# Electrical Intervention of the Heart

**Seil Oh, MD, PhD**

Seoul National University College of Medicine

**12/3/2008 공대**

**No relationships to disclose**

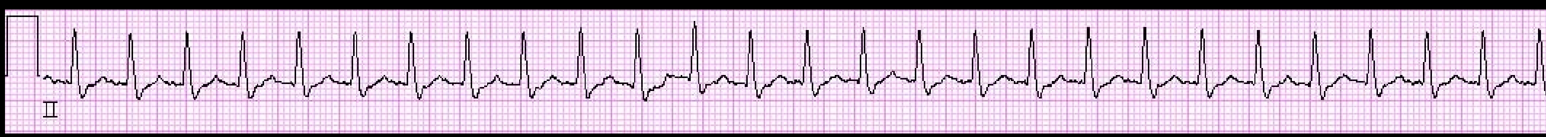

딱 한 놈만 살아남는다!
좋은놈
나쁜놈
이상한놈
〈장화, 홍련〉〈달콤한 인생〉 김지운 감독작품 송강호 이병헌 정우성
2008.7
www.3nom.co.kr


SERGIO LEONE
CLINT EASTWOOD
ELI WALLACH
LEE VAN CLEEF
THE GOOD
THE BAD
AND THE UGLY

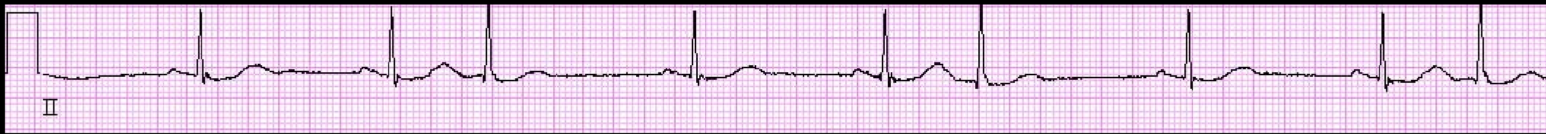
# What is Arrhythmia?

## The Slow

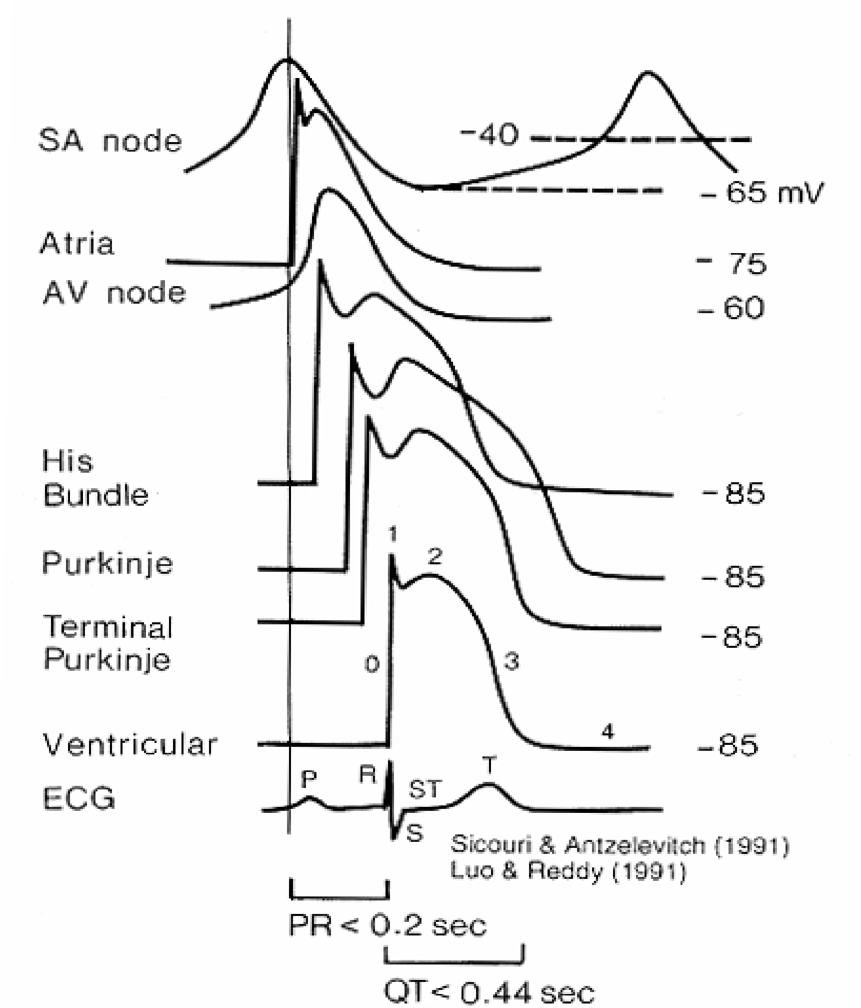

## The Fast

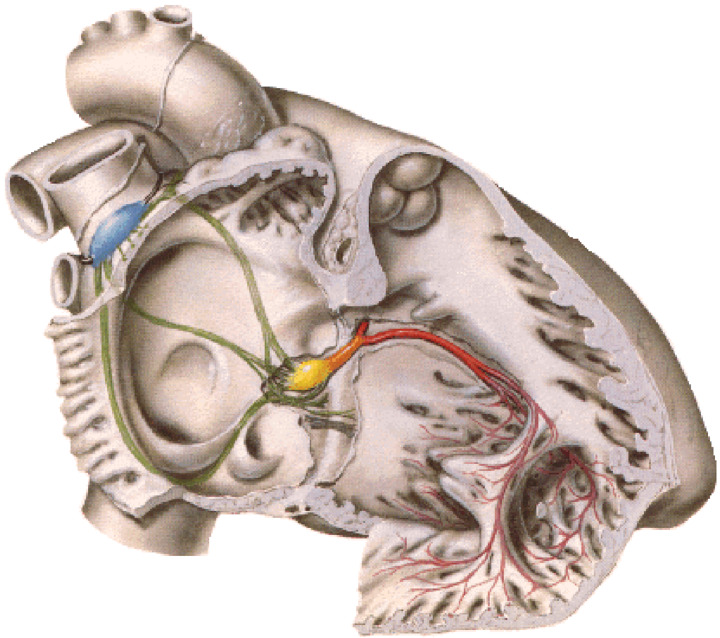



## The Irregular



# Conduction System



# Normal Activation Sequence

| Structure | Conduction velocity (m/s) | Intrinsic frequency (bpm) |
|---|---|---|
| SA node | <0.01 | 60-100 |
| Atrium | 1.0-1.2 | - |
| AV node | 0.02-0.05 | 40-55 |
| His bundle | 1.2-2.0 | 40-55 |
| Bundle branches | 2.0-4.0 | 25-40 |
| Purkinje fibers | 2.0-4.0 | 25-40 |
| Ventricle | 0.3-1.0 | - |

Katz. Physiology of the Heart, 4th ed., 2006, p.429

# 부정맥의 원인

1. 원인 불명 : 원발성 전기적 현상
2. 심장질환 : 허혈성 심질환, 판막질환, 선천성 심질환, 심근증
3. 폐질환 : 폐색전증, 저산소혈증, 과탄산혈증
4. 자율신경이상 : 과민성 경동맥동
5. 전신질환 : 갑상선기능항진증, 고열, 빈혈
6. 약물중독 : 디지탈리스제제, 항부정맥제
7. 전해질대사이상 : 칼륨
8. 기계자극 : 인공심박조율기

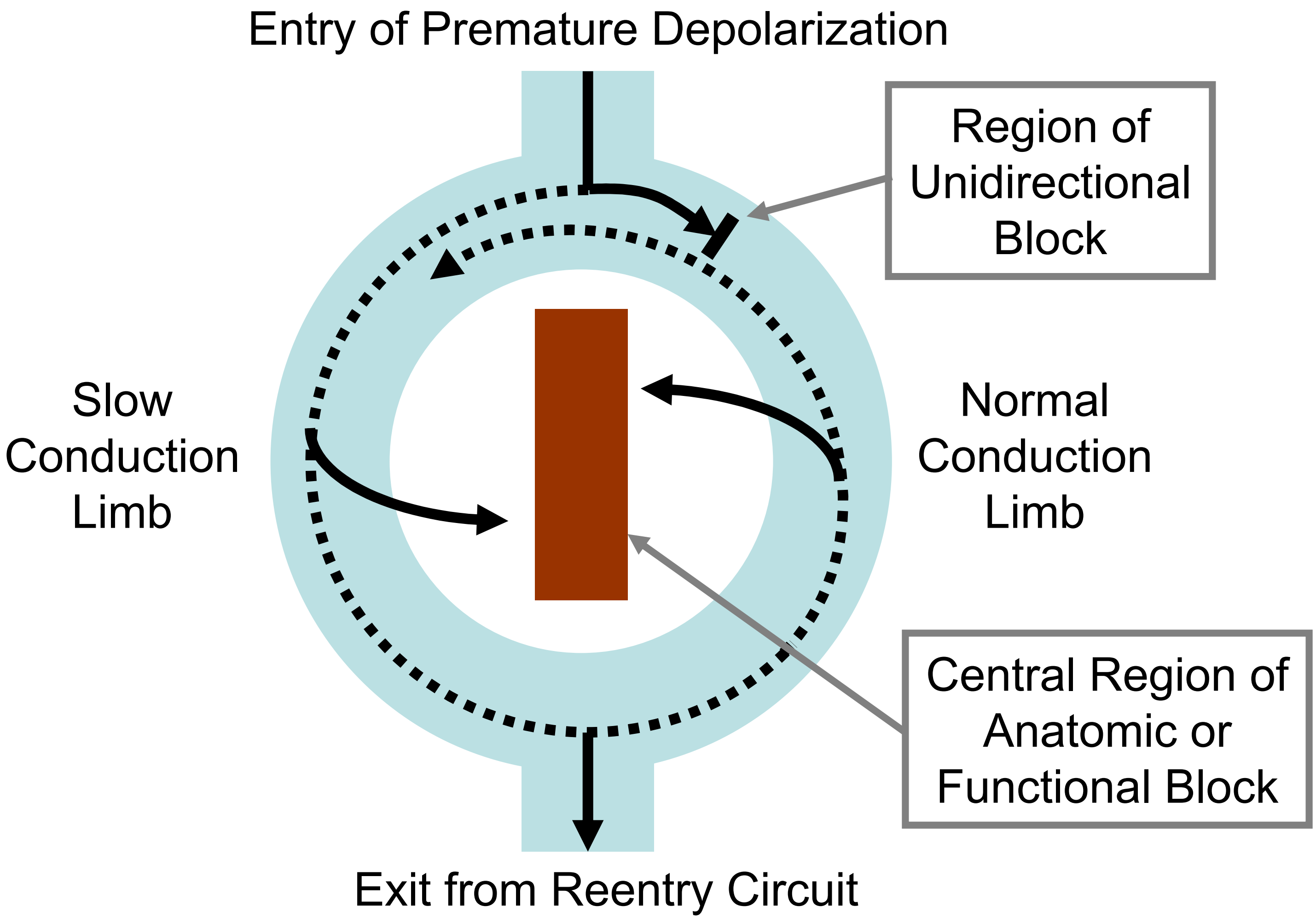
# Mechanism of Arrhythmia

1. 회귀 (reentry)
   - Propagation of an impulse around an anatomical or functional obstacle
   - 필요 조건: 회귀회로, 일방성 전도차단, 전도지연
   - 부정빈맥의 가장 흔한 발생기전임

2. 방아쇠 활동 (triggered activity)
   - 후탈분극에 의해 활동전위가 유발되는 현상
   - 후탈분극의 종류
     - Early afterdepolarization: phase 2 or 3
     - Delayed afterdepolarization: phase 4

3. 비정상적인 자동능 (abnormal automaticity)
   - Depolarization-induced automaticity

# Hypothetical Reentry Circuit



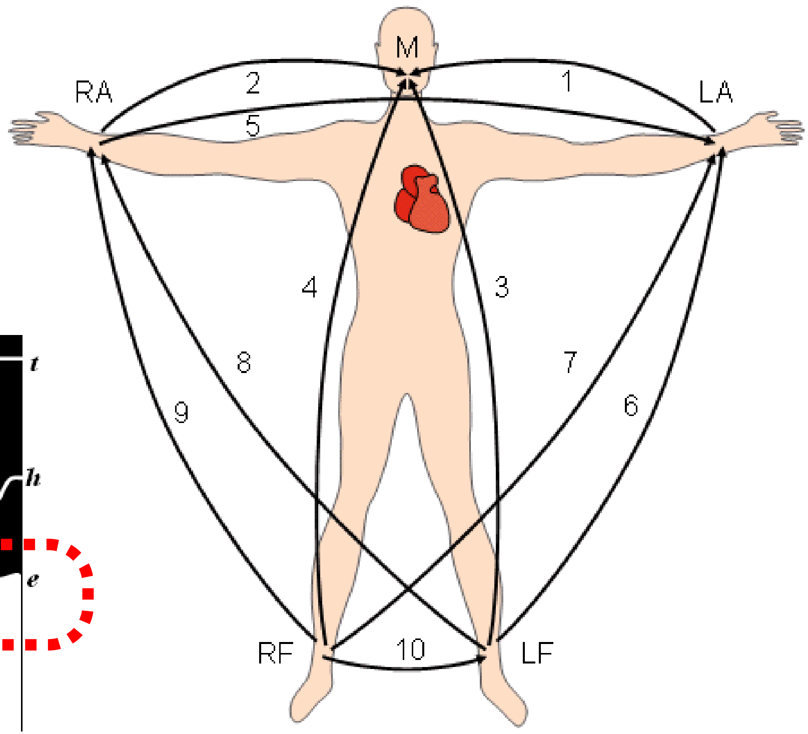
# 부정맥의 진단 방법

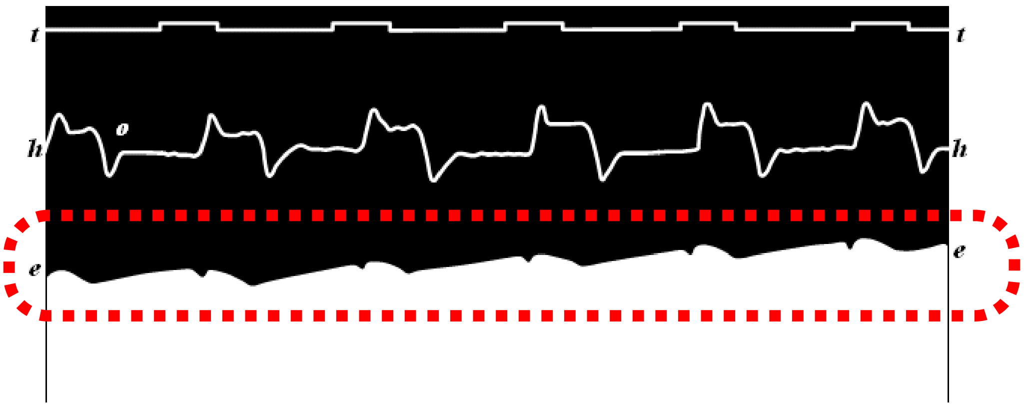
- 병력조사 및 이학적검사
- 표준 12유도 심전도
- 활동중 심전도 (Holter기록)
- 운동부하 심전도
- 심전기생리학검사(Electrophysiological study, EPS)

# Waller (1887)

- Measured the first human electrocardiogram in 1887 using Lippmann's *capillary electrometer*

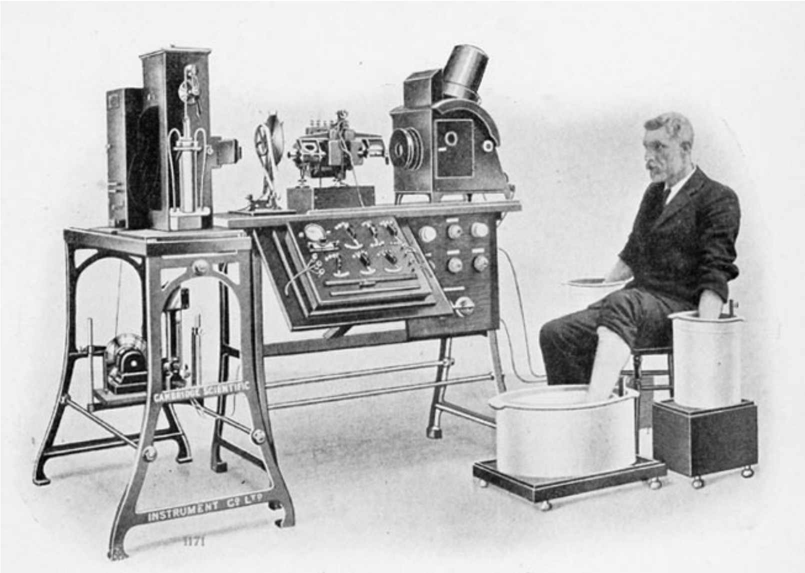
Waller's 10 ECG leads



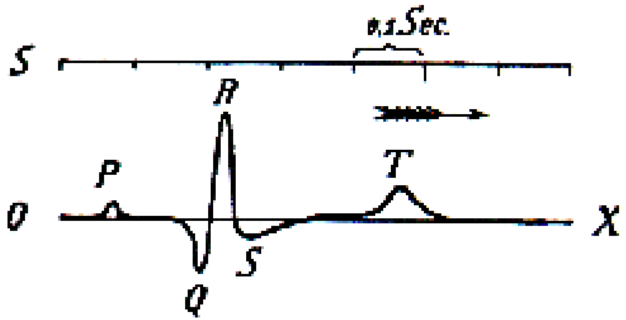



# Einthoven (1902)

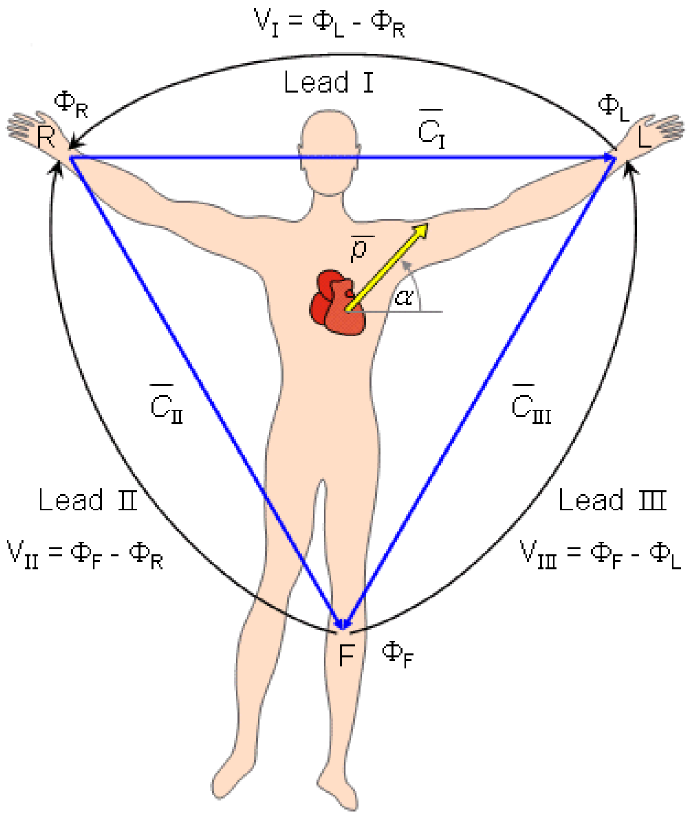
- ECG using string galvanometer



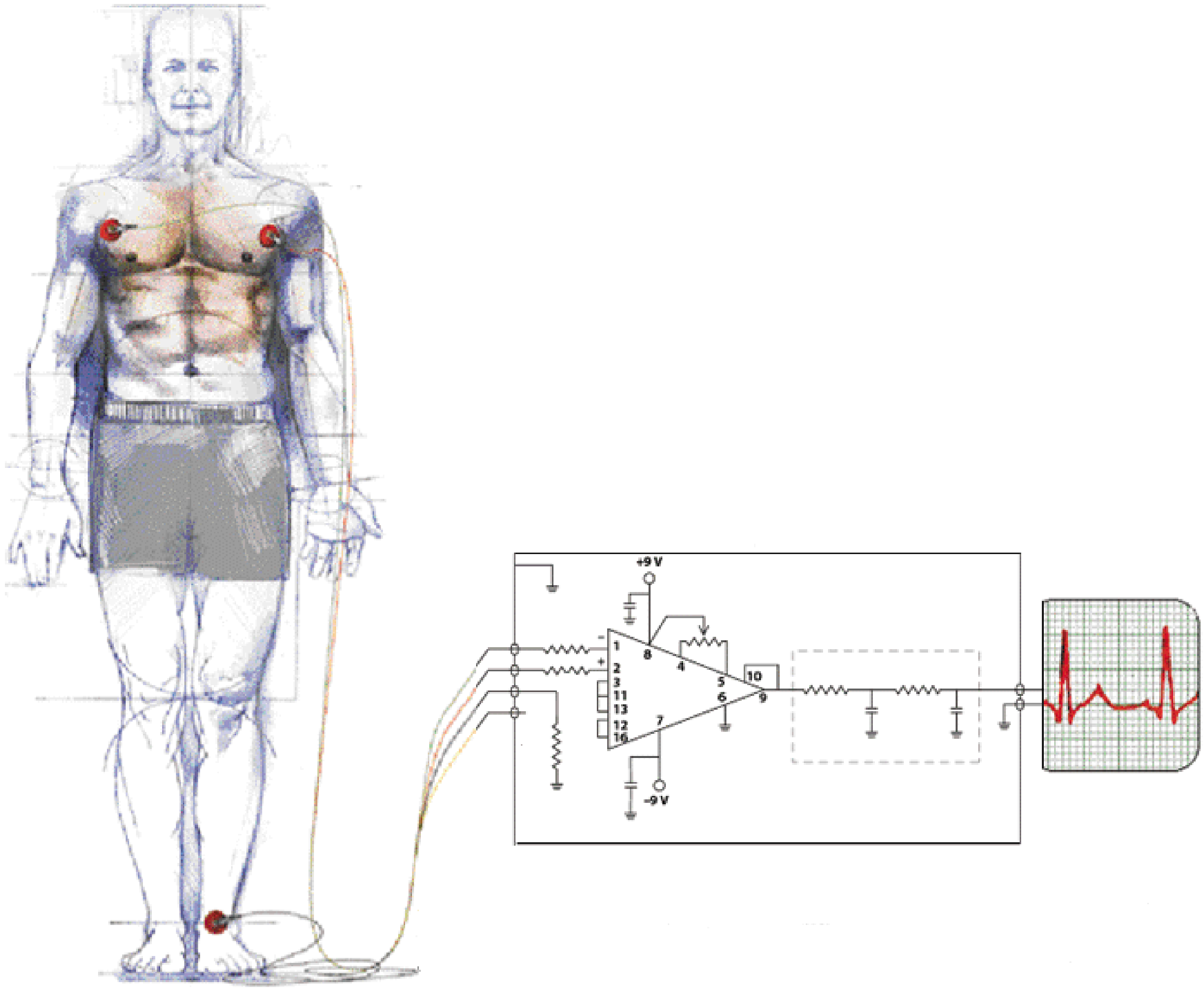

Photograph of a Complete Electrocardiograph, Showing the Manner in which the Electrodes are Attached to the Patient, In this Case the Hands and One Foot Being Immersed in Jars of Salt Solution




Einthoven's limb leads & triangle



# Home-made ECG System



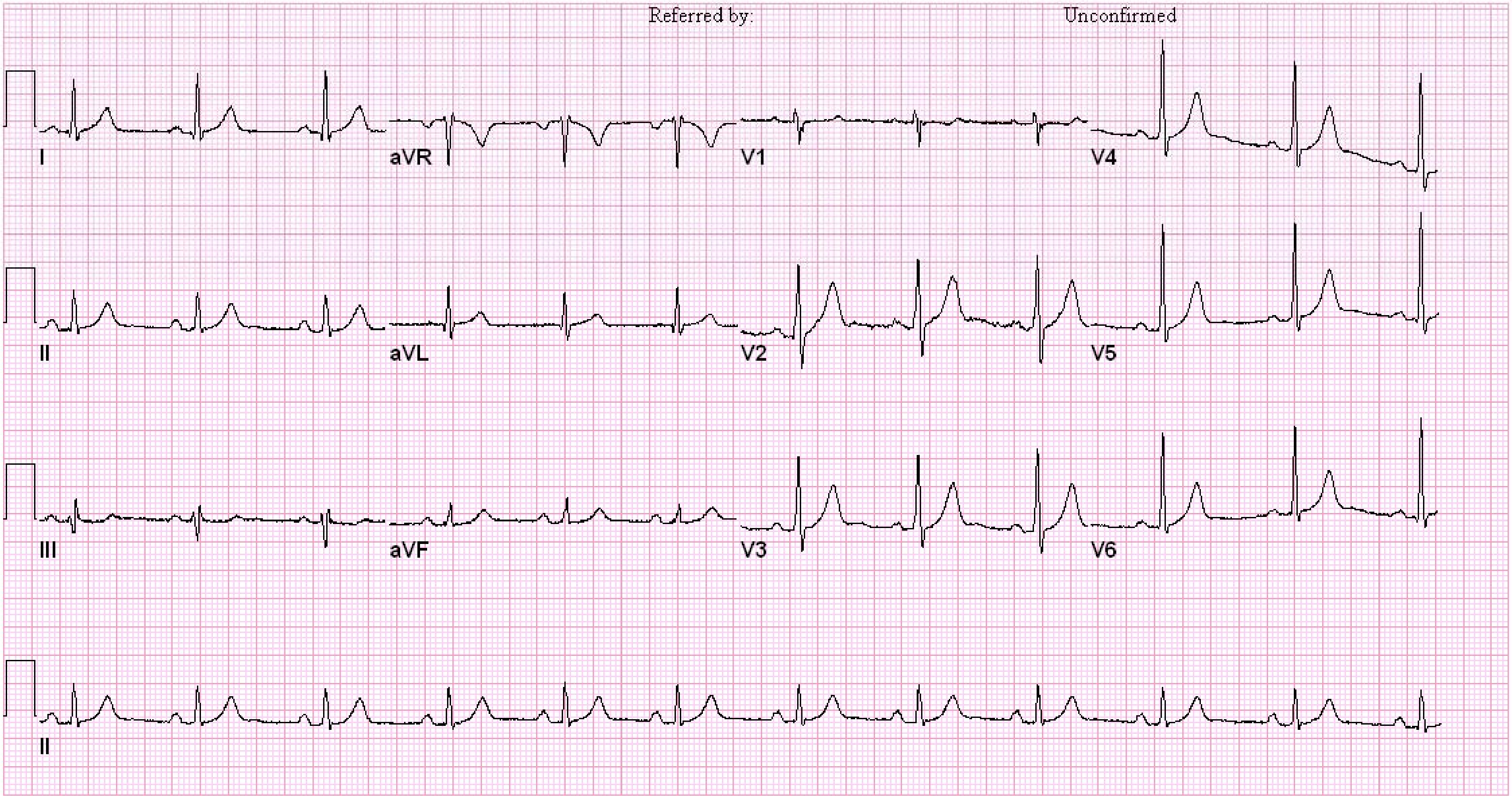

Sci Am, June 2000

ID:34836466 06-MAR-2006 10:59:40 SEOUL NATIONAL UNIVERSITY HOSP.

| | | | |
|---|---|---|---|
| 42 yr | Vent. rate | 69 | BPM |
| Male | PR interval | 162 | ms |
| | QRS duration | 88 | ms |
| Room: UR | QT/QTc | 376/402 | ms |
| Loc: 2 | P-R-T axes | 50 21 | 34 |

Normal sinus rhythm
Normal ECG

Technician: SHIN W.M.




25mm/s 10mm/mV 150Hz 005D 12SL 237 CID: 1

EID: Unconfirmed EDT: ORDER:

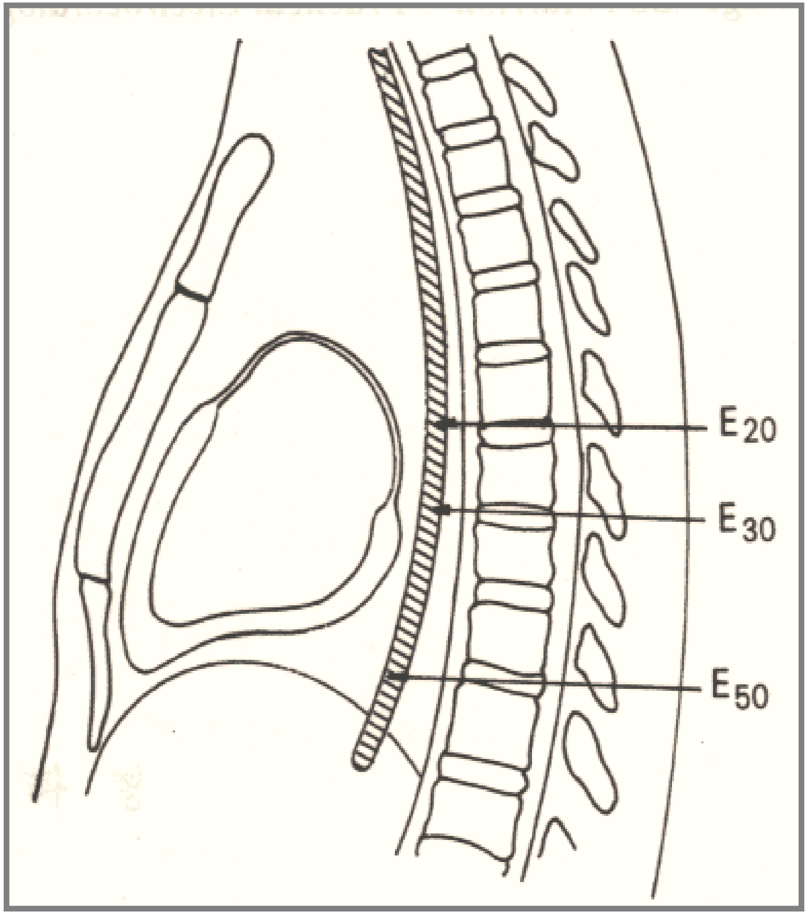
# Lead System

- Bipolar leads
  - Potential difference between two electrodes
- Unipolar leads
  - One electrode for measuring the potential
  - The other (indifferent electrode) is assumed not to be influenced by the dipole: zero potential

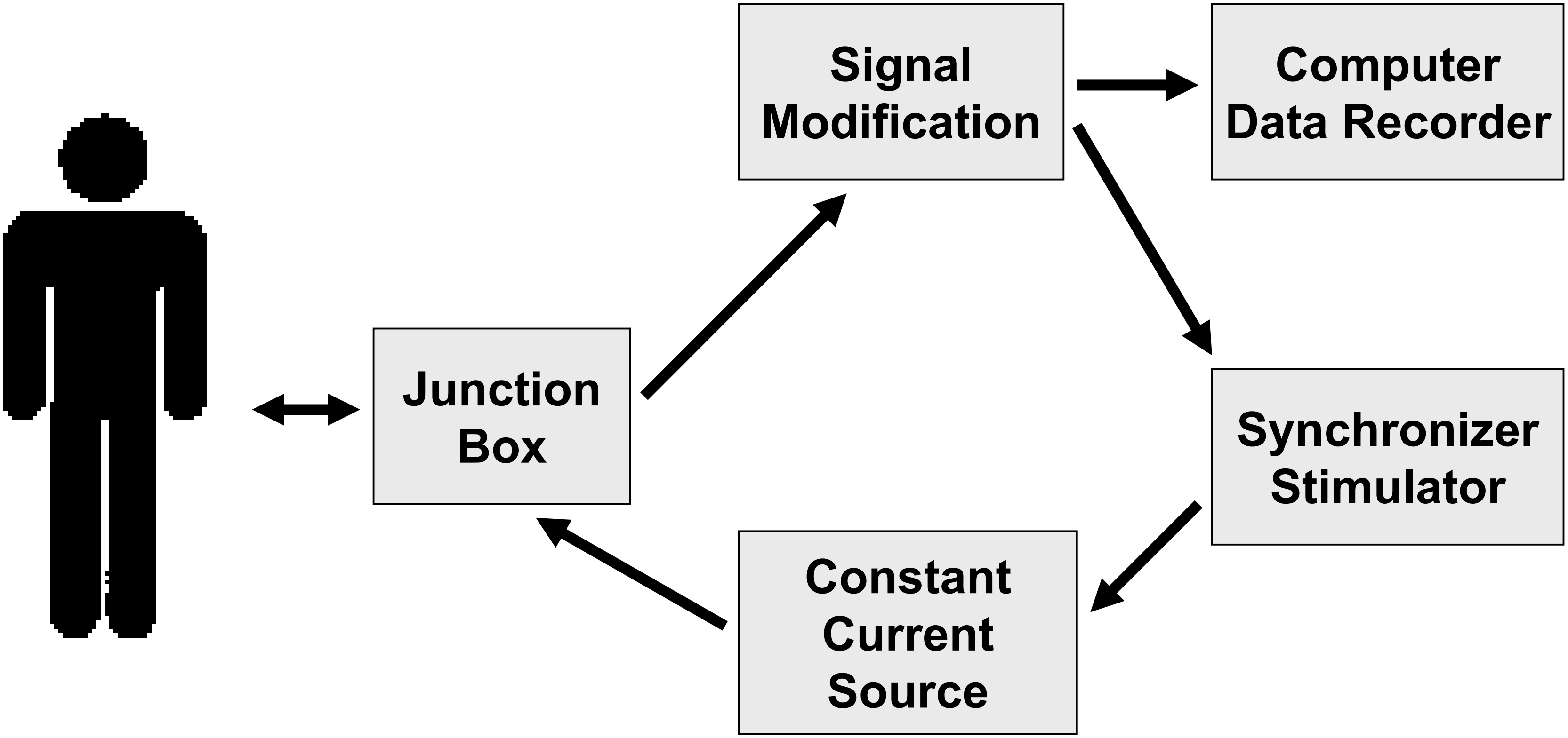
# Why Do we use so many leads?

# 기타 유도법

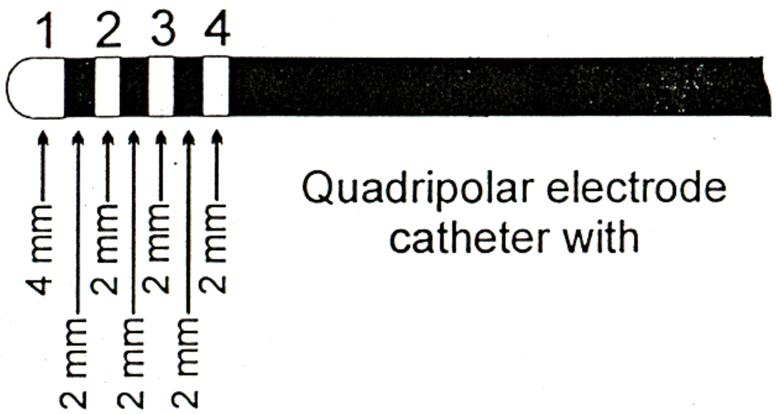
- Lewis lead: recorded @ I
  - R → ICS2 RSB
  - L → ICS4 RSB
- Monitor lead
  - modified chest lead
- Esophageal lead

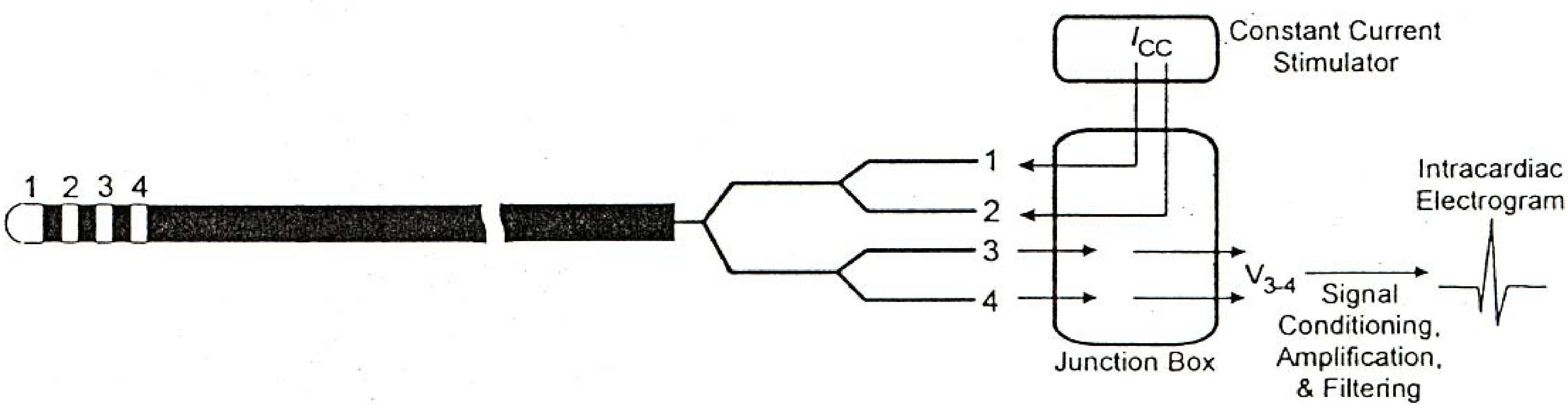


# EPS Lab

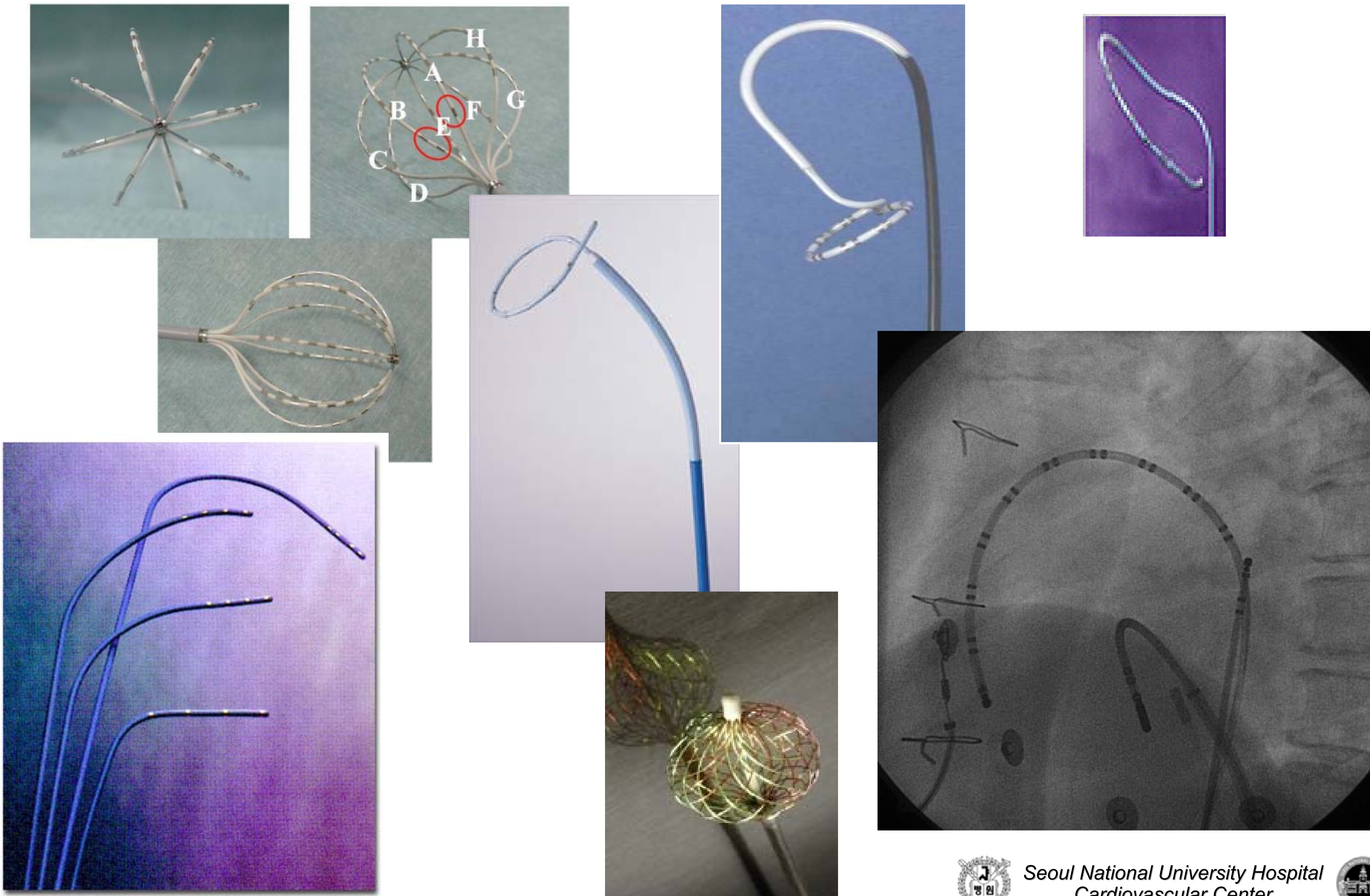

Signal Modification
Computer Data Recorder
Junction Box
Synchronizer Stimulator
Constant Current Source

