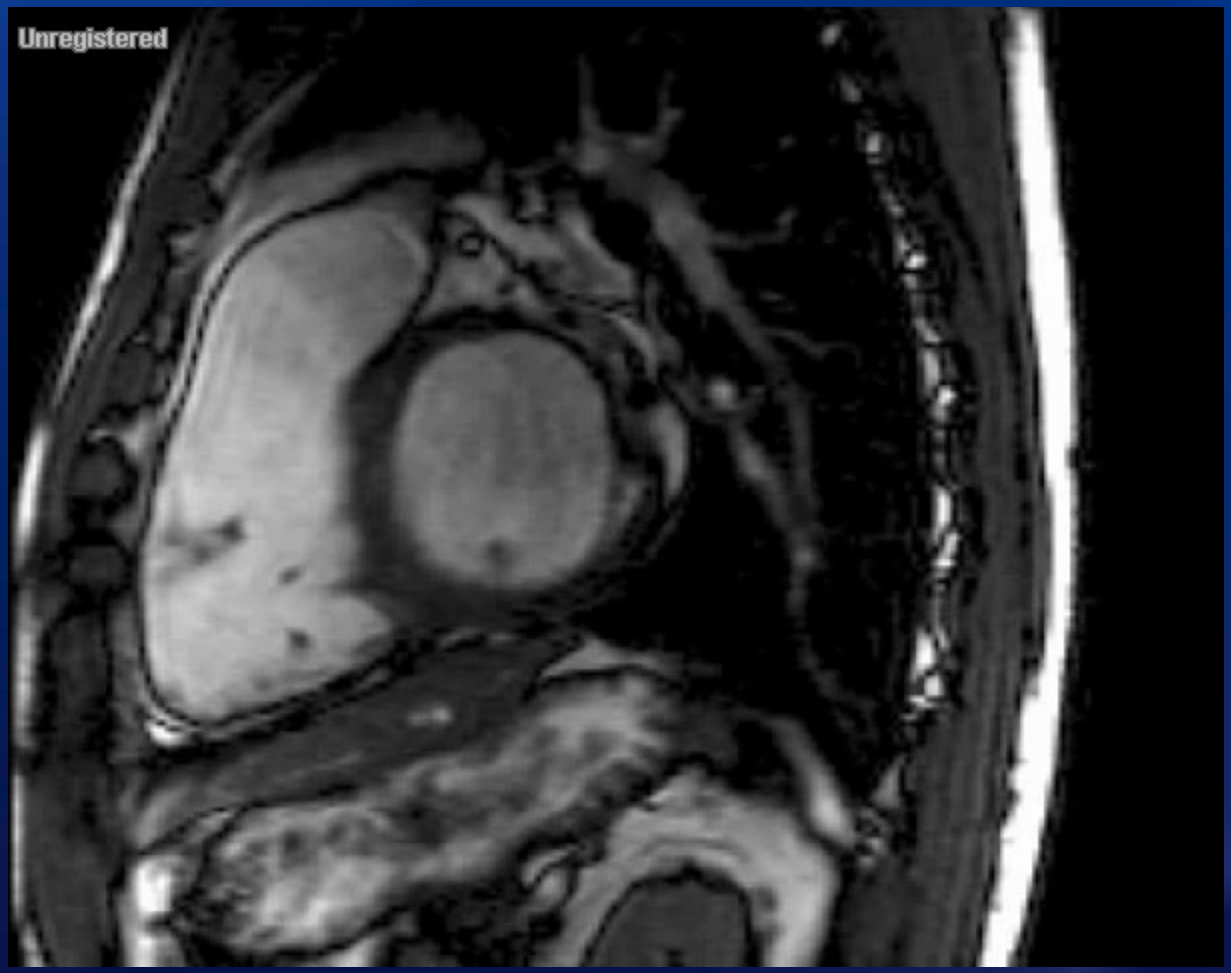






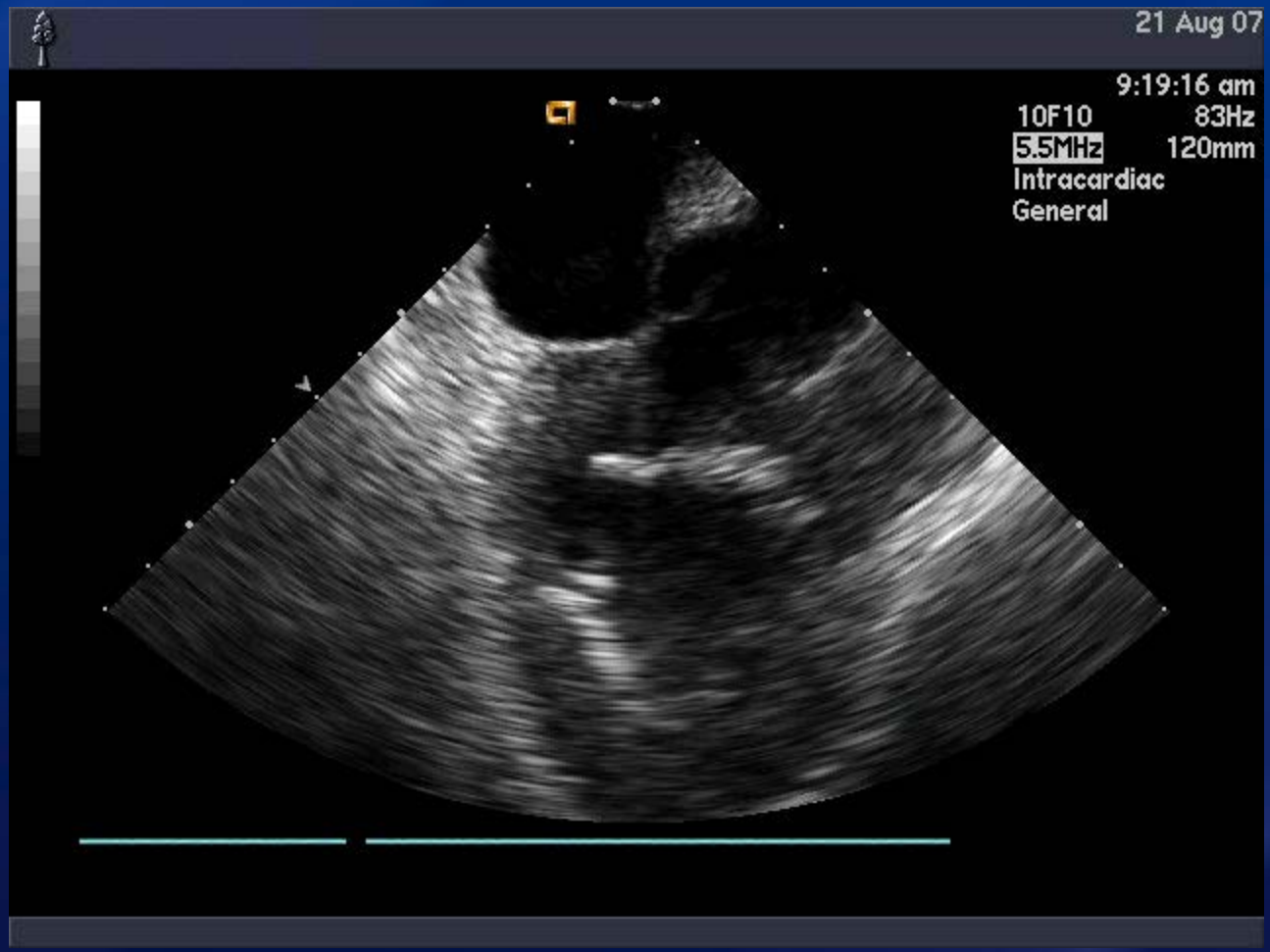


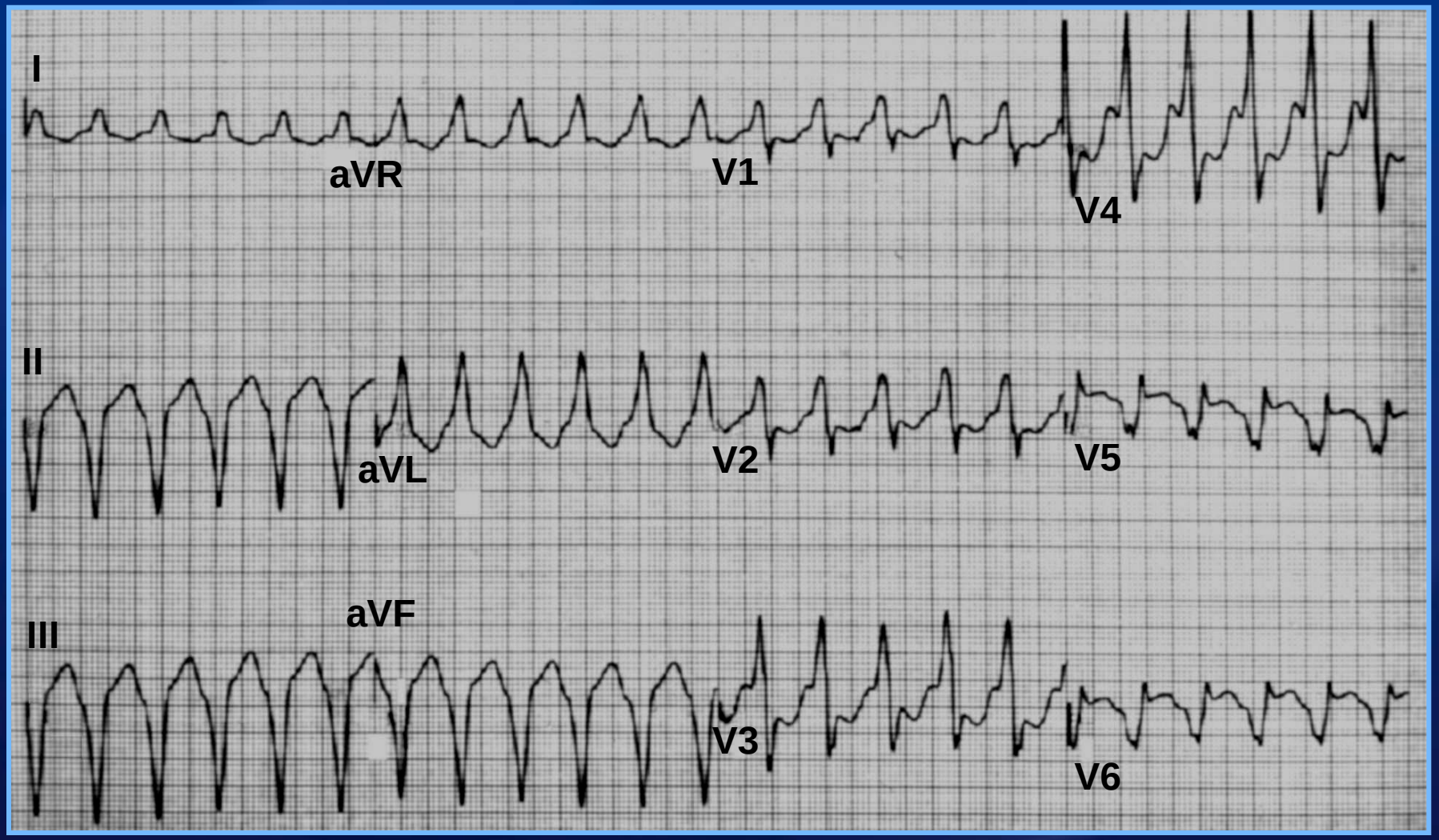


MAYO CLINIC

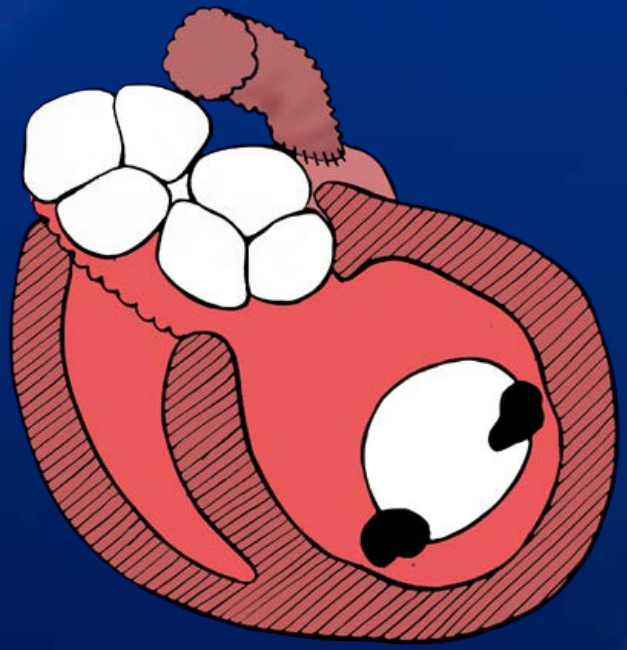
VT in the “Normal Heart”

1. Right ventricular dysplasia
2. Sarcoidosis
3. Cardiomyopathy, not tachycardia related
4. Coronary vascular malformation
5. Mitral valve prolapse
6. False tendon/moderator band
7. Non-compact myocardium
8. Atypical ventricular dysplasia pattern





