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Perioperative Electrophysiology:

Perioperative Management of Pacemakers

Lecture #2

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I have no conflict of Interest

What we discussed in Lecture #1

- Basic components of the pacemaker
  - Pulse generator
  - Leads
- Basic pacemaker-related physiology
  - Electricity/Batteries
  - Action Potential

Lecture #2

- Pacemaker capture
  - Capture fundamentals
  - Determination of capture thresholds
- Pacemaker sensing
  - Sensing fundamentals
  - Determination of P-wave and R-wave Amplitudes

Myocardial Stimulation Capture Requirements

- Four Components of Adequate Stimulus
  1. Intact source of electrical pulse (Pulse Gen)
  2. Conductor between source and stimulating electrode (Lead Conductor)
  3. Electrode for focused delivery of the pulse to the myocardium (Pacer Electrode)
  4. Area of excitable myocardium

Concept #1: Stimulus Density

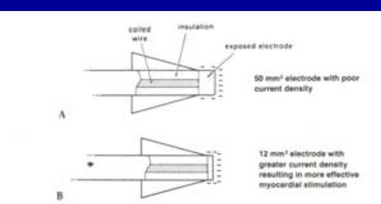
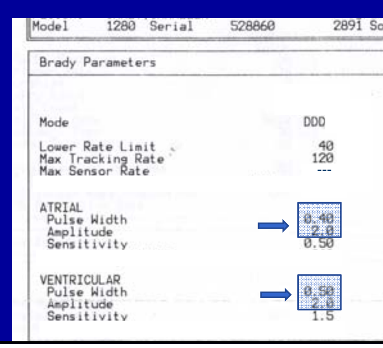


Figure 2-12 Current Density.
A: An older-model electrode tip of 50-mm² surface area has poor current density. **B:** When the same charge is sent through a 12-mm² electrode, the same number of electrons is more concentrated and stimulates the myocardium more effectively. For myocardial stimulation, the smaller electrode is the better; however, when electrode area is much less than 4 to 12 mm², the sensing ability of the electrode is impaired (polarization resistance rises, as discussed in Chapter 3).

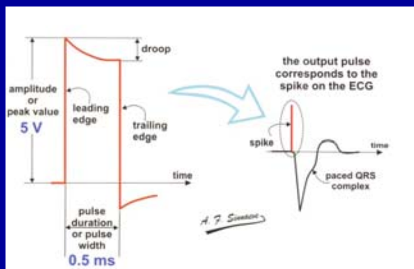
If the same charge is sent through a smaller electrode, the stimulus intensity is greater

Moses, Cardiac Pacing page 38

Concept #2: Pacing Output is described in Amplitude and Duration

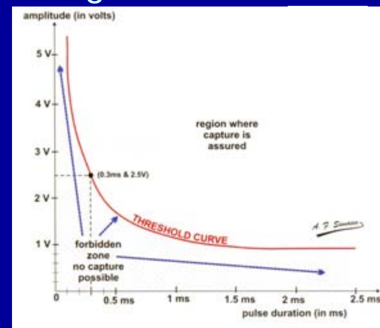


Pacing Output: Amplitude and Pulse Wave Duration



Barold SS, Cardiac Pacemakers and Resynch., p. 23

Strength-Duration Curve



Barold SS, Cardiac Pacemakers and Resynch. P.28

Key Term: Rheobase

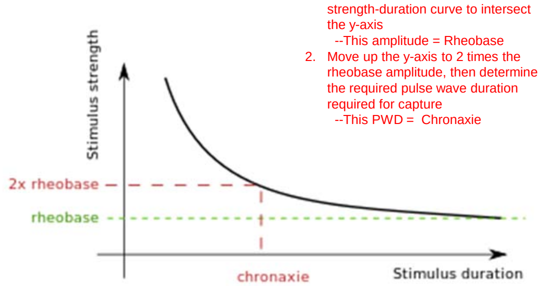
- Rhe = current
- Base = bottom
- The lowest capture threshold (amplitude) possible with a very long pulse width

Key Term: Chronaxie

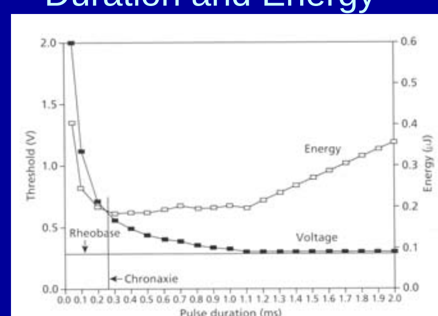
- Chron = time
- The pulse wave duration required for capture using amplitude of 2 X the Rheobase amplitude

Rheobase and Chronaxie

1. Draw a line from the nadir of the strength-duration curve to intersect the y-axis
   --This amplitude = Rheobase
2. Move up the y-axis to 2 times the rheobase amplitude, then determine the required pulse wave duration required for capture
   --This PWD = Chronaxie



Threshold Amplitude, Pulse Duration and Energy



Ellenbogen, Cardiac Pacing and ICDs p. 40

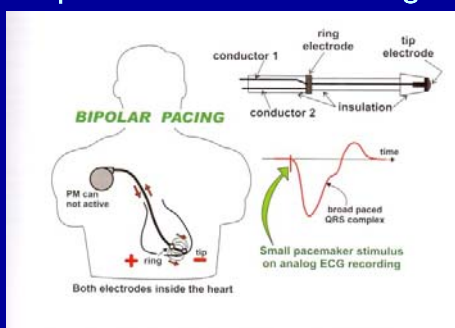
Clinical Use of the Rheobase and Chronaxie

- At implant, the programmer will often set the pacing amplitude at 2 X the Chronaxie amplitude at the Chronaxie PWD

