Lisa Lewis
Medtronic Senior Clinical Specialist

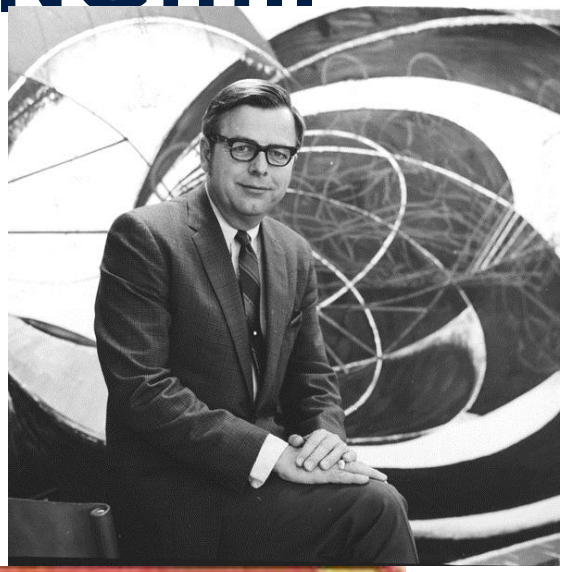
BASIC PACEMAKER REVIEW

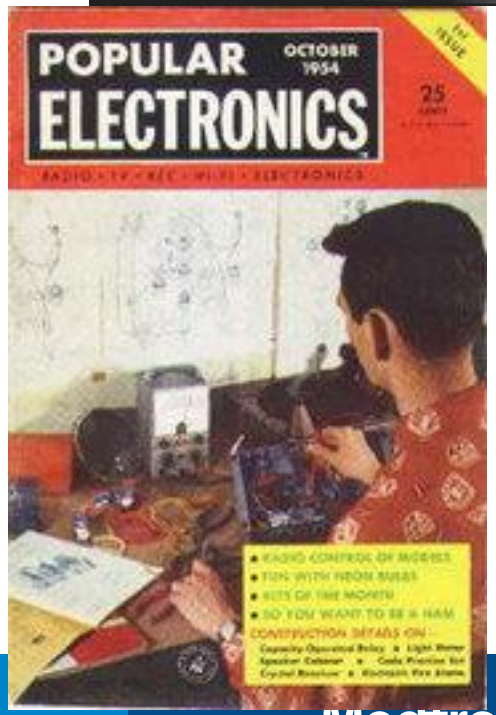
1957 IT WAS A DARK AND STORMY HALLOWEEN NIGHT AT THE UNIVERSITY OF MINNESOTA....

A DOCTOR'S DESIRE TO OVERCOME POWER OUTAGES

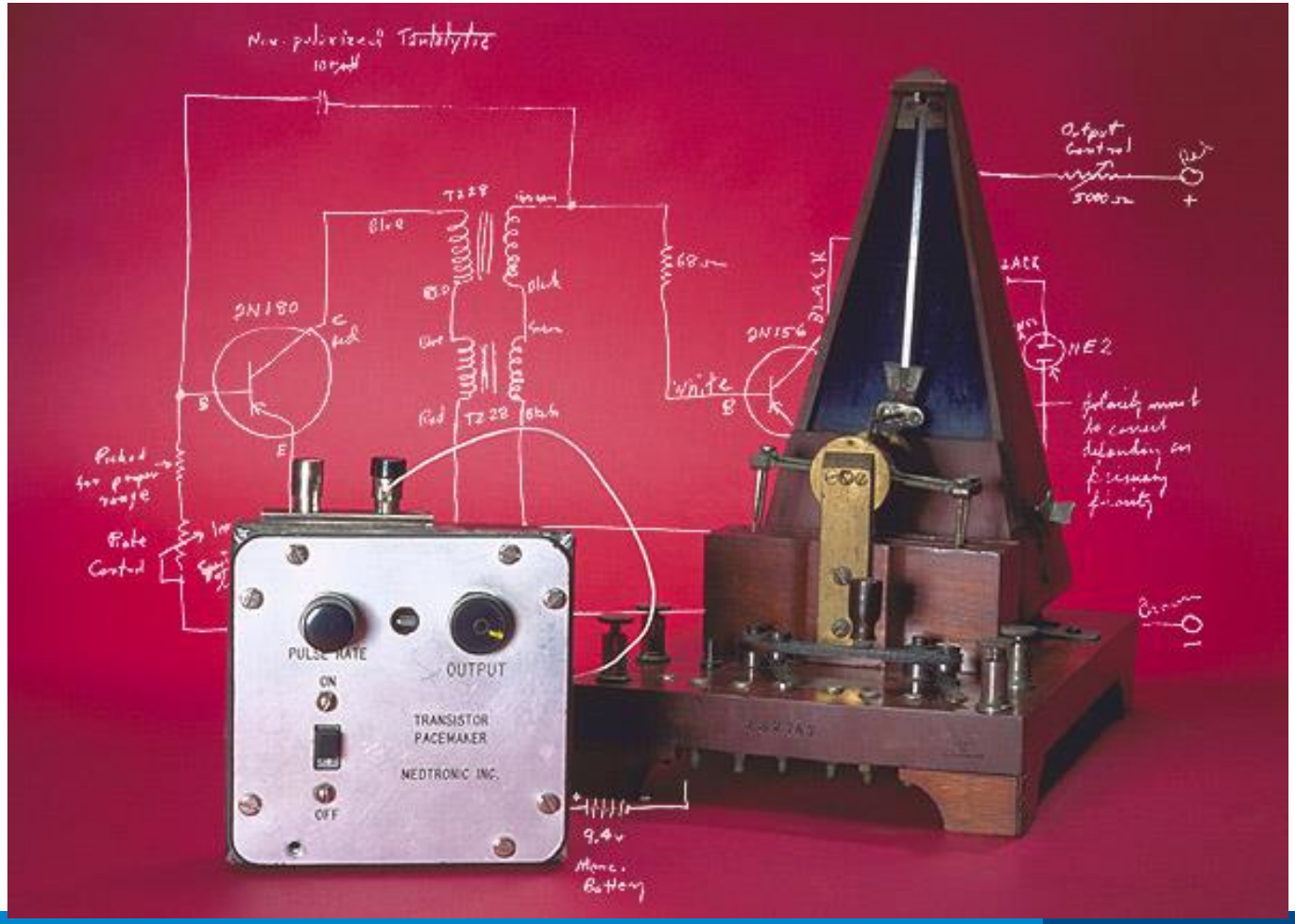
Medtronic

COMBINE THE FOLLOWING…..



