Review of Pacemakers and ICD Therapy: Overview and Patient Management

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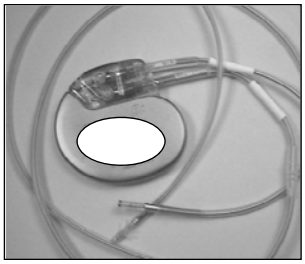
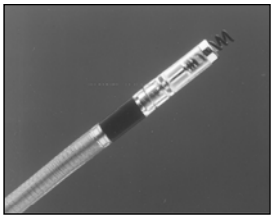
Ohio State University Medical Center

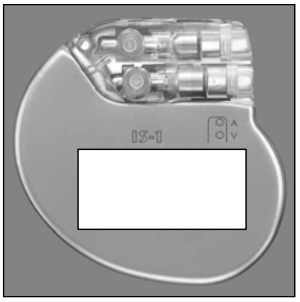
Disclosures

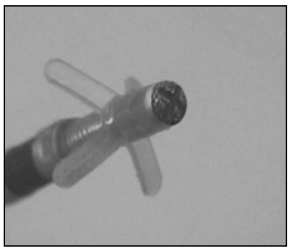
- **Consultant, Research Support, Honoraria**
  - **Boston Scientific**
  - **Cook Medical**
  - **Deringer-Ney**
  - **LeadExx**
  - **Medtronic**
  - **Spectranetics**
  - **St. Jude Medical**
  - **W.L. Gore**
- **Legal Consultant/Expert Witness**

Pacing Systems



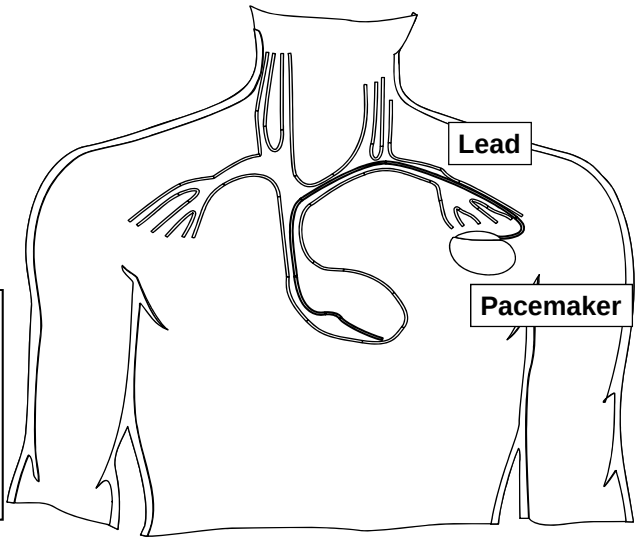


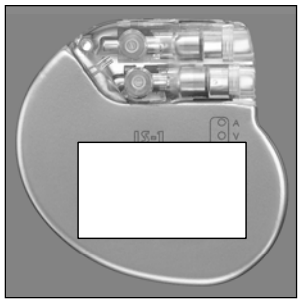


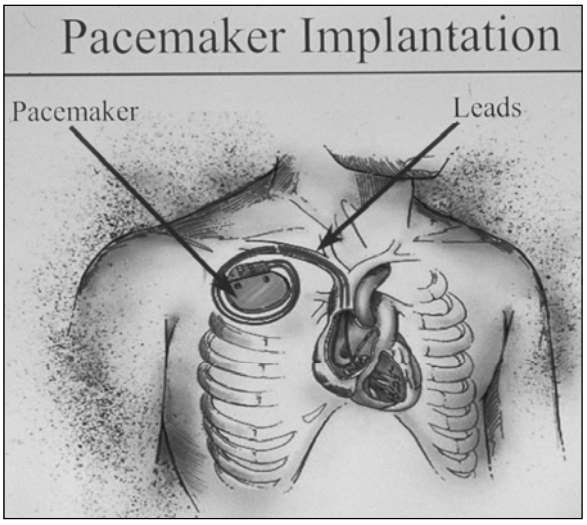


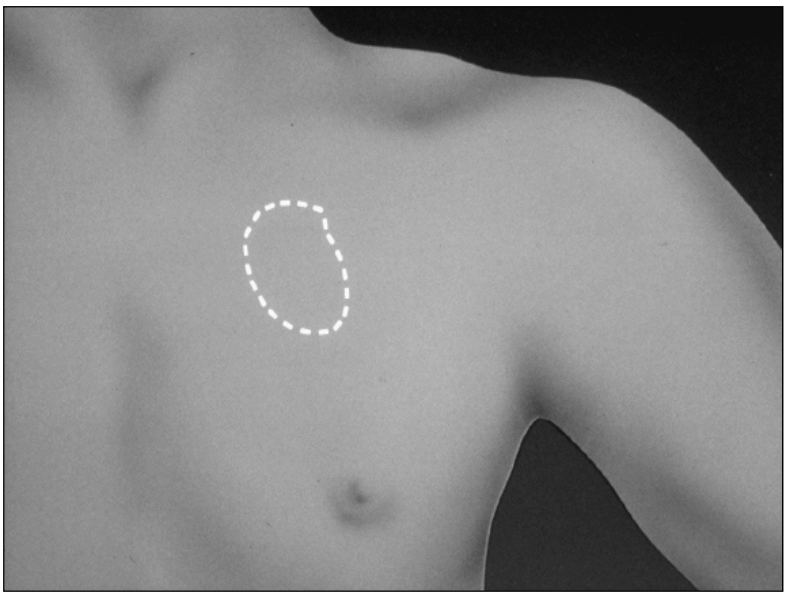
The Pacemaker System

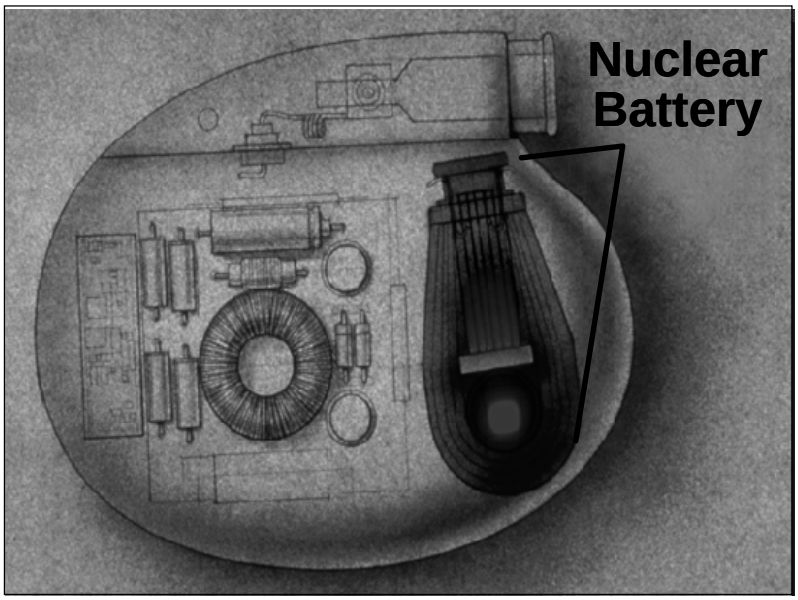
- Patient
- Lead
- Pacemaker
- Programmer