Concept #3

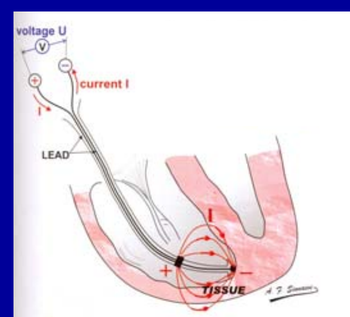
- Pacing can be Bipolar or Unipolar

Bipolar Electrode Pacing



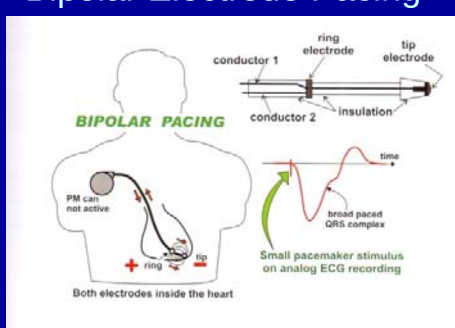
Barold, Cardiac Pacemakers and Resynch., p. 31

Bipolar Electrode Pacing



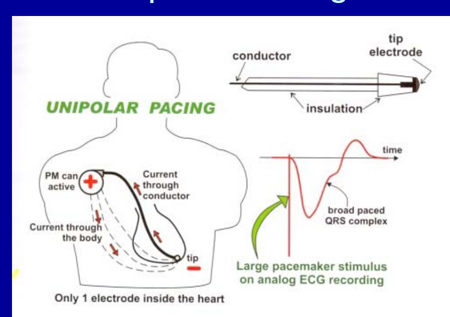
Barold, Cardiac Pacing and Resynchron. p.13

Bipolar Electrode Pacing



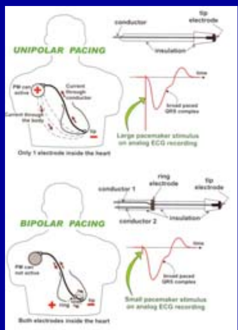
Barold, Cardiac Pacemakers and Resynch., p. 31

Unipolar Pacing



Barold, Cardiac Pacemakers and Resynch., p. 31

Unipolar vs Bipolar Pacing Comparison



Unipolar Pacing
- Single electrode in the heart
- Large stimulus artifact on EKG

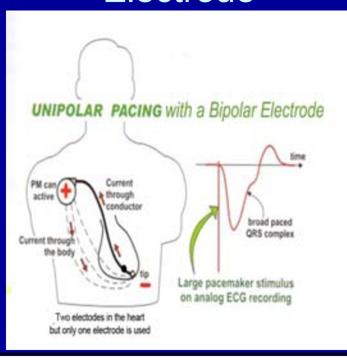
Bipolar Pacing
- Two electrodes in the heart
- Smaller stimulus artifact on EKG

Barold, Cardiac Pacemakers and Resynch., p. 31

Nota Bene

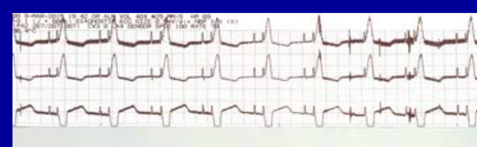
- One can unipolar pace with a bipolar electrode
  - Use one of the two electrodes on the lead as one limb of the circuit and use the pulse generator as the other limb

Unipolar Pacing with a Bipolar Electrode

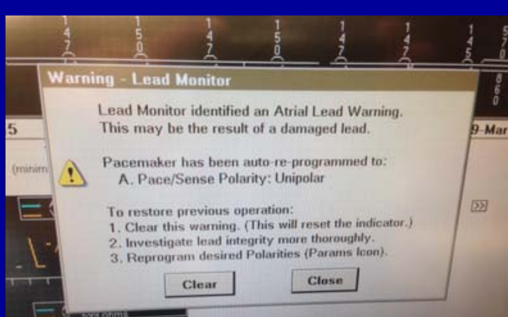


Bipolar vs Unipolar in Cardiac OR

Cryomaze procedure performed and EKG changed to the following

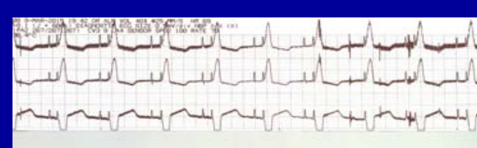


Post-Op Interrogation



Look at the Difference one more time

Cryomaze procedure performed and EKG changed to the following



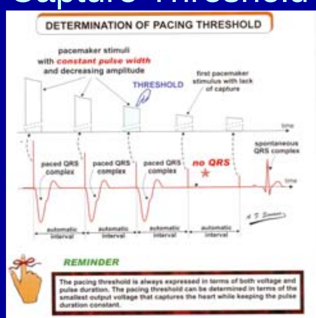
Pacemaker Capture Summary

- Pacing capture depends on sufficient amplitude delivered through a bipolar or unipolar electrode for a sufficient duration
- The amplitude and duration should be set to minimize battery depletion while ensuring an adequate margin of safety

Threshold Capture Testing

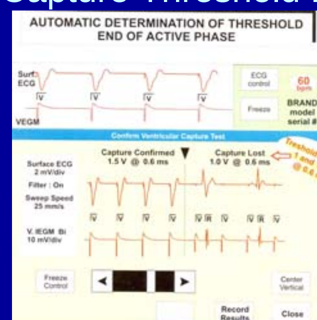
- Done automatically by the pacemaker
- Done manually by a programmer at scheduled intervals and whenever anything happens that could affect the pacemaker integrity
  - Cardiac surgery
  - High intensity EMI

Determination of Ventricular Capture Threshold



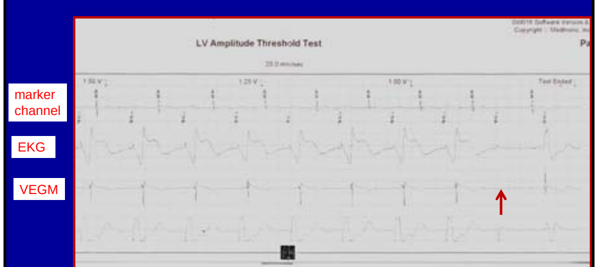
Barold, Cardiac Pacemakers and Resynch., p. 26