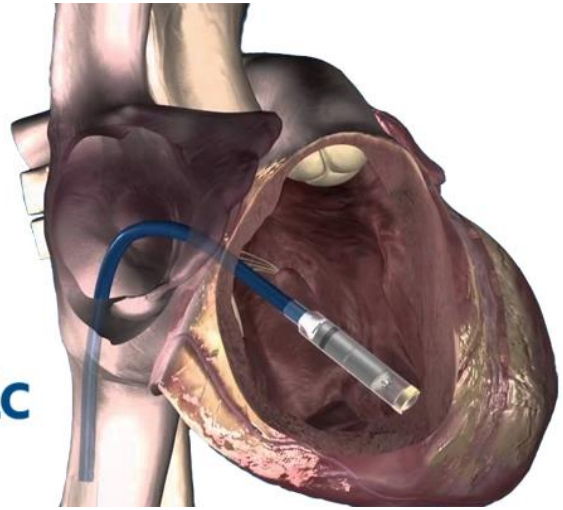


FIRST BATTERY EXTERNAL PACEMAKER



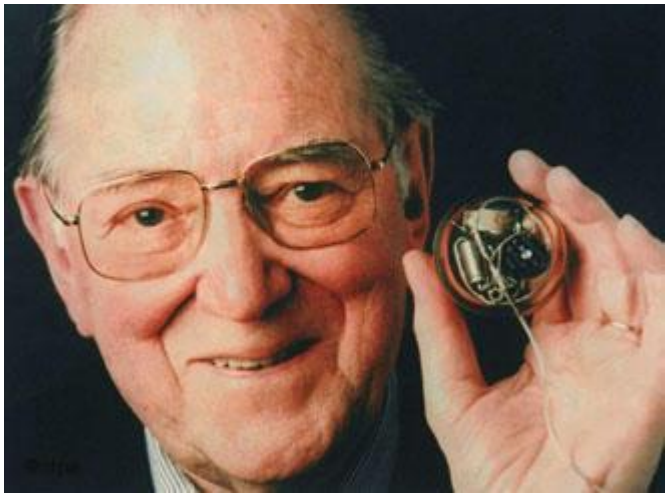
NEXT GENERATION OF PACEMAKER

- Leadless Pacemaker
- Implanted directly in the heart



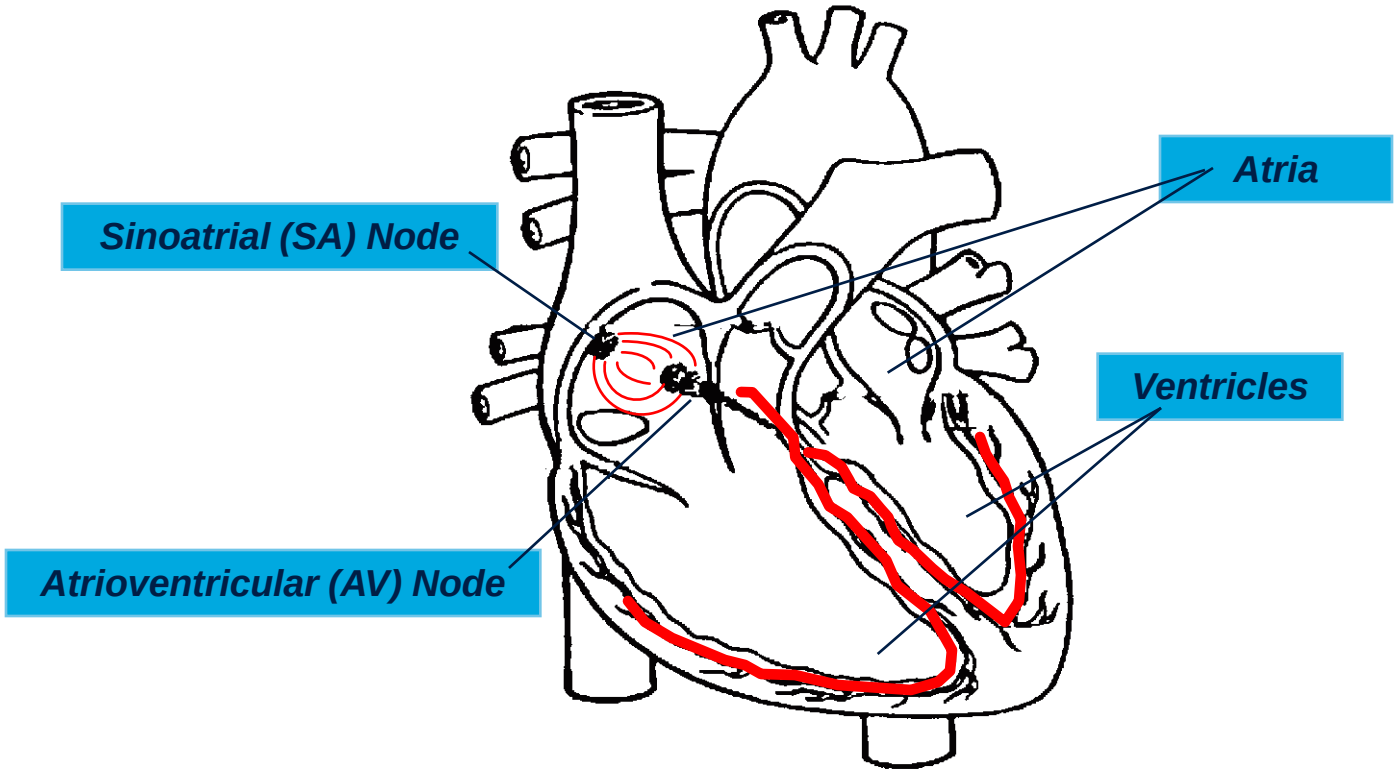
ARNE LARSON
FIRST INTERNAL RECIPIENT

- Received first implanted pacemaker in 1958
- 25 devices
- Died at the age of 86 in 2002
- Outlived his surgeons



Indications for a Pacemaker

DURING CONDUCTION, AN IMPULSE BEGINS IN THE SINOATRIAL (SA) NODE AND CAUSES THE ATRIA TO CONTRACT

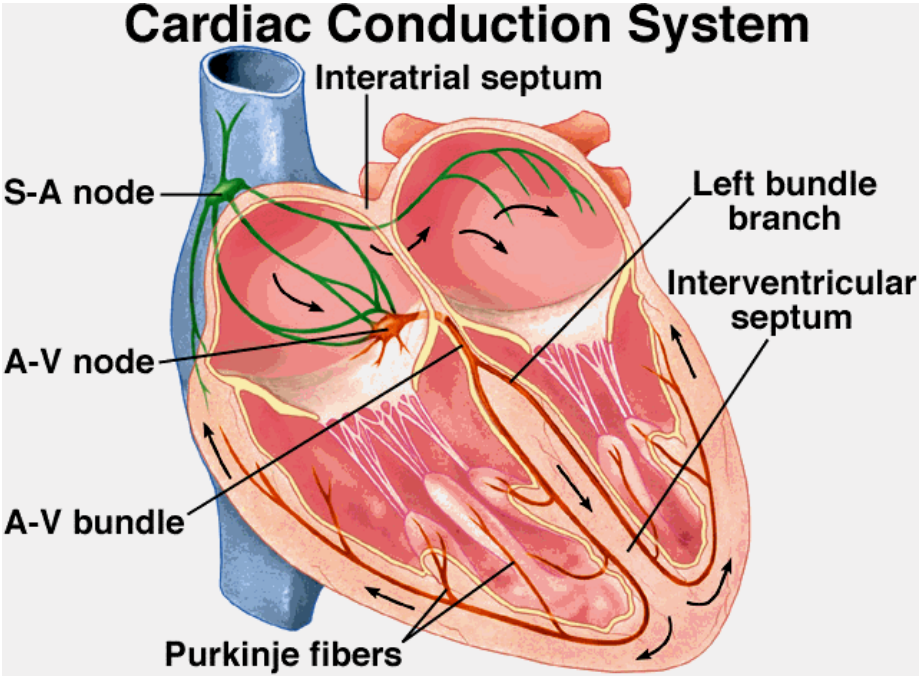


DISEASE STATES

- Pacemakers

- **SA Node**
  - Controls the rate of the heart
  - Dysfunction is called Sinus Node dysfunction or Sick Sinus Syndrome (SSS)
- **AV Node**
  - Controls AV synchrony
  - Dysfunction with AV node is called heart block

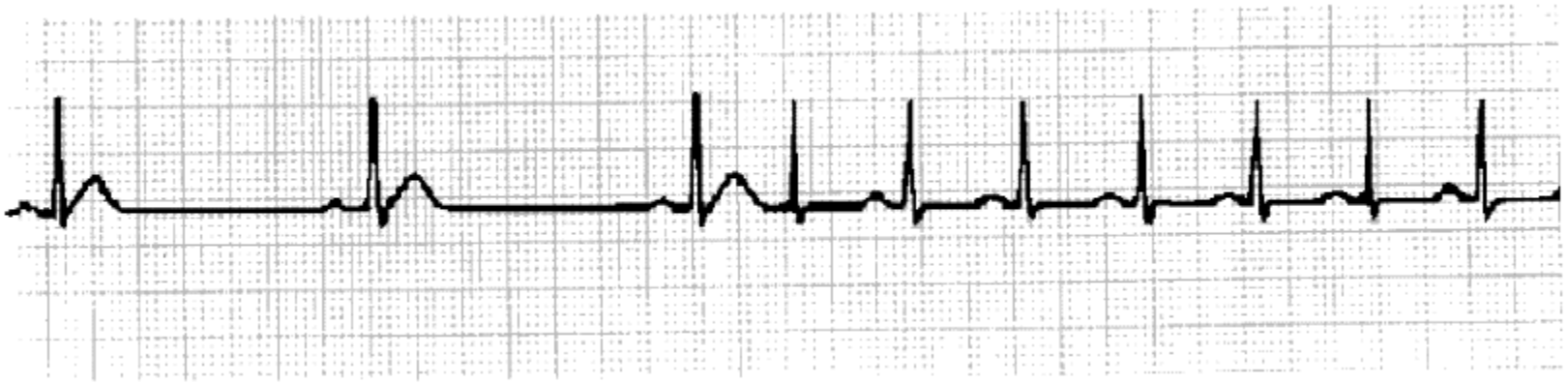
- Pacemakers treat **Slow** heart rates or **Bradycardia**