QRS Morphology Clues to VT Exit Site

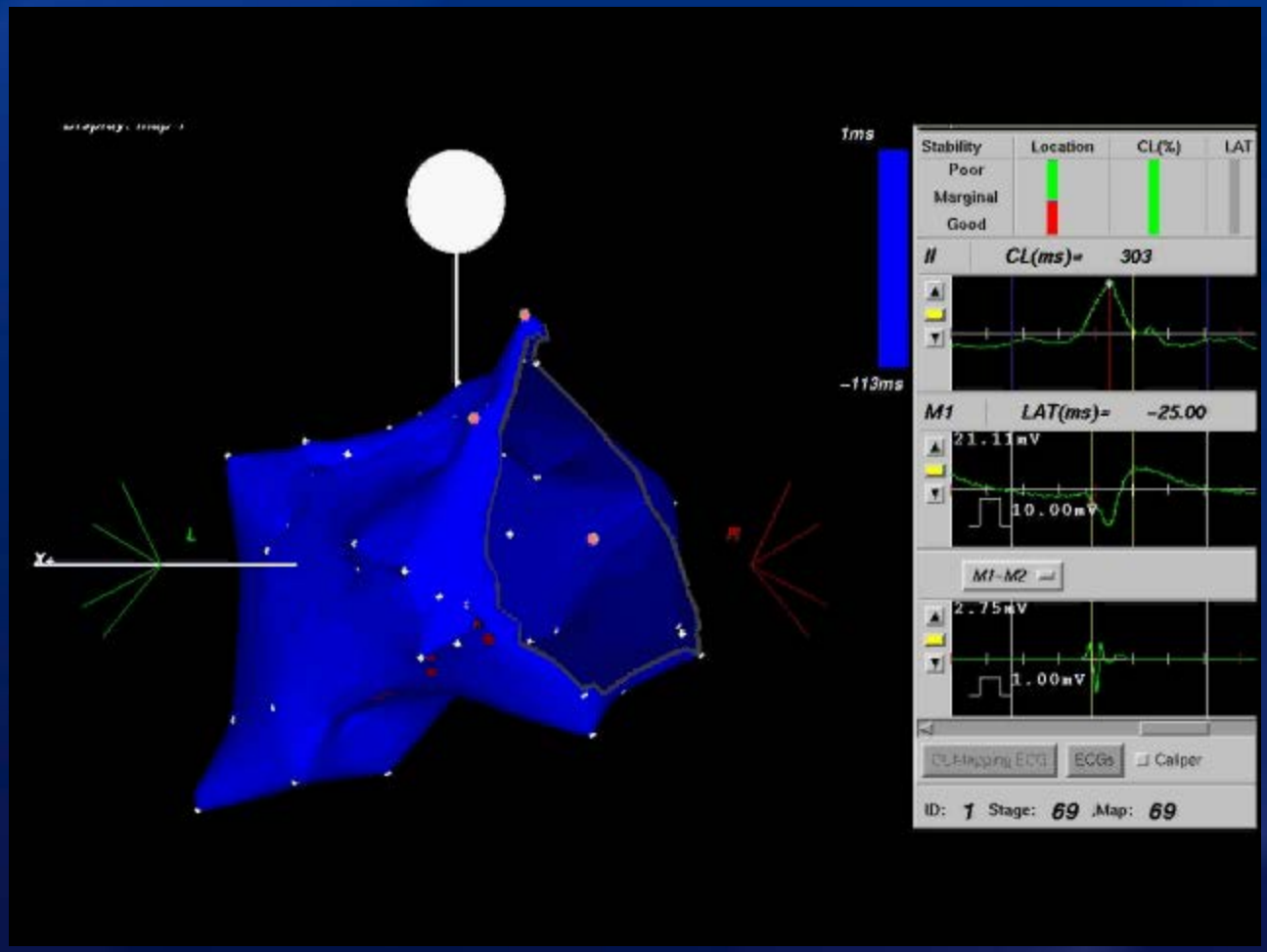


Septal

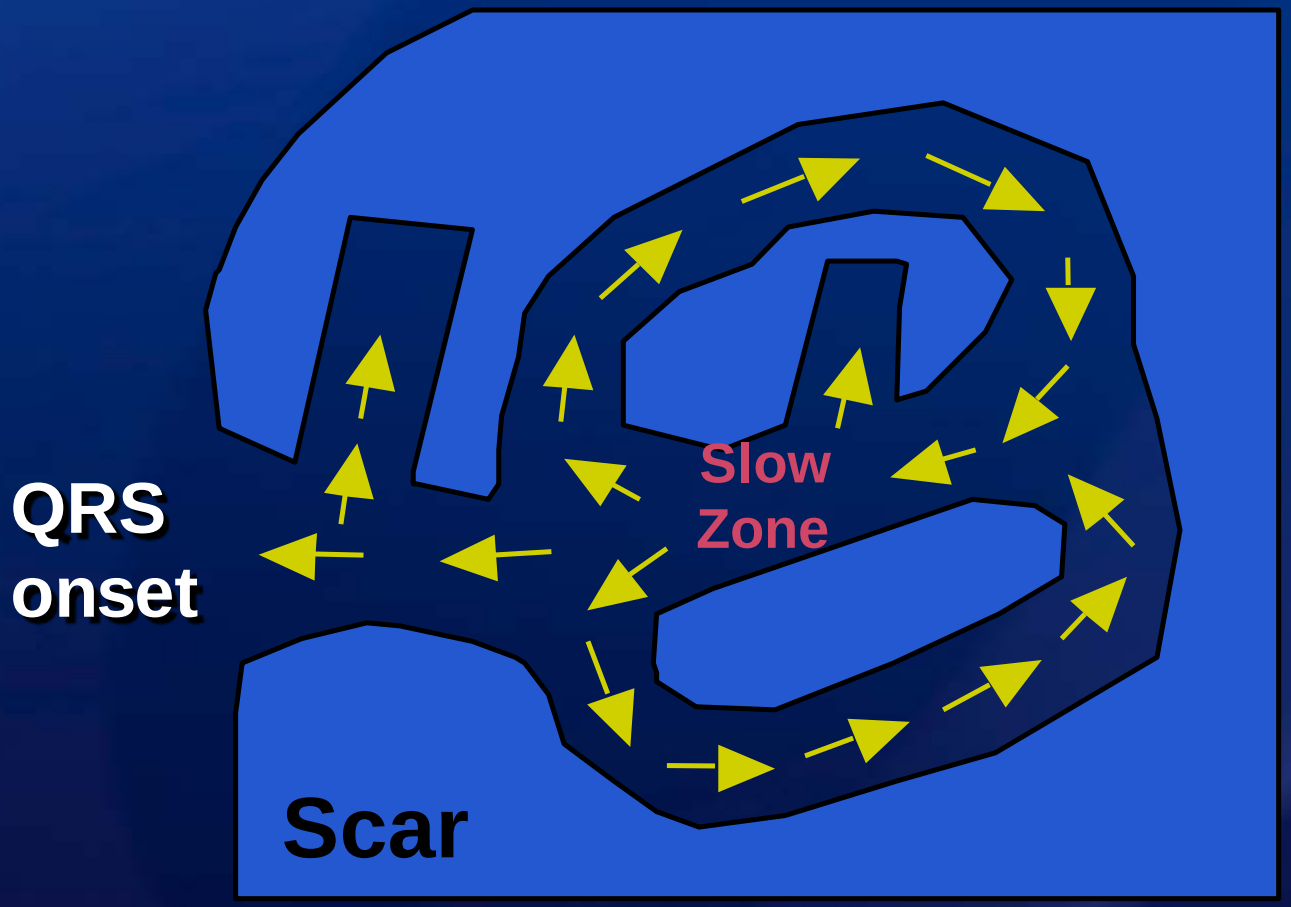
Lateral

I, aVL

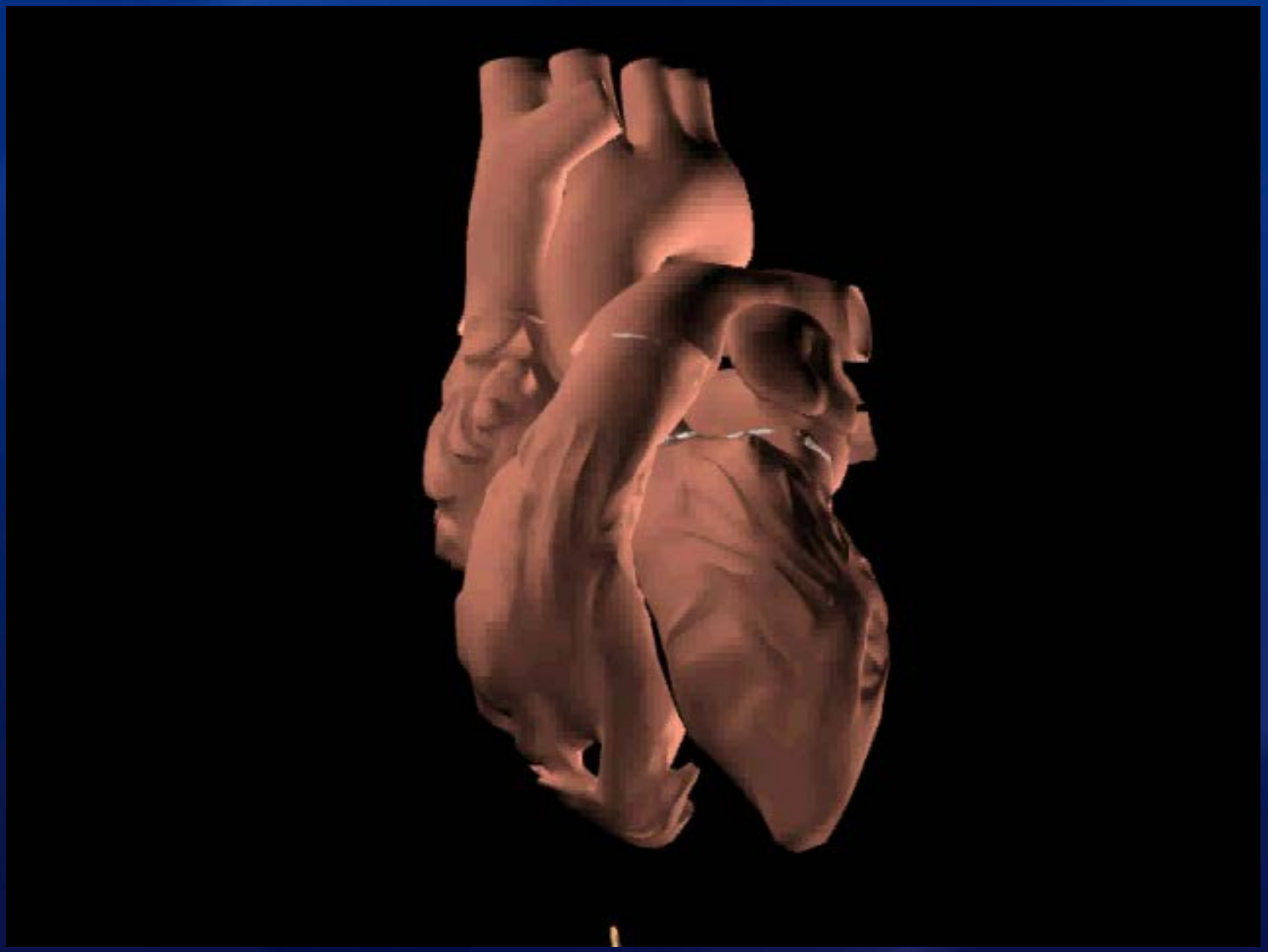
II, III, aVF

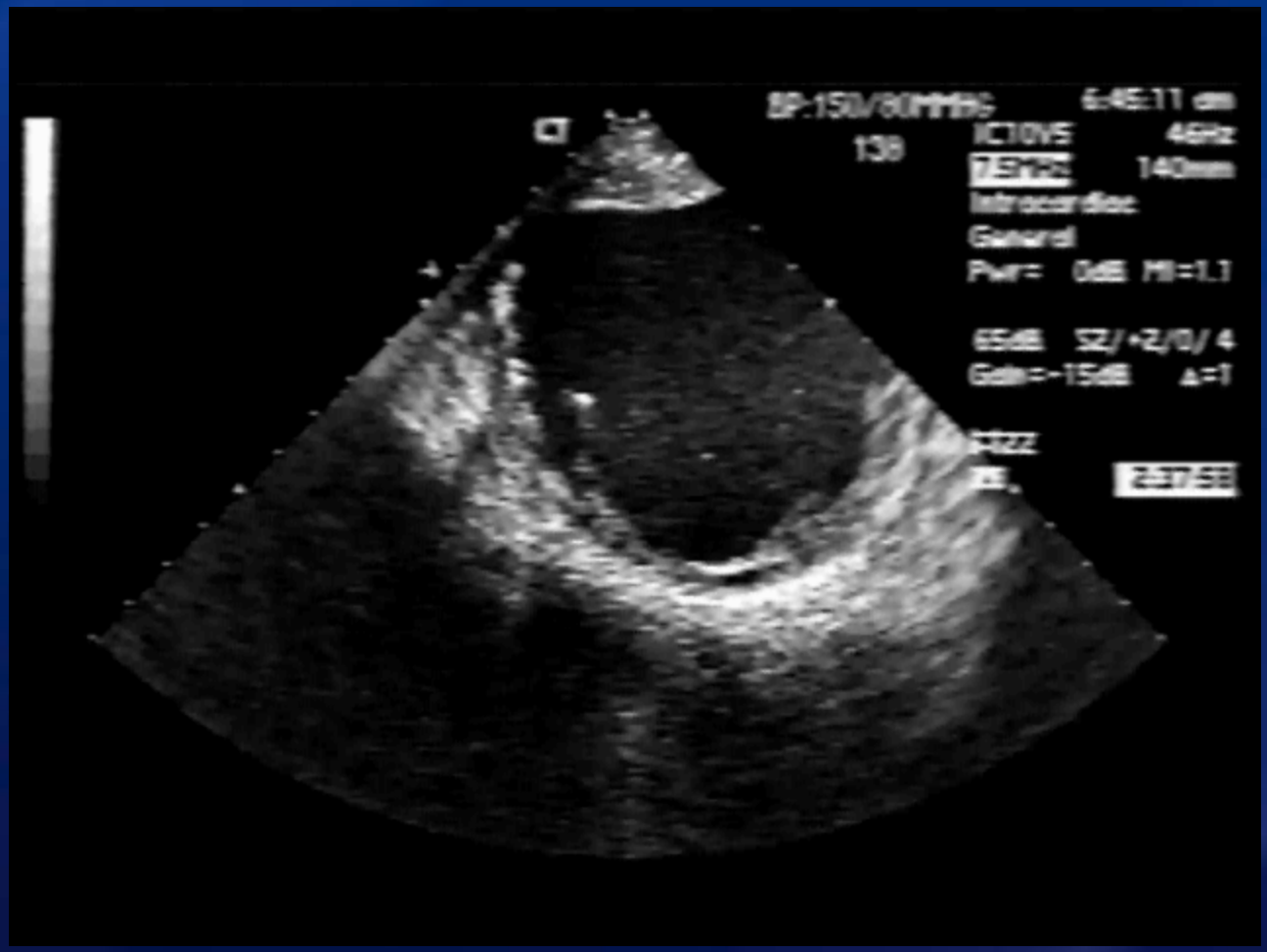


Reentrant Circuit in Ventricular Tachycardia



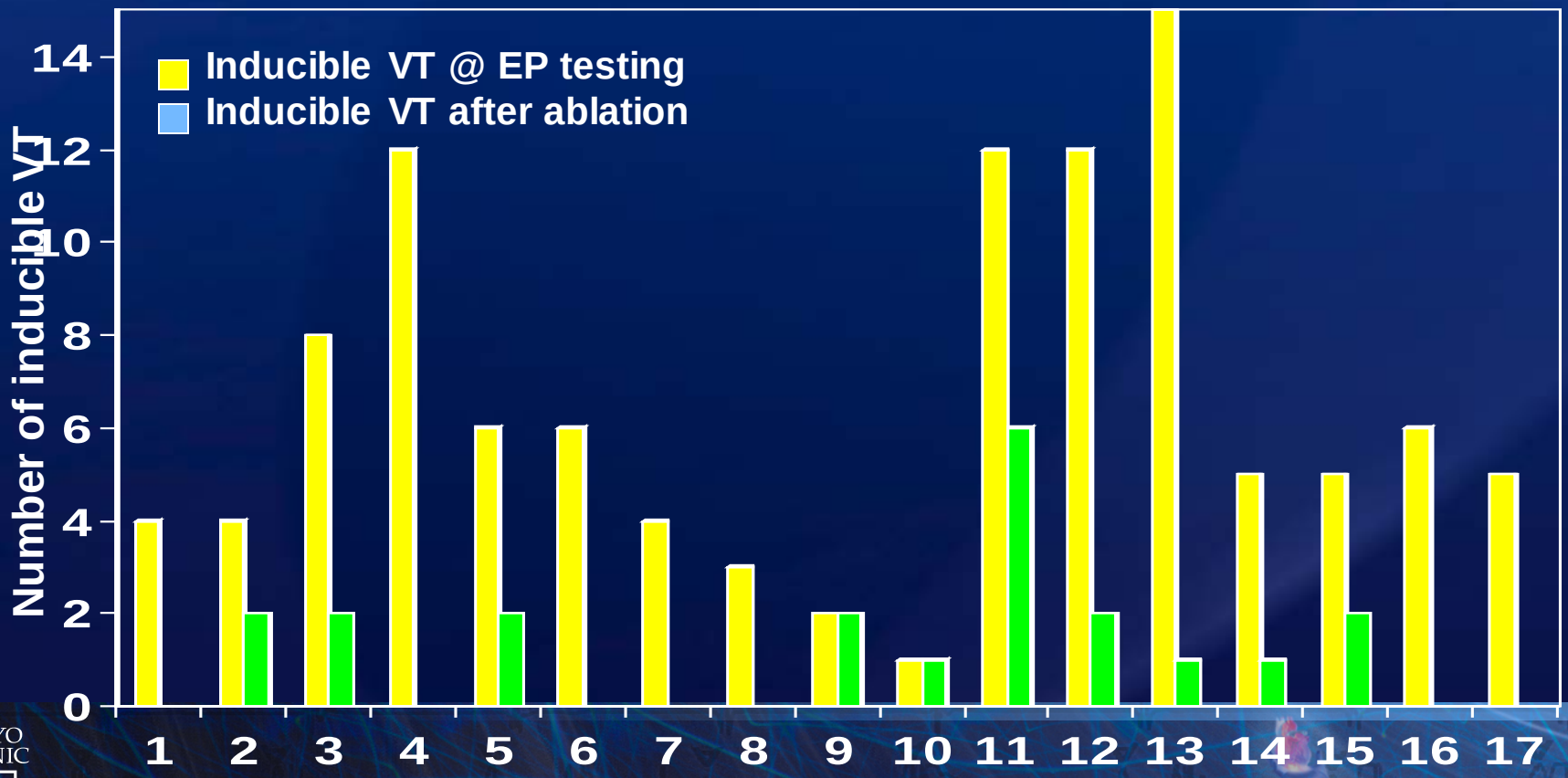
Hassan and Stevenson: JACC 19:307A, 1992





Hemodynamically Unstable VT in ICD Patients

Number of VT induced	95 (6/pt)
Cycle Length	393±105
Hemo-dynamic instability	49/70 (70%)
DCCV required	15/70 (70%)



