

## ***Demystifying Cardiac Devices***

**NTI 2021**  
**Course Code: C150M403**

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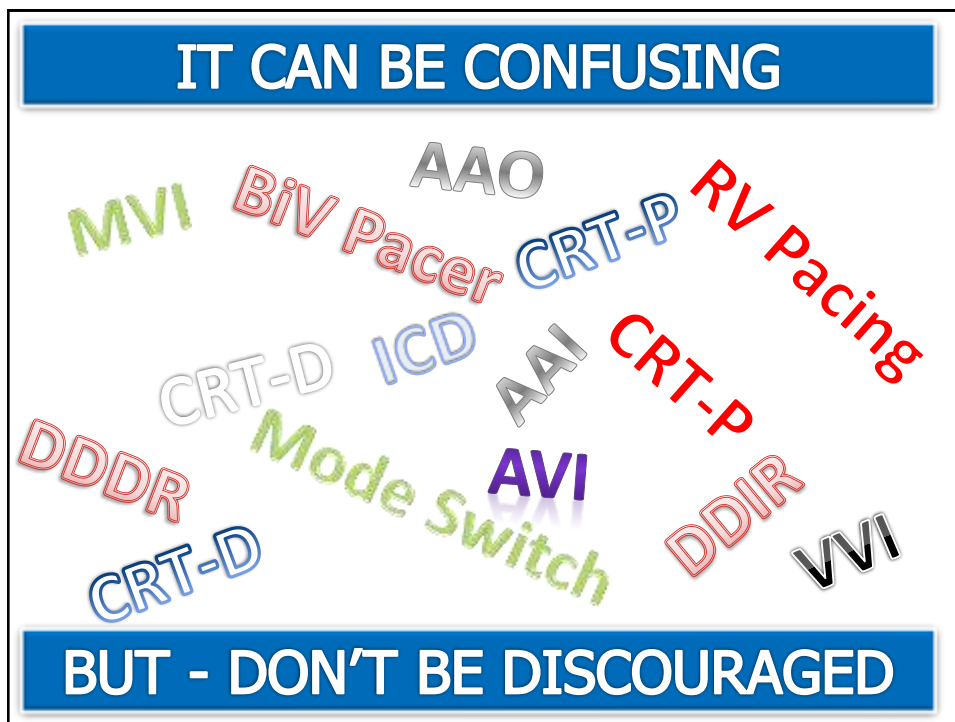
## **Thought for Today**

**People are like books. Eventually, the focus shifts from the cover to the story that cannot be read in one setting.**

**- Kat Lehmann**

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**LET'S BREAK IT DOWN**

**Standard Pacemaker**

- Single Chamber (RV)
- Dual Chamber (RA / RV)

**Biventricular Pacemaker (CRT)**

- Cardiac Resynchronization
- Triple Chamber (RA/RV/LV)

**Implantable Defibrillator**

- Single Chamber (RV)
- Dual Chamber (RA / RV)

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Electrical Conduction Pathway

Labels in diagram:

- Sinoatrial Node (SA Node)
- Interatrial Pathway (Bachmann's Bundle)
- Left Bundle Branch (LBB)
- Left Anterior Fascicle of LBB
- Left Posterior Fascicle of LBB
- Purkinje Fibers
- Right Bundle Branch
- Bundle of His
- AV Junction
- AV Node
- Internodal Pathways

Picture Courtesy of Cardiovascular Nursing Education Associates

- SA Node
- Interatrial / internodal pathways
- AV Node
- Bundle of His
- AV Junction
- Right and Left Bundle Branches
- Anterior and Posterior Fascicles
- Purkinje Fibers

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Indications for Pacing

Labels in diagram:

- Sinoatrial Node (SA Node)
- Interatrial Pathway (Bachmann's Bundle)
- Left Bundle Branch (LBB)
- Left Anterior Fascicle of LBB
- Left Posterior Fascicle of LBB
- Purkinje Fibers
- Right Bundle Branch
- Bundle of His
- AV Junction
- AV Node
- Internodal Pathways

Picture Courtesy of Cardiovascular Nursing Education Associates

- Sinus node dysfunction
- AV conduction system dysfunction - #1
- Symptomatic bradycardia
- Drug induced bradycardia

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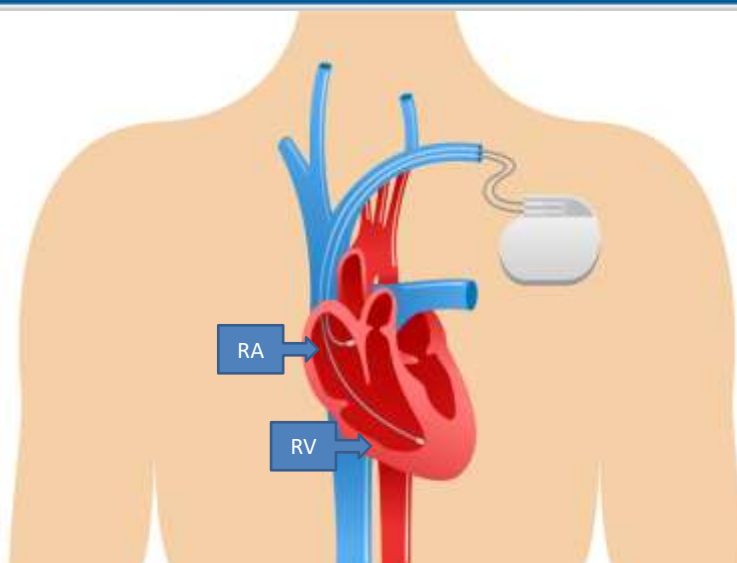
## Additional Indications for Pacing

- Chronic bi-fascicular and tri-fascicular blocks
- Sick Sinus Syndrome: Tachy-Brady Syndrome
- Cardiac support for treatment of arrhythmias requiring ablation and / or medications resulting in bradycardia
  - AV Node ablation will require permanent pacing
- Neurocardiogenic Syncope
- Hypertrophic Cardiomyopathy / Infiltrative disorders
- Pacing for termination of tachyarrhythmias (part of ICD therapy)
- CHF (biventricular pacing)

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## Pacing Basics



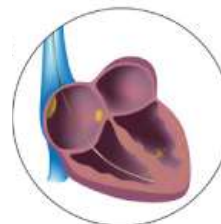
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## Types of Cardiac Pacing

- Temporary Transvenous Pacing
- Transcutaneous Pacing
- Epicardial Pacing
- Permanent Pacing
  - Single chamber
  - Dual chamber
  - Biventricular

SINGLE CHAMBER



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### Temporary Transvenous Pacing



Rate control

Output control (mA)


Sensitivity control

Battery compartment

- Internal jugular, subclavian, antecubital, or femoral vein
- Pacing wire threaded into the apex of the right ventricle for ventricular pacing
- Done under fluoroscopy in a cardiac cath lab or without fluoroscopy at the bedside
- Short term solution to short- or long-term problem – rhythm resolves
- Short term solution until long term solution is determine – permanent pacer
- Pacing wire (one wire for single chamber pacing) - has two tails
  - One marked positive or proximal
  - One marked negative or distal
  - Connected to the pulse generator via a bridging cable.

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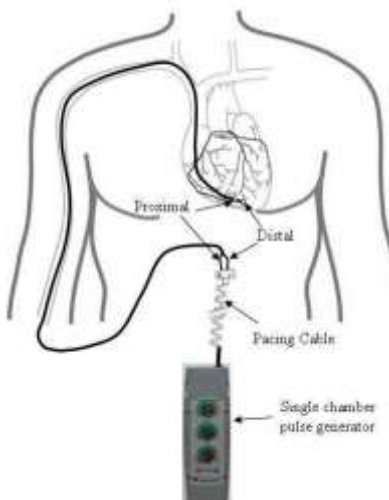


# Components of TTVP Generator

- On / Off Button
- Positive (proximal)/ Negative (distal) wire connections
- Heart Rate Dial
- Output (mA)
  - Milliamps
- Sensitivity (mV)
  - Millivolts
  - Asynchronous / Demand
- Battery

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## Temporary Transvenous Pacing




1. Connect the negative to negative.
2. Connect the positive to positive (Remember: PP = "proximal is positive.")
3. Set the rate at 60-80 beats per minute, or as ordered by the physician.
4. Set the output at 5 mA, then determine stimulation threshold and set 2-3 times higher than threshold.
5. Set the sensitivity at 2 mV and adjust according to sensitivity threshold.

Picture Courtesy of Cardiovascular Nursing Education Associates

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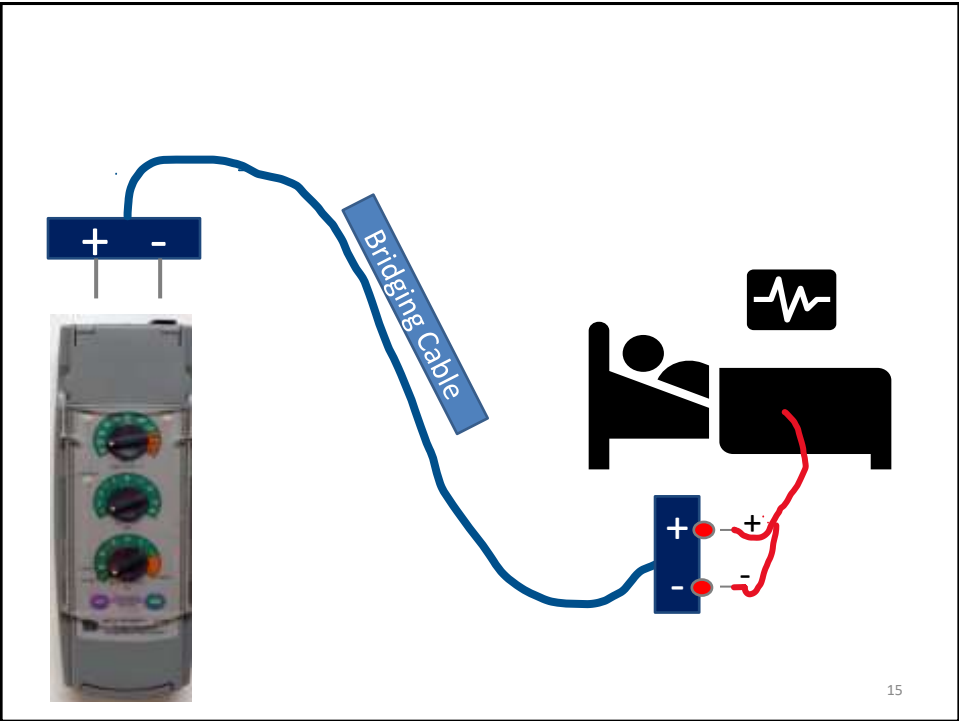
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1. Connect the negative to negative.
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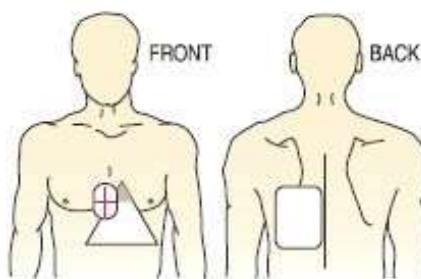
## External / Transcutaneous Pacing

- Noninvasive pacing
- **TEMPORARY** measure to emergently treat symptomatic arrhythmias
  - Asystole, severe bradycardia, overdrive pacing for tachyarrhythmias
- Adhesive electrodes attached to anterior/posterior chest wall and attached to pacer
- Requires large amount of energy
  - Sedation is a MUST

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## Transcutaneous Pacer



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# Permanent Pacemakers



This image displays various Medtronic permanent pacemaker components. At the top left is a single Medtronic Aduro XT DR MRI SureScan pacemaker. Below it, three more models are shown: the Cobalt XT VR ICD MRI SureScan, the Cobalt DR ICD MRI SureScan, and the Conquest HF Dual CRT-D MRI SureScan. To the right, two Micra AV leadless pacemakers are shown, which are small, cylindrical devices designed for minimally invasive implantation.

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# Pacer Parts

## Battery / Brains



This section shows the battery/brain components of a pacemaker. On the left is a tall, grey external battery unit with three green control knobs. To its right is a single Medtronic Aduro XT DR MRI SureScan pacemaker brain.

## Leads



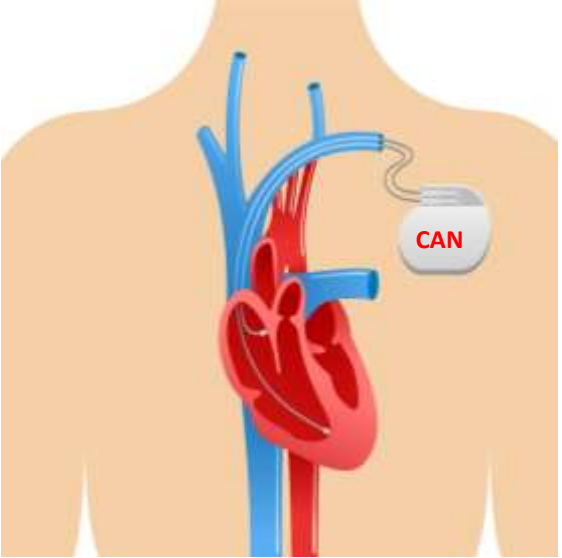
This section displays the leads used in pacemakers. It includes a long, thin lead with a coiled section, a shorter lead with a multi-tined tip, and a Medtronic Micra AV leadless pacemaker.