Determination of Ventricular Capture Threshold II



Barold, Cardiac Pacemakers and Resynch., p.273

Ventricular Capture Threshold Test III



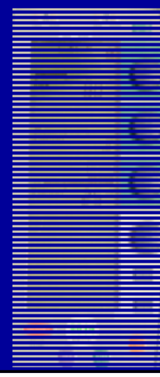
Testing Capture Threshold in Cardiac OR

- Set Pacer Rate in VVI mode at rate 10 bpm higher than intrinsic rate
- Start with Amplitude at 10-25 mA
- Confirm Pacemaker capture
- Decrease the Amplitude slowly until Pacer capture fails:
  - Pacer spike appears without a paced QRS
  - Intrinsic (non-paced) QRS appears

Testing Capture Threshold in Cardiac OR

- If the pacer captures at 5 mV, but not at 4 mV, the capture threshold is 5 mV

Ventricular Capture Test in OR

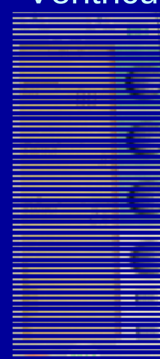


1. Set Pacer to rate 10 above intrinsic rate in VVI mode
2. Start with 10-25 mV and confirm capture
3. Decrease the output until capture fails

Initiation of Ventricular Capture Test

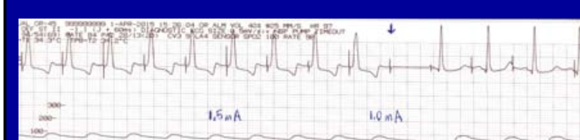
Ventricular pacing initiated at faster than intrinsic rate

Ventricular Capture Test in OR



1. Output down to 2.5 mA, but capture still present

Ventricular Capture Test in OR



- Ventricular Capture intact at 1.5 mA, but pacer spike fails to capture at 1.0 mA
- Intrinsic QRS complexes are seen after a short delay
- V-pacer spikes continue without capture
- Capture Threshold is 1.5 mA

Atrial Capture Threshold

- Essentially the same as Ventricular testing
- Progressive decrease in Atrial paced amplitude until loss of atrial capture occurs
  - Atrial pacer spike not followed by atrial depolarization (P-wave)
  - QRS rate falls to intrinsic rate

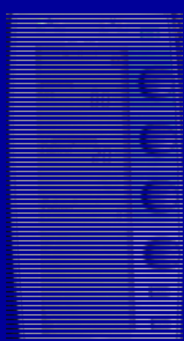
Atrial Capture Threshold Test

Pacer set in AAI mode

Atrial Capture Test in Cardiac OR

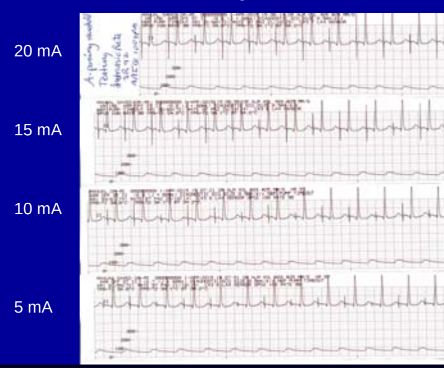
- Set Pacer to AOO or AAI at a rate 10 bpm greater than the intrinsic rate
- Start at maximum atrial output (20 mA)
- Decrease the output until pacer does not capture the atrium
  - Lose the P-wave
  - QRS rate falls back to intrinsic rate

Testing Atrial Capture in Cardiac OR

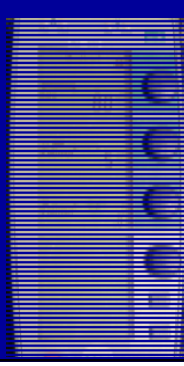


1. Set pacer to AOO with rate 10 bpm higher than intrinsic rate
2. Start with Max output
3. Confirm atrial capture
4. Decrease the amplitude until loss of atrial capture occurs

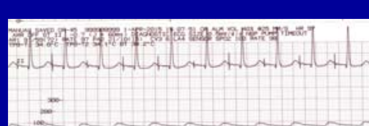
Atrial Capture Test



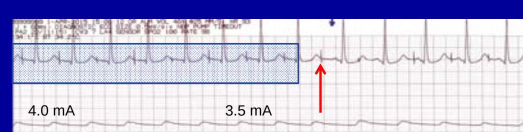
Testing Atrial Capture in Cardiac OR



There is still capture at 5 mA

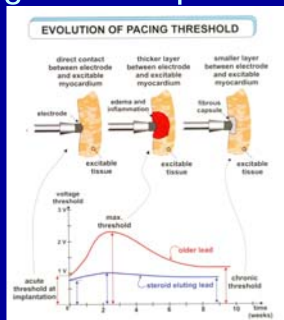


Note Where the Atrial Capture Test Ends



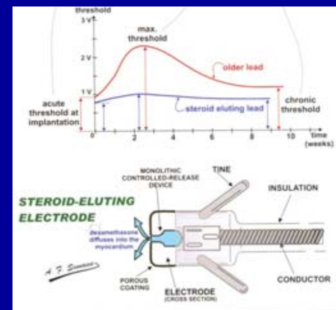
- Notice the paced spikes associated with relatively flat P-waves
- At the arrow the pacer spike is no longer tracked by the QRS
- The arrow head defines the native P-wave
- Multiple non-capturing atrial pacing spikes follow
- Since the pacer stopped capturing at 3.5 mA, the threshold is 4 mA

Does the Capture Threshold Change after Implantation?



Barold, Cardiac Pacemakers and Resynch., p. 36

Does the Capture Threshold Change after Implantation?



Barold, Cardiac Pacemakers and Resynch., p. 36

What Factors can Affect Capture Threshold Acutely?

