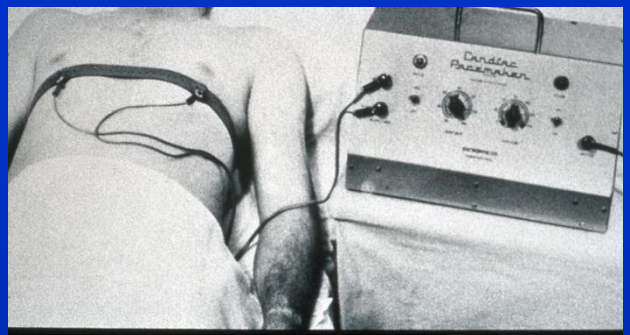
Pacemakers and ICDs

John Cogan, MD, FACC, FHRS

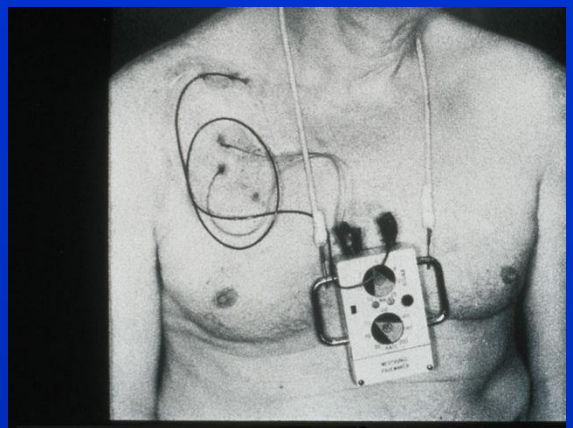
Arrhythmia Consultants of South Florida

Pacers



Principles And Techniques Of Cardiac Pacing. c. 1970;Page 4.
Courtesy of Dr. Paul Zoll

1952 Zoll

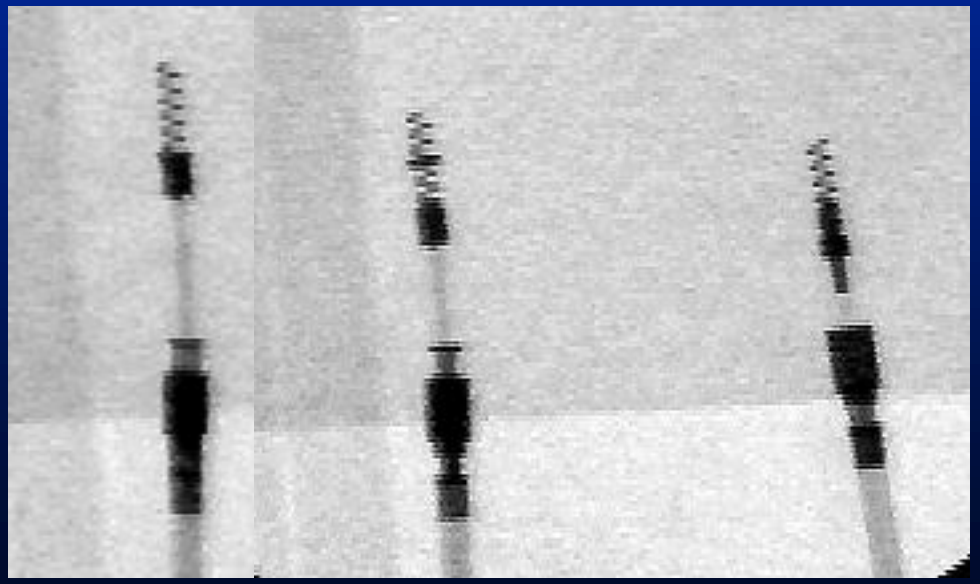


Principles And Techniques Of Cardiac Pacing. c. 1970;Page 73.
Courtesy Of New York Academy Of Sciences

1958

Principles And Techniques Of Cardiac Pacing. c. 1970; Page 6.

Leads



Unipolar vs. Bipolar

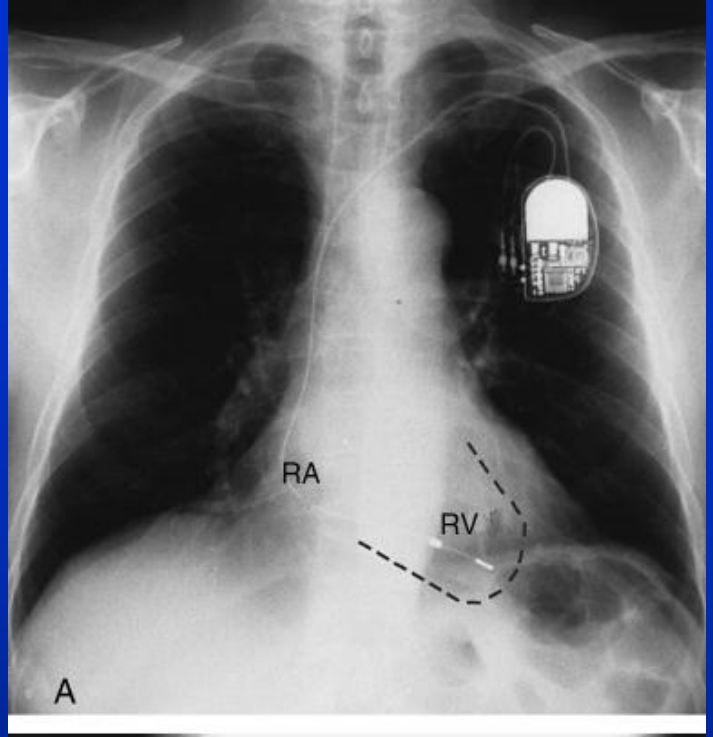
- Unipolar
  - Larger pacing spikes on EKG
  - Small diameter lead body
  - Less rigid lead body
  - More susceptible to oversensing
  - May produce muscle and nerve stimulation
- Bipolar
  - Larger diameter lead body
  - Tend to be stiffer
  - Less susceptible to oversensing
  - Unipolar programmable
  - Less likely to produce muscle and nerve stimulation

Basics

- Pulse generator:
  - Provides energy, and has an advanced timer with circuitry and memory chips
- Leads:
  - Pace and sense

Procedure

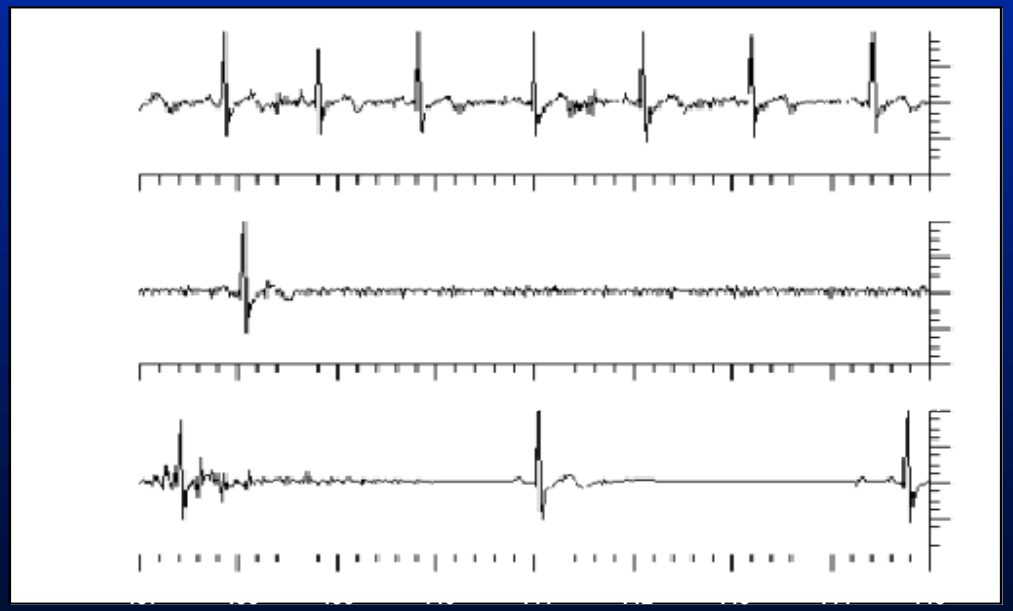
- Left or right infraclavicular incision
- Pocket
- Access (axillary, cephalic, subclavian)
- Lead insertion
- Pacer placement
- Closing



Pacemakers

- 92 y/o lady with history of recurrent syncope
- ECG and echo OK

Loop recorder:



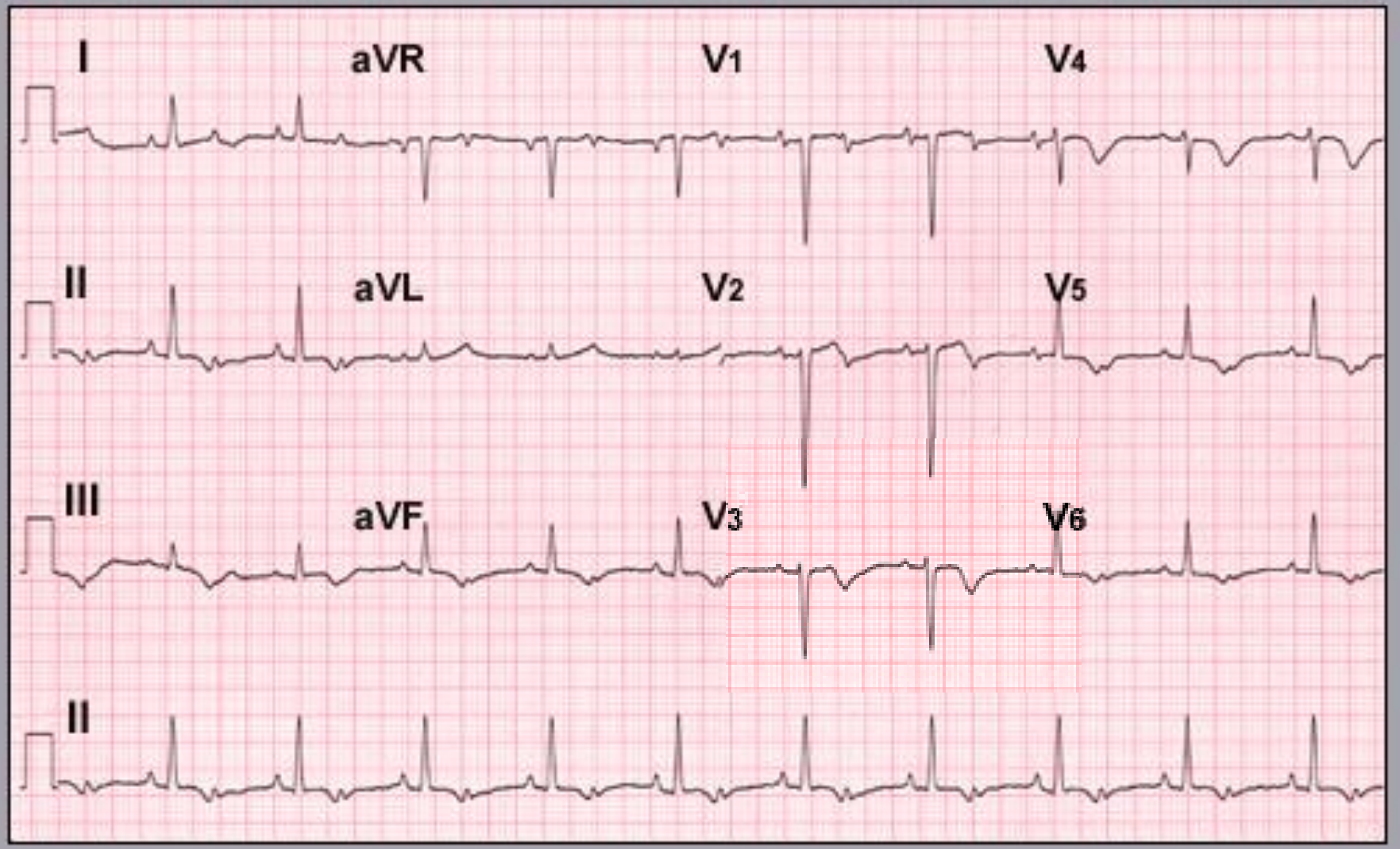
Dx???