Tabatabei, Heart Rhythm, 2007

Percutaneous LV Assist Devices

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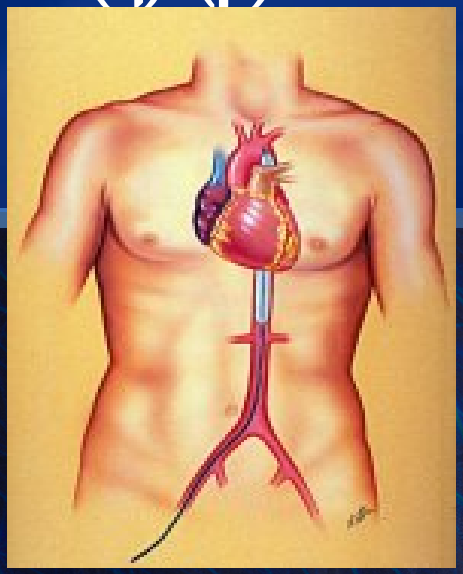
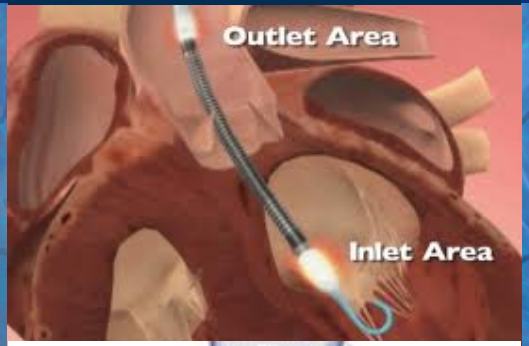
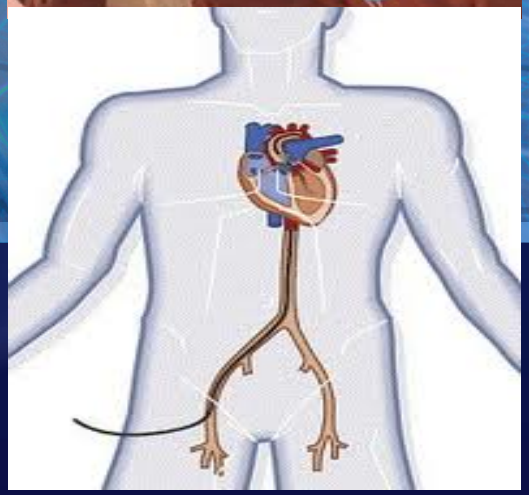
IABP



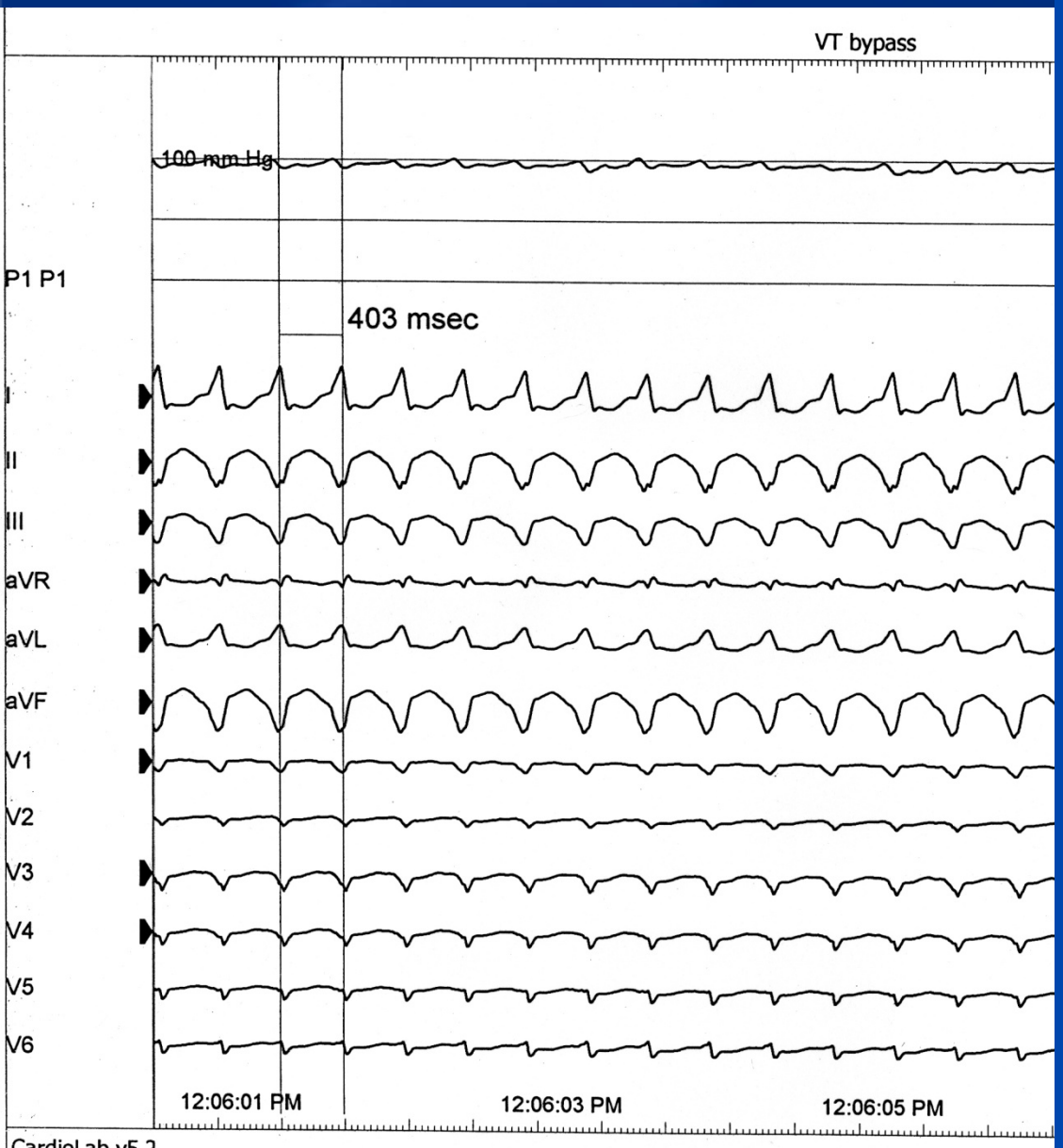
Rotary Pump

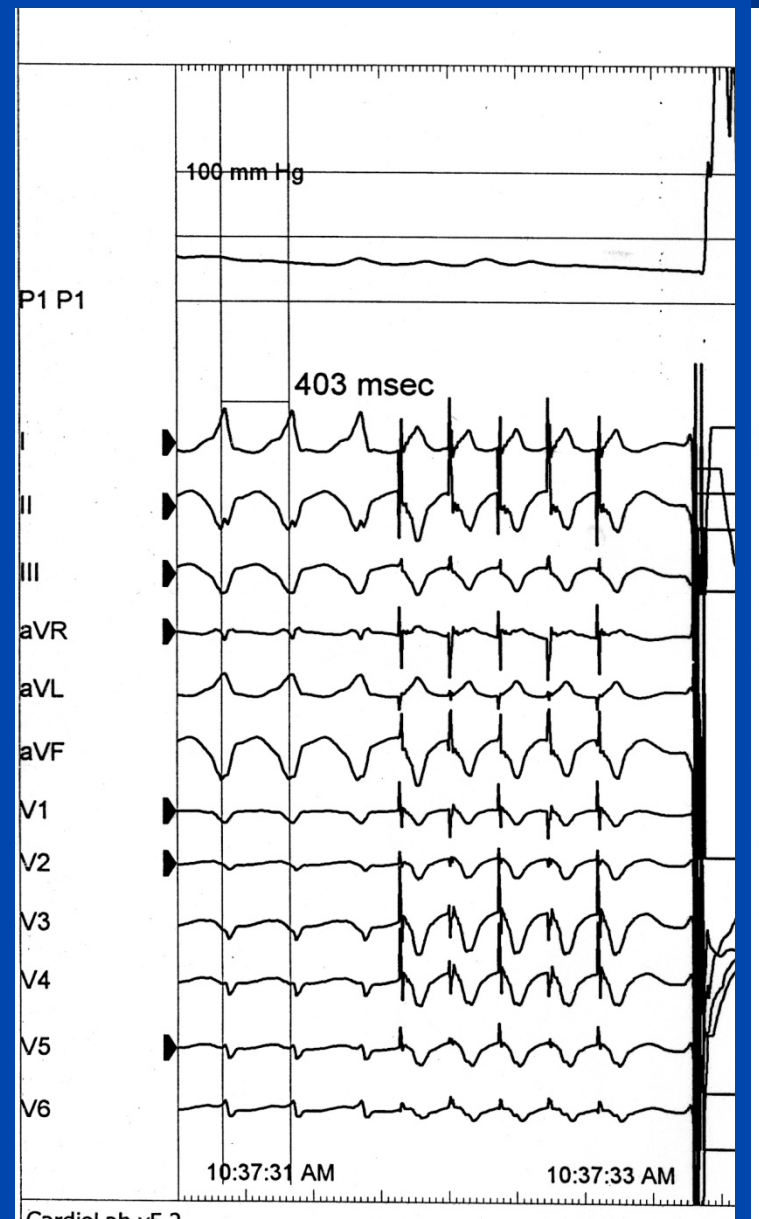
Microaxial





Induction of VT on vs. off LV Support





Use of the Impella ™ Microaxial Blood Pump for Ablation of Hemodynamically Unstable Ventricular Tachycardia

Abuissa H, Roshan J, Lim B, Asirvatham S

Use of the Impella™ Microaxial Blood Pump for Ablation of Hemodynamically Unstable Ventricular Tachycardia

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From the *Creighton University, Omaha, Nebraska, USA; †Christian Medical College, Vellore, India; ‡Division of Cardiovascular Diseases and Internal Medicine, Mayo Clinic, Rochester, Minnesota, USA; and §Department of Pediatric and Adolescent Medicine, Mayo Clinic, Rochester, Minnesota, USA

Impella™ for VT Ablation. **Ablation for ventricular tachycardia remains a challenge with suboptimal procedural success rates. One of the major causes of difficulty is precipitous hypotension when ventricular tachycardia is induced precluding even rapid mapping of the arrhythmia. We report the successful use of the Impella™ microcirculatory axial blood flow pump in 3 patients with hemodynamically unstable ventricular tachycardia that allowed successful completion of the procedure. In these 3 patients, there was no evidence of Impella™-related valvular disturbance, iatrogenic ventricular arrhythmias, or interference with mapping and ablation catheter movement.** *(J Cardiovasc Electrophysiol, Vol. 21, pp. 458-461, April 2010)*

catheter ablation, ventricular tachycardia, heart failure, intracardiac ultrasound

Introduction

Ventricular tachycardia (VT) ablation is being performed with increased frequency, particularly in patients with structural heart disease for management of symptoms and frequent ICD shocks.[1–5] VT ablation outcomes, however, remain suboptimal, and several causes for difficulty during ablation have been described.[2,6–9] One of these causes for difficulty is hypotension and hemodynamic instability that results. Several approaches have been tried to maximize results despite hemodynamically unstable VT including the use of antiarrhythmic agents to slow the arrhythmia, noncontact mapping, and substrate-based mapping approaches that do not require VT initiation.[10–15] While ablation success occurs with both substrate-based and with complete mapping of the VT circuit approaches, sometimes when the clinical VT morphology is known, specific mapping of that arrhythmia may be desirable to better anticipate clinical impact.[11,14] Circulatory assist devices have been tried to support systemic flow during induced VT;[16,17] however, large transseptal puncture is needed.

In this report, we describe 3 patients with highly symptomatic drug refractory VT and failed prior ablation as a result of hemodynamic instability that precluded detailed mapping and completion of the procedure. To our knowledge, this is the first description of using the Impella™ technology (Abiomed Inc., Danvers, MA, USA) to aid complex VT ablation. The Impella™ 2.5 is a miniaturized percutaneous cardiac assist device that provides up to 2.5 L/min forward flow from the left ventricle into the systemic circulation[12] (Fig. 1). This device is approved by the FDA for temporarily supporting the systemic circulation.[18,19]

Patient Number 1

A 52-year-old male presented with ischemic cardiomyopathy from a remote large anterior wall myocardial infarction. The patient had an anomalous coronary artery that was surgically reimplanted following the myocardial infarction. The patient developed hemodynamically significant VT and underwent defibrillator (ICD) implantation. The patient experienced increasing occurrences of VT that was refractory to amiodarone therapy. A previous attempt at radiofrequency ablation yielded partial decrease in VT occurrence, but hemodynamic instability had made mapping of clinical arrhythmias challenging.

Electrophysiology Study and Ablation

Because of continued symptomatic VT, a second radiofrequency ablation procedure was performed in addition to standard catheter access as described previously.[7,10] Intracardiac ultrasound (ICE) (Siemens™, Mountain View, CA, USA) with a linear phased-array catheter was used. VT was easily inducible and hemodynamically unstable. Using the left femoral arterial route, the Impella™ device was positioned in the left ventricle, crossing the aortic valve, as has been described.[20] Briefly, a multipurpose catheter was first advanced into the left ventricular apex to obtain guidewire access. Over the wire, the Impella™ device was positioned crossing the aortic valve with fluoroscopic (Fig. 2) and ICE guidance (Fig. 3). ICE was used to monitor aortic valve function and for online assessment of appropriate Impella™ positioning.

Multiple hemodynamically unstable VTs were induced. The clinical VT, that was a right bundle-branch block normal axis VT, was induced as well, but significant hypotension precluded arrhythmia maintenance and mapping. We performed a combined method approach that included extensive high density scar and arrhythmogenic channeled mapping. At sites of slow conduction between scars, exit site mapping for the VT as well as entrainment mapping of the induced clinical and repeatedly

Dr. Packer reports participation on research grants supported by Biosense Webster and Siemens, and serving as a consultant or on their advisory boards; receiving honoraria relevant to this topic; and owning a patent on 4D, 5D mapping. No other disclosures.

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doi: 10.1111/j.1540-8167.2009.01673.x

Abuissa et al. J CV EP, 21:458-461

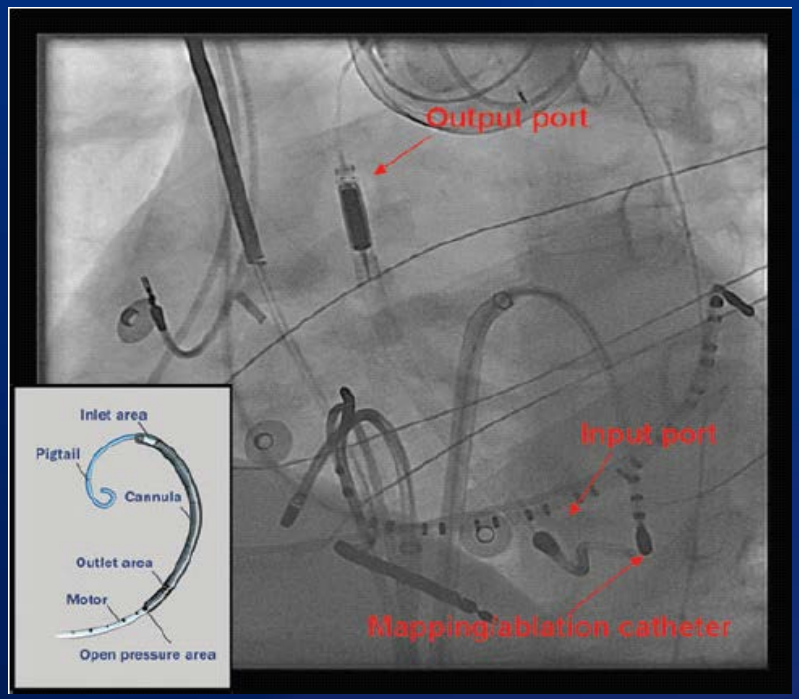
Micro Axial Blood Pump Support for Hemodynamically Unstable VT