	Increase threshold	*Decrease threshold*
Antiarrhythmic drugs	Class I Quinidine Procainamide Flecainide Propafenone	
Other drugs	β-blockers	Catecholamines Isoproterenol Corticosteroids
Metabolic conditions	Hyperkalemia Hyperglycemia Hypoxemia Hypercarbia Metabolic acidosis Metabolic alkalosis	
Activity/other conditions	Sleeping Eating Viral illness Vagal tone	Exercise Sympathetic tone

Ellenbogen, Cardiac Pacing and ICDs p. 47

Practice Assessment: RV Capture Threshold

Where does the test actually end?
What is the capture threshold?

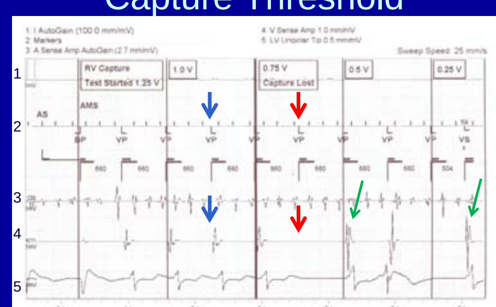
Answer

Test Results: Right Ventricular Capture

Page 1 of 6

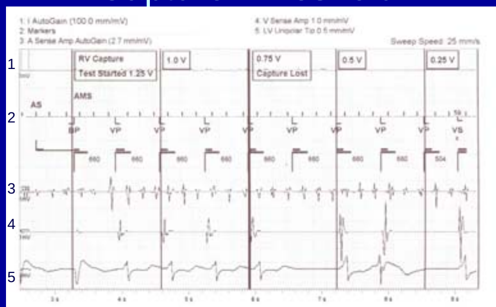
1.0 V @ 0.5 ms (Bi) Apr 6, 2015
Safety Margin: 2.0 : 1 @ 2.0 V
0.75 V @ 0.5 ms (Bi) Mar 13, 2015

Practice Assessment: RV Capture Threshold



Where does the test actually end?
What is the capture threshold?

Practice Assessment: RV Capture Threshold



What is the likely atrial rhythm? Estimate the approximate atrial rate

What does AMS stand for?

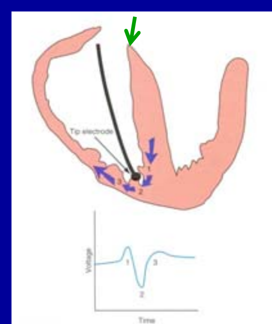
Pacemaker Sensing

- The pacemaker uses the pacemaker lead electrode(s) to monitor the intrinsic electrical activity of the heart.
- Sensing essentially describes how well the electrode(s) detect the intrinsic atrial P-waves or ventricular R-waves

Electrograms

- Electrogram—graphic display of the potential difference between two points in space over time
  - EKG
    - Recorded from electrodes on the skin many cms from the heart
    - Records the depolariz. and repolariz. of entire heart
  - Ventricular Electrogram
    - Recorded from a distinct area in the RV
    - Begins after the EKG signal since EKG detects atrial and proximal ventricular depolarization before the wavefront of depolarization gets to the pacer electrodes

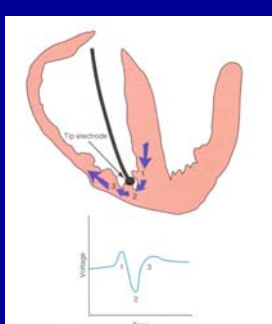
Endocardial Electrogram



1. The normal heart depolarization begins at the superior aspect of the ventricular septum (green arrow)
2. This is near the AV node
3. Depolarization goes toward the apex of the septum then into the RV and LV free walls
4. The normal conduction moves rapidly through specialized conduction cells giving rise to a relatively narrow QRS on an EKG

Ellenbogen, Clinical Cardiac Pacing, Defib, and Resync. 4th ed p.57

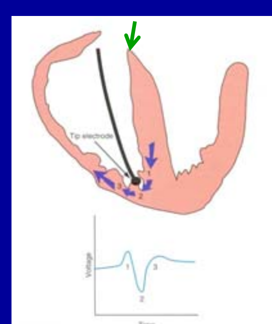
Endocardial Electrogram



1. Now consider the pacer lead
2. The depolarization wavefront descends along septum toward the electrode in the apex
3. Initial positive deflection in the EGM seen at time 1
4. Wavefront passes close to tip electrode at time 2 giving rise to the negative deflection of the EGM
5. Wavefront moves away from electrode along RV free wall leading to the final phase of the electrogram at time 3

Ellenbogen, Clinical Cardiac Pacing, Defib, and Resync. 4th ed p.57

Endocardial Electrogram

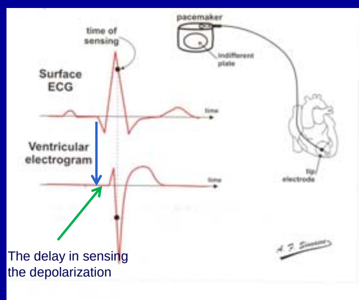


1. The EKG QRS begins when the ventricular depolarization is at the green arrow—near the AV node
2. The pacer electrode does not sense the depolarization until the depolarization wavefront reaches the first blue arrow
3. Thus there is a delay between when the EKG inscribes the QRS and when the ventricular electrogram inscribes the QRS