# Electrode Catheter for EPS



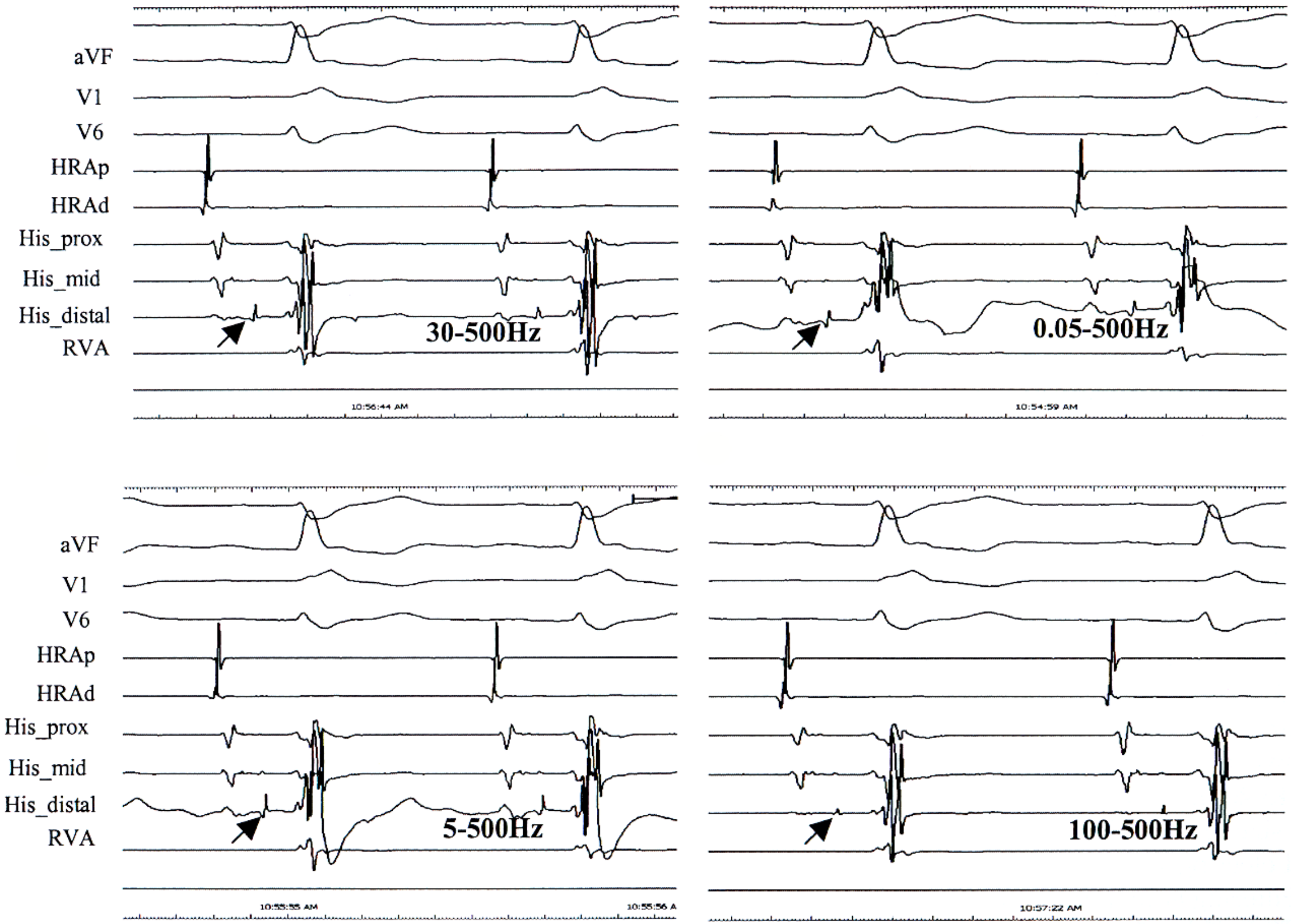
# Various Electrode Catheters



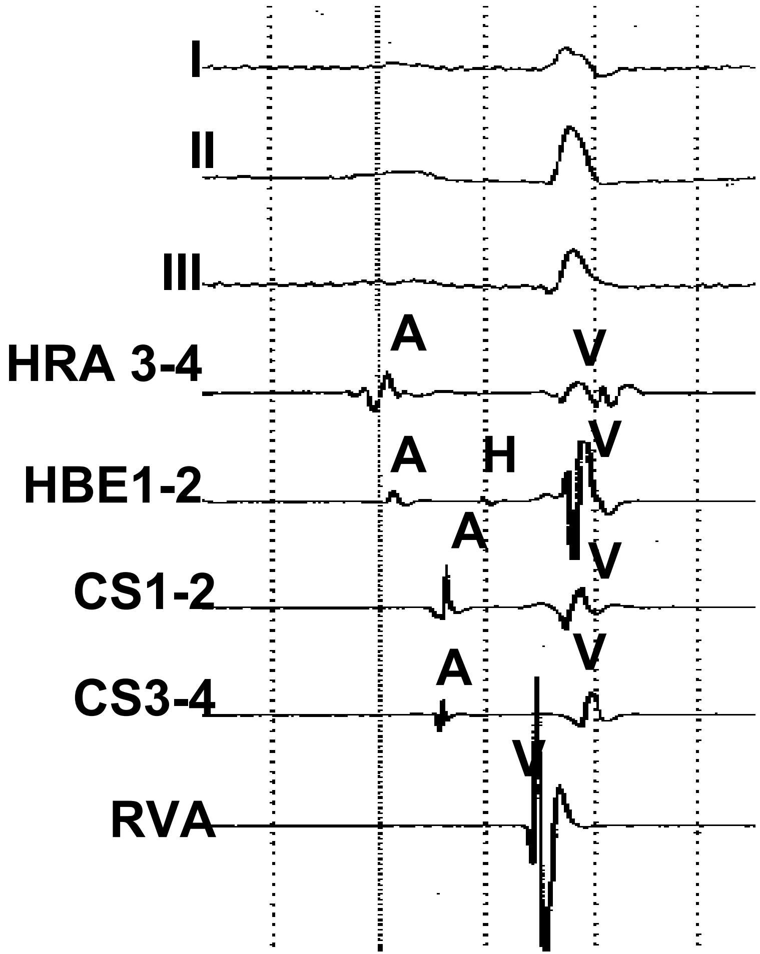
# Typical Filter Settings for EP Lab Recordings

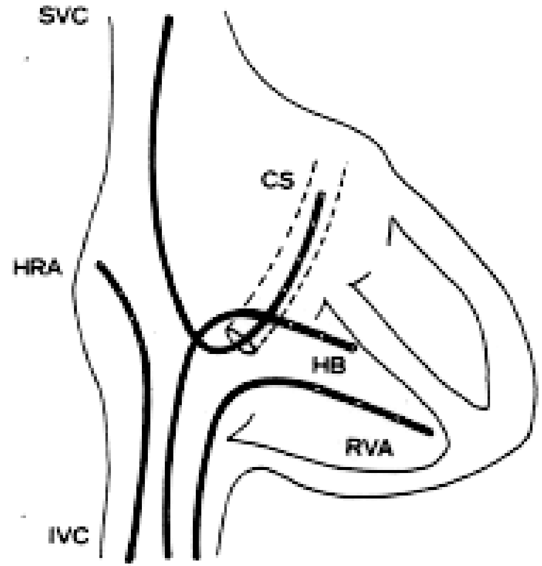
| Recording | High Pass (Hz) | Low Pass (Hz) |
|---|---|---|
| Surface ECG | 0.05-0.1 | 100 |
| Bipolar intracardiac | 30-50 | 300-500 |
| Unipolar intracardiac | DC-0.05 | > 500 |

# Signal Filtering & Electrograms

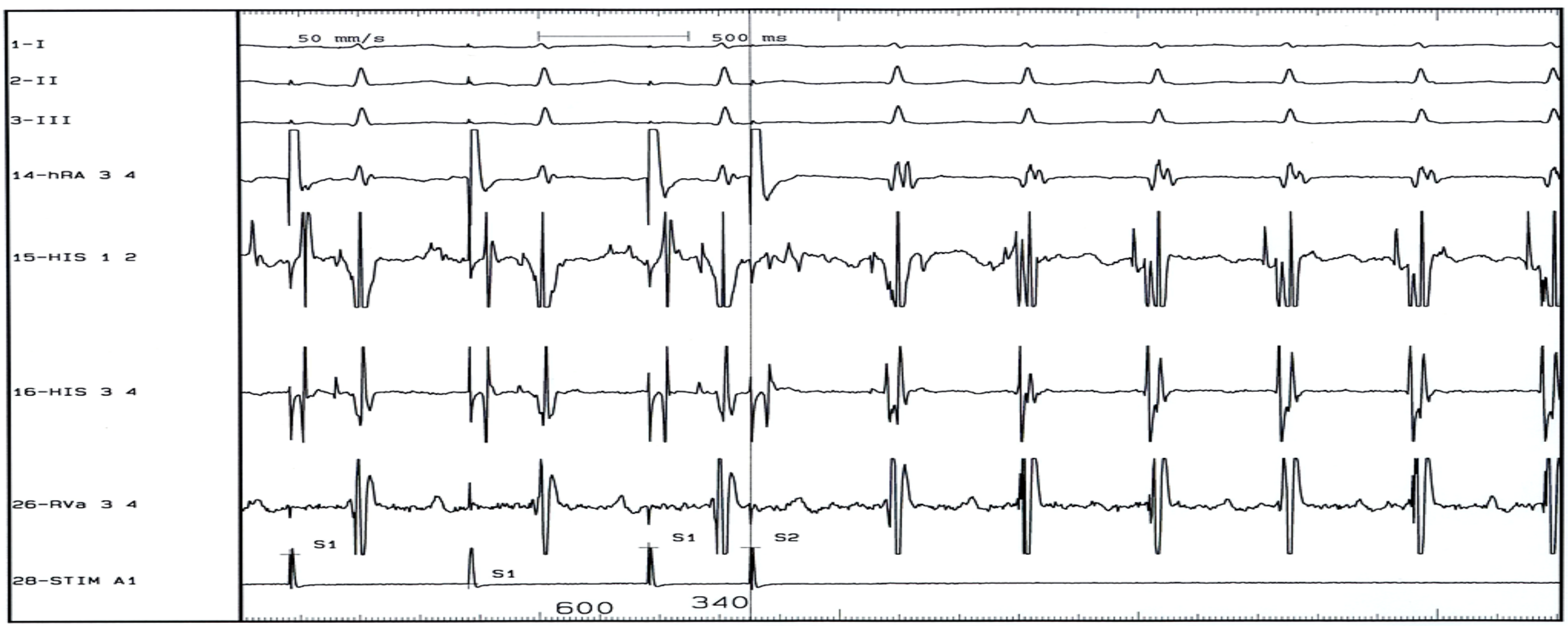


# Usual Catheter Position & Electrograms for EPS

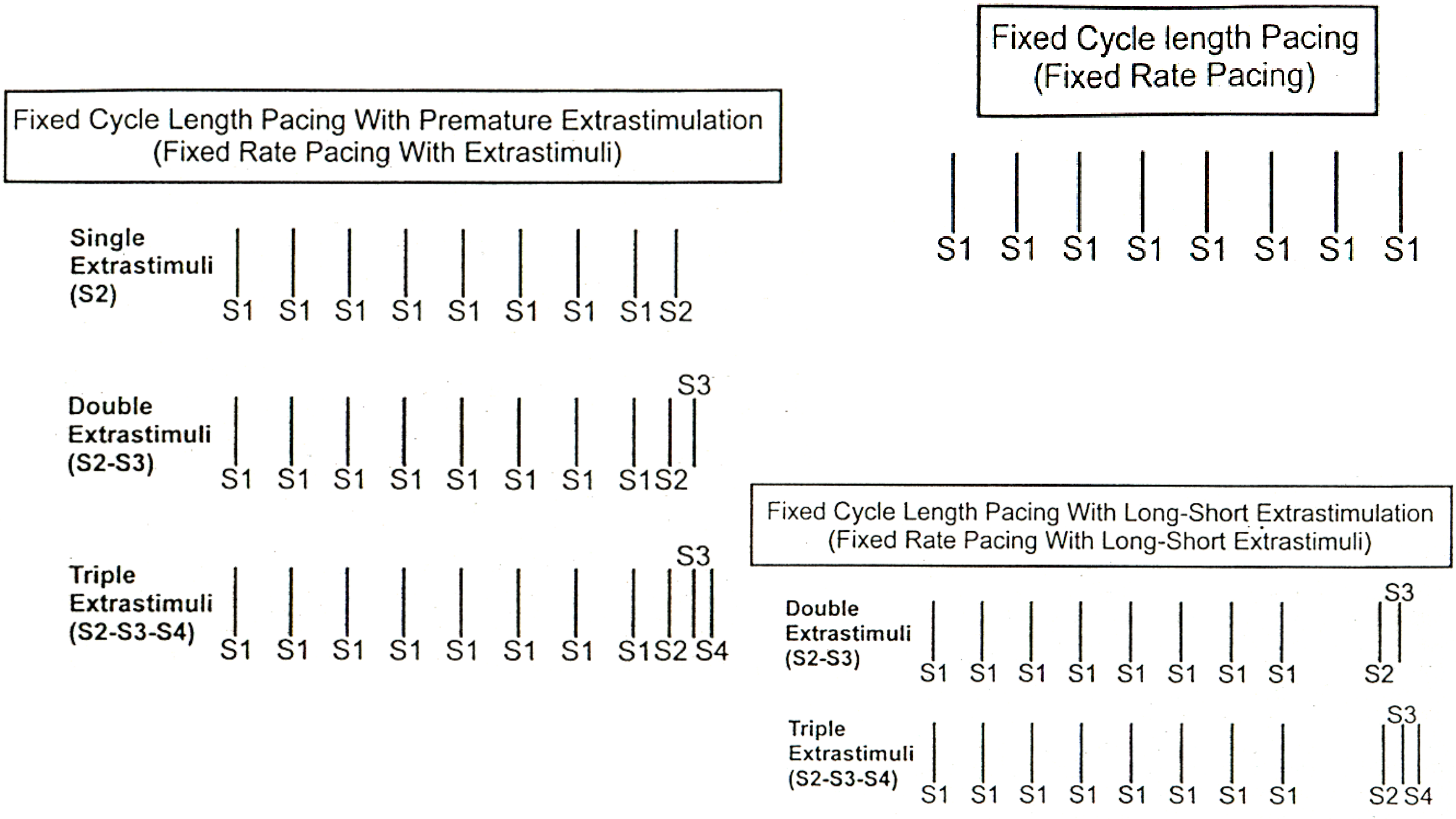


# Intracardiac electrograms are …

# Programmed Electrical Stimulation



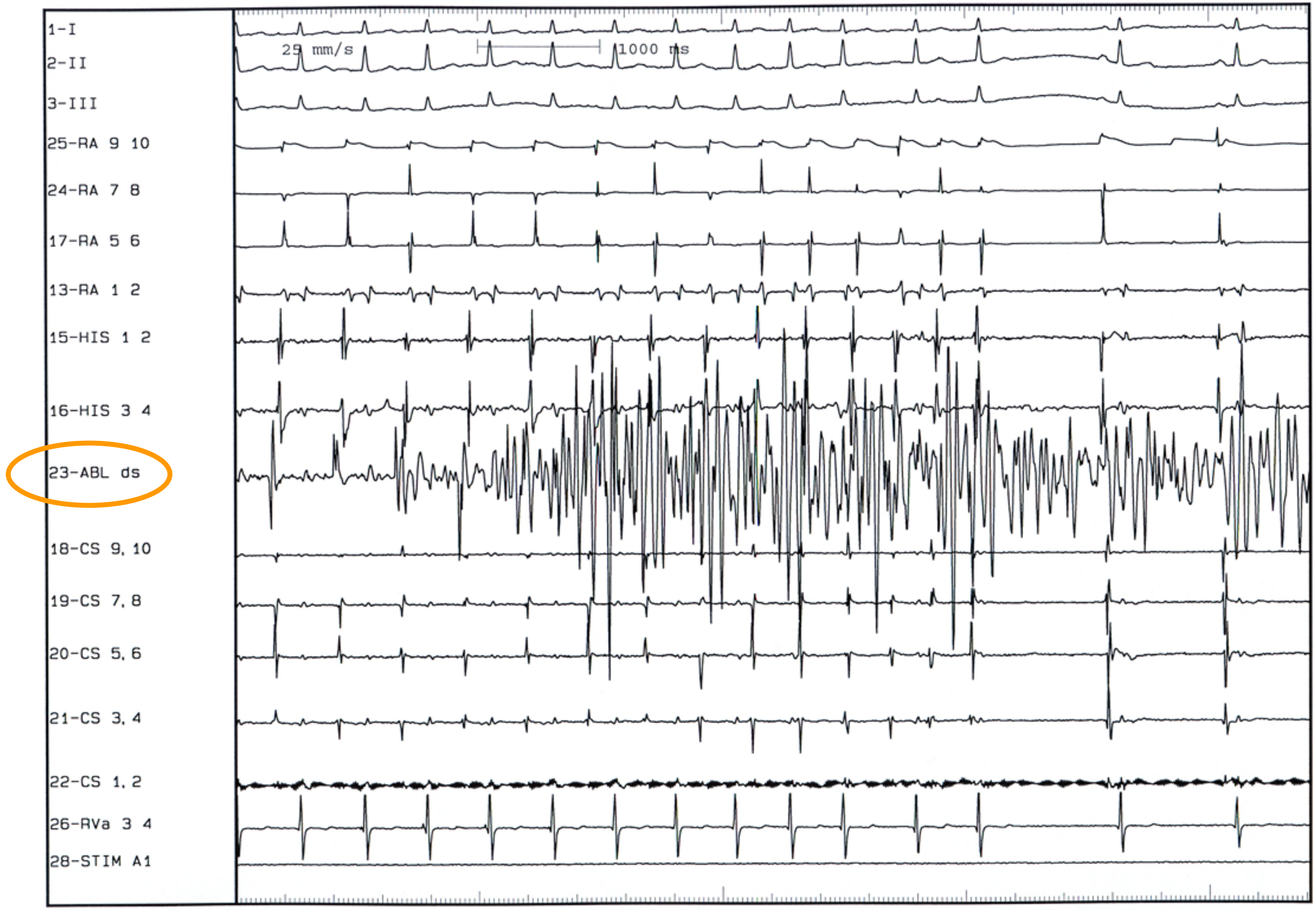
# Endocardial Mapping Technique

- Activation sequence mapping
- Pace mapping
- Entrainment mapping

# Activation Mapping

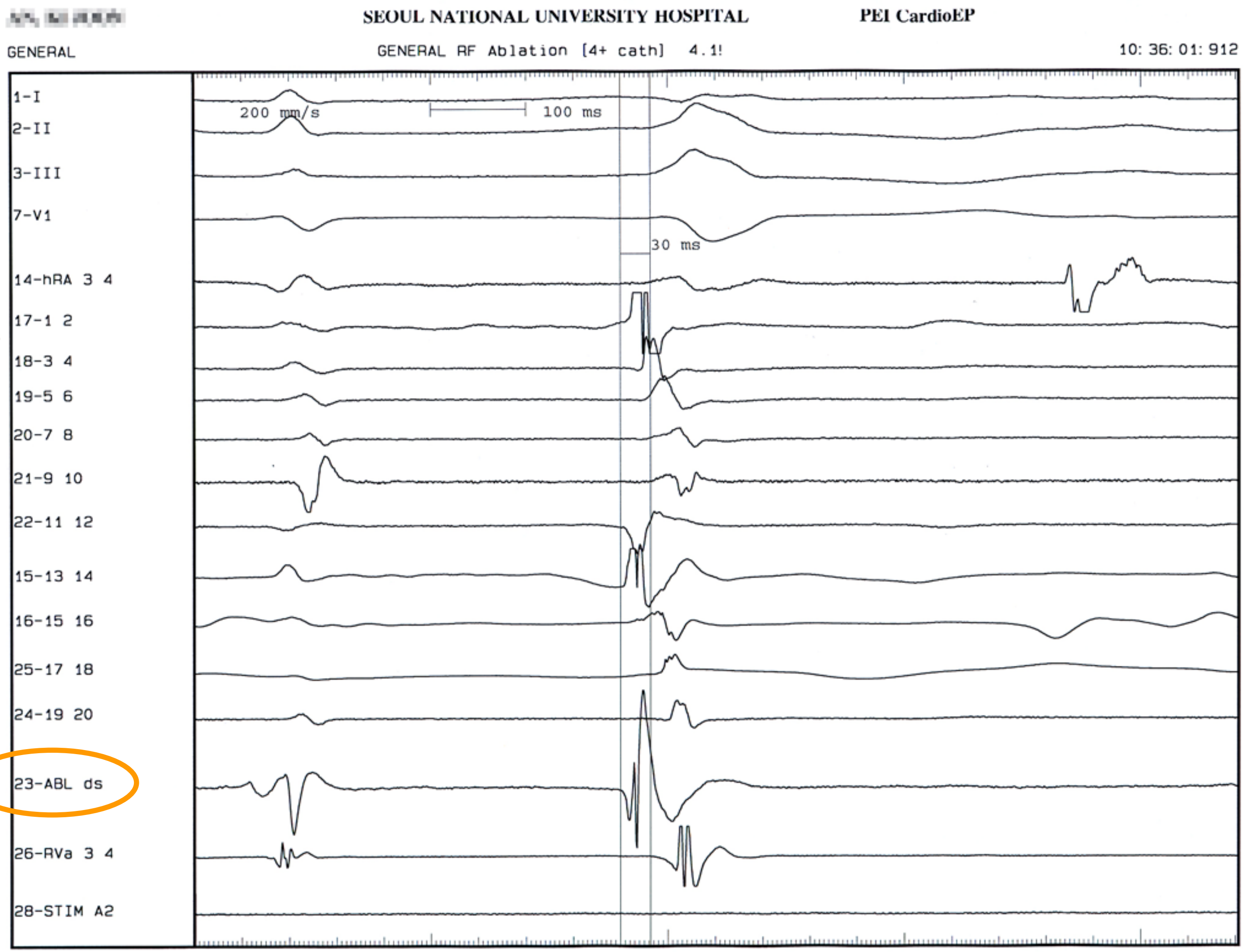
- Localization of the earliest activation site
- Determination of the activation sequence

# The Earliest Activation Site (Focal AT)



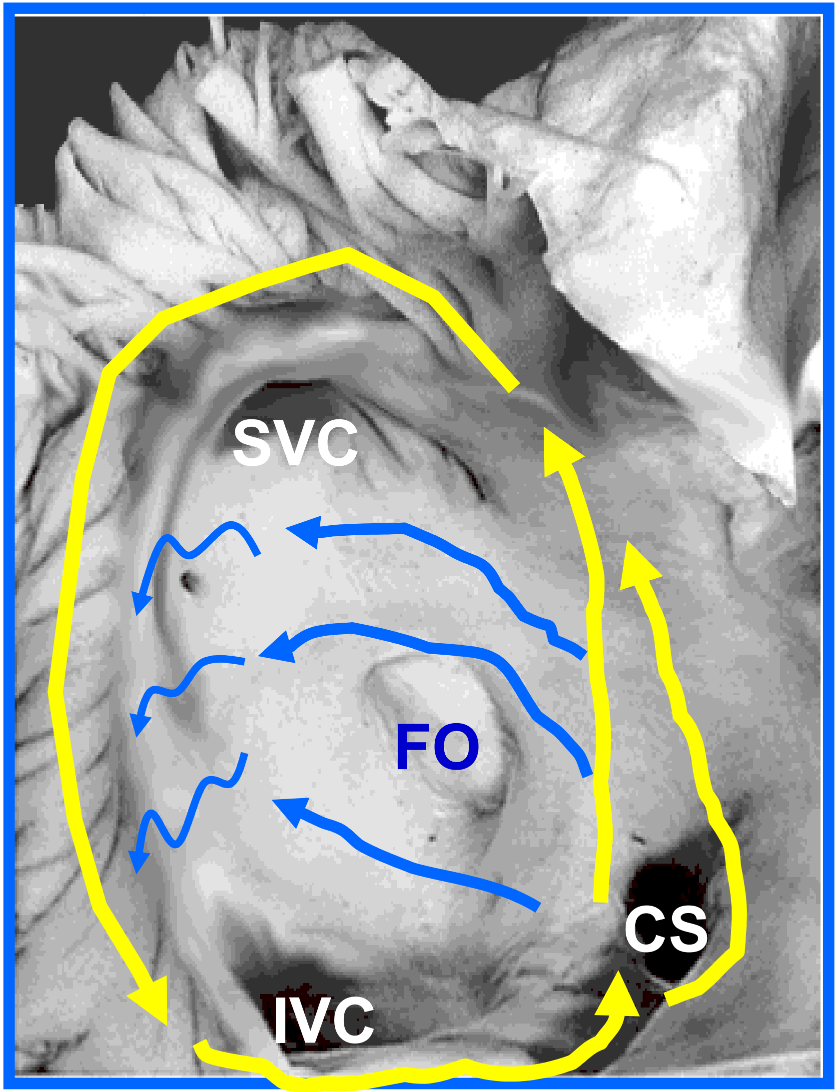

#36965199

# The Earliest Activation Site (RVOT VT)

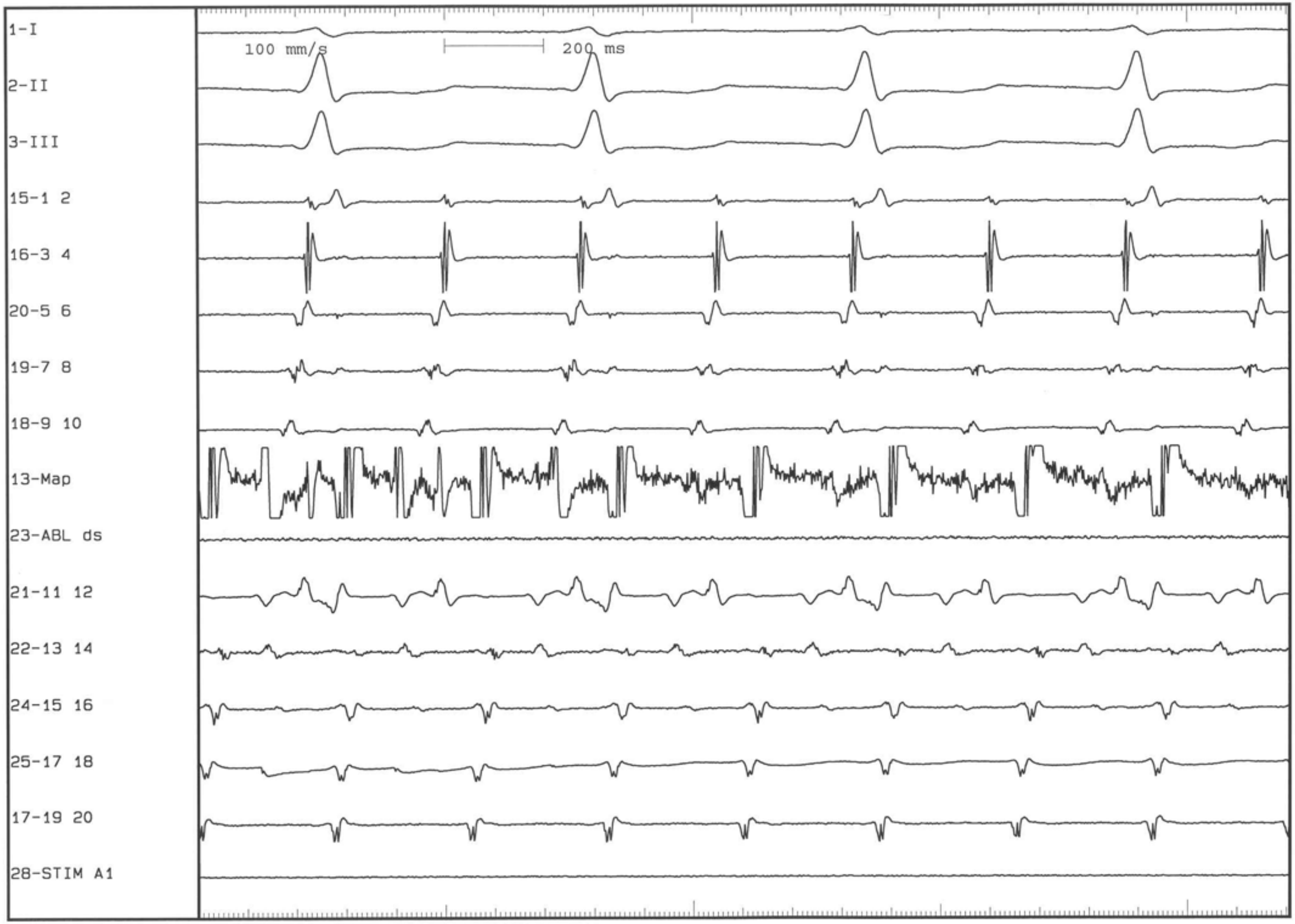



#34142426

# Common AFL: Isthmus dependent

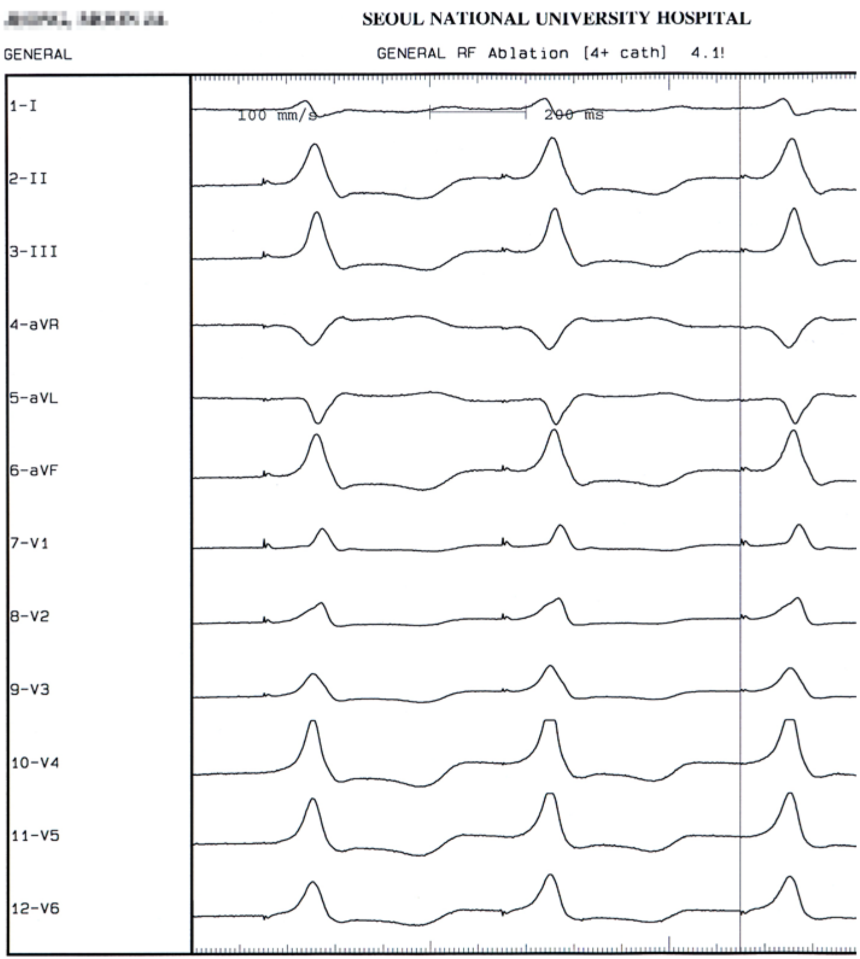


# Activation Sequence (AFL)

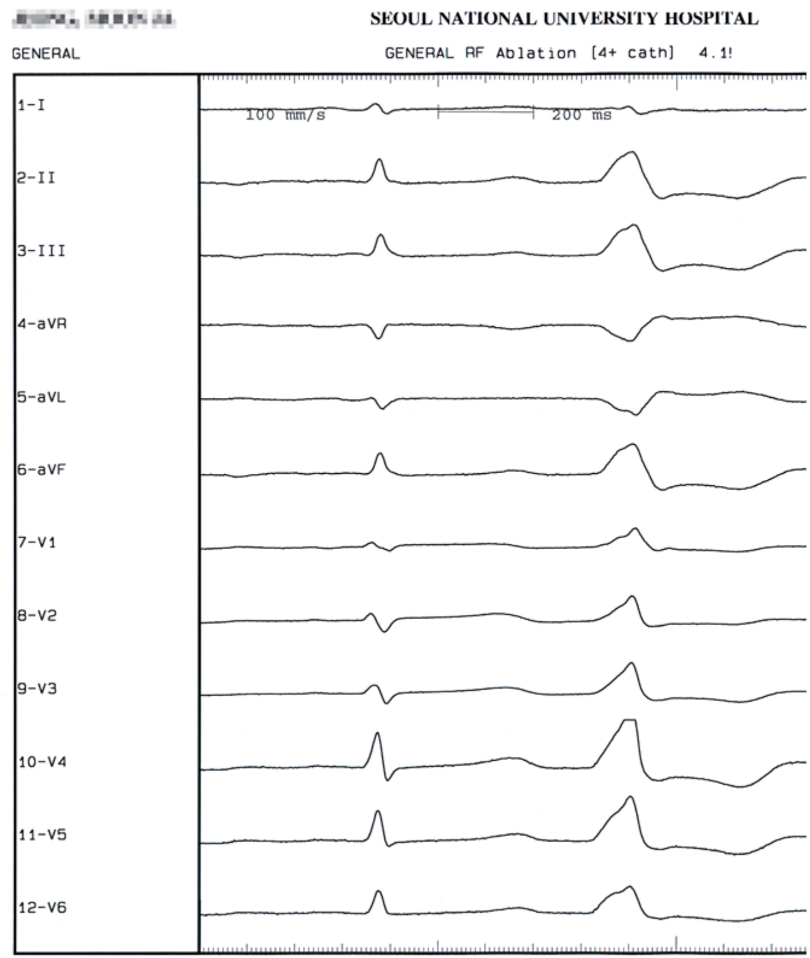


# Pace Mapping = Comparison

## Pacing




## VPC




#23687936

# Entrainment Mapping

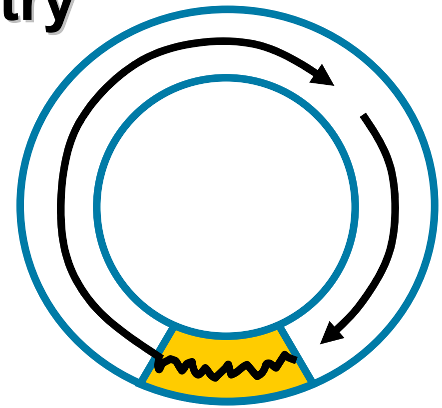
- Purposes
  - Confirmation of arrhythmia mechanism (reentry)
  - Localization of a reentrant circuit
  - Localization of critical portion for maintenance of reentry

# Entrainment Mapping

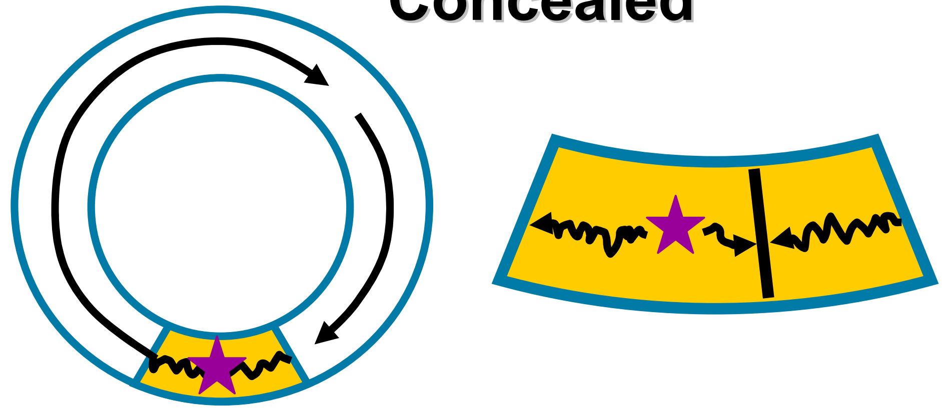
- Manifest versus concealed entrainment
  - Manifest: Constant or progressive fusion during overdrive pacing ➔ Mechanism is reentry !
  - Concealed ➔ You are on the protected isthmus !
- Postpacing interval (PPI)
  - PPI ≒ tachycardia CL ➔ You are on the critical path !

