Paced ECG Interpretation: A Case-Based Approach

David Hayes, MD

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Goals of this talk:

- Understand the components of available diagnostics
- Approach to device troubleshooting
- Understand value of making initial 'generic' diagnosis
- How to transition from 'generic' to 'specific' diagnosis
- Value of taking advantage of all available information

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CIED Diagnostics

- There are extensive and increasingly sophisticated diagnostics in contemporary devices
- Diagnostics are critical for determination of normal or abnormal device function
- A deep understanding of the diagnostics available from the manufacturer(s) implanted at your institution is invaluable
- In the clinical environment you will have the benefit of the patient's clinical information and programming – this talk purposefully approaches diagnostics without providing the benefit of all the usual information in the effort to develop a framework for a systematic approach

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Device Troubleshooting: *CRT builds on ICD builds on Brady*

Approach brady devices with simple steps:

- What's the underlying rhythm?
- Single vs dual-chamber pacing?
- Which chamber(s)?
- Identifiable timing intervals?
- Make a "Generic" Diagnosis
- Target specific dx based on clinical scenario for that generic differential diagnosis

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Troubleshooting Steps to Consider: Brady

- Re-interrogate if findings don't match what you expect from programming you believe to exist
- Try other pacing modes to overcome a problem, i.e. start with simplest (VVI) and change from there
- Telemetry: EGMS, marker channel etc.
- Patient Postural Testing
- Chest x-ray
- Technical manual
- Call manufacturer 24 hour support number (1-800-547-0394)
- Intraoperative troubleshooting

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Pacing Electrocardiography

Need to know and understand differential diagnoses of each of the following:

- Failure to sense
- Failure to capture
- Failure to output/over-sensing
- Rate variations
- Crosstalk / safety pacing

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Loss of Capture

Less Common
- Loose set-screw
- Exit block
- Perforation
- Battery failure
- Circuit failure
- Air in pocket (Unipolar)
- Pseudomalfunction
- Metabolic/drug

More Common
- Lead dislodgment
- Elevated thresholds
- Inappropriate lead placement
- Lead fracture
- Lead insulation failure

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Failure to Output

Less Common
- Loose set-screw
- Lack of anodal connector contact
- Incompatible lead/header
- Pseudomalfunction or device nuance - peculiarity

More Common
- Over-sensing
- Crosstalk
- EMI
- Battery failure
- Circuit failure
- Lead fracture
- Internal insulation failure

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Under-Sensing

- Change in intrinsic complex, i.e. BBB, VF, VT, AF
- Myocardial infarction
- Lead dislodgment/poor positioning
- Lead insulation failure
- Magnet application
- ERI
- Functional under-sensing

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Over-Sensing

- Lead fracture
- Lead insulation defect
- EMI
- Isoelectric ventricular event
- Sensing T wave, P wave, afterpotential, etc

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Rate Variations
(i.e. variations from programmed lower rate)

- Hysteresis
- Rate-adaptive pacing
- Oversensing
- Function of timing system, i.e. AA, VV, hybrid
- Specific Algorithms, i.e. Capture Control, Night Rate, etc.

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ICD Troubleshooting

- Failure to detect arrhythmia(s)
- Failure to convert arrhythmia(s)
- Overlapping Arrhythmias
- Inappropriate/unnecessary shocks

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CRT Troubleshooting

- Non-responder
- Suboptimal % biventricular pacing
- Atrial arrhythmias
- Ventricular arrhythmias
- Phrenic nerve stimulation

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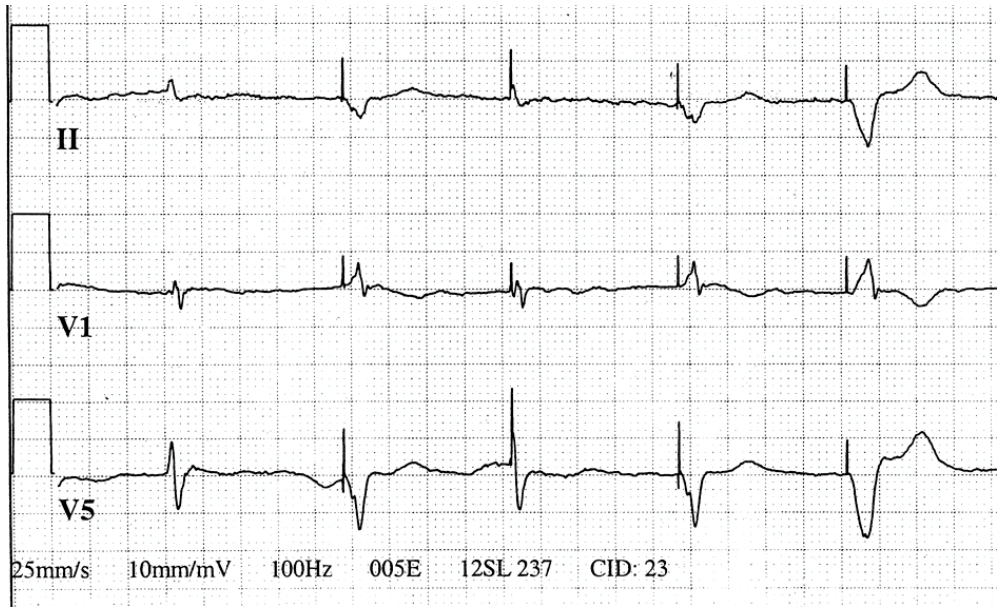