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### Permanent Pacemaker Insertion

- Electrophysiology Lab, Cardiac Catheterization Lab, Operating Room
- Local anesthesia
- Strict adherence to infection control procedures
- Pacer “can”
  - Battery and brains
- Leads implanted

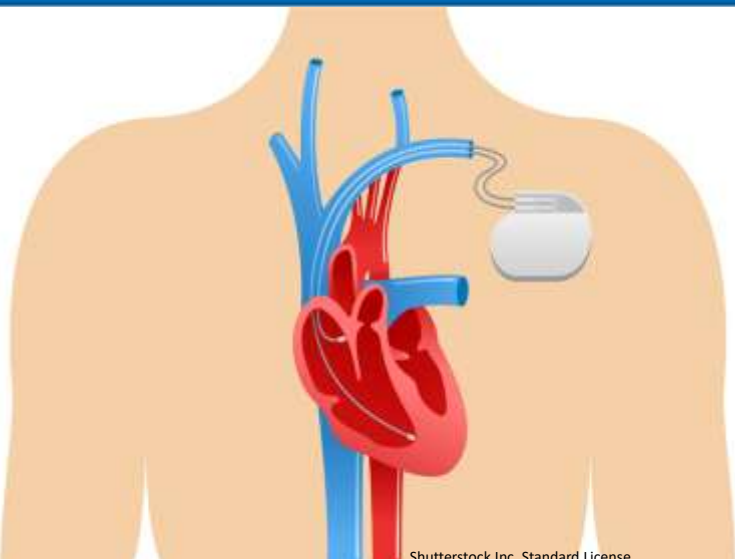


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### Pacemaker Function



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Basic Pacemaker Operation

Asynchronous Pacing Mode

- Programed rate
- No regard for normal heart function
- No sensing
- Dangerous
  - Potential for pacing stimuli to fall in vulnerable period and cause VF

Demand Pacing Mode

- Pacer functions when the heart fails to depolarize on its own
- Pacemaker fires “on demand”
- Pacemaker senses intrinsic activity and inhibits pacer output when intrinsic activity occurs

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THREE ACTIONS

Pace

- Ability of the pacemaker to send a stimulus to the myocardium
- Identified by a pacemaker spike on the ECG

Capture

- Ability of the pacing stimulus to depolarize (activate) chamber being paced
- Identified by a pacemaker spike that is immediately followed by a P wave or a QRS complex on the ECG

Sense

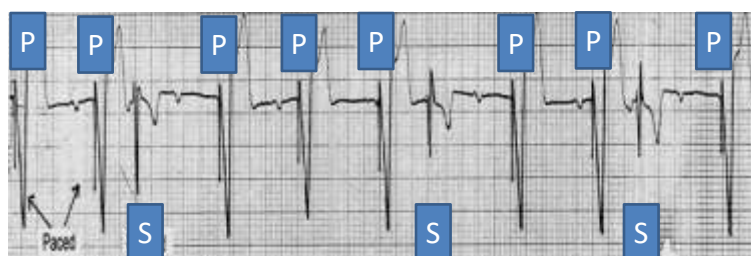
- Ability of the pacemaker to recognize and respond to intrinsic cardiac depolarization
- Identified by pacing when no intrinsic beats are present and not pacing when intrinsic beats are present

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## Pacing

- Identify automatic pacing interval (pacing rate)
  - Two consecutive pacer spikes
- Spikes should appear regularly unless pacer is inhibited by sensed intrinsic activity

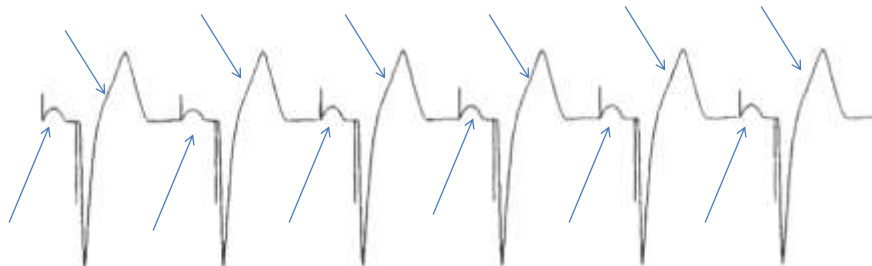


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## Capture

- Pacing stimulus results in depolarization of chamber being paced
- Each spike should be followed by a QRS unless it falls in heart's refractory period

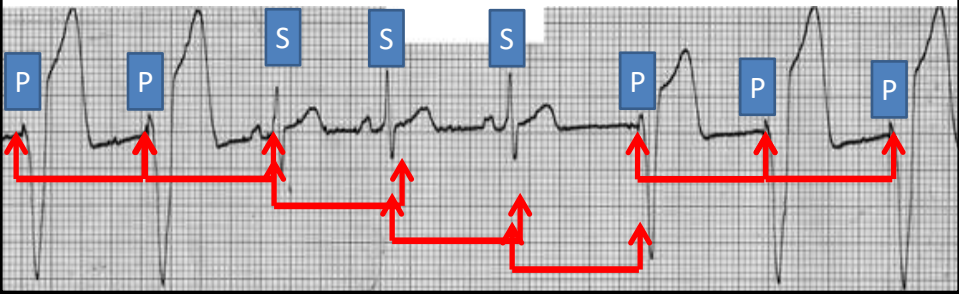


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## Sensing

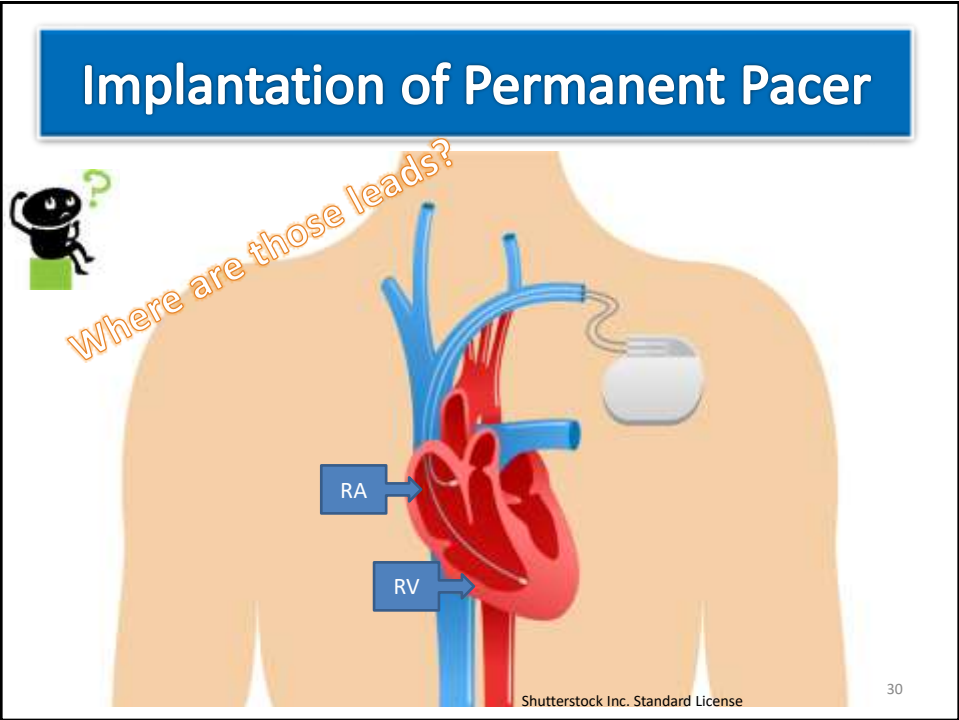
- Pacemaker sees and responds to intrinsic activity
- Must be given opportunity to sense
  - Must be in demand mode
  - There must be intrinsic activity to be sensed



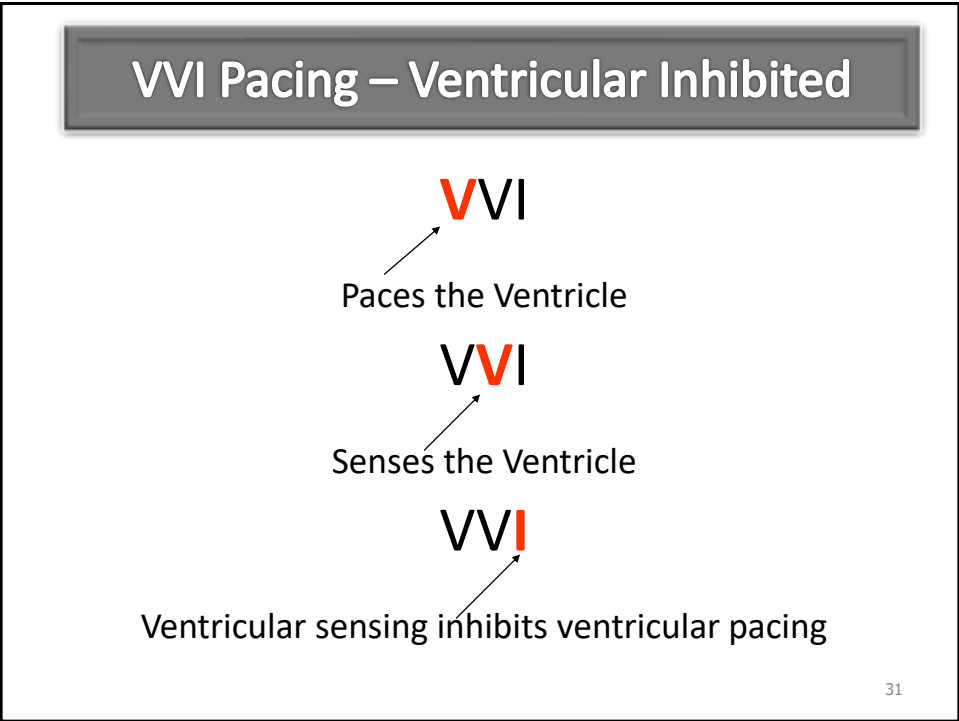
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Revised NASPE/BPEG Generic Code for Antitachycardia Pacing				
Position I	Position II	Position III	Position IV	Position V
Chamber(s) Paced	Chamber(s) Sensed	Response to Sensing	Rate Modulation	Multisite
O=None	O=None	O=None	O=None	O=None
A=Atrium	A=Atrium	T=Triggered	R=Rate modulation	P=Paced
V=Ventricle	V=Ventricle	I=Inhibited		S=Shocks
D=Dual (A+V)	D=Dual (A+V)	D=Dual (T+I)		D=Dual (P+SV)
(Bernstein et al., 2002)				29

