Review of Pacemakers and ICD Therapy: Overview and Patient Management

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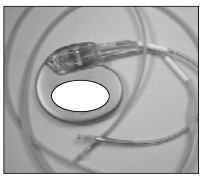
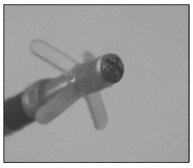
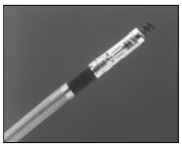
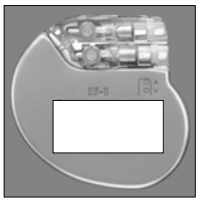
Director, Cardiac Rhythm Device Services
OSU Division of Cardiovascular Disease
President, International Board of Heart Rhythm Examiners
Ohio State University Medical Center

Pacing Systems

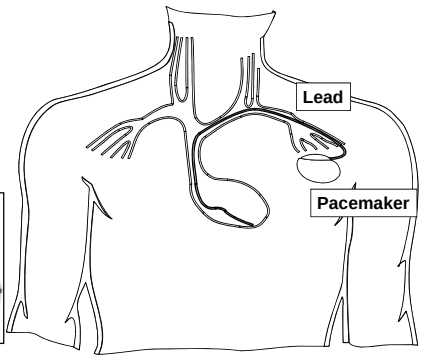





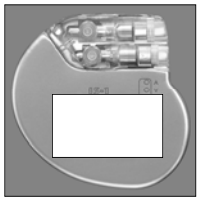
Disclosures

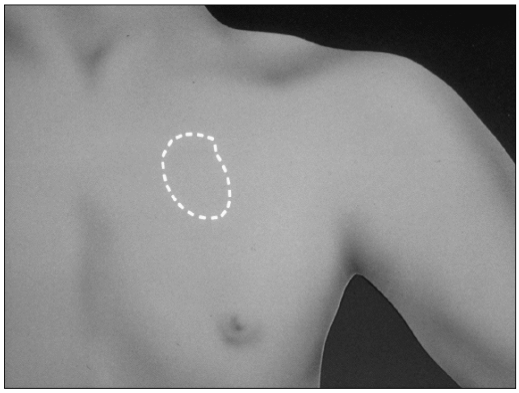
- **Consultant, Research Support, Honoraria**
  - **Boston Scientific**
  - **Cook Medical**
  - **Deringer-Ney**
  - **LeadExx**
  - **Medtronic**
  - **Spectranetics**
  - **St. Jude Medical**
  - **W.L. Gore**
- **Legal Consultant/Expert Witness**

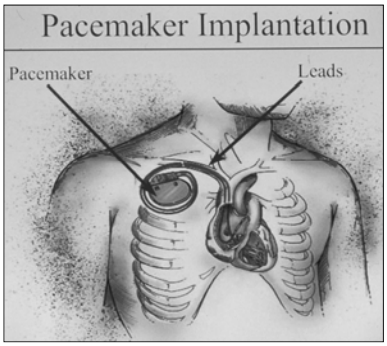
The Pacemaker System

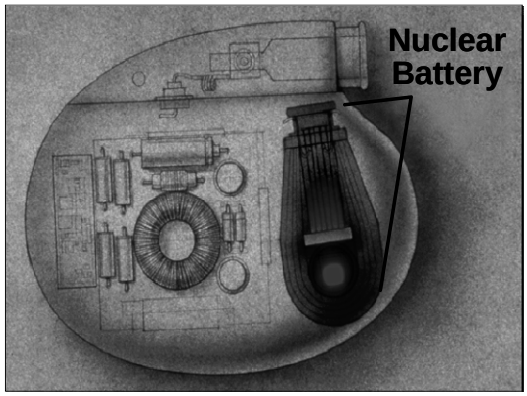
- **Patient**
- **Lead**
- **Pacemaker**
- **Programmer**