3.1 The tracing includes:

1. Intrinsic beat
2. Paced beat
3. Fusion beat
4. Pseudofusion beat
5. All of the above

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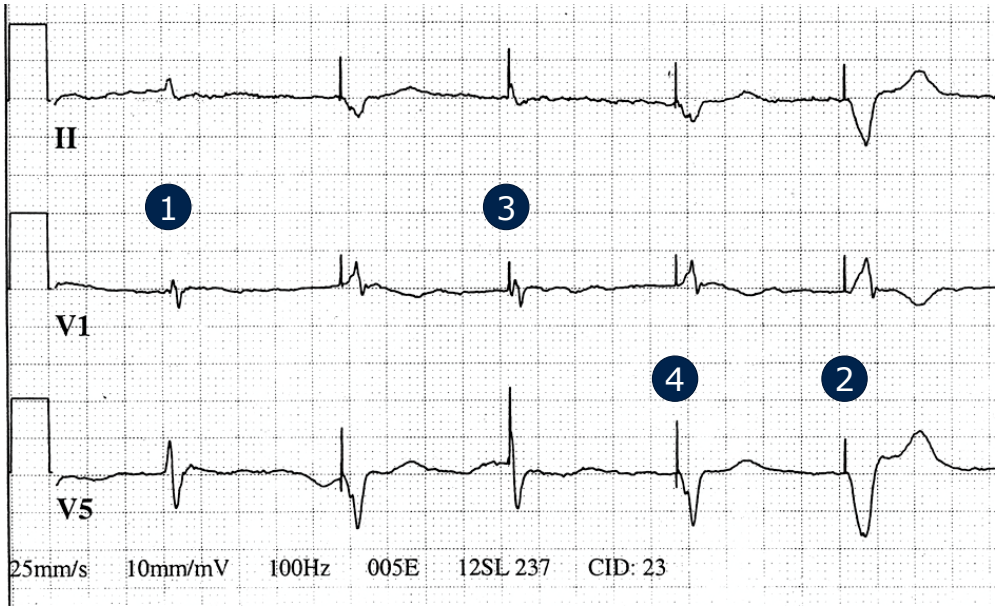

The tracing includes:
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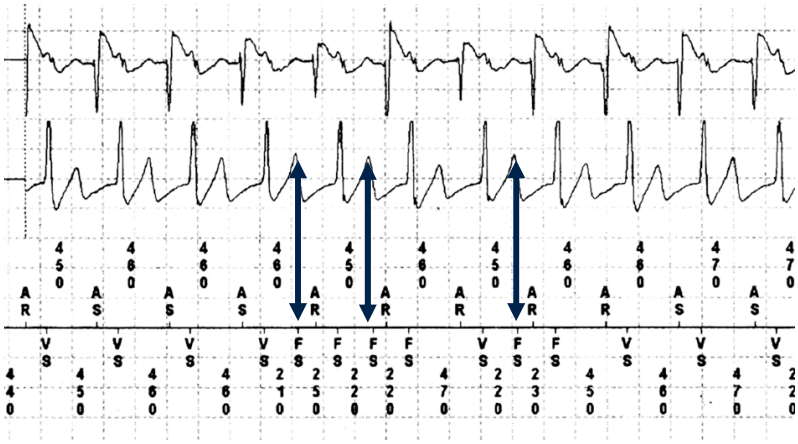

Inspect the ECG vertically as well as horizontally!

3.2 Tracing compatible with:
1. Frequent ventricular extrasystoles
2. Ventricular oversensing
3. Pacemaker mediated tachycardia
4. Crosstalk

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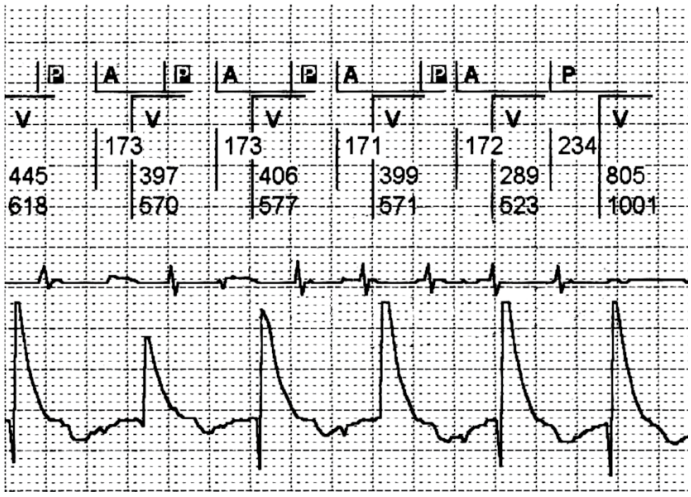

3.3 Tracing demonstrates all BUT:

1. Atrial pacing
2. Atrial sensing
3. Ventricular pacing
4. Atrial event in refractory
5. Ventricular event in refractory