Ellenbogen, Clinical Cardiac Pacing, Defib, and Resync. 4th ed p.57

EKG vs Ventricular Electrogram

Also note that the ventricular electrogram will not typically detect the P-wave

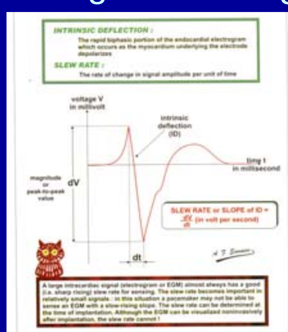


Barold, Cardiac Pacemakers and Resynch. p.43

Sensing Terminology

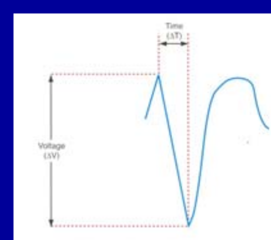
- Intrinsic deflection
  - The largest and steepest deflection of the local electrogram
- Amplitude
  - Peak to peak amplitude of the intrinsic deflection in mV
    - AEGM 1.5-6 mV VEGM 5-30 mV
- Slew Rate
  - Maximum rate of change of voltage of the intrinsic deflection in volts per second
    - AEGM 1-2 V/sec VEGM 2-3 V/sec

Sensing Terminology



Barold, Cardiac Pacemakers and Resynch., p. 60

Slew Rate



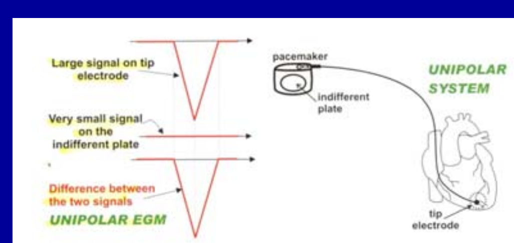
SENSING	ATRIUM	VENTRICLE
Electrogram	>1.5-2.0 mV	>5-6 mV
Slew rate (V/sec)	>0.3	>1.0

Ellenbogen, Clinical Cardiac Pacing, Defib, and Resync. 4th ed p.61

Pacemaker Sensing

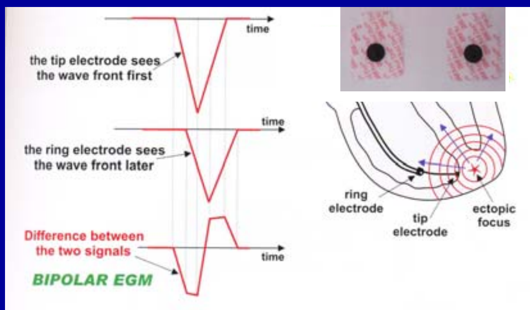
- The pacemaker sensing electrodes can be "unipolar" or bipolar
  - Unipolar
    - One electrode on the heart
    - Other electrode is the pulse generator
  - Bipolar
    - Both electrodes are in the heart—one distal and the other approximately 2 cm more proximal

Unipolar Electrode Sensing



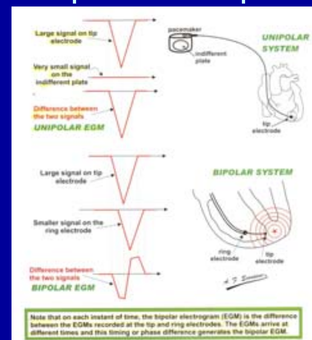
Barold, Cardiac Pacemakers and Resynch., p. 46

Bipolar Electrode Sensing



Barold, Cardiac Pacemakers and Resynch., p. 46

Unipolar vs Bipolar Sensing



- Unipolar signal is usually larger and therefore more easily detected by pacer
- Unipolar signal also more susceptible to EMI or muscle artifact

Barold, Cardiac Pacemakers and Resynch., p. 46

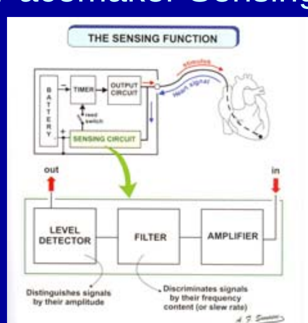
Pacemaker Sensing

- The pacemaker detects the intracardiac depolarization signal—then the pacer modifies/filters that signal prior to comparing the modified signal to a threshold level (a.k.a. "Sensitivity") which is set by the programmer

Sensing Sequence

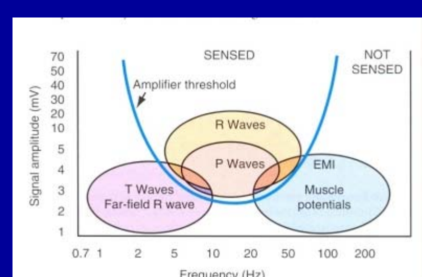
- Raw signal passes from lead to connector into the hermitically sealed can
- Passes through high frequency filter and high-voltage protection circuity
- Enters the sensing amplifier for signal amplification
- Enters the band pass filter to reduce the T-waves, myopotentials and EMI (filtering)
- Signal is then rectified to nullify effects of signal polarity
- This final signal is compared with the sensing-threshold voltage.
- If the processed signal exceeds the sensing threshold voltage, a sensed event is declared to the timing circuits indicated by a marker pulse on the programmer marker channel

Pacemaker Sensing



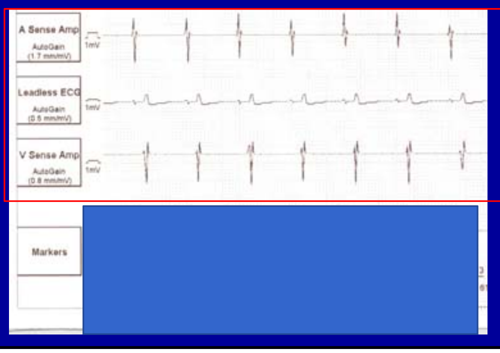
Barold, Cardiac Pacemakers and Resynch., p. 59

Filter

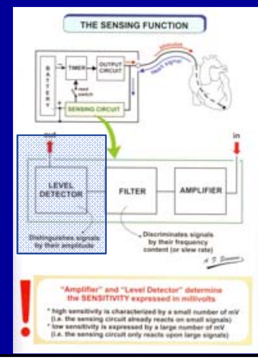


Ellenbogen, Clinical Cardiac Pacing, Defib, and Resync. 4th ed p.60

Pacemaker Electrogram



The Sensing Function



Pacemaker Electrogram

Signal Amplitude vs Sensitivity

- Amplitude=the actual size of the signal in mV
- Sensitivity=the adjustable level or setting in (mV) above which the intracardiac signal is recognized as an intracardiac event
  - A threshold level set by the programmer

Confusing Terminology?