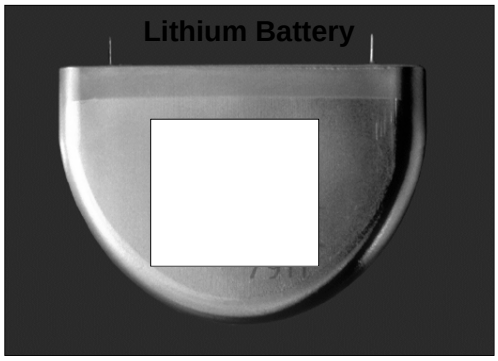



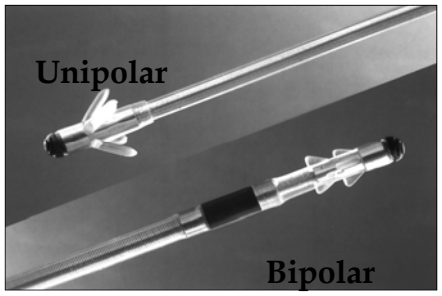





Pacemaker Implantation
Pacemaker
Leads

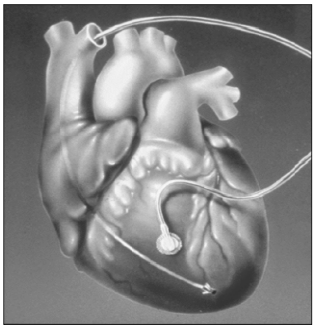

Nuclear
Battery



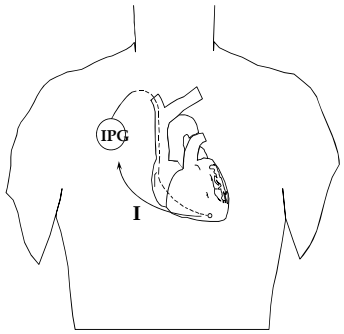


Leads

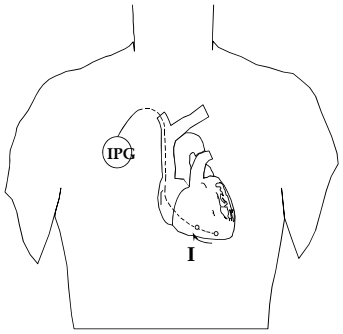
- Endocardial
- Epicardial



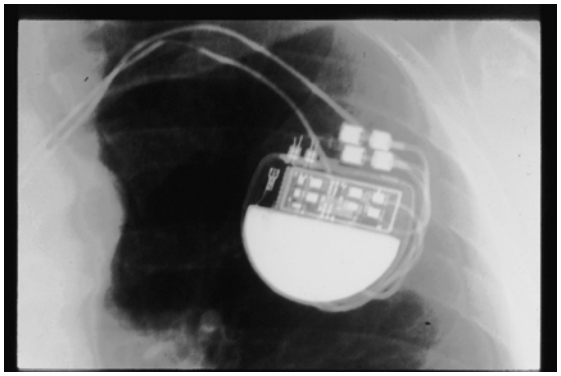
Unipolar



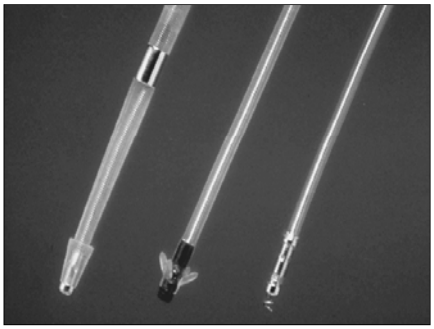
Bipolar Configuration



Leads; The Weak Link

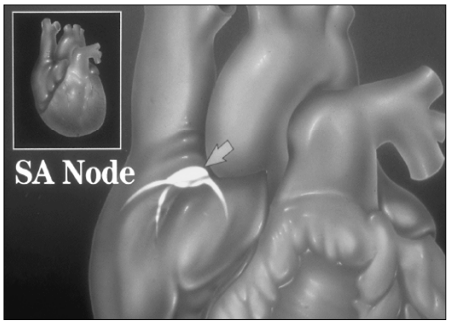


Fixation Mechanisms



Indications for Pacing

Indications for Pacing



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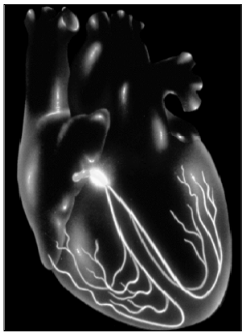
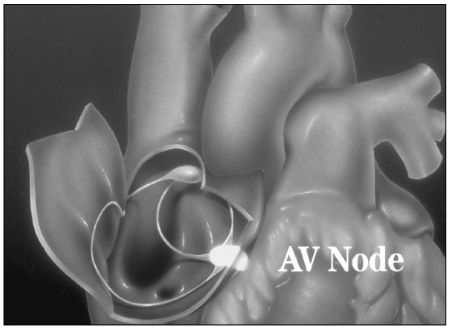