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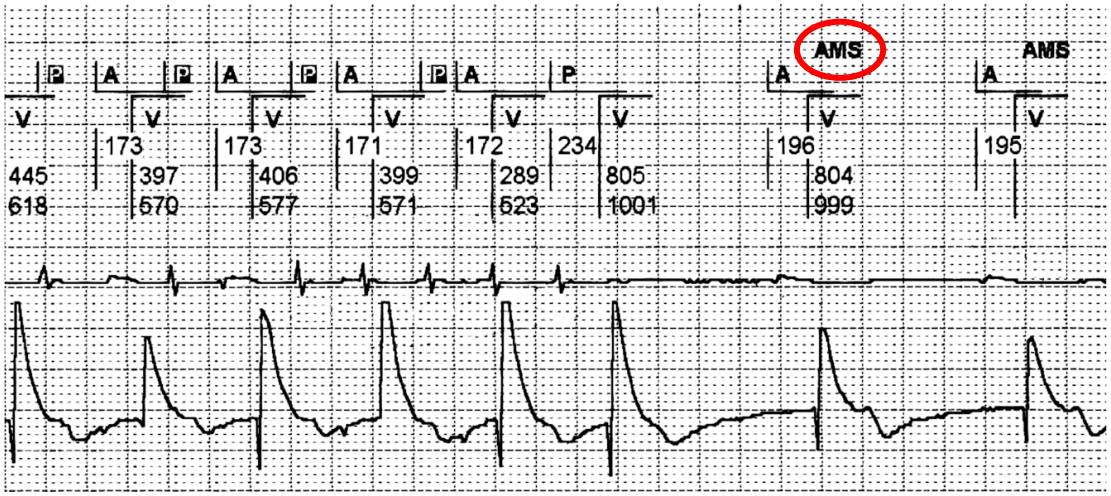

3.4 Tracing compatible with:

1. Appropriate mode-switching
2. Far-field sensing
3. Pacemaker mediated tachycardia
4. Normal rate-adaptive pacing

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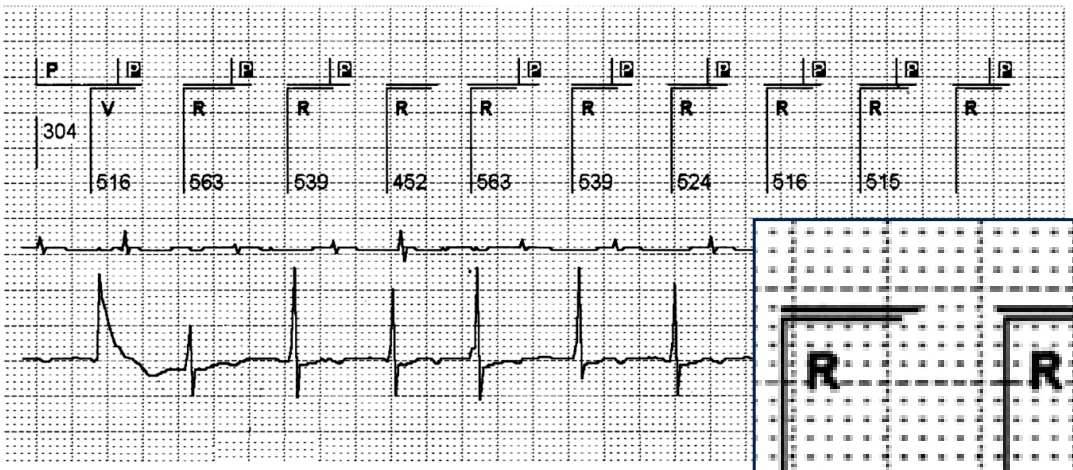

3.5 Tracing compatible with:

1. Functional under-sensing
2. Far-field sensing
3. Crosstalk
4. Pacemaker mediated tachycardia

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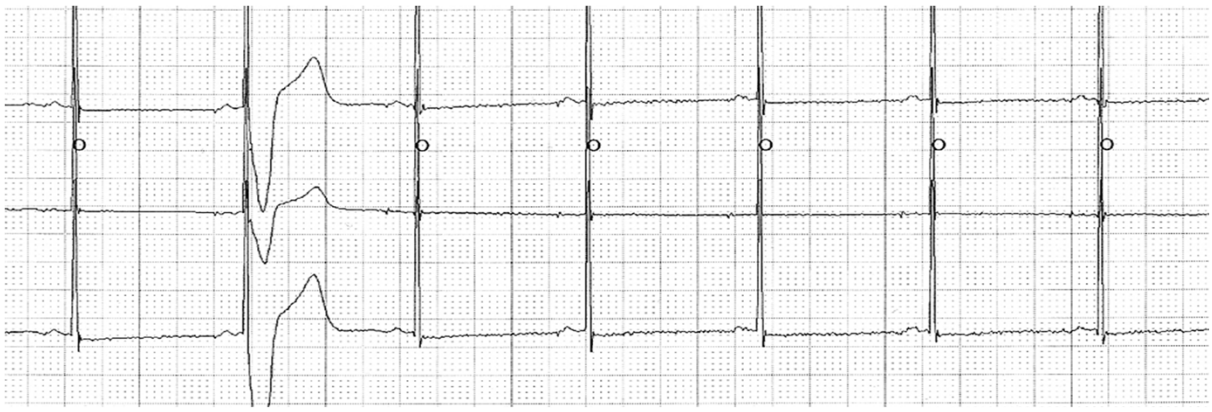

3.6 66 year old female 1 wk post-implant. The only compatible etiology of the problem is:

1. Crosstalk
2. Ventricular lead dislodgment
3. Ventricular avoidance pacing algorithm
4. Ventricular oversensing
5. Exit block