# Entrainment

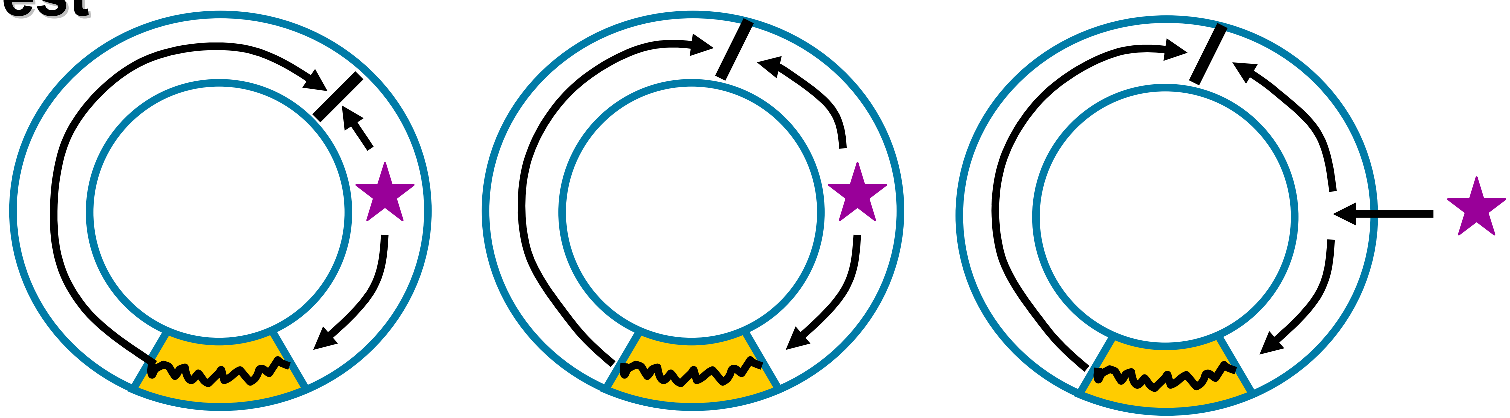
## Reentry



## Concealed



## Manifest



# Advanced Mapping Systems

- CARTO
- EnSite (noncontact)
- EnSite NavX
- LocaLisa
- RPM

# Advantages of Advanced Mapping Systems

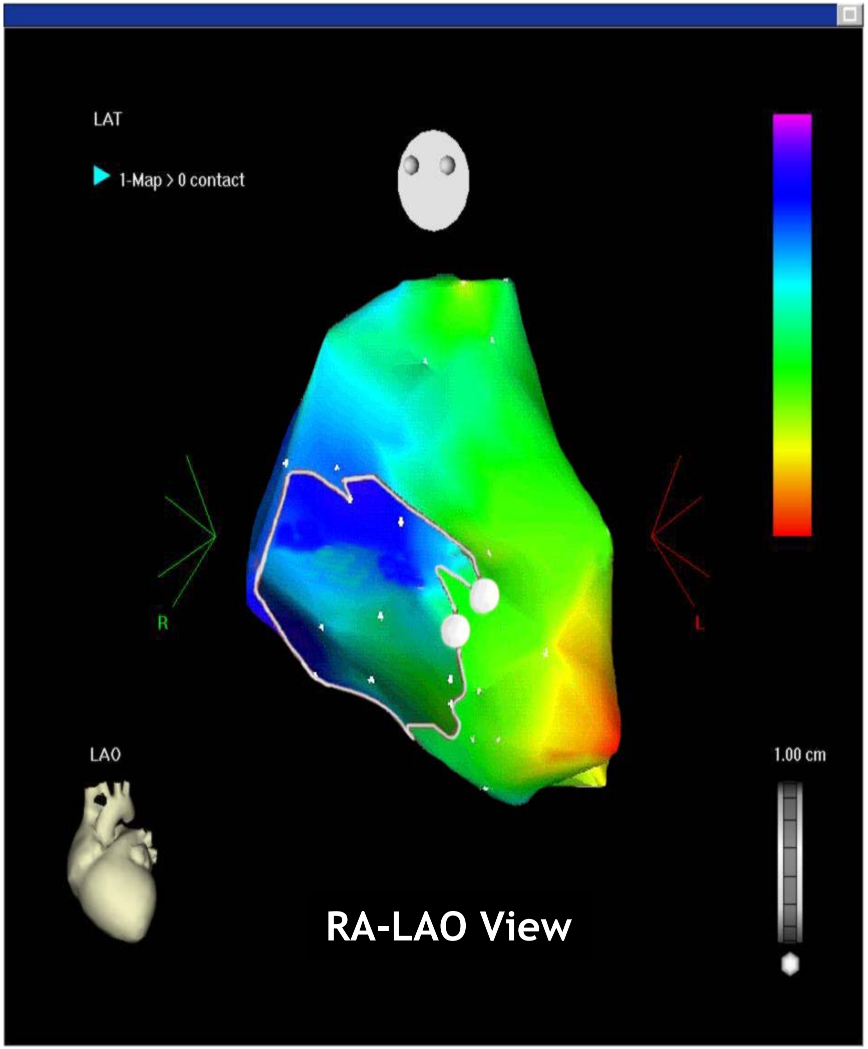
- True 3-D mapping and navigation
- Reduction in fluoroscopy
- Identification of complex arrhythmic substrates & circuits the location of which may not be obvious from conventional mapping data
- Increasingly accurate anatomical model
- Some allow global mapping from a single beat
- Identification of potential arrhythmic substrates during sinus rhythm
- Guide ablation

# Advanced Mapping Systems

| System | Principles | Activation mapping | Voltage mapping | Multiple catheter visualization | Special catheters required | Image integration | Advantages / Disadvantages |
|---|---|---|---|---|---|---|---|
| CARTO (Biosense Webster) | Magnetic field | O | O | X | O | O | Contact mapping |
| EnSite (ESI) | Electrical field | O | O | X | Balloon catheter (MEA) | O | Single beat activation / loss of accuracy in large chambers |
| NavX (ESI) | Electrical field | X | O | O | X | O | Requires EnSite system |
| LocaLisa (Medtronic) | Electrical field | X | X | O | X | X | Inexpensive / no electrical information |
| RPM (Boston Scientific) | Ultrasound | O | X | O | O | X | Proprietary catheters needed |

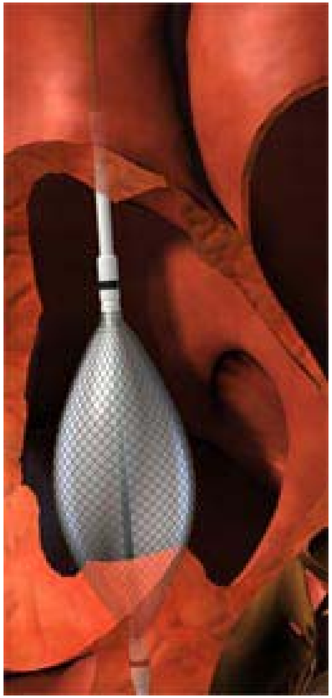
# CARTO: Shape of Reconstructions

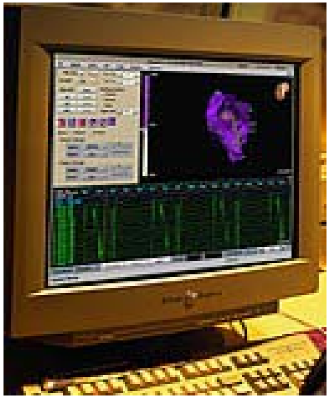
- 3D maps based on acquired electrogram location points
- Mapping area is visualized only as points are added
- Areas are extrapolated between acquired points

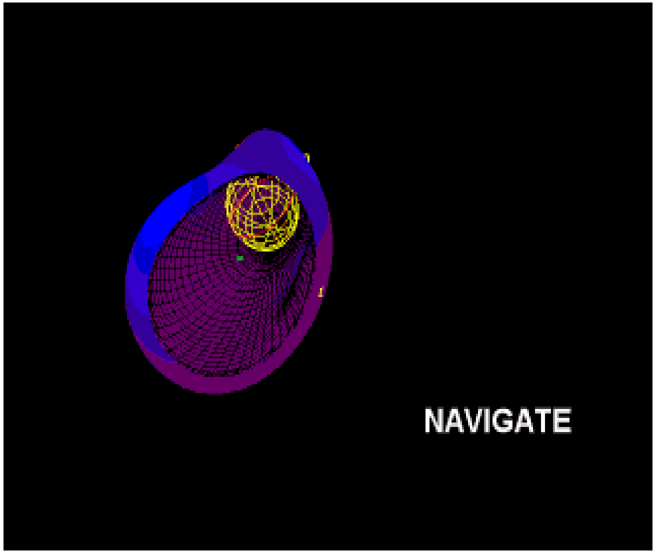


# EnSite System

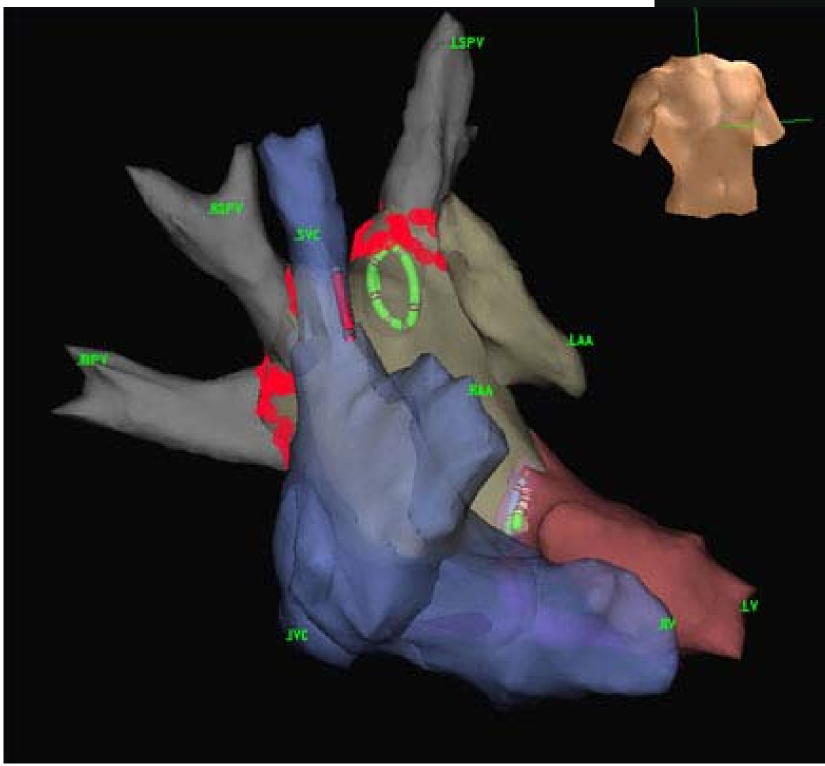
## Multielectrode Array (MEA)



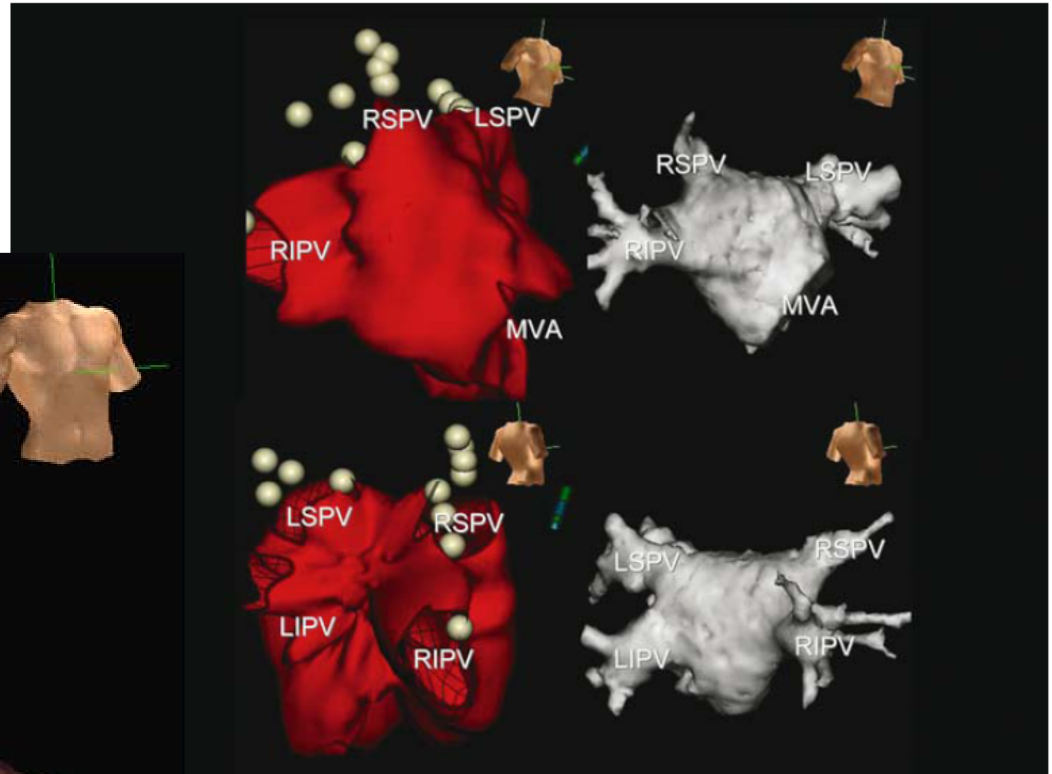




# NavX System

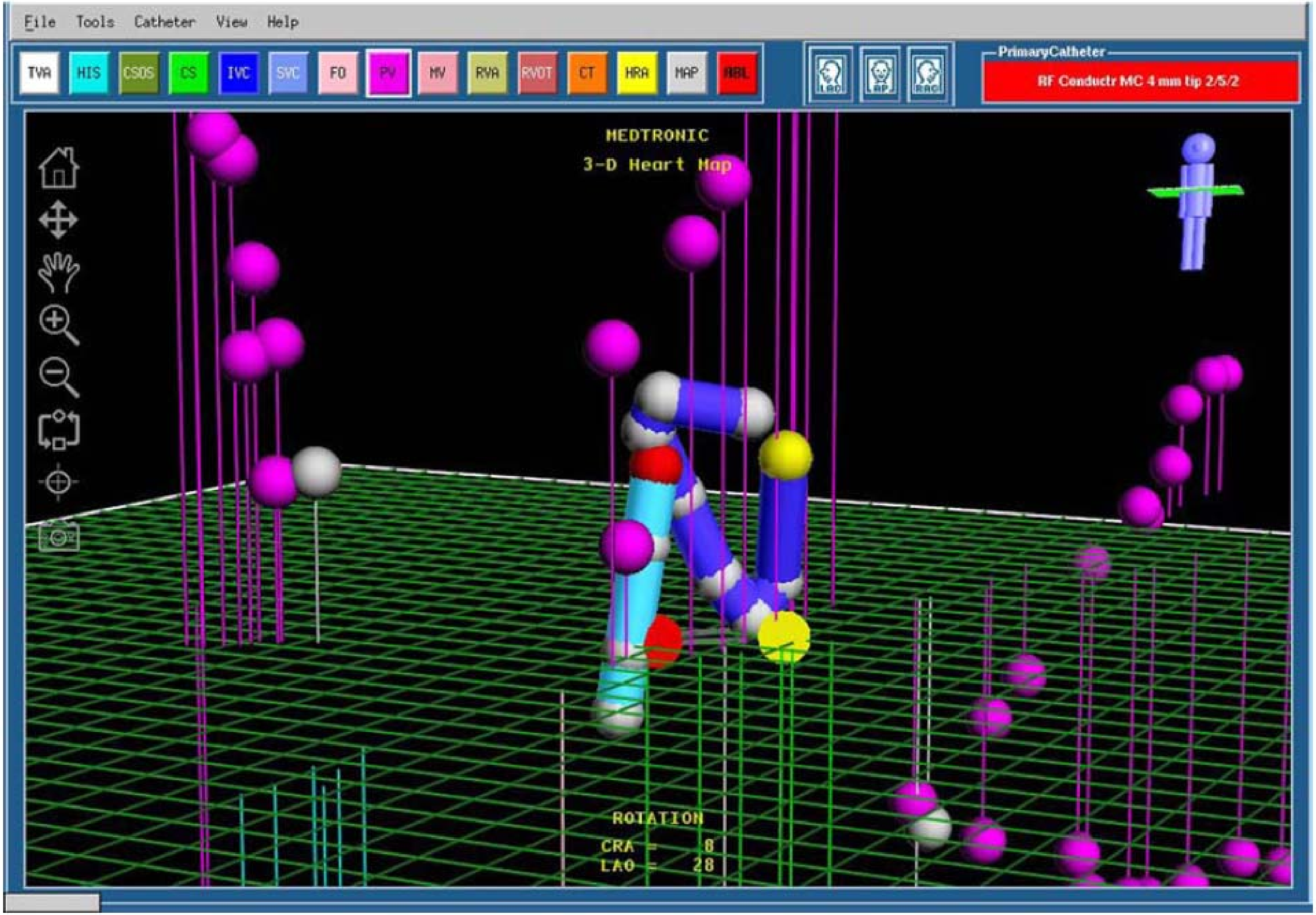


LSPV
RSPV
SVC
LAA
IVC
LV

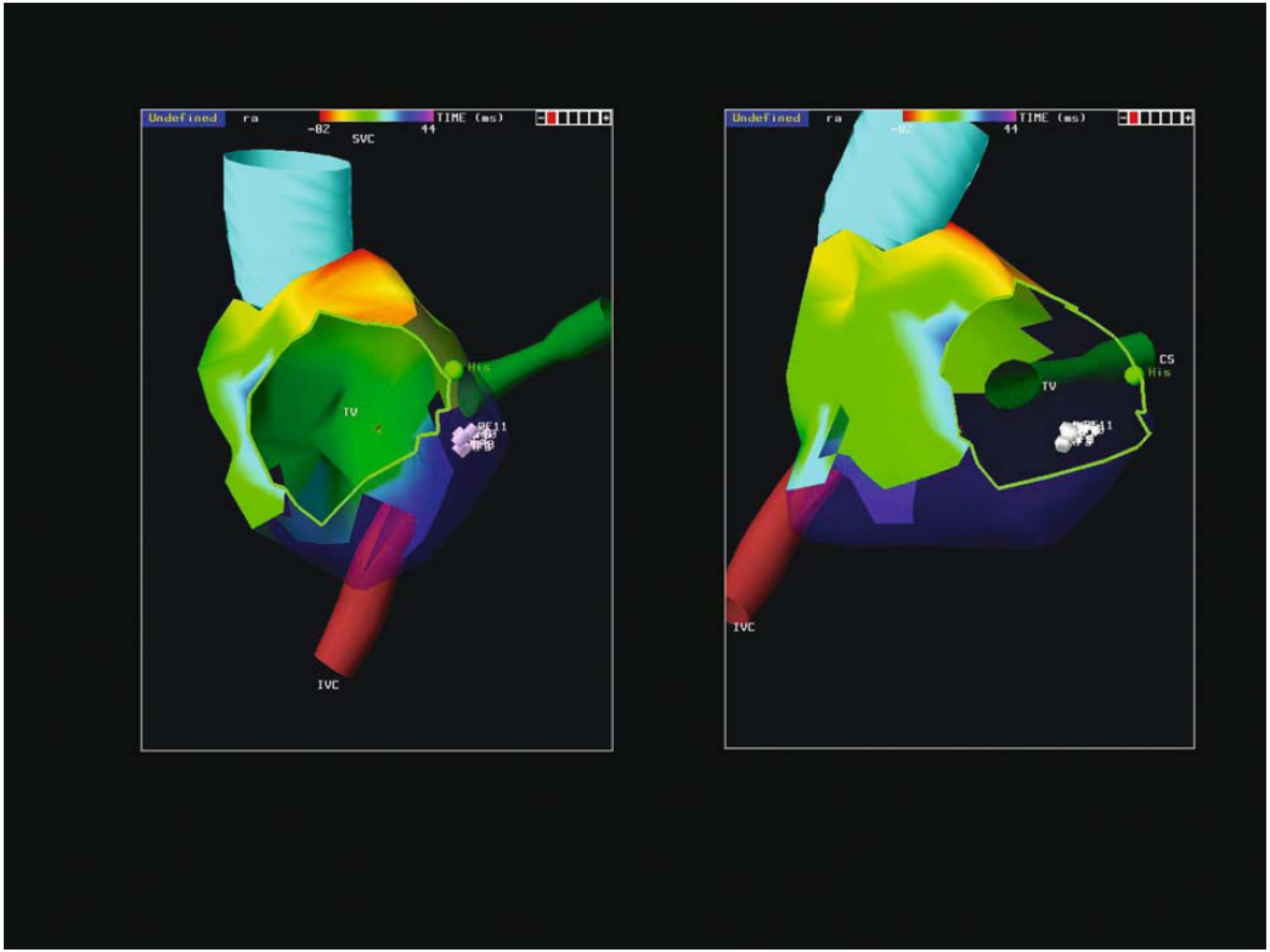



RSPV
LSPV
RIPV
MVA
RSPV
LSPV
RIPV
MVA
LSPV
RSPV
LIPV
RIPV
LSPV
RSPV
LIPV
RIPV

# LocaLisa System



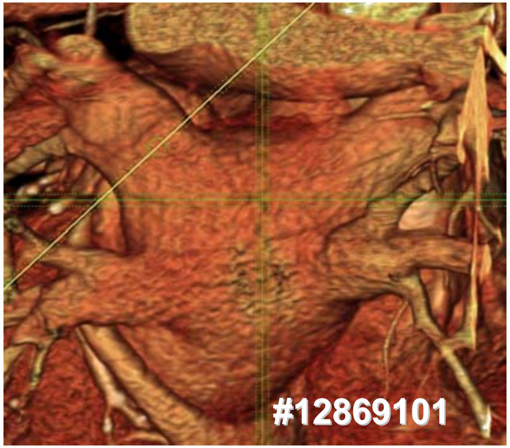
# RPM (Real time Position Management) System

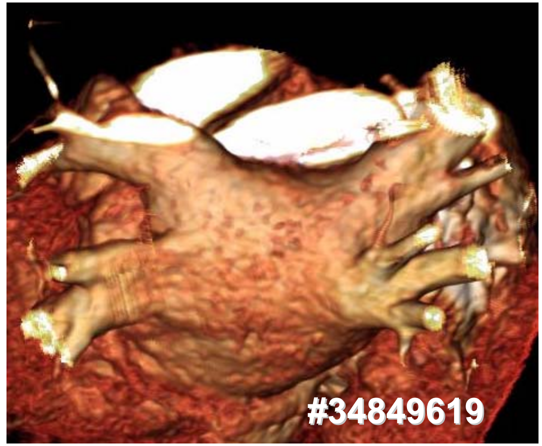


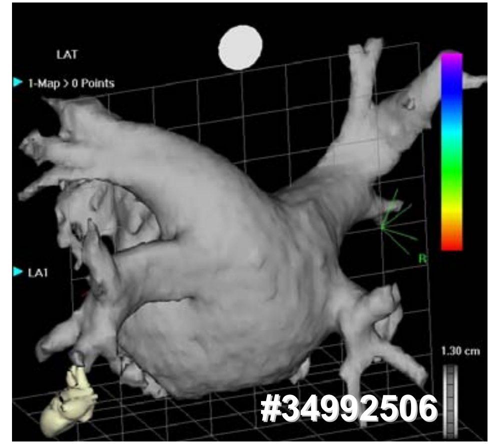
# Anatomical Approach

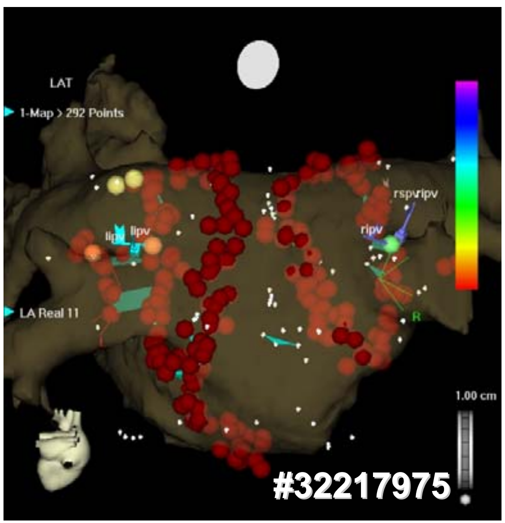
- Fluoroscopy
- ICE (intracardiac echocardiography)
- 3D mapping system
- Image integration

# Importance of Anatomy: eg. LA & PV Antrum

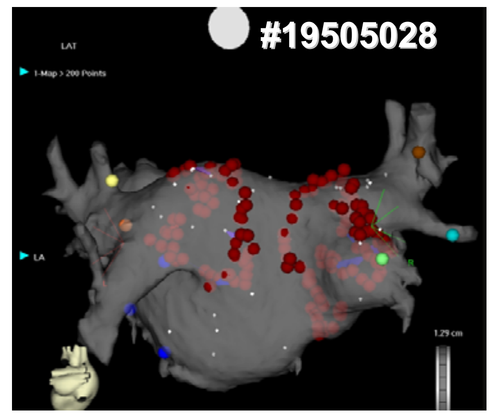


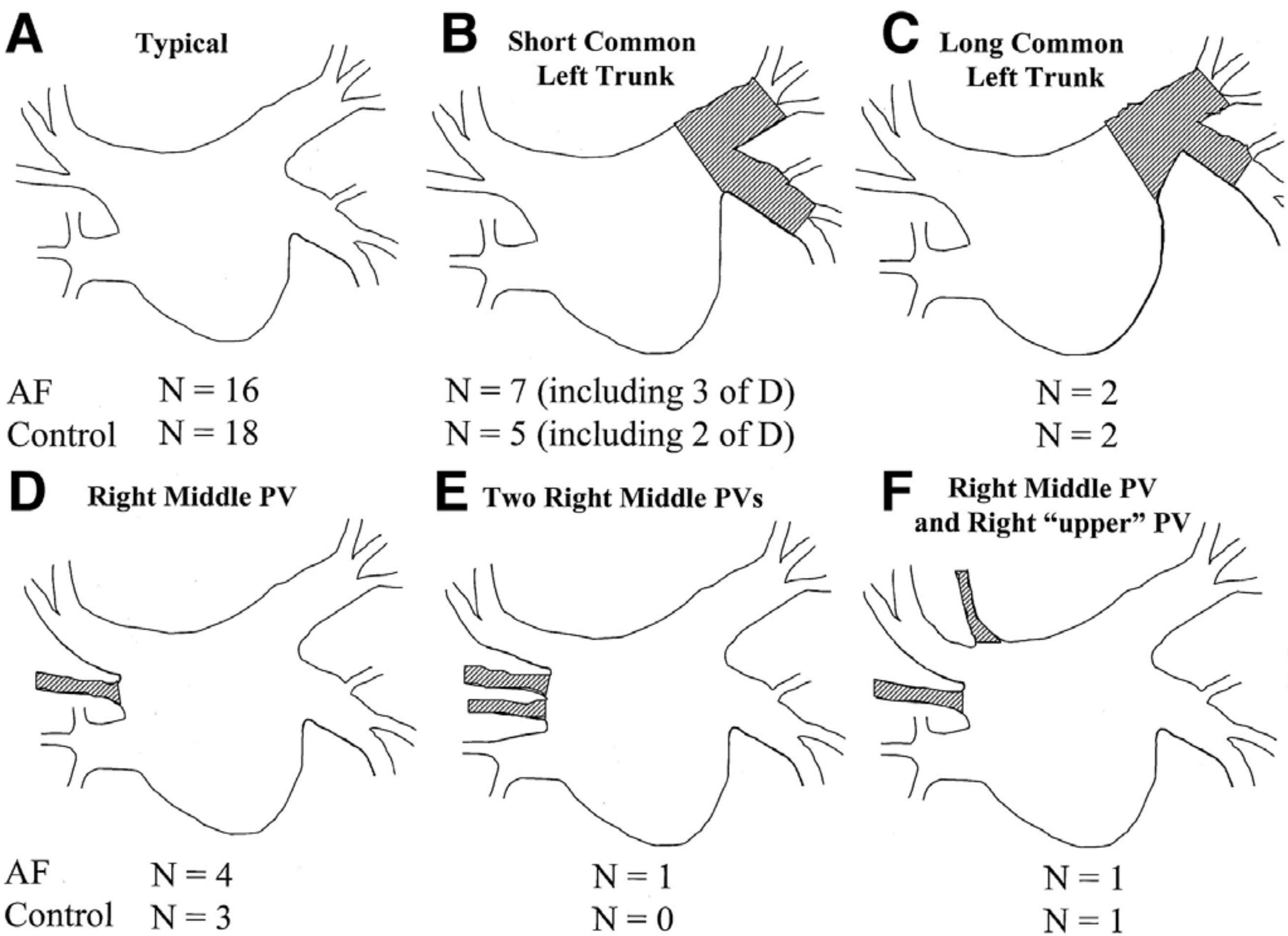





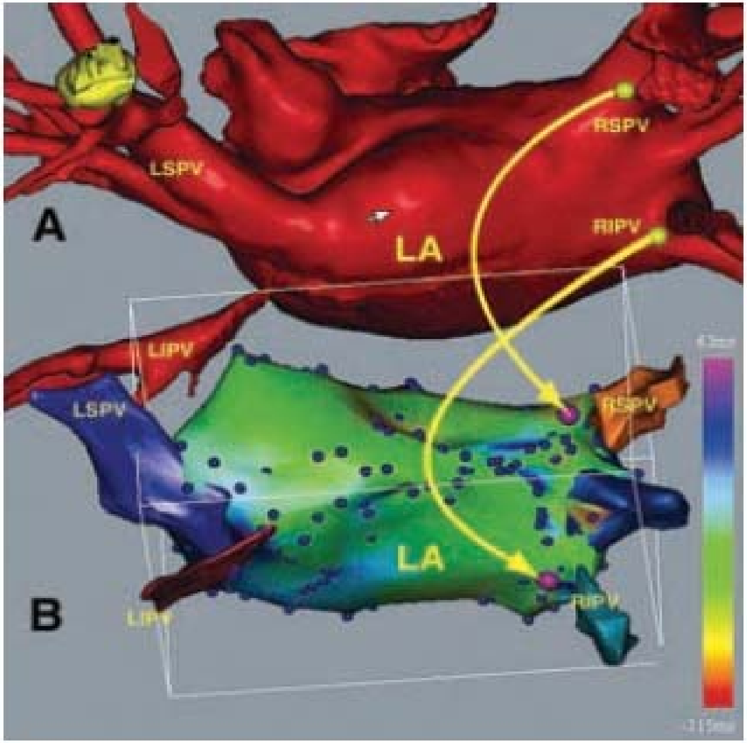


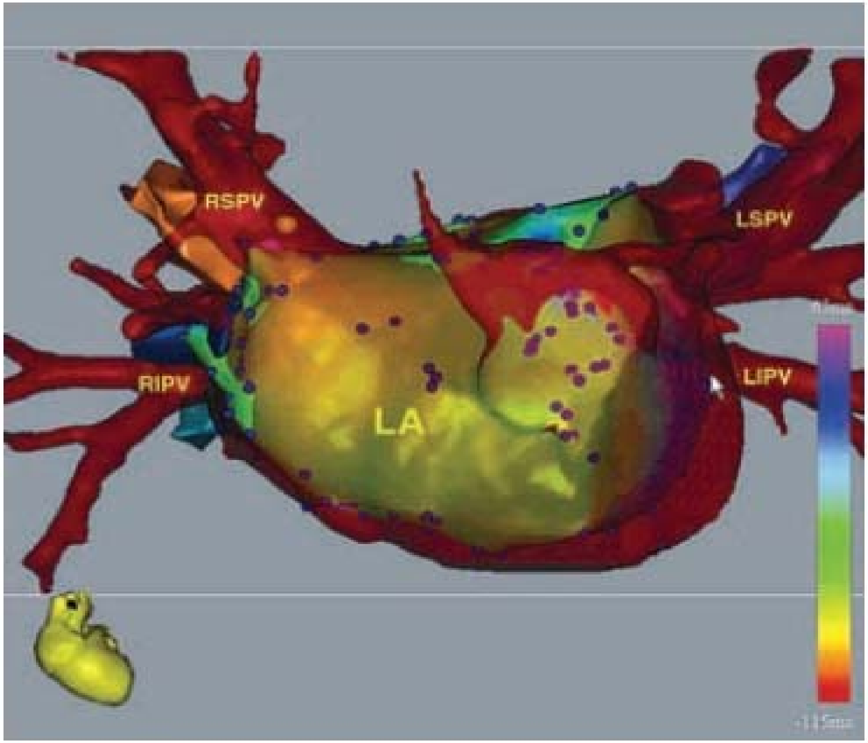
# Branching Pattern of PV Anatomy




Kato et al. Circulation 2003;107:2004-2010

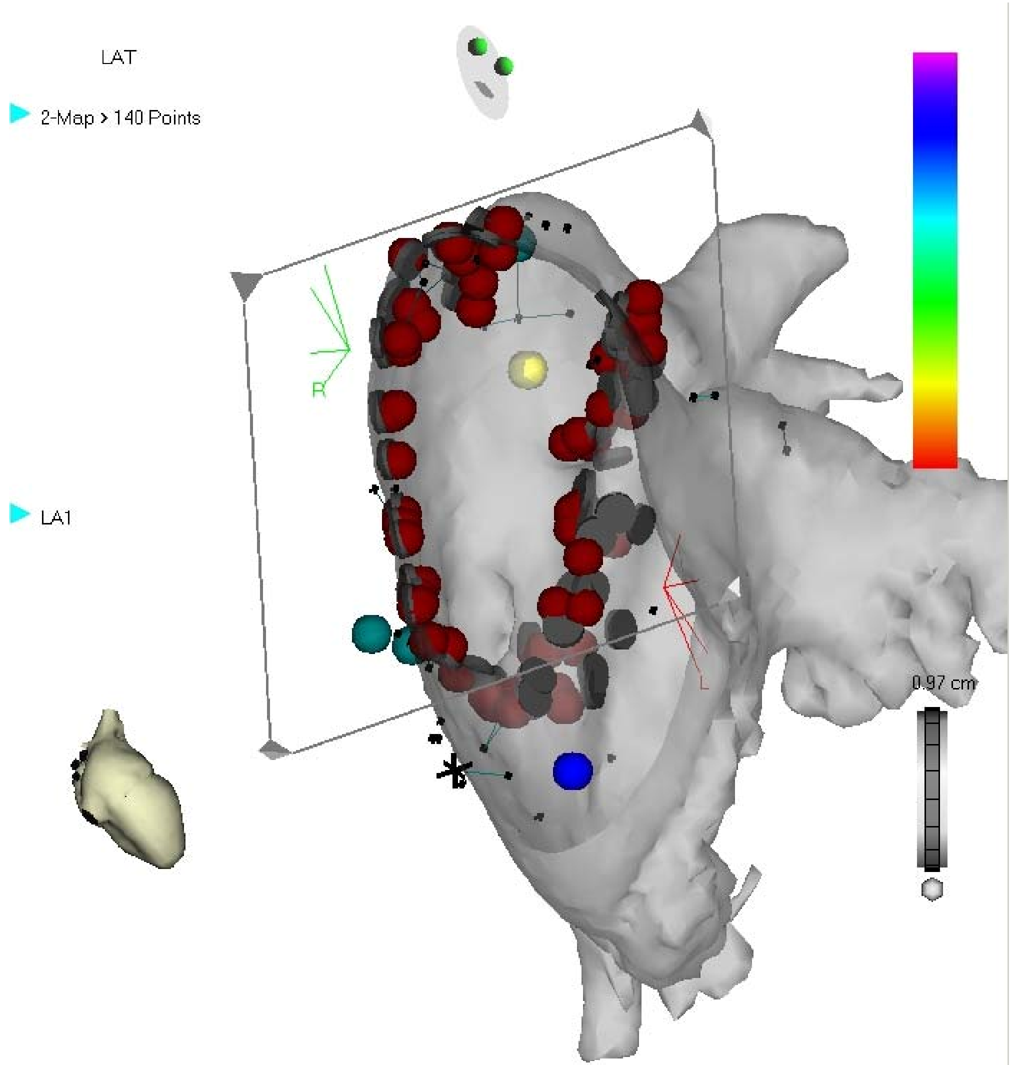
# Image Integration




**CARTOMERGE**
**the first human data, Cleveland Clinic**

# Anatomy-Based Mapping & Ablation



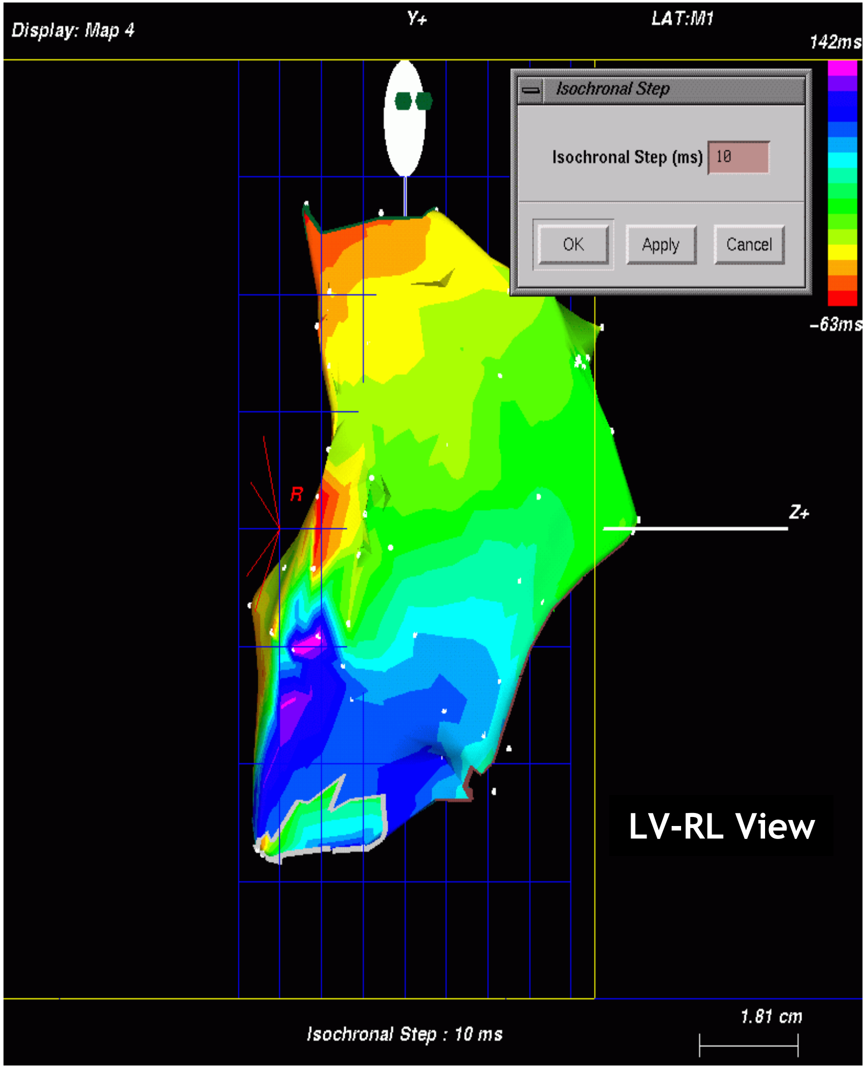

#16299634

# Working with Electroanatomical Mapping System

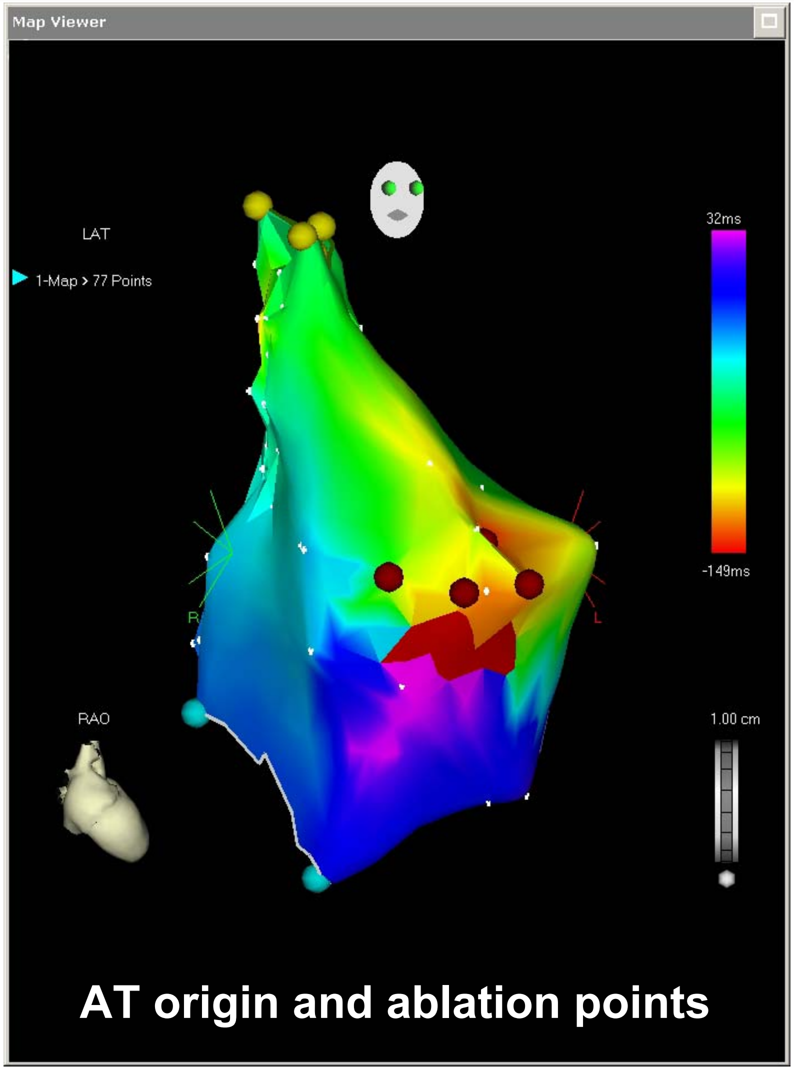
- Activation map
- Propagation map
- Voltage map
  - Scar delineation

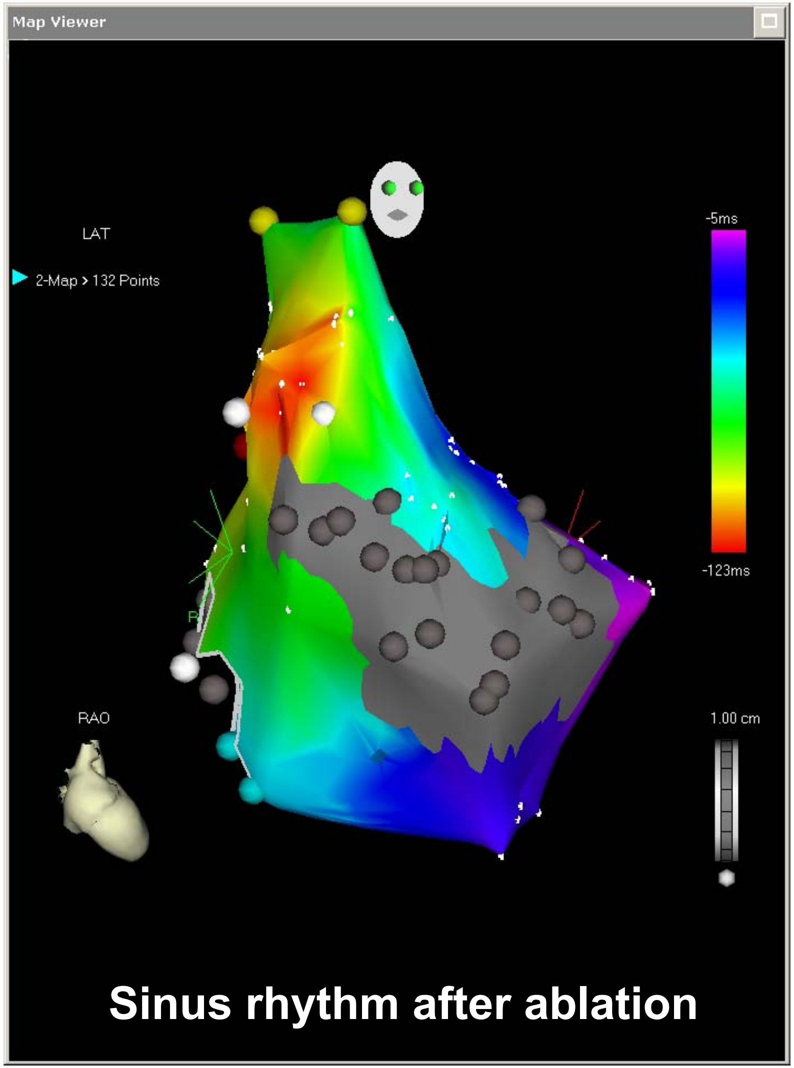
# Isochronal Map

- 3D-activation using color-coded isochronal areas
- Readjust the isochronal step
- Color scale bar based on the isochronal step