SINUS NODE DYSFUNCTION

- Sinus Bradycardia
- Sinus arrest
- Sinus block
- Brady-tachy syndrome
- Chronotropic incompentence

SINUS NODE DYSFUNCTION
BRADY-TACHY SYNDROME



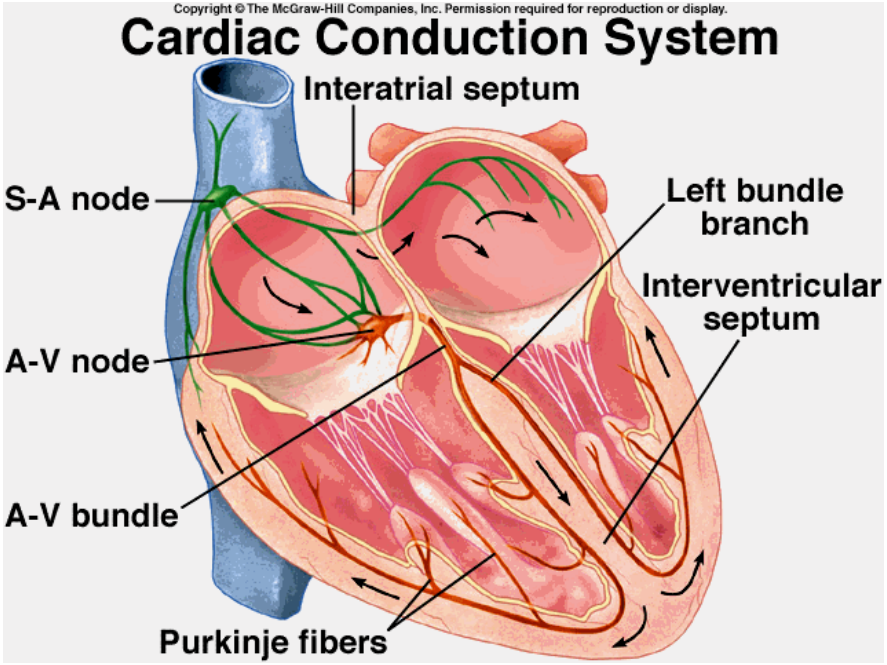
- Intermittent episodes of slow and fast rates from SA node.
  - Rate during bradycardia – 43bpm
  - Rate during tachycardia – 130bpm

SINUS NODE DYSFUNCTION
SINUS ARREST

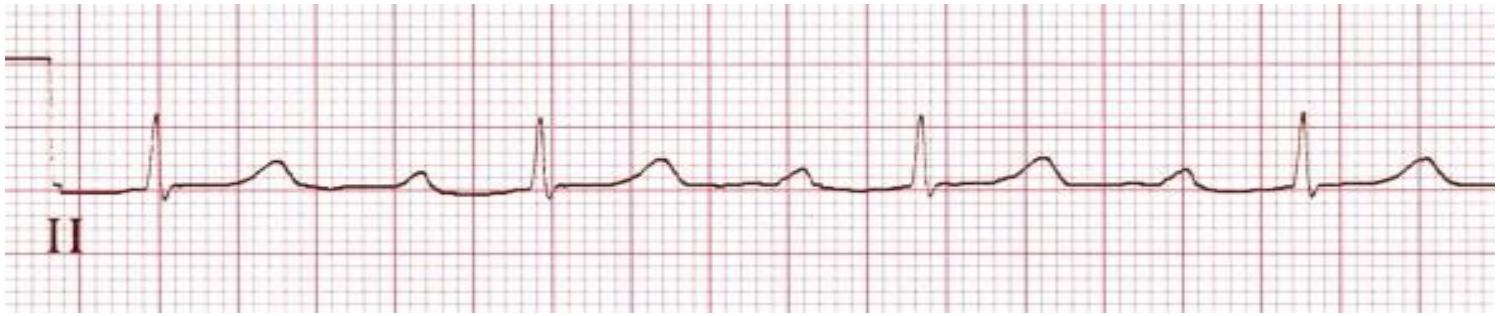
- Sudden absence of electrical activity initiated by the SA node.
- Causes drop in blood pressure, longer the pause the further the drop in BP

HEART BLOCK
ATRIOVENTRICULAR (AV) BLOCK

- First degree AV block
  - Symptomatic?
- Second degree AV block
  - Mobitz type I and II
- Third degree AV block
- Bifascicular and trifascicular block

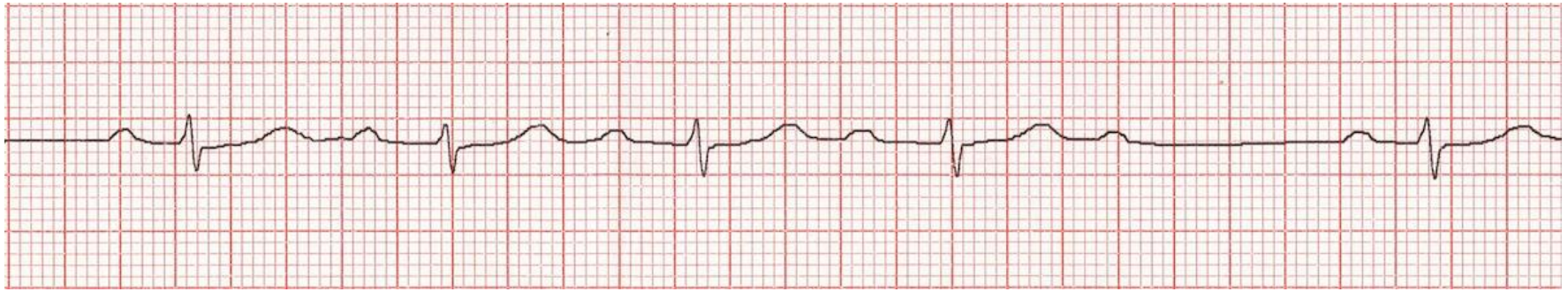


AV BLOCK
FIRST DEGREE BLOCK



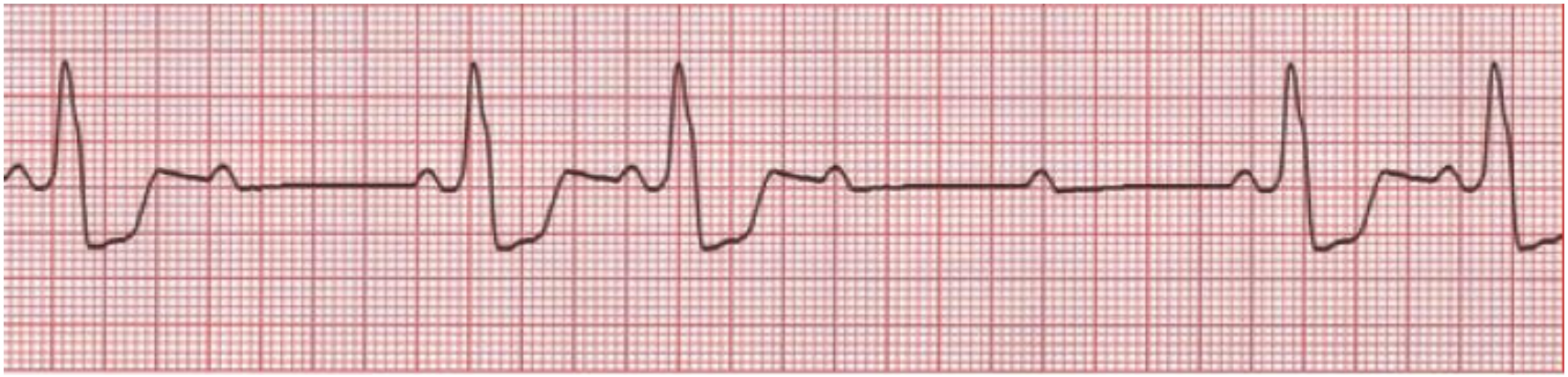
- PR interval greater than 200ms
- Once you recognize a prolonged PR interval you should determine the type of AV block that is present.