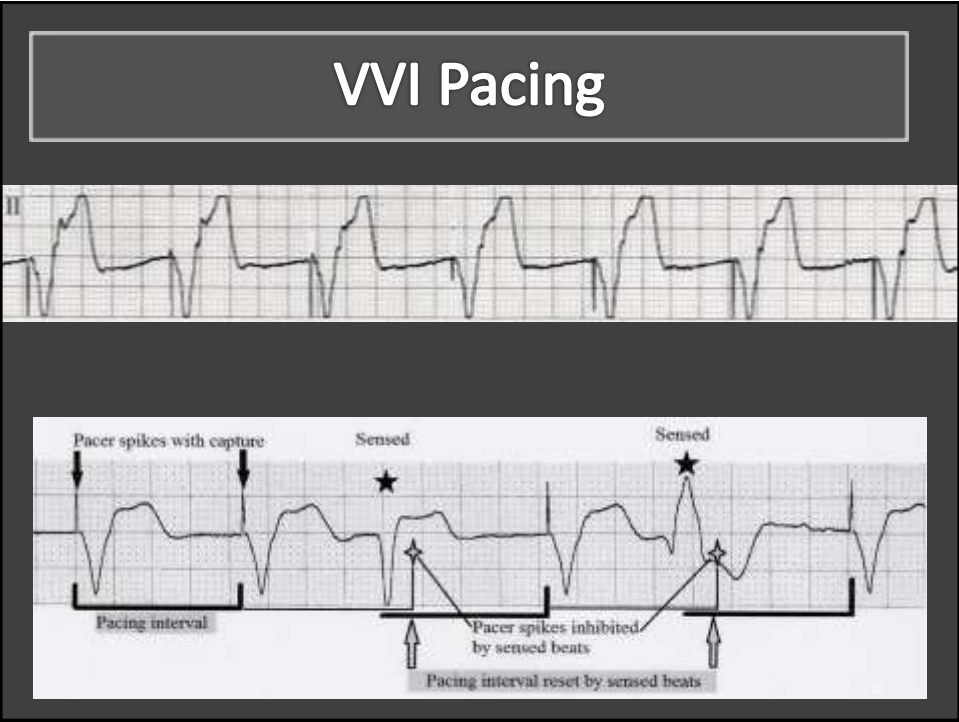
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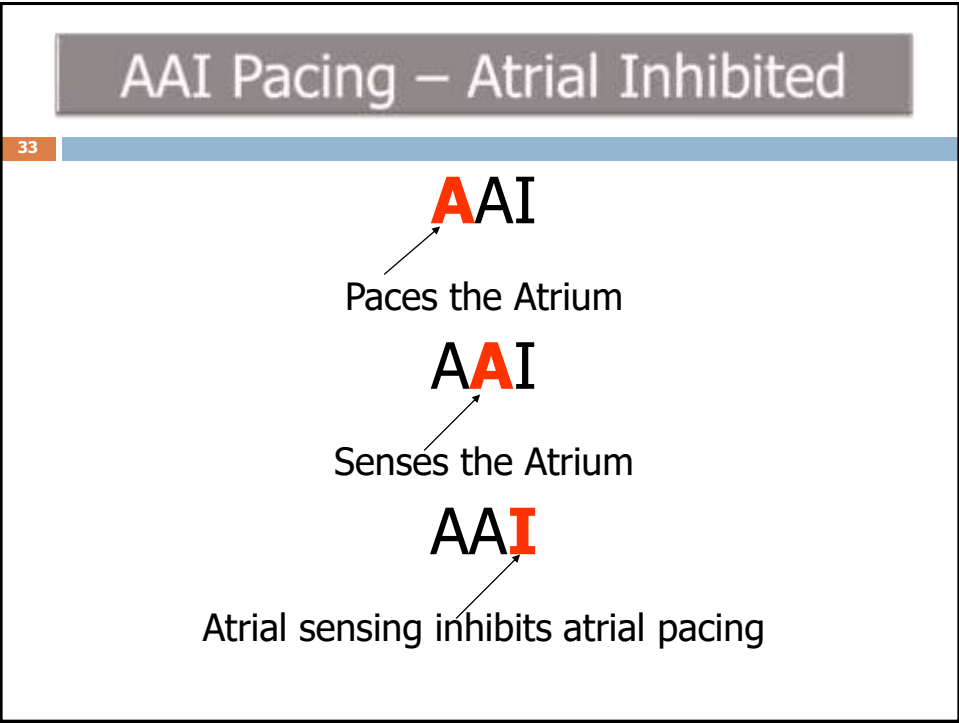
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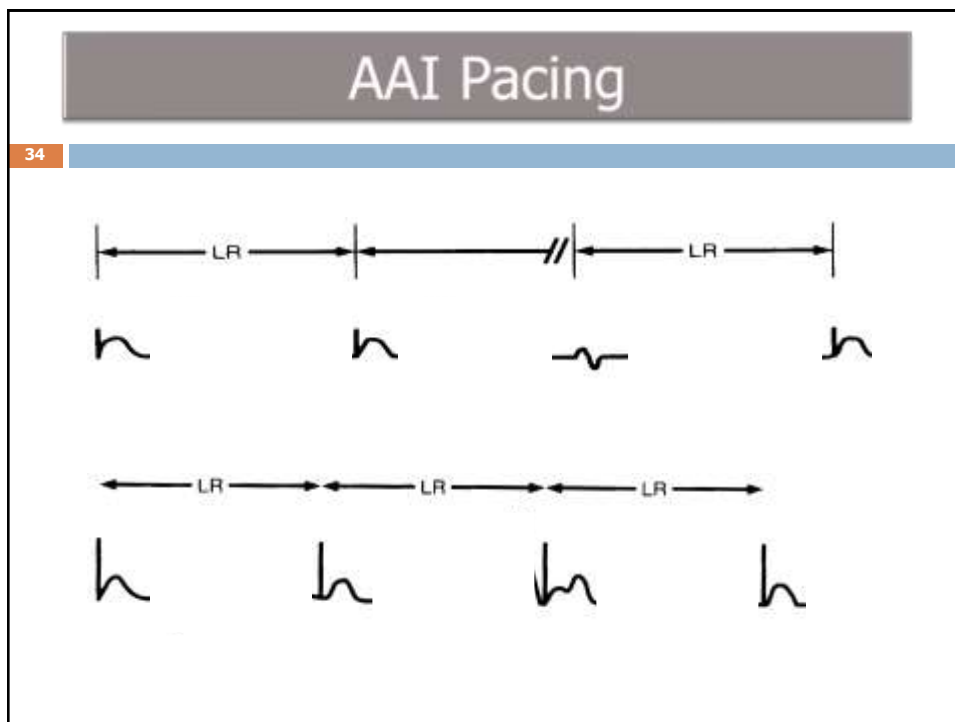
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## Dual Chamber Pacers

**First there was one wire – then there were two!**

- Provide AV synchrony
  - Maintains atrial kick
  - Improves hemodynamics in those with heart blocks
- Tracks atrial activity
  - Ventricular pacing occurs in response to atrial activity
  - Improved hemodynamics
- Decreased incidence of pacemaker syndrome

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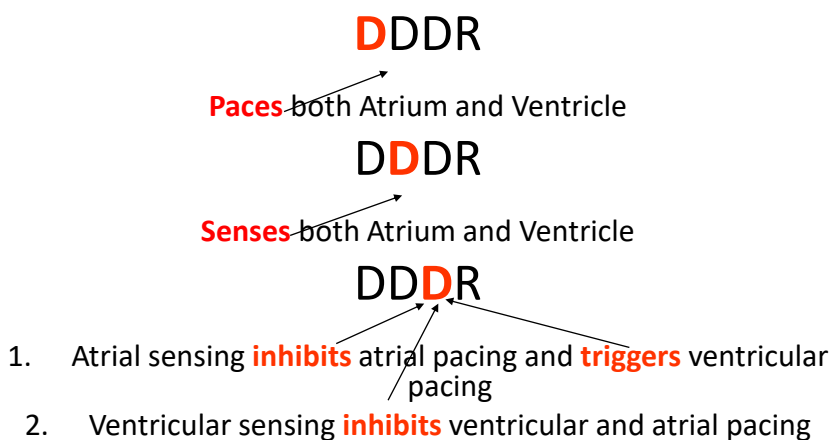
## Basic Pacemaker Timing

- Low Rate
  - Lowest rate allowed by the pacer before a paced beat is initiated
- High Rate
  - Upper rate limit
  - Highest rate that can be achieved and still maintain AV synchrony

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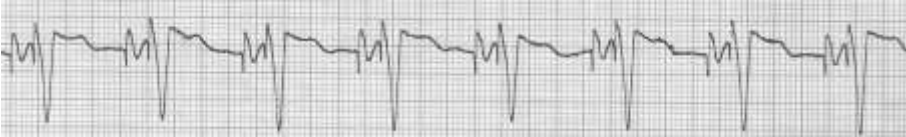
## DDDR Pacing



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DDD Pacing:  
AV Sequential Pacing State




1:1 AV Pacing with AV Capture

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DDD Pacing:  
Atrial Pacing State




1:1 atrial pacing with atrial capture  
and appropriate ventricular sensing

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DDD Pacing:  
Atrial Tracking State

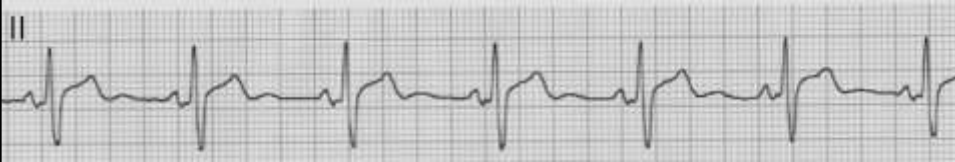
An ECG strip on a grid background. It shows a series of cardiac cycles. Each cycle begins with a small P wave, followed by a sharp, narrow QRS complex. The P waves are consistently followed by the QRS complexes, indicating a 1:1 relationship. The QRS complexes are narrow and have a characteristic shape, suggesting ventricular capture. The overall rhythm is regular.

1:1 ventricular pacing with ventricular capture and appropriate atrial sensing

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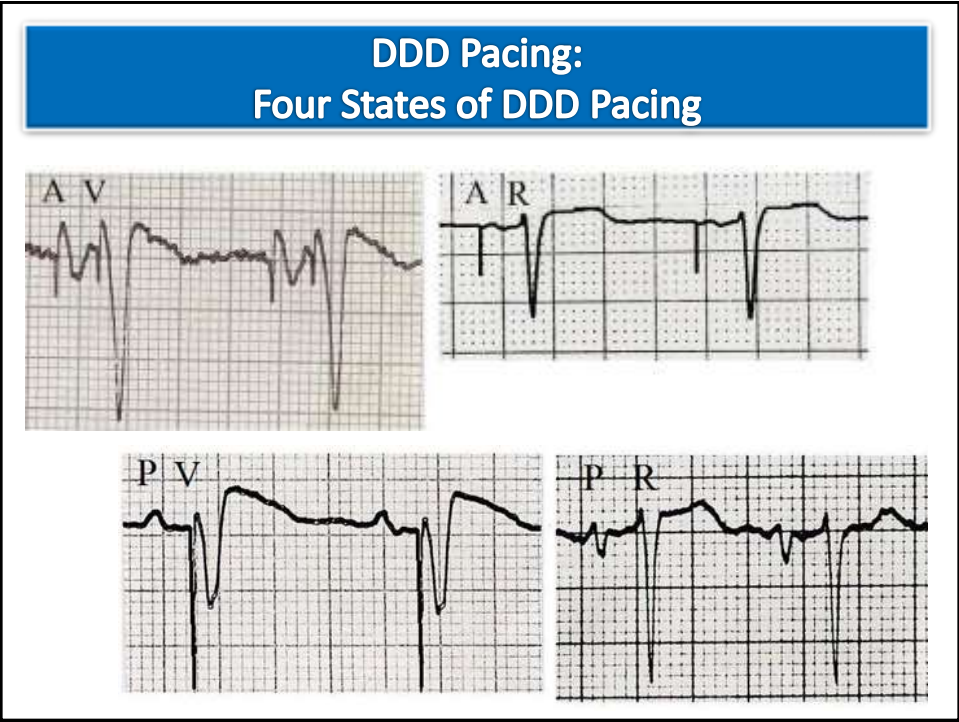
DDD Pacing:  
Atrial Sensing and Ventricular Sensing State

An ECG strip on a grid background, labeled 'II' in the top left corner. It shows a series of cardiac cycles. Each cycle begins with a P wave, followed by a narrow QRS complex. The P waves are consistently followed by the QRS complexes, indicating a 1:1 relationship. The QRS complexes are narrow and have a characteristic shape, suggesting ventricular capture. The overall rhythm is regular.

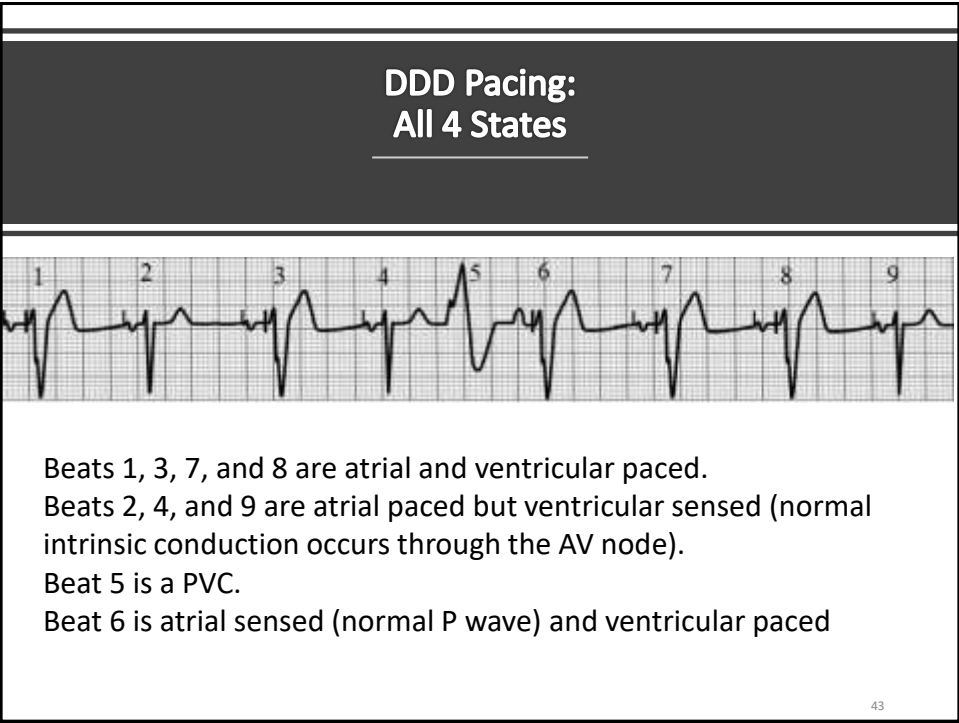
NSR with appropriate atrial and ventricular sensing

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## Troubleshooting Pacemakers