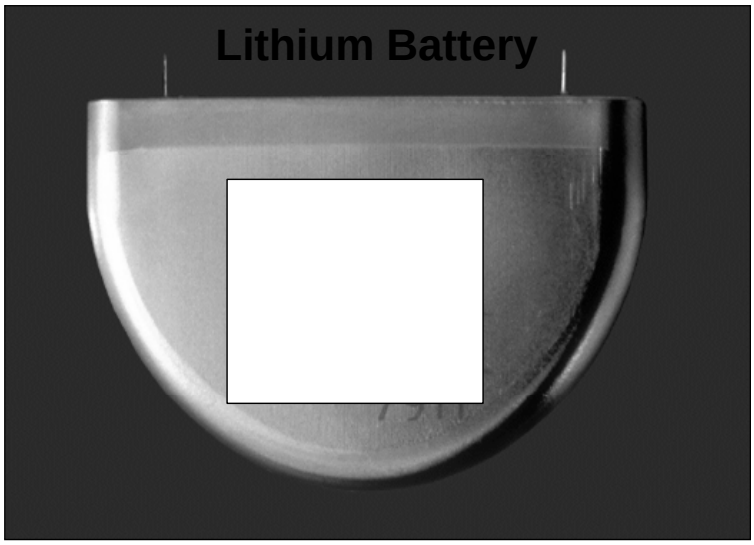





Pacemaker Implantation
Pacemaker
Leads

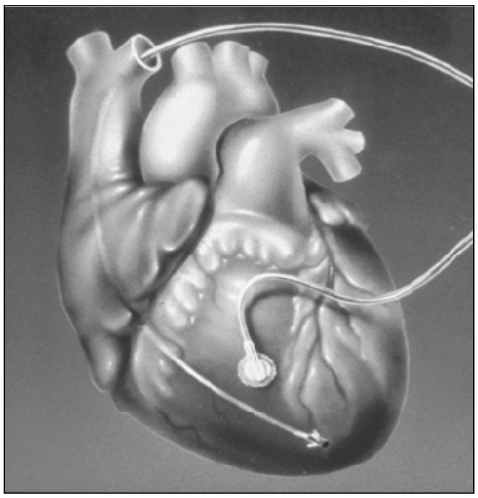


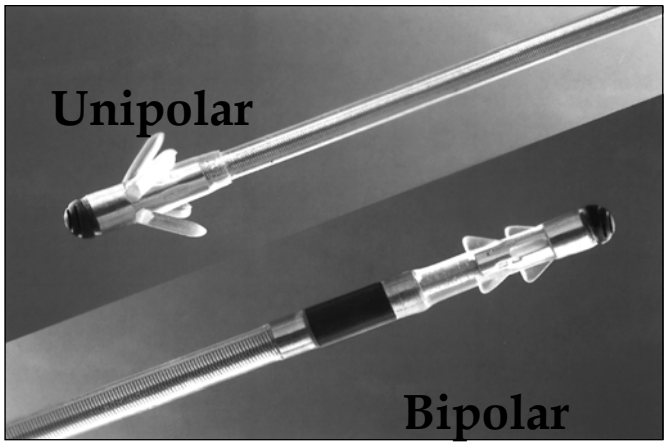

Nuclear
Battery



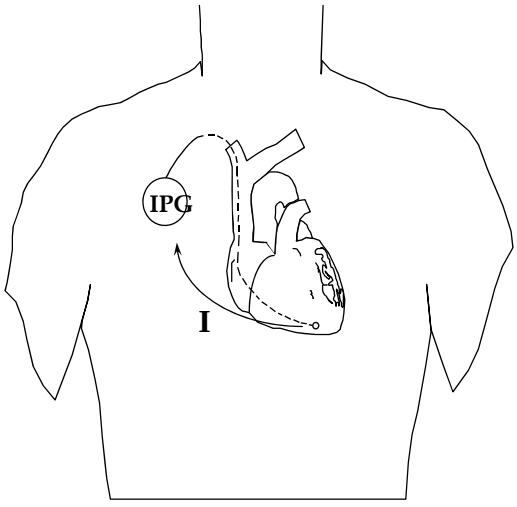
Leads

- **Endocardial**
- **Epicardial**

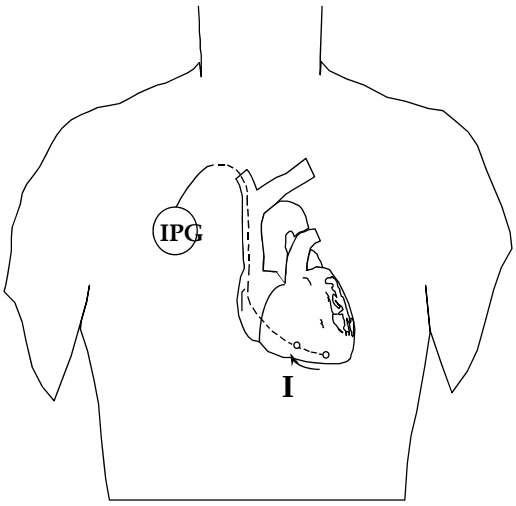




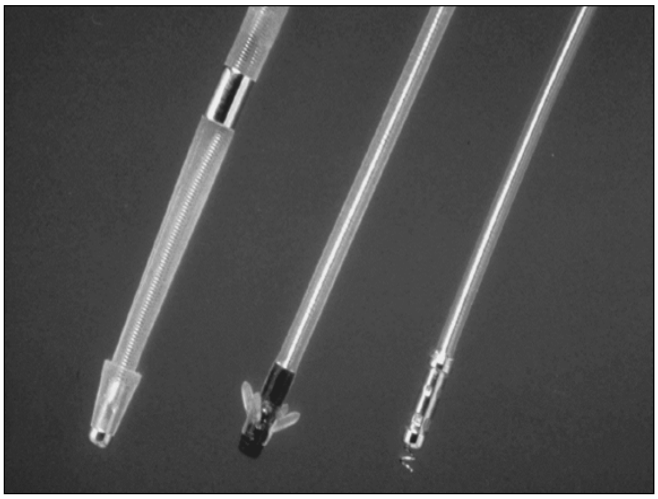
Unipolar



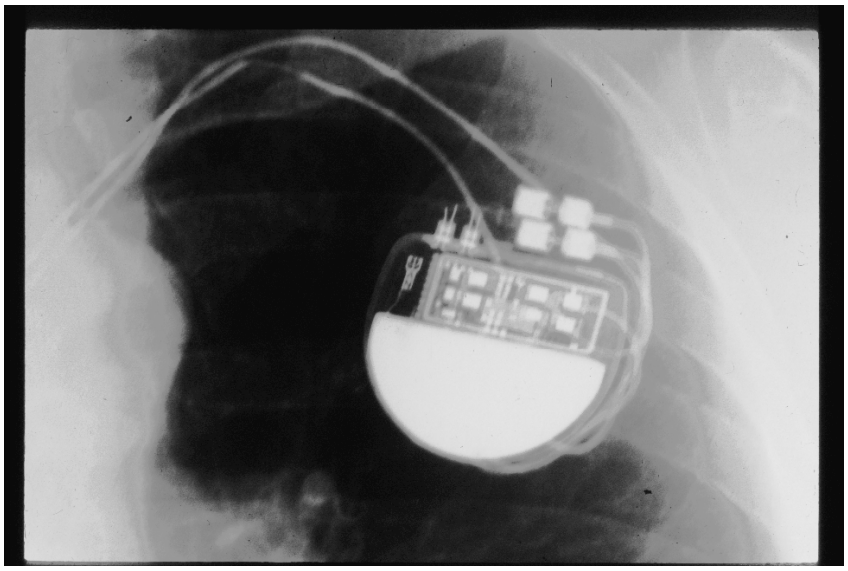
Bipolar Configuration



Fixation Mechanisms

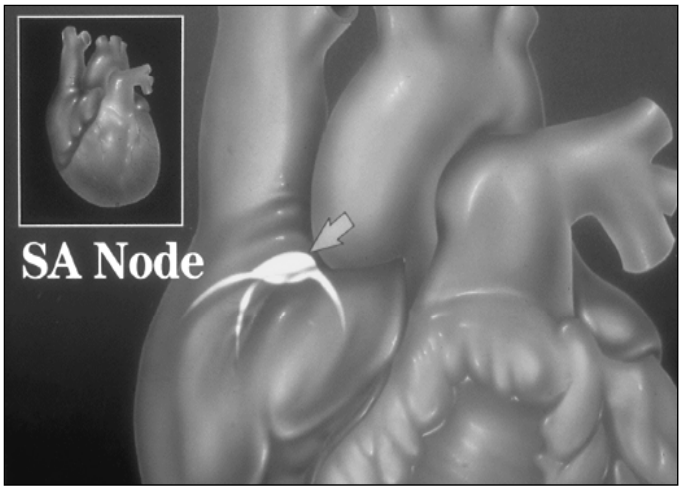


Leads; The Weak Link



Indications for Pacing

Indications for Pacing



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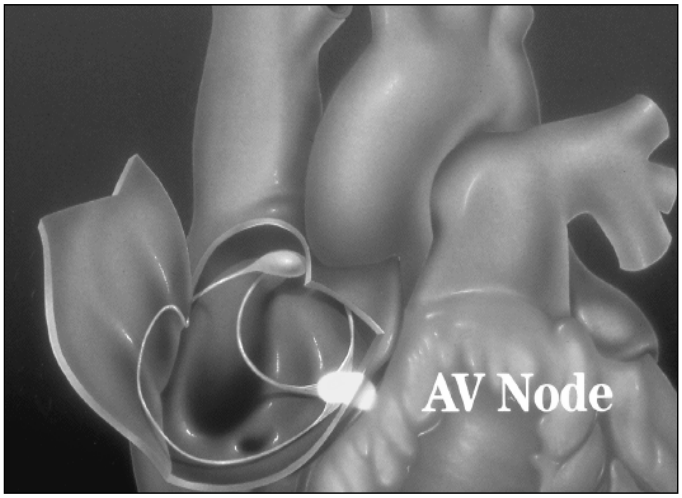

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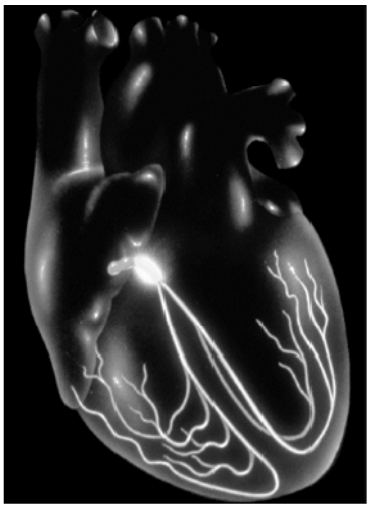