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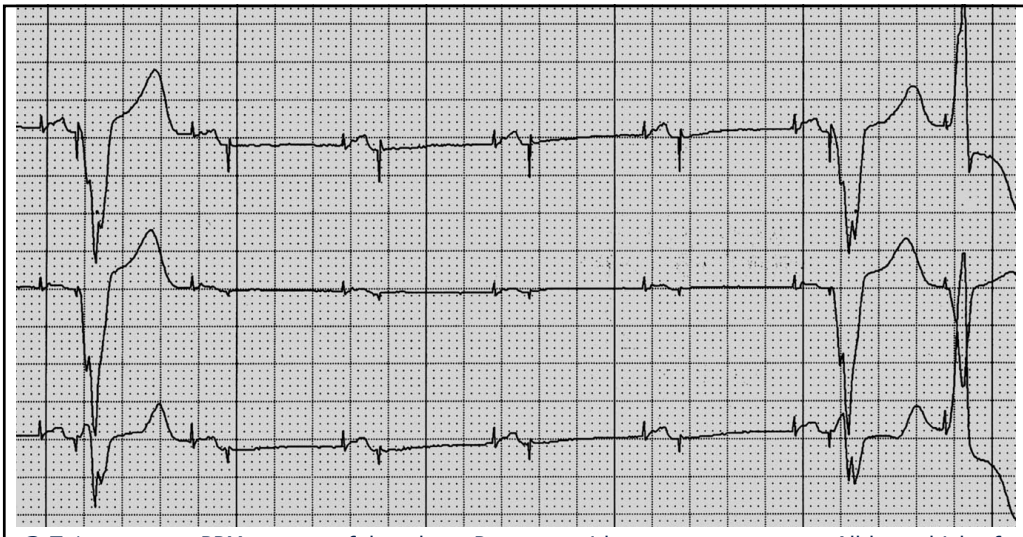

3.7 1 year post PPM; uneventful to date. Presents with recurrent syncope. All but which of the following **could** be responsible:

1. Exit block
2. Threshold ↑ secondary to medications
3. Lead dislodgement
4. Complete break of the conductor coil

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1 year post PPM; uneventful to date

Presents with recurrent syncope. All but which of the following could be responsible:

1. Exit block - *> 1 month post-implant with failure to capture is compatible with exit block; would not likely occur at 1 year; usually earlier*
2. Threshold ↑ secondary to medications - *failure to capture is compatible*
3. Lead dislodgement - *compatible with failure to capture*
4. Complete break of the conductor coil - *with complete transection, current would not get through and no artifact would be seen*

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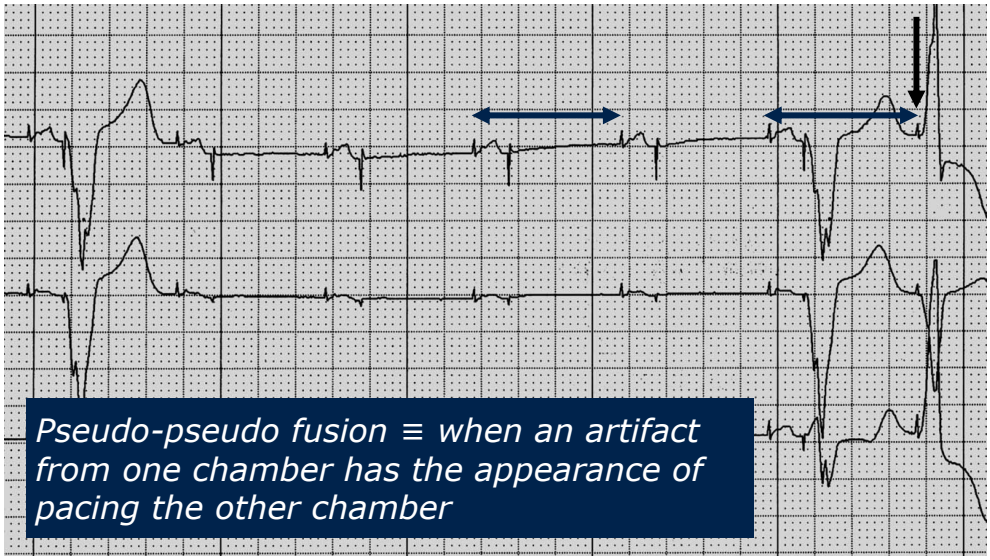
What is occurring at the arrow?



Pseudo-pseudo fusion ≡ when an artifact from one chamber has the appearance of pacing the other chamber

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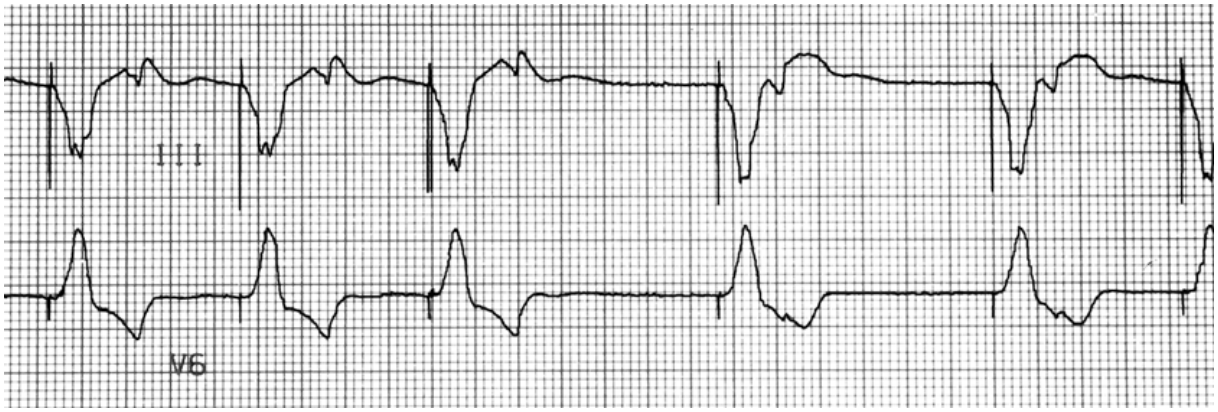