# Activation Map: Focal AT

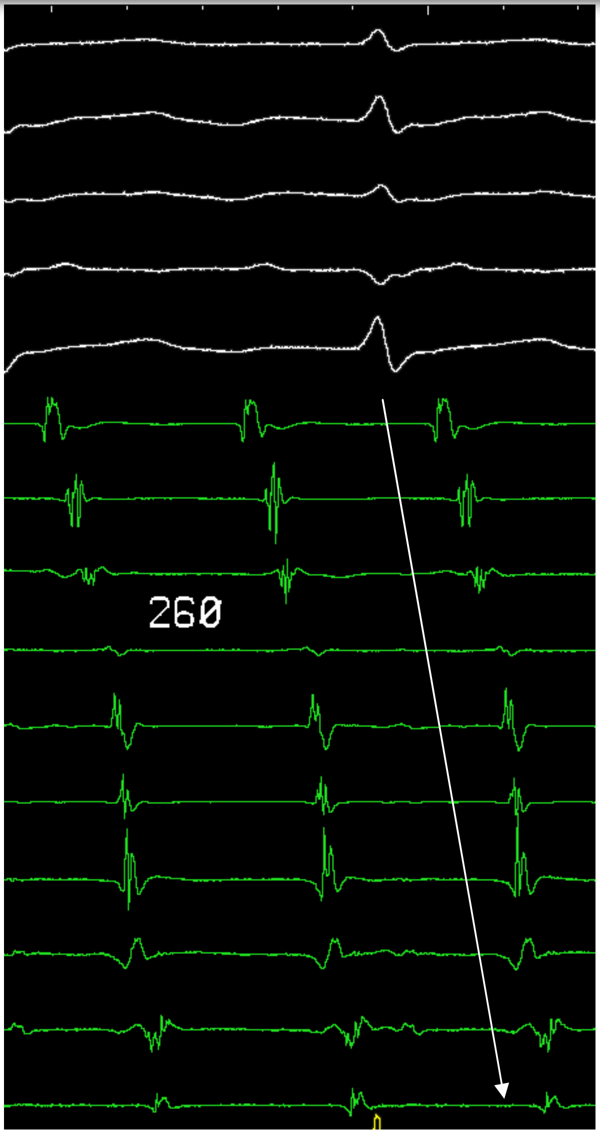


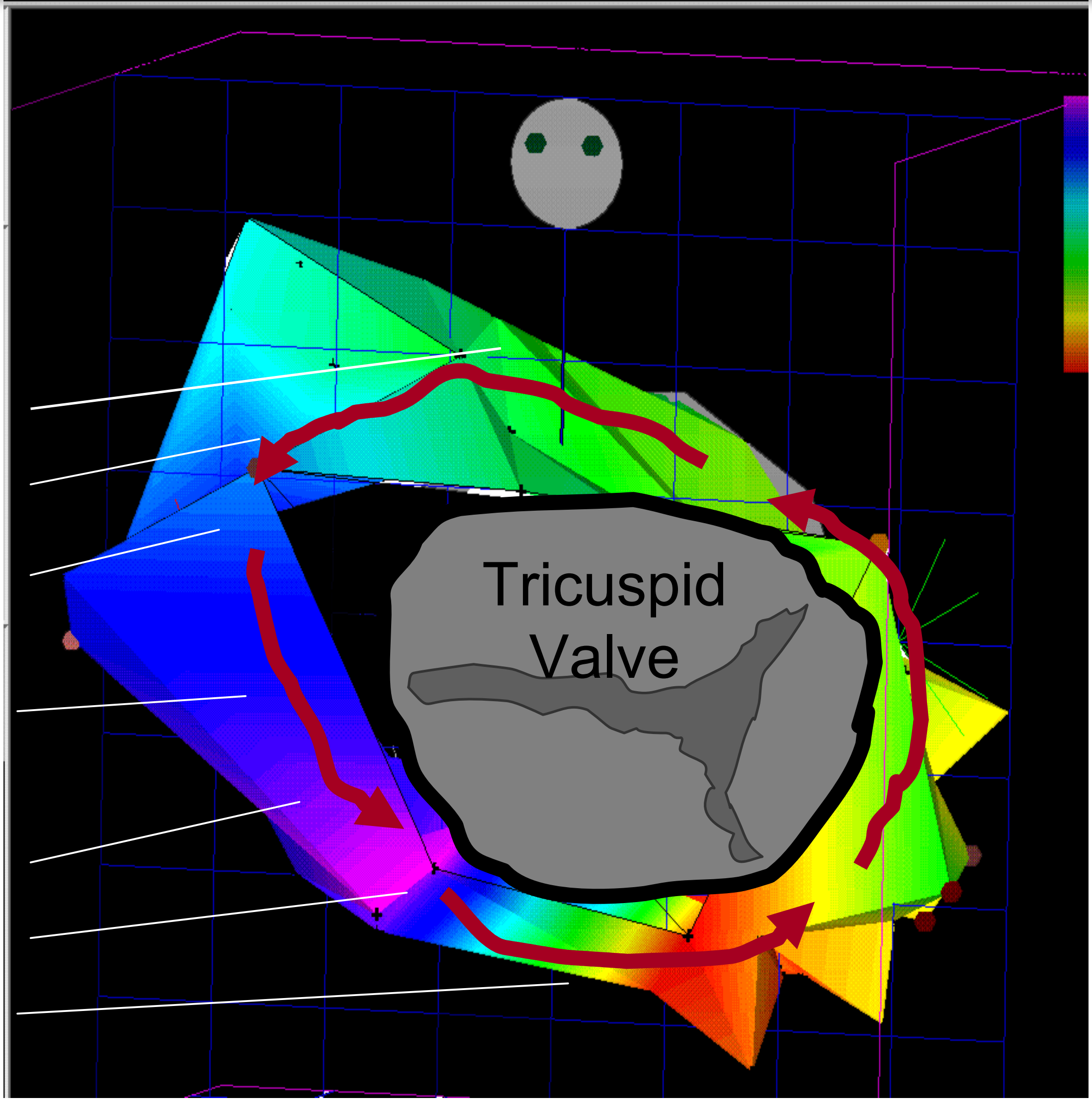




SNUH Data

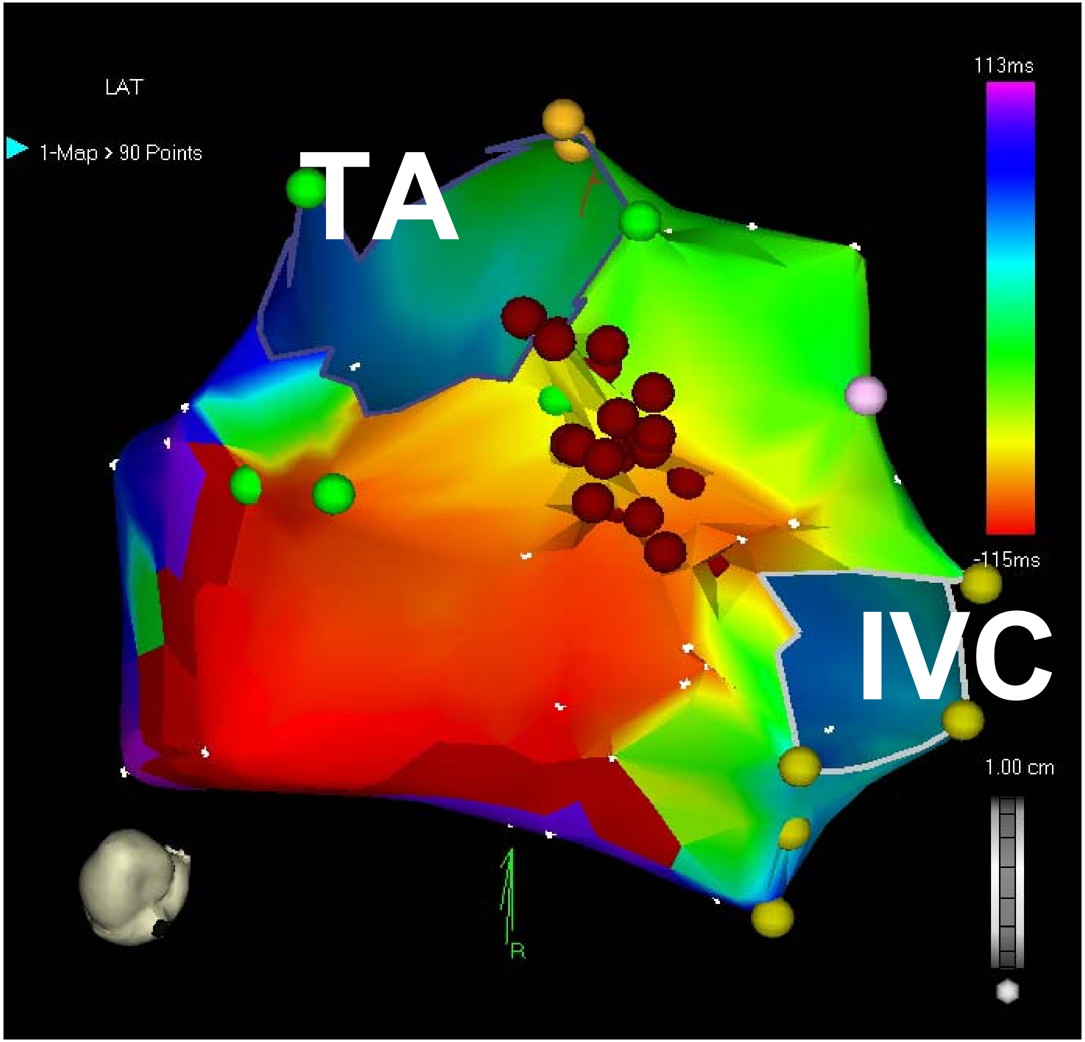
Seoul National University Hospital
Cardiovascular Center

# Counterclockwise Atrial Flutter



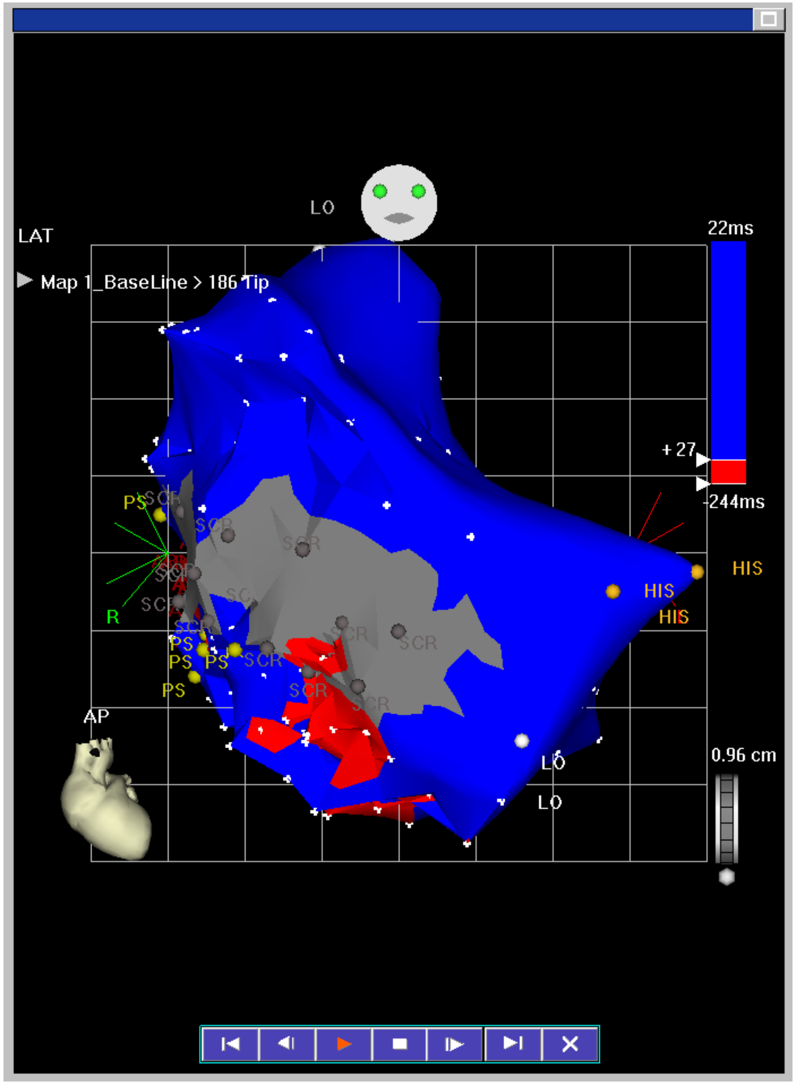



# AFL Ablation

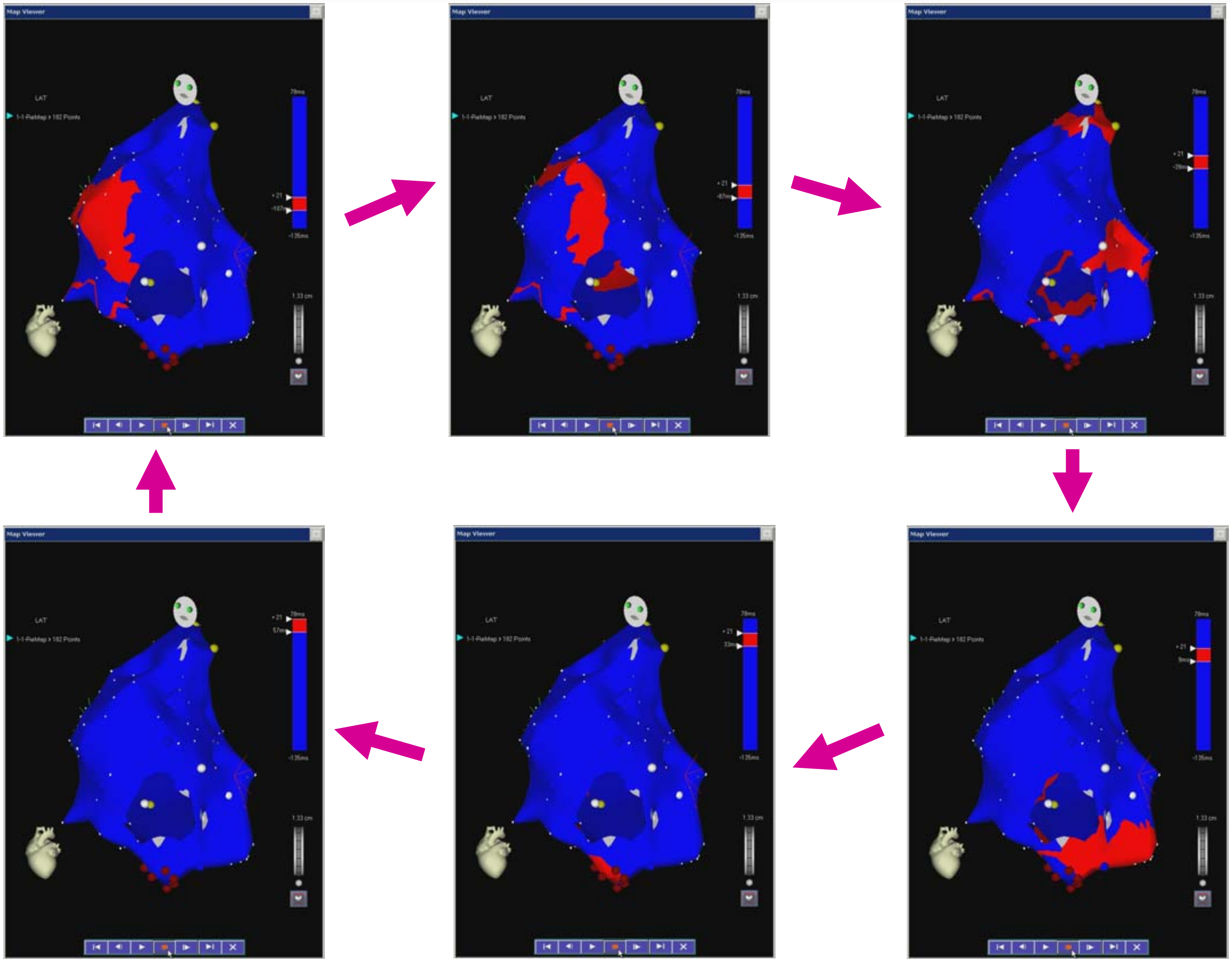



#34288942

# Propagation Map



# Propagation Map



#35737067

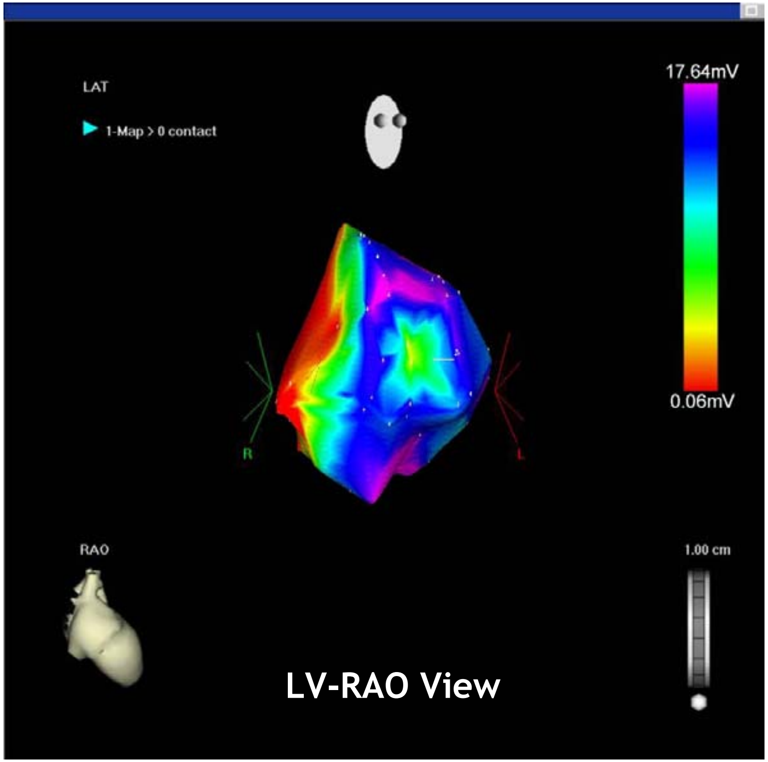
Seoul National University Hospital
Cardiovascular Center

# Voltage Map

- Maximum Unipolar and Bipolar Voltage Maps

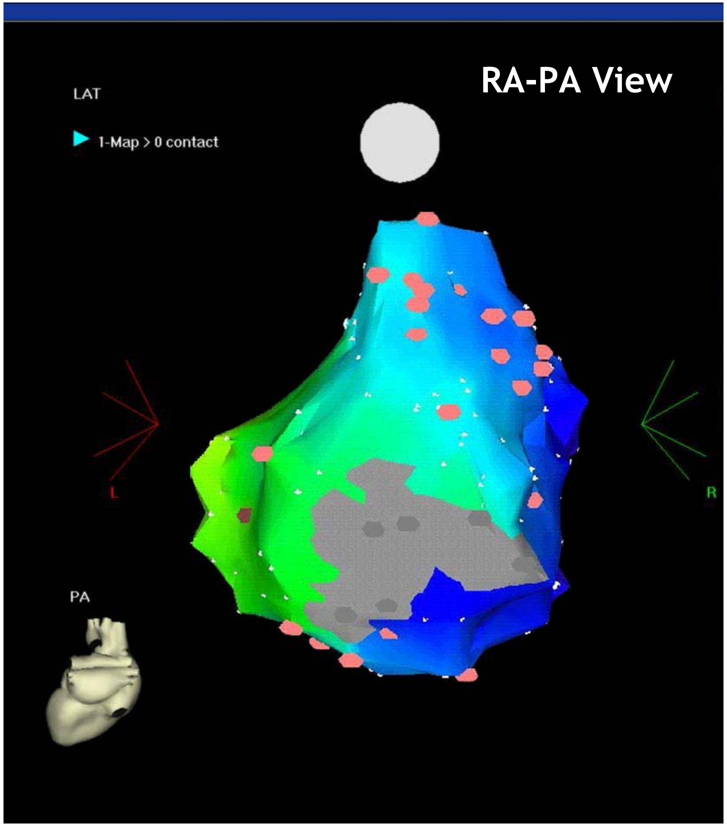
- Maximum voltage maps display the peak-to-peak value of the voltage

- Unipolar or bipolar signals

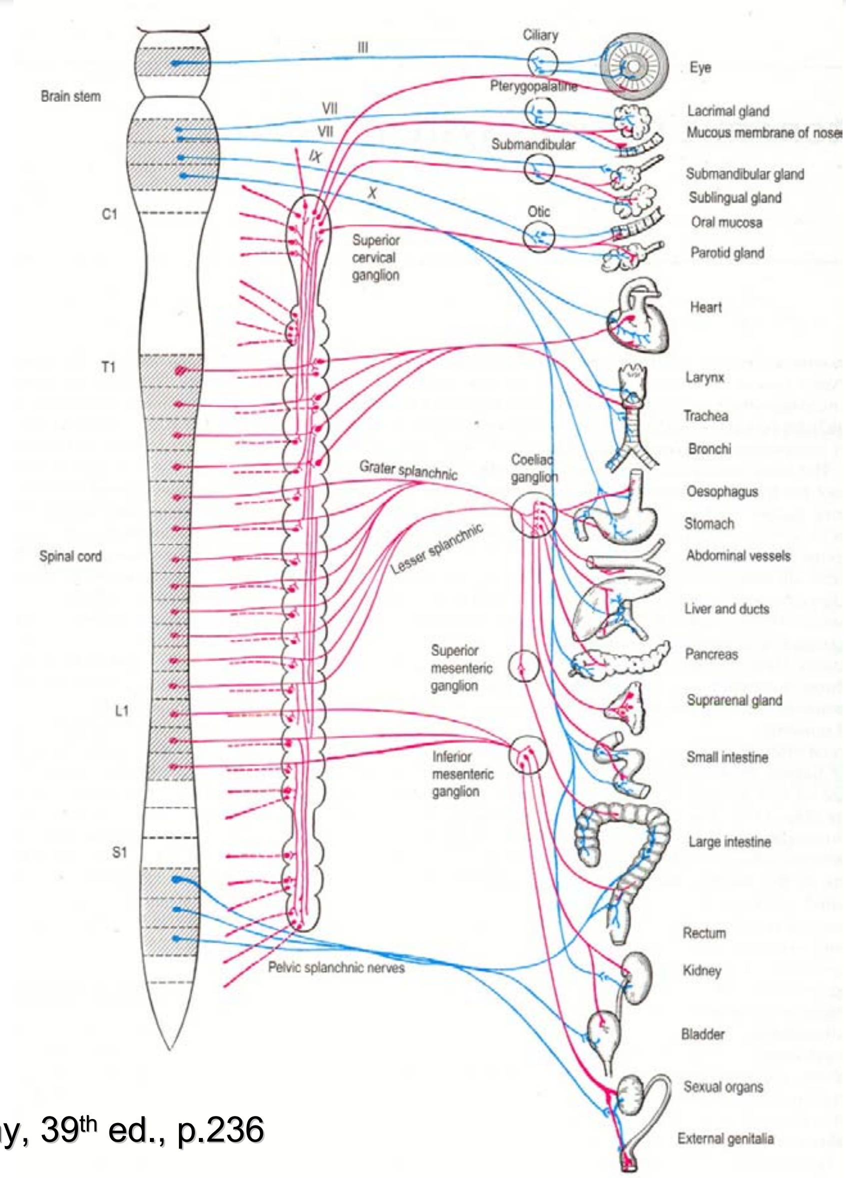


# Scar Delineation

- A grid point with the closest “real” point to it tagged as scar, is colored gray.
- No color interpolation across a scar area



# Autonomic Nervous System



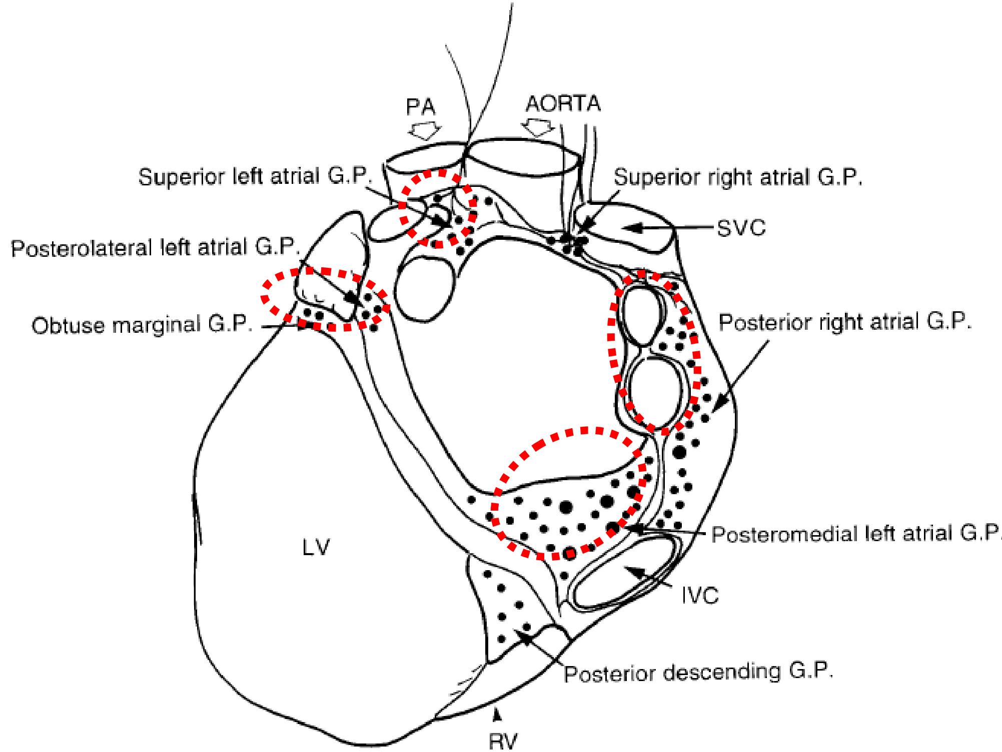


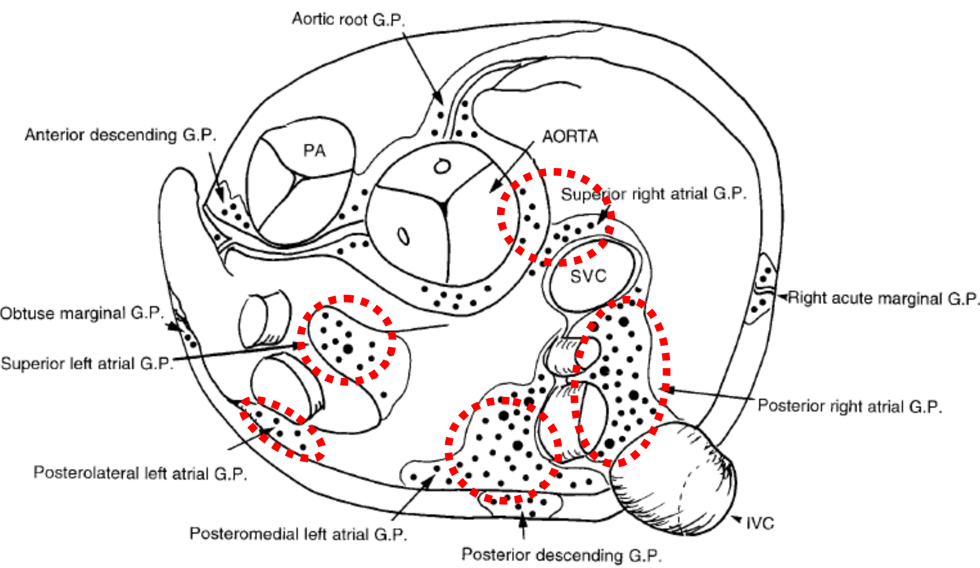
Gray's Anatomy, 39th ed., p.236

Seoul National University Hospital
Cardiovascular Center

# Human Heart: Major GPs

Armour et al., Anat Rec 1997;247:289-298



# GP Mapping Methods

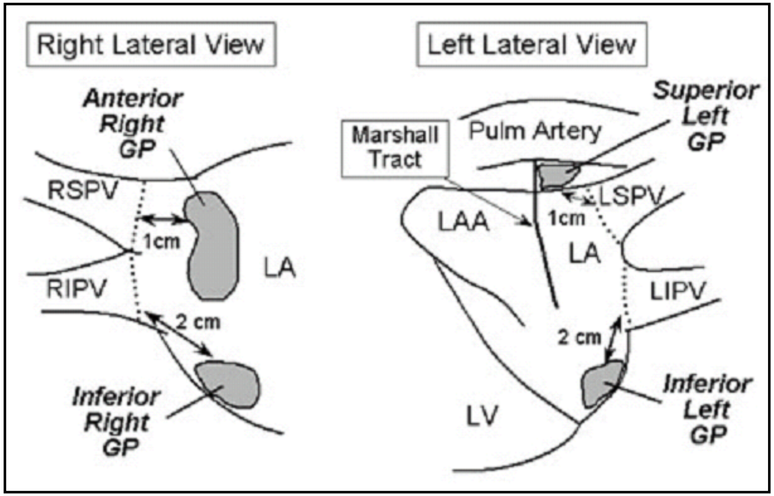
- Vagal response-guided mapping
  - Passive: detected during RF energy delivery
  - Active: high-frequency stimulation (HFS)

# High-Frequency Stimulation (Human)

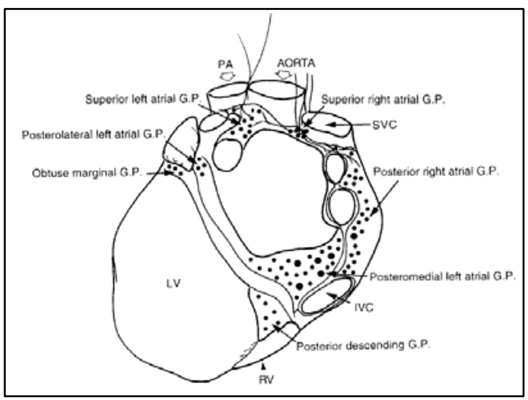
- Usually under deep sedation or general anesthesia
- Stimulator: eg. Grass stimulator S-88
- Intensities to evoke vagal response

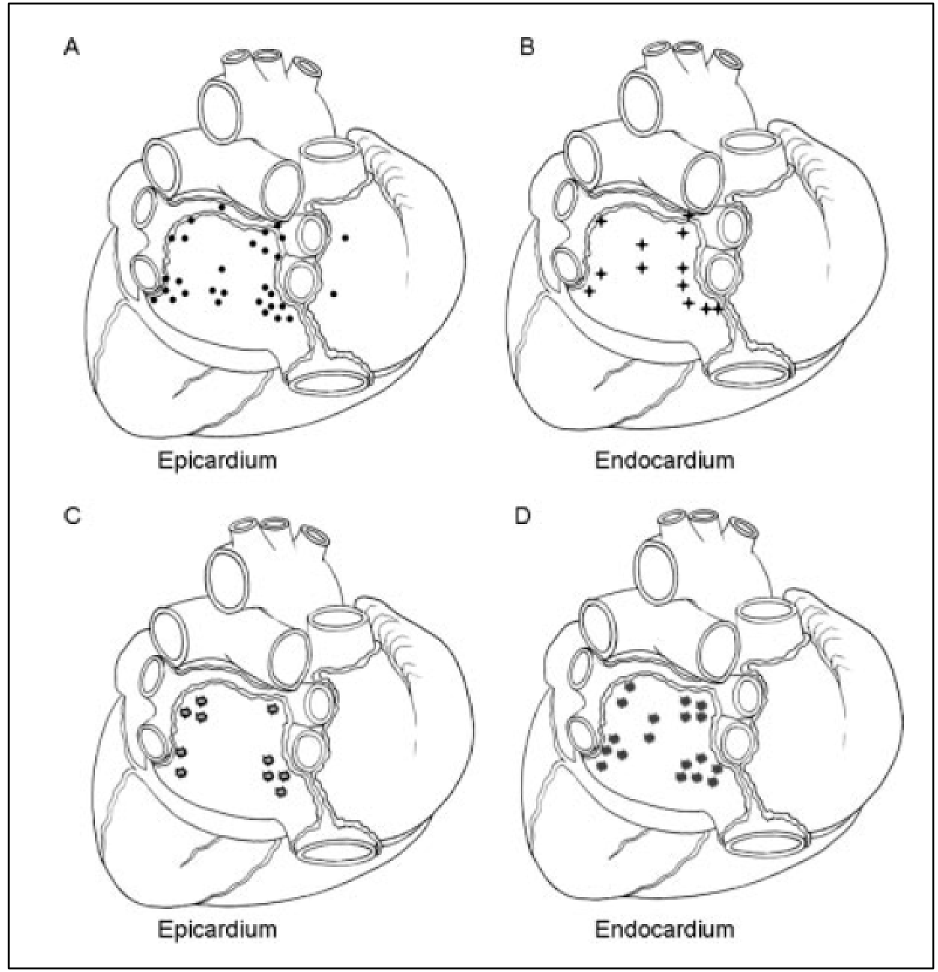
| Frequency | Pulse width | Voltage | Sites | References |
|---|---|---|---|---|
| 20 Hz | 2 ms | 10-30 V | SVC | Schauerte et al.<br>Circulation 2001 |
| 17 Hz | 0.5 ms | 8 V | CS | Vago et al.<br>JCE 2004 |
| 20 Hz | 1-10 ms | 12 V | Endocardial | Scherlag et al.<br>JICE 2005 |
| 20-50 Hz | 10 ms | 5-15 V | Endocardial | Lemery et al.<br>Heart Rhythm 2006 |
| 20 Hz | 4 ms | ~100 V | Epicardial<br>Endocardial | Scanavacca et al.<br>Circulation 2006 |

# Sites Showing Vagal Response Evoked by HFS



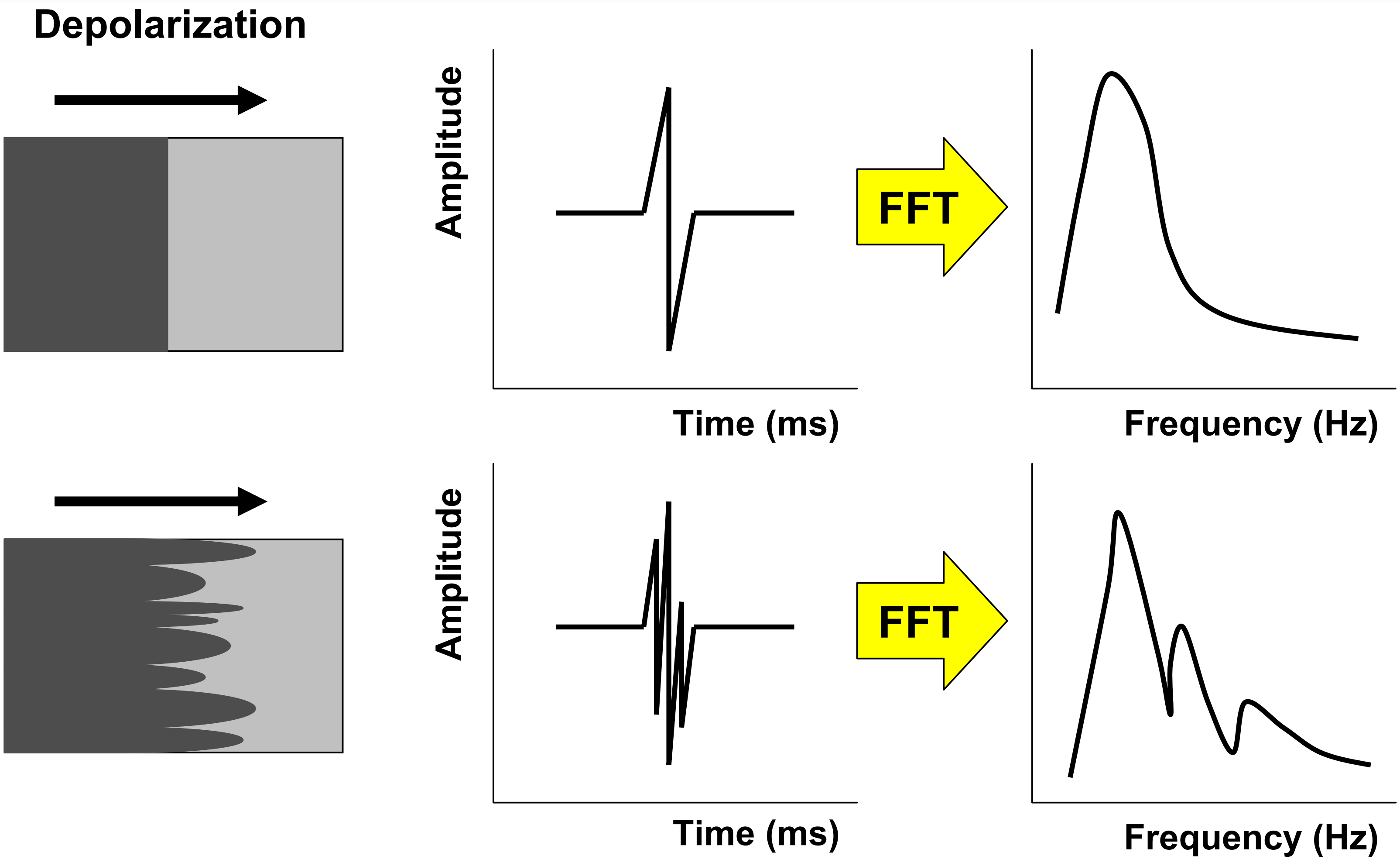

Nakagawa et al., HRS 2005 2(Suppl):S10-S11
Scherlag et al. JICE 2005;13:37-42




Scanavacca et al., Circulation 2006;114:876-885

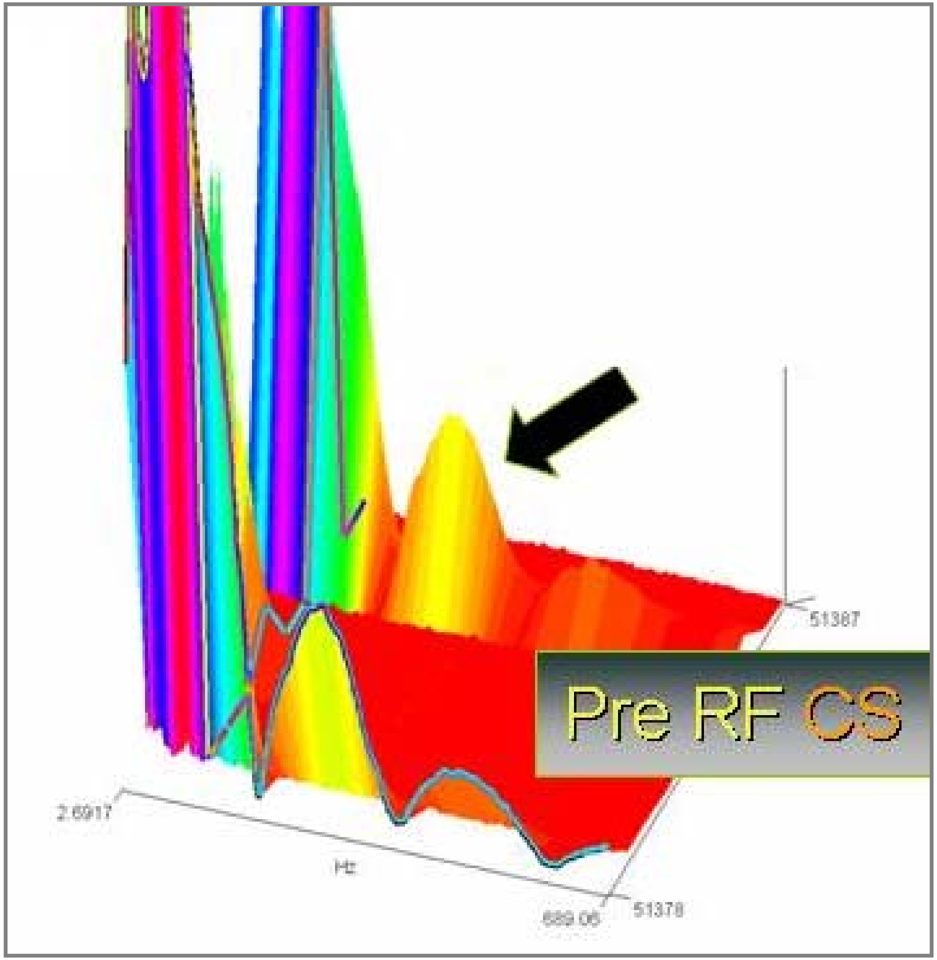
# Activation Pattern & Spectral Analysis

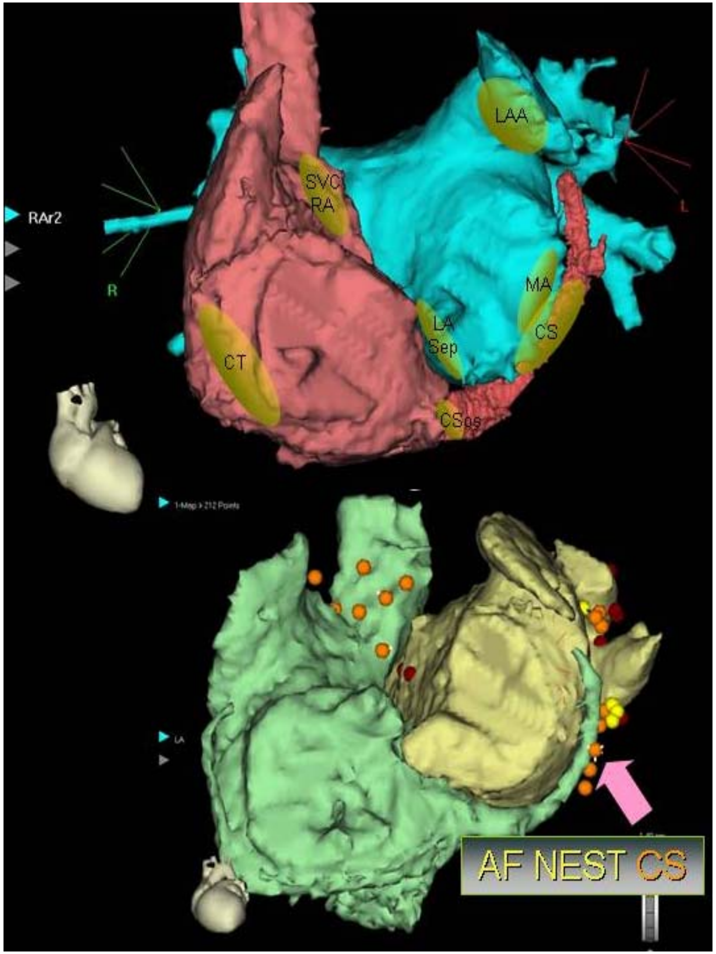



High frequency component in spectral analysis of electrogram might be associated with structural inhomogeneity of underlying cardiac tissue, which could be a substrate of arrhythmia.