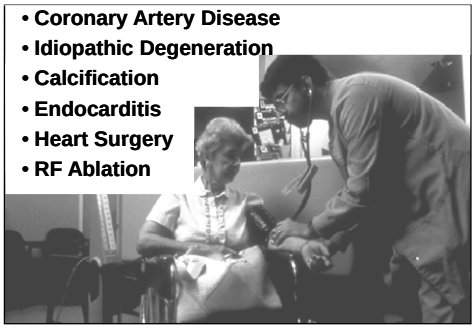
Bundle of His

Indications for Pacing



Causes of Conduction Defects

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



Indications for Pacing

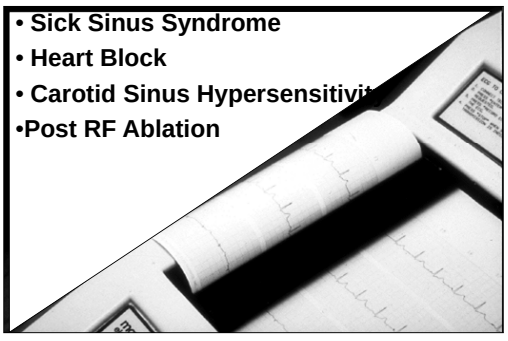
Symptomatology + Documented Events = Reliable Indications for Pacing

Sick Sinus Syndrome

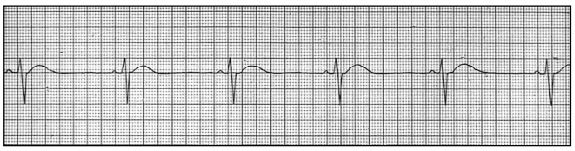
- **Sinus Bradycardia**
- **Sinus Arrest**
- **SA Exit Block**
- **Atrial Fibrillation with a Slow Ventricular Response**
- **Tachy-brady Syndrome**

Indications for Pacing

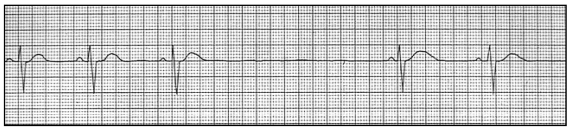
- **Sick Sinus Syndrome**
- **Heart Block**
- **Carotid Sinus Hypersensitivity**
- **Post RF Ablation**