3.8 What is your ECG diagnosis?

1. Hysteresis
2. Over-sensing retrograde events
3. Fallback behavior
4. Normal sensor-driven pacing

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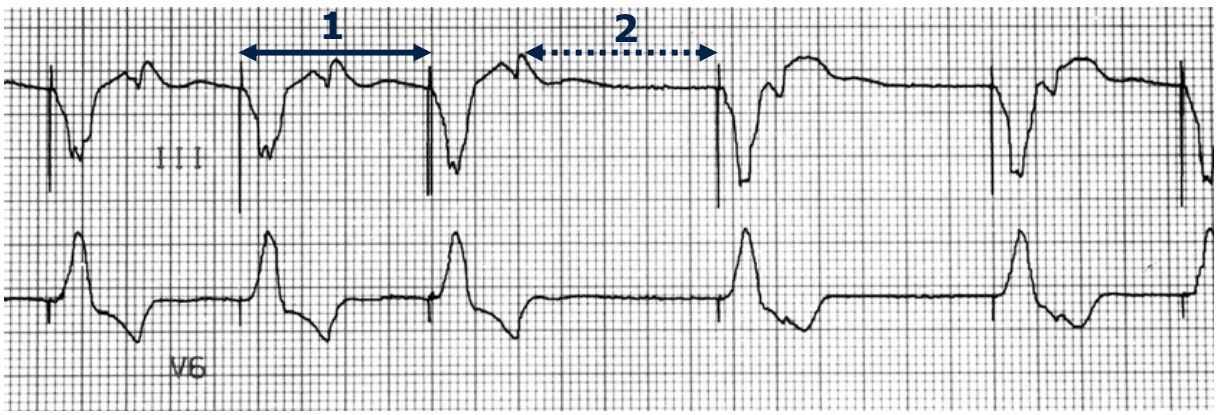

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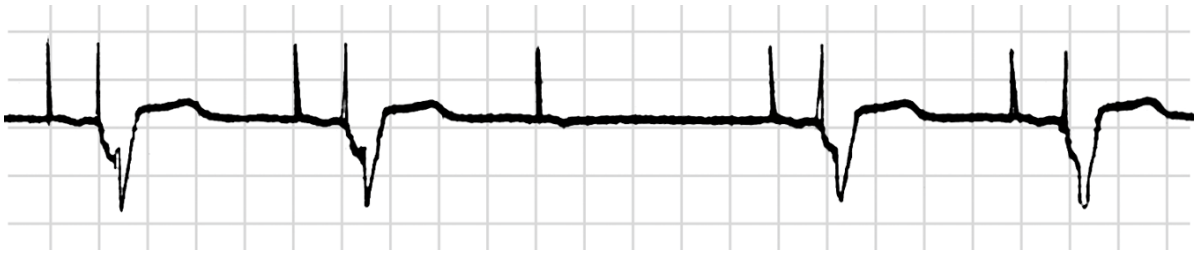

3.9 The ECG is obtained the morning after pacemaker implant. Which of the following is the most likely problem?

1. Crosstalk in absence of safety pacing
2. Ventricular lead dislodgment
3. Artifact
4. Ventricular lead fracture
5. Myopotential over-sensing

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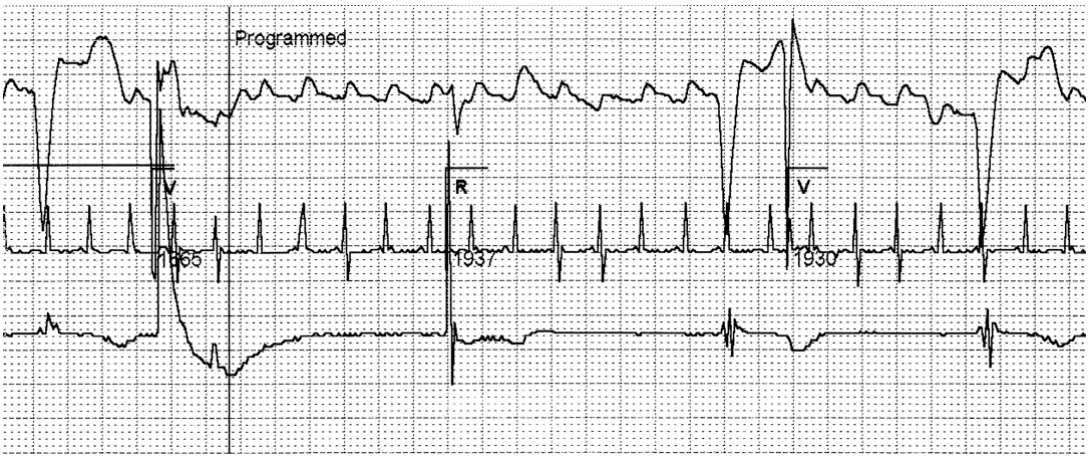

3.10 What would correct the observed abnormality:

1. Increase V pacing output
2. Make V more sensitive
3. Increase V pacing rate
4. Turn off PVARP extension

Pay attention to what the device tells you, but pay equal attention to what it "doesn't" tell you!