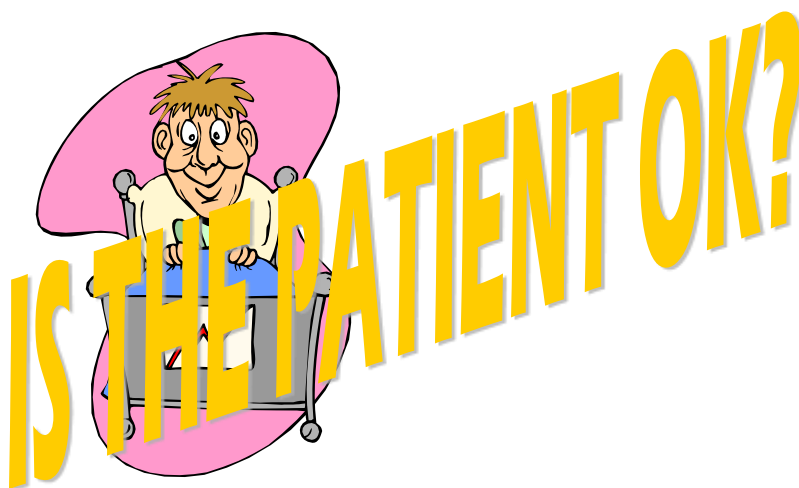
- Is there evidence that the pacemaker fires?
  - Failure to fire / pace.
- Is there evidence that the pacemaker captures?
  - Failure to capture
- Is there evidence that the pacemaker senses intrinsic activity?
  - Failure to sense
    - Over sensing
    - Under sensing



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## #1 Question To Ask



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## Troubleshooting Pacemakers

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### □ Failure to Pace (Fire)

- ▣ Pacer does not fire when indicated
- ▣ Pacer spike is not present when expected
- ▣ Recognized by pauses longer than the automatic interval or the absence of pacer spike at the end of the escape interval



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## Troubleshooting Pacemakers

### Failure to Pace (Fire)

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- Causes of Failure to Pace (Fire)
  - ▣ Pacer not turned on
  - ▣ Oversensing
    - ▣ So sensitive that it is sensing external electrical signals, T wave potentials, or myopotentials from surrounding muscle
  - ▣ Loose or broken connections
    - ▣ Can produce “false signals” from intermittent separation of a broken lead or intermittent contact of connections in the pacemaker.
  - ▣ Battery Failure

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## Troubleshooting Pacemakers

### Interventions for Failure to Pace

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- Emergently treat patient as condition requires
- Pacer not turned on
  - ▣ Turn Pacer on!
- Oversensing:
  - ▣ Turning the sensitivity down – make the pacemaker less sensitive by increasing the sensitivity value (i.e. if sensitivity is set at 0.5 mV, change it to 0.8 mV).
  - ▣ Decrease mA if they are set very high, as this can produce an afterpotential that can be sensed by the pacemaker.
  - ▣ Put in asynchronous mode to verify that the pacemaker is capable of releasing stimuli
- Loose or broken connections
  - ▣ Check and tighten all connections
  - ▣ Chest x-ray to identify broken lead
- Battery Failure
  - ▣ Replace battery



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## Troubleshooting Pacemakers

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- **Failure to Pace (Fire)**
  - ▣ Pacer does not fire when indicated
  - ▣ Pacer spike is not present when expected
  - ▣ Recognized by pauses longer than the automatic interval or the absence of pacer spike at the end of the escape interval



**Connections at the top of a temporary pacemaker were not tight, creating intermittent loss of contact with the bridging cable and the absence of pacer spikes where they would be expected.**

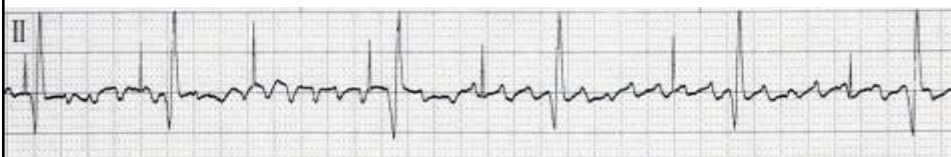
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## Troubleshooting Pacemakers

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### ❑ **Failure to Capture**

- ❑ **Pacemaker fires but depolarization does not occur**
- ❑ **Recognized by spike not followed by depolarization**



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## Troubleshooting Pacemakers

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### **Causes of Failure to Capture**

- ❑ Output (mA) too low
- ❑ Pacing stimulus fall in the refractory period
- ❑ Catheter tip no longer in contact with myocardium
- ❑ Battery failure

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## Troubleshooting Pacemakers

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### Interventions for Failure to Capture

- Emergently treat patient as condition requires
- Output too low – turn up mA
  - ▢ Pacing threshold can change
    - Acute MI, electrolytes
- Impulse occurs during intrinsic refractory period
  - ▢ Unable to capture due to being refractory
  - ▢ Could be a sensing issue
- Lead displacement – catheter tip no longer in contact with myocardium
  - ▢ Reposition patient – often on left side
  - ▢ May need lead replaced
- Chamber perforation
  - ▢ Monitor for tamponade, diaphragmatic pacing
- Replace battery or pulse generator



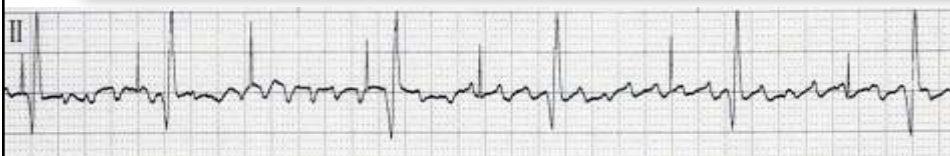
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## Troubleshooting Pacemakers

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### □ Failure to Capture

- Pacemaker fires but depolarization does not occur
- Recognized by spike not followed by depolarization



**Failure to capture occurred when the patient was turned to his right side. Capture returned when placed on his back or left side.**

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# Sensitivity: The Fence

The diagram illustrates three scenarios of a fence representing sensitivity. In scenario A, the fence is too high, and a red signal spike does not clear it. In scenario B, the fence is at the correct height, and the red signal spike clears it. In scenario C, the fence is too low, and the red signal spike clears it easily. A photograph of a pacemaker sensitivity control knob is shown in the top right corner.

Sensitivity is too low (fence is too high). Increasing sensitivity will lower fence.

Picture Courtesy of Cardiovascular Nursing Education Associates

Sensitivity is too high (fence is too low). Decreasing sensitivity will raise the fence.

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# Troubleshooting Pacemakers

- Failure to Sense (Undersensing)**
  - Pacer fails to recognize intrinsic activity (fence too high)
  - Recognized by pacer spikes falling closer to the intrinsic beats than the escape interval; spikes land indiscriminately throughout the cardiac cycle

An ECG tracing on a grid showing a regular rhythm of pacer spikes. Red arrows indicate the escape interval between pacer spikes. Two orange stars mark points where pacer spikes occur too close to intrinsic beats, indicating undersensing.

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## Troubleshooting Pacemakers

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### □ Interventions for Undersensing

- Emergently treat patient as condition requires
- Lead positioning or replacement may be necessary
- Make sure pacer is not on asynchronous
- Increase sensitivity (turn to demand mode – more sensitive)
- Check connections
- Change pacer rate – independent of patients own rhythm
- Chest X-ray to verify position and check for lead fractures
- Change from bipolar system to unipolar system to increase sensing signal – occurs with permanent pacer programmer



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## Troubleshooting Pacemakers

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### □ Causes of Undersensing

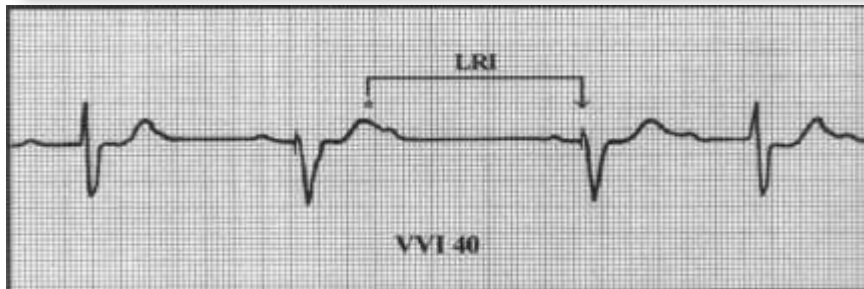
- Asynchronous mode of pacing
- Spontaneous ventricular activity falling in the pacemaker's refractory period
- Catheter out of position or lying in infarcted tissue
- Low QRS voltage reducing size of signal to sensing circuit. This can be due to drug therapy, electrolyte imbalances, or disease process.
- Break in connections, faulty pulse generator, or battery failure

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## Troubleshooting Pacemakers

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- **Failure to Sense (Oversensing) – fence too low!**
  - Pacemaker recognizes extraneous electrical activity or the wrong intrinsic electrical activity as the inhibiting event
  - Recognized by the absence of pacer spikes and failure to fire



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## Troubleshooting Pacemakers

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- Causes of Oversensing
  - Sensitivity set too high
  - Electromagnetic interference
  - Myopotentials
  - T wave potentials

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## Troubleshooting Pacemakers

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### Interventions for Oversensing

- ▣ Too sensitive - decrease sensitivity (turn to a higher value)
- ▣ If mA is high – decrease
- ▣ Chest X-ray to assess lead placement
- ▣ Remove from EMI
- ▣ Ensure that all equipment is properly grounded
- ▣ Switch from unipolar to bipolar

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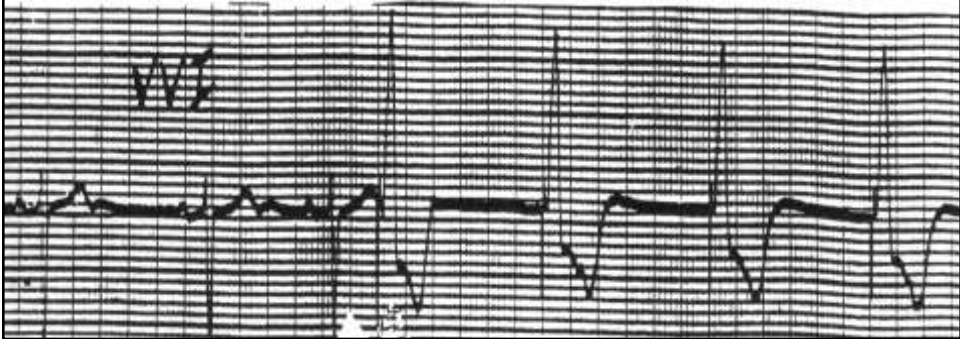
# LET'S PRACTICE

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This strip demonstrates normal pacemaker function.

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- 1. True
- 2. False

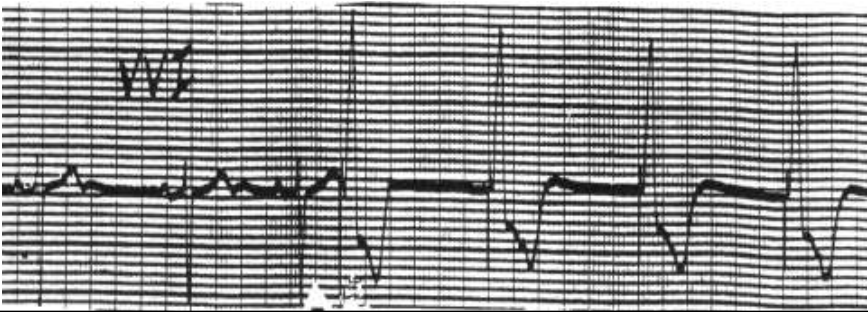


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This strip demonstrates

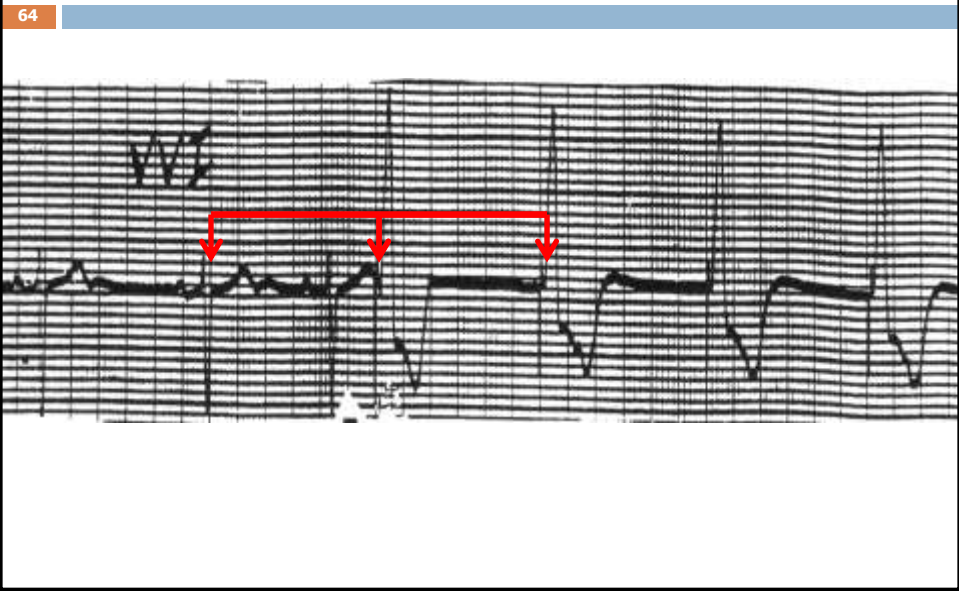
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- 1. Pacemaker failure to pace
- 2. Pacemaker failure to capture
- 3. Pacemaker failure to sense