Patients

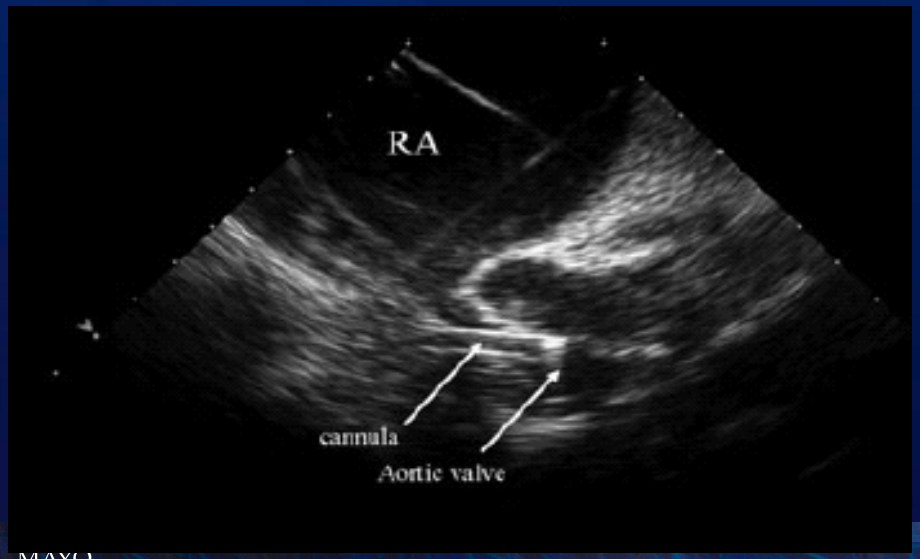
72 y.o with Isch CMP + VT

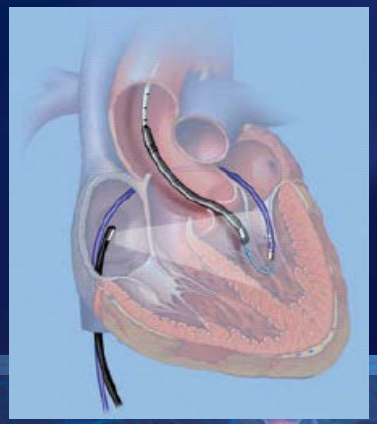
72 y.o. with Non-Isch CMP + ICD

42 y.o. Idiopathic CMP + VT



Positioning





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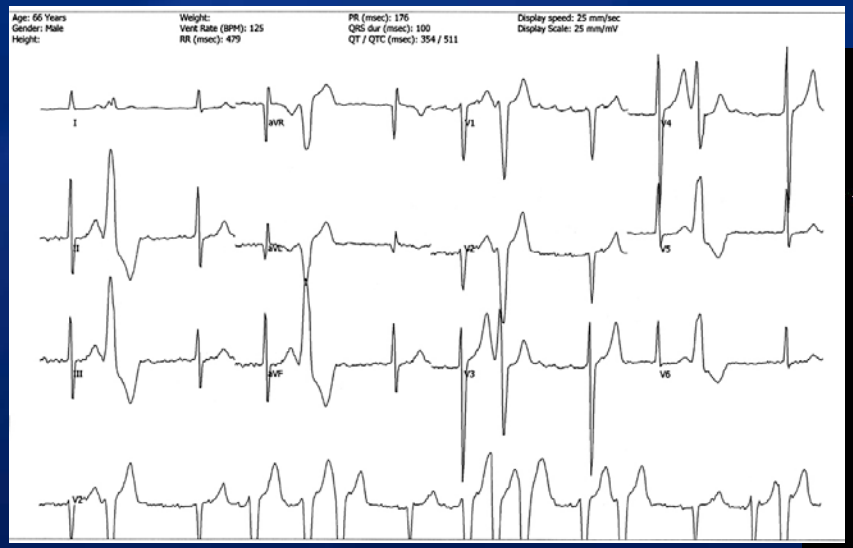
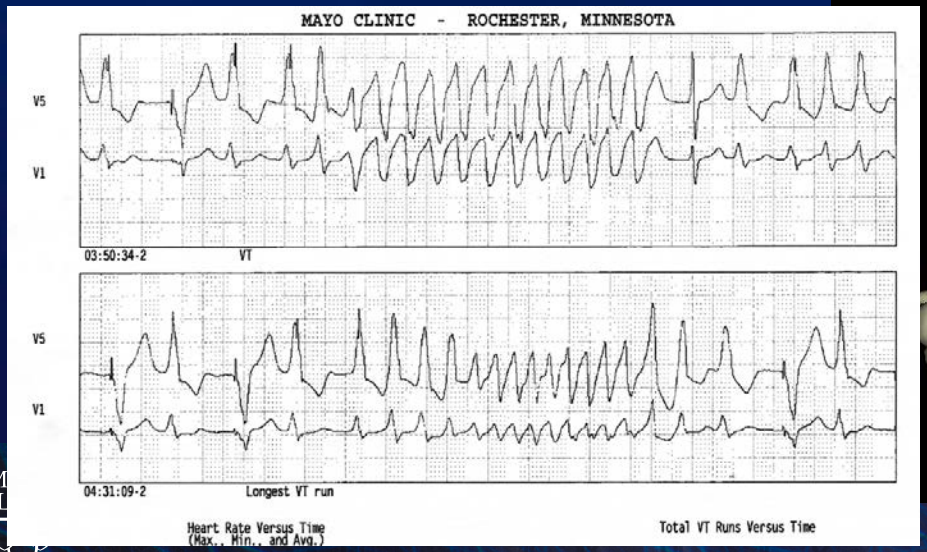
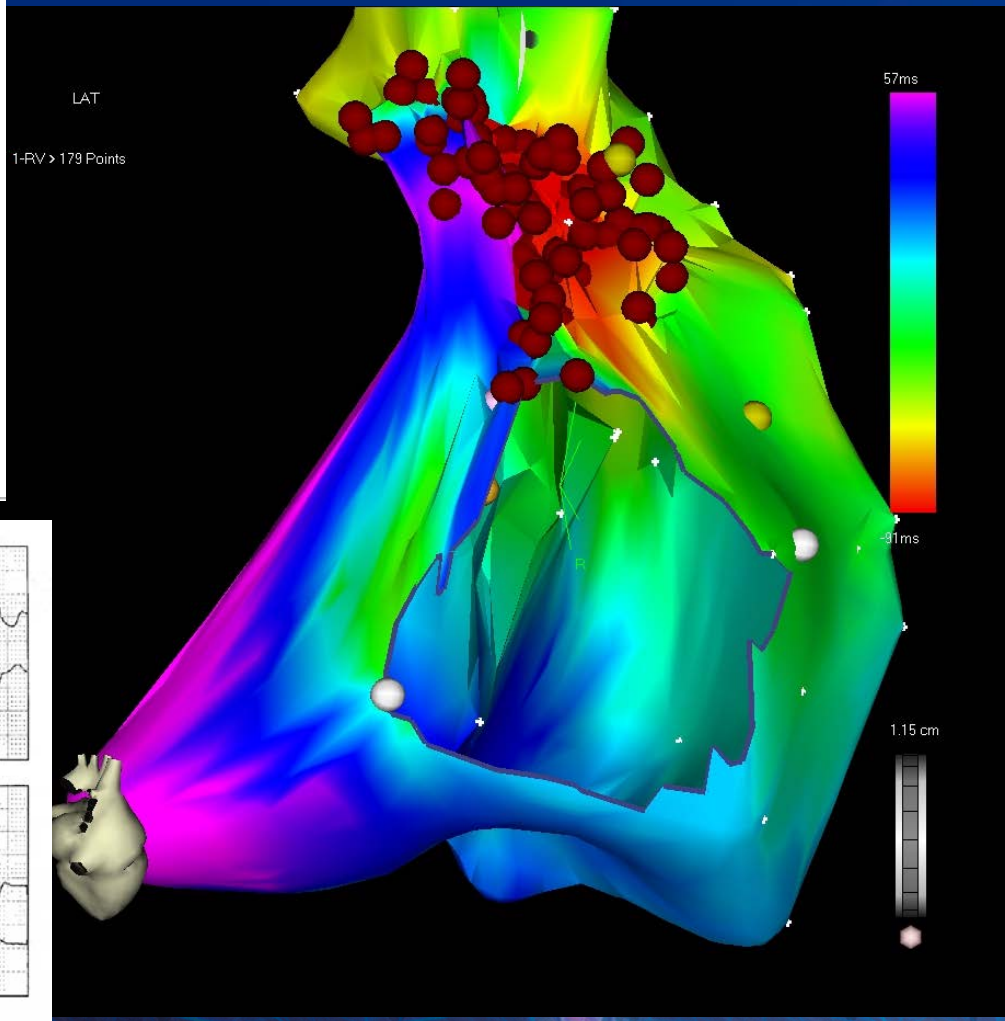
Abuissa/Asirvatham JCE 21:458, 2010

Ablation of Unstable Polymorphic VT







Application of Hemodynamic Support Devices in VT Ablation

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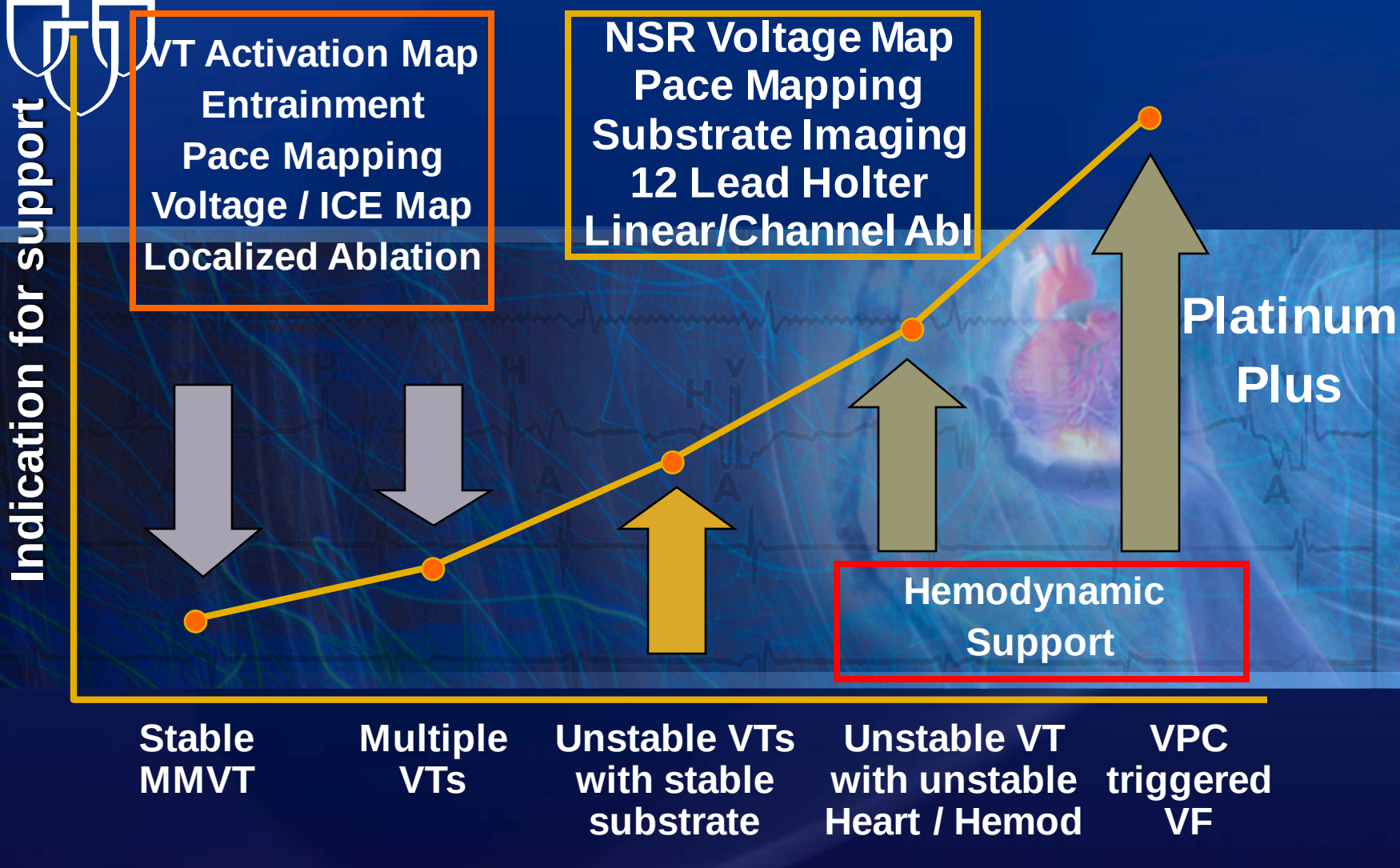
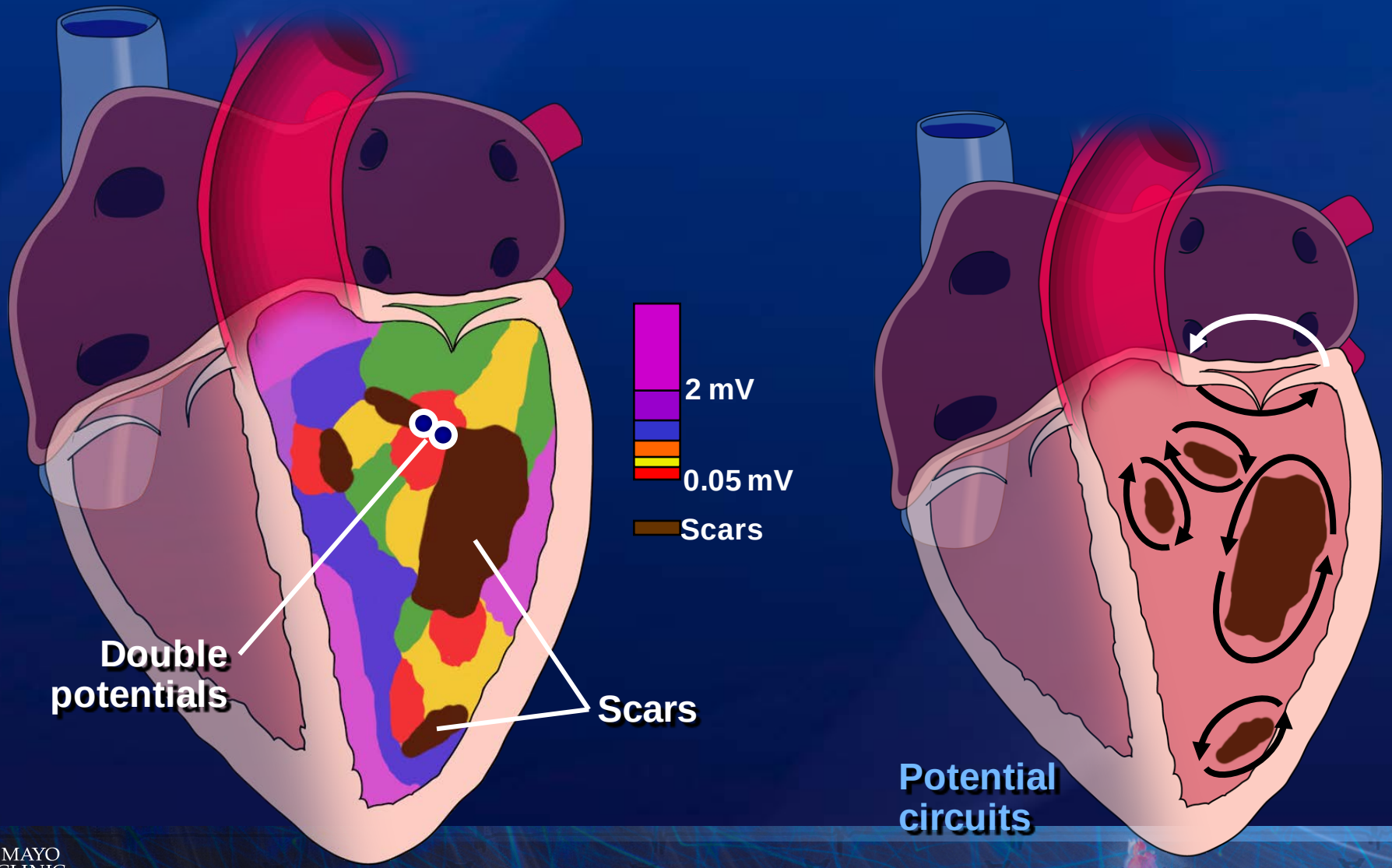


Reentrant Ventricular Tachycardia

‘Scar Mapping’