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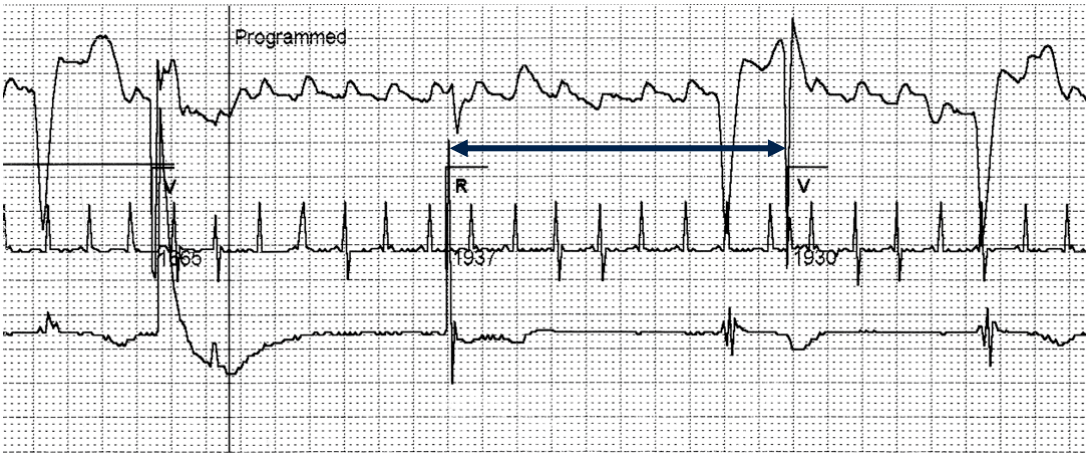

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3.11 The programmed P-AVI is 240 ms. Labeled QRS complex (*) occurs in:

1. Crosstalk sensing window
2. Post-Atrial Ventricular blanking period
3. Alert window

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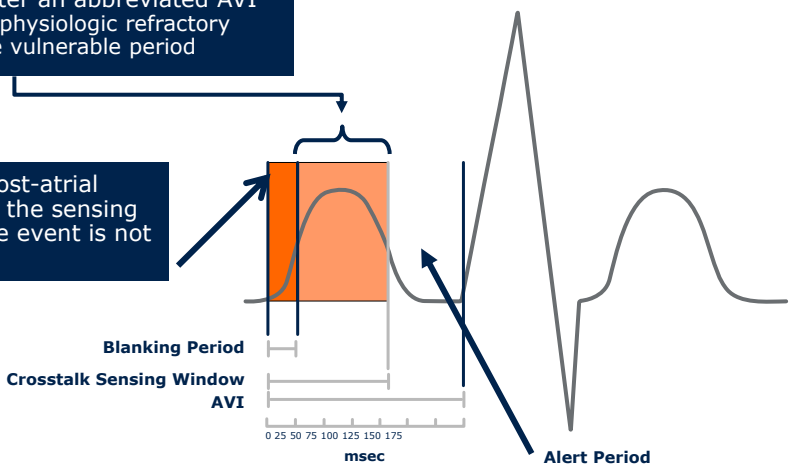
If the event occurs in the crosstalk sensing window is sensed, the V is paced after an abbreviated AVI (light orange), falling in the physiologic refractory period, ie, does not fall in the vulnerable period

If the event occurs in the post-atrial ventricular blanking period, the sensing circuit is turned 'off' and the event is not seen (dark orange)



If sensing occurs during the 'alert' period, ventricular output is inhibited.

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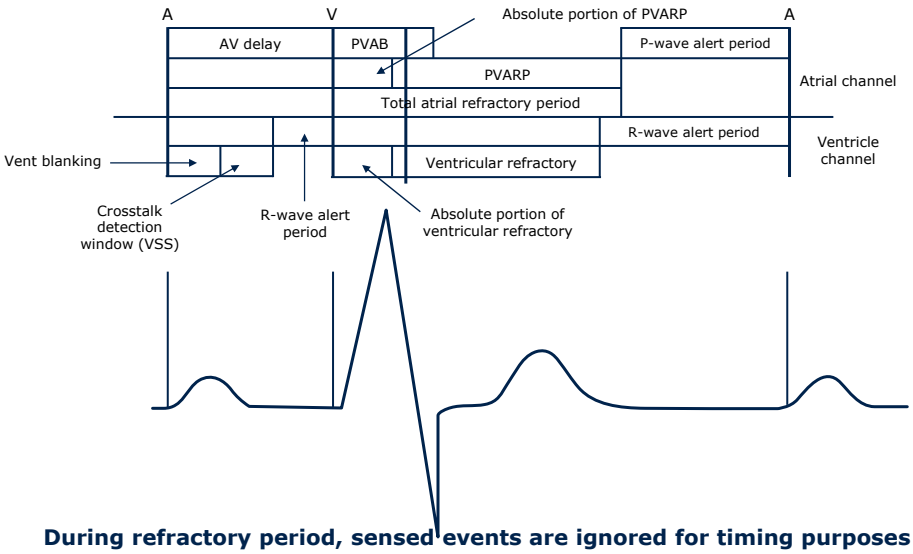

During refractory period, sensed events are ignored for timing purposes

During BP, sensing amplifier is turned off and sensing cannot take place

Pattern of refractory and BPs play a critical role in determining the beat-to-beat behavior of the pacemaker