AV BLOCK
SECOND DEGREE TYPE 1 - WENCKEBACH



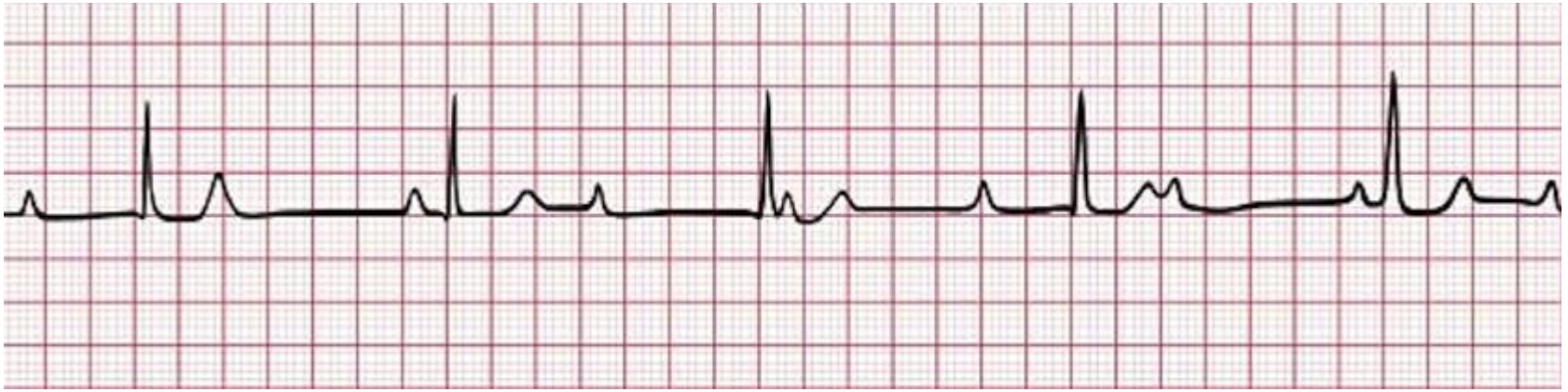
- Prolongation of the PR interval culminating in a non conducted P wave

AV BLOCK
SECOND DEGREE TYPE 2 - MOBITZ



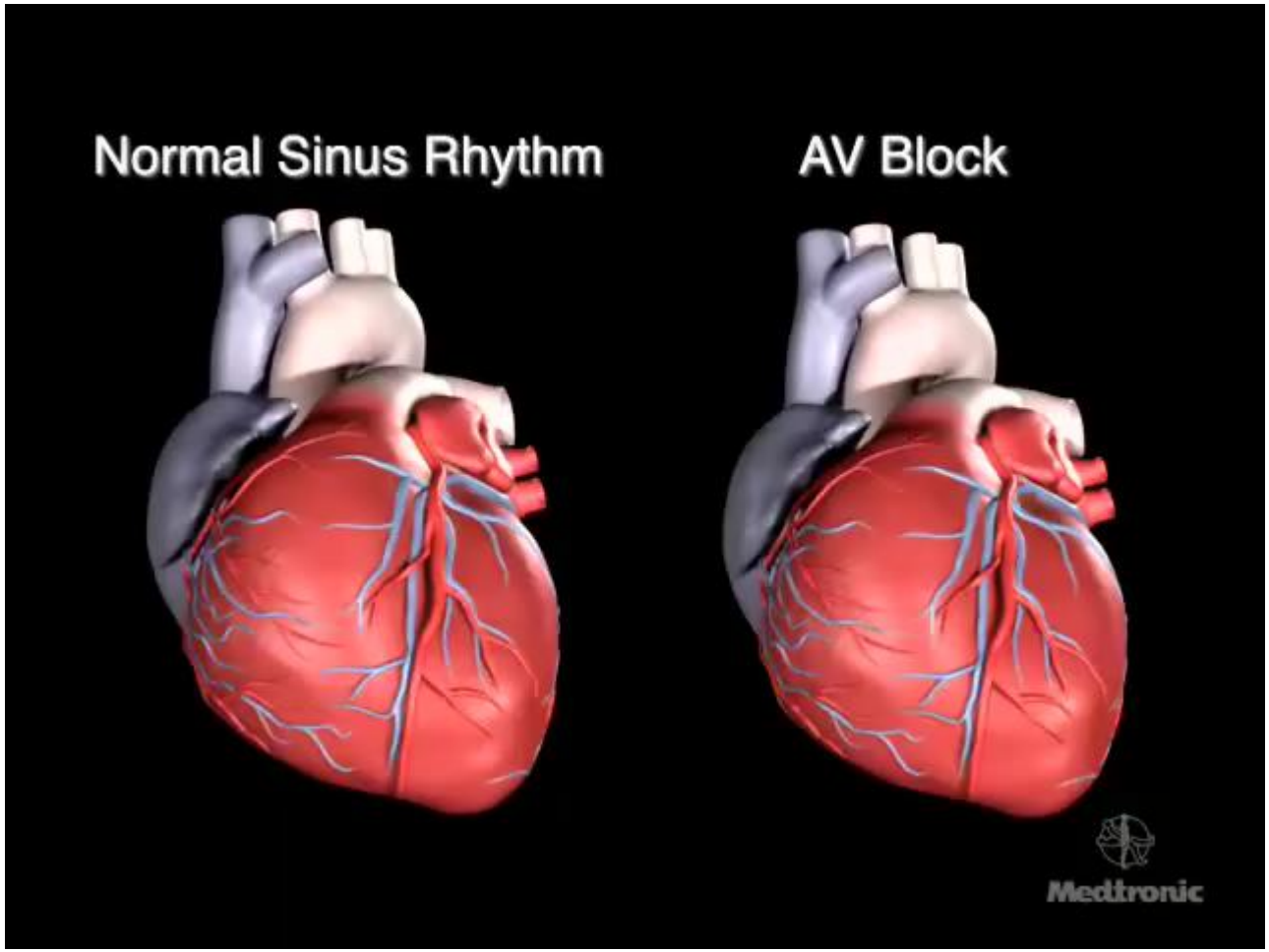
- Intermittent non conducted P waves without progressive prolongation of the PR interval .
- The PR interval on conducted beats remains constant.
- Sometimes appears 2:1

AV BLOCK
THIRD DEGREE BLOCK



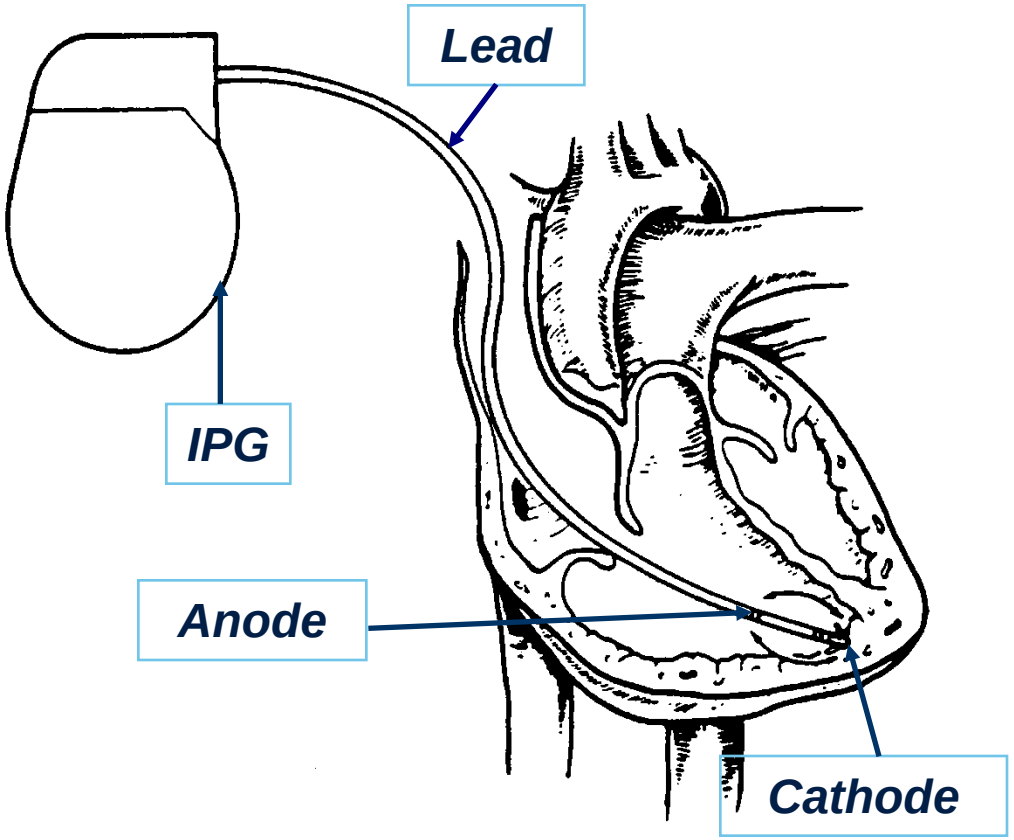
- Complete absence of AV conduction
- Ventricular escape rhythm
- Different PR intervals
- No relation between P waves and R waves