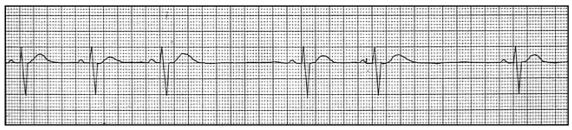
Sinus Bradycardia



Sinus Arrest and Sinoatrial Exit Block

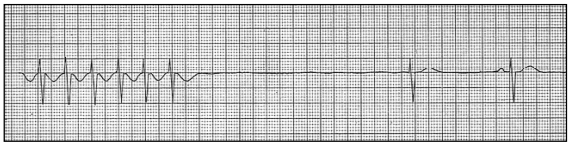


Sinus Arrest

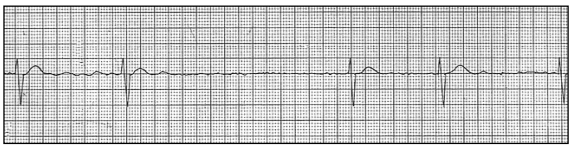


SA Exit Block

Tachycardia-Bradycardia Syndrome



Atrial Fibrillation with Slow Ventricular Response

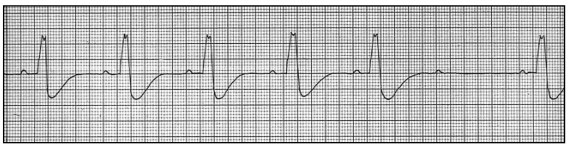


Indications for Pacing

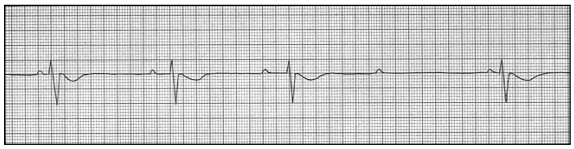
Second Degree A-V Block

- Mobitz Type I (Wenckebach)
- Mobitz Type II

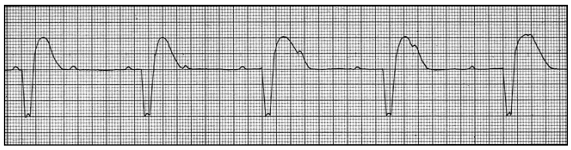
Mobitz Type II



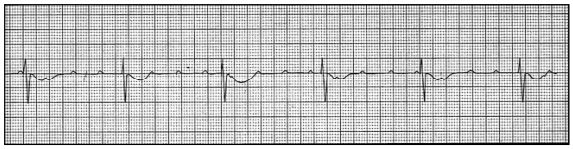
Second Degree A-V Block (Mobitz or Wenckebach)



Third Degree A-V Block

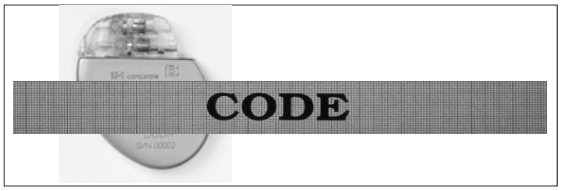


Congenital Third Degree A-V Block



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)			

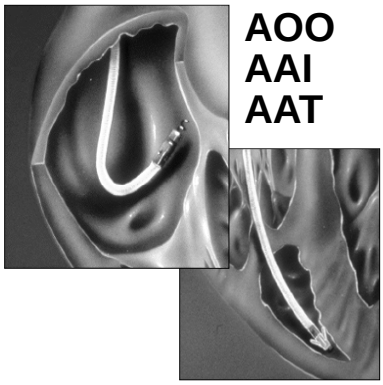
NASPE / BPEG (NBG) PACEMAKER CODE



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)			