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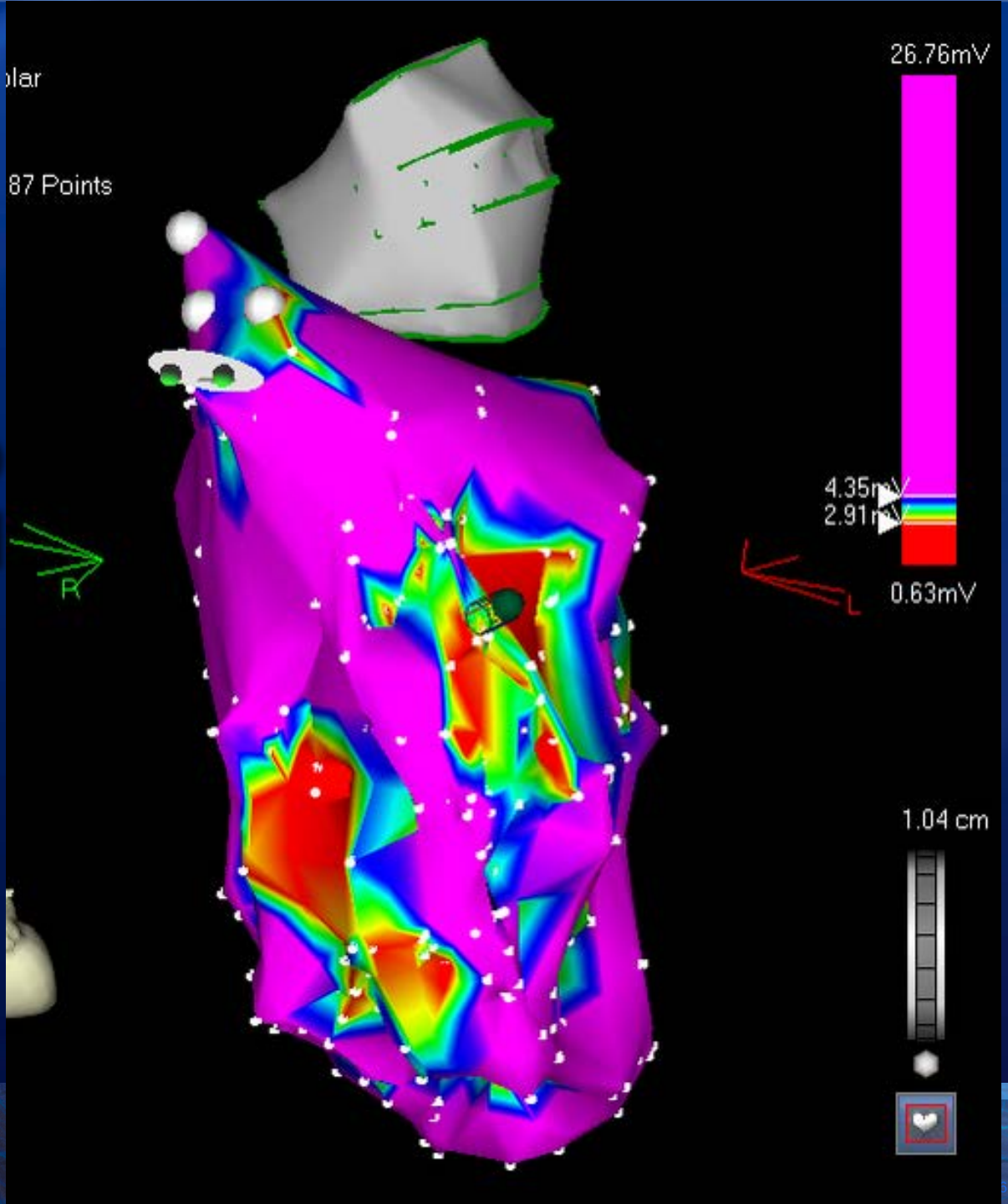
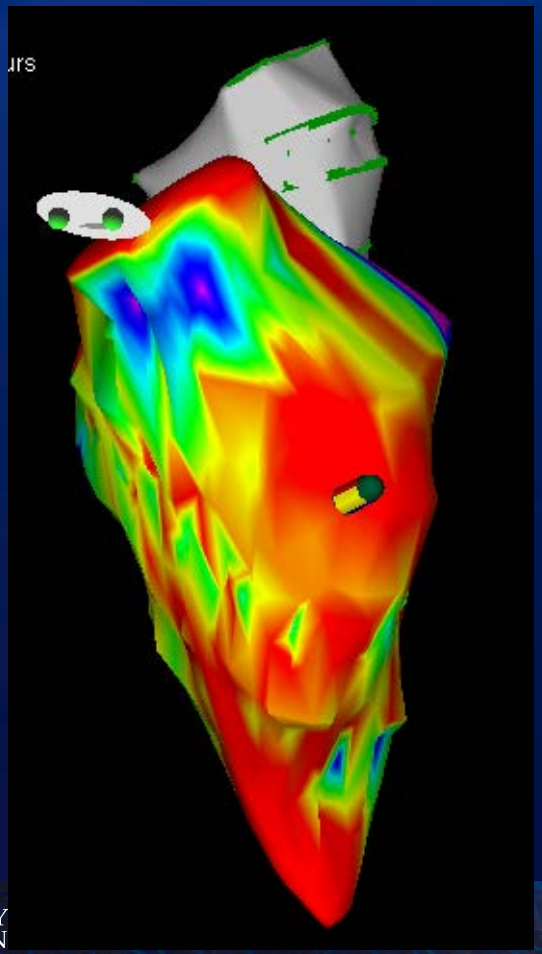
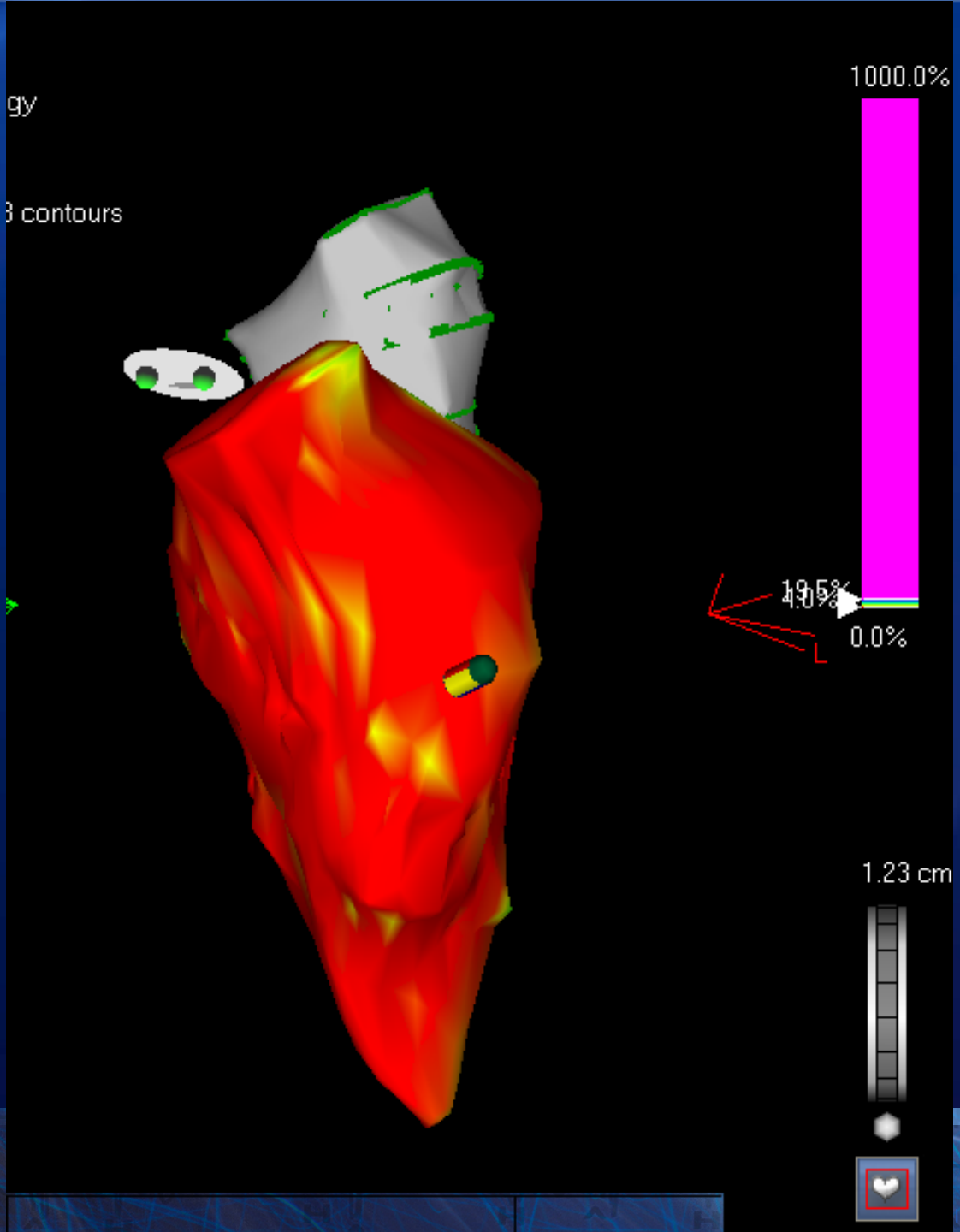
Voltage Map of Lateral MI