DISEASE STATES
HEART BLOCK

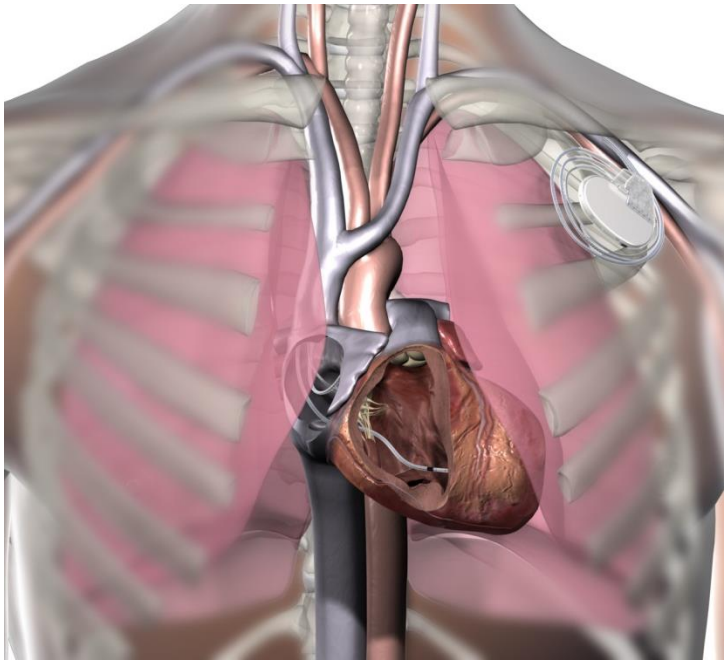


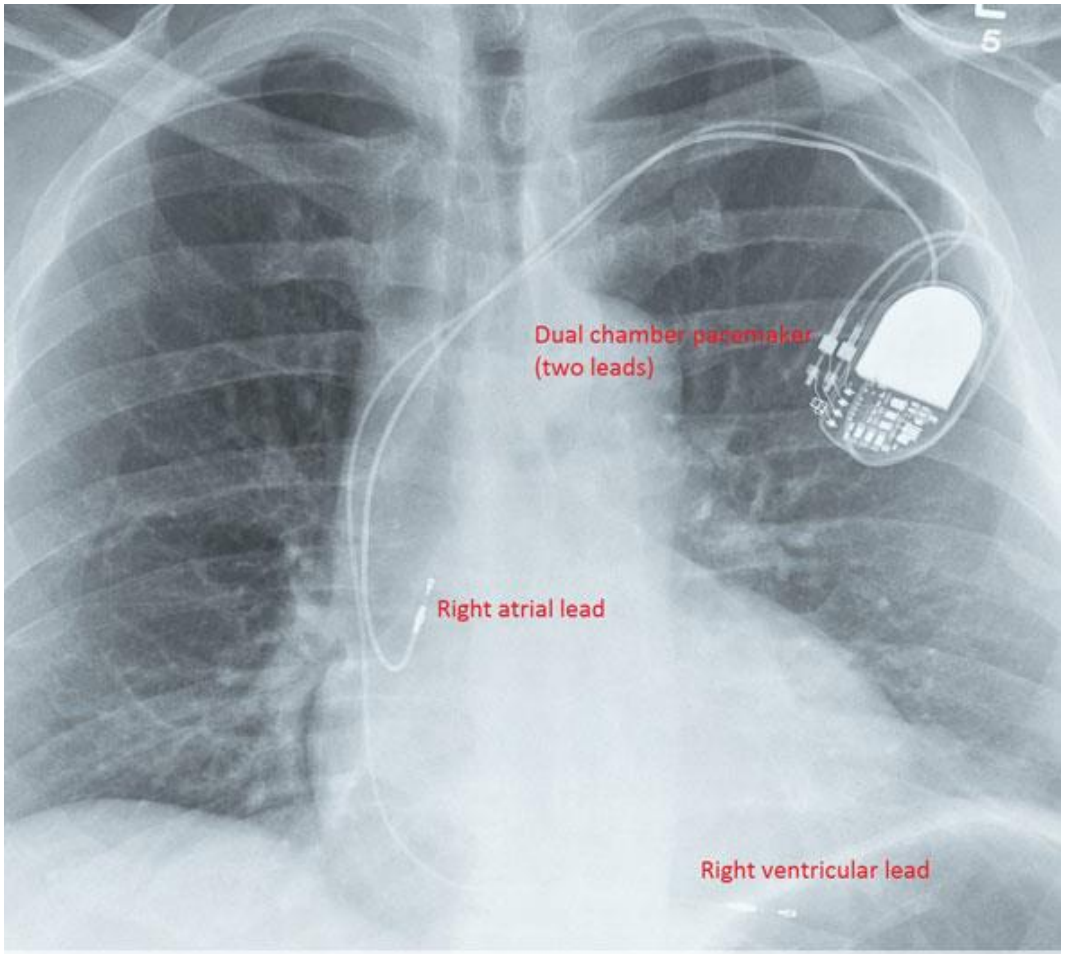
IMPLANTABLE PACEMAKER CIRCUIT

- **Implantable pulse generator (IPG):**
  - Battery
  - Circuitry
  - Connector(s)
- **Leads or wires**
  - Cathode (negative electrode)
  - Anode (positive electrode)
- **Body tissue**