Bundle of His

Causes of Conduction Defects

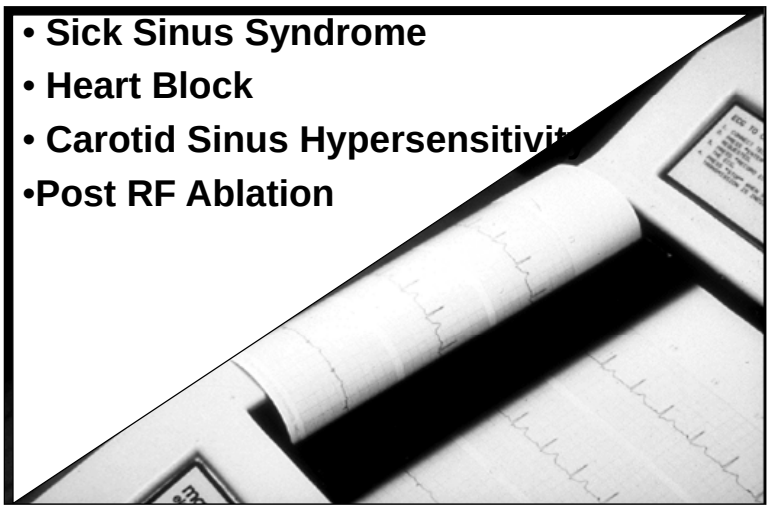
- **Coronary Artery Disease**
- **Idiopathic Degeneration**
- **Calcification**
- **Endocarditis**
- **Heart Surgery**
- **RF Ablation**

Indications for Pacing

Symptomatology + Documented Events = Reliable Indications for Pacing

Indications for Pacing

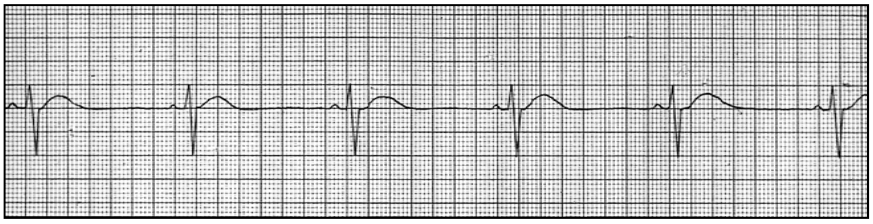
- **Sick Sinus Syndrome**
- **Heart Block**
- **Carotid Sinus Hypersensitivity**
- **Post RF Ablation**



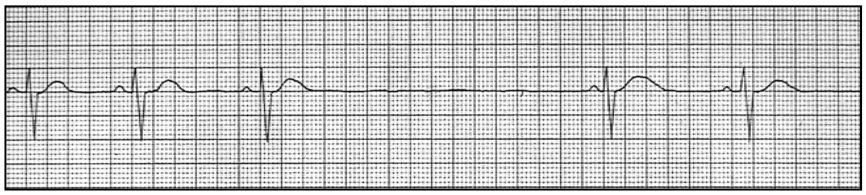
Sick Sinus Syndrome

- Sinus Bradycardia
- Sinus Arrest
- SA Exit Block
- Atrial Fibrillation with a Slow Ventricular Response
- Tachy-brady Syndrome