7 sec. pause

Indications

- SSS
- The short story:
  - NO SYMPTOMS: NO PACEMAKER

  - Symptomatic brady – not iatrogenic
  - Chronotropic incompetence
  - Syncope with evidence of SSS
  - Pauses (3 sec) or very slow HR (<40) while awake and symptoms

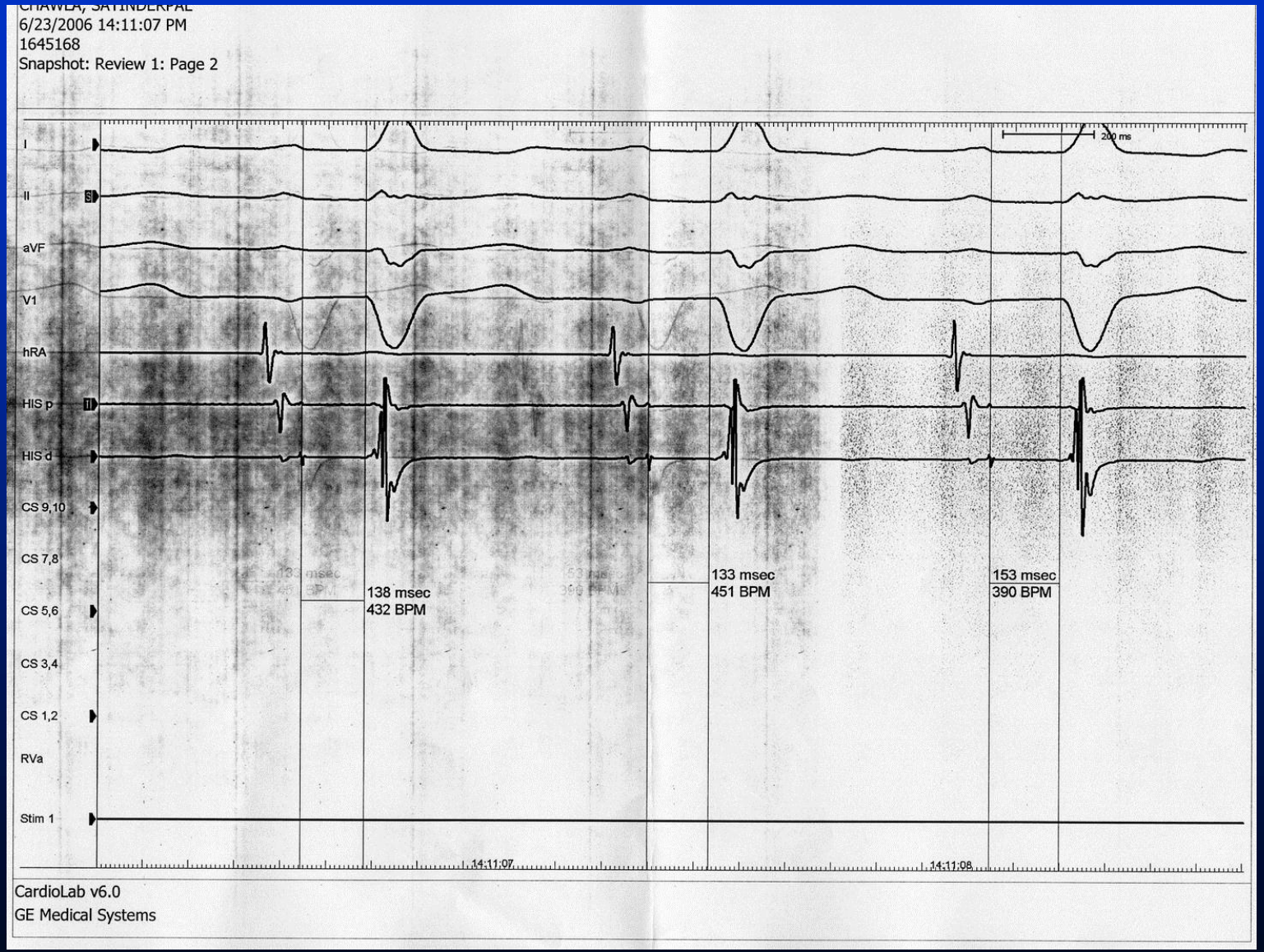

I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II

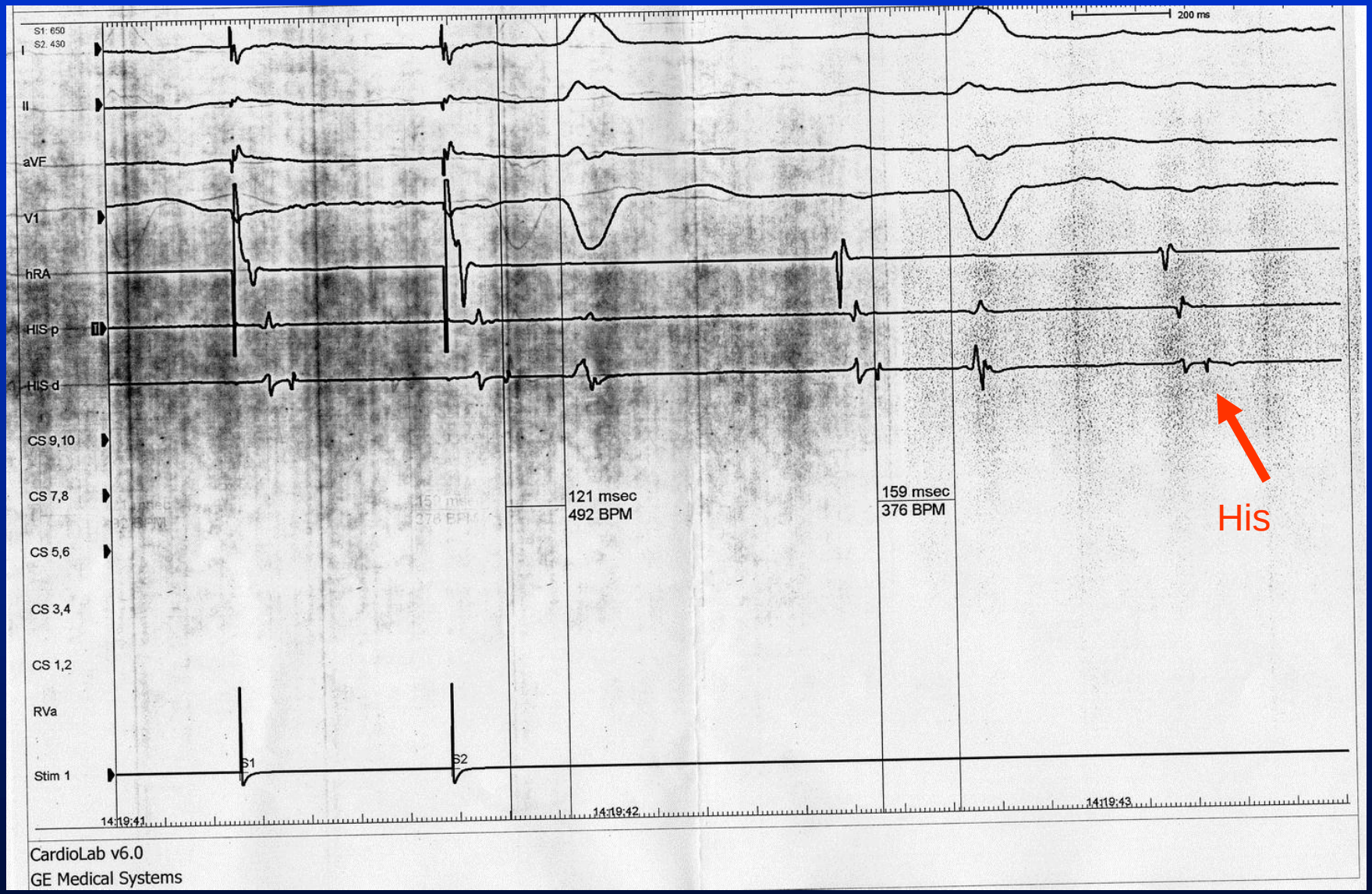
Indications

- AV Block
  - 3rd degree AVB, or 2nd degree AV block Mobitz II
  - Any 2nd degree AV block with symptoms
  - Mobitz I, proven to be intra or infra hisian with EPS
  - Some neuromuscular diseases (even without symptoms)

  - 2nd degree AV Mobitz I, no symptoms → No pacer

- 55 y/o with nl EF, SR with LBBB, asymptomatic 2nd degree AV block, looked like Mobitz I……