Battery and Lead Measurements Report Page 1

Last Interrogation: 11-Jun-2014 09:08:15

Battery Voltage
(ERI=2.81 V on 19-Feb-2014)
11-Jun-2014 02:15:01
Voltage 2.81 V EOL

Sensing Integrity Counter
(if >300 counts, check for sensing issues)
Since 10-Jun-2014 11:53:15
Short V-V Intervals 0

Atrial Lead Position Check
No measurement since reset

Lead Impedance
11-Jun-2014 09:09:22
A. Pacing 568 ohms
RV Pacing 536 ohms

Sensing
11-Jun-2014 05:32:41
P-Wave Amplitude 4.8 mV
R-Wave Amplitude 5.5 mV

Amplitude vs Sensitivity

Session Summary Page 1

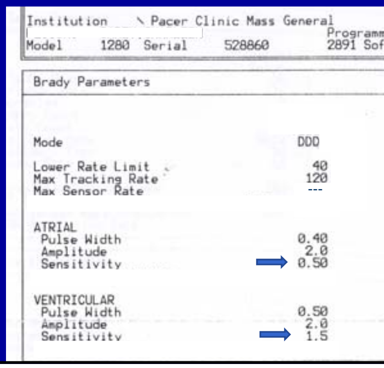
Device Information

Device	Medtronic	EnRhythm P1501DR	PNP460482H

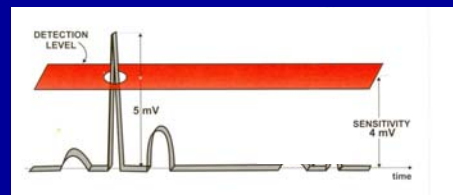
Device Status

	Atrial	RV	Measured on:
Battery Voltage (ERI=2.81 V on 19-Feb-2014)		2.81 V EOL	11-Jun-2014
Lead Impedance	568 ohms	536 ohms	11-Jun-2014
Programmed Amplitude/Pulse Width		2.5 V / 0.4 ms	
Measured P/R Wave	4.8 mV	5.5 mV	11-Jun-2014
Programmed Sensitivity	2.1 mV	2.1 mV	

Sensitivity (mV)



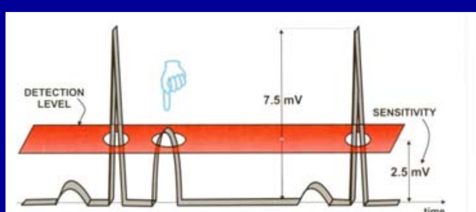
Ventricular Sensing



Voltage of INTRACARDIAC ELECTROGRAM must exceed Sensitivity Setting (mV) in order for the electrical event to be sensed by the pacemaker

Barold SS, Cardiac Pacemakers and Resynch. P.49

Ventricular Oversensing

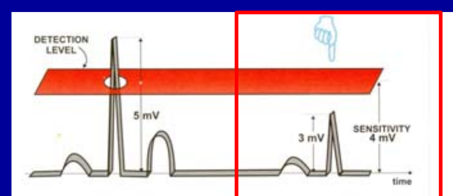


Sensitivity threshold set too LOW so T-wave detected

Sensitivity set too HIGH

Barold SS, Cardiac Pacemakers and Resynch. P.49

Ventricular Undersensing



Intracardiac electrogram not detected in this situation as Sensitivity threshold set too HIGH

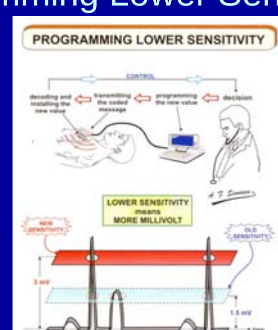
This means the Sensitivity is set too LOW

Barold SS, Cardiac Pacemakers and Resynch. P.49

Does one Test the Sensitivity Threshold?

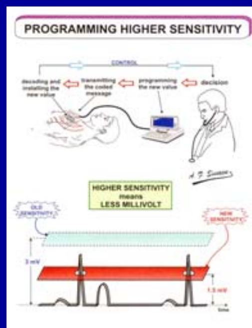
- Indirectly
- One determines the amplitude of the cardiac signal by progressively decreasing the sensitivity (raising the threshold level) until the signal is no longer sensed
- The sensitivity is then set accordingly (or the lead is repositioned) to ensure an adequate safety margin without too much risk of detecting unwanted signals

Programming Lower Sensitivity



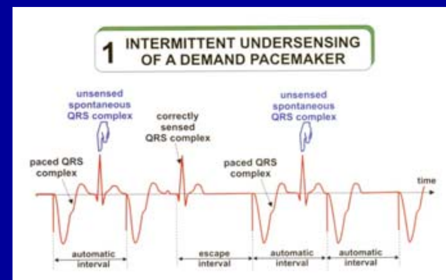
Barold SS, Cardiac Pacemakers and Resynch., p. 67

Programming Higher Sensitivity



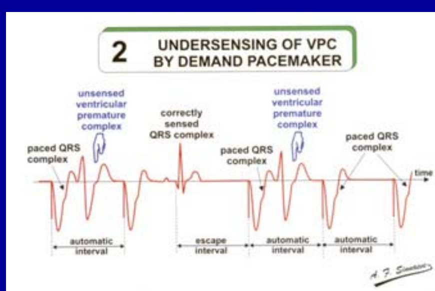
Barold SS, Cardiac Pacemakers and Resynch., p.68

Clinical Examples of Sensing



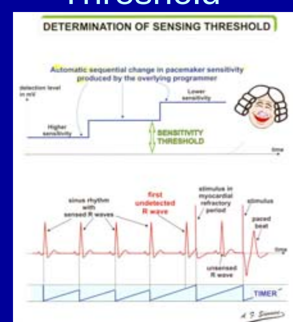
Barold SS, Cardiac Pacemakers and Resynch., p.48