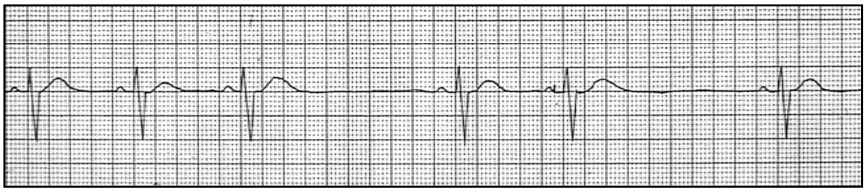
Sinus Bradycardia



Sinus Arrest and Sinoatrial Exit Block

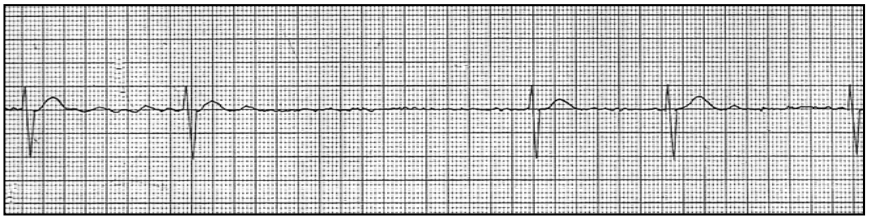


Sinus Arrest

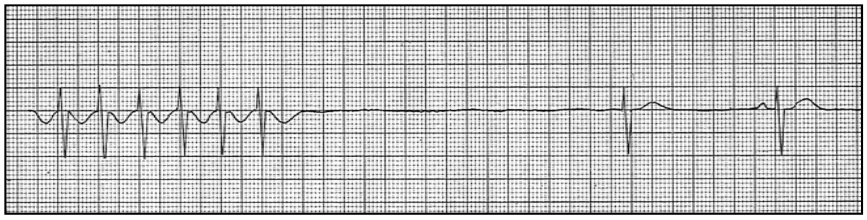


SA Exit Block

Atrial Fibrillation with Slow Ventricular Response



Tachycardia-Bradycardia Syndrome

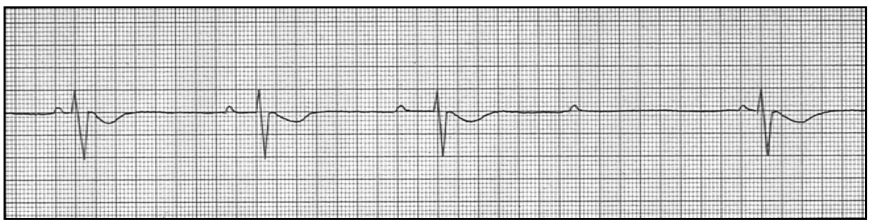


Indications for Pacing

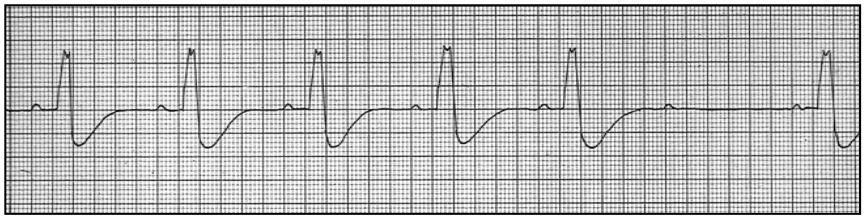
Second Degree A-V Block

- Mobitz Type I (Wenckebach)
- Mobitz Type II

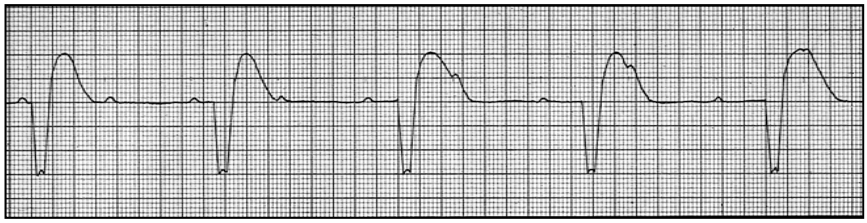
Second Degree A-V Block (Mobitz or Wenckebach)



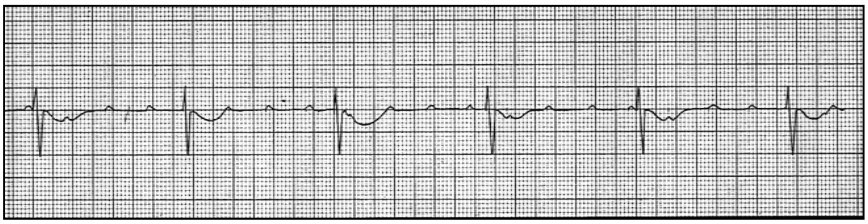
Mobitz Type II



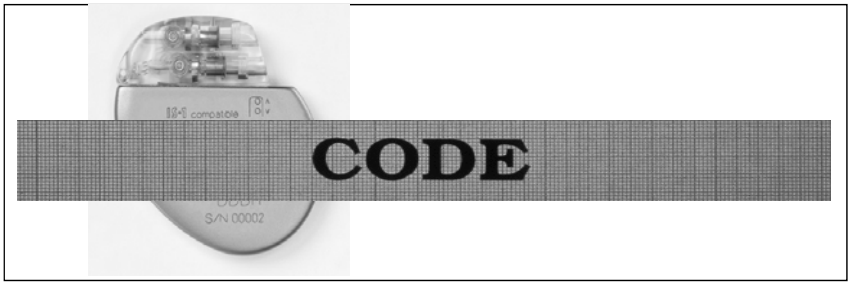
Third Degree A-V Block



Congenital Third Degree A-V Block



NASPE / BPEG (NBG) PACEMAKER CODE



The NASPE/BPEG Generic (NBG) Code

Position	I	II	III	IV	V
Category	Chamber(s) Paced	Chamber(s) Sensed	Response to Sensing		
Letters Used	O-None A-Atrium V-Ventricle D-Dual (A+V)	O-None A-Atrium V-Ventricle D-Dual (A+V)	O-None T-Triggered I-Inhibited D-Dual (T+I)		
Manufac-turer's Designation Only	S- Single (A or V)	S- Single (A or V)			

The NASPE/BPEG Generic (NBG) Code

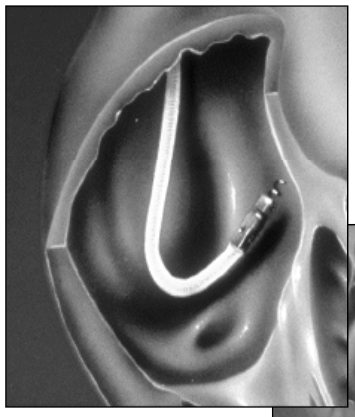
Position	I	II	III	I	V
Category	Chamber(s) Paced	Chamber(s) Sensed	Response to Sensing		
Letters Used	O-None A-Atrium V-Ventricle D-Dual (A+V)	O-None A-Atrium V-Ventricle D-Dual (A+V)	O-None T-Triggered I-Inhibited D-Dual (T+I)		
Manufac-turer's Designation Only	S- Single (A or V)	S- Single (A or V)			

The NASPE/BPEG Generic (NBG) Code

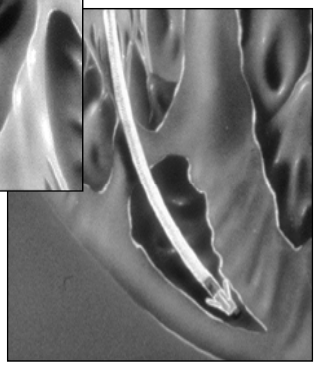
Position	I	II	III	IV	V
Category	Chamber(s) Paced	Chamber(s) Sensed	Response to Sensing		
Letters Used	O-None A-Atrium V-Ventricle D-Dual (A+V)	O-None A-Atrium V-Ventricle D-Dual (A+V)	O-None T-Triggered I-Inhibited D-Dual (T+I)		
Manufac-turer's Designation Only	S- Single (A or V)	S- Single (A or V)			