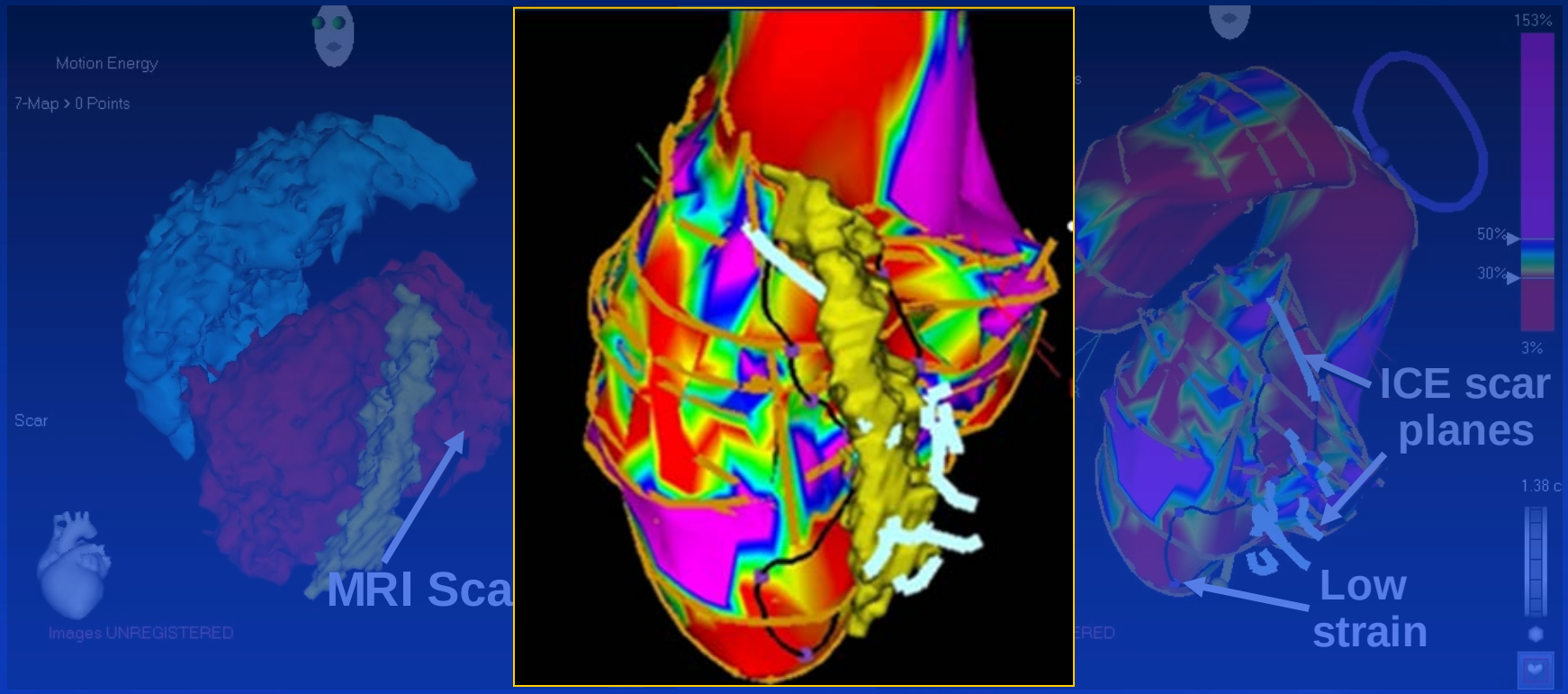


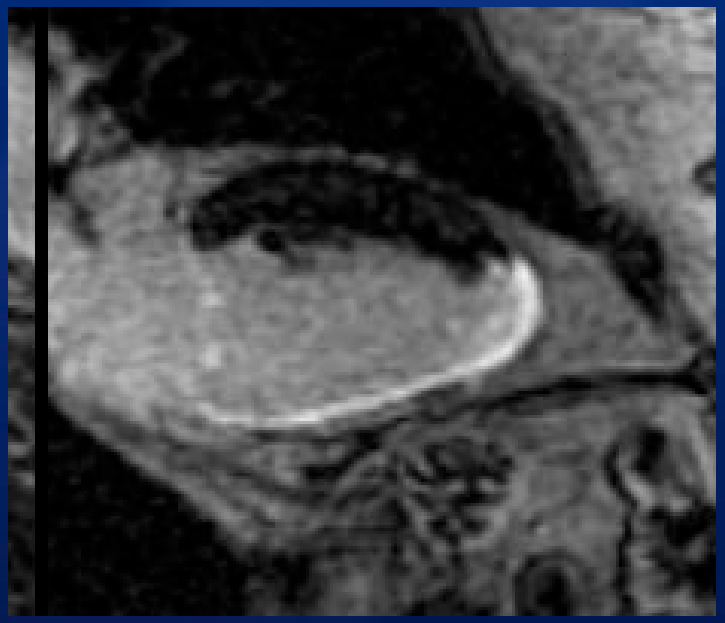
Impaired Strain at Site of Lateral MI



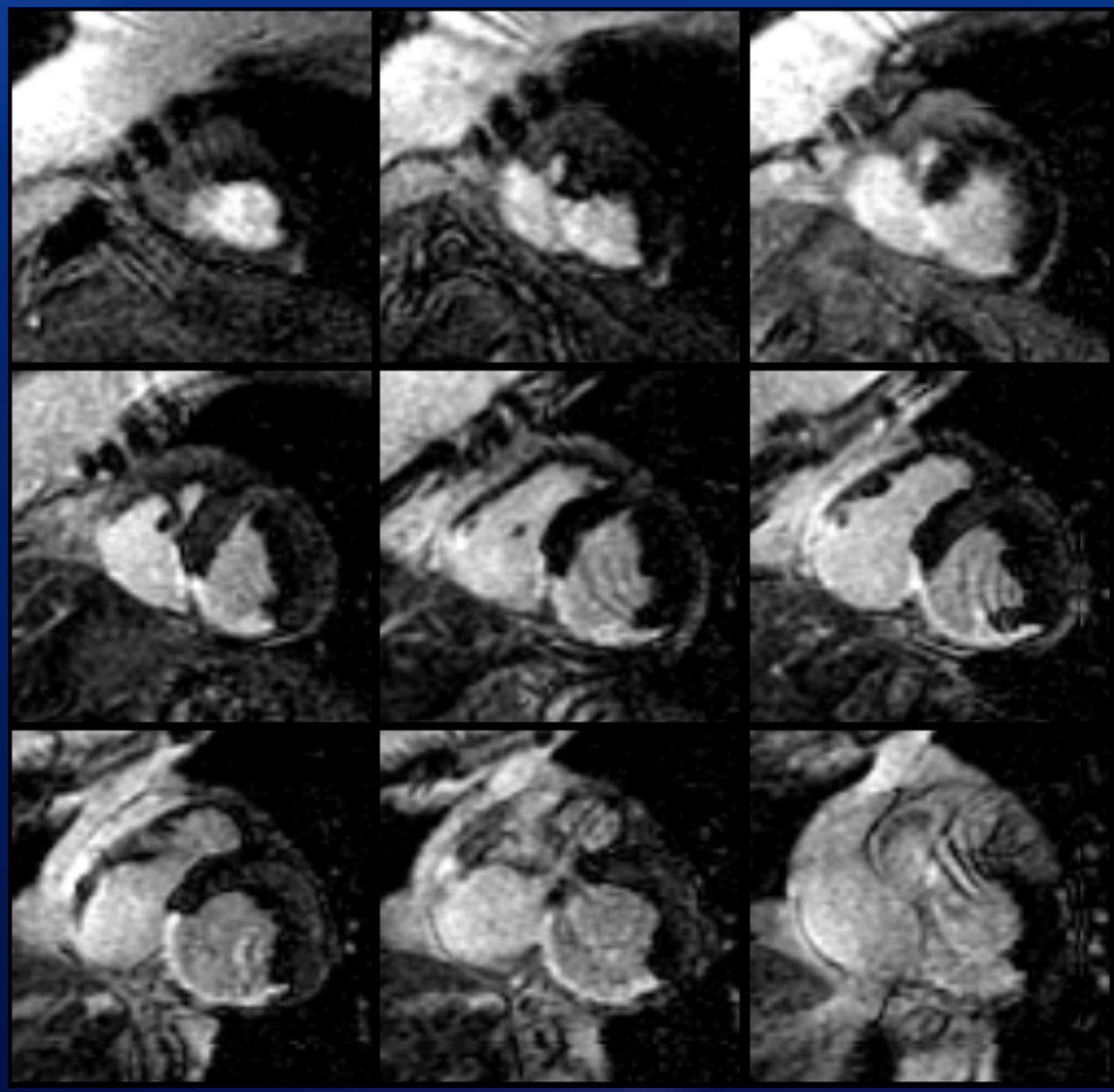


Multi-Modality Scar Integration





Gadolinium
T2 weighted
H2O imaging



Follow-up scan now at 6 weeks
Only thin scar remaining in inferior wall

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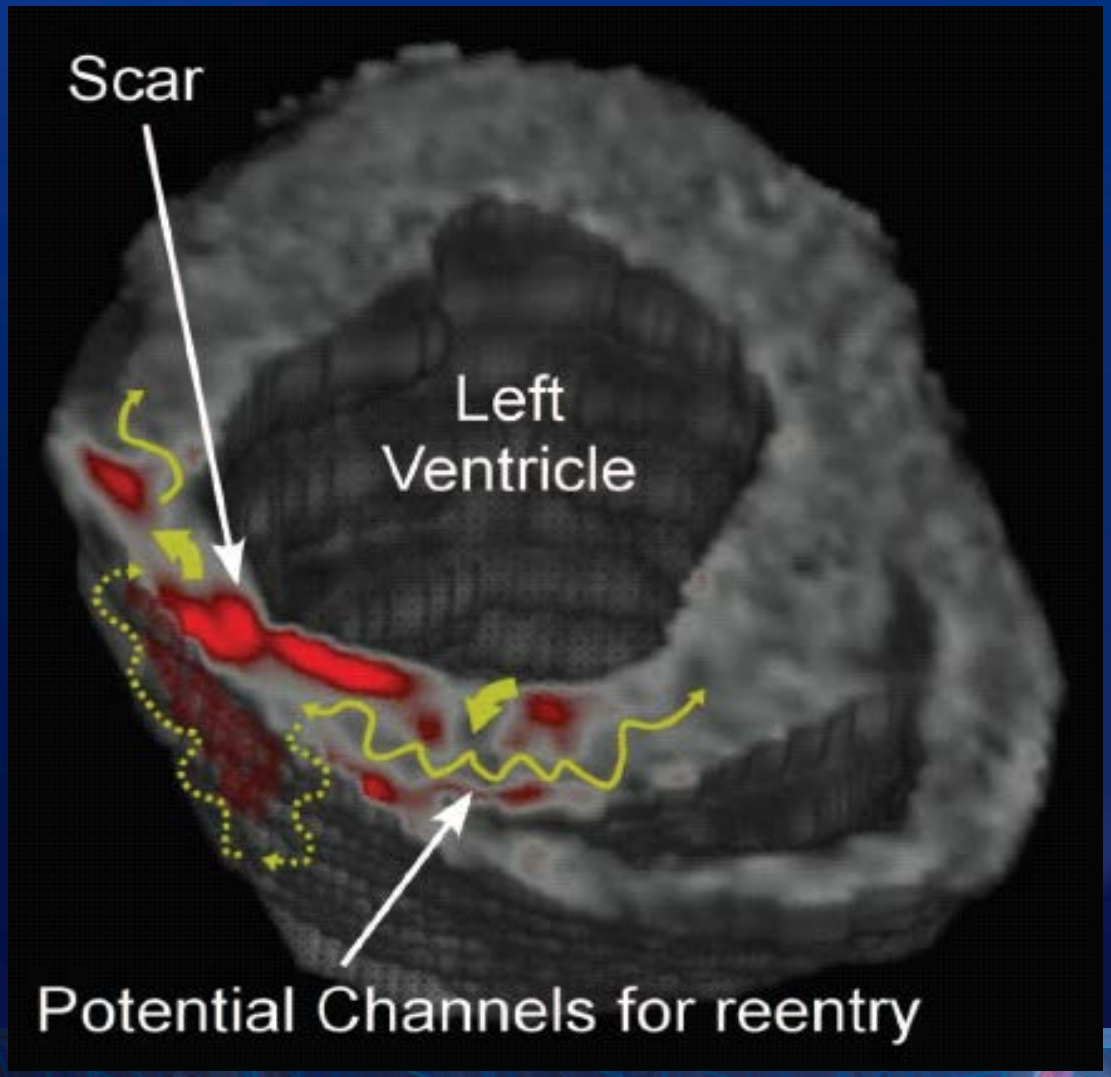
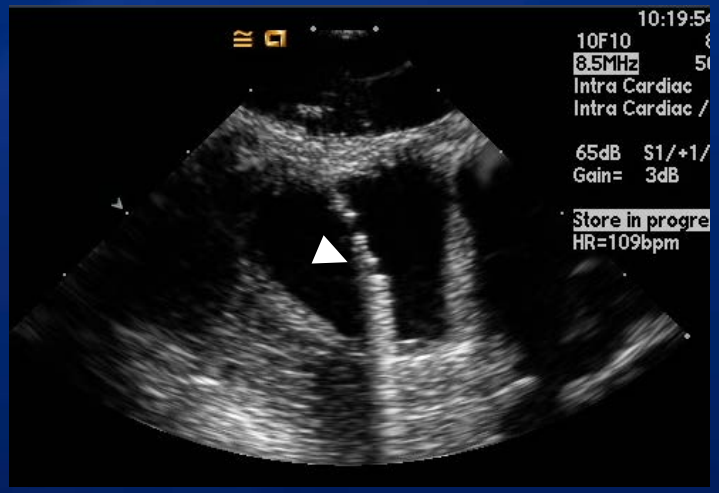
DE-MR Scarring Providing Candidate Reentrant Sites



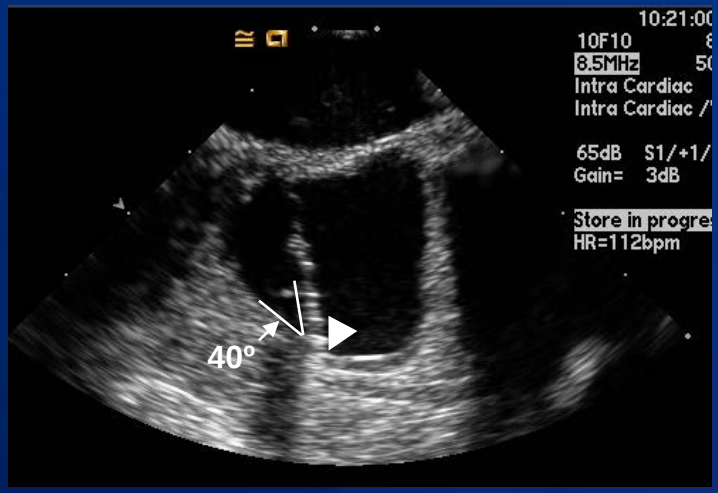
Nazarian/Halperin Circ A&E 2:63, 2009

ICE-based Catheter Tip/Tissue Contact

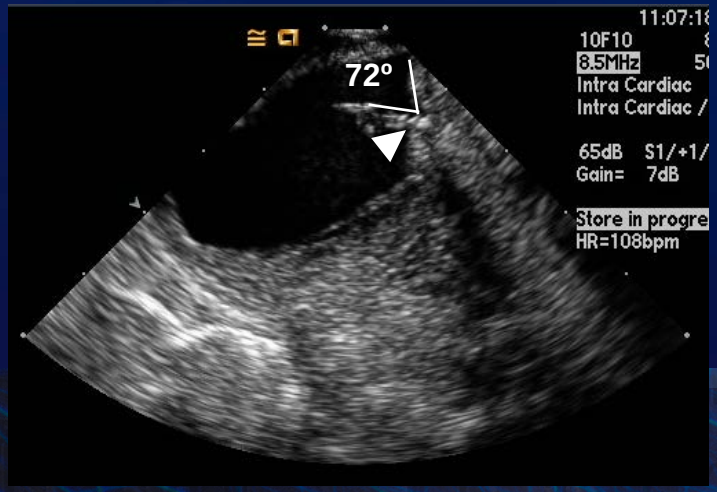
No Contact



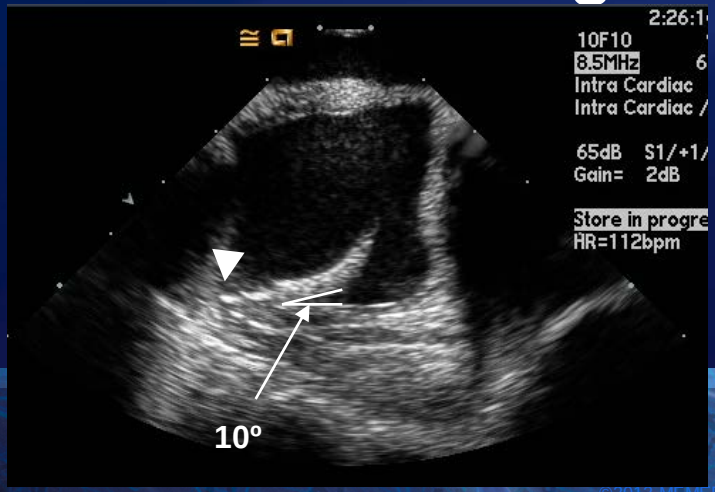
Minimal Contact



Consistent Contact



Tissue Tenting



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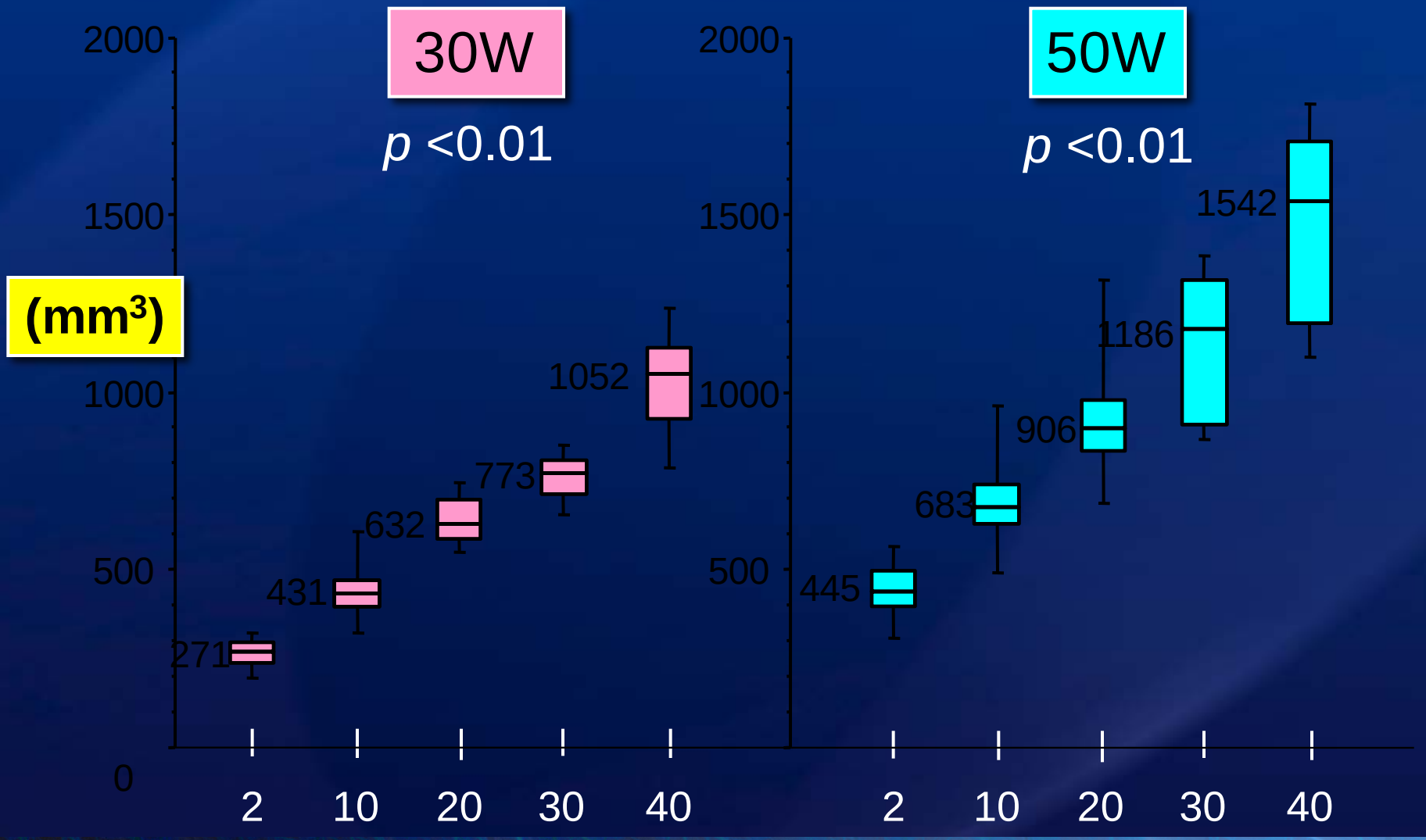
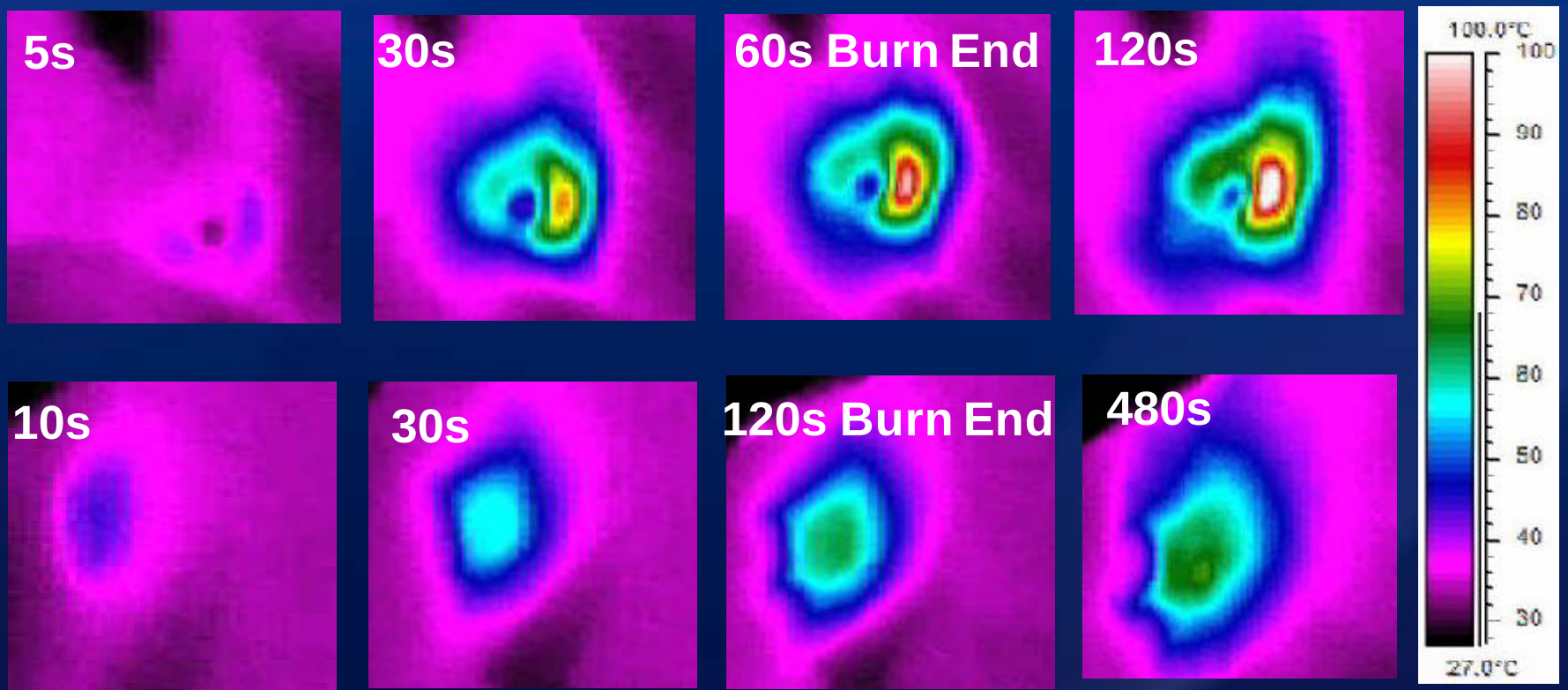
Lesion Volume vs. Contact Force