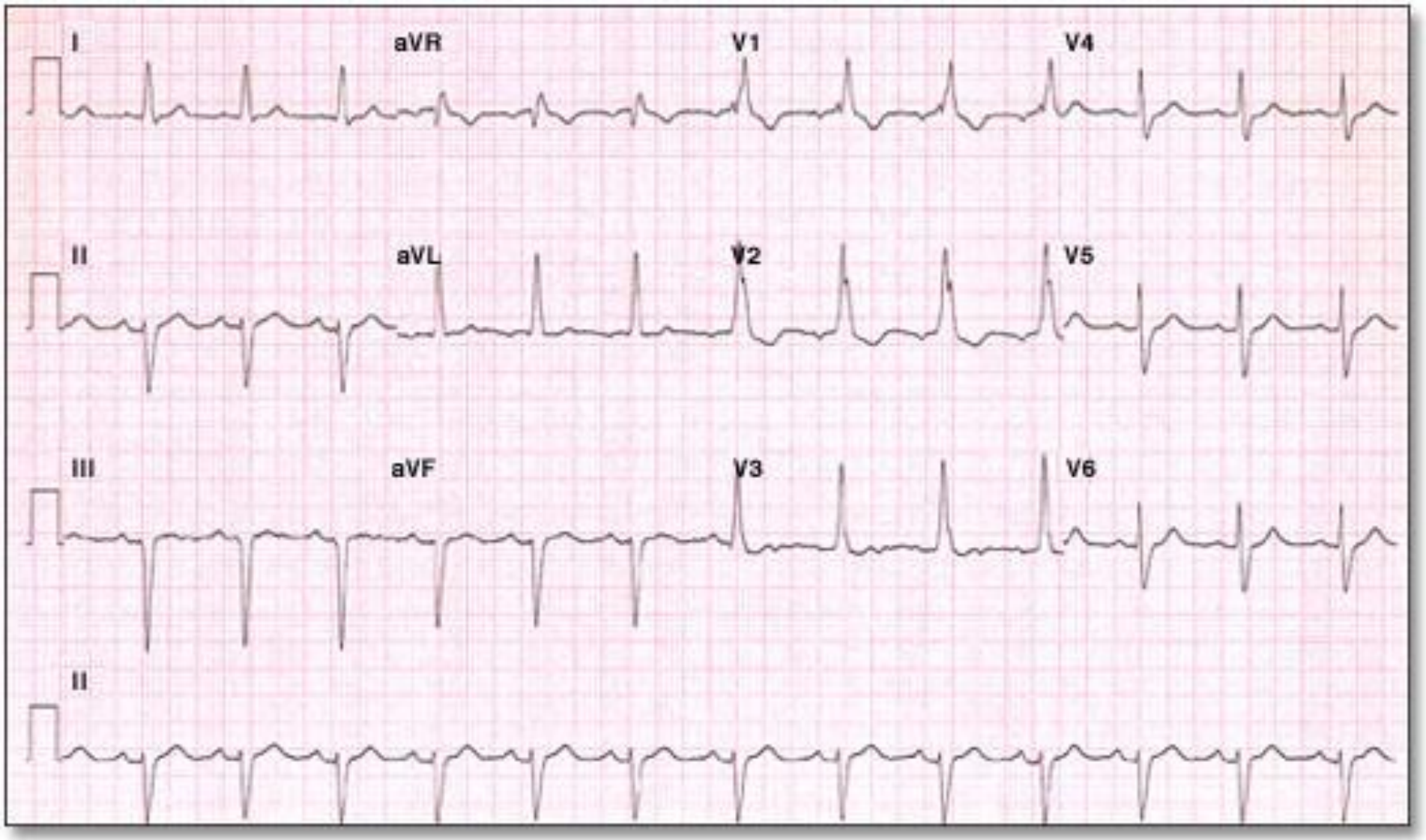

S1: 650
S2: 430
200 ms
I
II
aVF
V1
hRA
HIS p
HIS d
CS 9,10
CS 7,8
CS 5,6
CS 3,4
CS 1,2
RVa
Stim 1
S1
S2
121 msec
492 BPM
159 msec
376 BPM
His
14:19:41
14:19:42
14:19:43
CardioLab v6.0
GE Medical Systems

Indications

- Syncope with HV >70
- Asymptomatic with HV>100
- Infrahisian block, not physiologic

- Long QT
  - Same as others, plus pts with pause dependant VT

Bifascicular Block



Indications

- Bifascicular or “trifascicular” block
  - Same as regular AV block
  - No symptoms or AV block → no pacer
- Vasovagal/Neurocardiogenic
  - Not indicated for most patients
- Carotid hypersensitivity syndrome
  - Syncope plus + CSM=Pacer
  - No symptoms, even with + CSM=no pacer
- HCM
  - Same as SSS
  - Medically refractory with high LVOT gradient
  - Not indicated in the absence of gradient even with symptoms

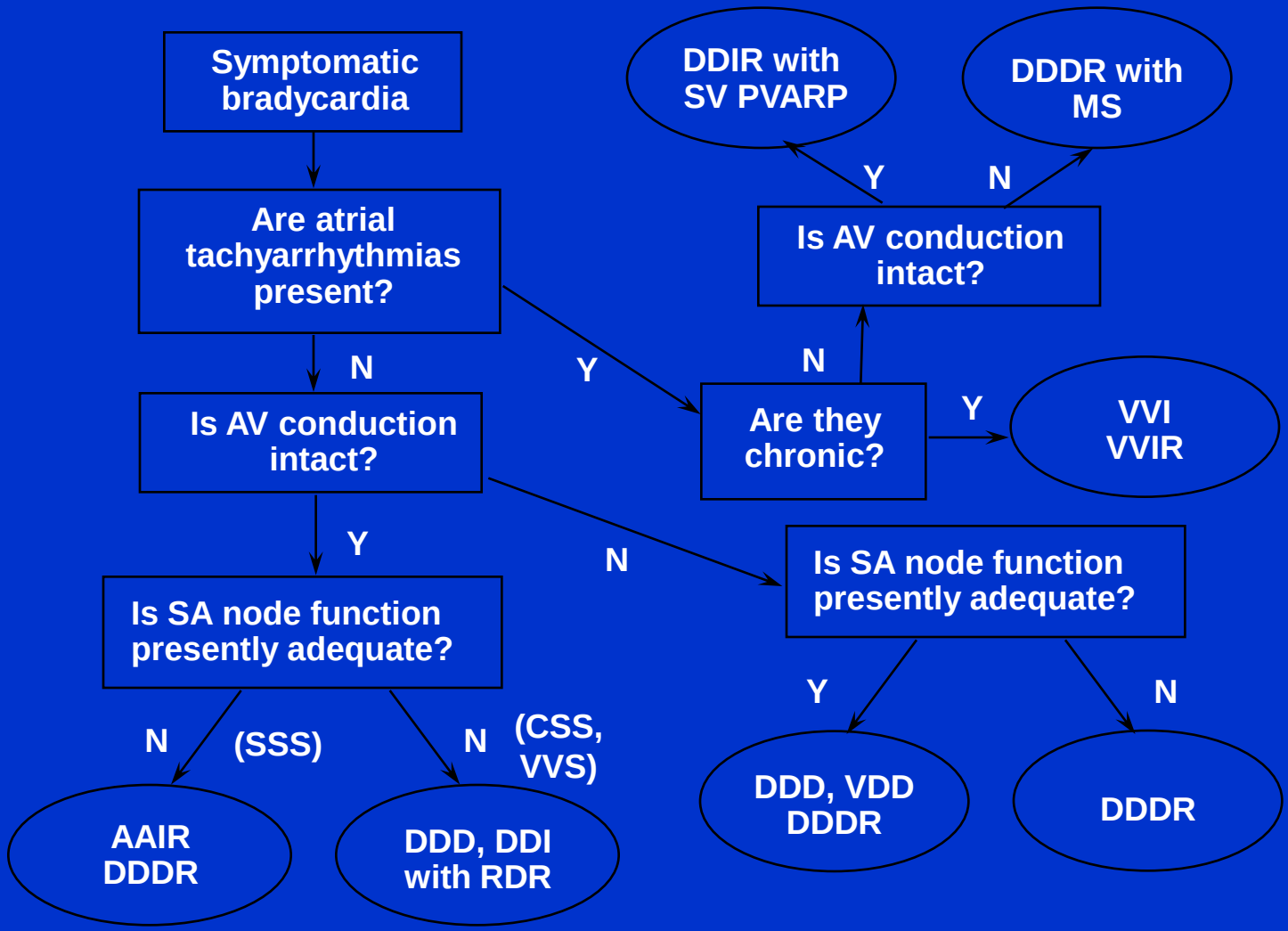
Temporary Pacer

- Refractory symptomatic sinus node dysfunction (Temp if reversible or post MI)
- Complete heart block
- Alternating bundle-branch block
- New bifascicular block in AMI
- Bradycardia-dependent ventricular tachycardia

NBG Code Review

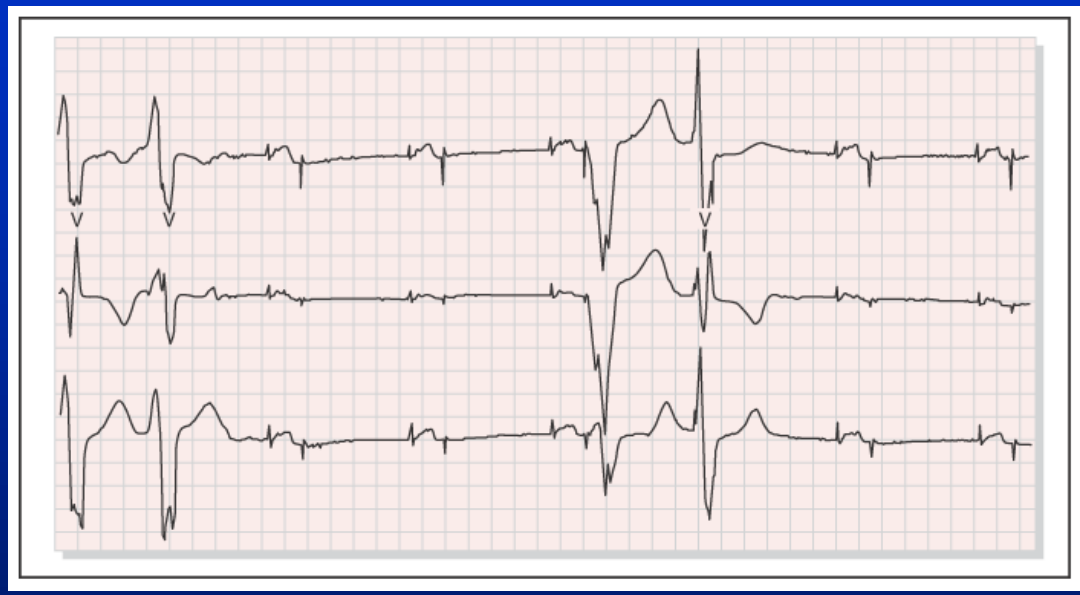
I Chamber Paced	II Chamber Sensed	III Response to Sensing	IV Programmable Functions/Rate Modulation	V Multisite Pacing
V: Ventricle	V: Ventricle	T: Triggered	P: Simple programmable	P: Pace
A: Atrium	A: Atrium	I: Inhibited	M: Multi-programmable	S: Shock
D: Dual (A+V)	D: Dual (A+V)	D: Dual (T+I)	C: Communicating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