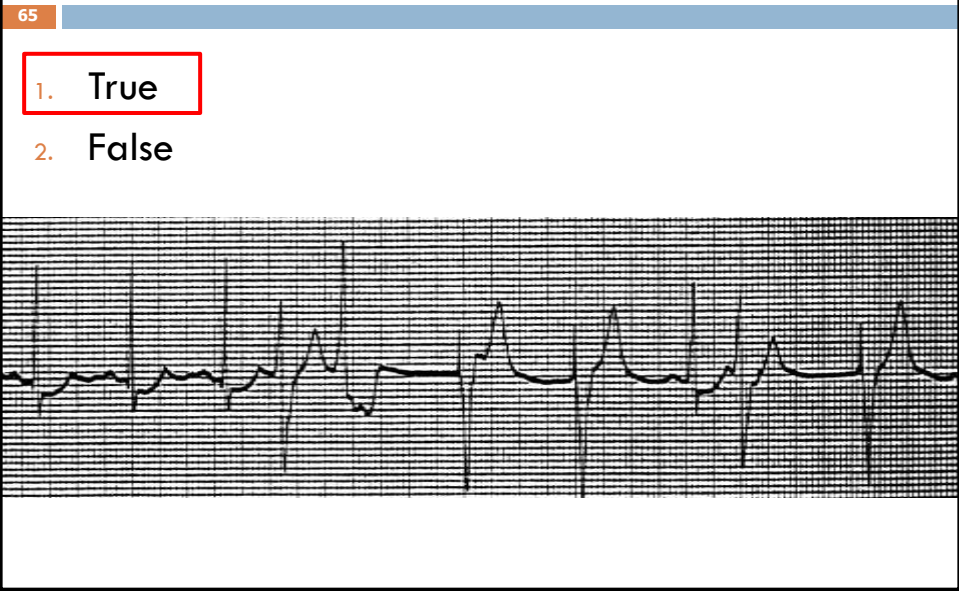
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# Let's Practice VVI

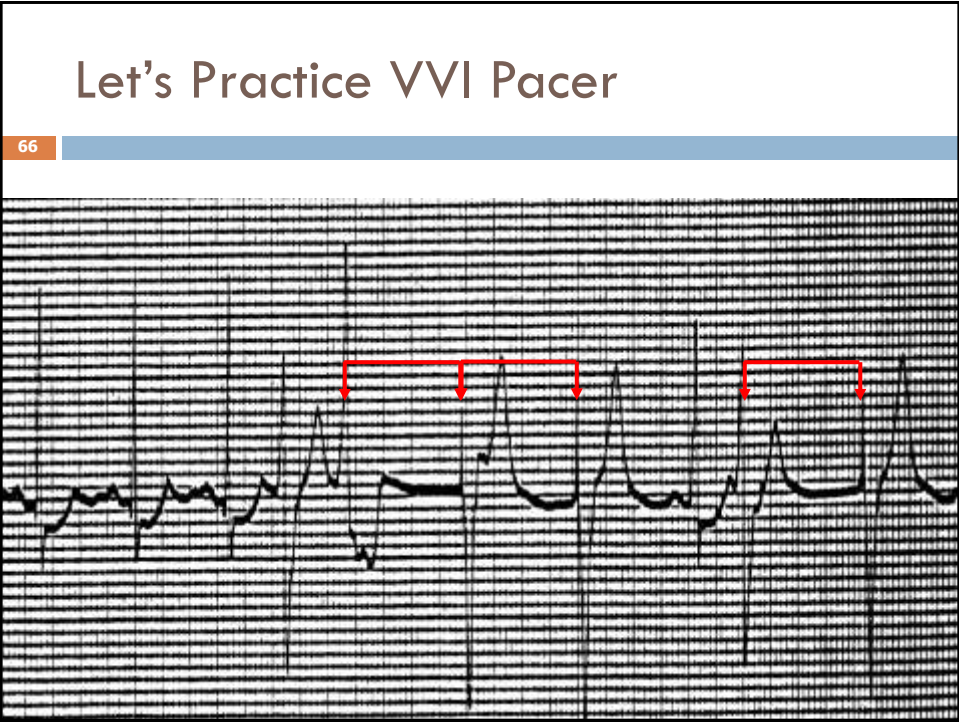


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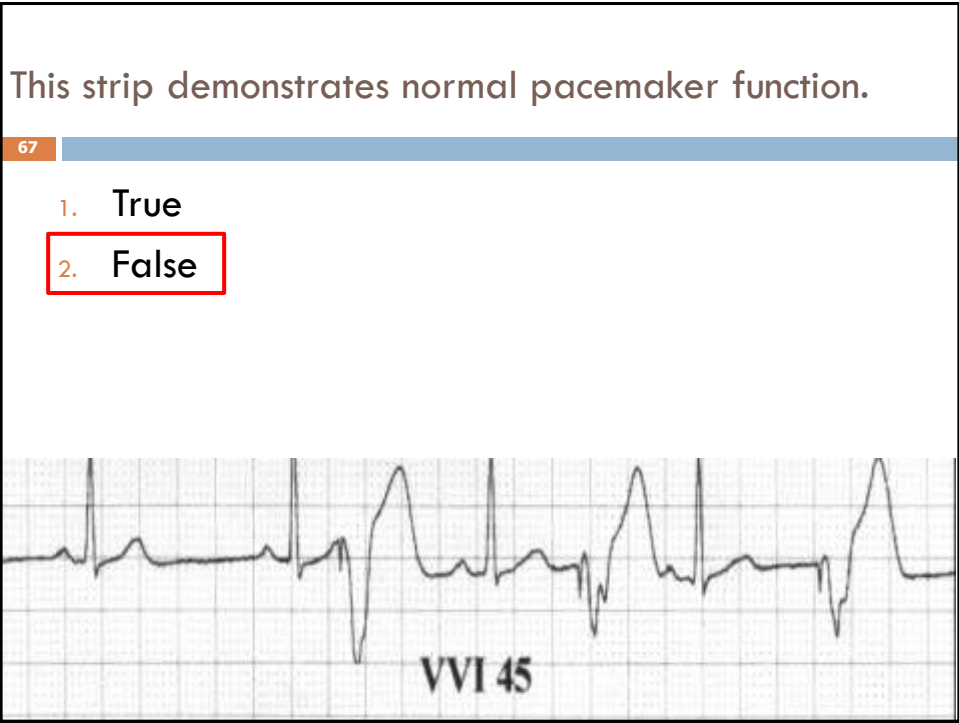
This strip demonstrates normal pacemaker function.



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This strip demonstrates.

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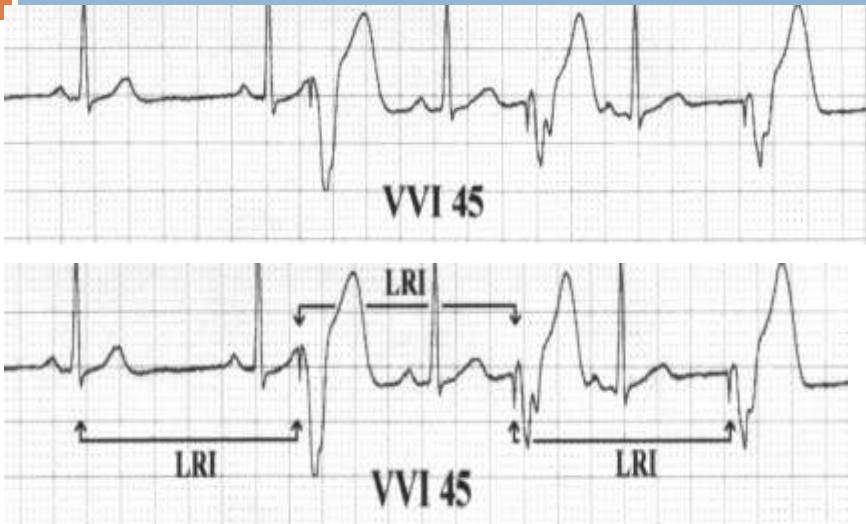
- 1. Pacemaker failure to pace
- 2. Pacemaker failure to sense
- 3. Pacemaker failure to capture



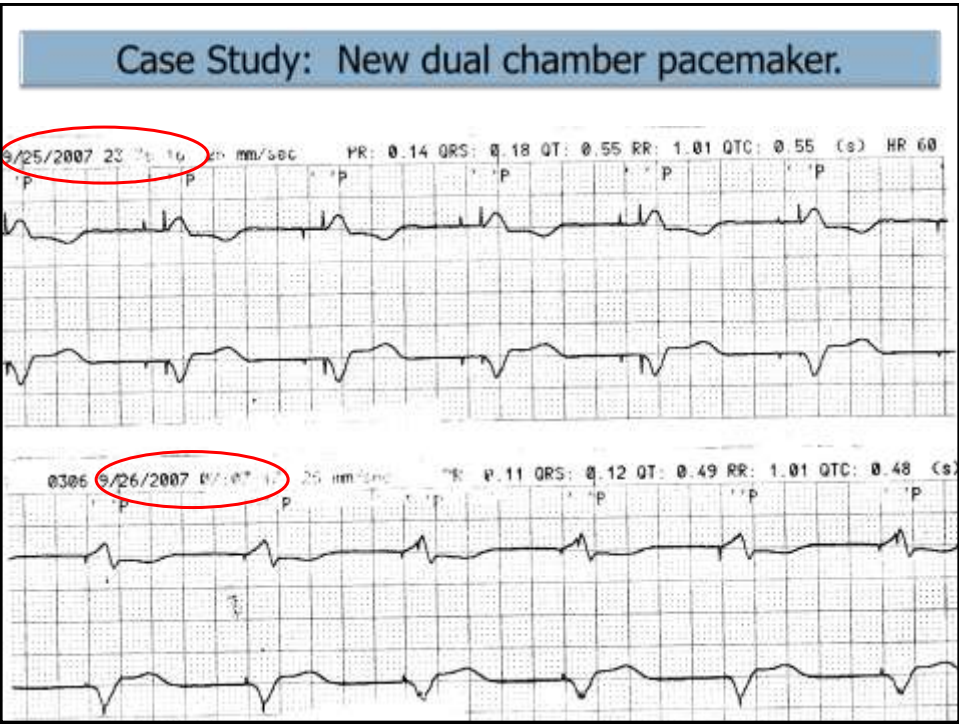
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Let's Practice VVI Pacer

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“ADDITIVES” IN DEVICE  
THERAPY

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## Adaptive—Rate Pacing

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- Rate Responsiveness
- Sensors detect changes in physiologic needs
- Increase pacer rate in response to needs
- Sensors detect changes in metabolic demand
  - ▣ Sense motion
  - ▣ Physiologic indicators
    - Minute ventilation – depth of breath

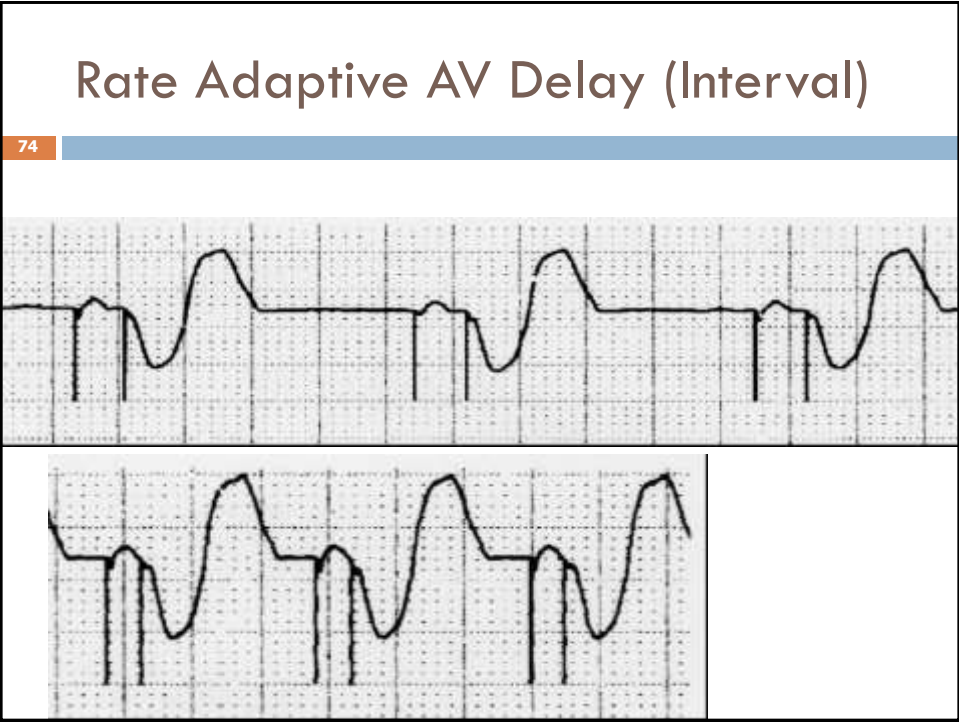
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## Adaptive—Rate Pacing Examples