# AF Nest

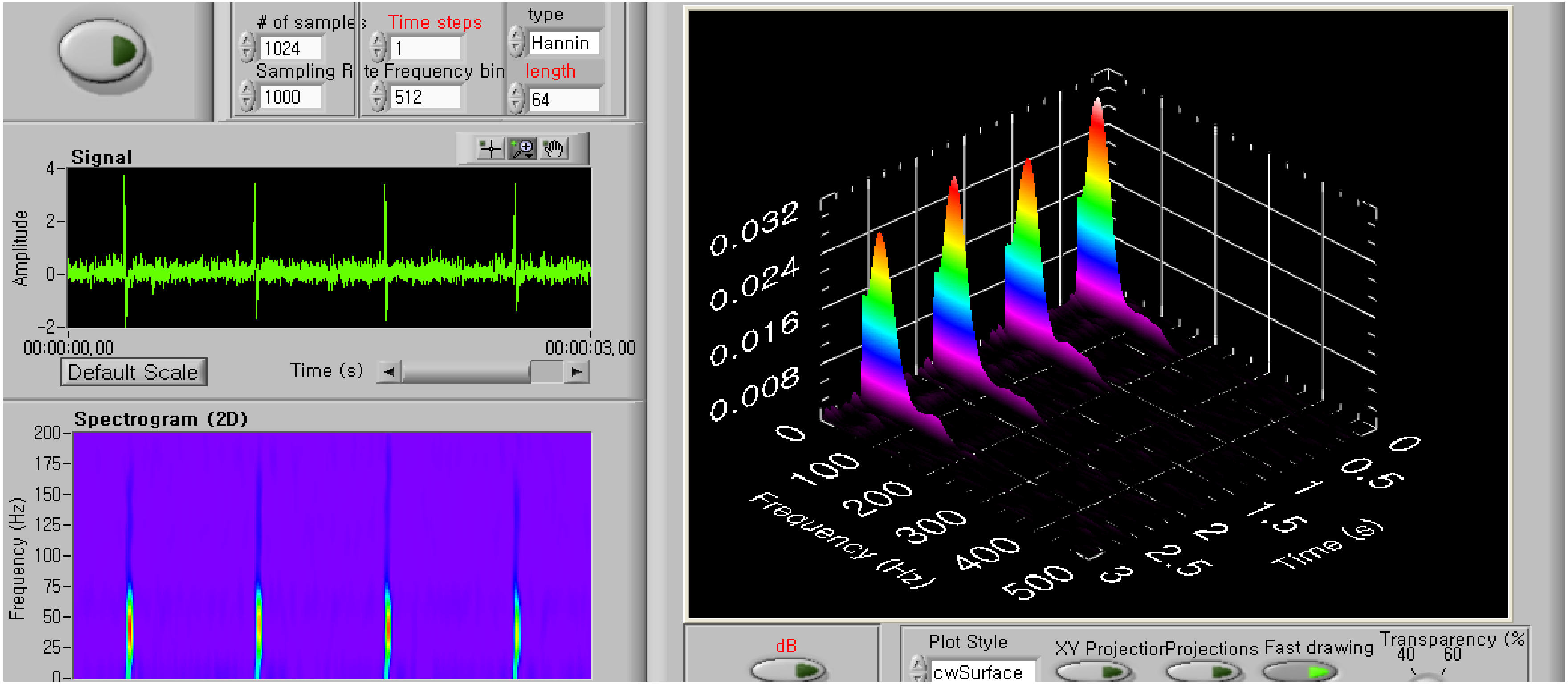
- Examples of spectral analysis in substrate mapping: AF nest



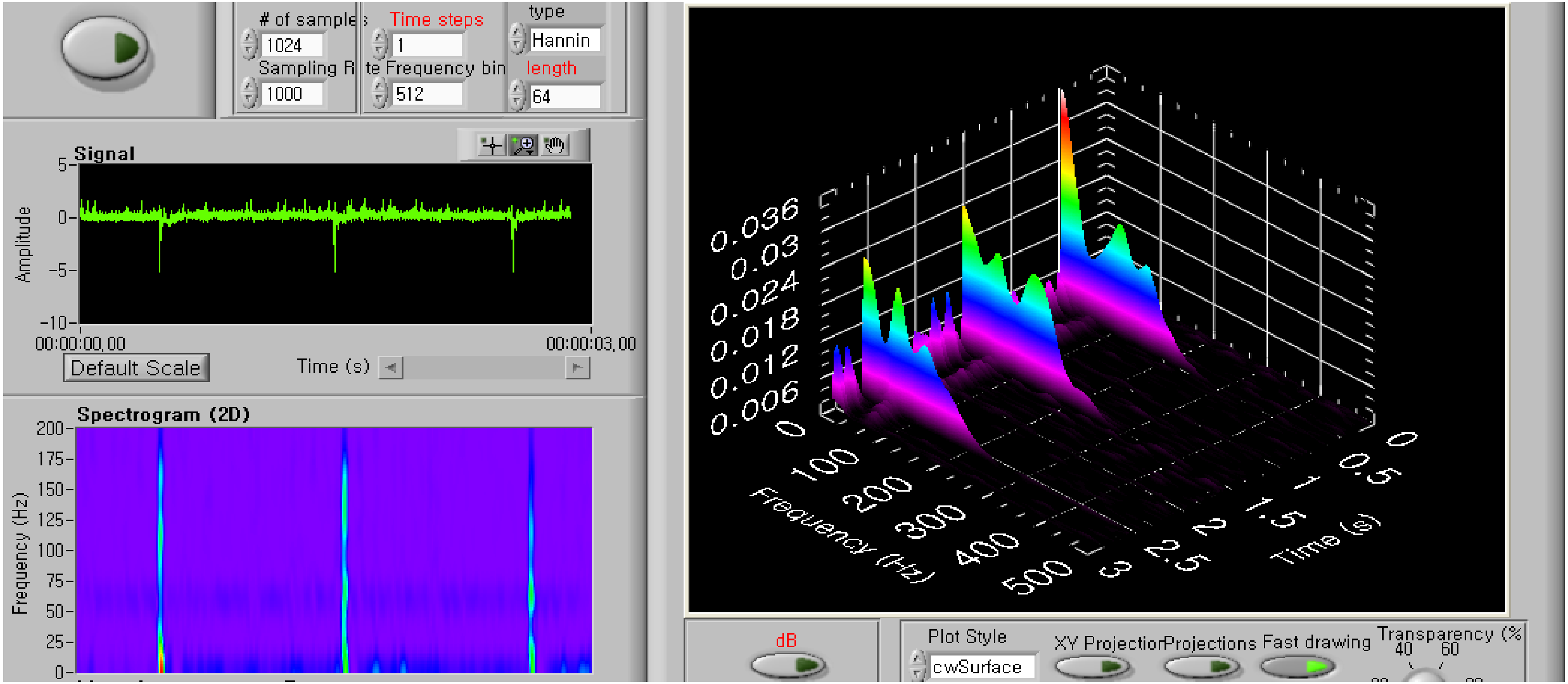

Courtesy of Dr. Mauricio Arruda, Cleveland Clinic

# Normal Site During Sinus Rhythm




**SNUH Data**

# AF Nest During Sinus Rhythm

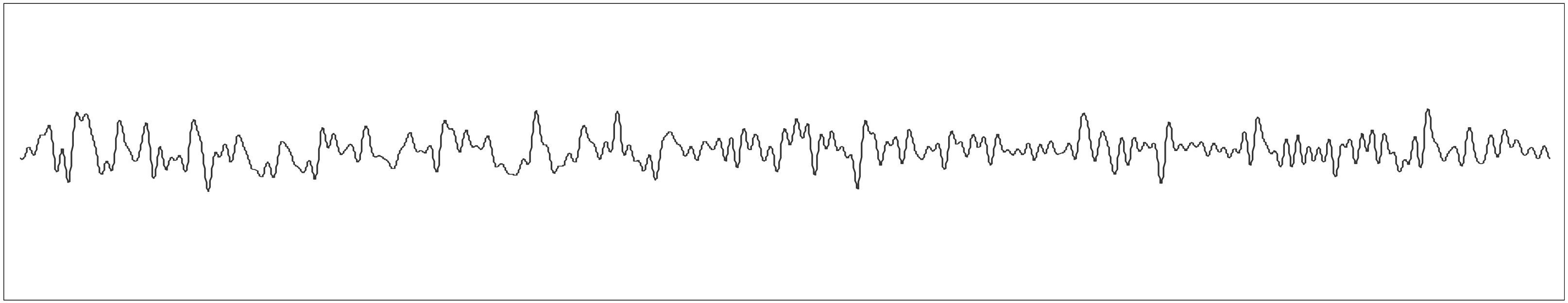



**SNUH Data**

*Seoul National University Hospital*
*Cardiovascular Center*

# CFAE During AF

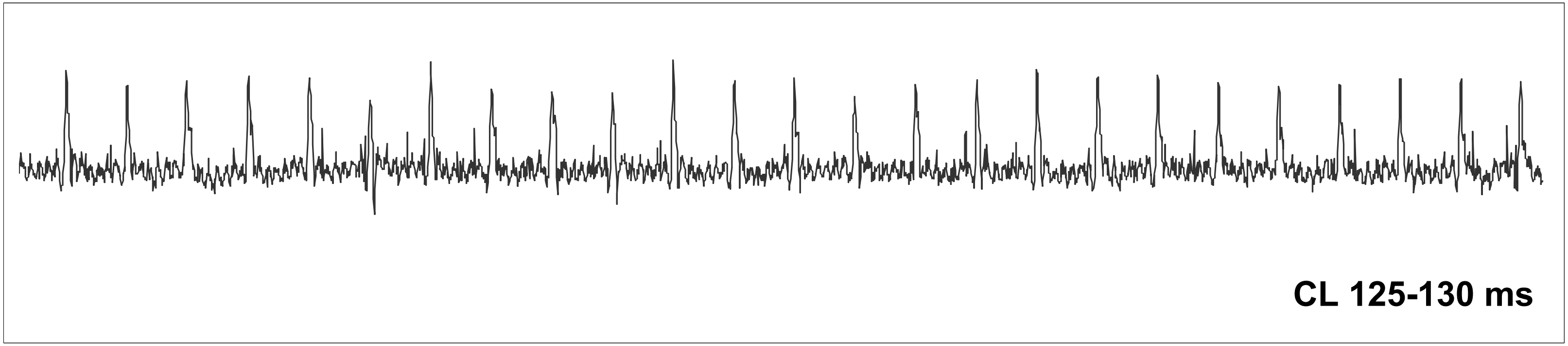
## CFAE site



0 1500 3000

Time (ms)

## Non-CFAE site

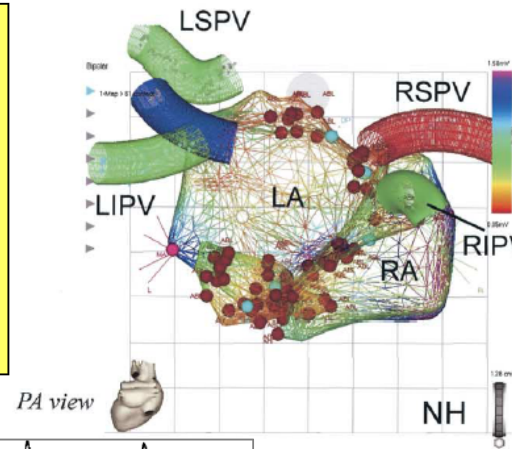


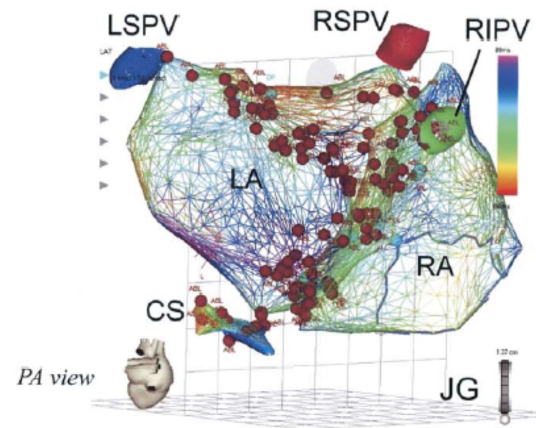

**SNUH Data**

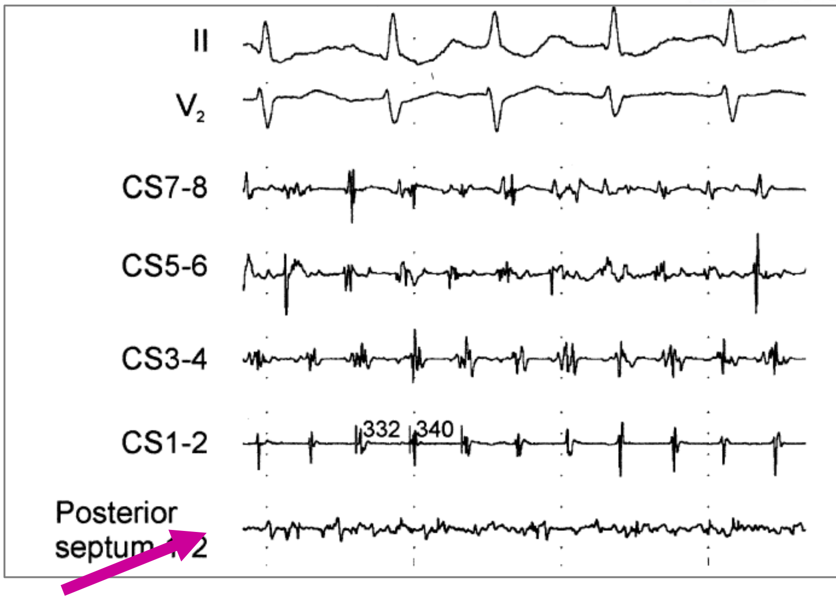
# Complex Fractionated Atrial Electrograms (CFAE)

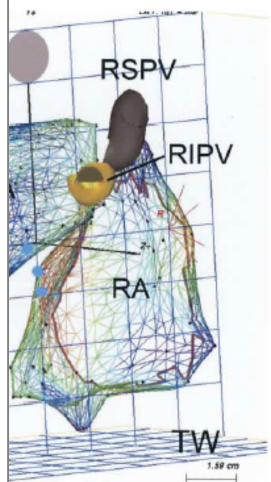
**CFAE ablation (n=121)**

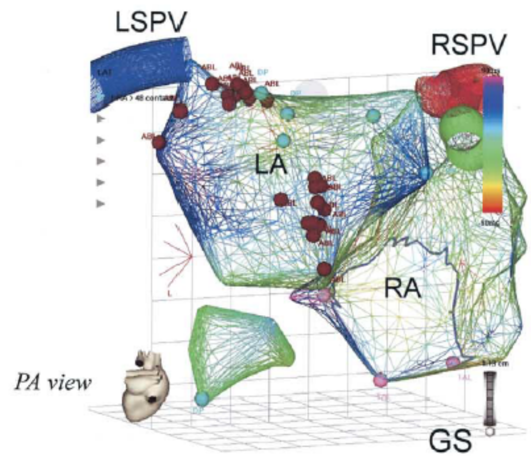
- 1-year F/U
- AF free 110 (91%)
  - One ablation 92 (76%)
  - Two ablation 18 (15%)



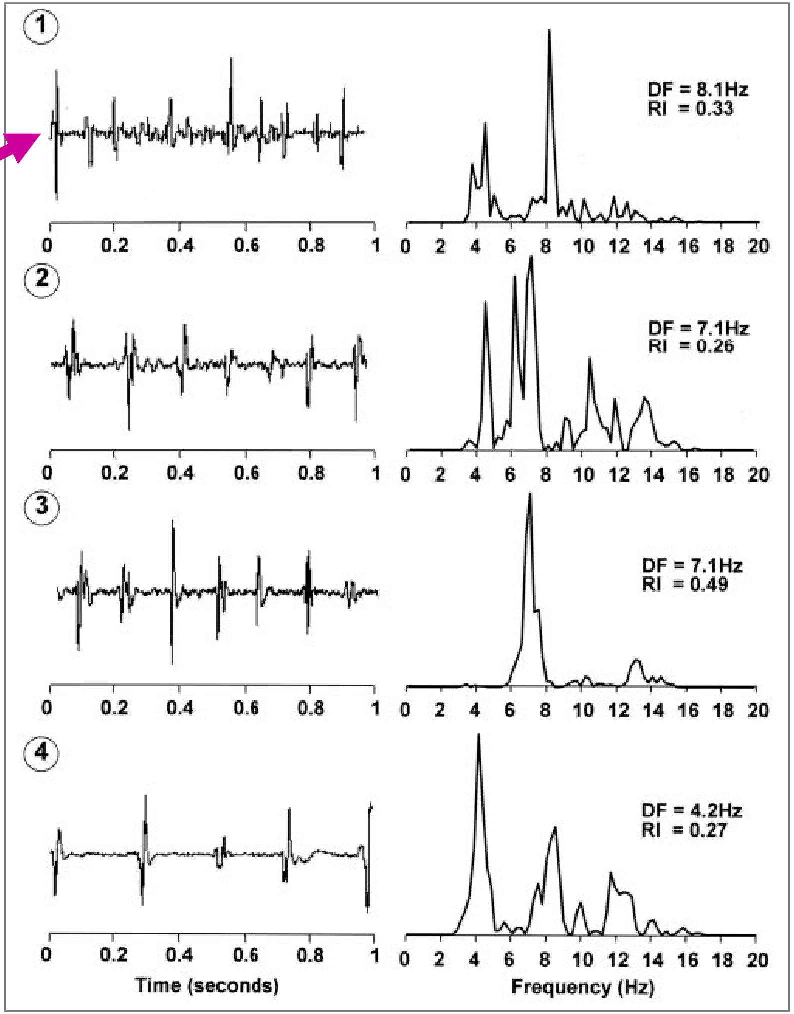



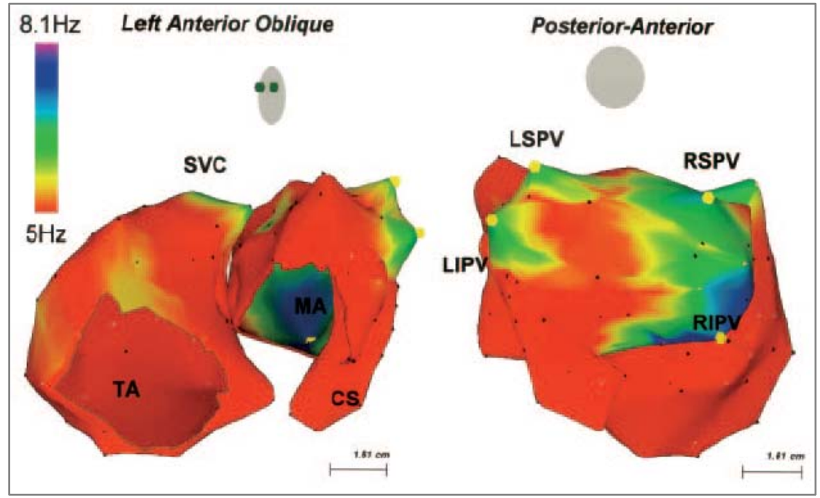



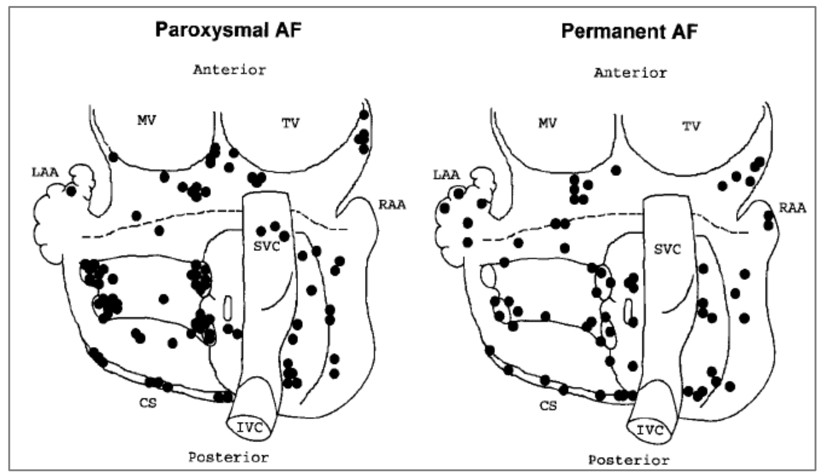




Nademanee et al. JACC 2004;43:2044-53

# High DF (Dominant-Frequency) Sites

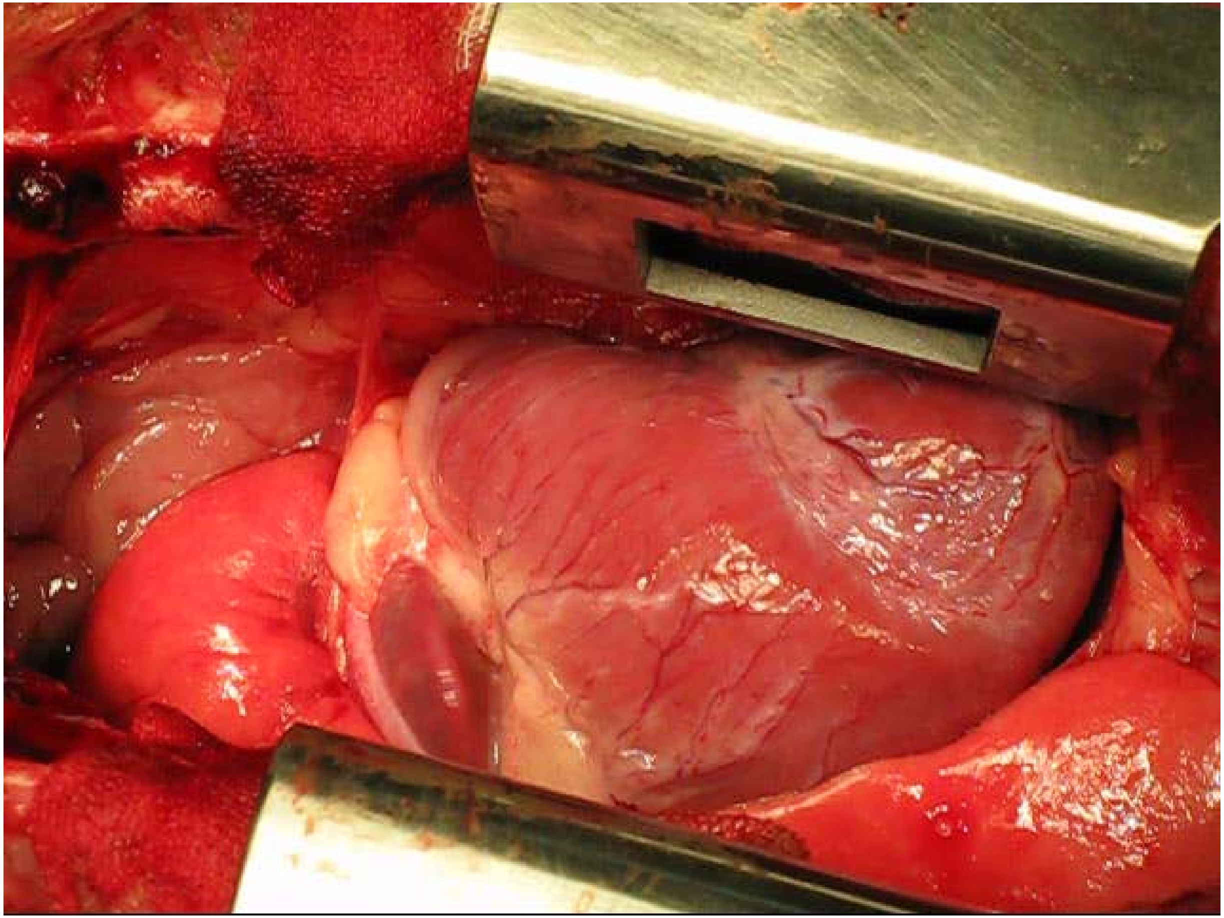



Sanders et al. Circulation 2005;112:789-97

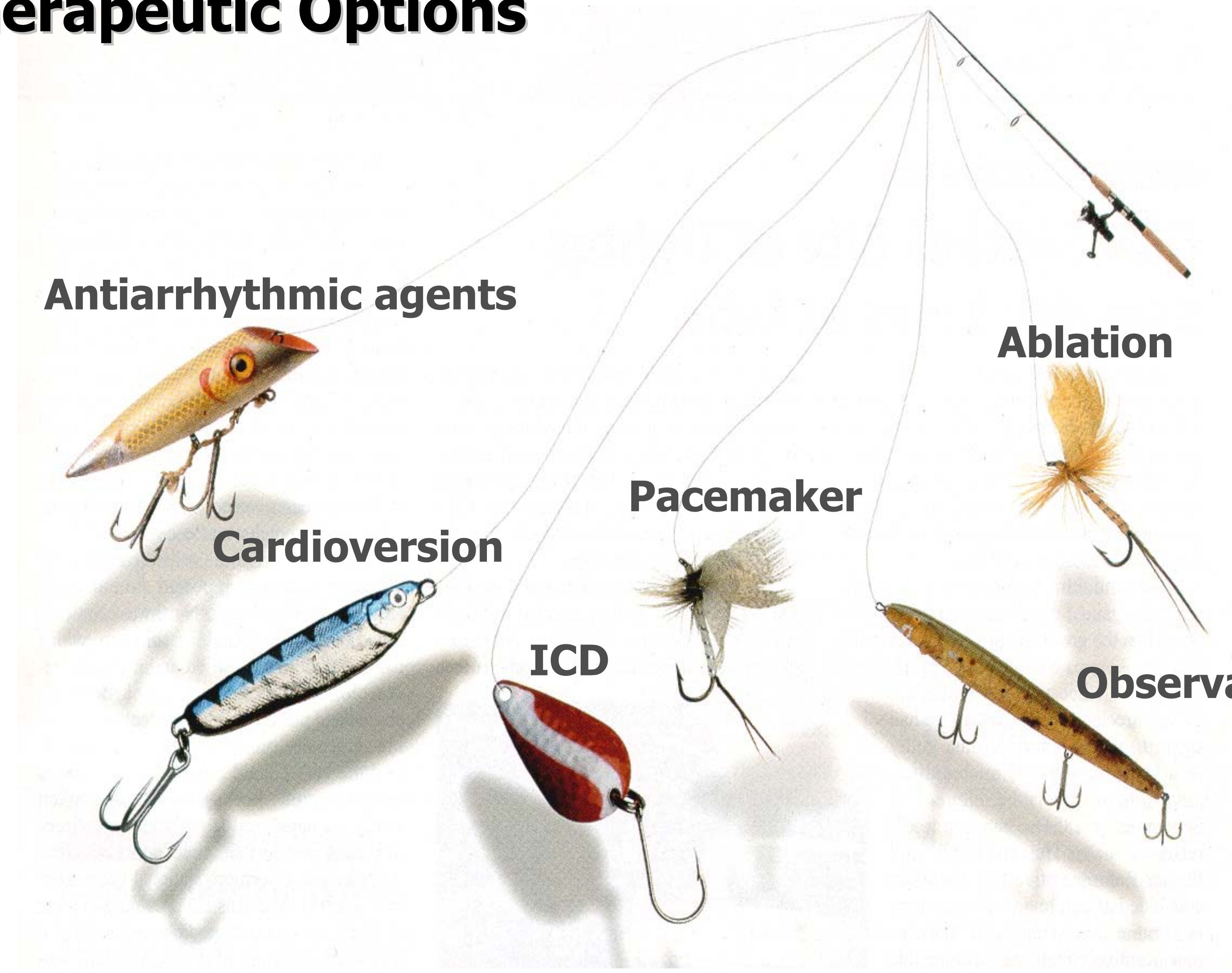
# Safety: DC 9V Battery can induce VF



# 부정맥 치료전 고려사항들

1. 부정맥의 정확한 진단
2. 원인질환 진단
3. 유발요인 진단(커피, 흡연, 술 등)
4. 치료의 필요성 결정
5. 비약물치료를 우선 실시
6. 적절한 단기 및 장기 치료법 선택

# Therapeutic Options



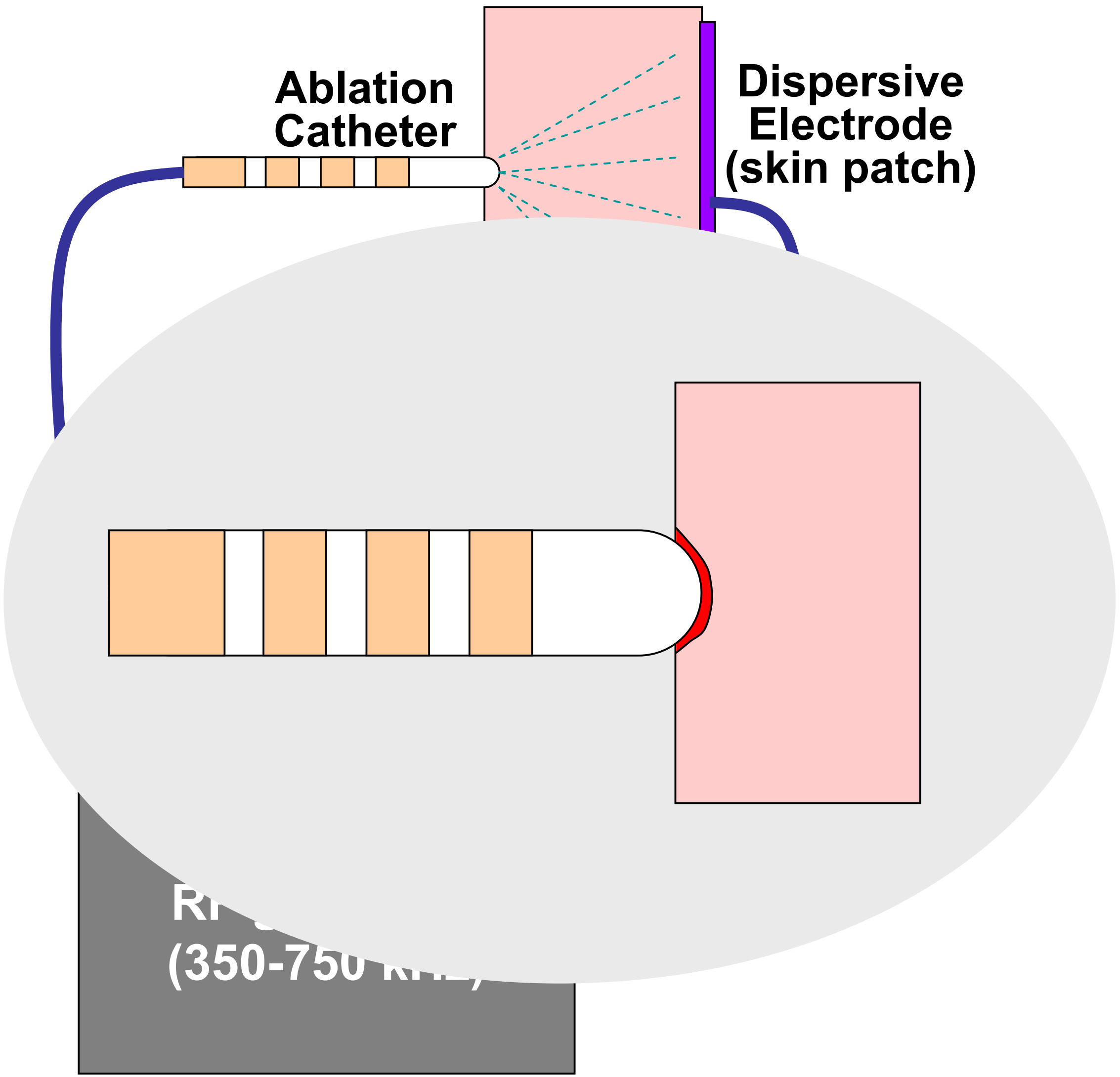
# RF Catheter Ablation

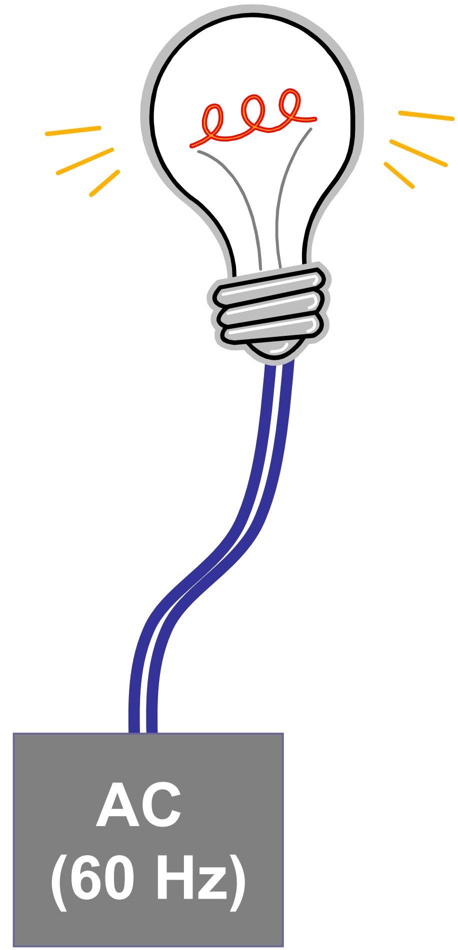
The NEW ENGLAND JOURNAL of MEDICINE

## TABLE OF CONTENTS

Volume 324 June 6, 1991 Number 23

# RF Ablation – Resistive Heating as a Heat Source



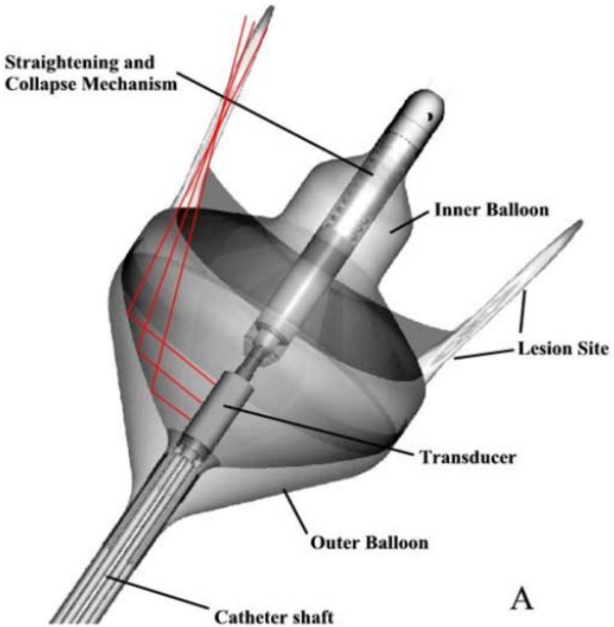



# New Technology – Alternative Energy Sources

- **Cryo**
  - Cryocath
  - Balloon
- **Ultrasound**
  - HIFU balloon
- **Laser**
  - Balloon
- **Microwave** (UHF ~: 300 MHz - 300 GHz)

| | RF | Laser | Micro | US | Cryo |
|---|---|---|---|---|---|
| Clinical experience | ++++ | + | + | + | ++ |
| Endocardial thrombogenicity | ++ | ++ | ++ | ++ | + |
| Mapping | +/− | − | − | − | + |
| Transmural efficacy/ contact forgiving | − | + | +++ | ++++ | − |

# Focused Ultrasound Ablation System





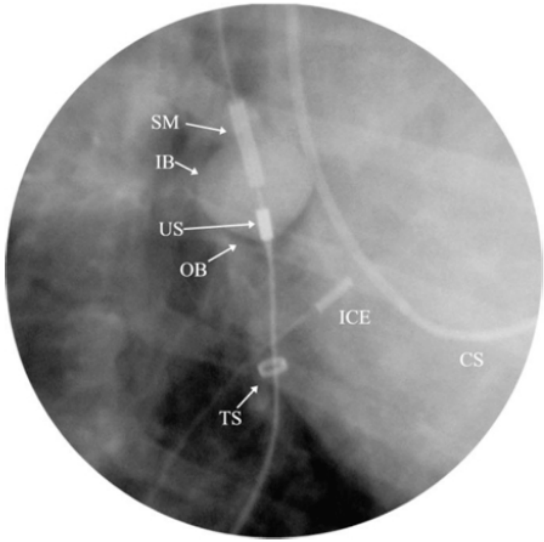
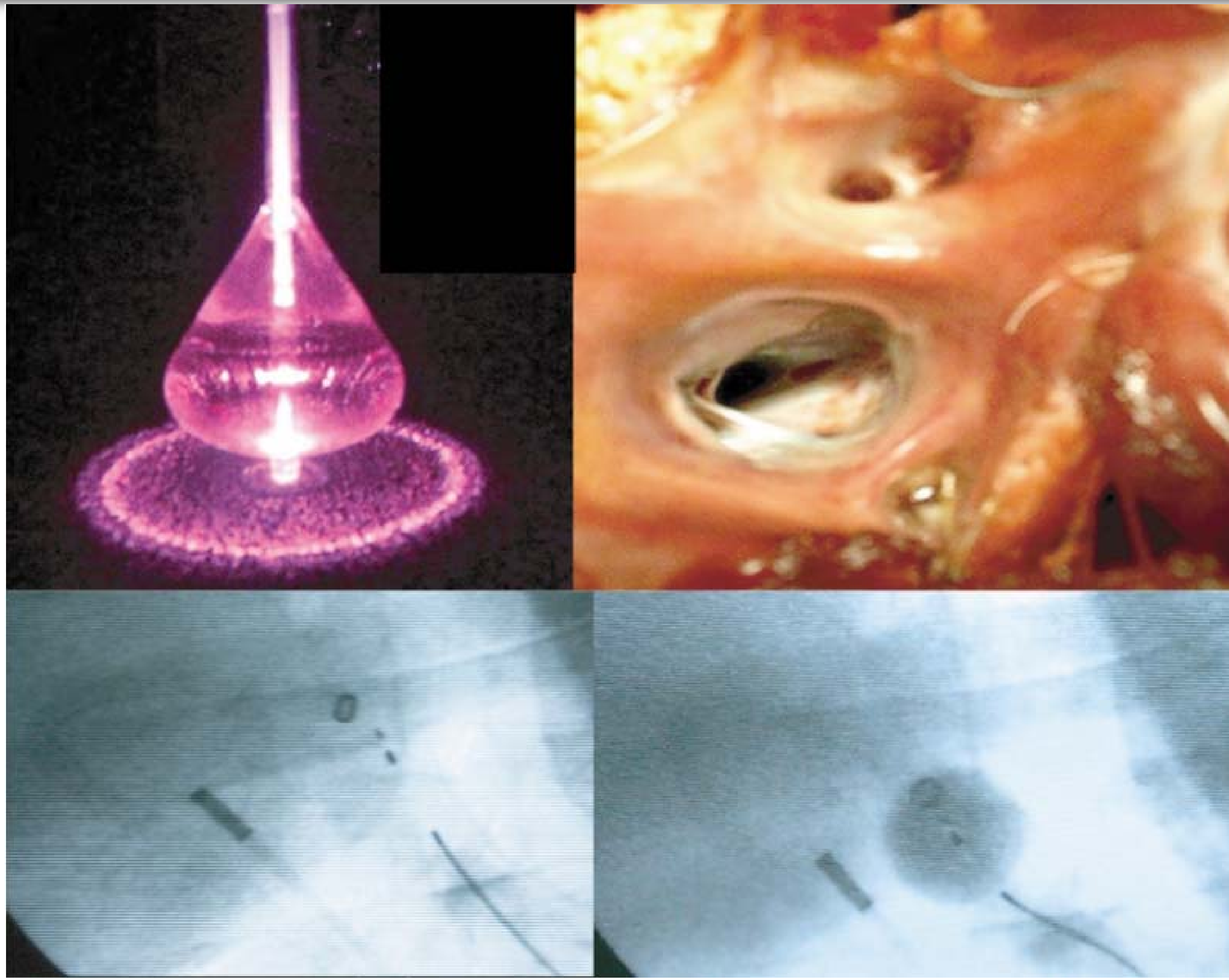



*Fig. 2. Fluoroscopic image of the focused ultrasound balloon ablation system engaged in the right superior pulmonary vein (AP projection). Inner balloon is inflated with sterile water/contrast solution, the outer balloon is filled with carbon dioxide. (IB = inner balloon; OB = outer balloon; TS = transseptal sheath; CS = coronary sinus catheter; ICE = intracardiac echocardiography probe; US = ultrasound transducer; SM = straightening mechanism).*