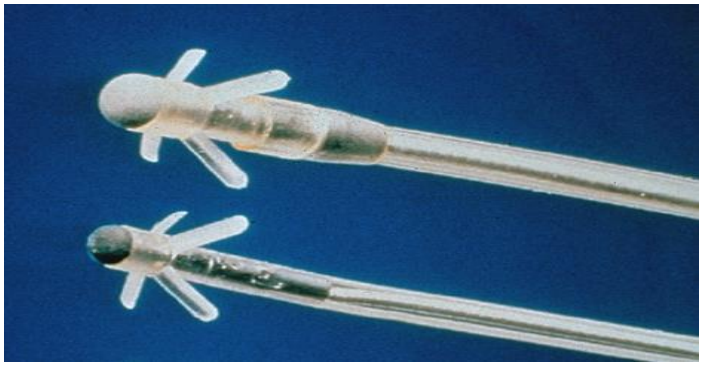
WHAT IS A PACEMAKER
IMAGES



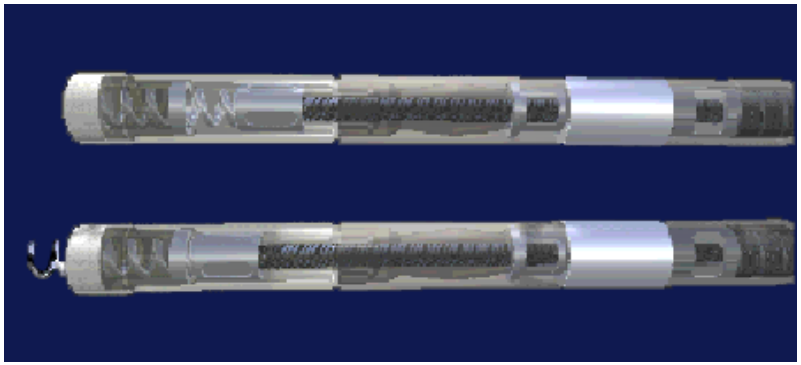


LEAD FIXATION

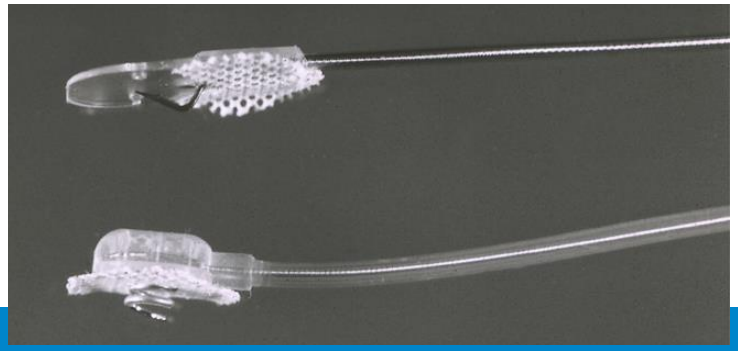
- Passive fixation



- Active Fixation



- Epicardial



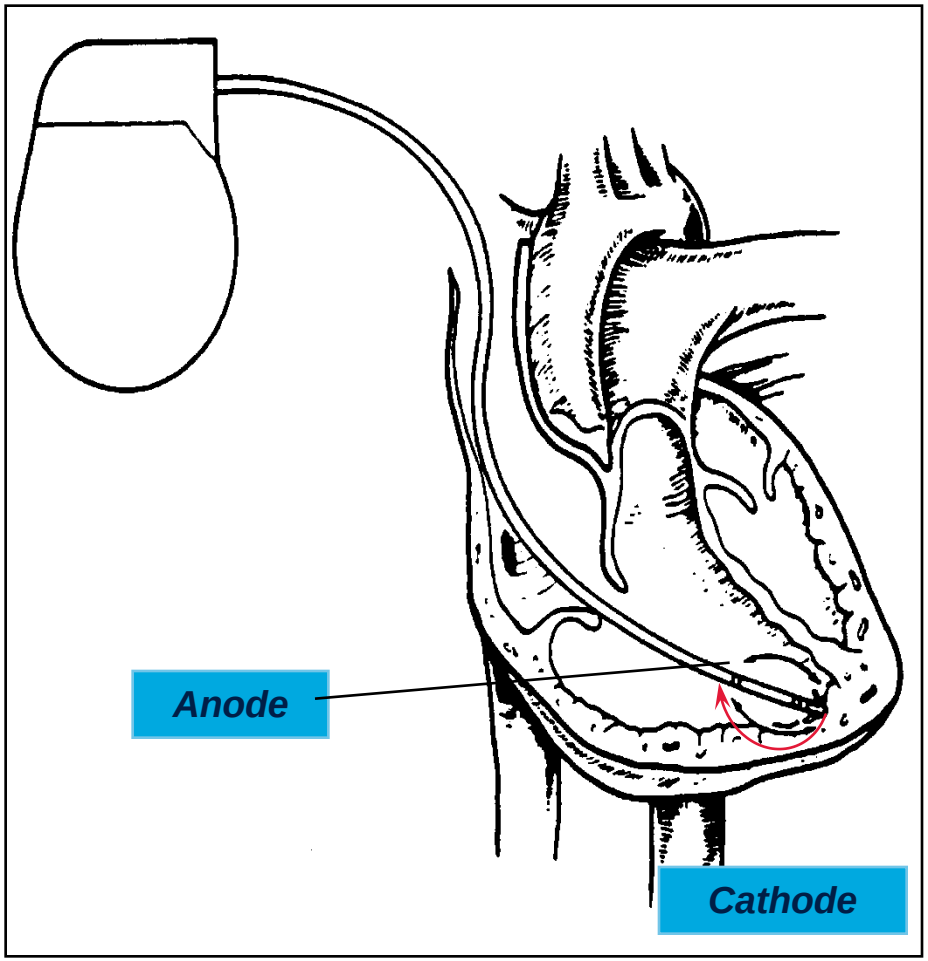
DEVICE FUNCTIONS

FUNCTIONS

1. Stimulate cardiac depolarization - **Pacing**
2. Sense intrinsic cardiac function - **Sensing**
3. Respond to increased metabolic demand by providing rate responsive pacing
4. Provide diagnostic information stored by the pacemaker

FUNCTIONS
PACING

- **The Impulse:**
  - Flows through the tip electrode (cathode)
  - Stimulates the heart
  - Returns to the ring electrode (anode)



FUNCTIONS
PACING

- **Ohm's Law** is fundamental Principle of pacing
  - Describes the relationship between voltage, current, and resistance

$$V = I \times R$$
$$I = V / R$$
$$R = V / I$$

VOLTAGE

- Voltage is the force, or “push,” that causes electrons to move through a circuit
- In a pacing system, voltage is:
  - Measured in volts (V)
  - Represented by the letter “V”
  - Provided by the pacemaker battery
  - Often referred to as amplitude or pulse amplitude

Note: The terms “amplitude” and “voltage” are often used interchangeably in pacing.

CURRENT

- The flow of electrons through a completed circuit
- In a pacing system, current is:
  - Measured in milliamps (mA)
  - Represented by the letter “I”
  - Determined by the amount of electrons that move through a circuit

Note: One ampere is a unit of electrical current produced by 1 volt acting through a resistance of 1 ohm. 1 Ampere = 1000 milliamps

IMPEDANCE

- The opposition to current flow
- In a pacing system, impedance is:
  - Measured in ohms (Ω)
  - Represented by the letter "R"
  - The sum of all resistances to the flow of current
    - Lead conductor resistance
    - The resistance to current flow from the electrode to the myocardium
    - Polarization impedance (the accumulation of charges of opposite polarity in the myocardium at the electrode-tissue interface)

OHM'S LAW TELLS US:

1. If the impedance (R) remains constant, and the voltage decreases, the current decreases
2. If the voltage is constant, and the impedance decreases, the current increases

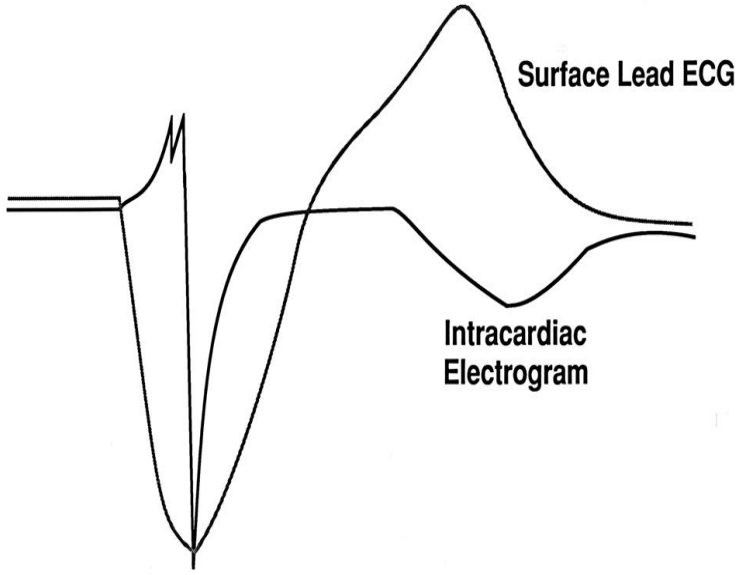
$$V = I \times R$$

Why is this important to clinical management of pacemakers?

The relationship between voltage, current, and impedance provides the rationale for decisions we make during evaluation of pacing systems and reprogramming. Proper management of electrical characteristics is important for patient safety and device longevity.