Mode Selection Decision Tree

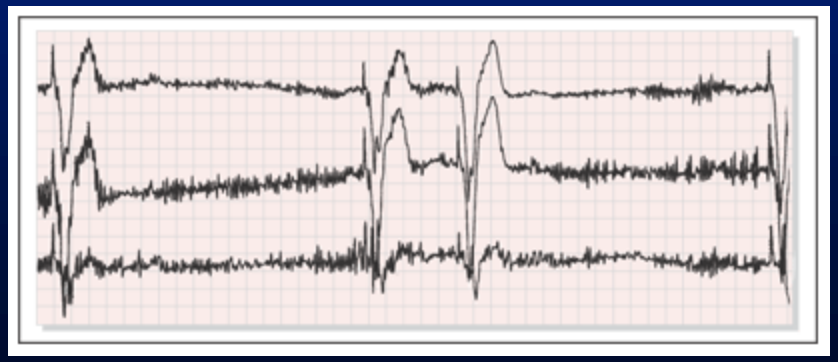


Troubleshooting
Sensing or Capture problems
Too much, or too little

crosstalk

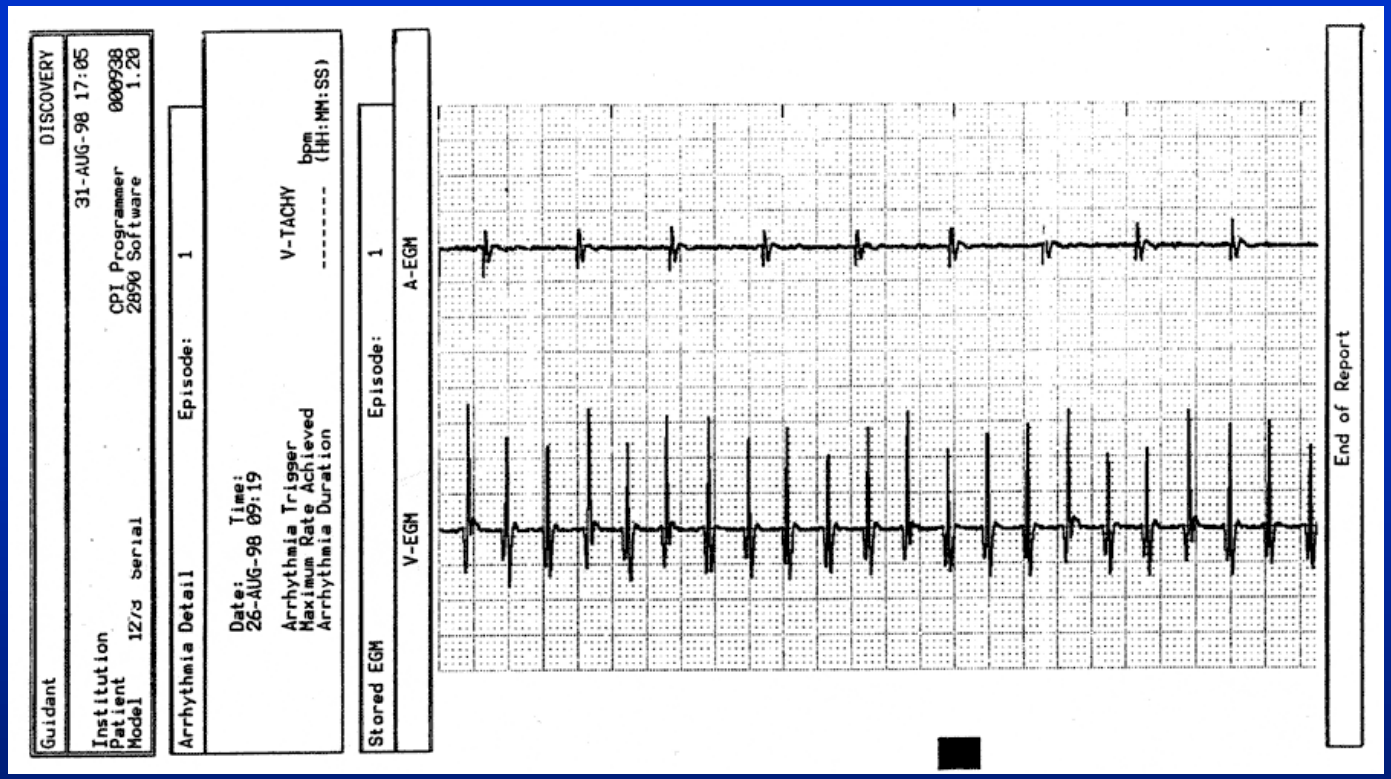


No capture

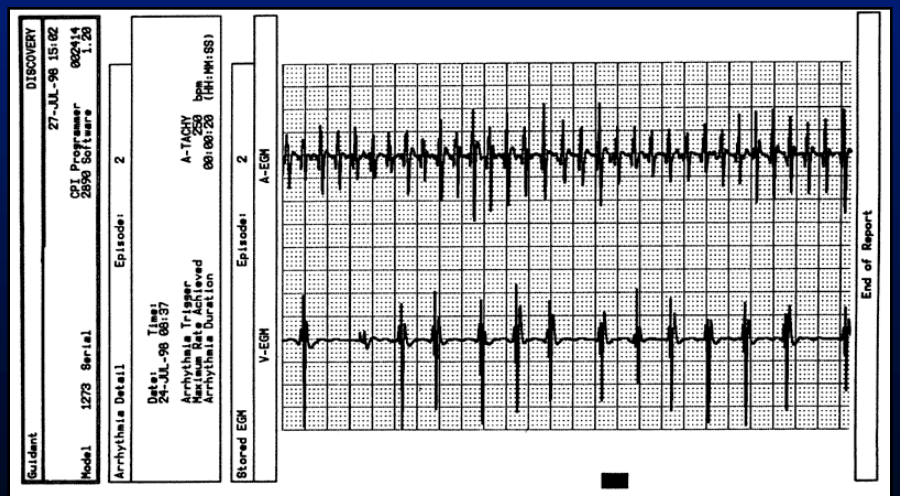


myopotentials

Diagnostics



VT

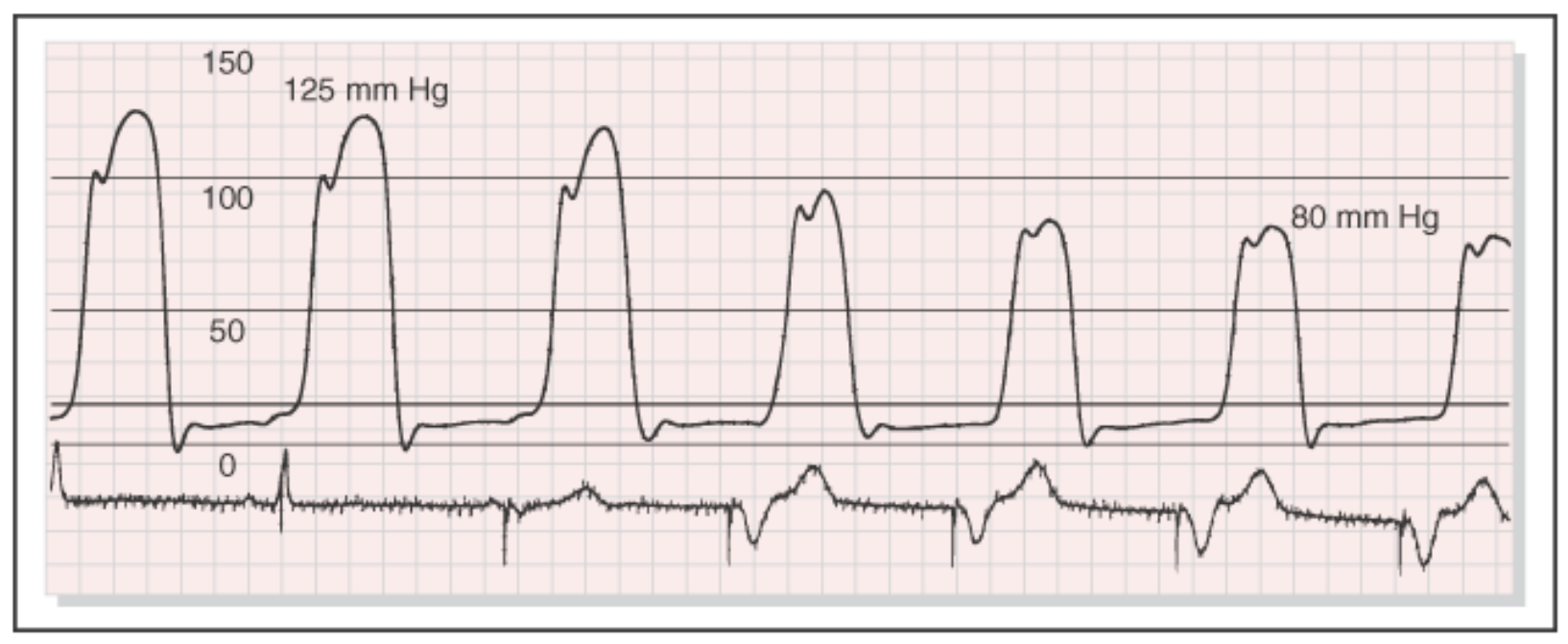


AFIB

Pacemaker syndrome

- Symptoms:
  - syncope or near-syncope, orthostatic dizziness, fatigue, exercise intolerance, weakness, lethargy, chest fullness or pain, cough, uncomfortable pulsations in the neck or abdomen, right upper quadrant pain, and other nonspecific symptoms.
- Cause:
  - Loss of AV synchromy, most common in VVI or DDI mode.

Pacemaker syndrome



ICDs

History of ICD Therapy

- 1966: Device conception
- 1980: First human implant at Johns Hopkins Hospital. To meet criteria, the patients had to have survived two episodes of cardiac arrest not associated with an infarction and VF had to be documented at least once.