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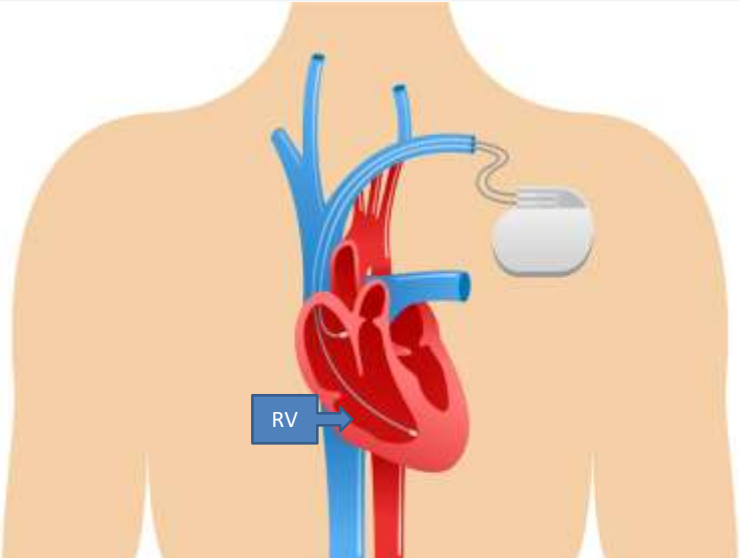
**Why has pacing become so confusing?**

**MINIMIZING RIGHT VENTRICULAR PACING**

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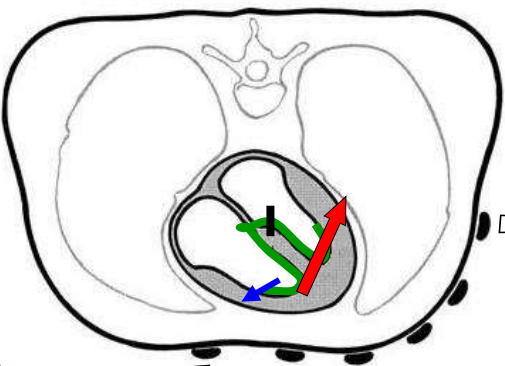
RV Pacing creates a physiologic  
Left Bundle Branch Block



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76

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Left Bundle Branch Block



$V_1 = QS$

$V_6 = \text{wide R}$

$V1 = rS$

**Therefore:**  
**A right ventricular paced QRS in  $V_1$  should be negative.**

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Drawing Courtesy of Cardiovascular Nursing Education Associates

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## The Dual Chamber And VVI Implanted Defibrillator (**DAVID**) Trial

- Published 2003
- Evaluated the impact of dual chamber pacing (DDDR-70) vs ventricular backup pacing (VVI-40) for patients with standard indications for ICD and not brady pacing.
- 506 patient with LVEF  $\leq 40\%$  randomized to either arm
- Results:
  - Combined endpoint of mortality or hospitalization for CHF at one year was 16.1% (VVI-40) vs. 26.7% (DDDR-70), ( $p \sim 0.03$ )
  - Mortality 6.5% (VVI-40) vs. 10.1% (DDDR-70) ( $p \sim 0.15$ )
  - CHF hospitalization 13.3% (VVI-40) vs. 22.5% (DDDR-70) ( $p \sim 0.07$ ).
- Conclusion: For ICD patients, DDDR-70 pacing exhibits no clinical advantage over VVI-40 pacing and may increase CHF and mortality

Wilkoff, Bruce L. "The dual chamber and VVI implantable defibrillator (DAVID) trial." *Pacing and Clinical Electrophysiology* 26.7p1 (2003): 1566-1566. <sup>78</sup>

78

## Mode Selection Trial (**MOST**)

- Evaluated the incidence, predictors, and treatment of pacemaker syndrome in patients with sinus node dysfunction treated with ventricular-based (VVIR) pacing
- 996 patients with VVIR Pacing
  - 18.3% met criteria for Pacemaker syndrome
- Post-implantation predictors of pacemaker syndrome were a higher percentage of paced beats, higher programmed low rate, and slower underlying spontaneous sinus rate.
- Quality of life decreased at the time of diagnosis of pacemaker syndrome and improved with reprogramming to atrial-based pacing.

Link, Mark S., et al. "High incidence of pacemaker syndrome in patients with sinus node dysfunction treated with ventricular-based pacing in the Mode Selection Trial (MOST)." *Journal of the American College of Cardiology* 43.11 (2004): 2066-2071. <sup>79</sup>

79

### The Clinical Implications of Cumulative Right Ventricular Pacing in the Multicenter Automatic Defibrillator Trial II

- Study designed to assess whether RV pacing in the implantable cardioverter defibrillator (ICD) arm of the MADIT II trial was associated with an unfavorable outcome.
- Patients in MADIT II who were predominantly paced had a higher rate of new or worsened heart failure and were more likely to receive therapy for VT/VF. These results suggest the deleterious consequences of RV pacing, particularly in the setting of severe LV dysfunction.

Steinberg, Jonathan S., et al. "The clinical implications of cumulative right ventricular pacing in the multicenter automatic defibrillator trial II." *Journal of cardiovascular electrophysiology* 16.4 (2005): 359-365.

80

80

### SAVE PACE Trial

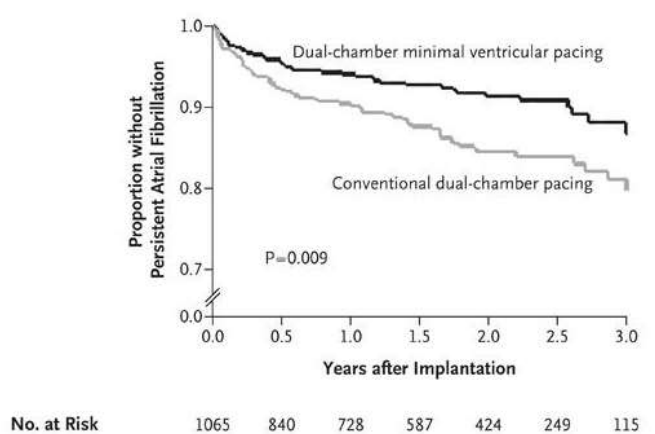
- Evaluate whether dual chamber pacing incorporating a strategy to minimize right ventricular stimulation could reduce the risk of persistent atrial fibrillation compared to conventional dual chamber pacing in patients with sinus node disease.
- 1065 patients with symptomatic bradycardia randomized to dual chamber minimal ventricular pacing (530) or conventional dual chamber pacing
- Trial terminated early due to benefit
- The incidence of persistent atrial fibrillation was reduced by the ventricular pacing minimization strategy (HR 0.60, CI 0.41–0.88,  $p=0.004$ ).
- Patients without persistent AF had fewer HF hospitalizations (3.2% vs. 7.3%,  $p=0.03$ ).

Sweeney, M. O., et al. "Search AV Extension and Managed Ventricular Pacing for Promoting Atrioventricular Conduction (SAVE PACE) Trial. Minimizing ventricular pacing to reduce atrial fibrillation in sinus-node disease." *N Engl J Med* 357.10 (2007): 1000-8.

81

81

40% decrease in the relative risk of persistent atrial fibrillation at any time interval among patients in the group assigned to dual-chamber minimal ventricular pacing as compared with those in the group assigned to conventional dual-chamber pacing.



Sweeney, M. O., et al. "Search AV Extension and Managed Ventricular Pacing for Promoting Atrioventricular Conduction (SAVE PACE) Trial. Minimizing ventricular pacing to reduce atrial fibrillation in sinus-node disease." *N Engl J Med* 357.10 (2007): 1000-8. <sup>82</sup>

82

## Minimizing RV Pacing with Dual Chamber Pacers

- Increased hospitalizations for HF (DAVID Trial)
- Increased mortality (DAVID Trial)
- No improvement in mortality, HF hospitalizations or stroke free survival when compared to VVI (MOST Trial, CTOPP Trial)
- AAI pacing demonstrates improved outcomes
- **Reducing RV pacing to less than 10%** in patients with dual chamber pacemakers reduced the relative risk of developing persistent atrial fibrillation by 40% compared to conventional dual chamber pacing (SAVE PACE Trial)

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This is when pacing become  
very confusing!

MINIMIZING RIGHT VENTRICULAR  
PACING

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Minimizing RV Pacing with **DUAL**  
Chamber Pacemakers

Pacer Lead Placement  
Options

Programming Options

- His Bundle
- RV outflow tract
- RV septal sites
- Dual pacers in RV
- LV pacing
- Biventricular pacing

- DDIR mode
- AAIR mode with mode switching
- VVI mode with low rate for those being paced as defibrillation back up only
- **Long AV delays**

85

85

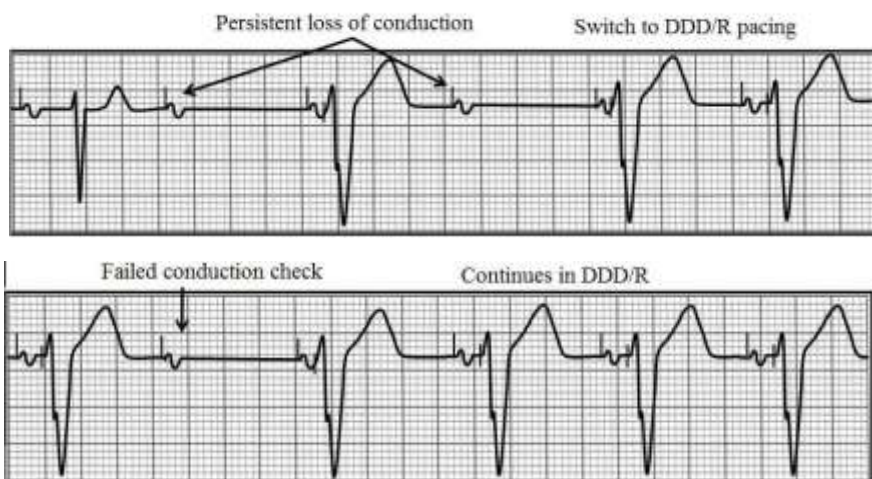
## Managed Ventricular Pacing (MVP)

- Promotes Intrinsic Conduction
- Reduces unnecessary RV pacing
- Risk of atrial fibrillation increases as the percentage of ventricular pacing increases
- AAI(R) pacing
- Back up dual chamber system available
- Medtronic Program
- VIP (Ventricular Intrinsic Preference) – St. Jude

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## Managed Ventricular Pacing



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AV Search Hysteresis

- Guidant Program
- Functions in DDD/R mode and automatically searches for intrinsic AV conduction by extending the AV delay by 10% - 100% (programmable value) to look for intrinsic conduction
- If intrinsic conduction is present, AV delay remains long until conduction fails, then pacer returns to DDD/R mode

© GUIDANT, Inc.

31 32 1 2 // 1 2

150 ms AV Delay 225 ms AV Delay 200 ms PR Interval 225 ms AV Delay 150 ms AV Delay

88

88

Search AV Operation

- Search AV periodically measures AV intervals
- Determine the effect of Search AV delay in reducing unnecessary ventricular pacing, especially in patients with 1:1 conduction
- Encourage intrinsic conduction

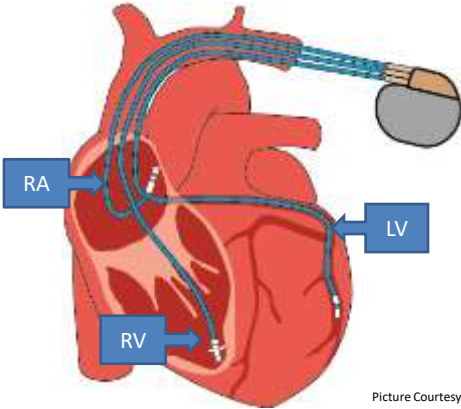
Search AV extension

A P V H 180 A P V H 177 A P V H 180 A P V S 192 A P V S 187 A P V S 137

89

89

Cardiac Resynchronization Therapy



RA

RV

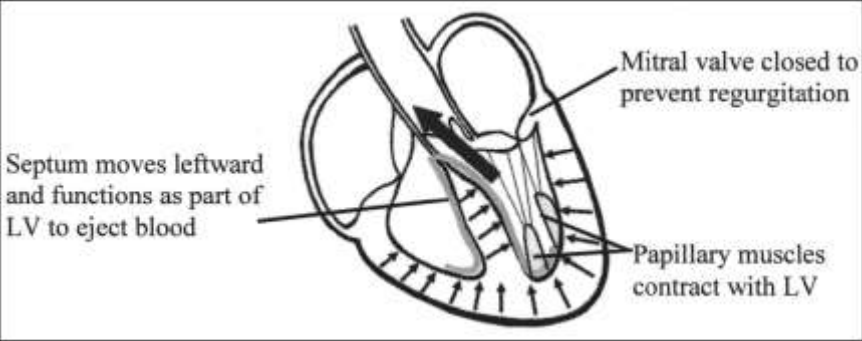
LV

Picture Courtesy of Cardiovascular Nursing Education Associates

First there was one wire, then there were two, and now there might be three!