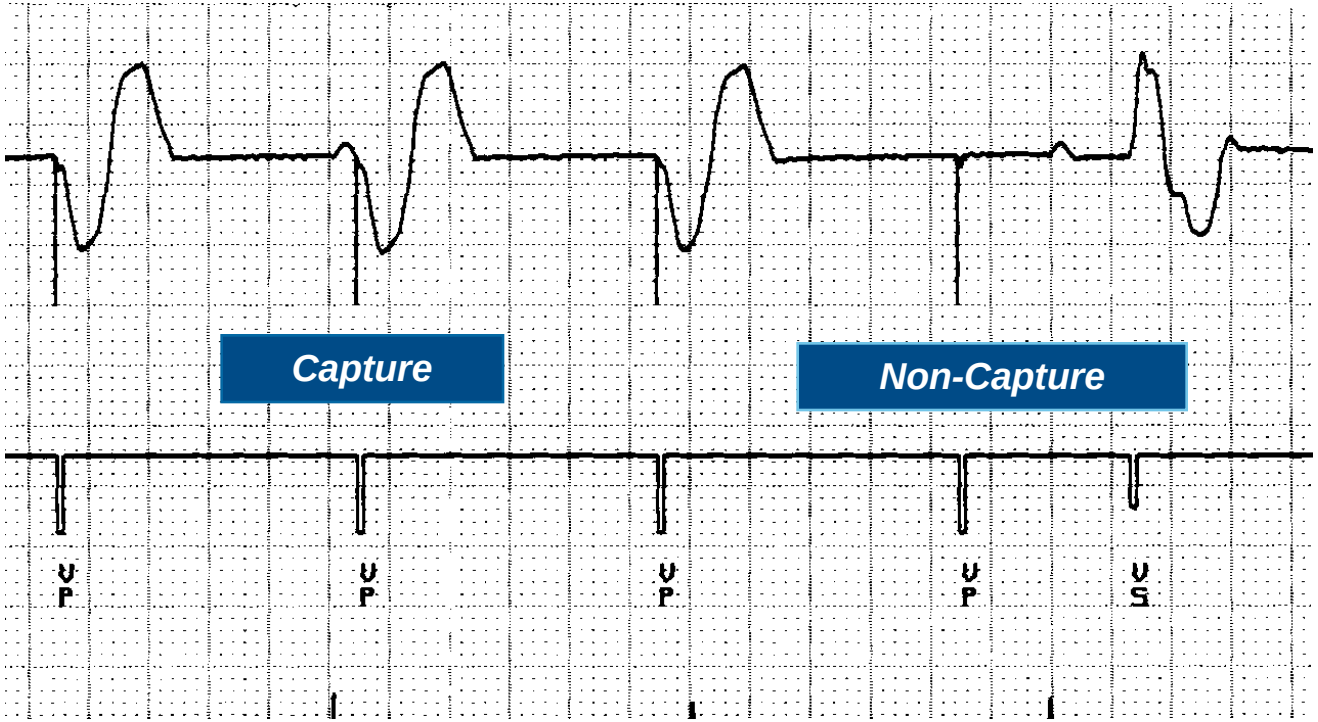
FUNCTIONS
SENSING

- Recording patient's intrinsic electrical signal
- Sensing is seeing when a natural (intrinsic) depolarization is occurring
  - Pacemakers sense cardiac depolarization by measuring changes in electrical potential of myocardial cells between the anode and cathode
- An **Electrogram (EGM)** is the recording of the cardiac waveform taken from within the heart



CAPTURE THRESHOLD

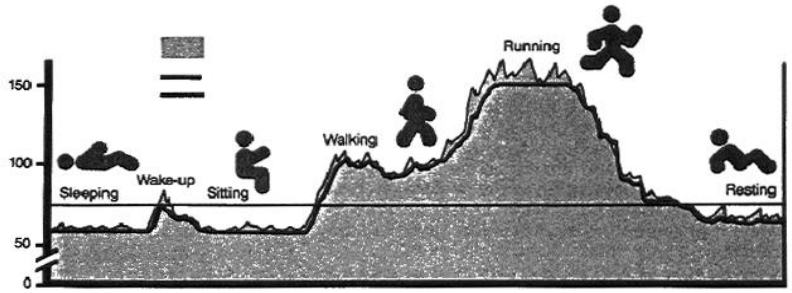
- The minimum electrical stimulus needed to consistently capture the heart outside of the heart's own refractory period



Ventricular pacemaker 60 ppm

FUNCTIONS
RATE RESPONSE

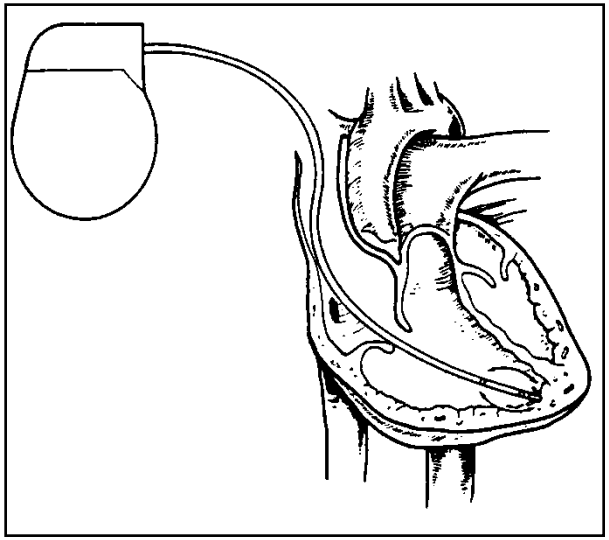
- When should rate response be programmed?
  - When the patient's activity increases, the pacemaker ensures that the heart rate increases to provide additional cardiac output.
- Dynamic pacing rate based on activities



TYPES OF PACEMAKERS

SINGLE CHAMBER SYSTEM

- One lead
  - Atrium
  - Ventricle (most common)
- May be used for patients in chronic AF (VVI pacemaker) or patients with sinus node dysfunction and no history of AV block (AAI pacemaker)



VVI Pacemaker

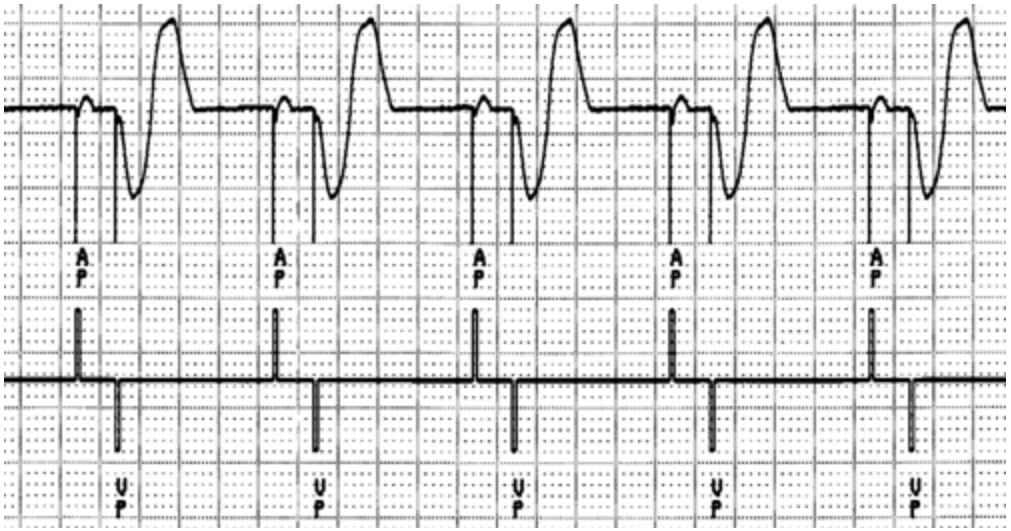
AAI Pacemaker

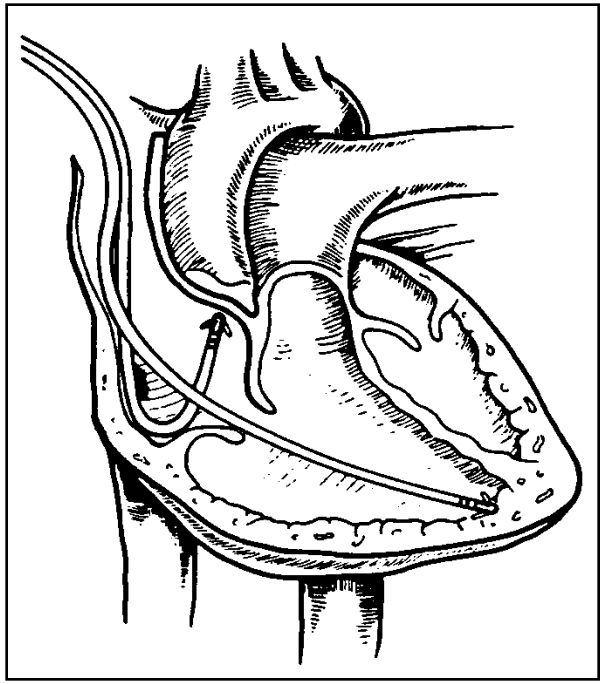
DUAL CHAMBER SYSTEM

- Two leads
  - One lead implanted in the atrium
  - One lead implanted in the ventricle

- Provides AV synchrony and pacing support in both atrium and ventricle if needed