First Clinical Model

- 250 g
- Short-lived
- Shock only
- Nonprogrammable
- No data storage
- Committed
- Required thoracotomy and abdominal implant

Implantable Defibrillators (1989-2001)

209 cc

113 cc

80 cc

80 cc

72 cc

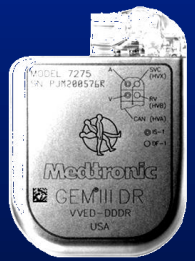
54 cc

62 cc

49 cc

39.5 cc

39 cc



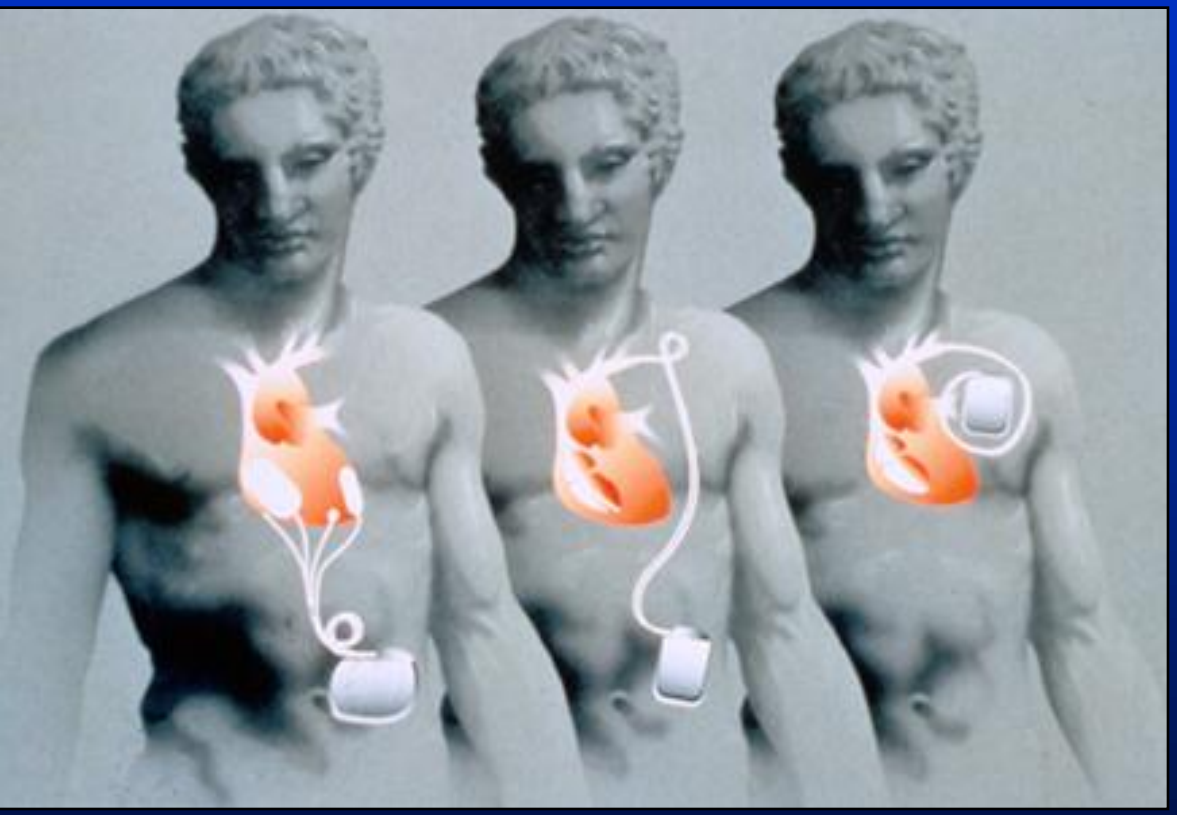
39.5 cc

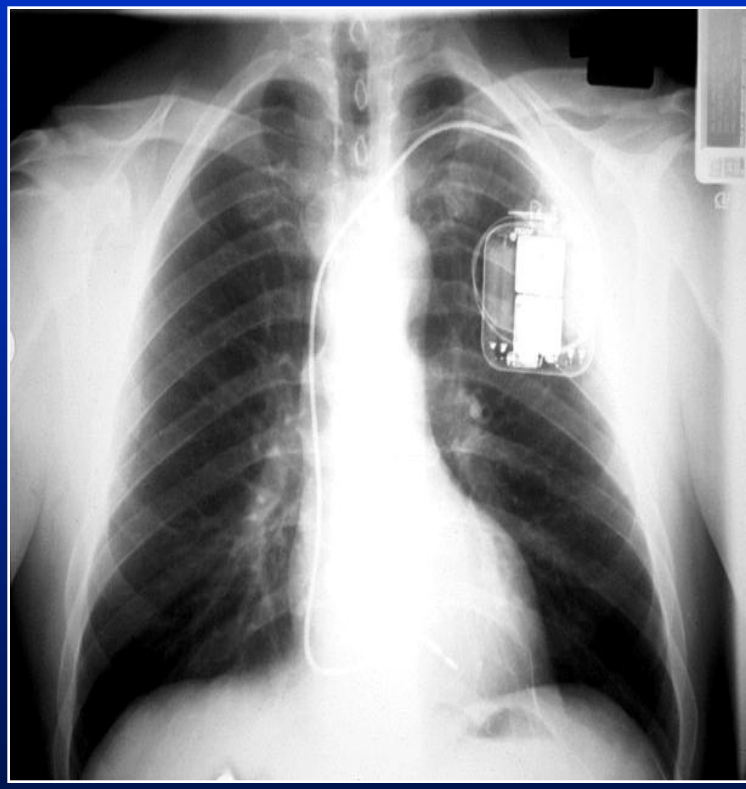
39 cc

39.5 cc

36 cc

Device Evolution



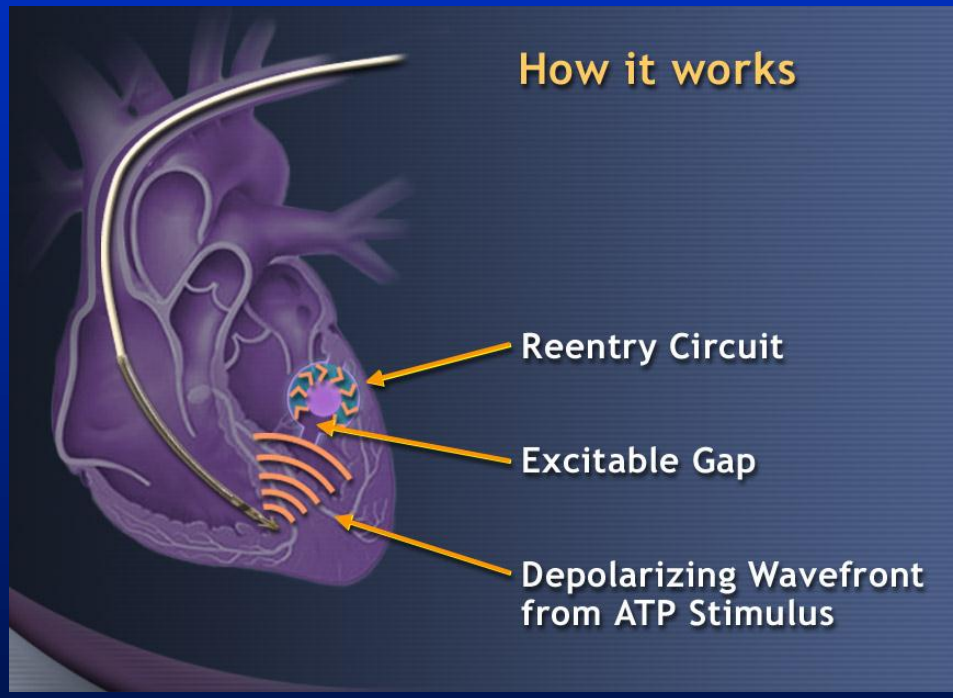


1985 1991 1995

Device Features

- Programmable therapy options
  - Energy selection
  - Multiple zones
  - Antitachycardia pacing
- Data storage
- Discrimination of SVT and VT
- Single, dual-chamber or bi-ventricular pacing
- Audible patient alerts
- Longevity up to 8 years:

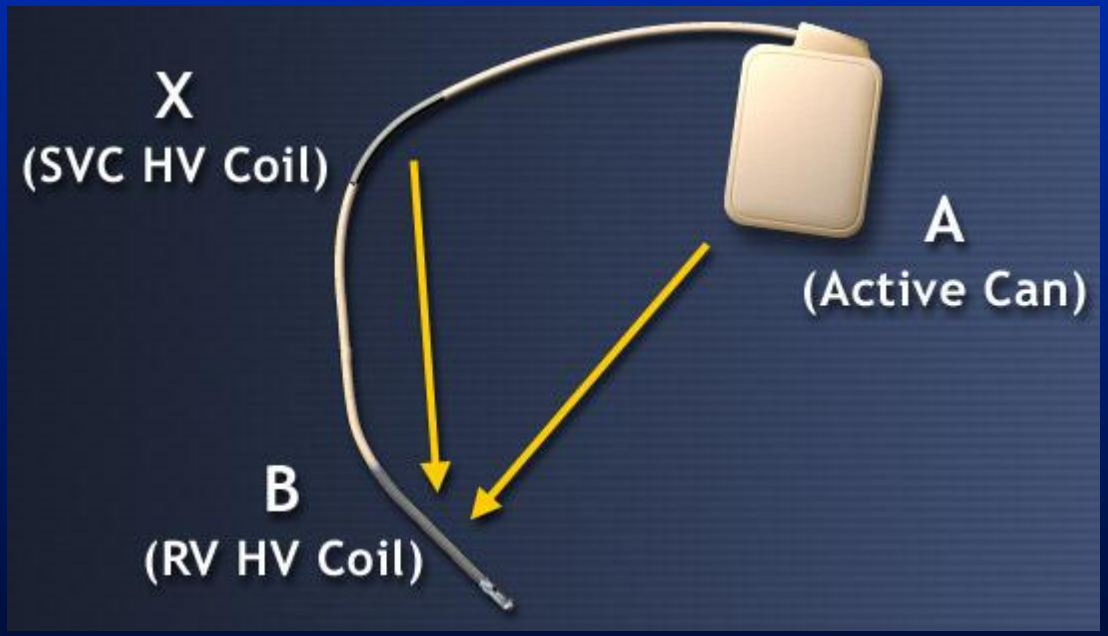
Antitachycardia Pacing



Shocking Circuit Vectors

Example of Dual Coil: AX > B

(Active Can + SVC HV Coil > RV HV Coil)



Implantable Cardioverter Defibrillator Trials for Secondary Prevention of SCD

	STUDY GROUP	Mortality Control	Mortality ICDs	Rel RR	P Value
AVID	VF, sustained VT; EF ≤ 40% ICD vs amiodarone Mean EF 35% F/U: 18 mo	24%	15.8%	30%	0.02
CIDS	VF, symptomatic VT; EF ≤ 35%, CL < 400ms Mean EF 34% F/U: 36 mo	29.6%	25.3%	-30%	0.14
CASH	Survivors of SCD (VF/VT) propafenone/metoprolol/ amiodarone/ICD Mean EF 45%, F/U: 57 mo	44.4%	36.4%	23%	0.08
Meta-analysis				28%	0.006

AVID = Antiarrhythmics vs Implantable Defibrillators. NEJM 1997; 337:1576 (terminated early)
CIDS = Canadian ICD study. Circulation 2000;101:1297
CASH = Cardiac Arrest Study of Hamburg. Circulation 2000;102:748