Clinical Example of Sensing



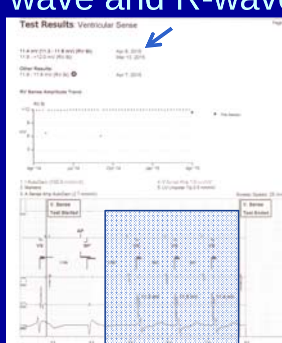
Barold SS, Cardiac Pacemakers and Resynch., p. 48

Determination of “Sensing Threshold”

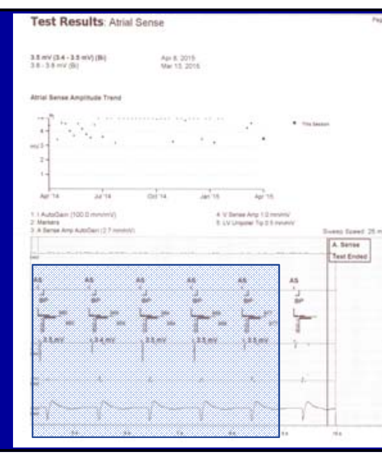


Barold SS, Cardiac Pacemakers and Resynch., p.69

Modern Method of Testing P-wave and R-wave Amplitudes



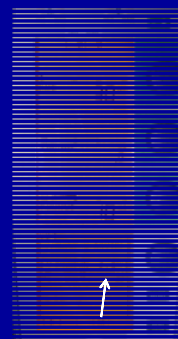
Some programmers have an auto mode that more accurately determines the amplitude of the R-waves and P-waves



Sensing Threshold Example in the Cardiac OR

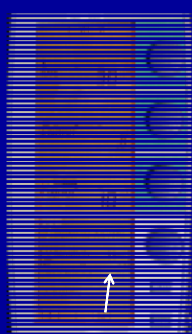
- Patient must have an acceptable underlying ventricular rhythm to determine R-wave amp.
- Set the pacer to a rate 10-15 bpm BELOW intrinsic rhythm
  - Patient rate 40
  - Set VVI to 30
- Gradually decrease the sensitivity (increase the threshold number) until the pacer starts to pace

Ventricular Sensing Threshold in the OR



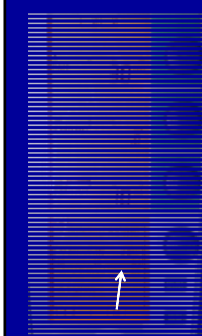
1. Start with the pacer in a VVI mode
2. The default setting for vent sensitivity is 2.0 mV
3. This is a very sensitive setting so the pacer will easily sense the intrinsic R-waves
4. The EKG will demonstrate spontaneous QRS complexes without any pacing

Ventricular Sensing Threshold in the OR



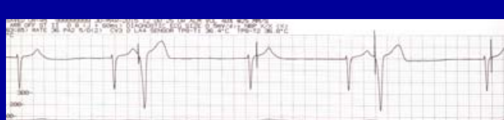
1. At this point the threshold has been increased to 18 mV, which means the sensitivity is now quite low.
2. The intrinsic R-wave has an amplitude of at least 18 mV since the pacer is still sensing intrinsic R-waves and not pacing

Ventricular Sensing Threshold in the OR



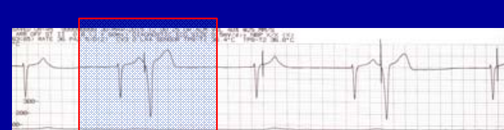
1. With the threshold now set at 20 mV, the intrinsic R-wave is no longer sensed and erratic pacing begins
2. The R-wave amplitude must be less than 20 mV but more than 18 mV
3. By definition we would call the R-wave amplitude 18 mV

What happens when Pacer no longer senses the intrinsic R-wave?



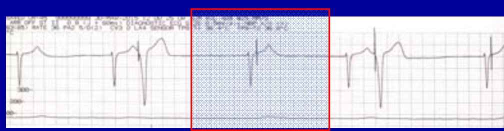
Answer: It starts to V-pace when it looks as though it should not!

Closer Analysis



- Here the sensitivity was just decreased to 20 mV (the threshold was increased to 20)
- The pacer did not sense the native QRS and paced in the relative refractory period—thus it captured the myocardium giving rise to a paced beat

Closer Analysis



- Because the pacer does not sense the intrinsic QRS, it V-paces again
- Because it does so in the ABSOLUTE refractory period, there is no pacer capture

Closer Analysis

- The third V-pace spike occurs in the RELATIVE refractory period again giving rise to another V-paced beat

Recap the Key Concept

- When the threshold is increased above the level of the intrinsic R-wave, the pacer no longer senses that R-wave.
- The pacer signifies this loss of sensing, by V-pacing at the set rate (of 30 in this case)
- The pacing looks inappropriate and could theoretically be dangerous
- The R-wave amplitude can be assumed to approximate the threshold setting where sensing last occurred—in this case 18 mV

Clinical Testing

- If one were doing this test with a programmer, the test would stop after the first un-sensed intrinsic QRS for safety
- Since the intrinsic QRS was not sensed when the setting was adjusted to 20 mV, the R-wave amplitude is said to approximate the last setting in which the QRS was sensed—at 18 mV

Clinical Situation

- Thus the R-wave amplitude as sensed by the epicardial electrodes with our temporary pacemaker was approximately 18 mV.
- The baseline ventricular SENSITIVITY setting for a pacemaker (when we turn it on) is 2.0 mV
- This represents a 9-fold safety margin