Results: Thermal Latency Effect

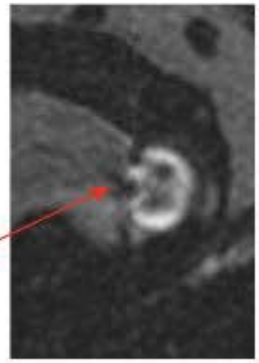
RAA

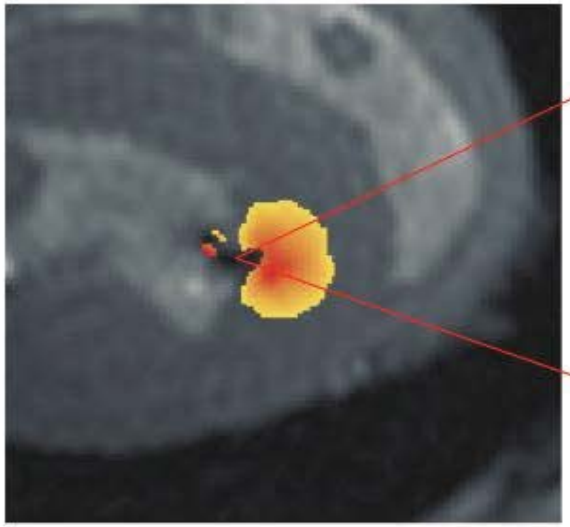


LV

Progressive Heating Judged by Delayed Enhancement

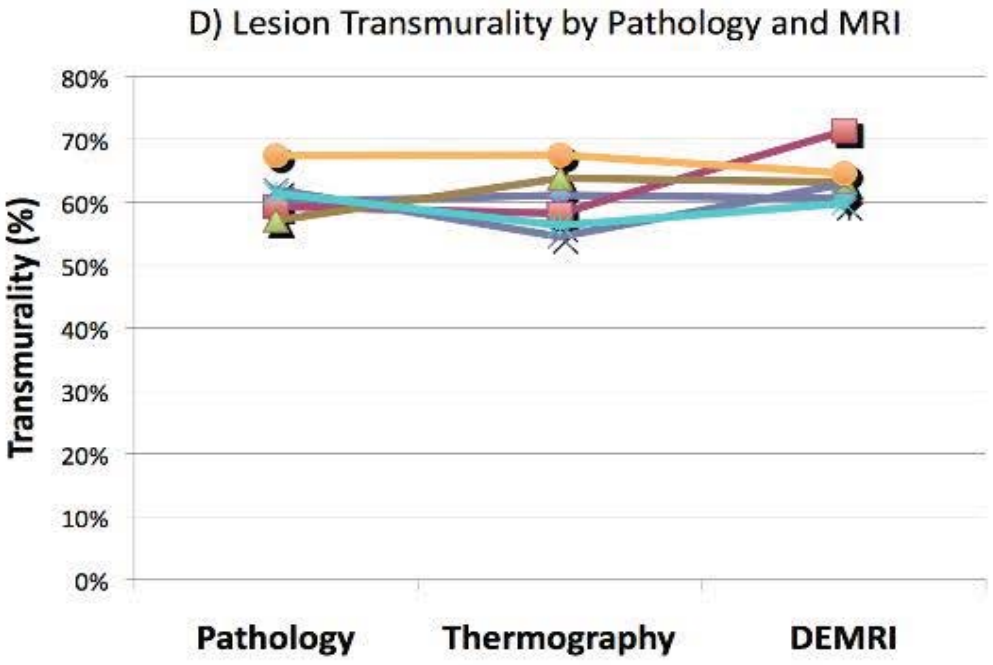
B) Delayed Gadolinium Enhancement image





A) Temperature Change > 50°C

C) TTC Stained Gross Pathology



Kolandaivelu / Halperin et al, Circ A&E 3:324, 2010

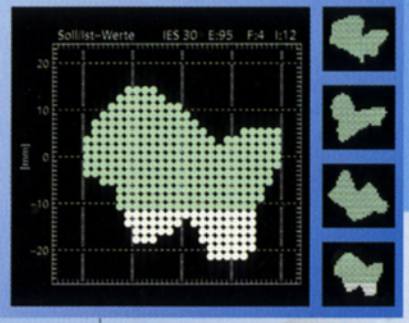
Synchrotron (Particles up to 70% of light speed)

Ion Source Carbon

Ion Source Proton

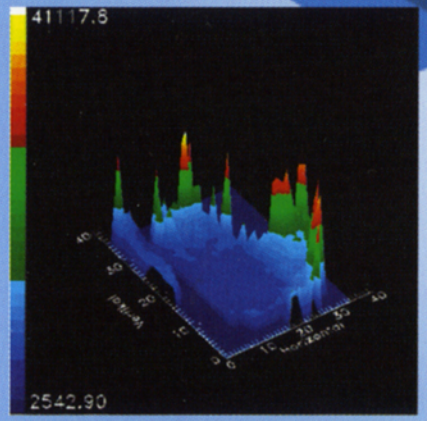
Linear Accelerator

Online Monitoring



Scanning System

Monitor System



Intensity distribution of one slice

The intensity for each pixel is delivered according to the calculated treatment plan. Areas which have been already passed by a particle beam receive less dose in subsequent irradiations.

Wire Chambers

Ionization Chambers

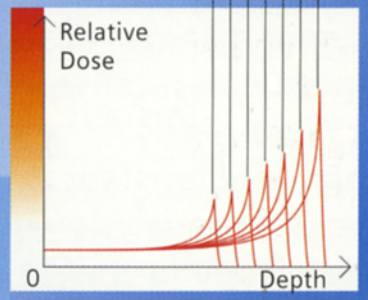
Radiation Control

Cross-section through the irradiated tumor volume. Every section represents a different beam range. The treated elements are shown in green.

Example

Depth 5 cm:
Proton 80 MeV
Carbon 145 MeV/u

Depth 25 cm:
Proton 195 MeV
Carbon 375 MeV/u



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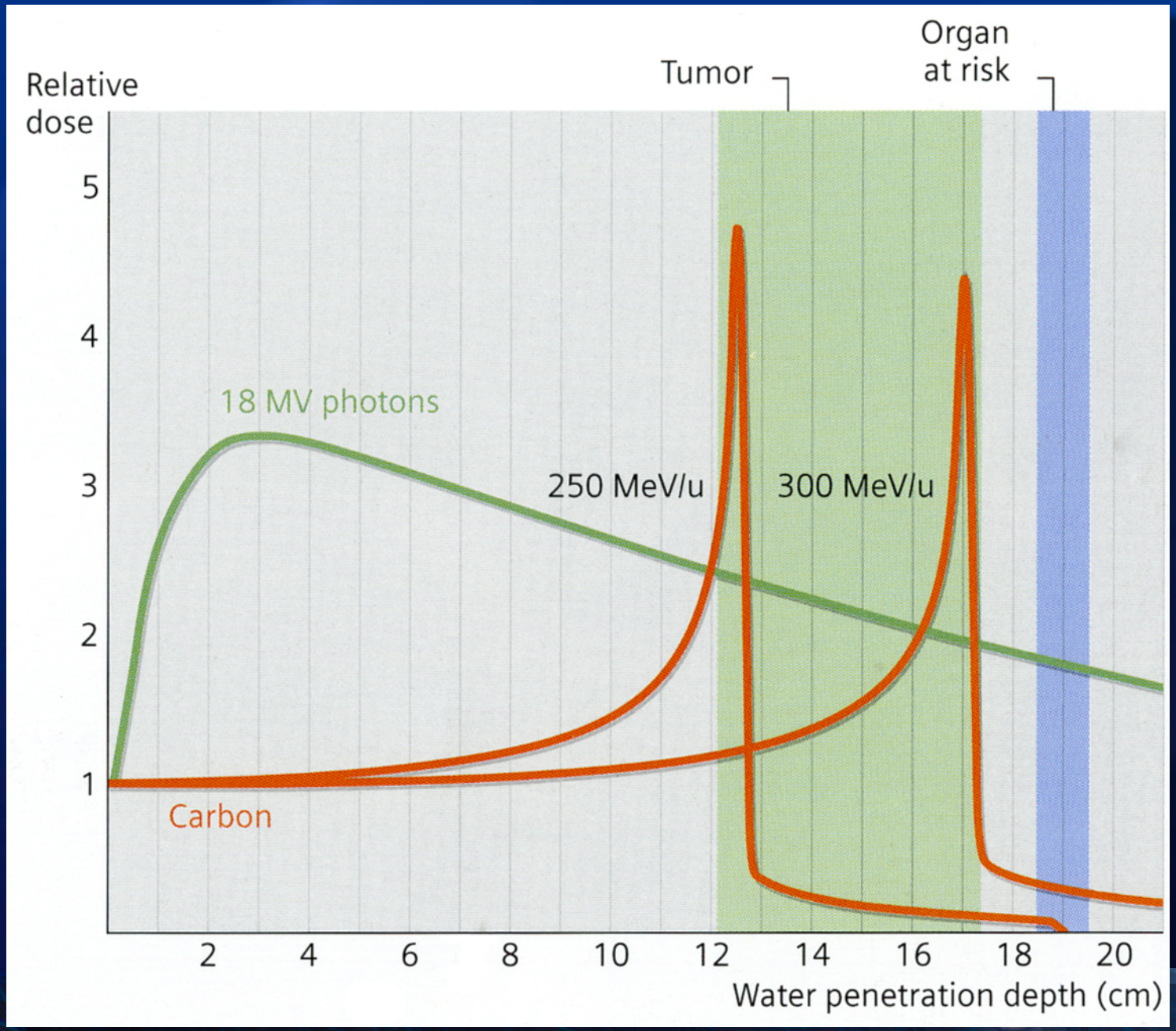
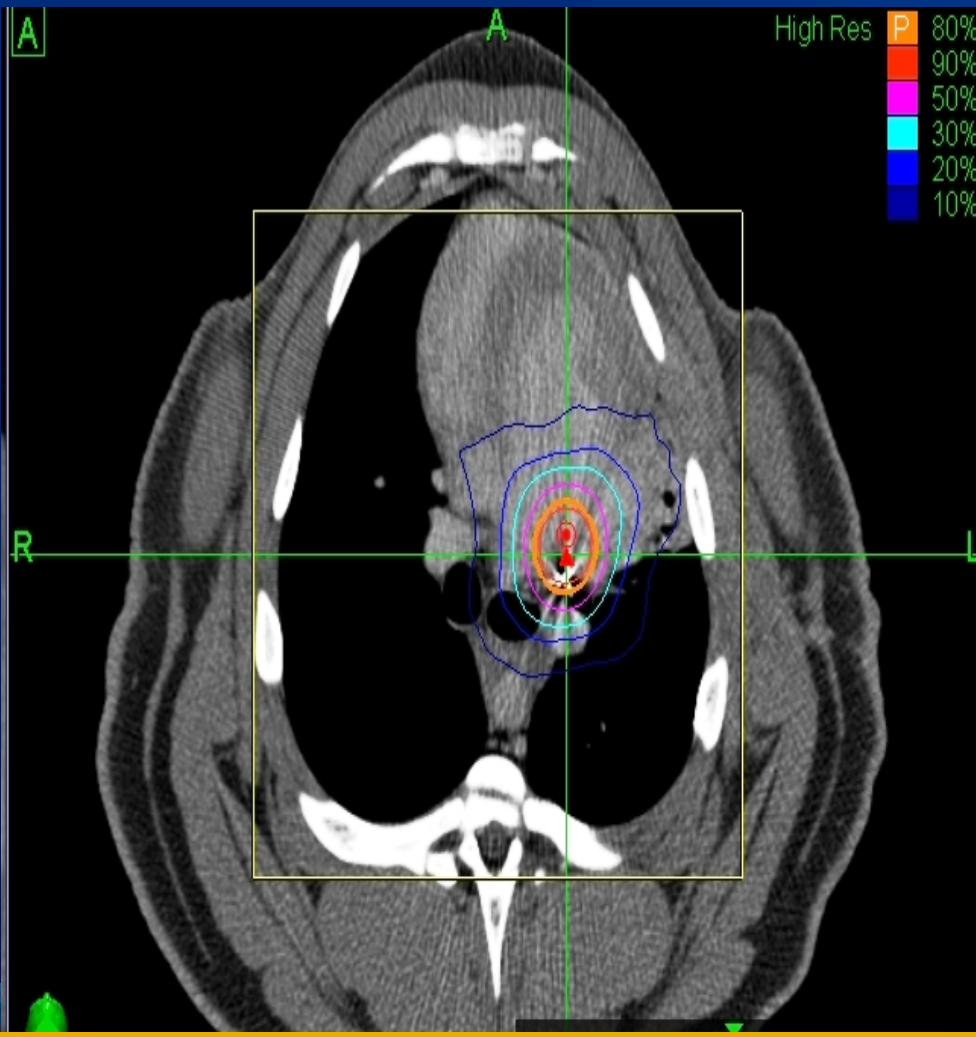