# Laser Balloon System

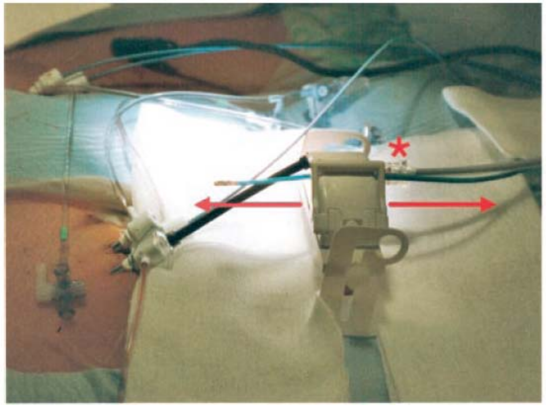


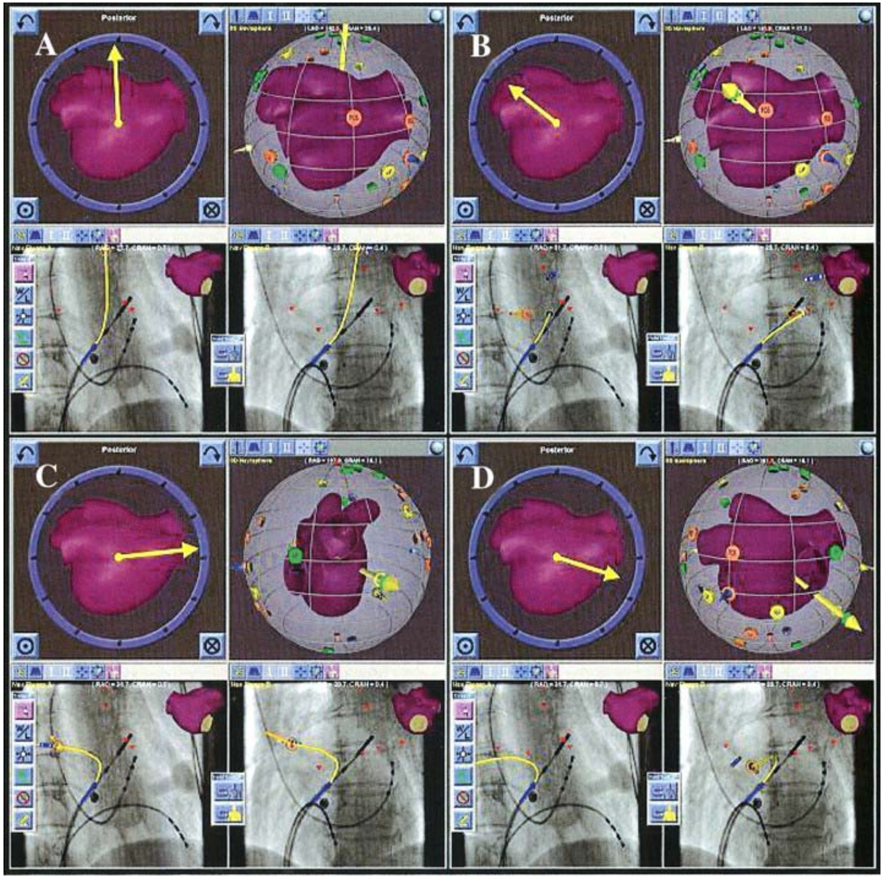
# Catheter Navigation Technology

- Magnetic navigation system
    - Niobe (Stereotaxis)
- Robotic catheter control system
    - Sensei (Hansen Medical)

# Magnetic navigation system

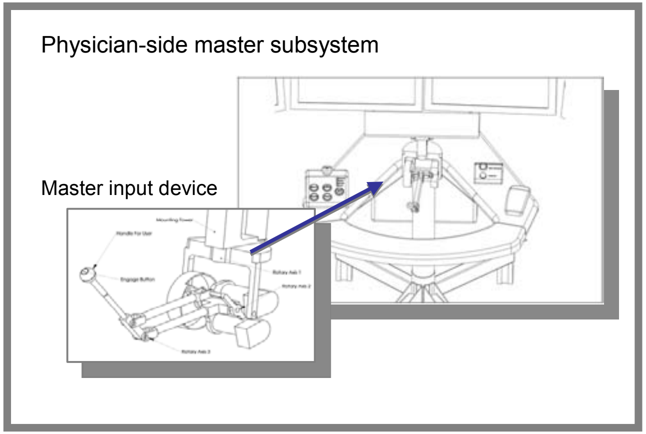
- Niobe (Stereotaxis)

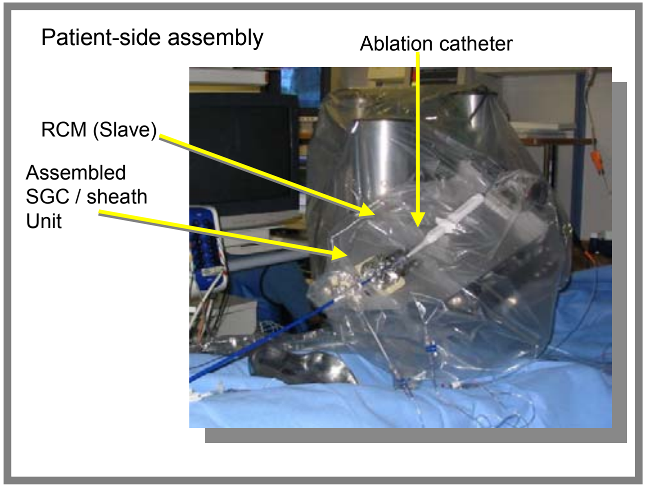


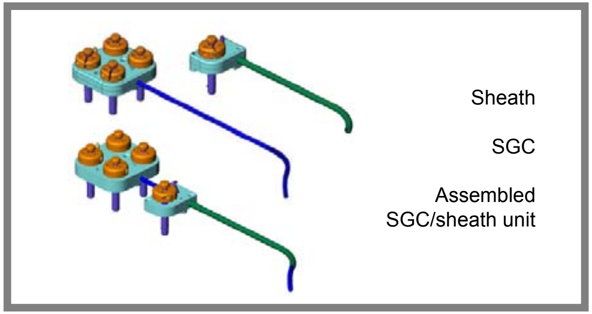


# Robotic Catheter Control System

- Sensei (Hansen Medical)

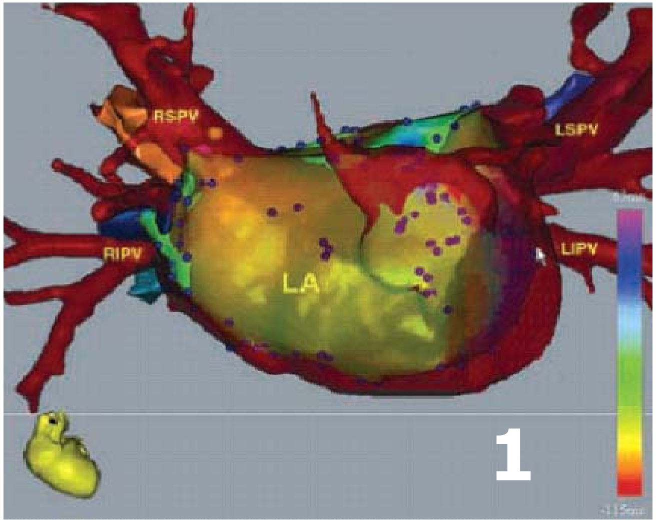


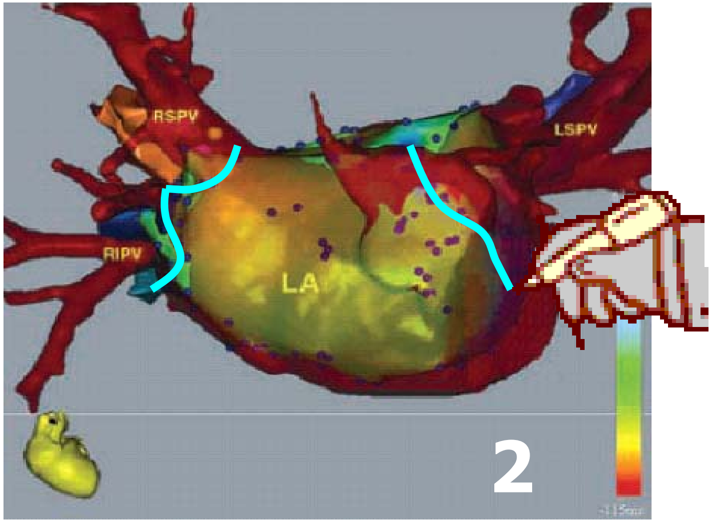



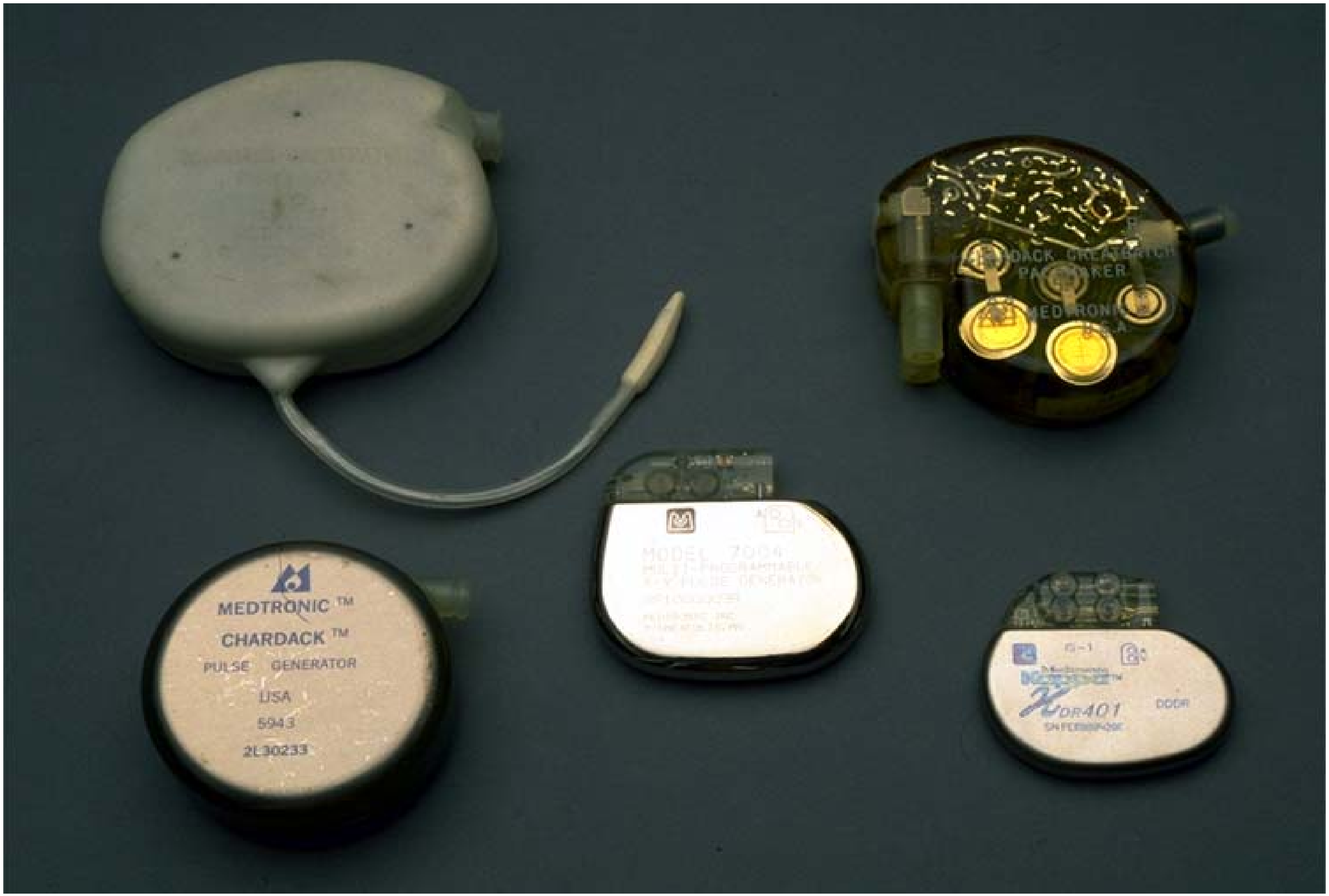
# EP Lab in the Near Future

1. Image integration
2. Lesion design on the integrated images
3. Computer-controlled catheter manipulation & lesion creation

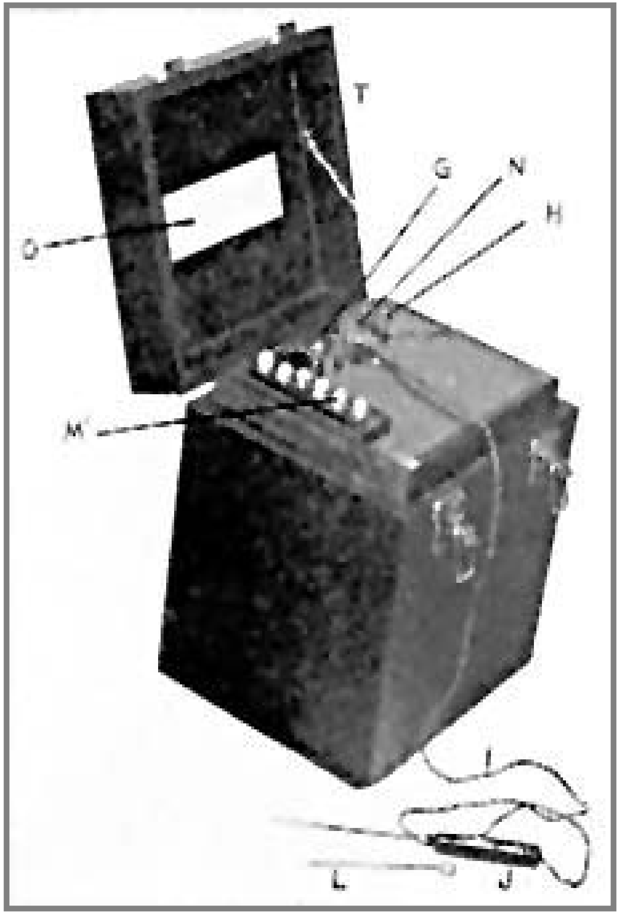



# A Brief History of Pacemakers



# History - Hyman's 1931 Pacemaker



**August 28, 1952** Paul Zoll performs the first human clinical cardiac pacing in Boston, Massachusetts.

## Transthoracic Cardiac Pacing

The first transthoracic cardiac pacing was accomplished with a Thyratron physiologic stimulator designed for laboratory use. The "stimulating electrodes were attached to needles placed subcutaneously in the chest wall at points in a line transversing the ventricles." "Electric shocks 2 milliseconds in duration were given at frequencies from 25 to 600 per minute. The intensity of the shocks was increased until ventricular responses were observed." "…On August 28, 1952, because of 2 severe Stokes-Adams attacks," a 75 year old man was the "first time it was possible to keep a patient alive during a ventricular asystole…" In the discussion Dr. Zoll speculates that a simplified pulse generator might be better suited for clinical purposes and that an additional circuit permitting bursts of alternating current might possibly be able "to defibrillate the human heart across the unopened chest initially and then to arouse it from ventricular standstill by pacing." In the accompanying editorial, this article is described as "an exceedingly promising report…"

**Zoll PM.** Resuscitation of the Heart in Ventricular Standstill by External Electric Stimulation. **N Engl J Med 1952;247:768-771**

# History (1958)



Lillehei was responsible for the world's first use of a small, portable, battery-powered pacemaker, invented at his behest by Earl Bakken (a University of Minnesota employee who later founded Medtronic).

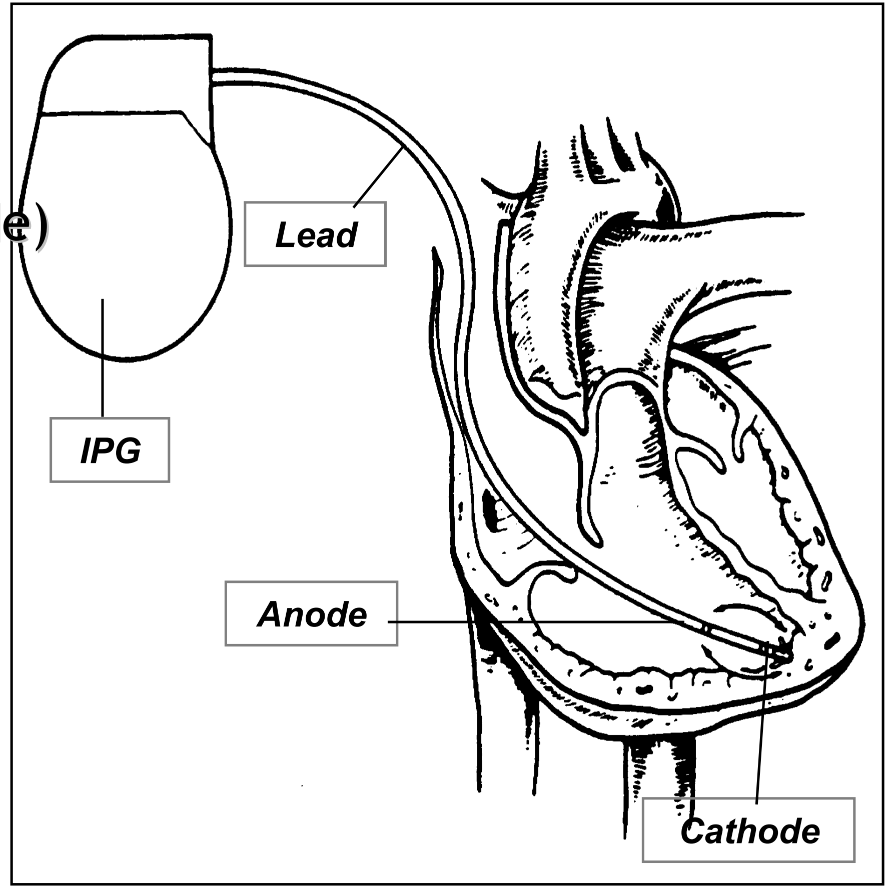
# Fully Implanted Pacemaker

**Åke Senning**, Surgeon, Karolinska Hospital
**Rune Elmqvist**, Engineer at Elema-Schönander, Stockholm

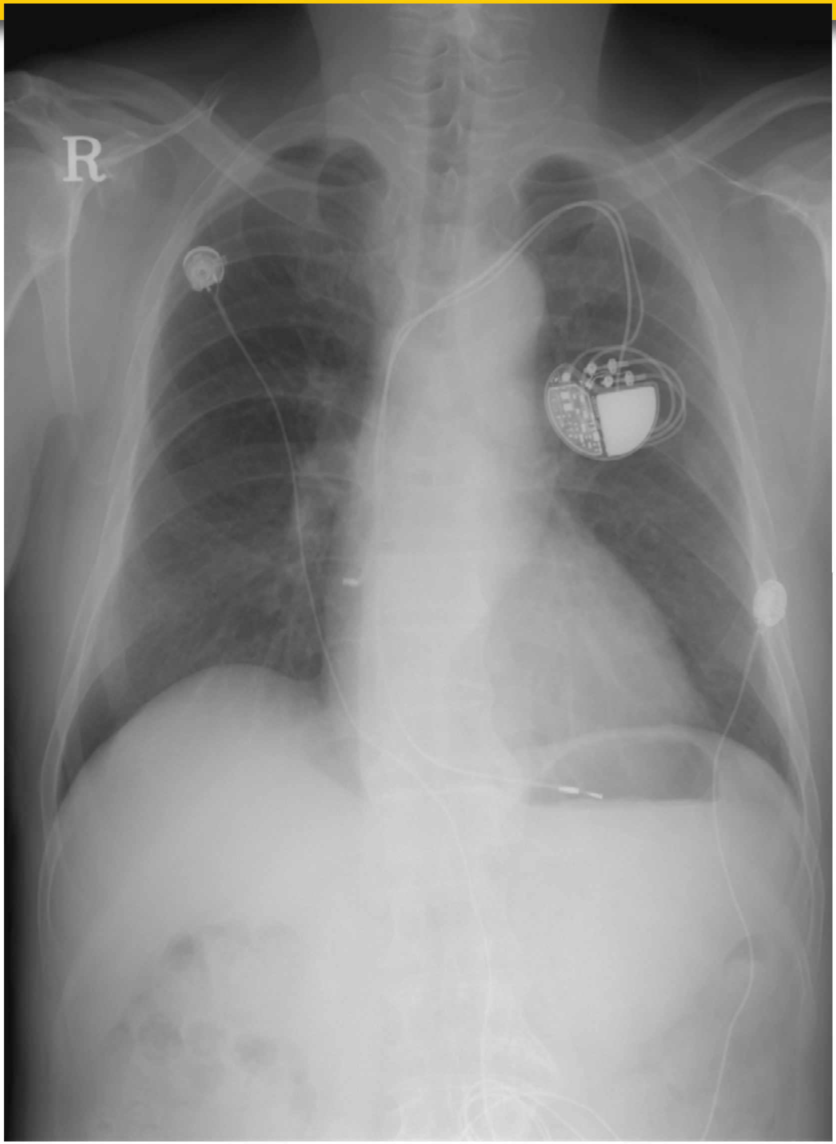

Arne Larsson : CAVB
OCT 8, 1958 (43YO) # 1
OCT 8, 1958 # 2
NOV 19, 1961 # 3
………
JAN 29, 1993 # 26
NOV 7, 1996 # 27
DEC 28, 2001 (86YO)
death by malignancy not related to pacemaker

# Pacemaker Components Combine with Body Tissue to Form a Complete Circuit

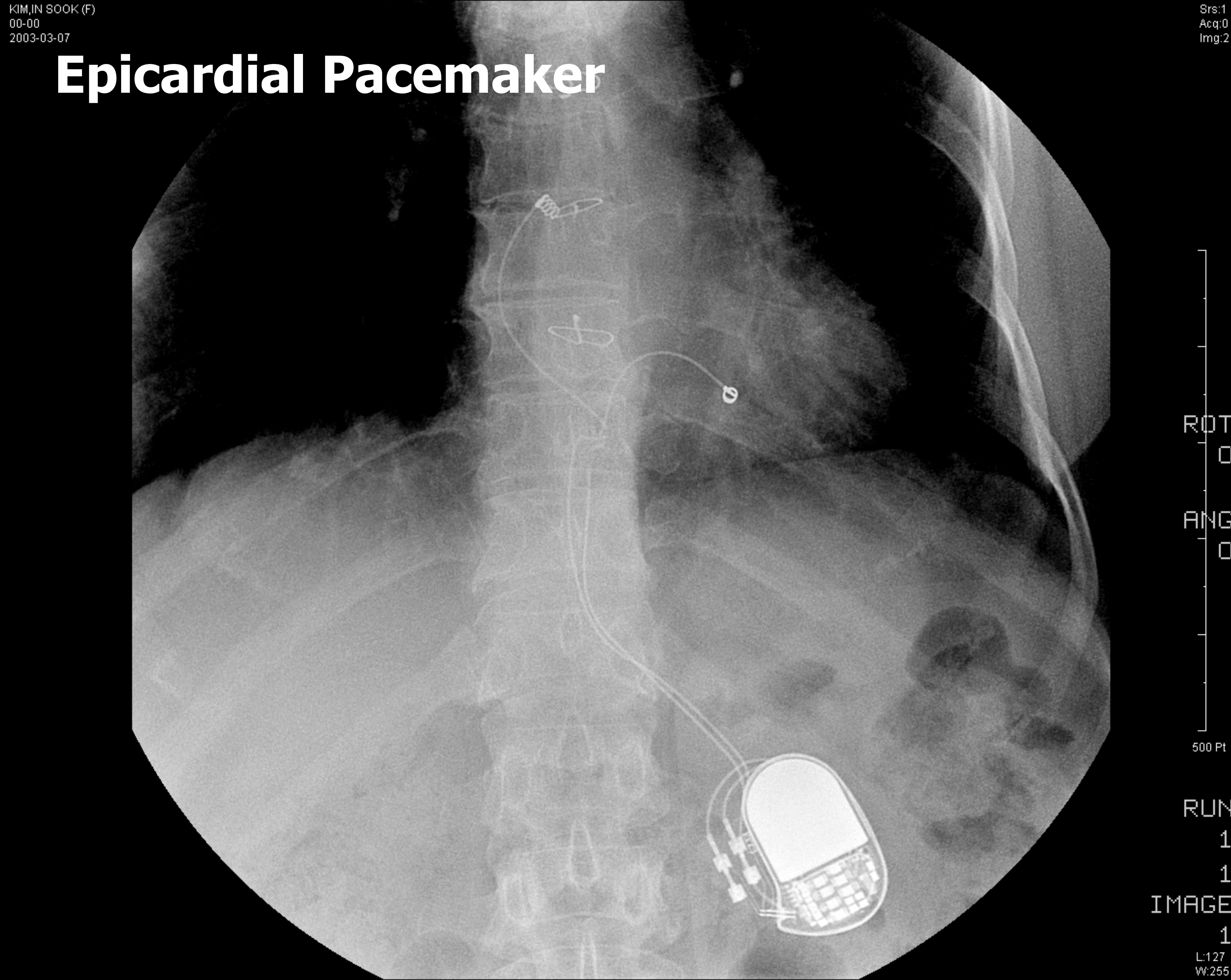
- Pulse generator: power source or battery
- Leads or wires
- Cathode (negative electrode)
- Anode (positive electrode)
- Body tissue

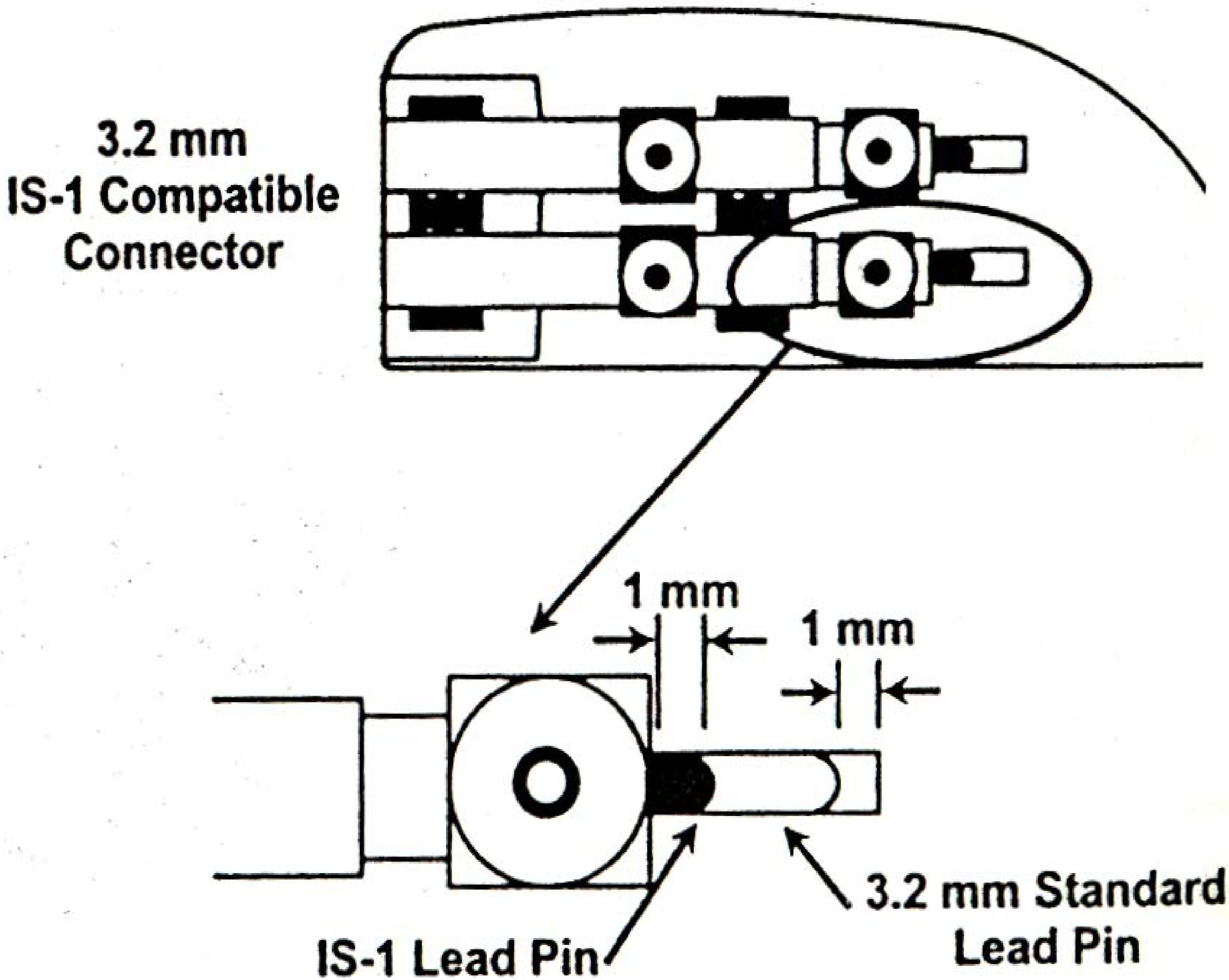


# Pacemaker Implantation

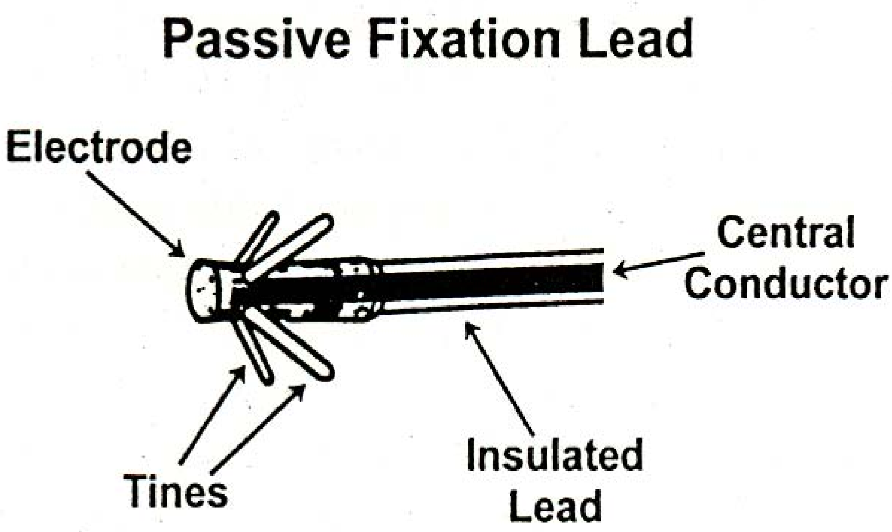


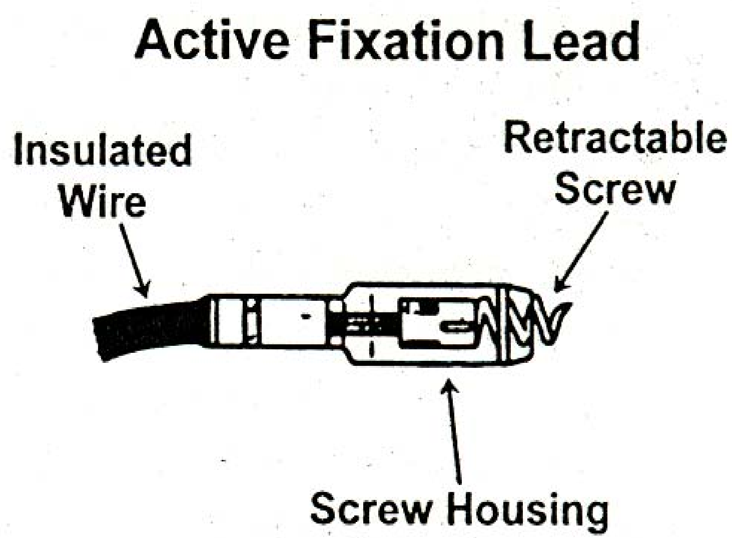
# Epicardial Pacemaker

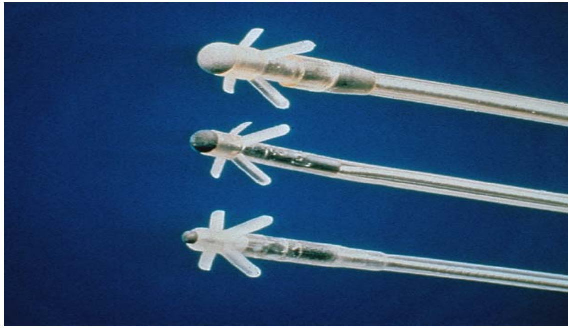


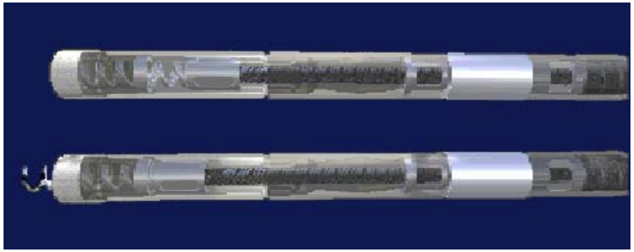

3.2 mm
IS-1 Compatible
Connector
1 mm
1 mm
IS-1 Lead Pin
3.2 mm Standard
Lead Pin

# Lead

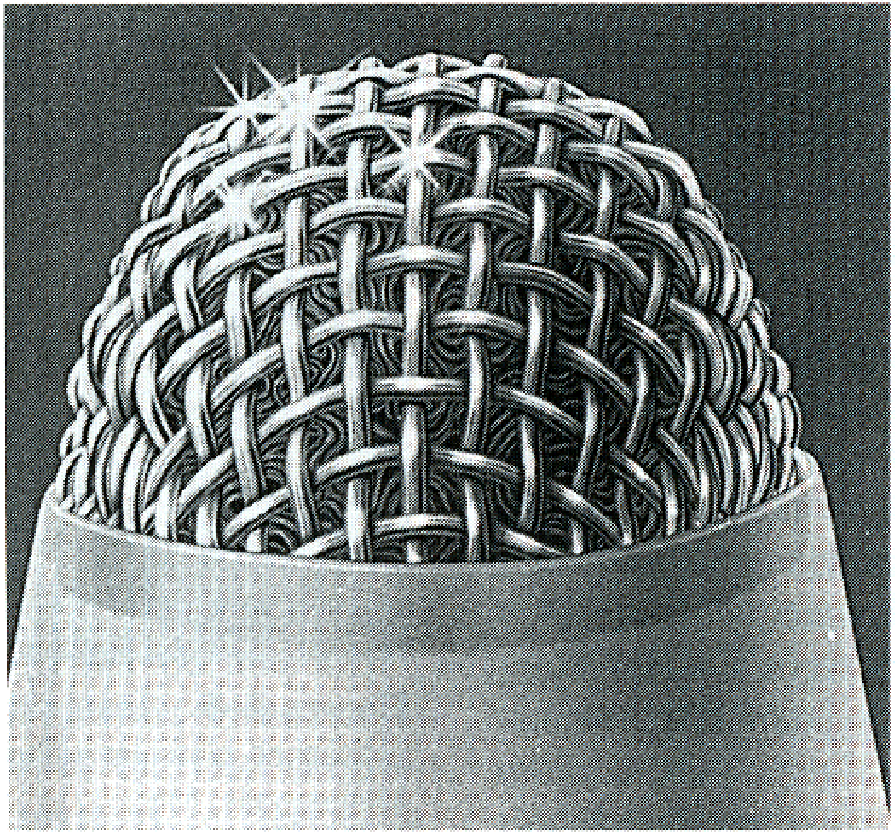

Passive Fixation Lead
Electrode
Central
Conductor
Tines
Insulated
Lead

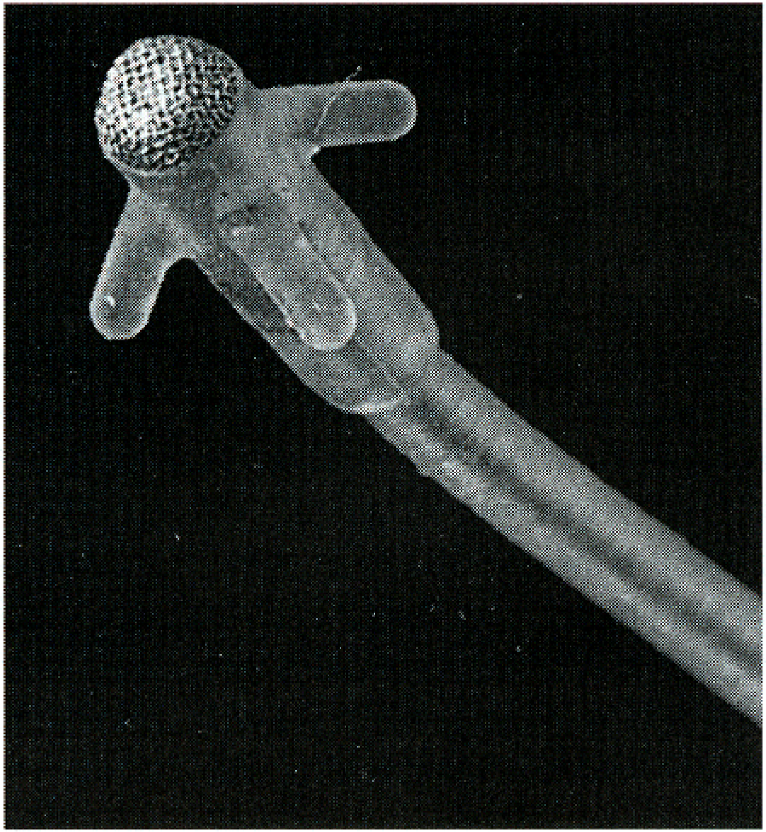

Active Fixation Lead
Insulated
Wire
Retractable
Screw
Screw Housing



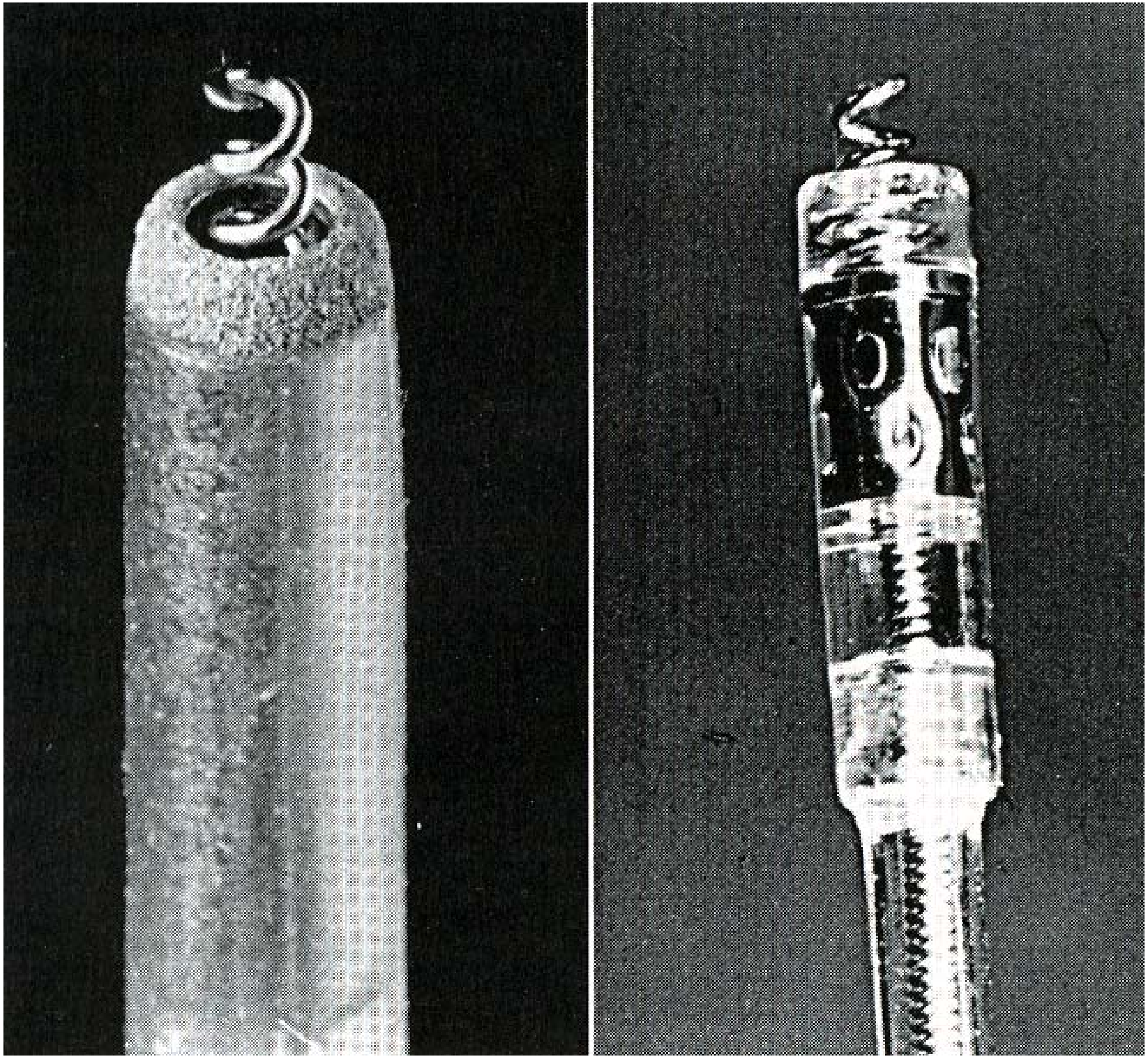


# Lead Tip – passive fixation



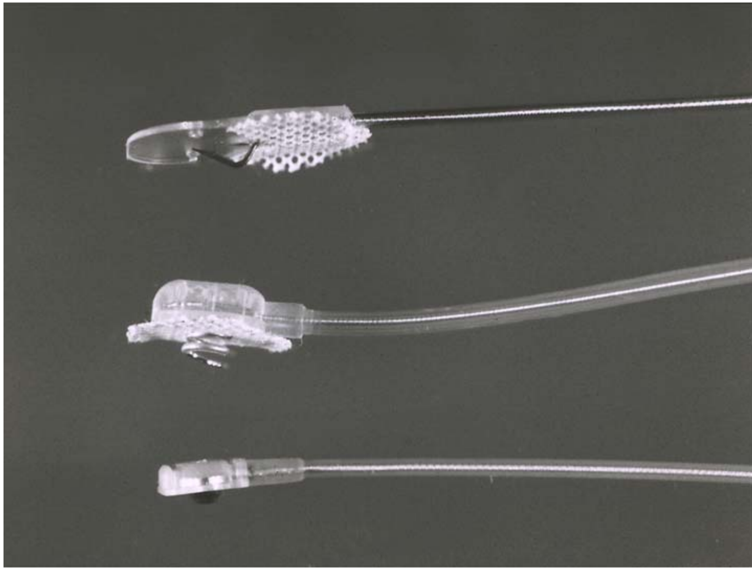


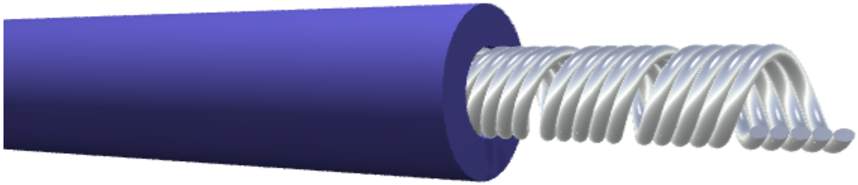
# Lead Tip – active fixation



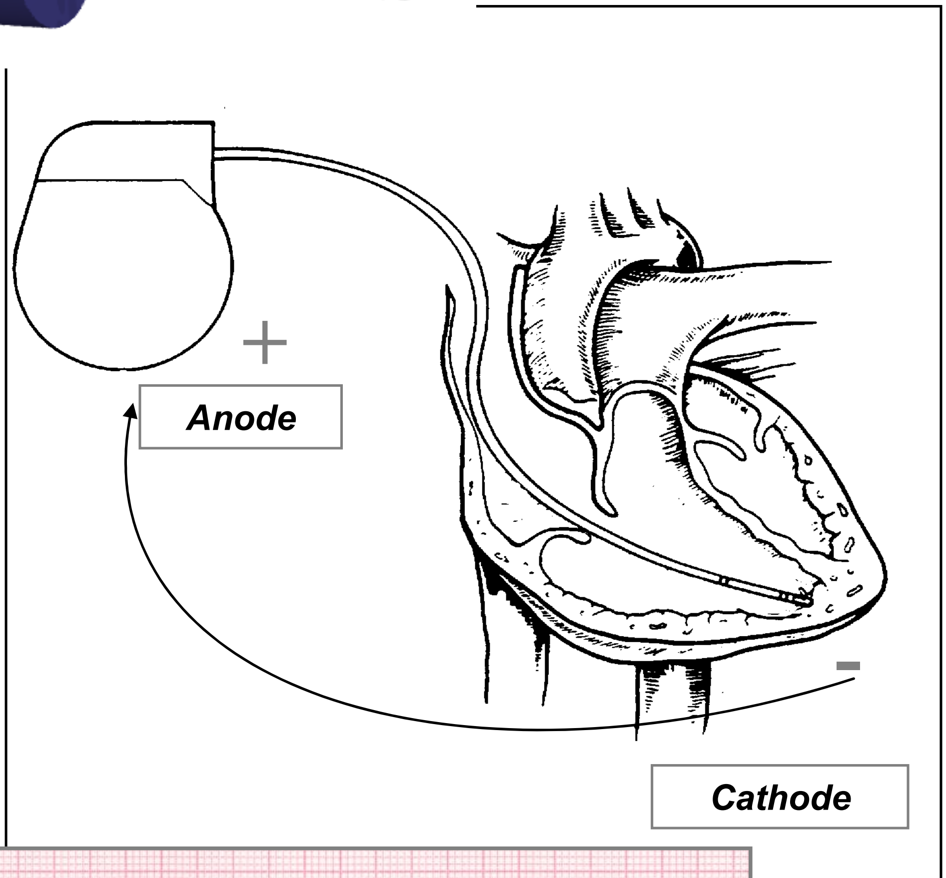
# Myocardial and Epicardial Leads

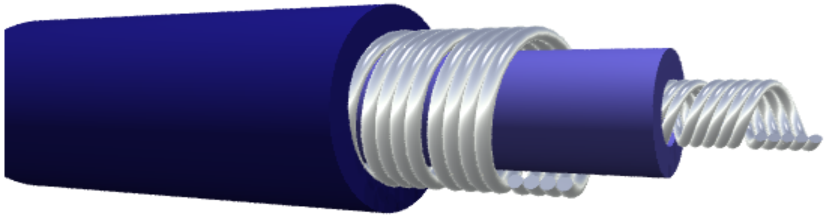
- Leads applied directly to the heart
  - Fixation mechanisms include:
    - Epicardial stab-in
    - Myocardial screw-in
    - Suture-on