The NASPE/BPEG Generic (NBG) Code

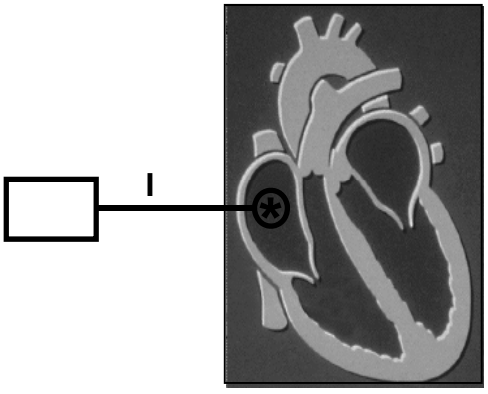
Position	I	II	III	IV	V
Category	Chamber(s) Paced	Chamber(s) Sensed	Response to Sensing	Rate Modulation	Multi Chamber Pacing
Letters Used	O-None A-Atrium V-Ventricle D-Dual (A+V)	O-None A-Atrium V-Ventricle D-Dual (A+V)	O-None T-Triggered I-Inhibited D-Dual (T+I)	O-None R-Rate modulation	O-None A-Atrium V-Ventricle D-Dual
Manufac-turer's Designation Only	S- Single (A or V)	S- Single (A or V)			



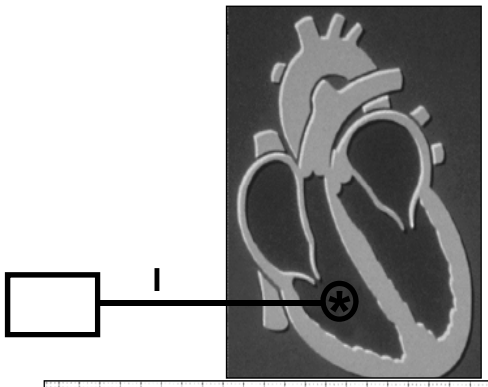
AOO
AAI
AAT



VOO
VVI
VVT



AAI

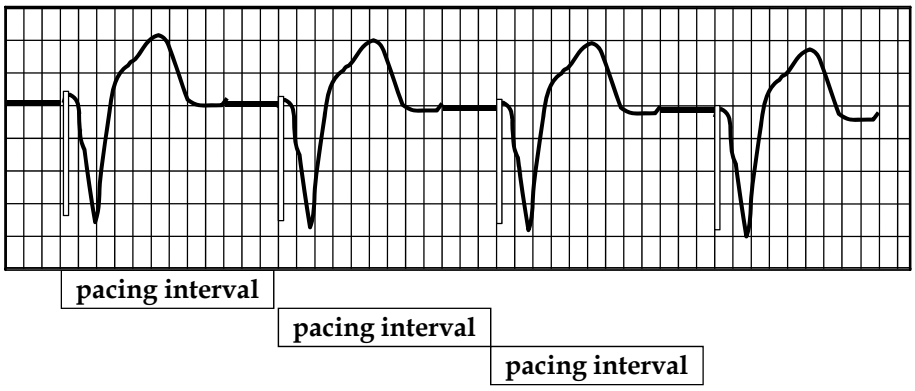


VVI

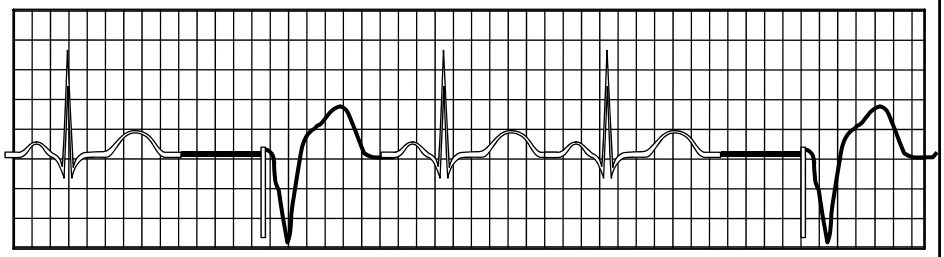
I

Ventricular Capture

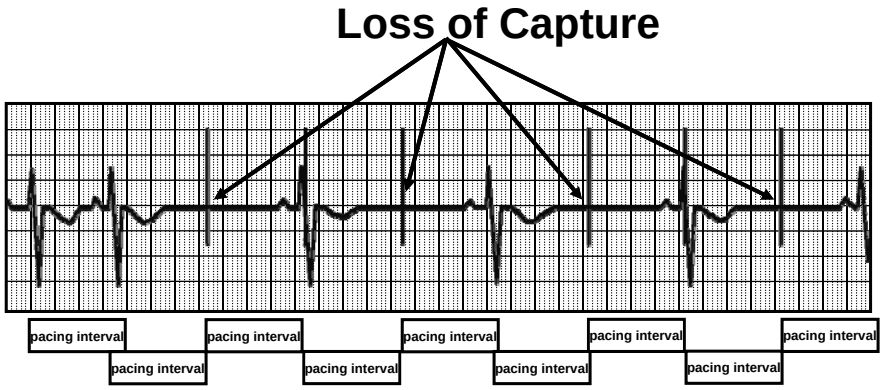
- **Paced Ventricular events re-start the pacing interval**