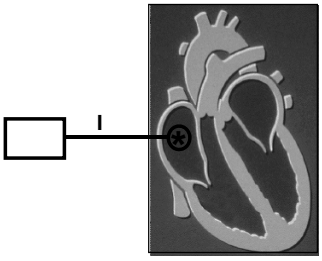


AOO
AAI
AAT

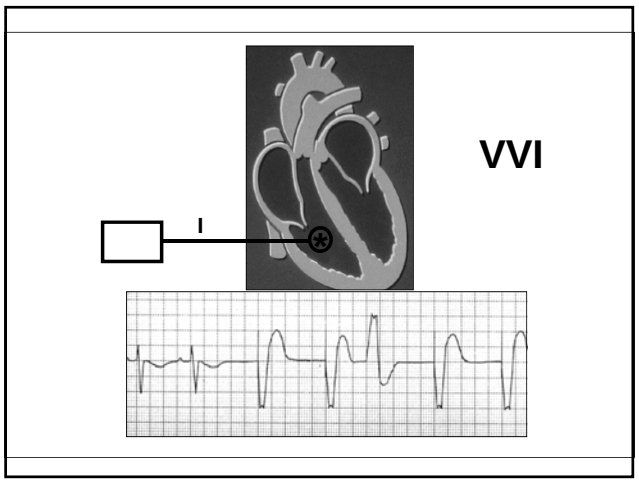
VOO
VVI
VVT

The NASPE/BPEG Generic (NBG) Code

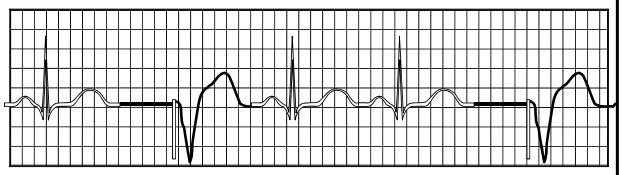
Position	I	II	III	IV	V
Category	Chamber(s) Paced	Chamber(s) Sensed	Response to Sensing	Rate Modulation	Multi Chamber Pacing
Letters Used	O-None A-Atrium V-Ventricle D-Dual (A+V)	O-None A-Atrium V-Ventricle D-Dual (A+V)	O-None T-Triggered I-Inhibited D-Dual (T+I)	O-None R-Rate modulation	O-None A-Atrium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



AAI

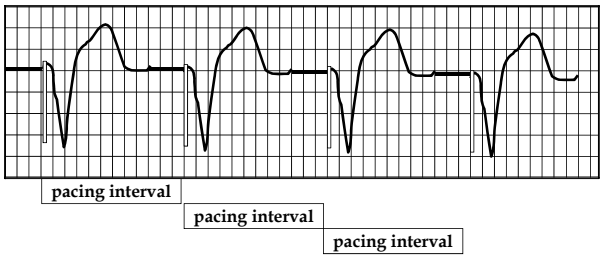


Ventricular Sensing / Inhibition

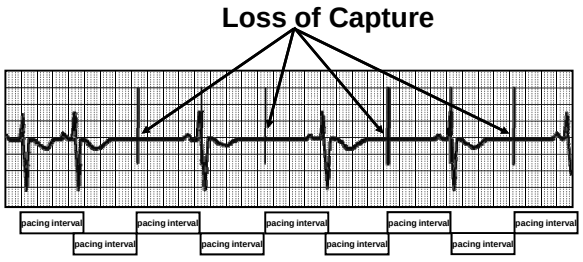


Ventricular Capture

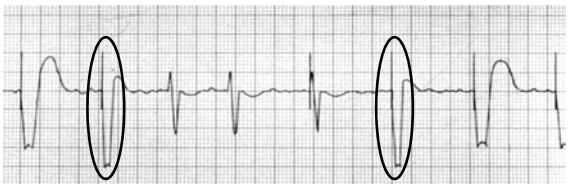
- **Paced Ventricular events re-start the pacing interval**