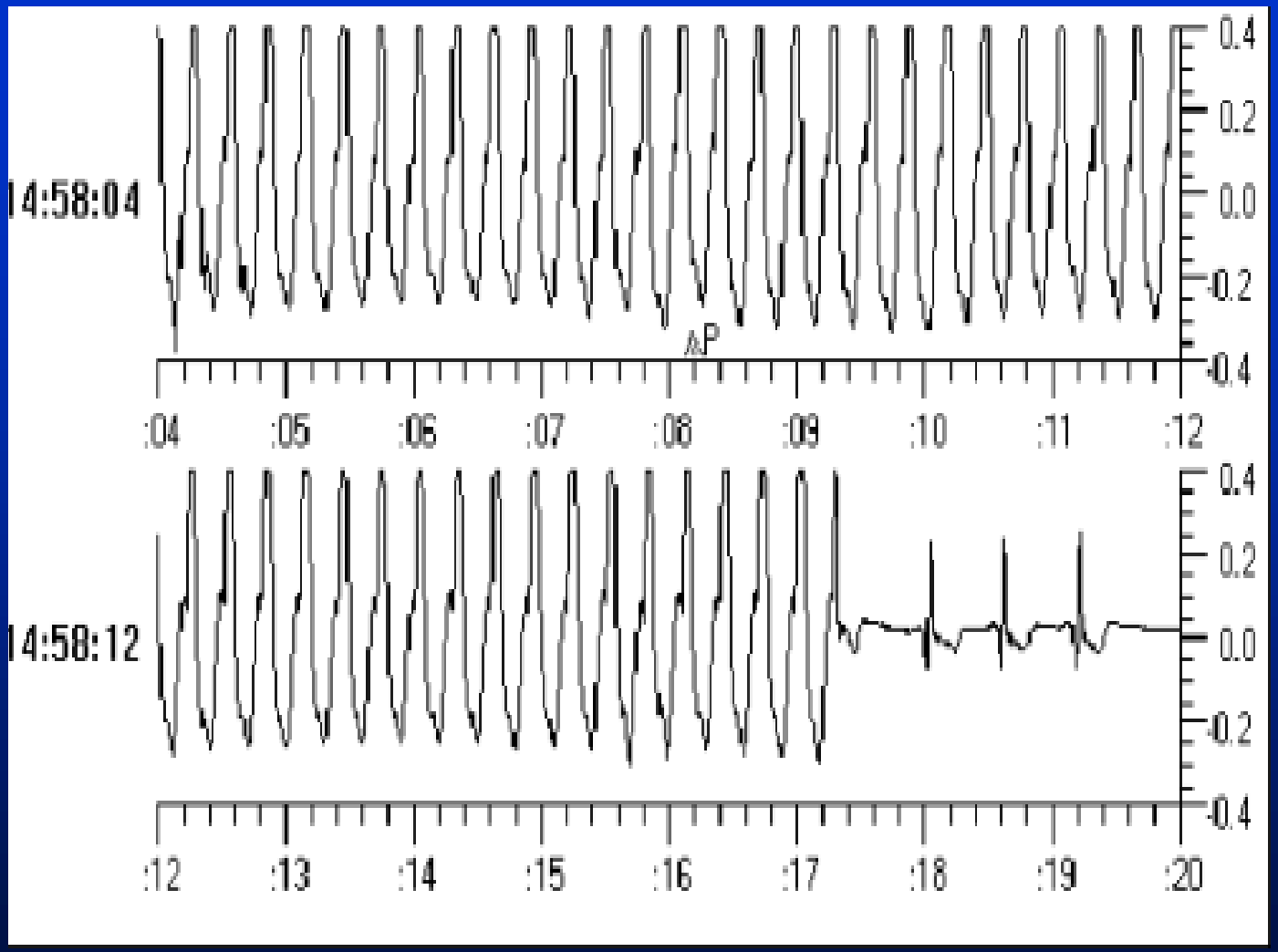
ICD for 1ry Prevention Study Criteria Comparison

Inclusion Criteria	MADIT[1] 1996 (n = 196)	MUSTT[2] 1999 (n =704)	MADIT II[3] 2002 (n =1232)	SCD-HeFT (n =2521)
CAD/Post-MI	✓	✓	✓	
LV Dysfunction	✓ **(≤35%)**	✓ **(≤40%)**	✓ **(≤30%)**	✓ **(≤35%)**
NSVT	✓	✓		
Inducible VT on EPS	✓	✓		
Inducible, non-suppressible VT on EPS	✓			

[1] Moss AJ. *N Engl J Med*. 1996;335:1933-40.
[2] Buxton AE. *N Engl J Med*. 1999;341:1882-90.
[3] Moss AJ. *N Engl J Med*. 2002; 346:877-83.

28 y/o man with recurrent syncope

- Nl ECG, some PVCs
- Nl Echo
- Nl MRI heart
- Recurrent syncope


14:58:04
ΔP
0.4
0.2
0.0
-0.2
-0.4
:04
:05
:06
:07
:08
:09
:10
:11
:12
14:58:12
0.4
0.2
0.0
-0.2
-0.4
:12
:13
:14
:15
:16
:17
:18
:19
:20

Time for an ICD?????

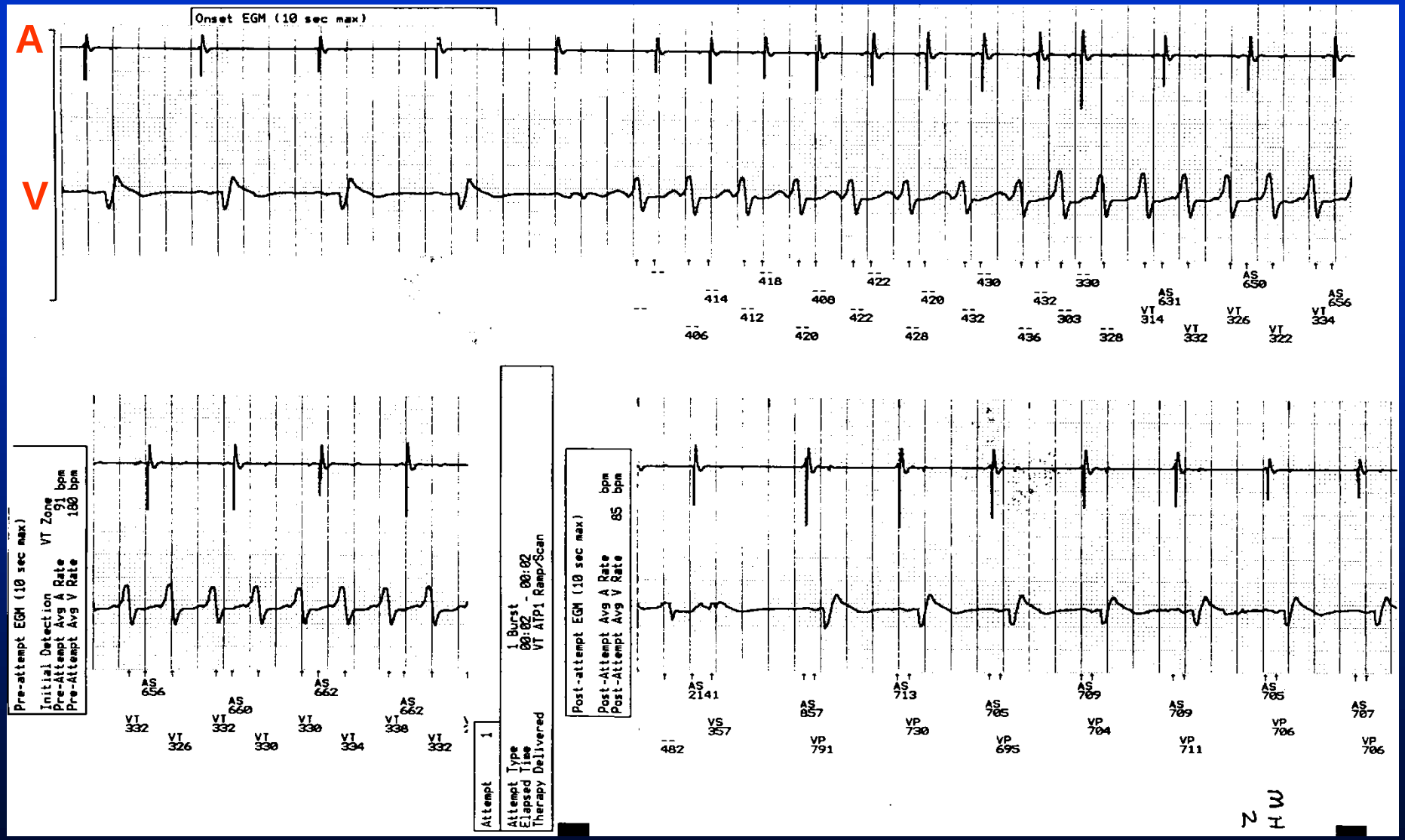
Indications for ICD

- **Spontaneous or inducible VT/VF**
- **Sustained VT with structural heart disease**
- **Unexplained syncope with inducible VT/VF or in very high risk patients**
- **High risk inherited conditions (Long QT, Brugada)**
- **LVEF < 35% ischemic or non-ischemic**

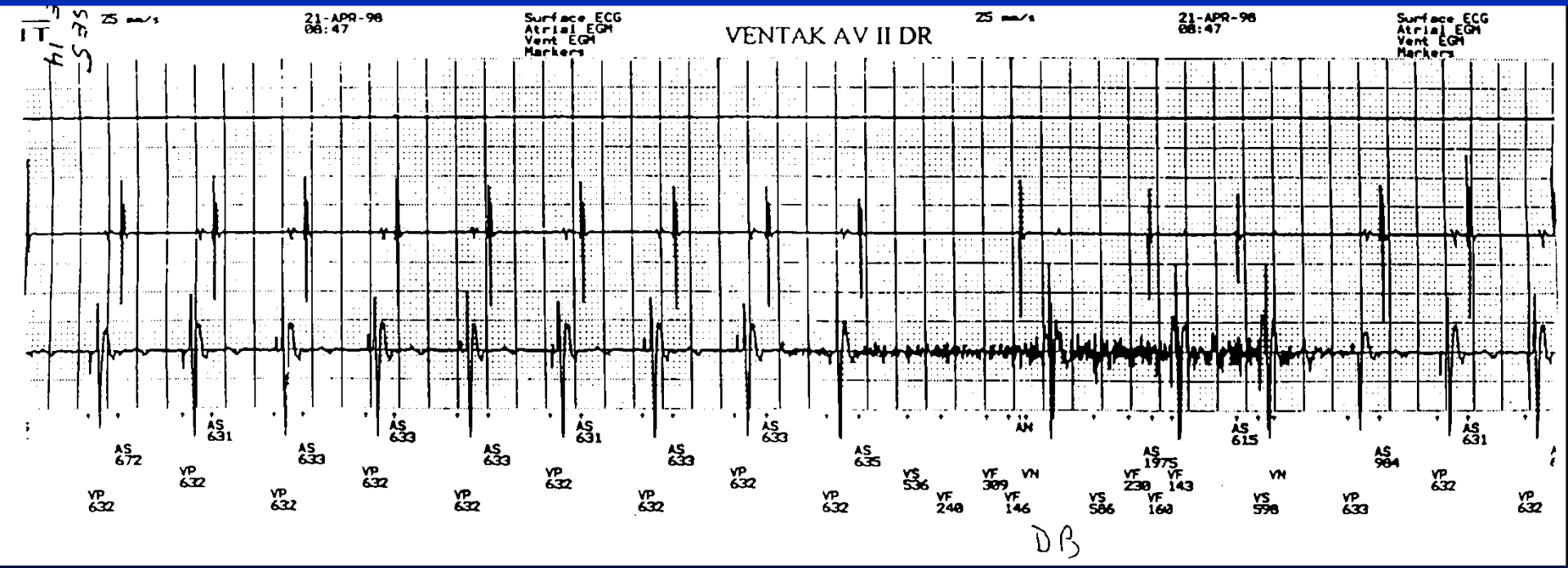
Contraindications

- **Incessant VT or VF**
- **VT or VF due to a completely reversible cause**
- **Psychiatric illness potentially aggravated by ICD therapy**
- **Terminal illness**
- **Class IV CHF without option of cardiac transplantation (except bi-V)**