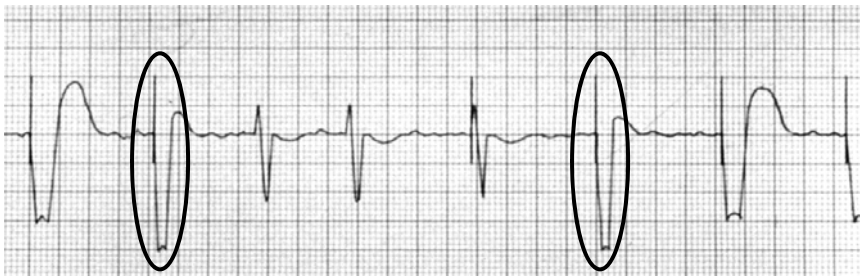
Ventricular Sensing / Inhibition



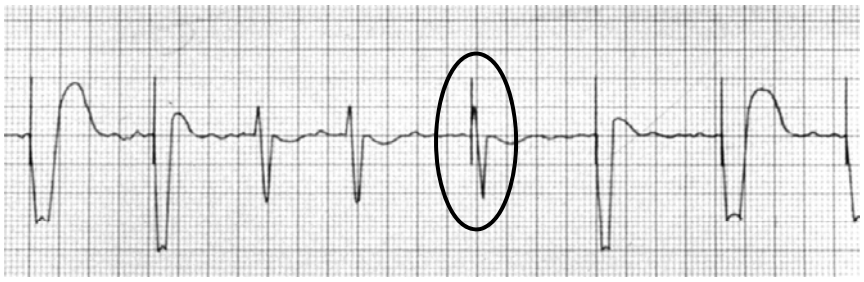
Ventricular Loss of Capture



Ventricular Fusion

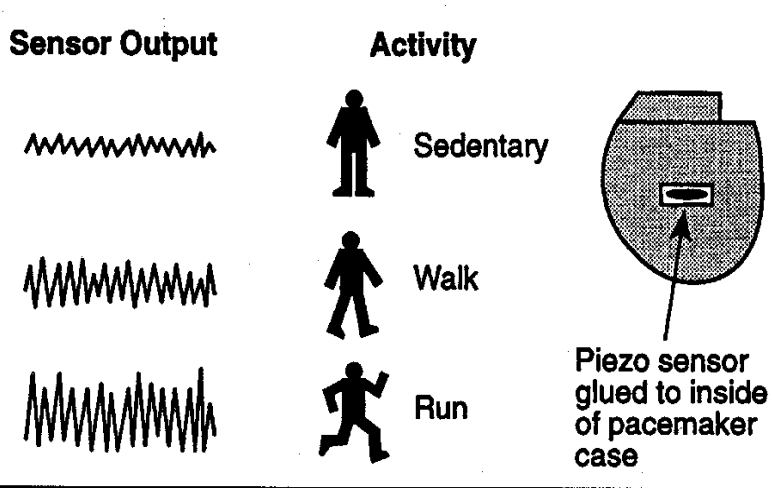


Ventricular Pseudofusion

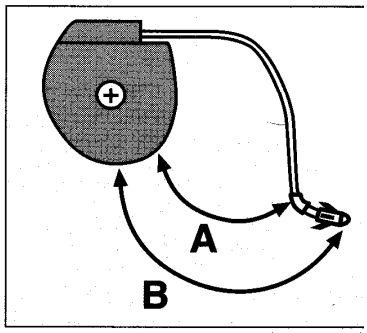


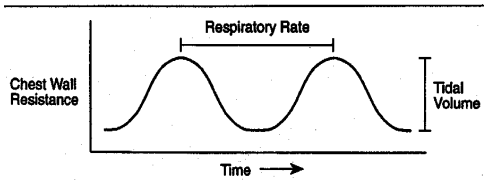
VVIR

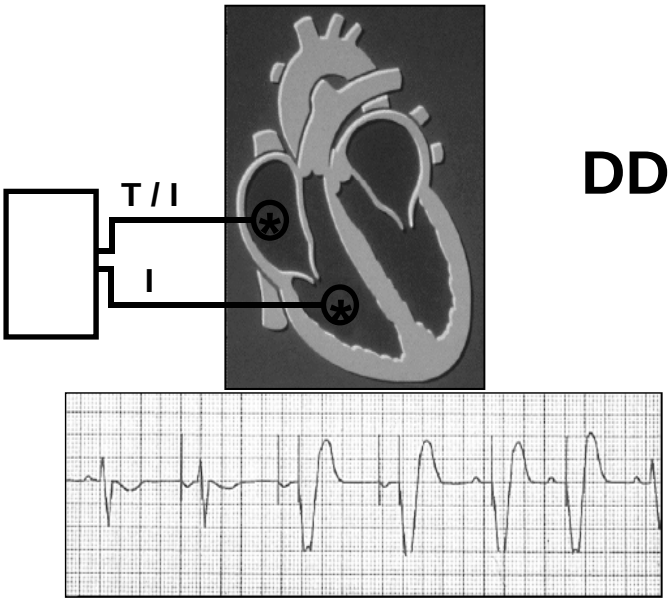
Activity Sensor



Minute Ventilation

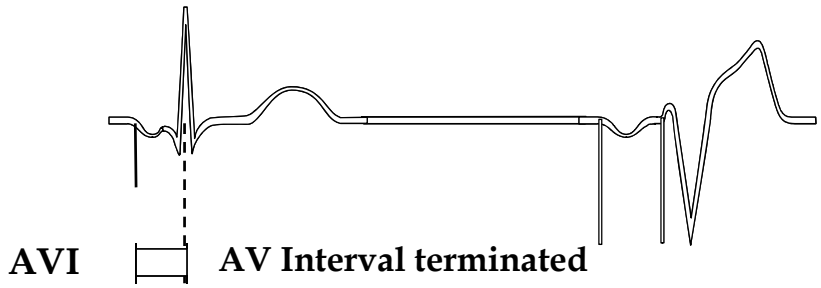




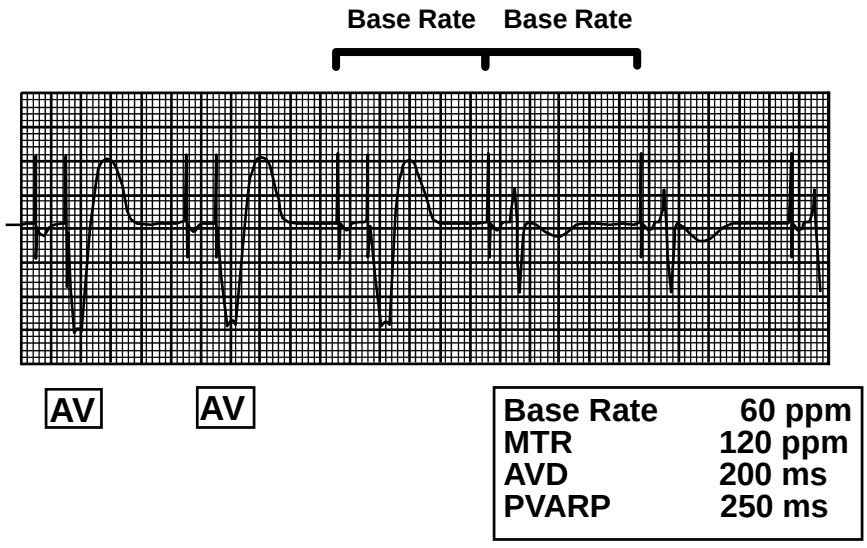


DDD

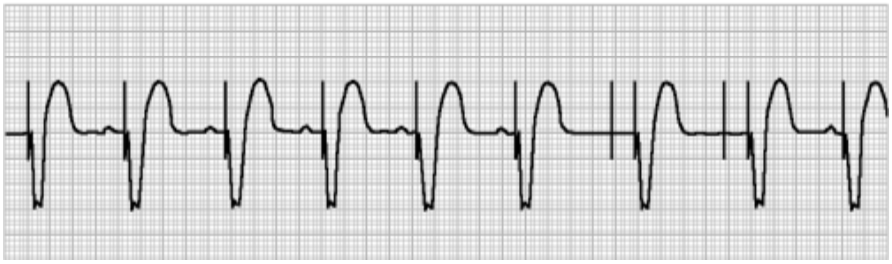
AV Delay



An intrinsic R-wave came from the patient so the AV Delay was terminated

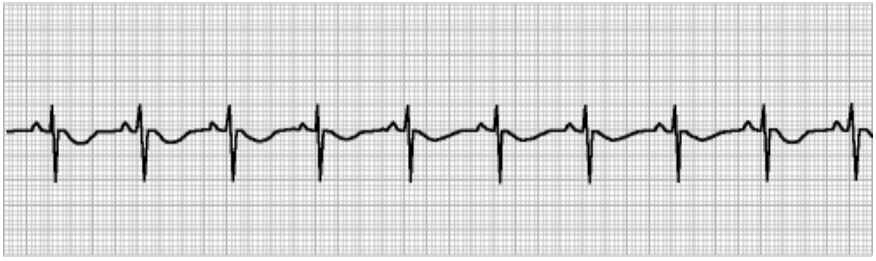


ECG # 2



Base Rate	**60 ppm**
MTR	**120 ppm**
AVD	**200 ms**
PVARP	**250 ms**

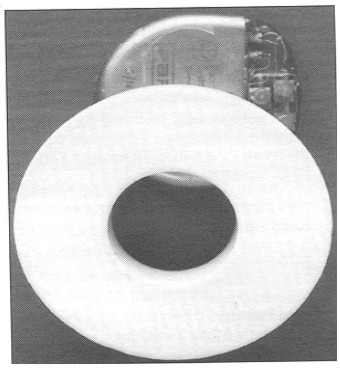
ECG # 3