3 D Treatment Plan with Dose Isochrone Lines

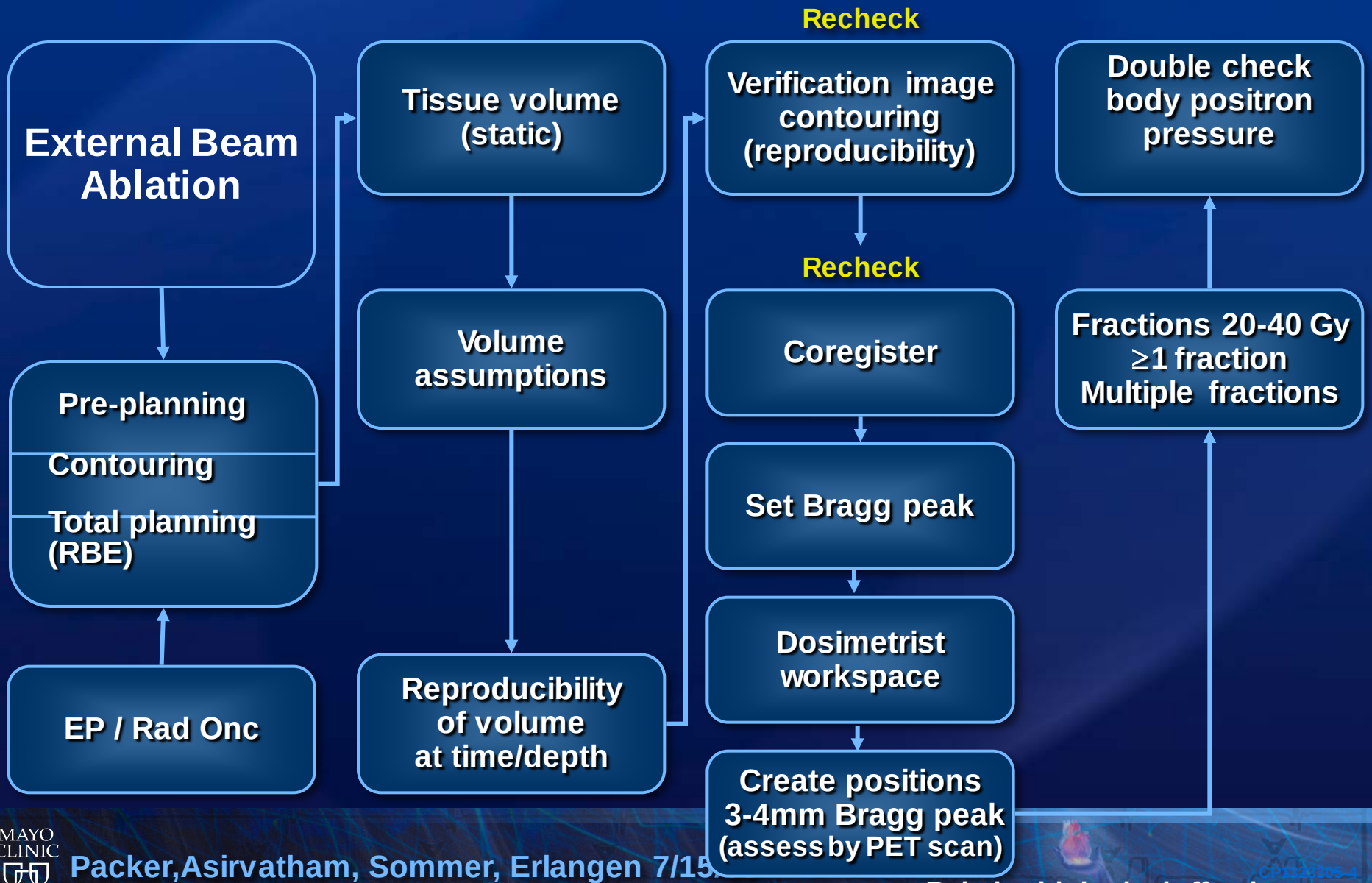
Sagital

Transaxial

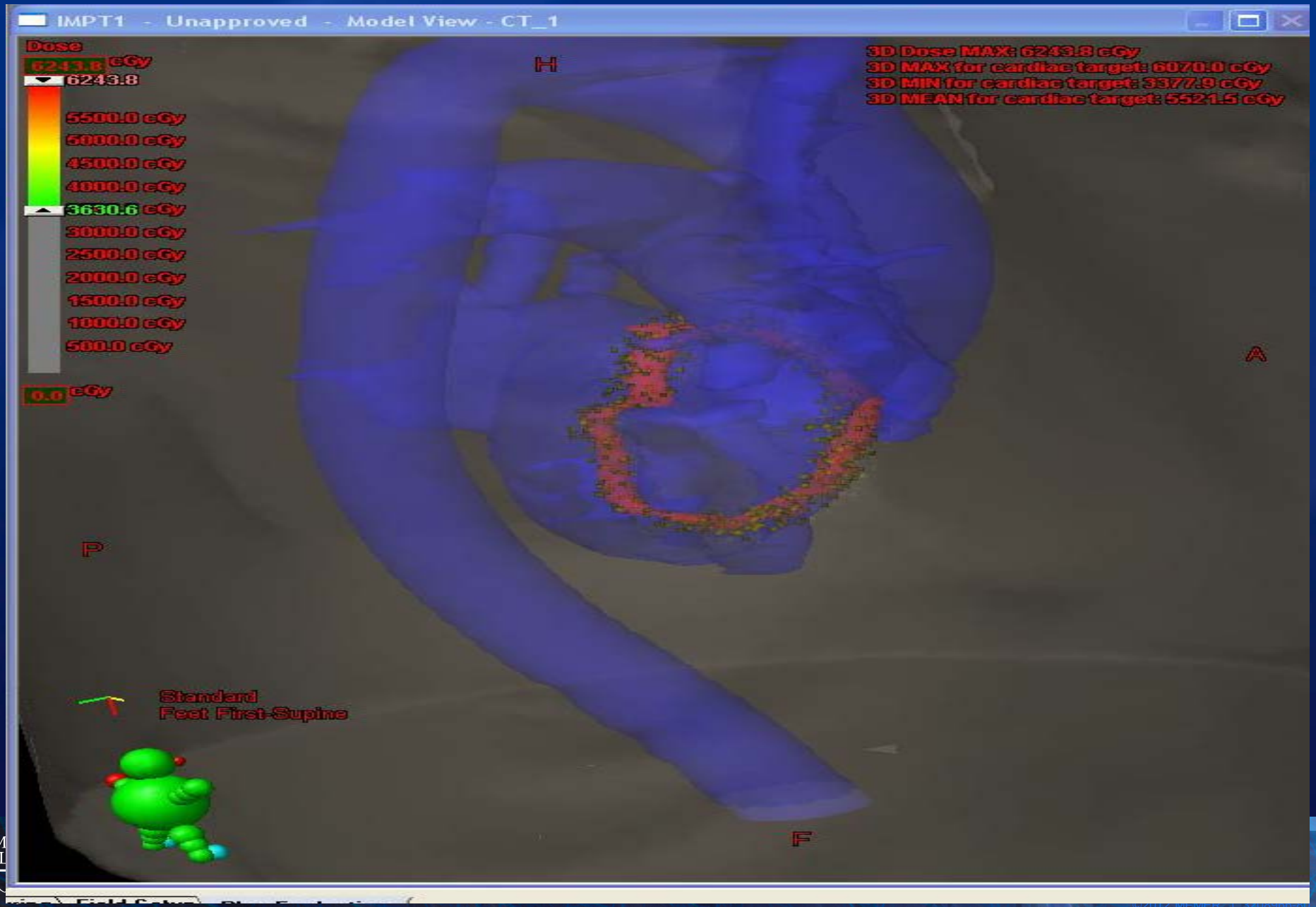


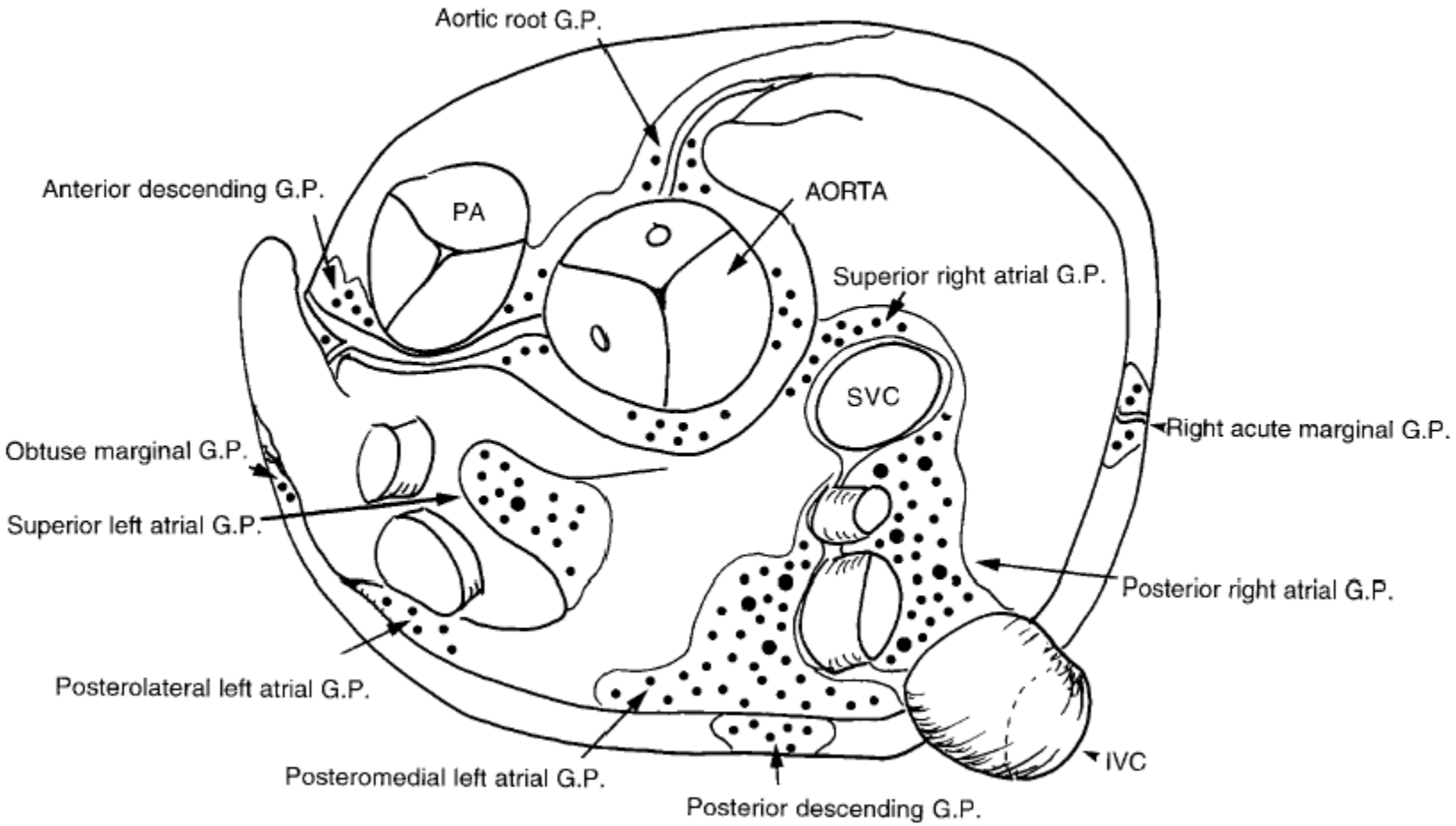
Dose, or energy fall off, occurs rapidly, so only a discrete area is ablated.

Approach to Energy Delivery



2 Field Scanned Proton Dose Cloud

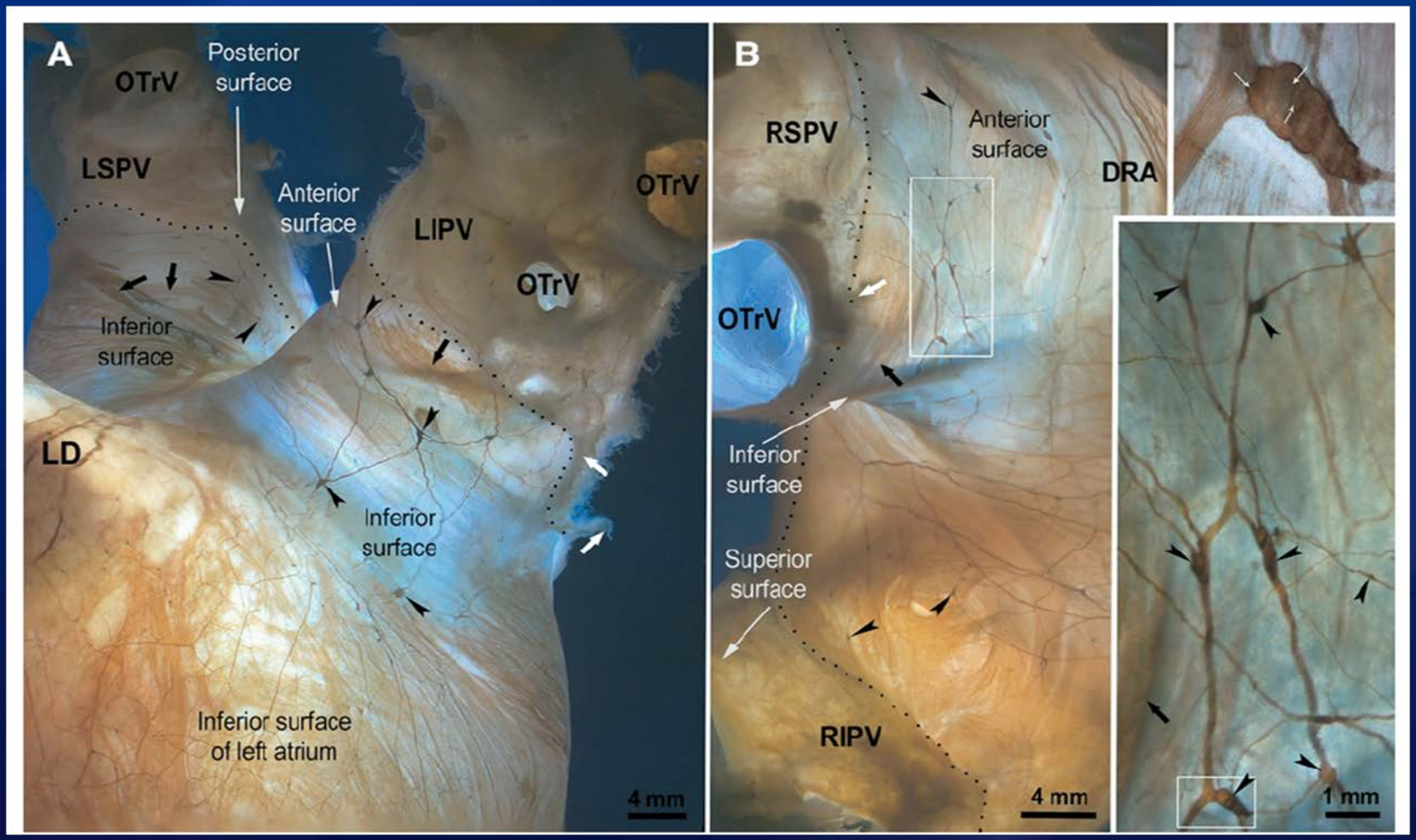




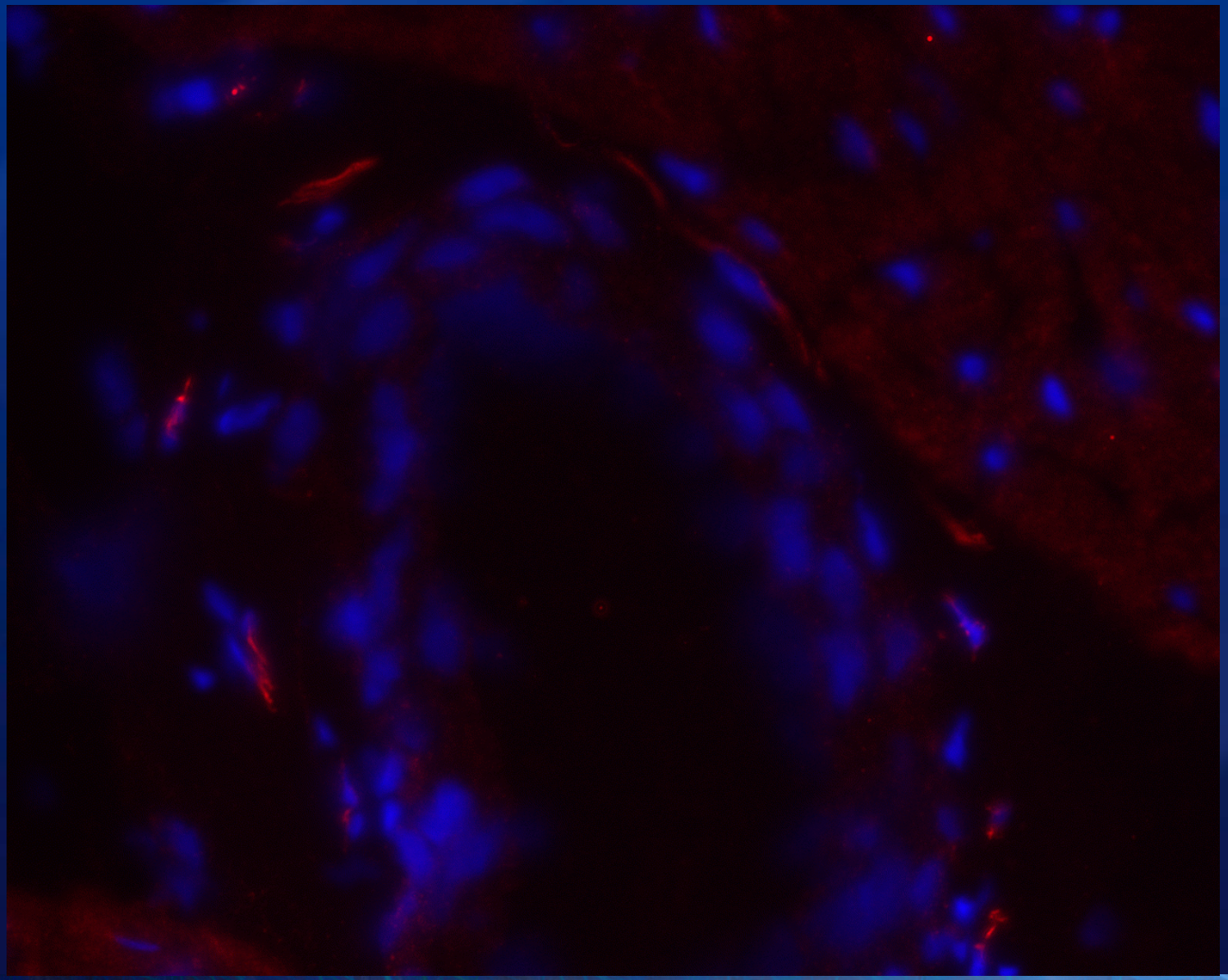
Courtesy of Dr. Michael Ackerman

MAYO CLINIC

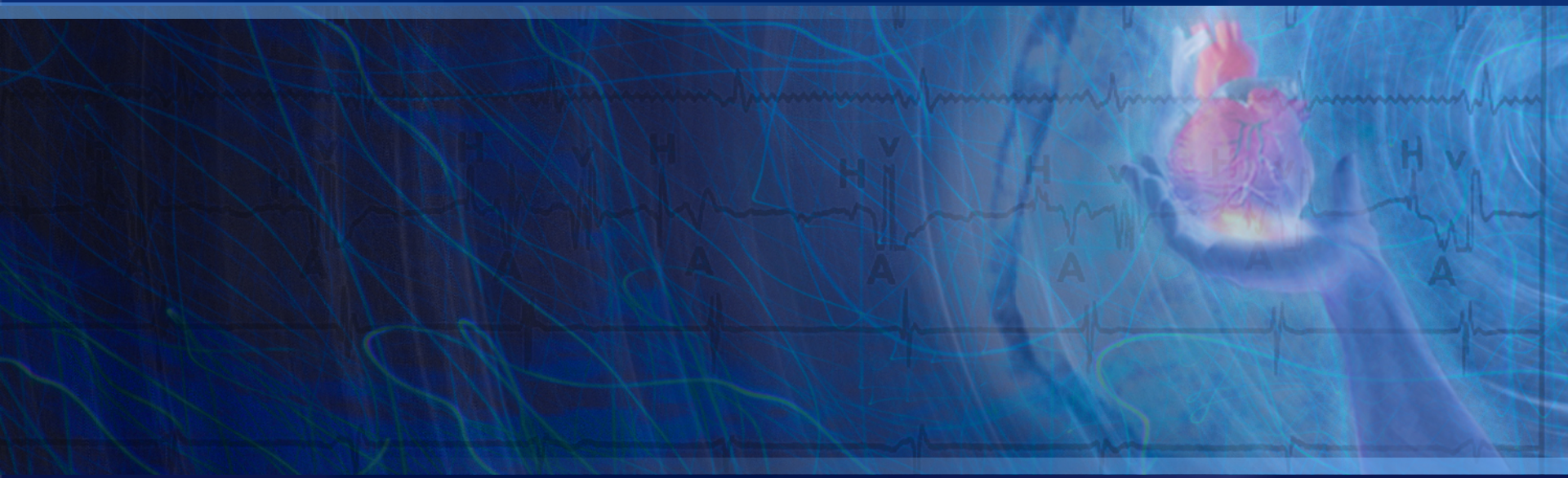
Figure 1A



Left Ventricle, Epicardium, Acetic Acid/Ethanol, Dako (Kit)



Ventricular Tachycardia Ablation in Patients with Structural Heart Disease



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