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Normal Ventricular Contractility



Mitral valve closed to prevent regurgitation

Septum moves leftward and functions as part of LV to eject blood

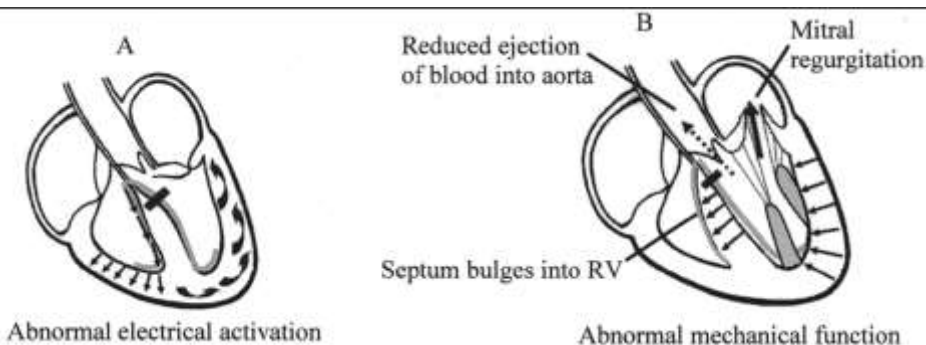
Papillary muscles contract with LV

91

Picture Courtesy of Cardiovascular Nursing Education Associates

91

## Ventricular Depolarization and Contractility with LBBB



92  
Picture Courtesy of Cardiovascular Nursing Education Associates

92

## Cardiac Resynchronization Therapy

- Treatment modality for heart failure
  - NOT JUST PACING
  - Used in conjunction with optimal medical therapy
- Dyssynchrony
  - 1/3 of patients with progression of HF will have prolongation of QRS
  - Associated with worse survival
- CRT-P (CRT-Pacer) or CRT-D (CRT-Defibrillator)
  - Evidence for benefit of CRT-P in Class III/IV HF
  - Most all Class II HF trials involved CRT-D

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## Cardiac Resynchronization Therapy (CRT)

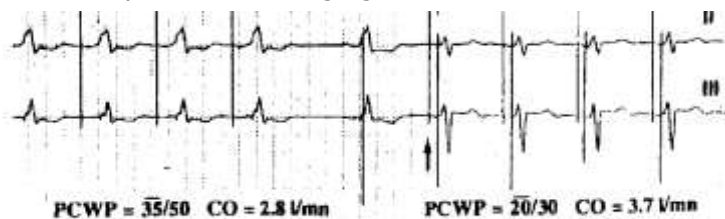
- Goals:
  - Improves contractile function
  - Diminishes secondary mitral regurgitation
  - Can reverse ventricular remodeling
  - Can improve LVEF
  - Improvement in blood pressure may allow for increased up titration of medications – furthering increasing LV function
  - May decrease diuretic needs
  - Improve quality of life
  - Decrease mortality and morbidity

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## Cardiac Resynchronization Therapy

- Allows LV to complete contraction and begin relaxation earlier,
  - increases filling time and improves "atrial kick."
- Causes ventricles and septum to contract simultaneously
  - forces the septum to contract with the LV and prevents it from bulging into the RV during systole.
- Atrial-biventricular pacing
  - restores normal timing between left atrial and left ventricular contraction, allowing the LV papillary muscles to contract earlier and put tension on the mitral valve leaflets to reduce or prevent mitral regurgitation.



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# Indications for CRT

LVEF  $\leq$  35%

GDMT for > 3 months OR GDMT > 40 days if myocardial infarction

Expected survival > 1 year

NYHA class I

- LVEF  $\leq$ 30%
- QRS  $\geq$ 150 ms
- LBBB pattern
- Ischemic cardiomyopathy
- QRS  $\leq$ 150 ms
- Non-LBBB pattern

NYHA class II

- LVEF  $\leq$ 35%
- QRS  $\geq$ 150 ms
- LBBB pattern
- Sinus rhythm
- LVEF  $\leq$ 35%
- QRS 120-149 ms
- LBBB pattern
- Sinus rhythm
- LVEF  $\leq$ 35%
- QRS  $\geq$ 150 ms
- Non-LBBB pattern
- Sinus rhythm
- QRS  $\leq$ 150 ms
- Non-LBBB pattern

NYHA class III & Ambulatory class IV

- LVEF  $\leq$ 35%
- QRS  $\geq$ 150 ms
- LBBB pattern
- Sinus rhythm
- LVEF  $\leq$ 35%
- QRS 120-149 ms
- LBBB pattern
- Sinus rhythm
- LVEF  $\leq$ 35%
- QRS  $\geq$ 150 ms
- Non-LBBB pattern
- Sinus rhythm
- LVEF  $\leq$ 35%
- QRS 120-149 ms
- Non-LBBB pattern
- Sinus rhythm

Special CRT Indications

- Anticipated to require frequent ventricular pacing (>40%)
- Atrial fibrillation, if ventricular pacing is required and rate control will result in near 100% ventricular pacing with CRT

Green: Class I (Benefit >> Risk)

Gold: Class IIa (Benefit > Risk)

Orange: Class IIb (Benefit  $\geq$  Risk)

Red: Class III (No benefit or harm)

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# HOW DO YOU KNOW YOUR PATIENT IS RECEIVING RESYNCHRONIZATION THERAPY BY LOOKING AT THE RHYTHM STRIP?





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# CRT

**Goal: Force biventricular pacing**  
**Goal: Ventricular Pacing 90% of time or greater**

Causes of Loss of Bi V pacing:

- Long AV Delays
- Prolonged PVARP
- ST with 1 degree AV Block
- Lead dislodgement
- Atrial fibrillation
- Ventricular Ectopy

Optimization

- ✓ Echo guided
- ✓ Device driven

**Routine re-evaluation of  
pacing burden is important in  
the treatment of HF. If HF  
worsens assess CRT function.**

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# Internal Monitoring with CRT

- Heart rate variability
- Patient activity
- Night heart rate
- Impedance

**Diuretic dose  
may need to be  
decreased after  
initiation of CRT.**

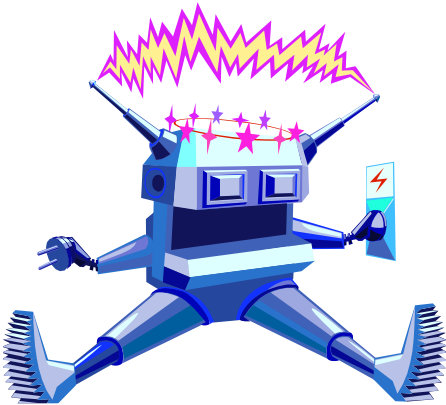
**Routine re-evaluation of pacing burden is  
important in the treatment of HF.  
If HF worsens assess CRT function.**

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# Implantable Cardioverter Defibrillators


CRT-P  
versus  
CRT-D



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# Implantable Cardioverter Defibrillators



A high proportion of HF deaths occur suddenly and unexpectedly

- ✓ Many due to electrical disturbances, including ventricular arrhythmias, bradycardia and asystole

ICD reduces risk of death from Sudden Cardiac Death (SCD) does not treat HF

- ✓ Purpose: Improve survival

**Shared Decision Making:** Median survival in presence of multiple hospitalizations and CKD < 2 years

- ✓ ICD can also reduce the incidence of bradycardia secondary to backup pacing with ICD
- ✓ Patients with ischemic heart disease (IHD) are at > risk of sudden death than patients with Non IHD
- ✓ Patients with longer QRS also derive greater benefit from ICD
- ✓ If QRS is prolonged with LBBB – CRT-D should be considered

HOWEVER: Frequent shocks can decrease QOL from PTSD

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## ICD Primary Indications

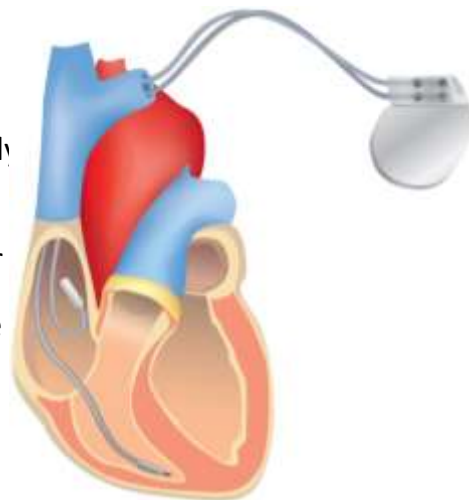
- ICD is recommended: **LVEF of  $\leq 35\%$**
- Post MI  $\geq 40$  days or post revascularization  $\geq 90$  days,
- NYHA class II or III HF despite GDMT
- Meaningful survival is  $>$  than 1 year.

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## Standard ICD Device

- **Pulse Generator**
  - Can / Battery / Brains
  - Prepectoral subfascial pocket
  - Implanted subcutaneously
- **Defibrillator lead**
  - Single chamber, dual chamber, or biventricular pacing
  - Defibrillator lead capable of pacing and defibrillating
  - Placed in right ventricle
  - Detects arrhythmias
  - Delivers therapy



Shutterstock Inc. Standard License

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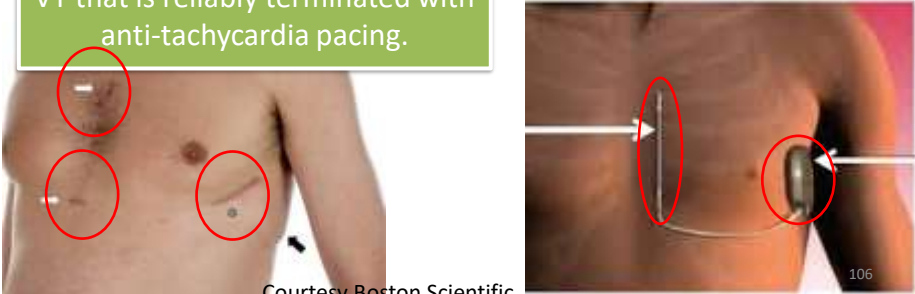
105

## Subcutaneous ICD

For the treatment of life-threatening ventricular tachyarrhythmias in patients who **do not** have symptomatic bradycardia, incessant VT, or spontaneous, frequently recurring VT that is reliably terminated with anti-tachycardia pacing.

Possible Candidates

- No venous access
- High risk complications
- High risk for infections
- History of endocarditis
- Channelopathies





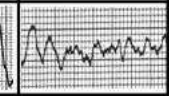


Courtesy Boston Scientific

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## ICD Function – Rhythm Detection

- **Heart Rate**
  - Monitors ventricular rate and delivers therapy when rate exceeds programmed tachycardia detection rate
  - Defined rate boundaries
    - Tachycardia zones
- **Sudden Onset**
  - Detects sudden shortening of cycle length

Sinus	Tach 1	Tach 2	Tach 3	V Fib
				

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## ICD Function – Rhythm Detection

- **Interval stability**
  - Looks for variability in cycle lengths
  - Differentiates regular from irregular rhythms
- **Morphology**
  - Measures width of electrogram
  - Only treats if width is greater than programmed value

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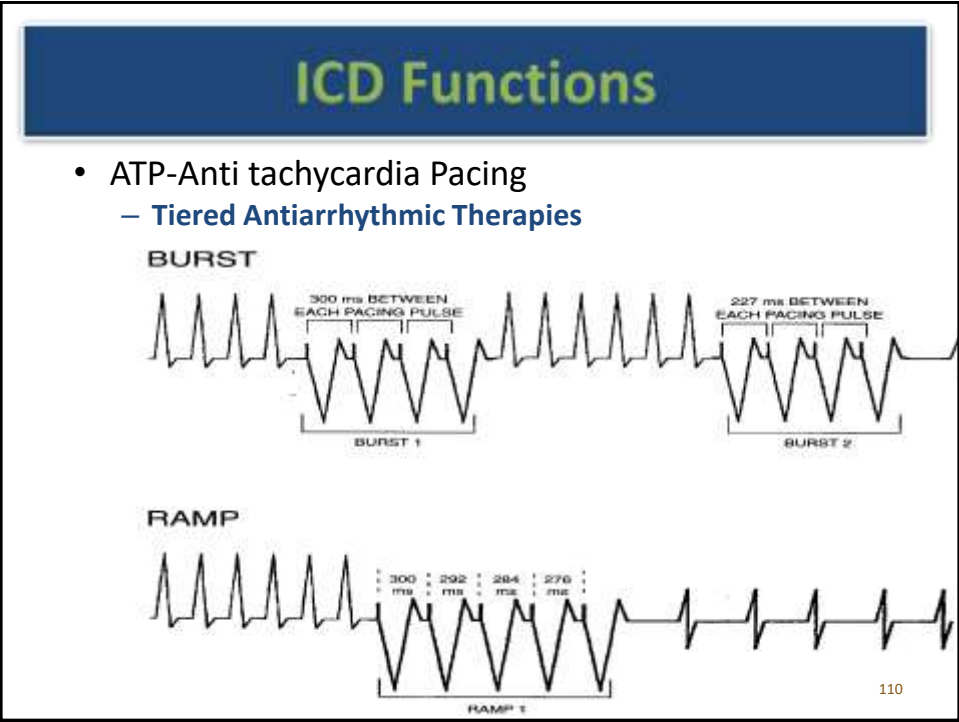
108