Ventricular Loss of Capture

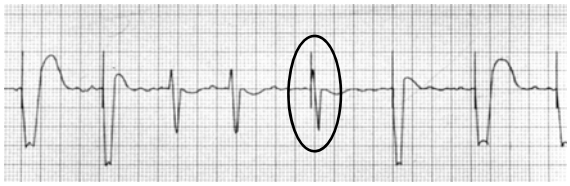


Ventricular Fusion

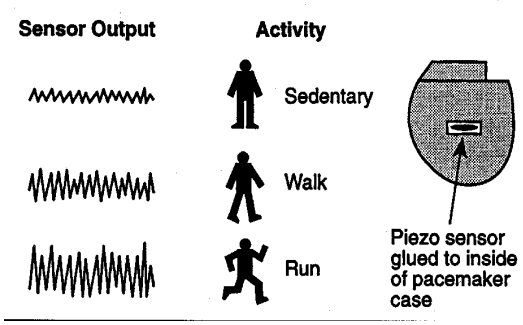


VVIR

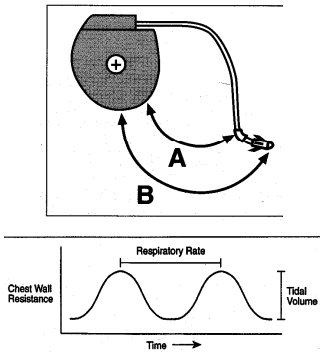
Ventricular Pseudofusion



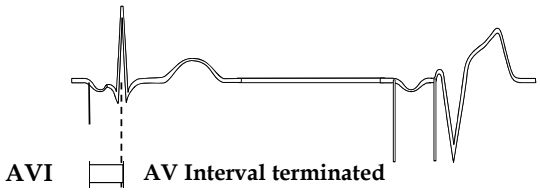
Activity Sensor



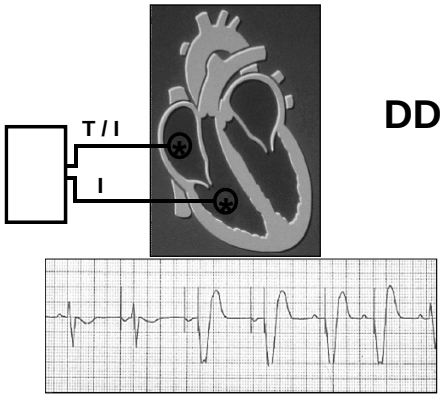
Minute Ventilation



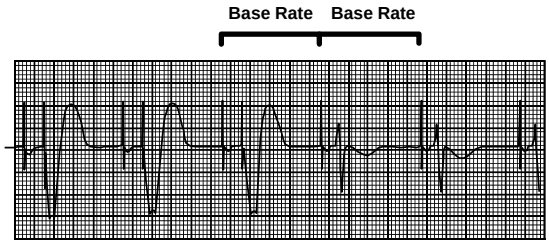
AV Delay



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

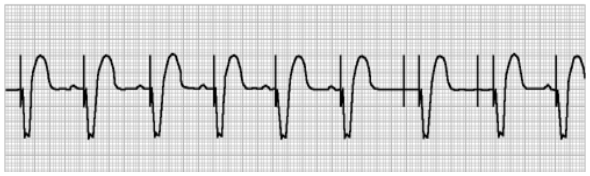


DDD



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

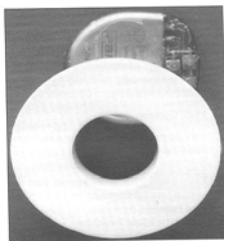
ECG # 2



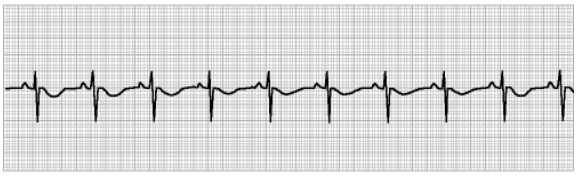
Base Rate	60 ppm
MTR	120 ppm
AVD	200 ms
PVARP	250 ms

ECG # 3

Magnet Application



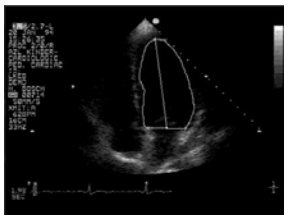
1) Pacemaker
2) ICD



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

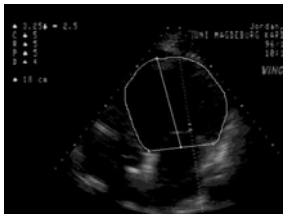
ECG # 16

Normal Ventricle



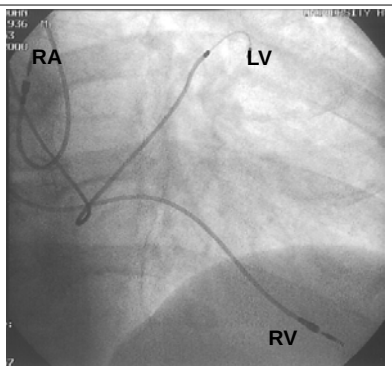
Courtesy of A. Auricchio, University of Magdeburg, Germany.