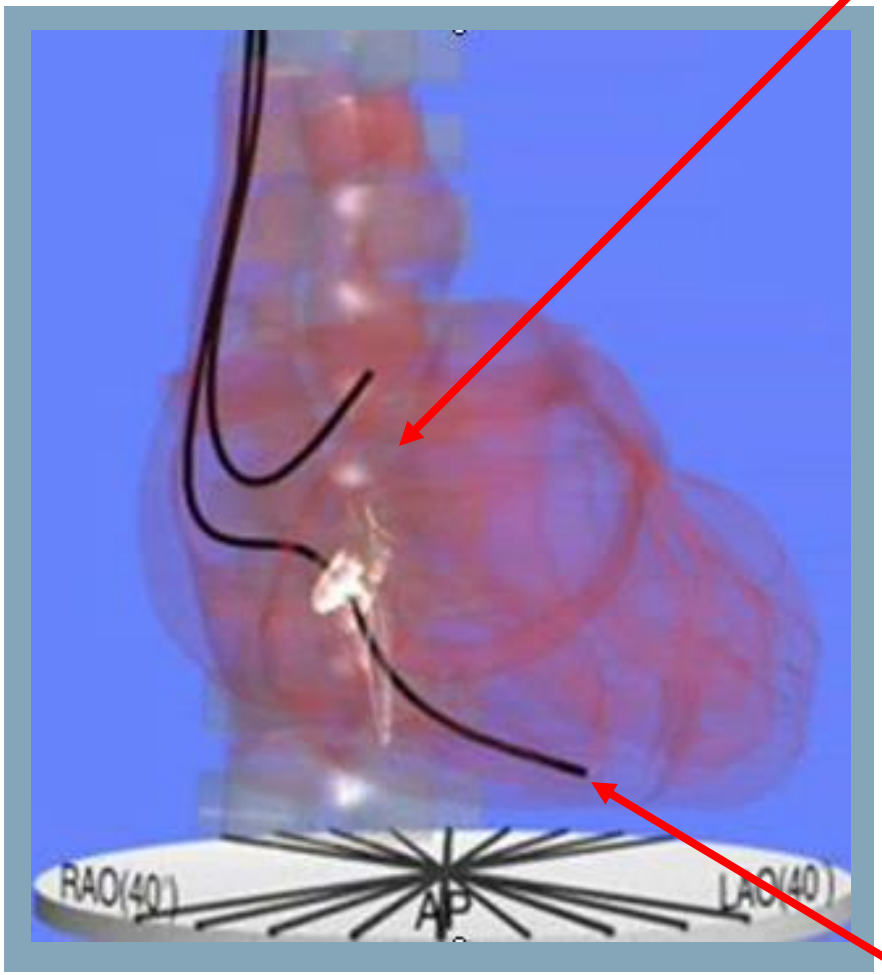
DDD Pacemaker

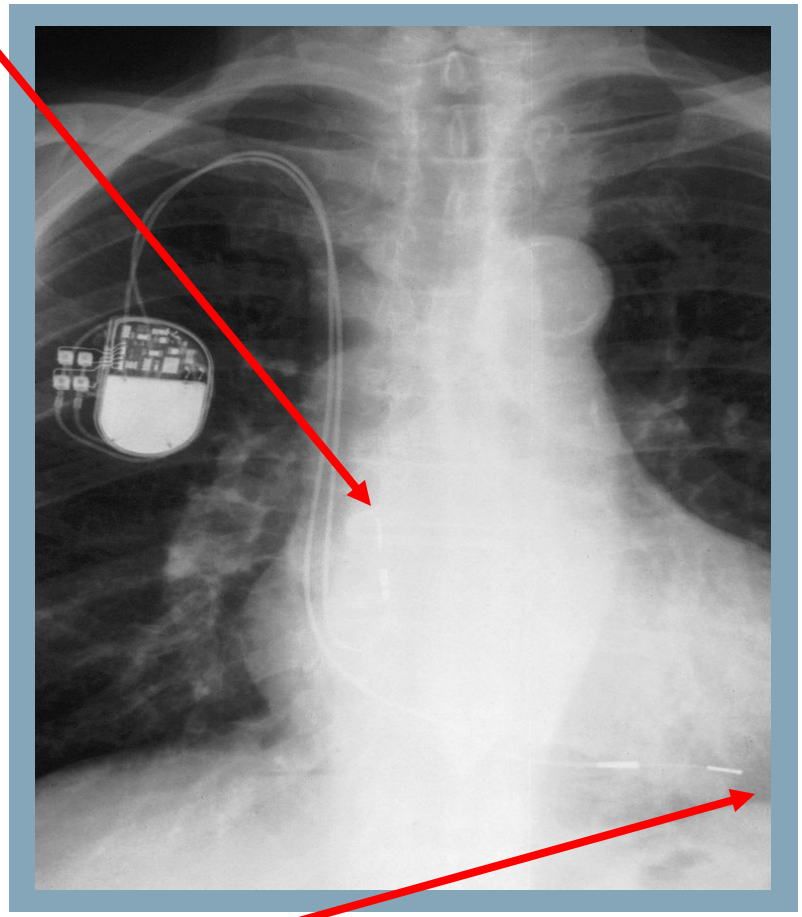




DUAL CHAMBER PACEMAKER

RA Lead in Appendage



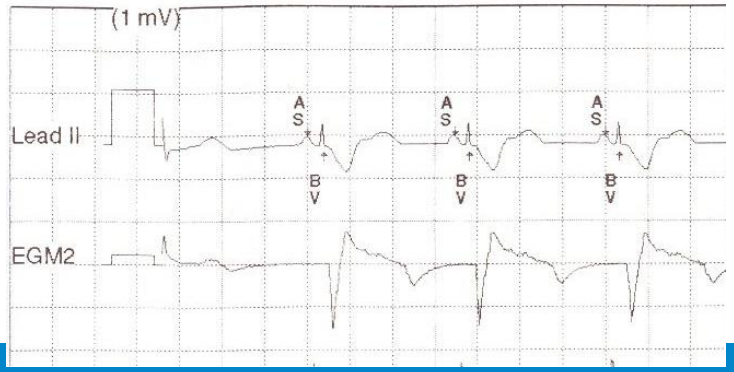


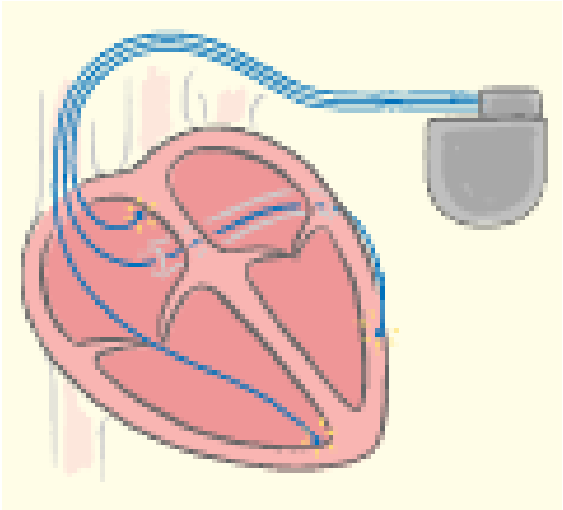
RV Lead at the Apex

TRIPLE CHAMBER SYSTEM

- Three Leads:
  - Right Atrium
  - Right Ventricle
  - Left Ventricle (via the Coronary Sinus vein)
- Most commonly called a Bi-Ventricular Pacemaker but also called Cardiac Resynchronization Therapy (CRT–P)
- Paces both ventricles together to “resynchronize” the beat

DDD BiV Pacemaker





NBG CODE – THE USUAL PACING MODES

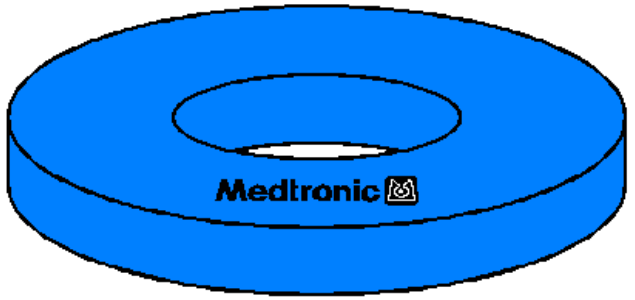
I	II	III	IV	V
Chamber(s) Paced	Chamber(s) Sensed	Response to Sensing	Rate Modulation	Multisite Pacing
O = None **A** = Atrium **V** = Ventricle **D** = Dual (A + V) **S** = Single (A or V)	**O** = None **A** = Atrium **V** = Ventricle **D** = Dual (A + V) **S** = Single (A or V)	**O** = None **T** = Triggered **I** = Inhibited **D** = Dual (T + I)	**O** = None **R** = Rate modulation	**O** = None **A** = Atrium **V** = Ventricle **D** = Dual (A + V)

Examples of pacing modes which are typically programmed:

DDD
DDDR
VVI
VVIR
DDIR
AAIR

MAGNET OPERATION

- Pacers=Pacing
  - -DOO/VOO at a set rate
- ICDs=Detection
  - -Suspends Therapy



Thank you

Q&A

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