## ICD Termination Therapies

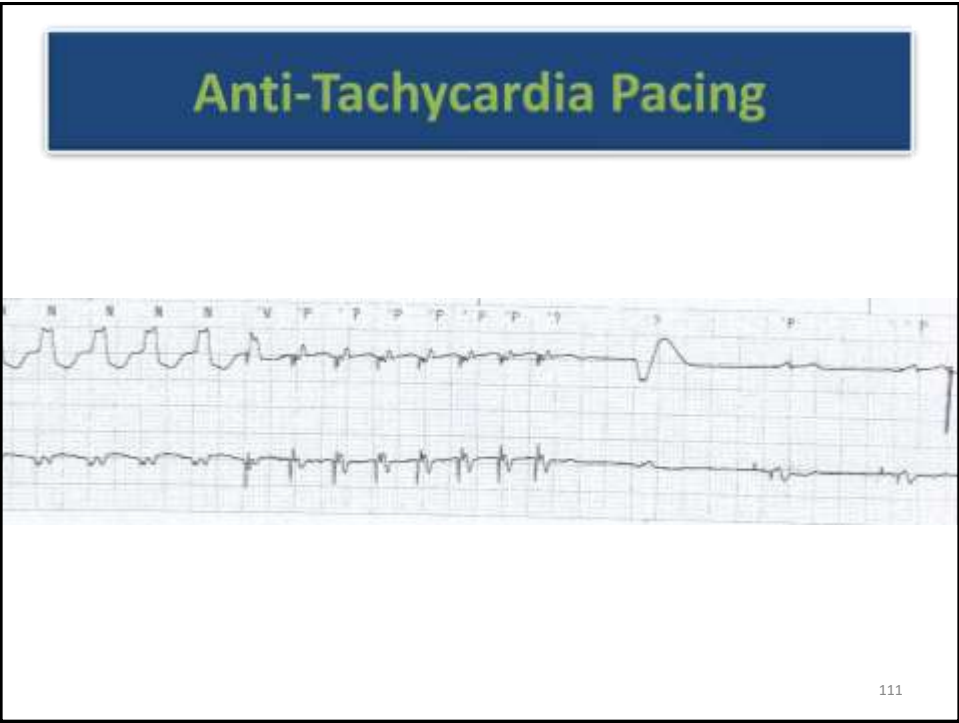
- ATP-Antitachycardia Pacing
  - Painless
  - “Slow” VT’s
  - Burst
  - Ramp
- Cardioversion shock
  - Not commonly used
- Defibrillating shock
  - **Clinical pearl: HR is one criterion:** Rate control in atrial fibrillation is essential

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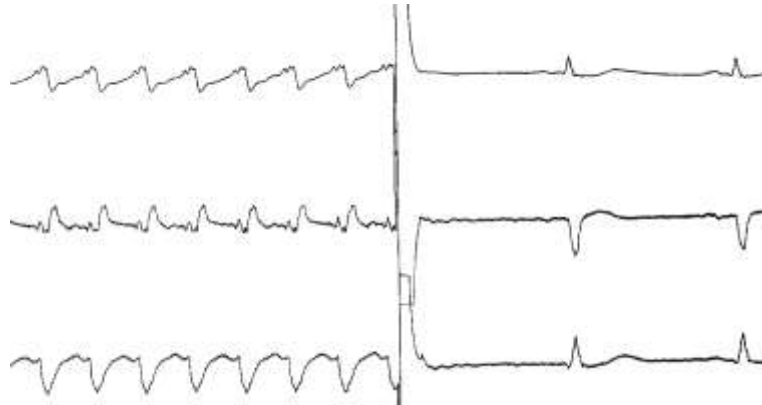


111

## ICD Functions

- **Cardioversion Shock**

- Delivers shocks from 0.1 to 30 joules synchronized on the R wave



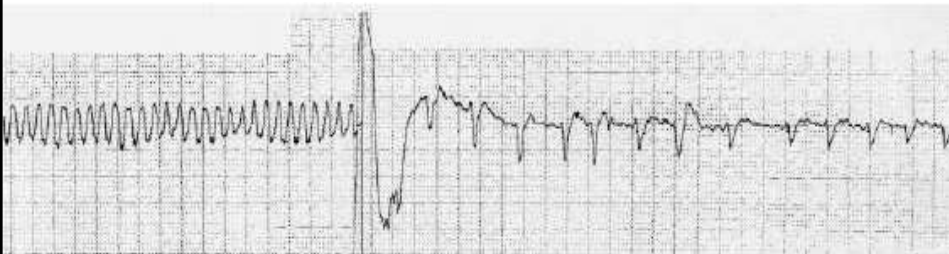
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## ICD Functions

- **Defibrillating Shock**

- Delivers high energy (20-34 joules) unsynchronized shock for VF



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## Care of Patient With ICD

- **Emergency Care for VT/VF**

- Device will deliver therapy within 10-15 seconds and will continue to deliver therapy as programmed
- DO NOT WAIT for device to deliver all its therapies if patient is hemodynamically unstable or in VF
- Defibrillate if necessary – avoid placing paddles directly over device
- Assure patient
- Document rhythm



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## Care of Patient With ICD

- **Emergency Care for VT/VF**

- Device will deliver therapy within 10-15 seconds and will continue to deliver therapy as programmed
- DO NOT WAIT for device to deliver all its therapies if patient is hemodynamically unstable or in VF
- Defibrillate if necessary – avoid placing paddles directly over device
- Assure patient
- Document rhythm



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Care of the Patient with ICD

- **Inappropriate firing of ICD**
  - Device may fire with SVT’s
  - Notify physician to have device deactivated
  - All ICDs can be turned off using a programmer
  - A round magnet over the generator will deactivate arrhythmia detection
  - Removal of magnet will reactivate arrhythmia detection
  - Considerations when the patient requires surgery

NOTE: Magnet works differently for ICD’s than pacemakers!

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Magnet Mode

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Beware of the Magnet!  
FUNCTIONS DIFFERENTLY WITH ICD’S  
THAN WITH PACEMAKERS

WHAT ABOUT THE MAGNET?

MAGNET with Pacemaker (No ICD) Switches the device to an asynchronous mode and pacing at the magnet rate.  Makes the pacer pace!	MAGNET with ICD Suspends tachyarrhythmia detection, causing no therapies to be delivered.  Device will not deliver therapies!
---	--

NURSING RESPONSIBILITY?

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## Care of the Patient with ICD

- **Patient / Family Education**

- Reason for ICD, how it works, what to expect
- Carry ID card always
- Continue to take antiarrhythmic medications if on them
- Importance of follow up visits
  - Every 4-6 months
- Family should learn CPR
- Activities
  - Contact sports restricted
  - Driving may be restricted
  - Swimming and boating OK but not alone
- Support groups

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## What To Do When ICD Fires

- If patient is aware of rhythm sit or lie down
- If receive only one shock – notify MD
- If receive multiple shocks or feels terrible after one shock– call 911
- If device fires and patient does not wake up immediately call 911.

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## Deactivation

- Study of 125 patients with ICDs who had died
  - 52% had do-not-resuscitate orders
  - In 100 patients the ICD had remained active in the last 24 hours of life
  - 31 received shocks in the final 24 hours
- In a survey of next of kin (patients with ICDs who died)
  - 27 of 100 reported discussion of ICD deactivation; 75% of discussion during last few days of life
  - 27% received ICD discharges in the last month of life, and 8% had received a discharge during the final minutes.
- The most important findings:
  - ICD patients often died in the hospital
  - 1/3 had VT events with shocks close to death
  - > ½ had a DNR order of which 51% with a DNR still had shock therapy programmed “on” at 1 hour before death allowing for painful shocks in the final hours of life

Kinch Westerdahl A, Sjoblom J, Mattiasson AC, Rosenqvist M, Frykman V. Implantable cardioverter-defibrillator therapy before death: high risk for painful shocks at end of life. *Circulation* 2014; 129:422–429. 120

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## HRS 2010 Expert Consensus Statement on the Management of Cardiovascular Implantable Electronic Devices (CIEDs) in Patients Nearing End of Life or Requesting Withdrawal of Therapy

- Communication about CIEDs should be a part of a larger conversation about patients’ goals of care.
  - Role of the clinician is to help patients determine how the benefits and burdens of device therapy align with their desired outcomes for their health care.
- Communication about CIED deactivation is an ongoing process
  - Starts prior to implant and continues over time as patient’s health status changes.
- The role of the clinician is to advise and assist the patient and family
  - Ultimate decision-making authority rests with the patient; or his/her surrogate, if the patient does not have capacity to make the decision.
- Multiple options are available to the patient, family, and clinicians with regard to the extent of deactivation of CIED therapy and the modalities available
  - Programming off only certain features such as shock therapy
  - Discontinuation of all therapy
  - Not replacing a depleting device

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# UTILIZING DEVICE DATA

- PVC BURDEN
  - INCREASE IN VT WITH ANTI TACHYCARDIA PACING
  - INCREASE IN PVCS
- LOW HEART RATE WITH ICD
- DECREASED ACTIVITY LEVEL
- A FIB CONVERSION WITH SHOCK
- DISCOVERING AF

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## Internal Monitoring with Devices

- Atrial fibrillation burden
- % Pacing
- Average Heart Rate
- Patient activity
- Heart rate variability
- Device Specific Features
  - Boston Scientific
  - St. Jude - ? ICD or CRT
  - Medtronic - ? ICD or CRT
- Ventricular arrhythmias and treatments

P = Program  
I = Interrogate  
F = Fibrilate

AT/AF total hours/day

V. rate during AT/AF (bpm)

% Pacing/day

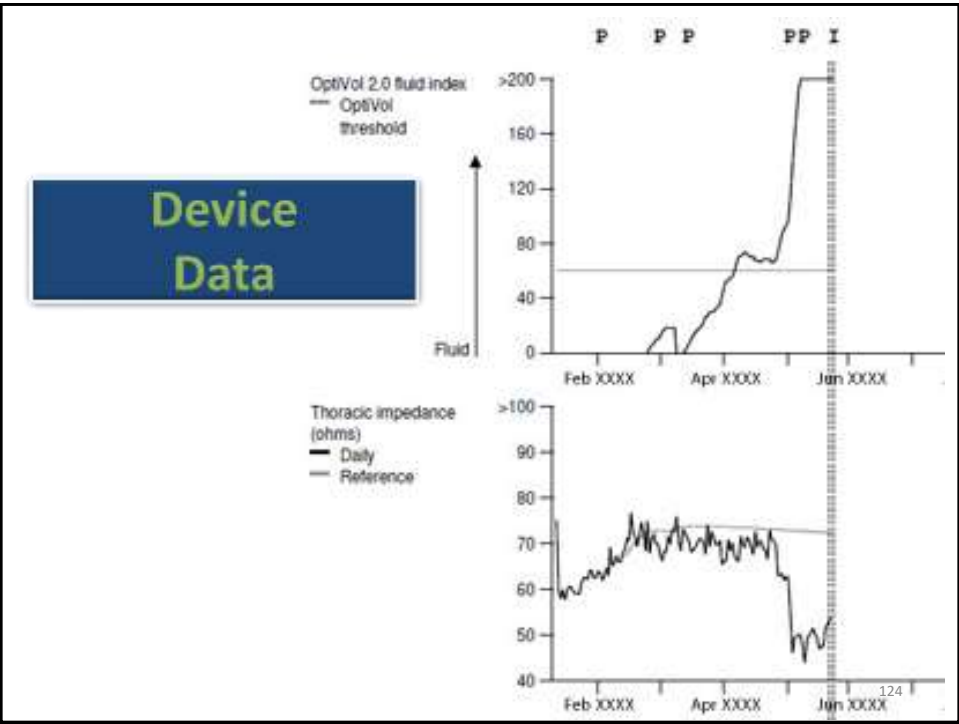
Avg. V. rate (bpm)

Patient activity (count/day)

Heart rate variability (ms)

Jun 2009 Aug 2009 Oct 2009 Dec 2009

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LATITUDE® Patient Management - Combined Follow-up Report  
Jul 27, 2017

Brady Counters	Reset Before Last 0 day(s) Oct 11, 2016 to Oct 11, 2016	Since Last Reset 195 day(s) Oct 11, 2016 to Apr 25, 2017
Counters		
% A Paced	29	2
% V Paced	31	2
Intrinsic Promotion		
AV Search	0	0
% Successful	0	0
Rate Hysteresis	0	0
% Successful	0	0
Atrial Arrhythmia		
% AT/AF	N/R	0
Total Time in AT/AF (min)	N/R	0.0
Episodes by Duration		
< 1 minute	1	1
1 min - < 1 hr	0	0
1 hr - < 24 hr	0	0
24 hr - < 48 hr	0	0
> 48 hr	0	0
Total PACs	57	7642
Ventricular Counters		
Total PVCs	29	842006
Three or More PVCs	4	0
Clinical Counters	Since Last Reset Oct 11, 2016	Device Totals
MRI Protection Mode	0	0

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**- Kat Lehmann**

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# My Vision Statement

*Practice with joy!  
Positively impact every patient and family on their journey and provide safe passage. Meet them where they are, connecting with them in a meaningful way, and delivering care with wisdom and intention.*

*- Cindy*

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Nurses Make a Difference



**BE THE BEST THAT YOU CAN BE  
EVERY DAY. YOUR PATIENTS ARE  
COUNTING ON IT!**

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