VT vs. SVT


A
V
Onset EGM (10 sec max)
Pre-attempt EGM (10 sec max)
Initial Detection VT Zone
Pre-Attempt Avg A Rate 91 bpm
Pre-Attempt Avg V Rate 180 bpm
Attempt 1
Attempt Type 1 Burst
Elapsed Time 00:02 - 00:02
Therapy Delivered VT ATP1 Ramp/Scan
Post-attempt EGM (10 sec max)
Post-Attempt Avg A Rate bpm
Post-Attempt Avg V Rate 85 bpm

Sometimes, it's just bad: Lead fracture, noise, oversensing (diaphragmatic myopotentials in this case)

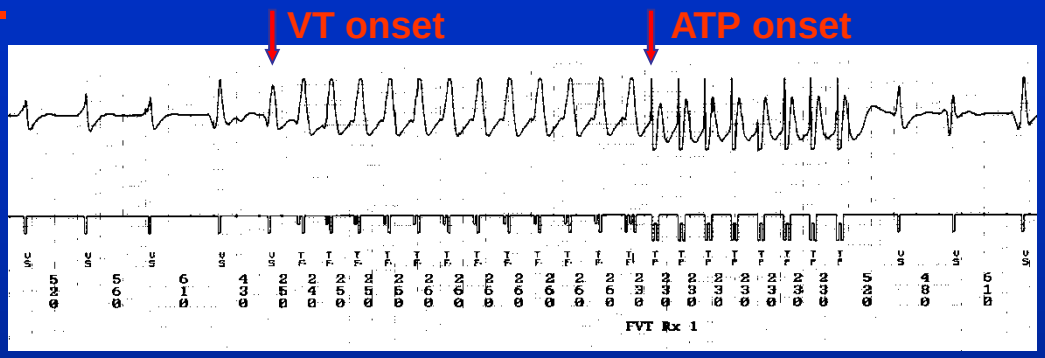


Deep breathing

Anti Tachycardia Pacing

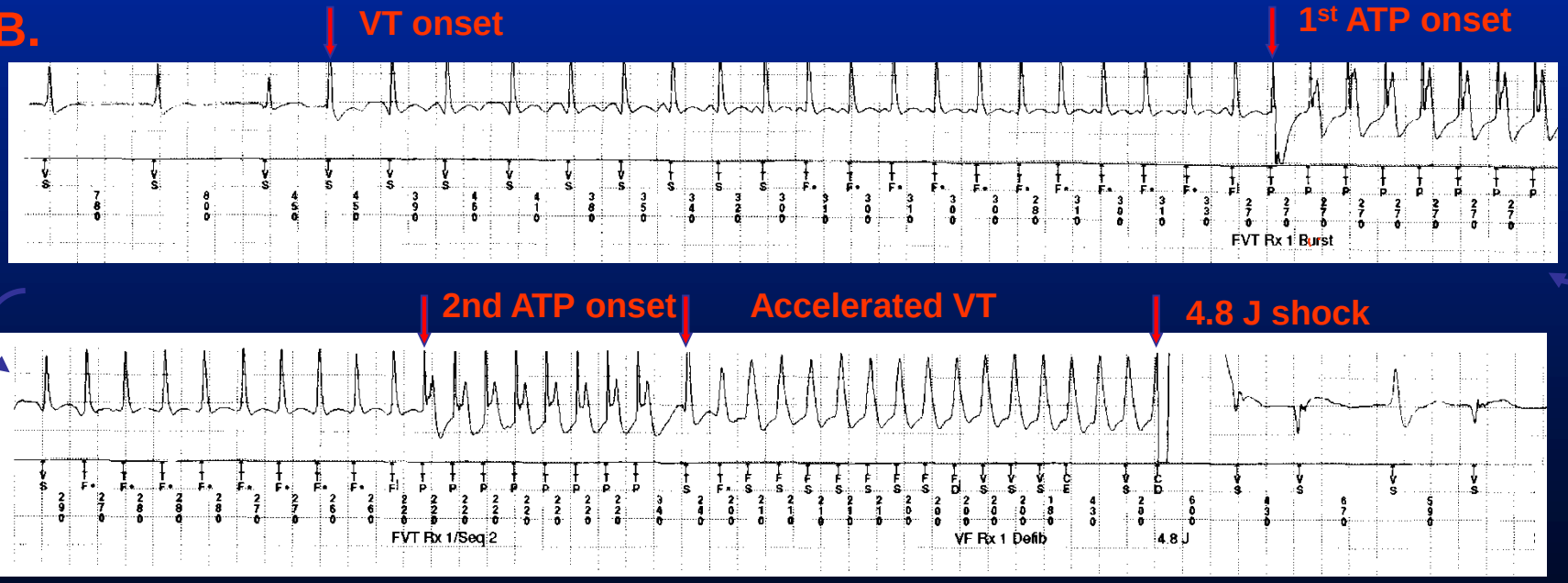
Examples of Success (A) and Failure (B)

A.



Episode duration = 5.3 s

B.



Episode duration = 16.8 s

Bi-V ICD

Bi-V

- Dyssynchrony is an anatomical-mechanical event involving:
  - Abnormal ventricular activation (EF)
  - Decreased ventricular filling
  - Abnormal ventricular wall motion
- Up to 50%-70% of patients with HF have ventricular dyssynchrony

Who Needs CRT?

Classic indication:

- NYHA = III-IV
- QRS duration ≥120 ms
- EF ≤ 35%

New Indication:

- NYHA = I-II
- EF <30%
- LBBB

Bi-V Trials

PATH-CHF

MUSTIC

MIRACLE

Contak CD

Miracle ICD

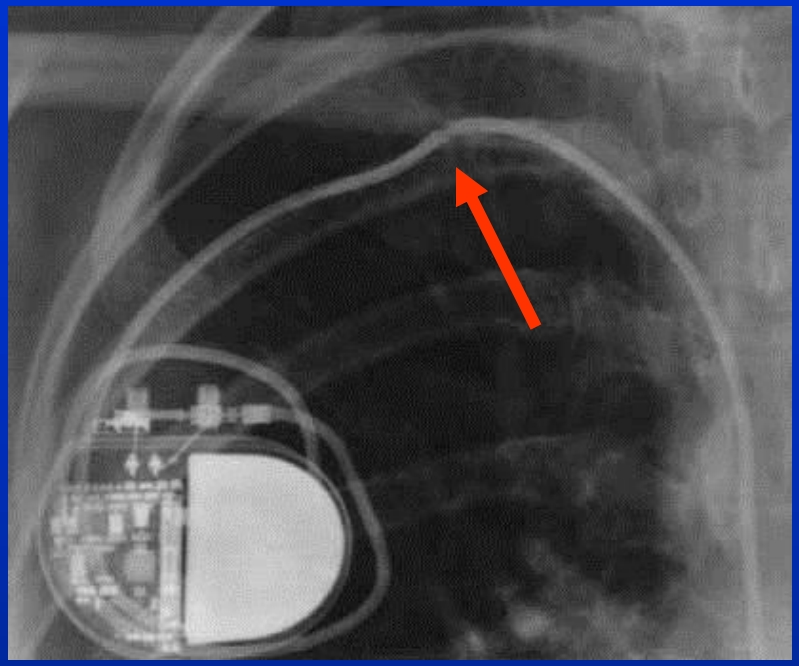
Companion

Care HF

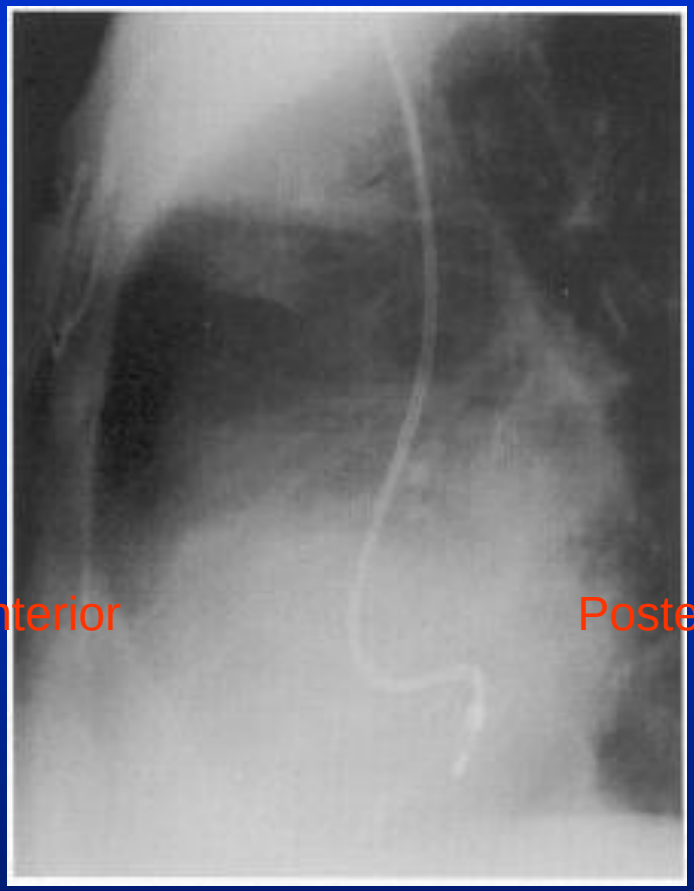
- These trials show:
  - Better exercise tolerance
  - Better QOL
  - Better NHYA class
  - Improved mortality