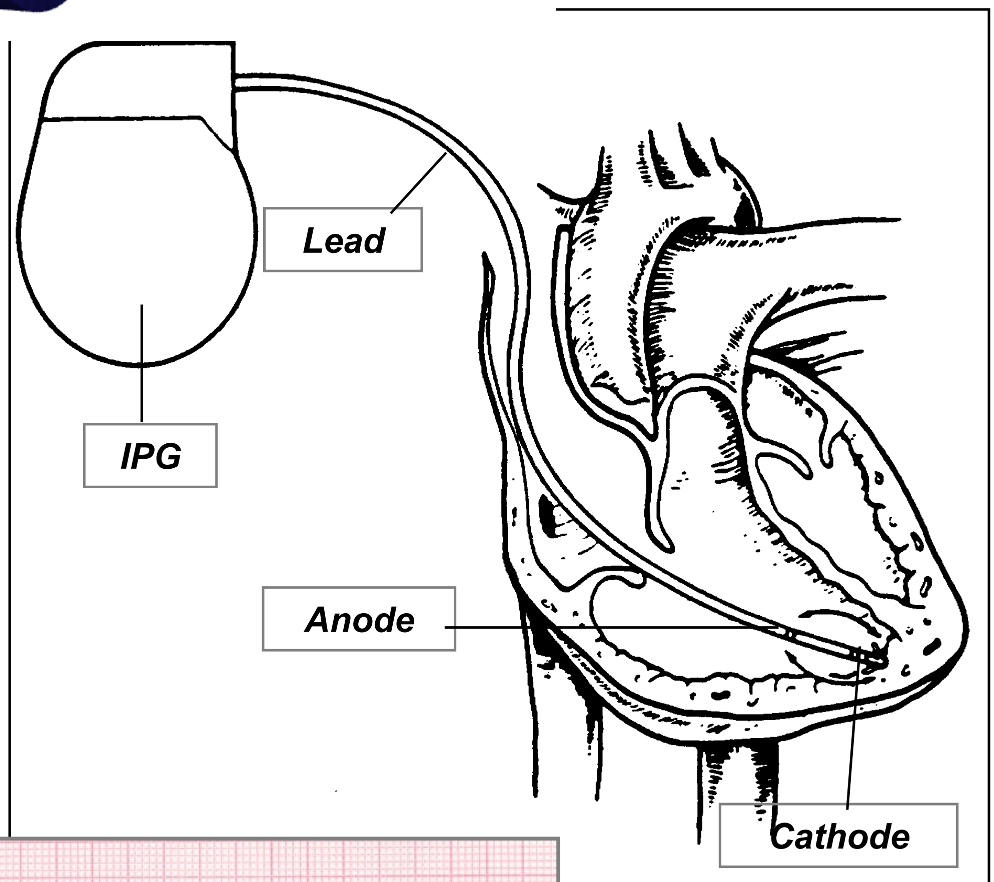


# Unipolar

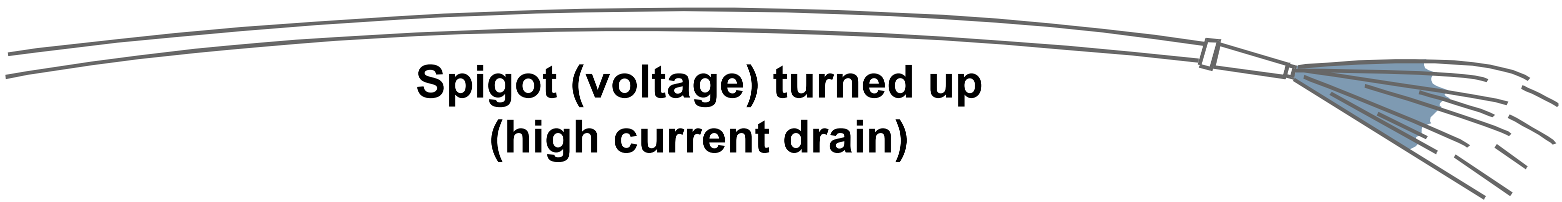


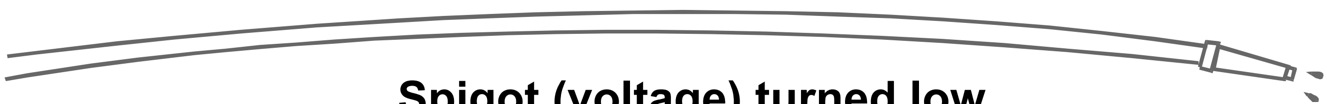
# Bipolar




# Voltage and Current Flow

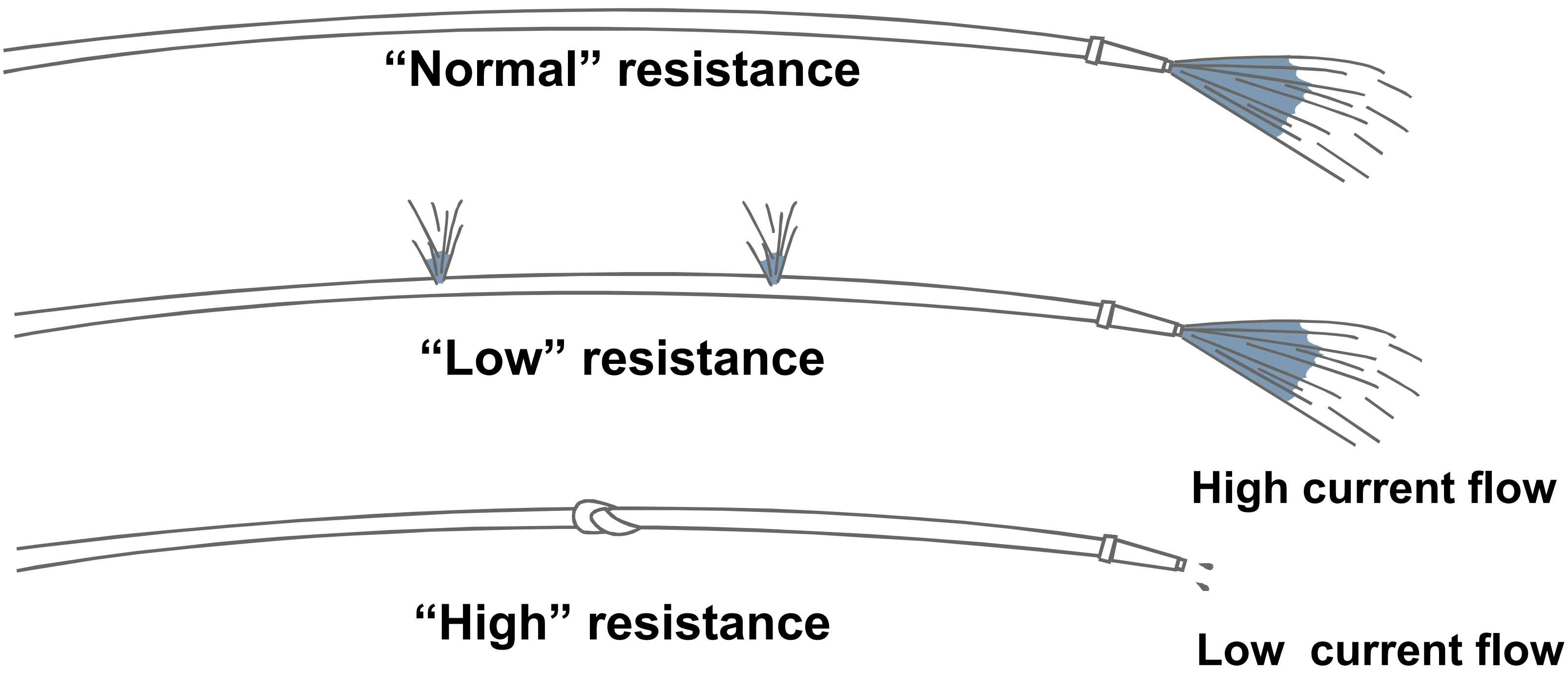


**Spigot (voltage) turned up**
**(high current drain)**



**Spigot (voltage) turned low**
**(low current drain)**

# Resistance and Current Flow



# Fundamentals of Electricity

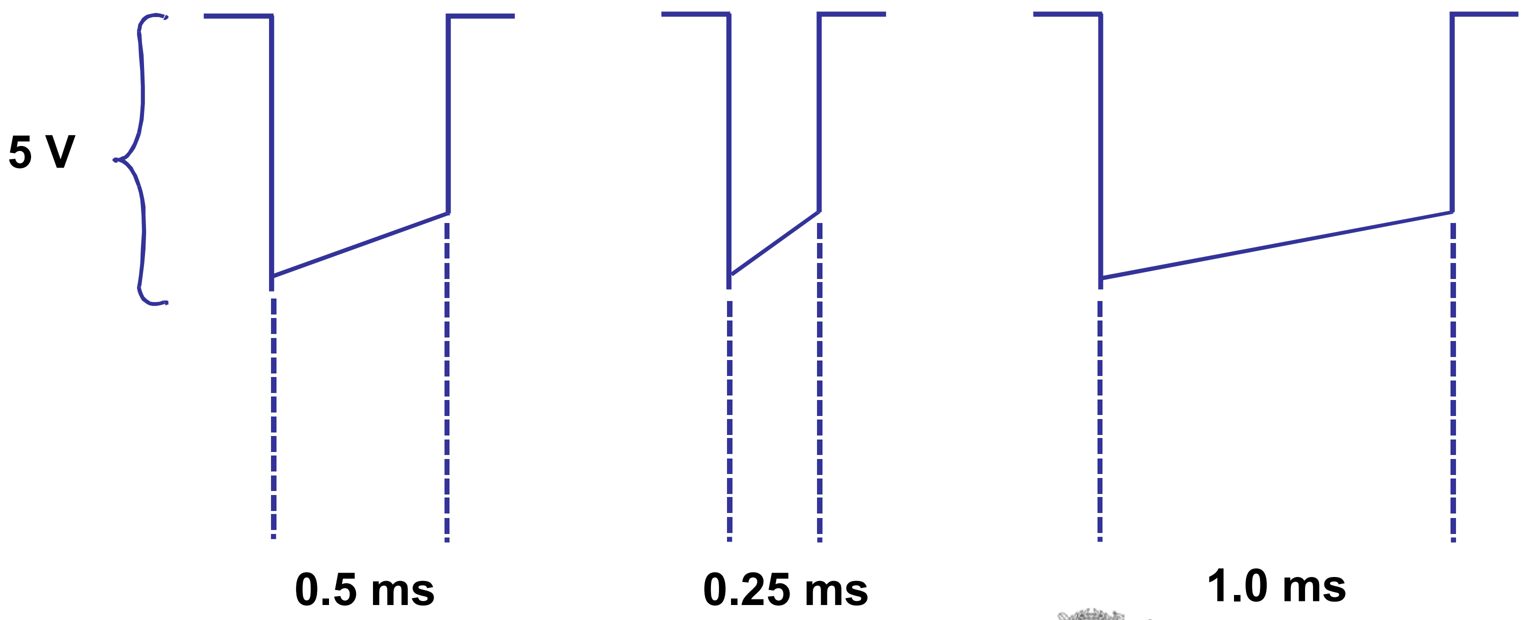
- $V = I \cdot R$ (Ohm's law)

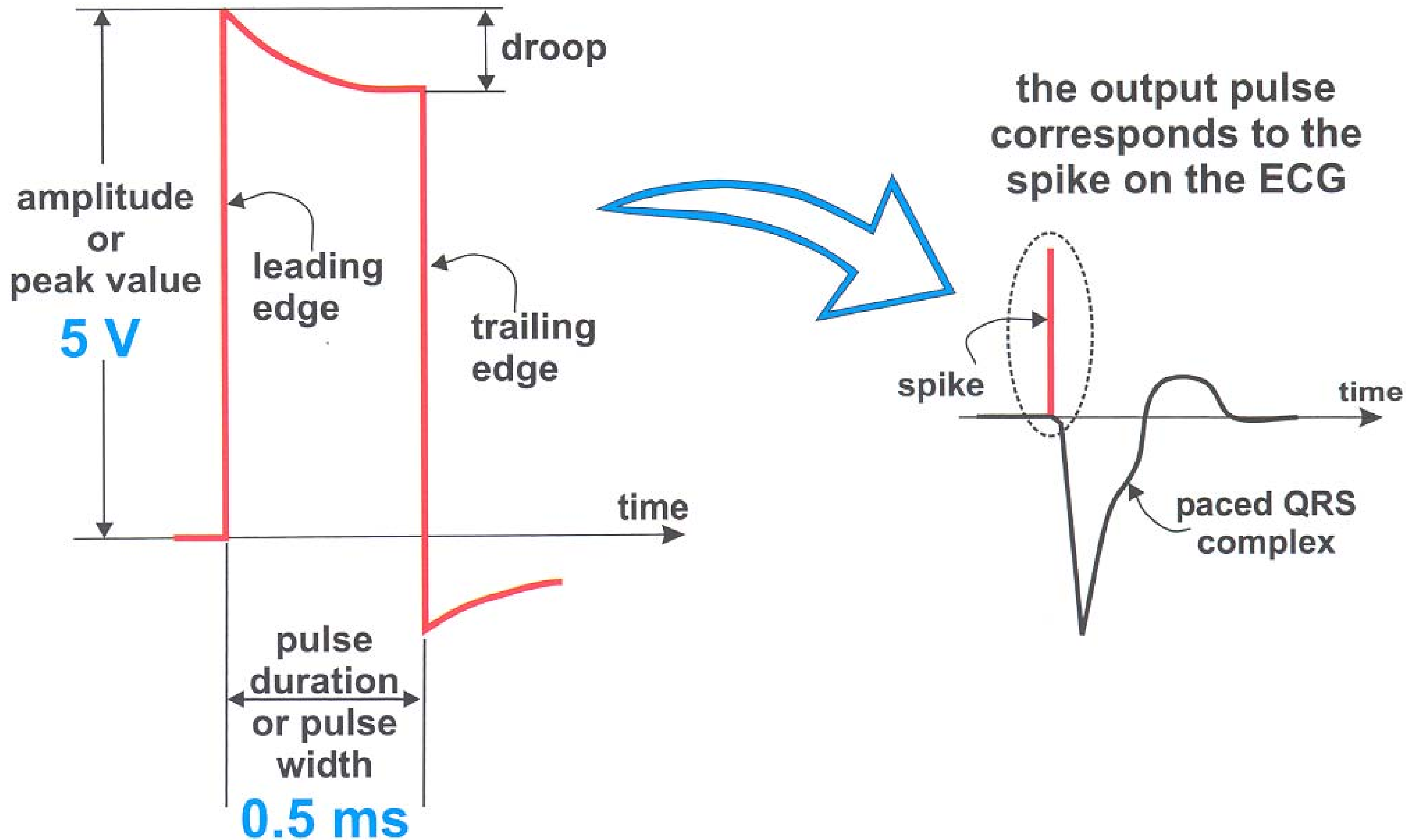
- Impedance
  - $R = V / I$
  - Insulation defect vs. normal vs. lead fracture

- $Q = I \cdot t$

# Pulse Width Is the Time (Duration) of the Pacing Pulse

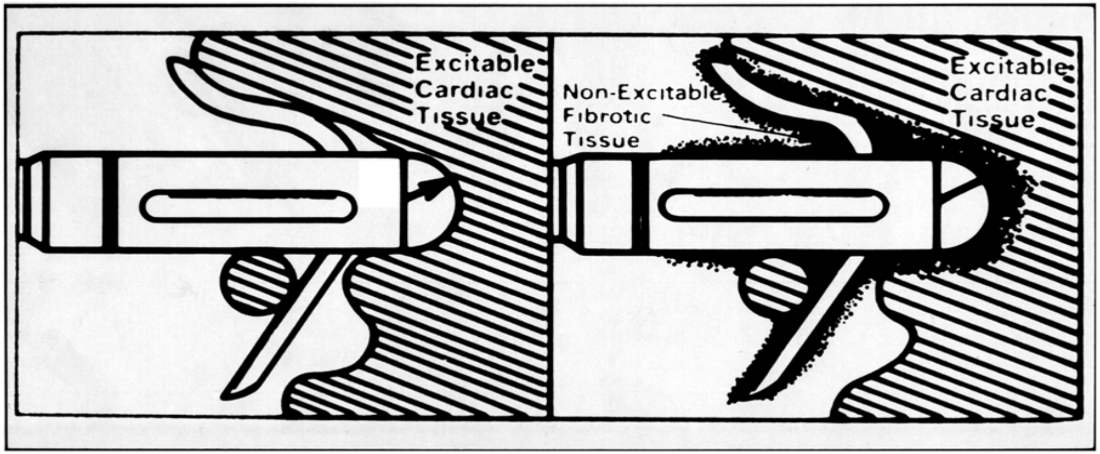
- Pulse width is expressed in milliseconds (ms)
- The pulse width must be long enough for depolarization to disperse to the surrounding tissue




droop
amplitude
or
peak value
5 V
leading
edge
trailing
edge
time
pulse
duration
or pulse
width
0.5 ms
the output pulse
corresponds to the
spike on the ECG
spike
time
paced QRS
complex

# Lead Maturation Process

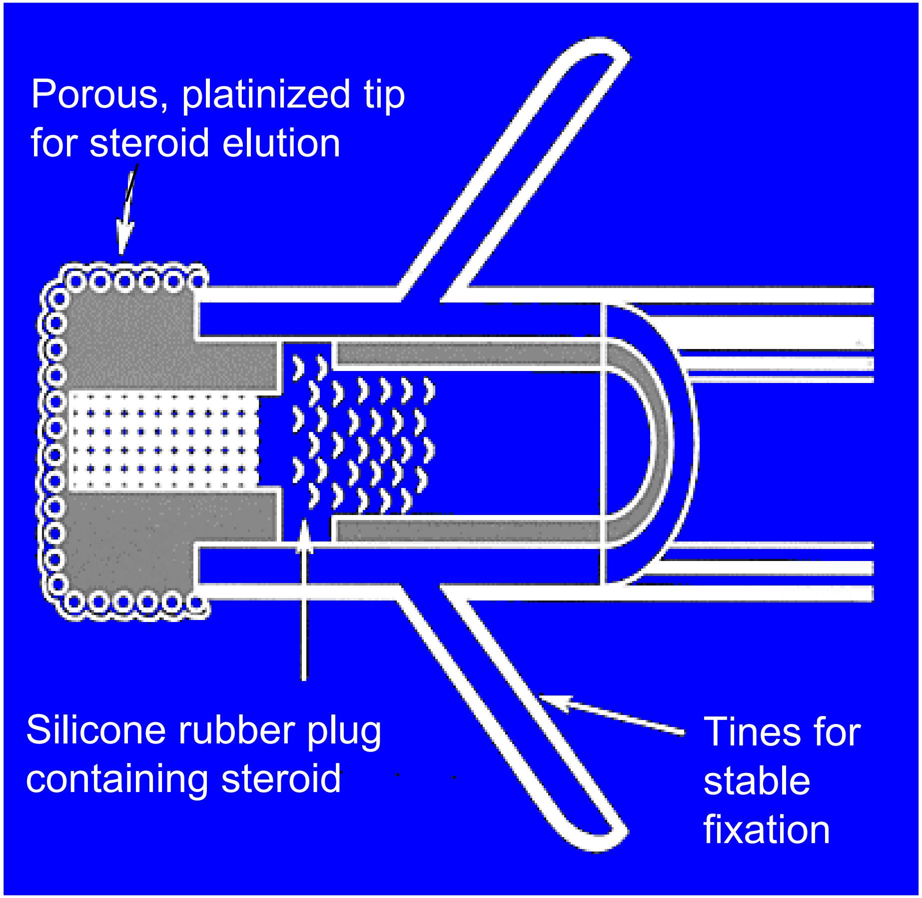
- Fibrotic "capsule" develops around the electrode following lead implantation



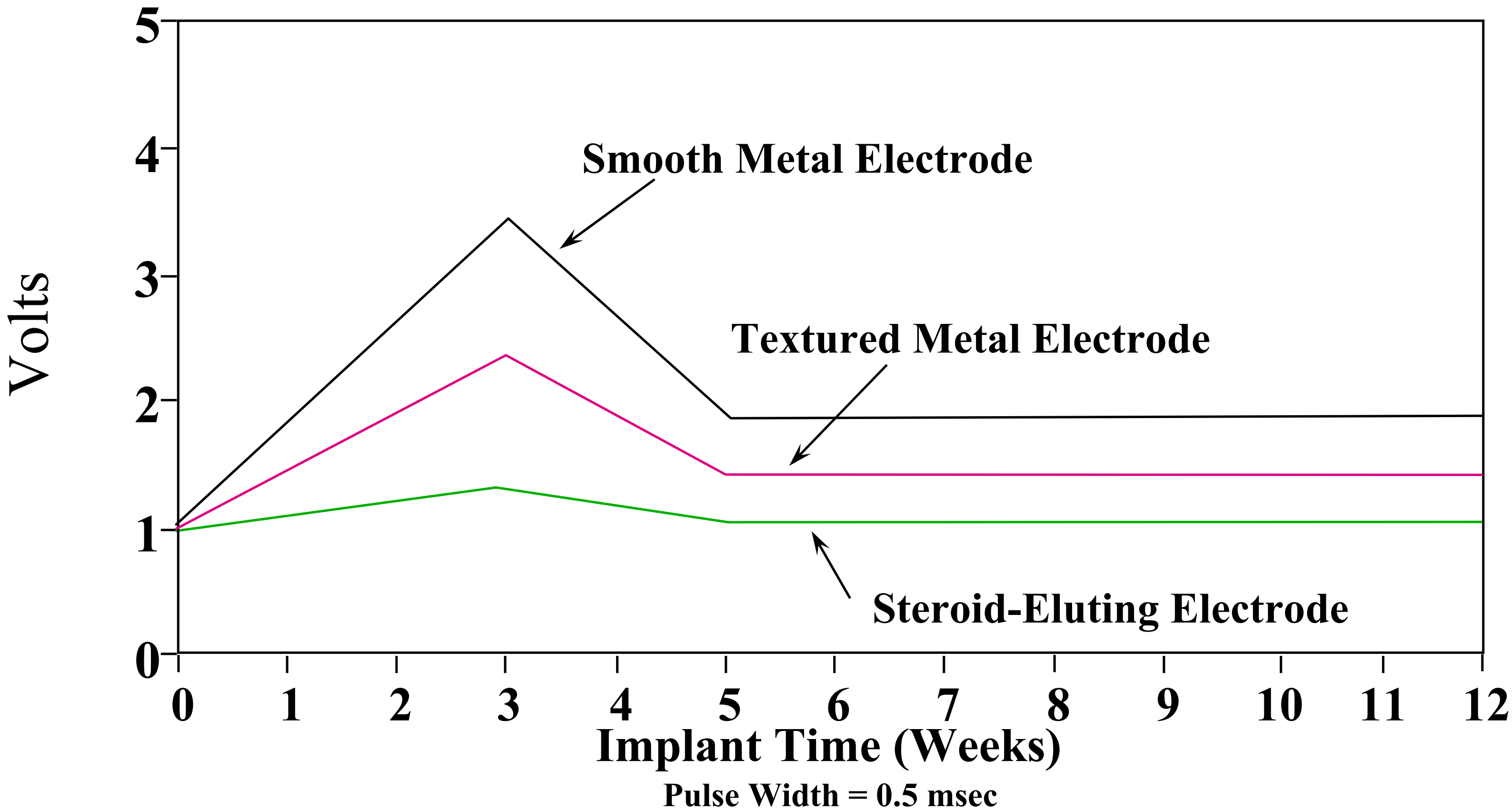

Acute Chronic

# Steroid Eluting Leads

- Steroid eluting leads reduce the inflammatory process and thus exhibit little to no acute stimulation threshold peaking and low chronic thresholds



# Evolution of Pacing Threshold



# Battery Life

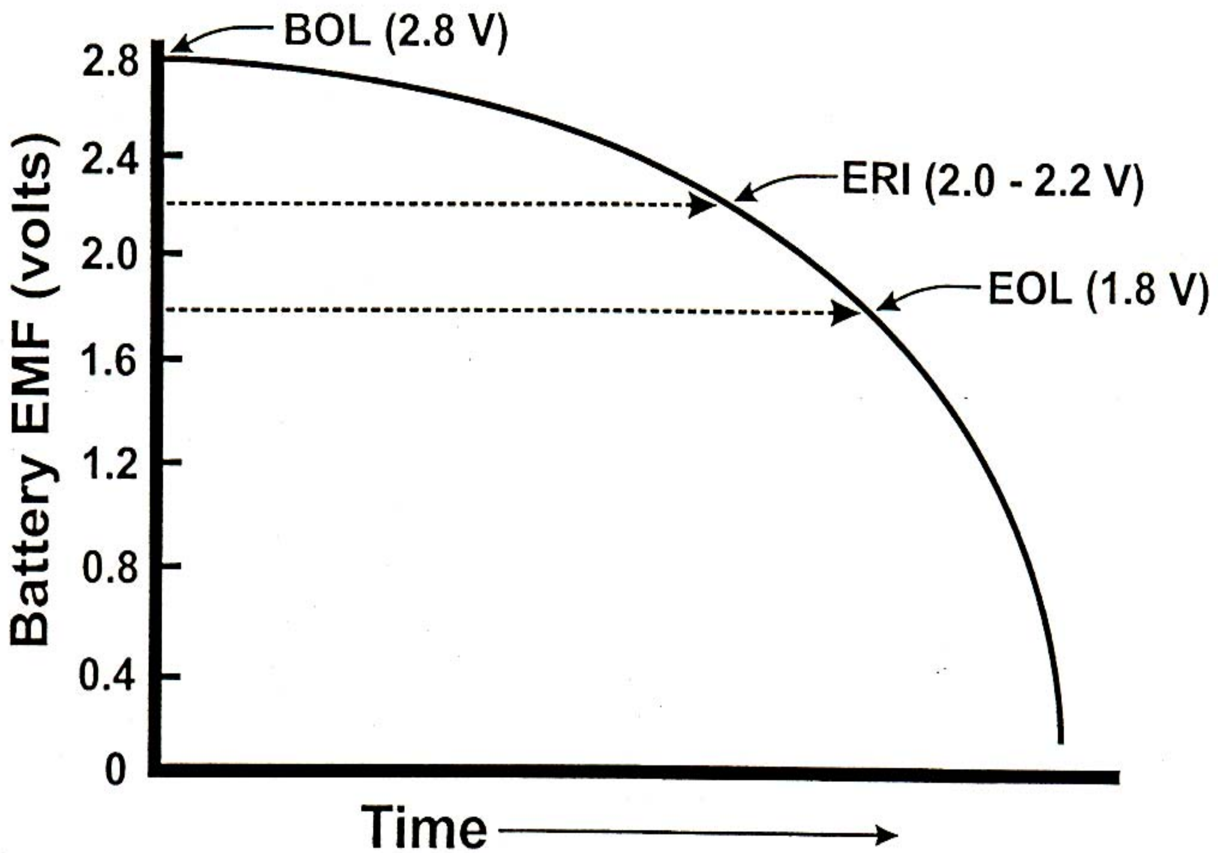
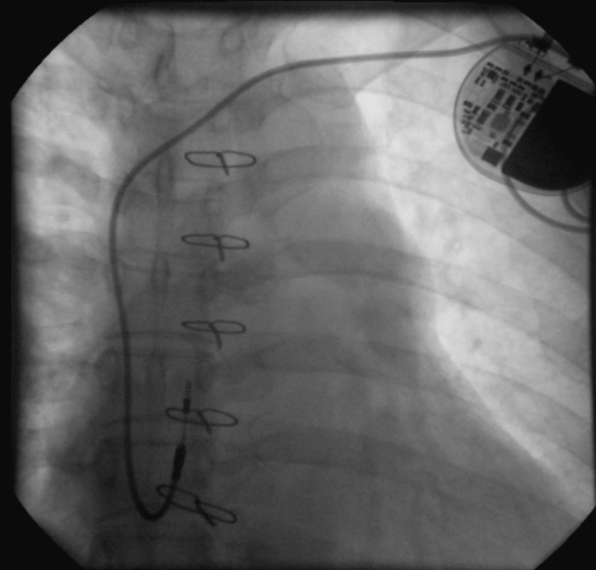


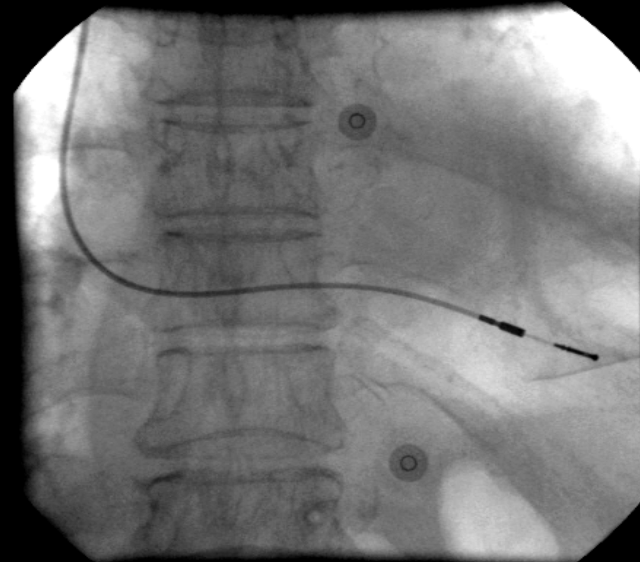

FIGURE 5-19. Schematic diagram illustrating battery depletion behavior of a lithium iodine battery. BOL, beginning of life; EMF, electromotive force; ERI, elective replacement indicator; EOL, end-of-life; V, volts.

# Factors Affecting Battery Longevity

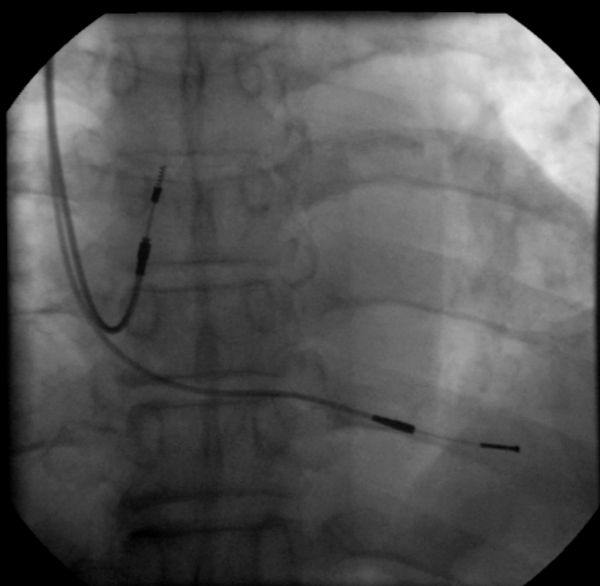
- Non-programmable factors
  - Battery capacity and self-discharge
  - Efficiency of pacing circuit
  - Efficiency of sensing circuit
  - Output impedance
- Programmable factors
  - Pacing rate
  - Output voltage
  - Duration of pulse width
  - Proportion of time engaged in pacing

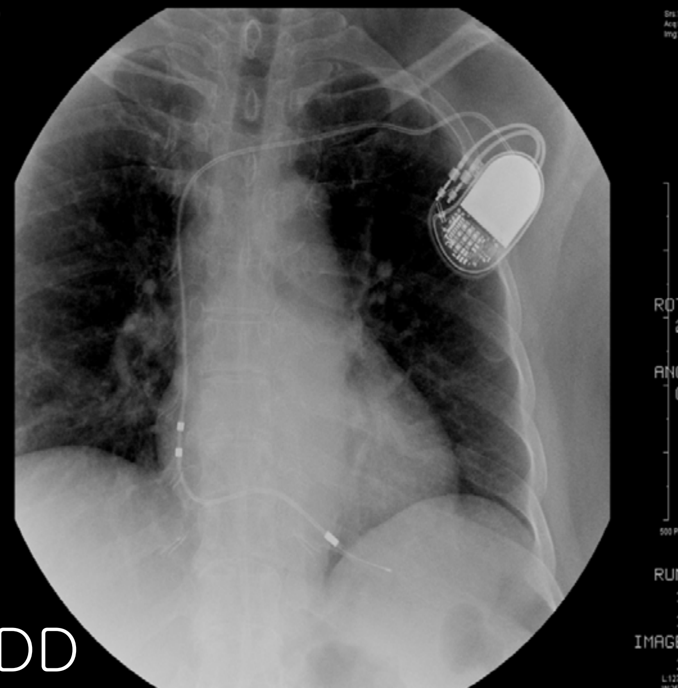
| I Chamber Paced | II Chamber Sensed | III Response to Sensing | IV Programmable Functions/Rate Modulation | V Multisite Pacing |
|---|---|---|---|---|
| V: Ventricle | V: Ventricle | T: Triggered | P: Simple programmable | V: Ventricle |
| A: Atrium | A: Atrium | I: Inhibited | M: Multi-programmable | A: Atrium |
| D: Dual (A+V) | D: Dual (A+V) | D: Dual (T+I) | C: Communicating | D: Dual (A+V) |
| O: None | O: None | O: None | R: Rate modulating | O: None |
| S: Single (A or V) | S: Single (A or V) | | O: None | |





AAI VVI

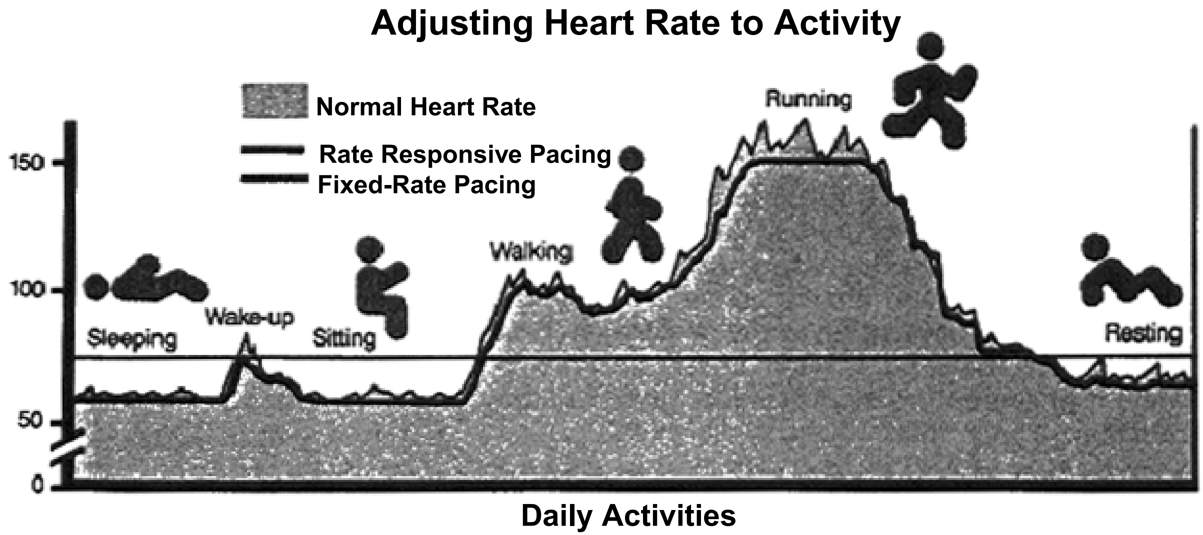




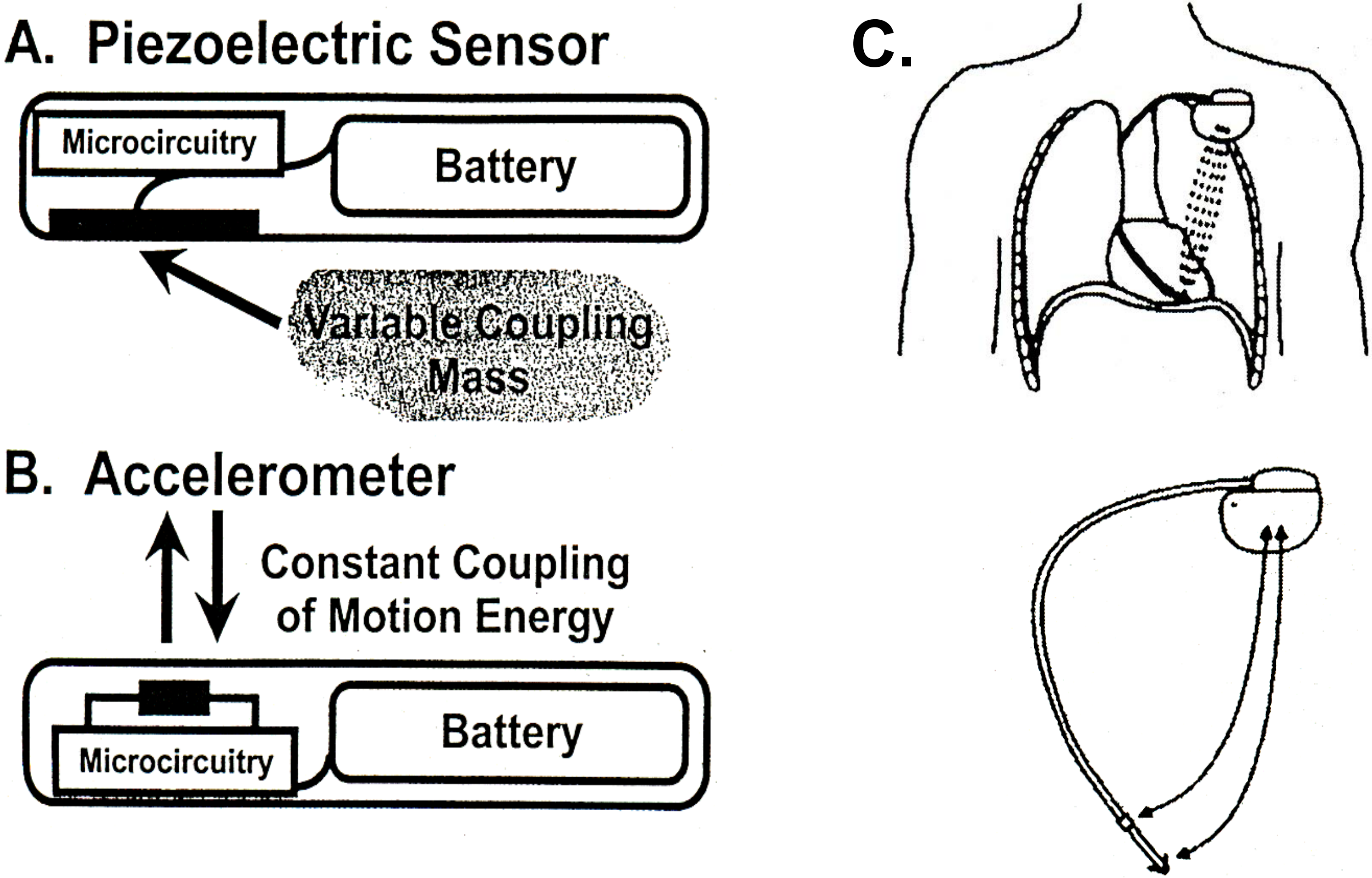

DDD VDD

# Rate Responsive Pacing

- When the need for oxygenated blood increases, the pacemaker ensures that the heart rate increases to provide additional cardiac output