Example of P-Wave Amplitude Testing in the Cardiac OR

- Patient has intrinsic atrial rhythm at 68
- Pacer in AAI mode with sensitivity at .5mV
- Pacer rate set BELOW intrinsic at 50
  - As long as the pacer senses the intrinsic P-wave the pacer will inhibit pacer output
  - When the pacer no longer senses the P-wave, because the sensing threshold is increased too high, the pacer will pace, seemingly inappropriately

Example in the Cardiac OR

- Patient has intrinsic atrial rhythm at 68
- Pacer in AAI mode with sensitivity at .5mV at a rate of 50

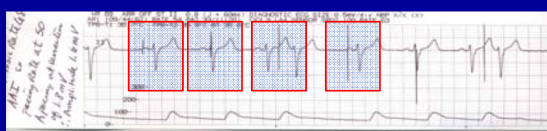
- A-sense and V-sense

Example in the Cardiac OR

- Sensitivity gradually decreased (threshold level increased) until the pacemaker no longer detects the native P-wave
- The pacer signifies this loss of sensing by A-pacing in a manner that appears inappropriate

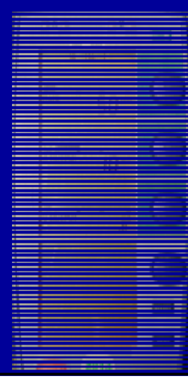
- Pacing started at sensitivity setting of 1.8 mV
- P-wave amplitude (as sensed by the electrodes on the heart) is therefore approximately 1.6 mV

What do we see here?



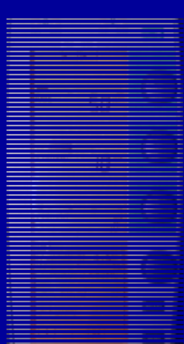
- First A-pace captures the atrium
- Second A-pace coincides with QRS—thus the atrium is refractory and no atrial capture occurs
- Third A-pace occurs in the ST segment, captures the atrium and a QRS follows—it looks like a PAC
- Fourth A-pace fires within an intrinsic P-wave

How to Measure P-wave Amplitude

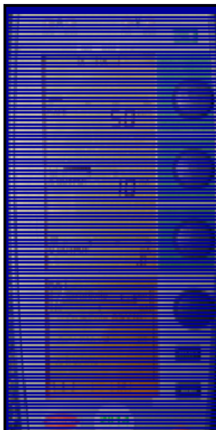


1. Turn on pacer
2. Turn off V output
3. Assumes AAI mode
4. Adjust rate to below the intrinsic rate
5. Atrial output can be set between 5-10 mA
6. Press MENU button

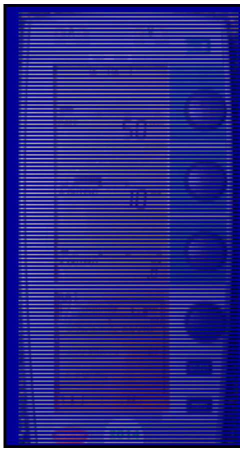
How to Measure P-wave Amplitude



7. Note that atrial sensitivity is set at 0.5 mV
8. Decrease the sensitivity (by turning knob counter clockwise) which increases the threshold voltage until you see atrial pacing spikes appear



With atrial sensitivity at 1.6 mV the pacer is still detecting P-waves through the atrial electrodes. Thus there is no pacer spike



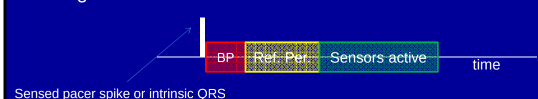
Atrial pacing begins when sensitivity set at 1.8 mV. Because the intrinsic P-wave has an amplitude of approximately 1.6 mV, the pacer no longer senses the intrinsic P-wave and A-paces. The test is complete.

Clinical Situation

- If we were doing this with a programmer, the Amplitude (or Sensitivity) test would have stopped after the first non-sensed intrinsic P-wave
- The P-wave amplitude as detected by the epicardial atrial electrodes in the OR is 1.6 mV
- The sensitivity set on the pacer defaults to 0.5 mV
- Thus there is a 3-fold safety margin

A Look Ahead: Blanking Periods and Refractory Periods

- The sense amplifier in the same chamber is turned off ("blanked") for a short blanking period to prevent double counting
- A "refractory period" follows the blanking period—the sense amplifier remains enabled but sensed events in this refractory period do not alter the pacemaker timing cycles…these signals can be sensed for tachy detection algorithms however



Lecture #2 Summary

- Pacing requires a pulse of sufficient amplitude and sufficient duration to capture the myocardium
- A Strength-Duration curve can be constructed using different combinations of amplitude and duration
- The lowest amplitude corresponds to the longest pulse wave duration and is called the Rheobase
- The duration associated with amplitude of 2 X the Rheobase is the Chronaxie
- Typically the best combination to conserve energy is to use the Amplitude and PWD of the chronaxie

Lecture #2 Summary

- Pacing can be unipolar or bipolar
- Bipolar pacing EKG artifact is smaller than that of unipolar
- To determine capture threshold set the pacer in a VVI mode at a rate approx 10 bpm above the intrinsic rate, then decrease the amplitude until the pacer stops capturing

Lecture #2 Summary

- A pacer senses intrinsic myocardial depolarization of sufficient amplitude and slew rate
- Slew rate is dV/dT
- Sensing, like pacing, can be unipolar or bipolar
- Unipolar pacing is more sensitive to EMI

Lecture #2 Summary

- The intracardiac electrogram describes what the pacemaker is sensing in the atrium or ventricle
- Amplitude is the size of sensed R-wave or P-wave
- Sensitivity is the adjustable threshold that determines which intracardiac signals are actually recognized by the pacer

Lecture #2 Summary

- A high sensitivity has a low threshold
- A low sensitivity has a high threshold
- The sensitivity threshold is set low enough to detect intrinsic R- and P-waves, but high enough to discard T-waves or noise
- To determine the amplitude of an R-wave or P-wave, set the pacing rate 10-20 bpm below the intrinsic rate, then gradually increase the threshold until pacing occurs

The End

Pebble Beach