Base Rate	**60 ppm**
MTR	**120 ppm**
AVD	**200 ms**
PVARP	**250 ms**

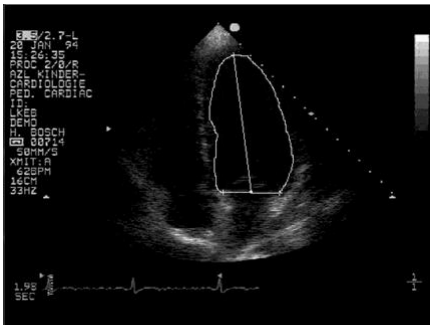
ECG # 16

Magnet Application



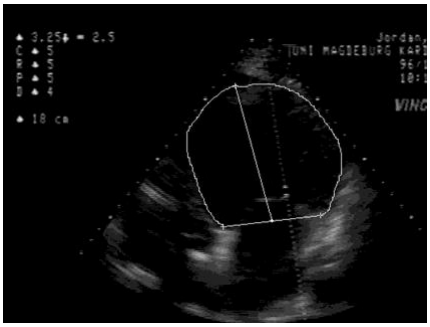
1) Pacemaker
2) ICD

Normal Ventricle



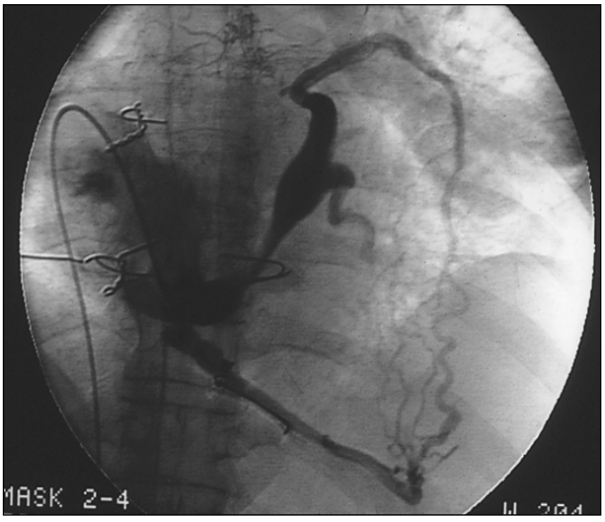
Courtesy of A. Auricchio, University of Magdeburg, Germany.

Dilated Cardiomyopathy with LBBB

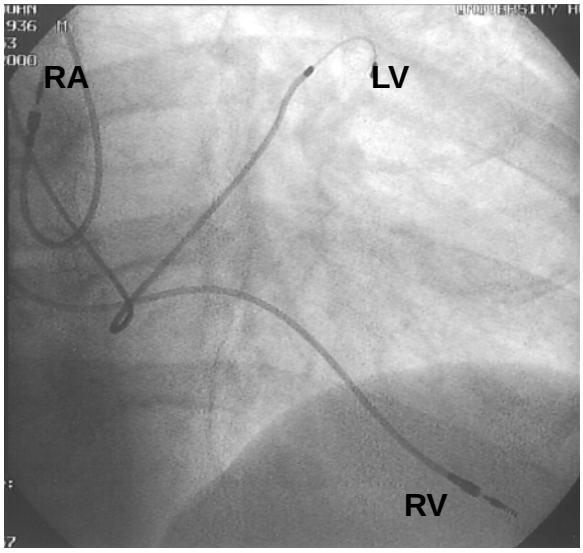


Courtesy of A. Auricchio, University of Magdeburg, Germany.

Coronary Sinus and Vein Anatomy



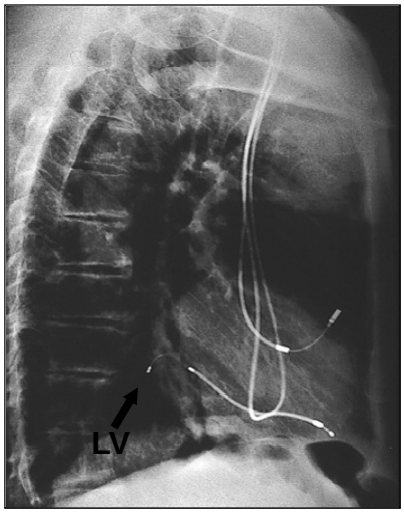
Placement of Leads for BiV Pacing

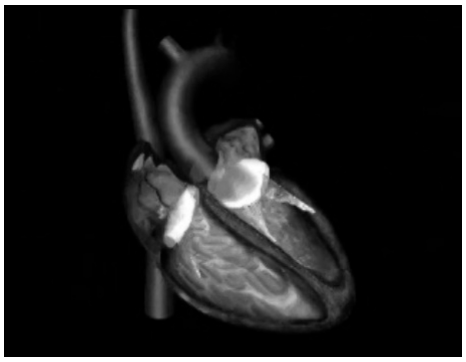


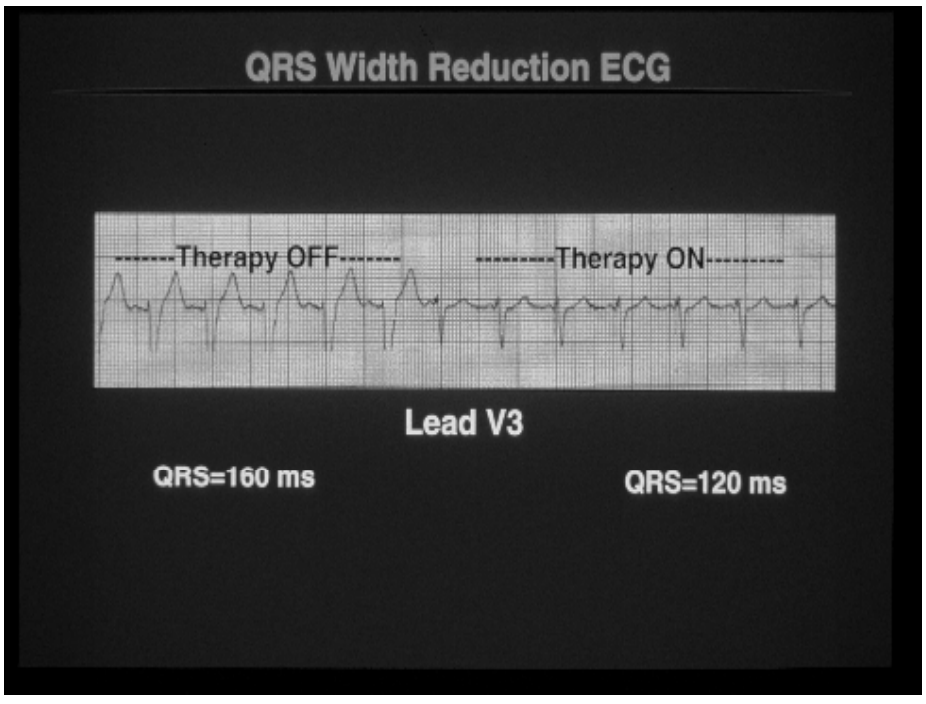
Left Ventricular Lead Placement

- **Chest x-ray, lateral view showing LV lead (Medtronic Attain LV model 2187) placed into a mid-lateral vein.**