Pacer/ICD Complications

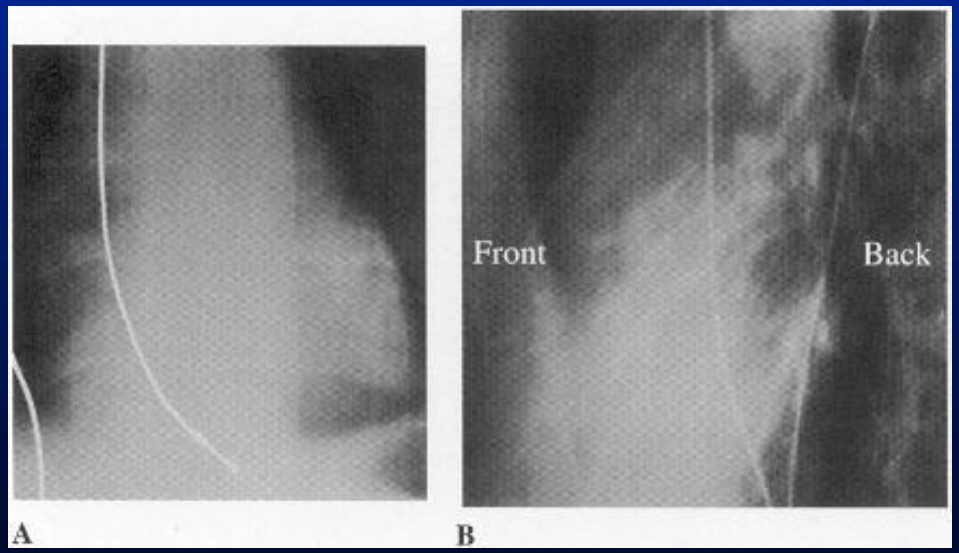
- Acute: Bleeding, pneumothorax, lead dislodgement, hematoma, lead malposition, perforation, PE, SCV DVT
- Infection or erosion in 1-2% of cases and requires system removal
- Malfunction of device; lead is the weakest link can fracture or fail
- Inappropriate shocks
- Ventricular pacing might be detrimental
  - **MADIT II demonstrated increased incidence of CHF in defibrillator patients**
  - **DAVID trial demonstrated 3.6% mortality increment with DDD versus backup VVI**



Lead fracture

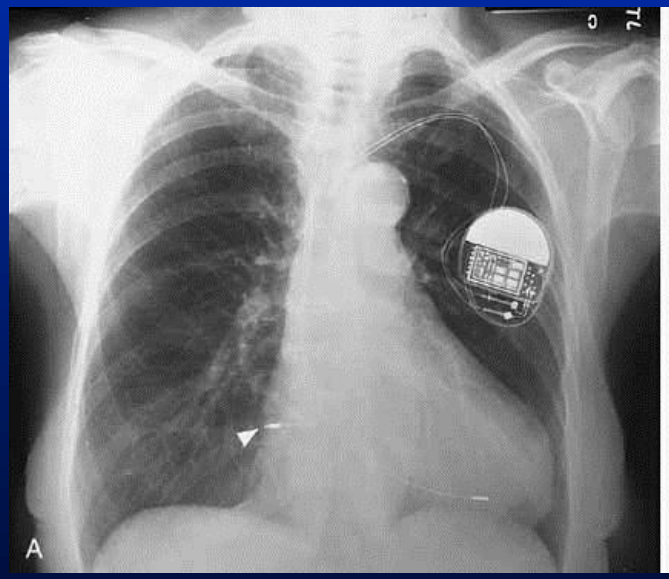


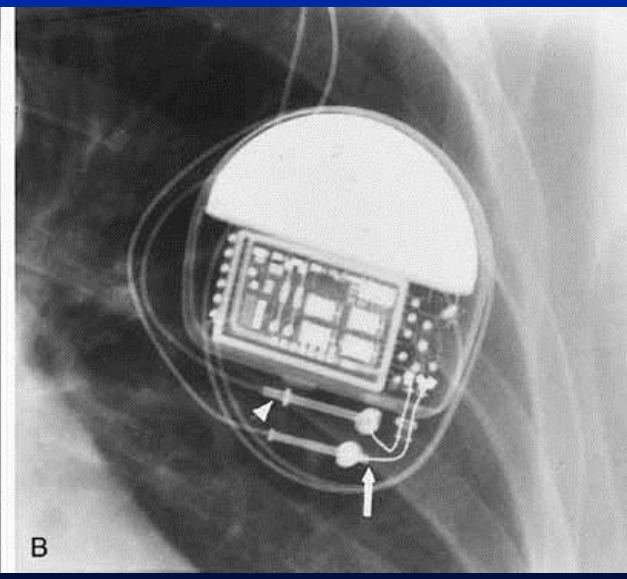
Middle cardiac vein



LV through ASD

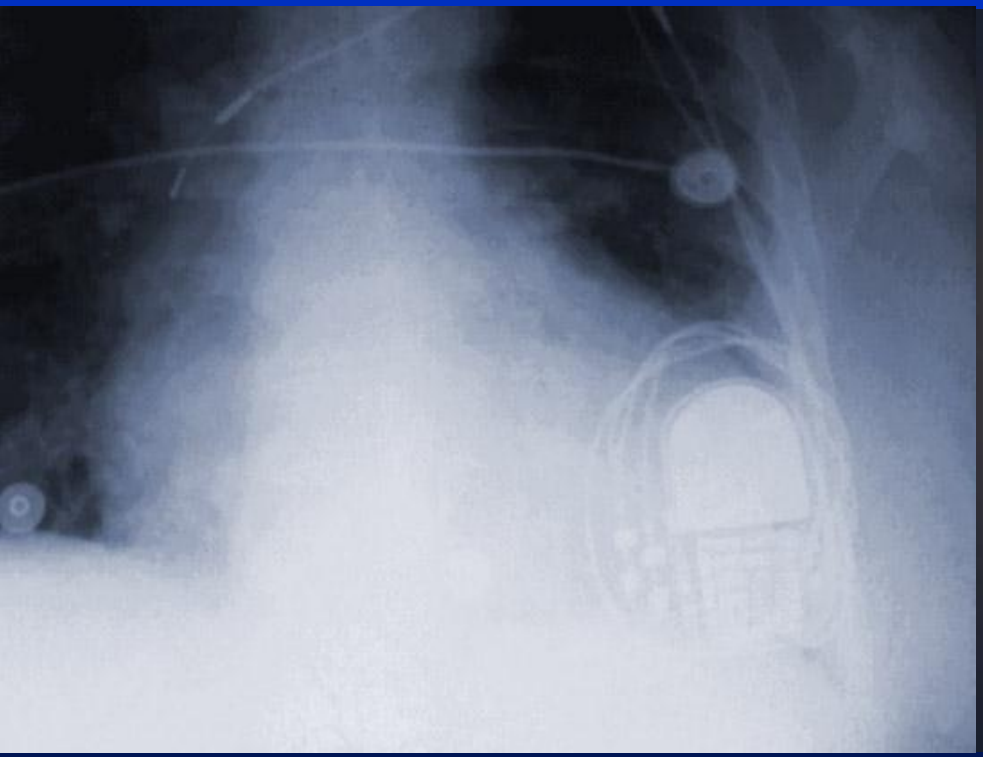
Pt with pain under rib cage post implant





Lack of capture post implant

Rare Complications

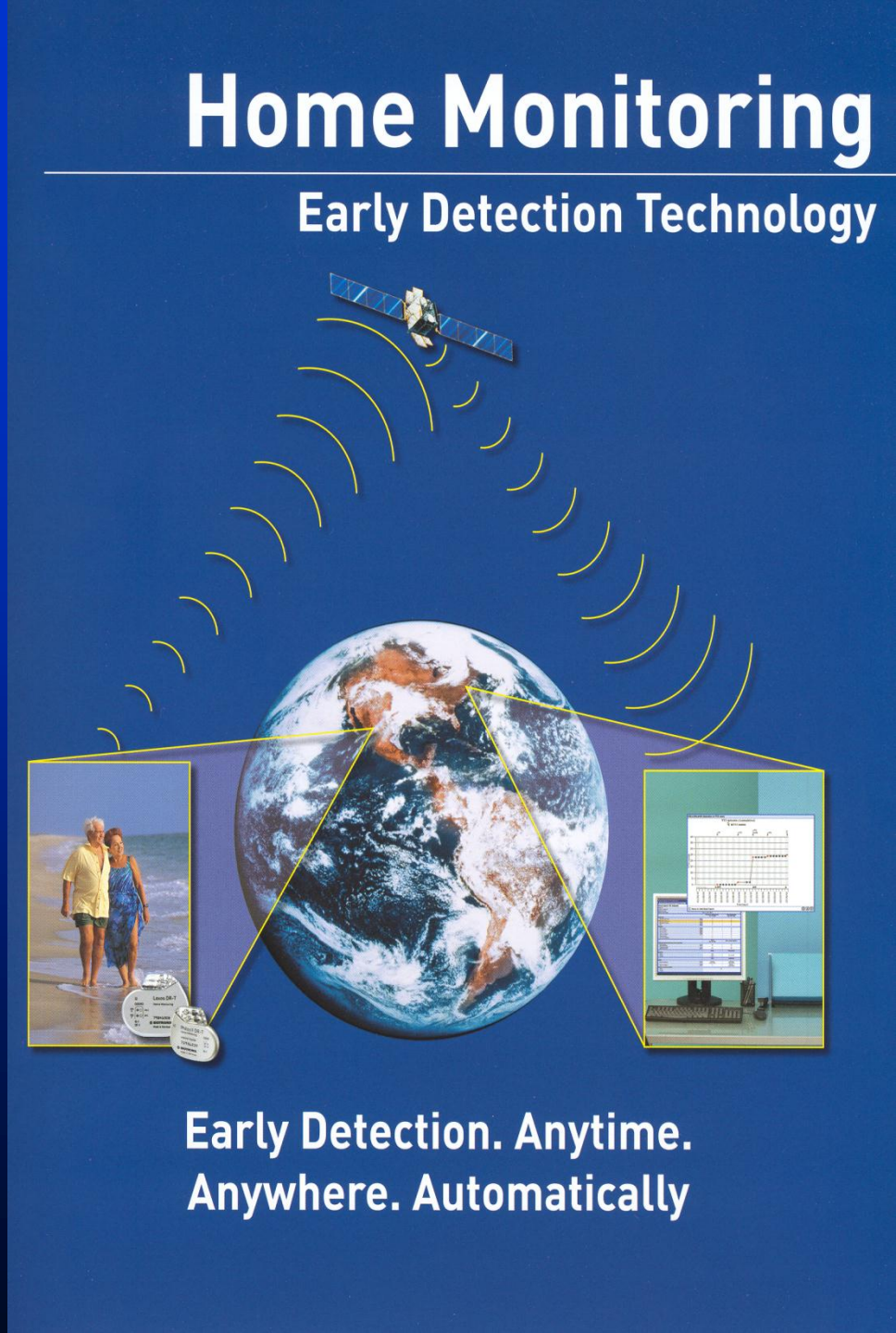


Twiddler Syndrome

Erosion

Follow up

- Wireless devices
- Routine ICD checks at home
- Interrogator to device without a cable
- Internet/satellite, GSM based interrogation
- No more: “go to the ER for a shock”



Questions?