Dilated Cardiomyopathy with LBBB

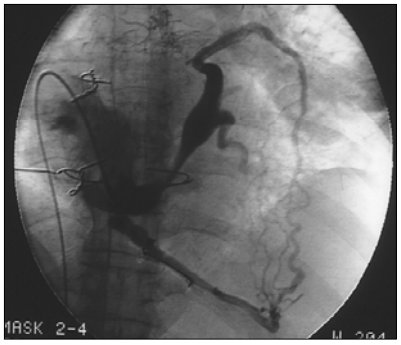


Courtesy of A. Auricchio, University of Magdeburg, Germany.

Placement of Leads for BiV Pacing



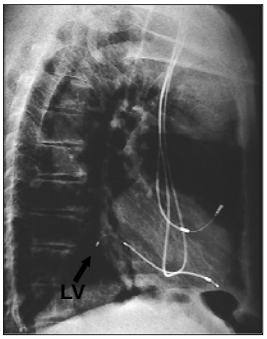
Coronary Sinus and Vein Anatomy

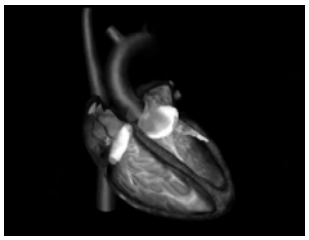


Left Ventricular Lead Placement

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

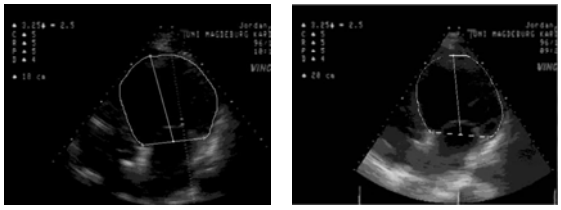
Posterior



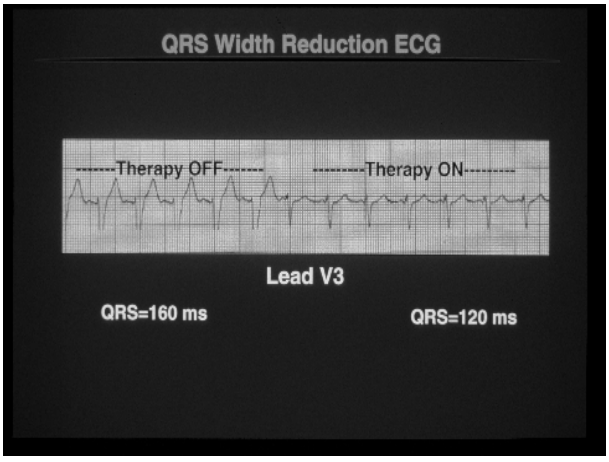


Resynchronization Therapy

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**

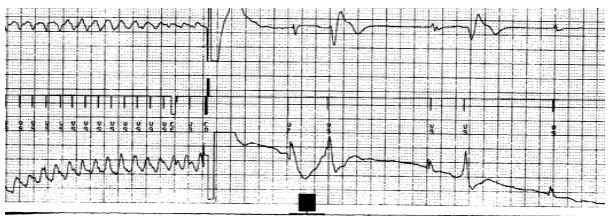
ICD Function

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

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

ICD Function



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

THERAPEUTIC RADIATION

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

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

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

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**

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**

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 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:

- 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:

- 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.