Posterior

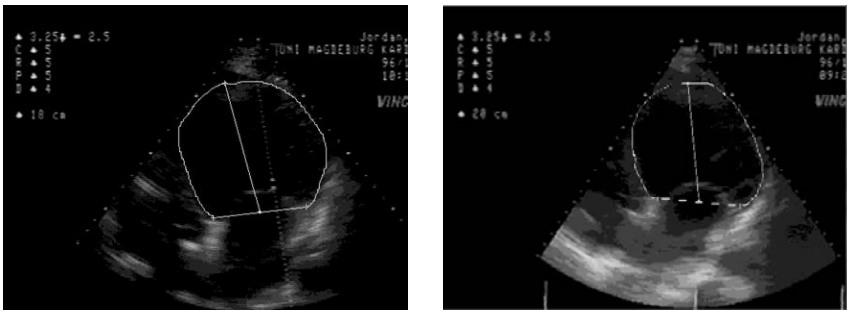





QRS Width Reduction ECG
--------Therapy OFF--------
---------Therapy ON---------
Lead V3
QRS=160 ms
QRS=120 ms

Resynchronization Therapy

Off **On**



Courtesy of A. Auricchio, University of Magdeburg, Germany.

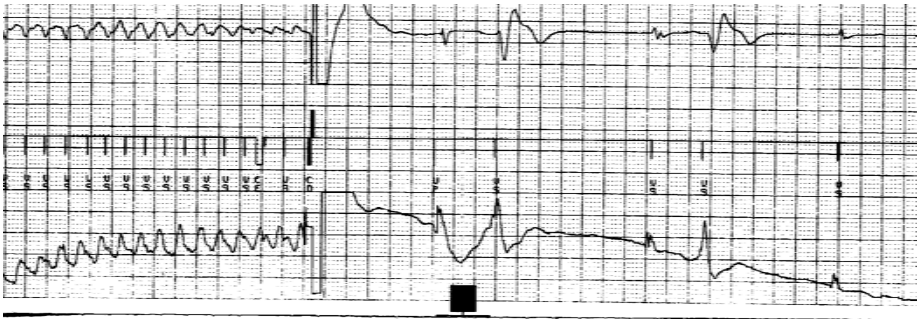
ICDs

- **Implantable Cardioverter Defibrillator**
  - **NOT AICD (this is a Trademarked brand name)**
- **Full pacemaker functionality**
- **Detects rapid ventricular rates**
- **Capable of delivering 800V at 20 amps**
  - **Peak output of 29-40 Joules**
    - **Can be lower output as skin in not in the way**

ICD Function

- Identifies fast ventricular rates
- May terminate the rhythm
  - Pacing pulses
  - Cardioversion
  - Defibrillation

ICD Function



CARDIOVERSION / DEFIBRILLATION

- Prior to any electrical procedure, device interaction must be analyzed
- Pacemaker interference is possible with cardioversion / defibrillation
- Paddles for cardioversion / defibrillation or electrocautery should be 4-6 inches away
- Paddles should be placed anterior / posterior if possible

EFFECTS OF ELECTROCAUTERY

- Reprogramming
- Permanent damage to the pulse generator
- Inhibition of the pulse generator
- Reversion to a fall-back*, noise reversion mode, or electrical reset. (*The characteristics of the fall-back mode should be know so that its presence is not confused with malfunction or end-of-service)
- Myocardial thermal damage secondary to transmission of electrical discharge to the heart via the lead (resulting in myocardial infarction or ventricular fibrillation or both)

MAGNETIC RESONANCE IMAGING (MRI)

- Generally contraindicated
- Asynchronous pacing
- Rapid pacing
- If absolutely necessary in the non-pacemaker dependent patient ONE should:
  - decrease output to non-capture
  - program OFF

LITHOTRIPSY

Guidelines for Lithotripsy in Paced Patients

- Program the pacemaker to the VVI or VOO mode
- Keep the focal point of the lithotriptor no closer than six inches from the pacemaker
- Cardiac monitoring throughout the procedure

THERAPEUTIC RADIATION

- Diagnostic / Therapeutic
- CMOS circuitry
- Cumulative effect
- Recommendations
  - shielding / repositioning device

CMOS CIRCUITS

- Damage may result with doses as low as 500 RADS
- In a typical pacemaker 5000 - 10,000 transistors are simultaneously under attack and potentially subject to failure

ADDITIONAL EMI SOURCES

Other Electromagnetic Sources

- **Microwaves**
- **Arc welding**
- **Automobile alternators**
- **Cellular phones**
- **Phantom Reprogramming**

CELLULAR PHONES

- **Analog vs. digital**
- **Potential interference can be minimized by avoiding direct contact of the antenna and the pulse generator**
- **May cause inappropriate inhibition, asynchronous pacing, safety pacing, inappropriate rate adaptation, and mode switching**

CELLULAR PHONES

Recommendations

- **Patients should avoid carrying their activated phone in a breast or shirt pocket that is overlaying the pacemaker**
- **Avoid placing the antenna in close proximity to the pulse generator**
- **Pacemaker dependent patients should discuss usage with their physician**

General Device Questions:

- **Can a patient use a microwave oven?**
  - **As long as the device is not placed in the oven, it is OK**
    - **We recommend starting the oven and taking a step or two away from it**

General Device Questions:

- **Can a patient go through airport security?**
  - **Procedures for this vary from airport to airport. We suggest that the patient identify themselves as a pacemaker or defibrillator patient, and present their device ID card. They are usually walked around the security gate and given a hand search.**

General Device Questions:

- **Can a patient walk through electronic article surveillance gates at the store?**
  - **Yes, but the rule is "Walk, don't linger".**
  - **Leaning on the gate, or staying in the scanning area may result in interference with proper device function until the patient moves out of the gate.**

General Device Questions:

- **Can a patient with an ICD drive a car?**
  - **Assuming they have a license, yes. This assumes that the patient has not had syncope or significant pre-syncope in the past 6 months. If an event compromising consciousness has occurred, the 6 month clock starts over.**

General Device Questions:

- **A patient with an ICD is going to have an operation. What needs to be done with the device?**
  - **The risk to the patient should be assessed by the physician who follows the device. The major risk is that the use of unipolar electrocautery will be oversensed by the ICD, interpreted as VF, and result in a shock being delivered.**