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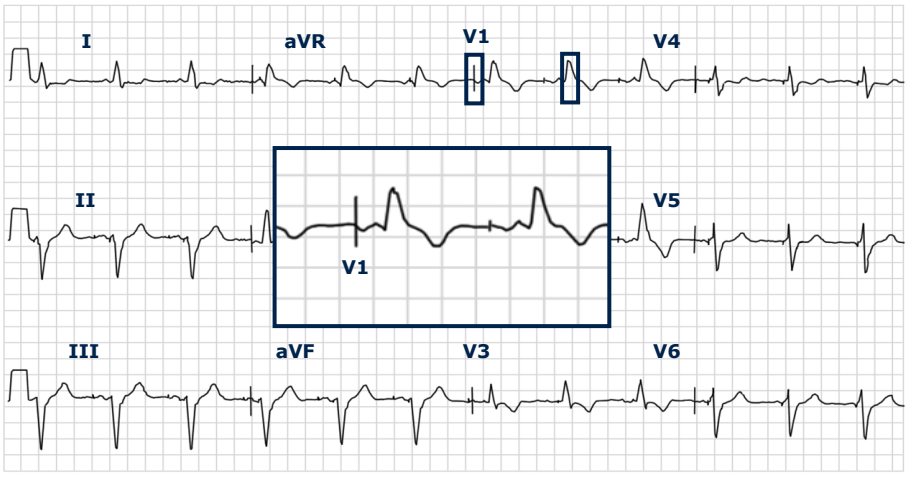

3.12 ECG following dual-chamber pacemaker implant suggests?

Look for 'patterns'

1. Inappropriate lead placement
2. Normal function
3. Pericardial irritation
4. Failure to capture the RV

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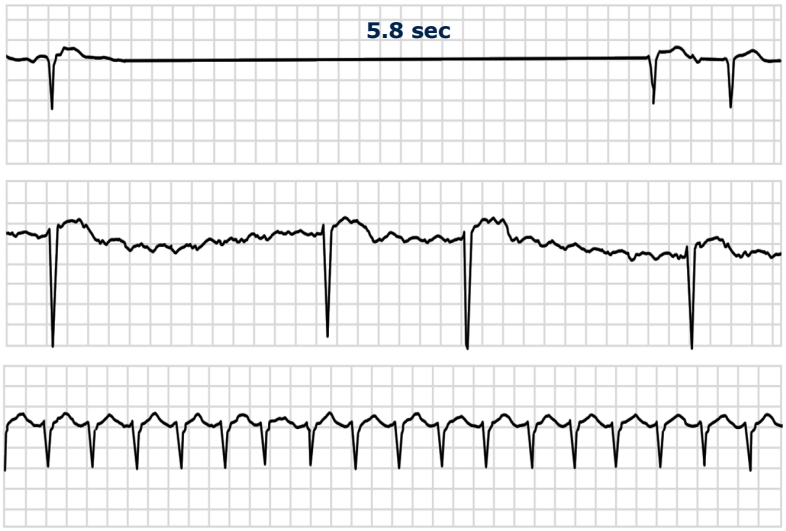

3.13 68 year old female in hospital; 3 rhythm strips collected within a 24-hour period. You would…

1. Start amiodarone
2. Implant ICD
3. Implant PPM
4. Start beta-blocker

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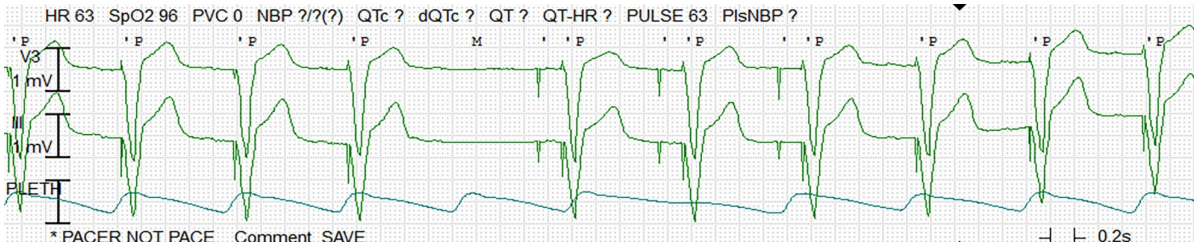
Rhythm strip obtained the afternoon after the pacemaker implant. Patient asymptomatic. RNs call pacemaker service…. Generic diagnosis?



1. Failure to capture
2. Failure to output
3. Under-sensing
4. Rate variation

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Failure to Output

- Oversensing
  - Crosstalk
  - EMI
- Battery failure
- Circuit failure
- Lead fracture
- Internal insulation failure
- Loose set-screw
- Incompatible lead/header
- Device nuance - peculiarity

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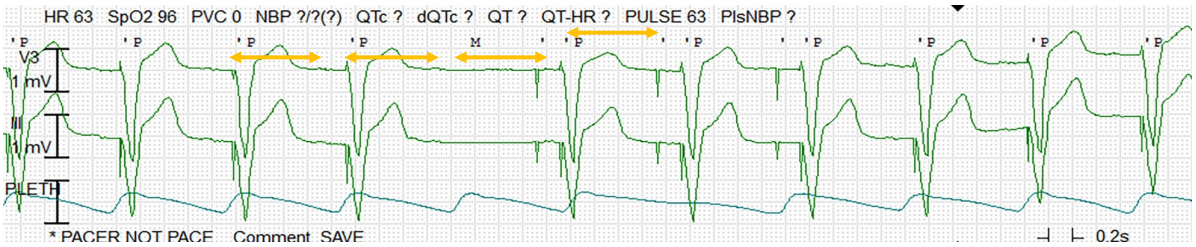
If intervals are regular and baseline steady, less likely to be over-sensing.