# Rate Responsive Pacing

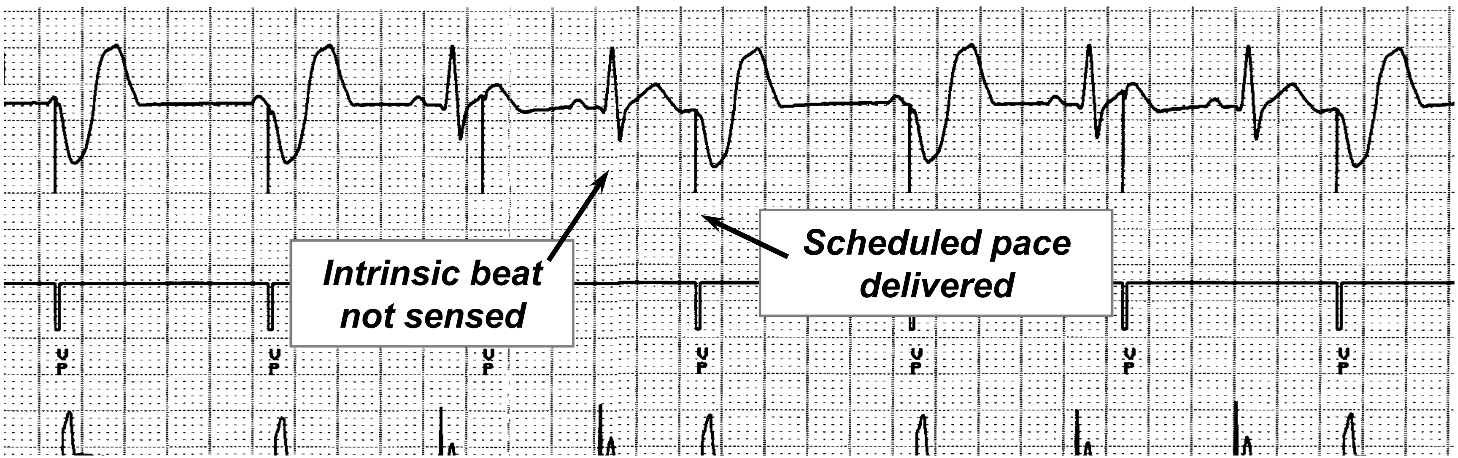


# Malfunction

- Sensing Failure
- Capture Failure (=Pacing Failure)

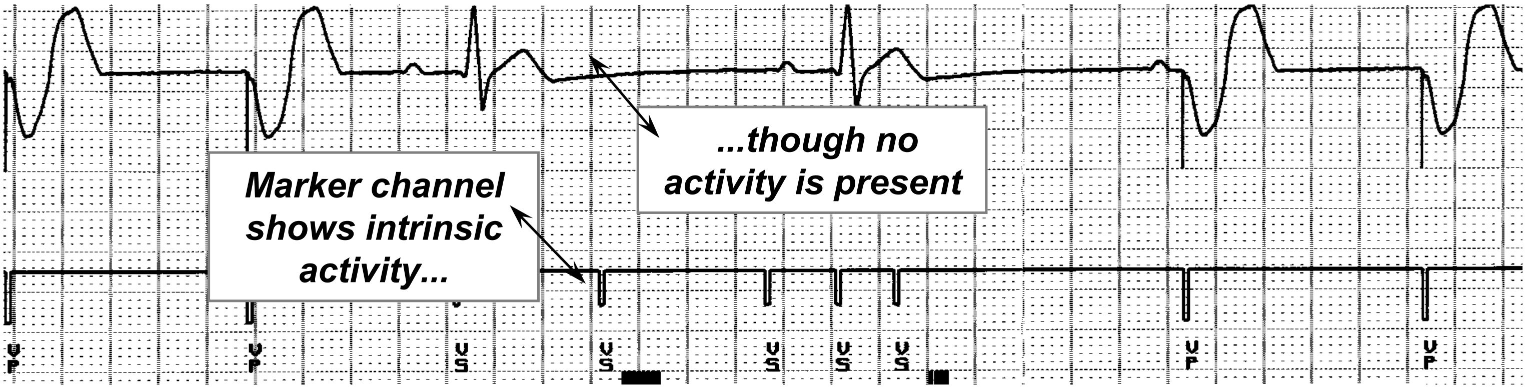
# Undersensing . . .

- Pacemaker does not "see" the intrinsic beat, and therefore does not respond appropriately




VVI / 60

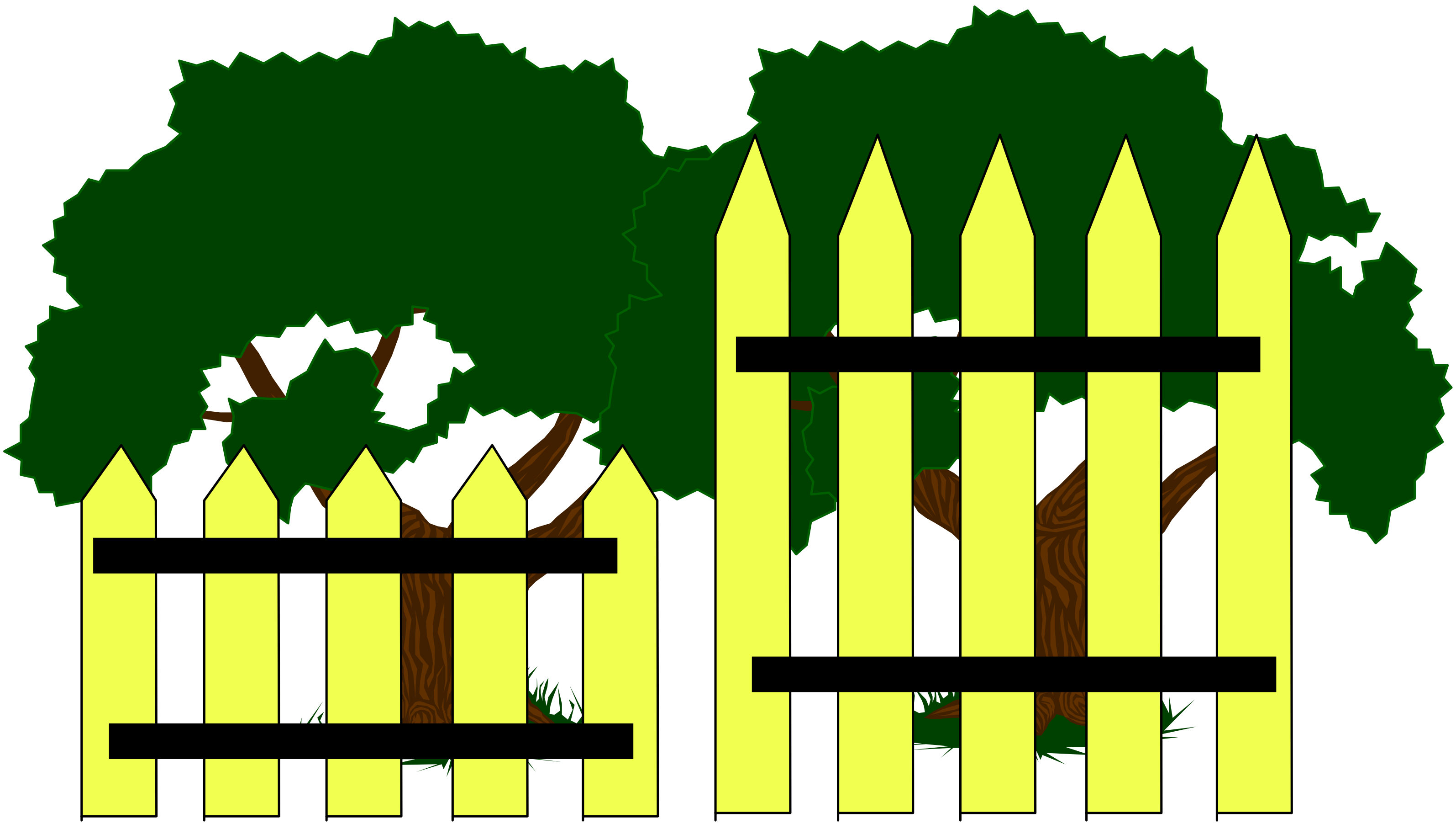
# Oversensing



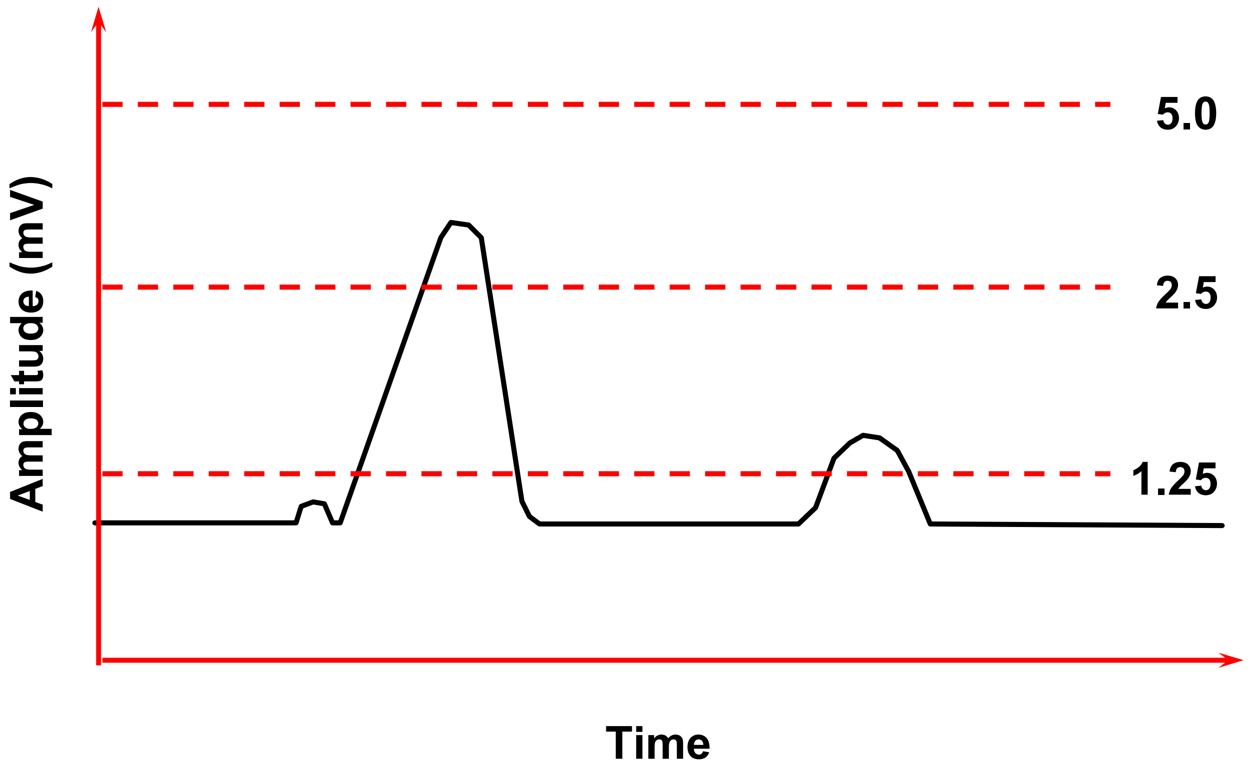

VVI / 60

- An electrical signal other than the intended P or R wave is detected

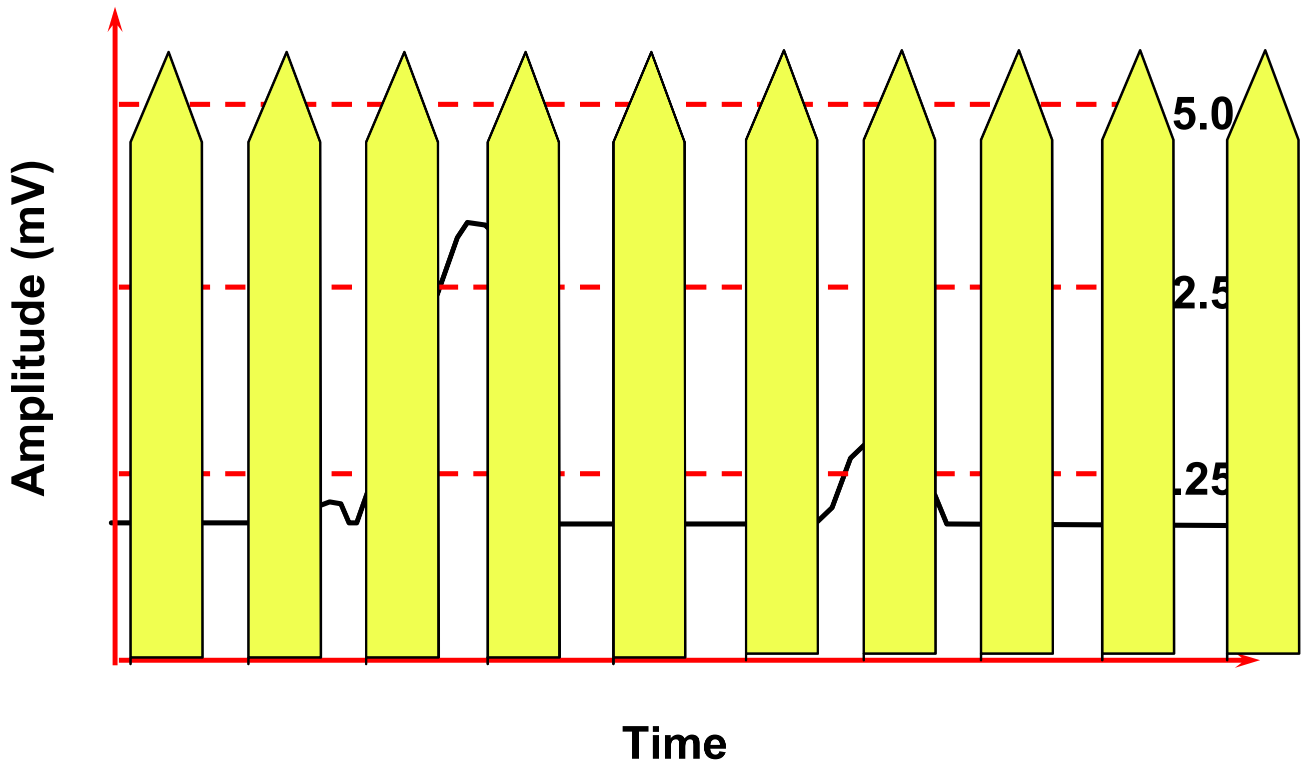
# Sensitivity – The Greater the Number, the *Less* Sensitive the Device to Intracardiac Events



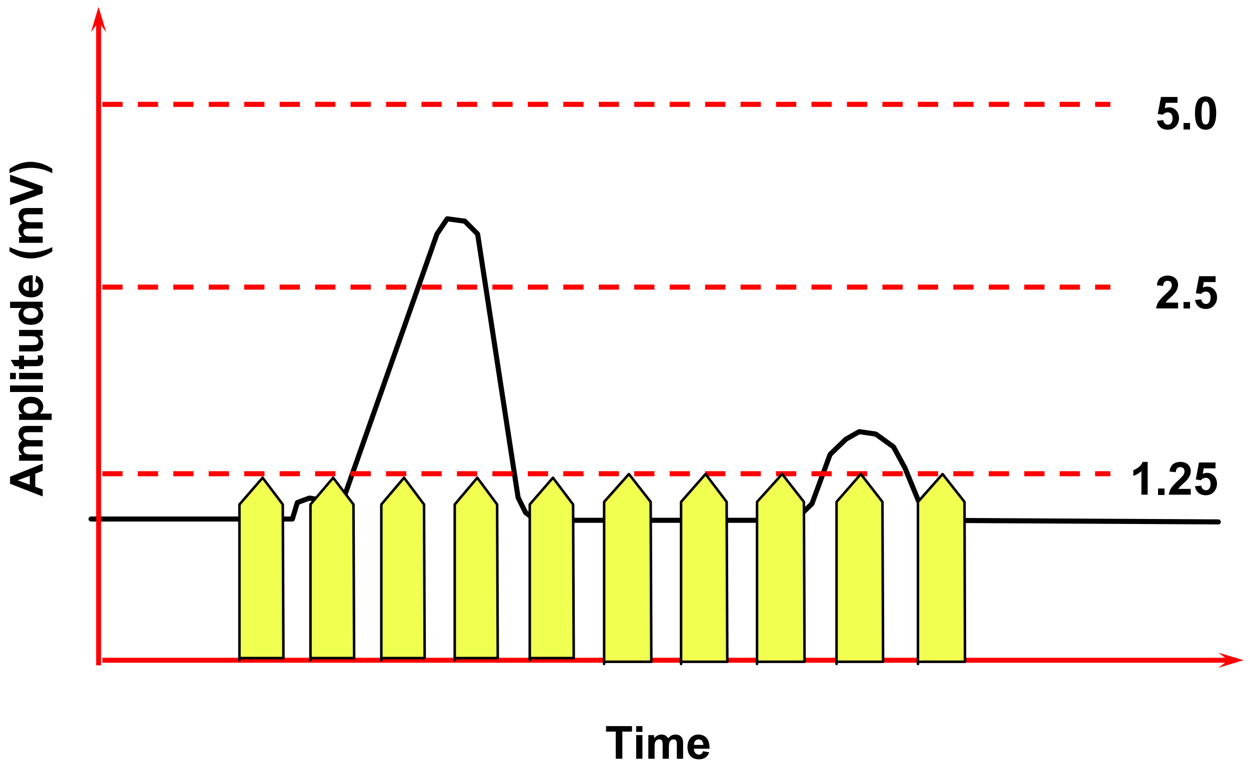
# Sensitivity



# Sensitivity

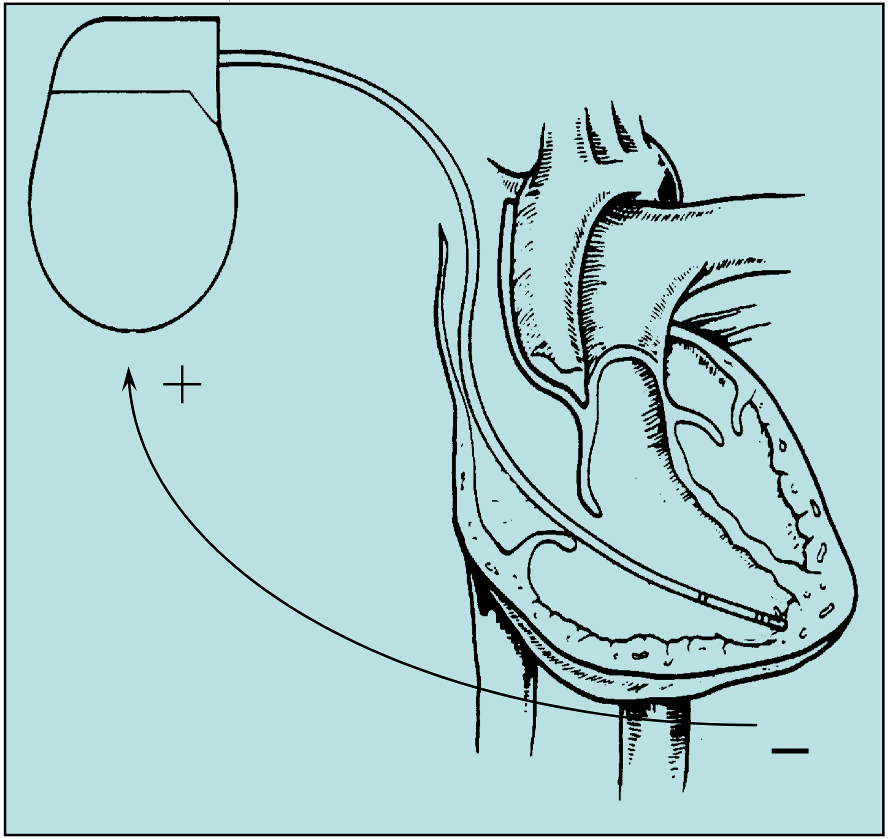


# Sensitivity



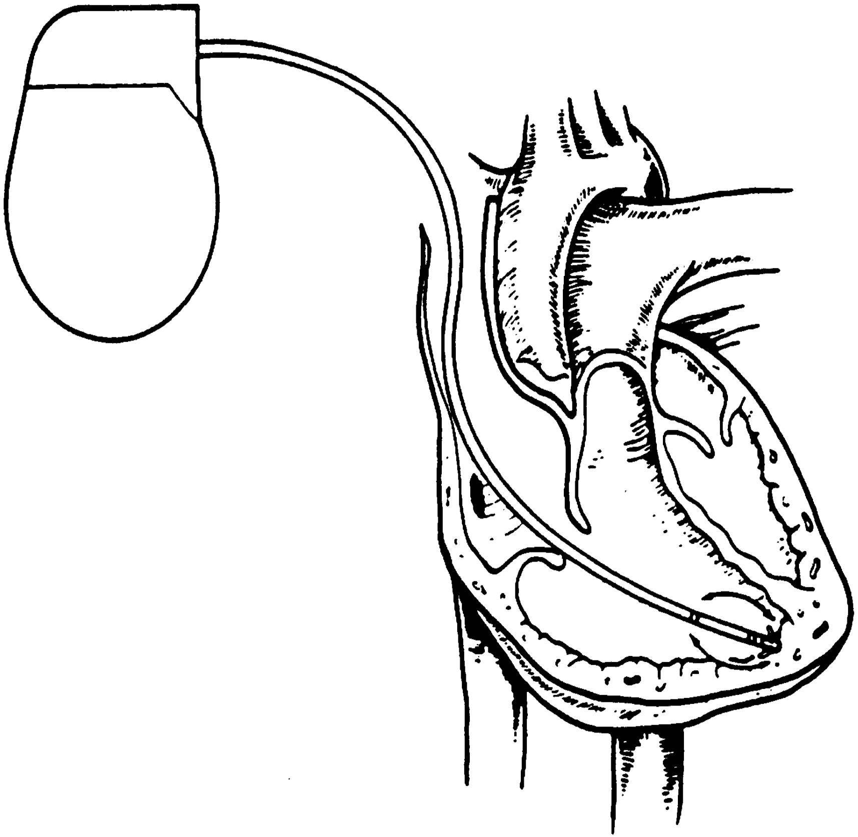
# Unipolar Sensing

- Produces a large potential difference due to:
  - A cathode and anode that are farther apart than in a bipolar system

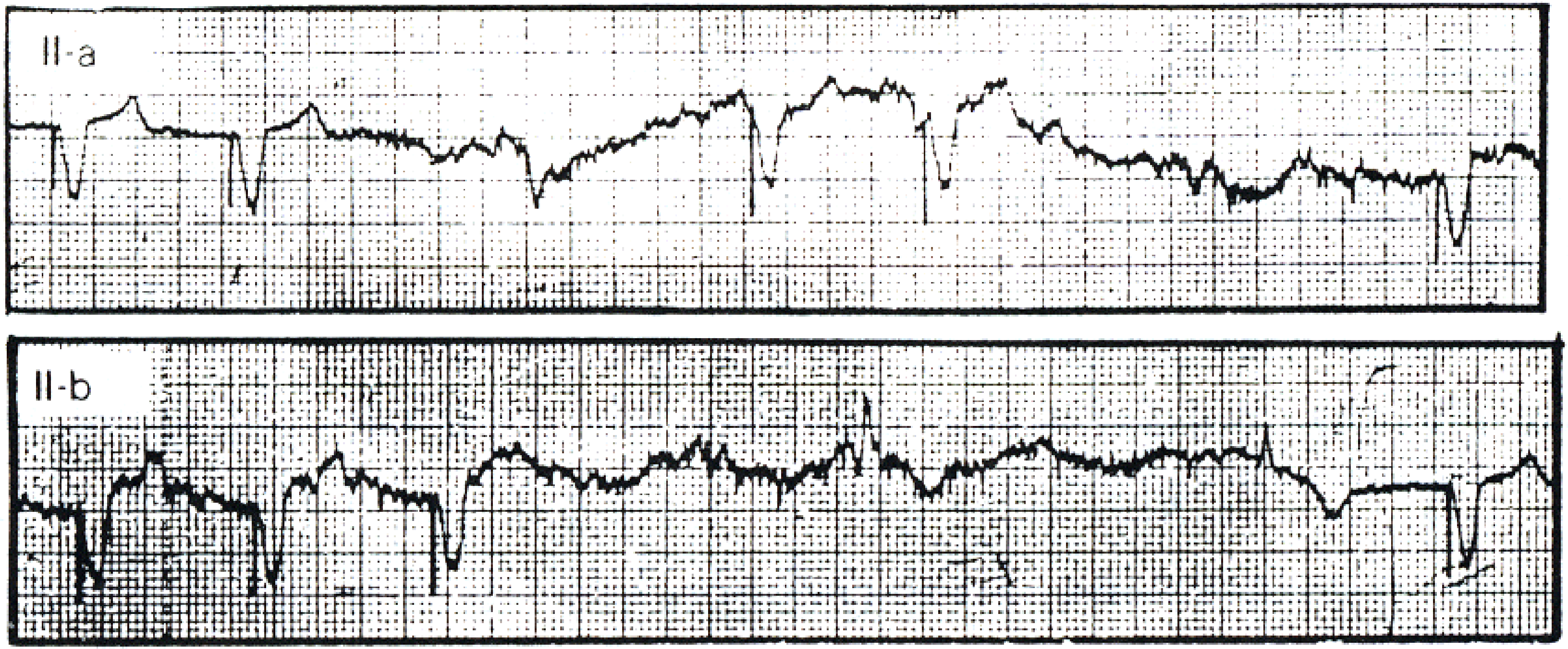


# Bipolar Sensing

- Produces a smaller potential difference due to the short interelectrode distance
  - Electrical signals from outside the heart such as myopotentials are less likely to be sensed



# Myogenic Potential



# Cardioversion

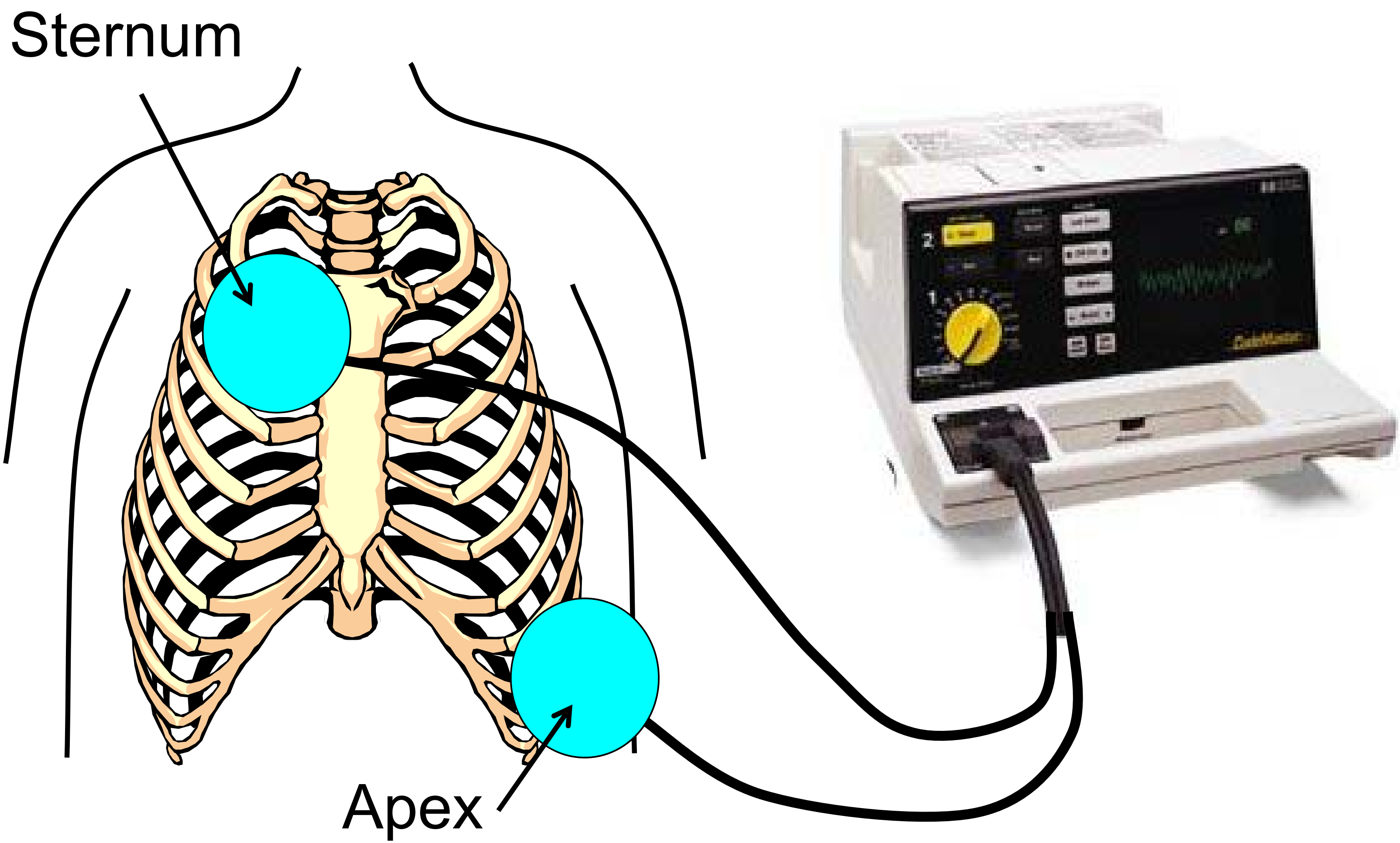
- 심장에 직류전기충격을 줌으로 심장을 일시에 탈분극시킴
- 전기량 : 부정맥 종류에 따라 50-300 J

- 종류
  - 응급 심율동전환 : VF, hemodynamically unstable tachycardia
  - 선택적 심율동전환 : hemodynamically stable AFL, AF, PSVT, VT

- 금기증
  - Digitalis 중독(VF을 유발하기 쉬움)

- 합병증
  - 부정맥 : 서맥, VF
  - 전신 색전증
  - 심근손상
  - Digitalis 중독증 악화

# Location of paddle

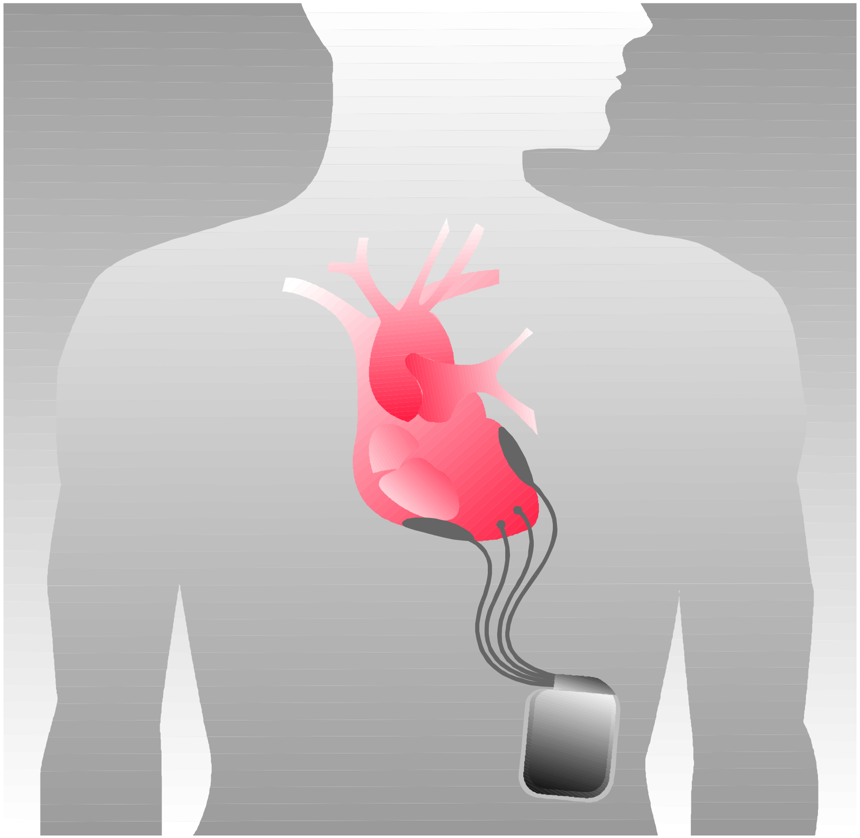


# ICD – Implantable Cardioverter-Defibrillator

- 최근 개발된 ICD의 특징
  - 경정맥수술 가능함
  - 기능 : 심율동전환, 심세동제거, 항서맥조율

- 적응증
  - SCD의 high risk인 ventricular tachyarrhyhtmia
  - Cardiac arrest survivor

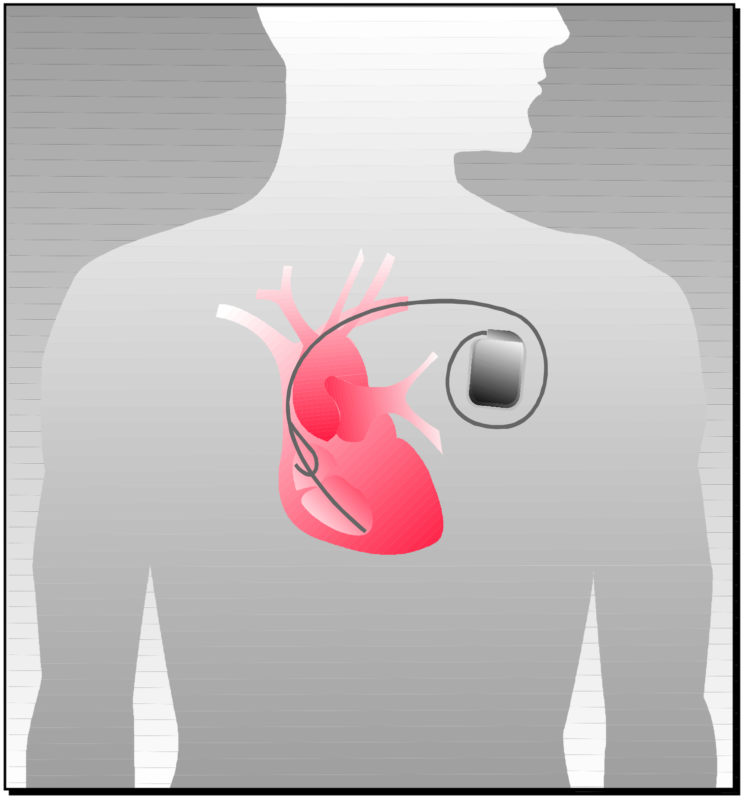
# 1980 Large devices -Abdominal site



- First human implants
- Thoracotomy, multiple incisions
- Primary implanter= cardiac surgeon
- General anesthesia
- Long hospital stays
- Complications from major surgery
- Perioperative mortality up to 9%
- Nonprogrammable therapy
- High-energy shock only
- Device longevity ≈ 1.5 years
- Fewer than 1,000 implants/year

# Implantable Cardioverter Defibrillator

## First-line therapy for patients at risk for VT/VF



- Small devices, pectoral implant site
- Transvenous, single incision
- Local anesthesia; conscious sedation
- Short hospital stays
- Few acute complications
- Perioperative mortality < 1%
- Programmable therapy options
- Single- or dual-chamber therapy
- Battery longevity up to 9 years
- 80,000 implants/year (2000 E)[1]

[1]Morgan Stanley Dean Witter. Investors Guide to ICDs. 2000.

# Implantable Defibrillators (1989 - )


209 cc | 120 cc | 80 cc | 80 cc | 72 cc | 54 cc

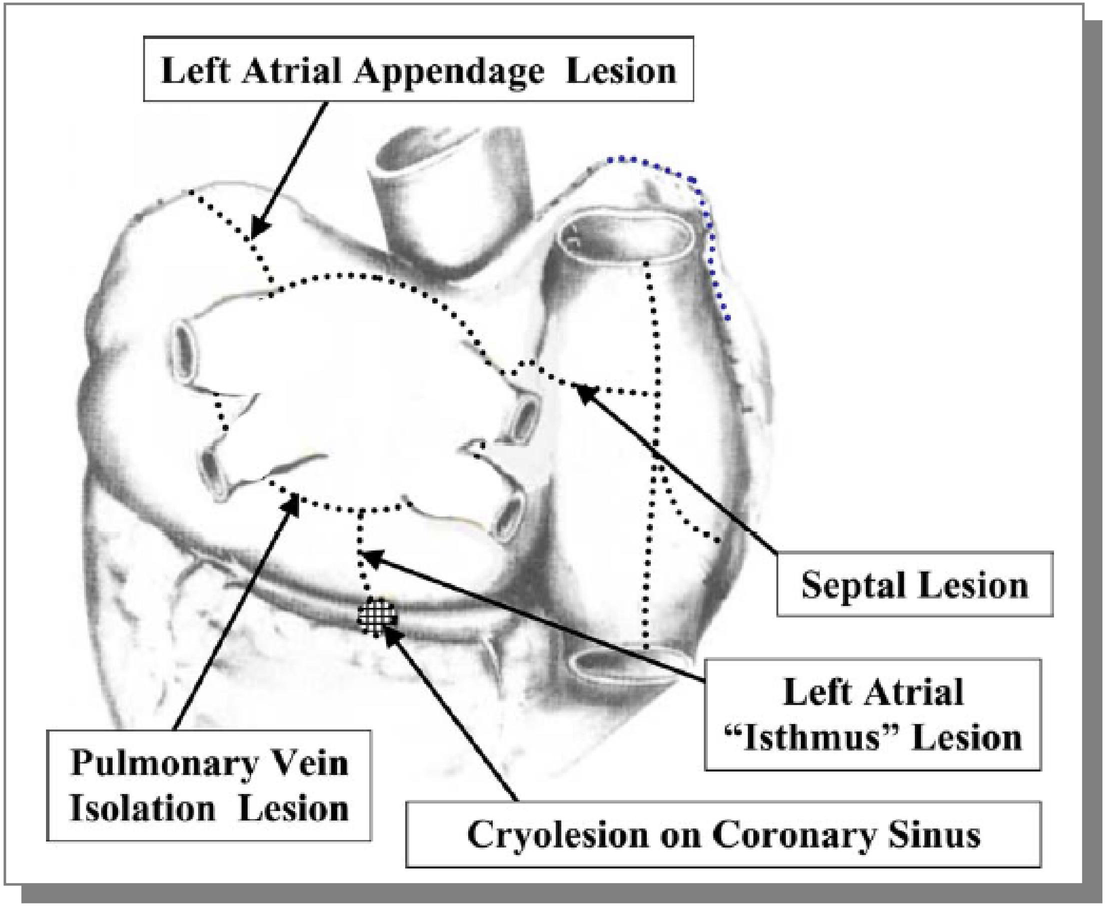

62 cc | 49 cc | 39.5 cc | 39.5 cc | 39.5 cc | 38 cc | 36 cc

**83% size reduction since 1989!**

*Seoul National University Hospital*
*Cardiovascular Center*

# Maze Procedure in AF Management

Standard Maze-III Procedure




Cox. Europace 2004;5:S20-S29; Cox JCE 2004;15:260-2; Cox et al. Ann Surg 1996;224:267-275.