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Failure to Pace (No output)

- ~~Oversensing~~
  - ~~Crosstalk~~
  - ~~EMI~~
- ~~Battery failure~~
- ~~Circuit failure~~
- ~~Lead fracture~~
- ~~Internal insulation failure~~
- ~~Loose set-screw~~
- ~~Incompatible lead/header~~
- Device nuance - peculiarity

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3.12 83-Year-Old Male with Increasing Dyspnea on Exertion

- History of coronary artery disease status post stent placement ×2
- Third-degree AV block, status post pacemaker placement 8 years earlier (Medtronic dual-chamber Kappa KDR 901, atrial lead 5568, ventricular lead 4076)
- Programmed DDDR, lower rate 60 bpm, upper rate 130 bpm

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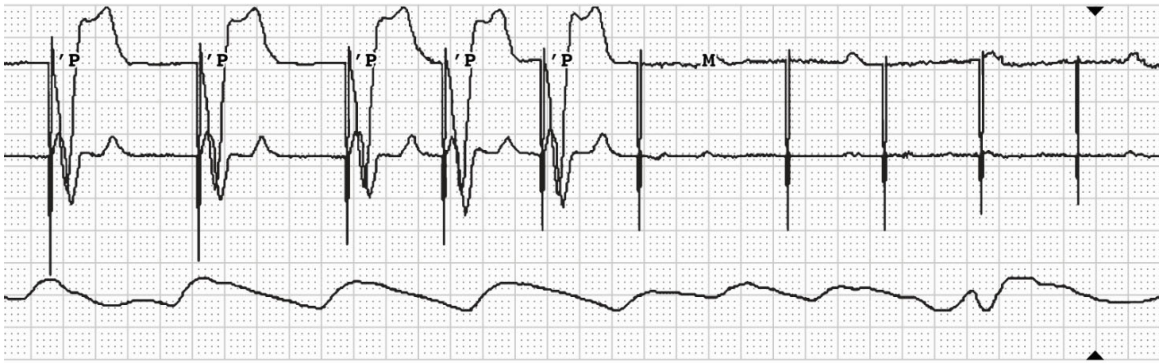

Prior to pacemaker interrogation, rhythm was ventricular pacing at 65 bpm. This tracing obtained when the programming wand is placed on the pacemaker. Tracing can be explained by:

1. Normal magnet function for this pacemaker
2. ERI (Elective replacement indicator)
3. EOS (End of service)
4. Ventricular lead loose in header

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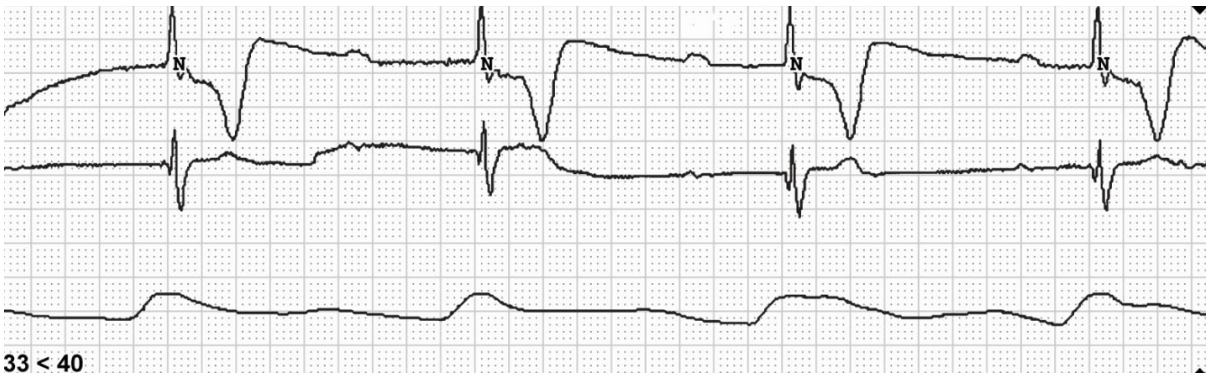

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Pacemaker Model: Medtronic.Kappa KDR901 Medtronic.Kappa 900 S
Serial Number: Copyright © Medtroni

Initial Interrogation Report

Patient/Device Information

Dependency:	Physician Name:
Implanted Defribillator?:	Physician Phone:

Pacemaker Model:	Kappa	KDR901	PKM418309	Implanted:	07/17/15 6:49 PM
Atrial Lead:					
Ventricular Lead:					

Pacemaker Status

Estimated remaining longevity: Replace Pacer
Battery Voltage/Impedance 2.06 V / 32,125 ohms

	Ventricular
Amplitude/Pulse Width	2.76 V / 0.40 ms
Sensitivity	2.00 mV
Measured Impedance	680 ohms
Lead Status	Polarity Switch

Clinical Status:

Diagnostic data not available.

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83-Year-Old Male with Increasing Dyspnea on Exertion

- Battery voltage of 2.06 is compatible with EOS (EOL), at which point no reliable pacing occurs and diagnostic information is unreliable. It is difficult for manufacturers to give a single specific voltage at which EOS occurs because of multiple variables that may be present
- For this old Medtronic device, the company states that a measured battery voltage of 2.2 is a reasonable value to consider for EOS, but some devices may reach EOS at a higher value, and some have been identified at <2.0 V before
- Battery impedance is often ignored. In this case, the battery impedance was 32,125 ohms. As a rule, if battery impedance is ≥ 10,000 ohms, there should be a heightened concern that battery is approaching EOS. If battery impedance is ≥ 20,000 ohms, there is a high likelihood the device is at or near EOS.

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Basics & Beyond

David Hayes, M.D. and Beth Davenport, MSN, RN Co-Directors

February 28th 3:00-5:00 PST (6:00-8:00 EST)

- Pacemaker Troubleshooting
- Rate Response and CLS
- Conduction System Pacing Overview

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Paced ECG Interpretation: A Case-Based Approach

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