Perioperative Electrophysiology:

Pacemaker-Electrocautery Interactions

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I have no conflict of Interest

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Pacemaker-Electrocautery Interactions

1. Asystole
2. Accelerated/erratic tracking
3. Noise reversion mode activation
4. Pacemaker reset
5. Rate response mode activation
6. Lead or circuitry damage

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Key Concept #1

- Cautery can be sensed by a pacemaker in any non-asynchronous pacing mode

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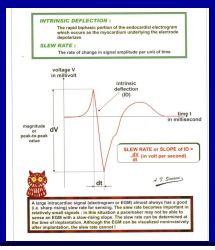
Cautery Sensed by Pacemaker

- If the amplitude and slew rate of the detected cautery signal are sufficient to meet the sensitivity threshold, the pacer will respond



Barold, Cardiac Pacemakers and Resynch., p. 60

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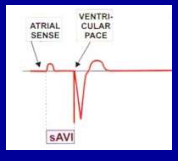
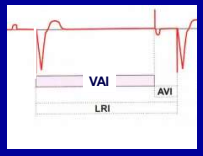
How Will a DDD Pacer Respond to Sensed Electrocautery?

- Atrial Channel
  - Inhibits the next atrial output
  - Starts an AVI timing cycle



- Ventricular Channel
  - Inhibits the next ventricular output
  - Starts a VAI timing cycle



Barold SS, Cardiac Pacemakers and Resynch.

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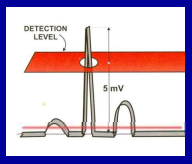
Key Concept #2

- The atrial sensing threshold is usually lower than the ventricular threshold



Barold SS, Cardiac Pacemakers and Resynch. P.49

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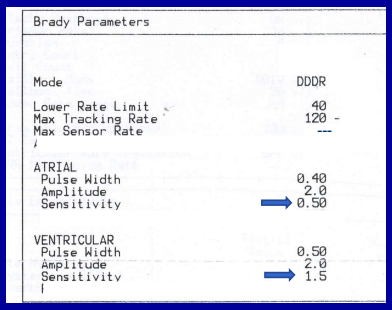
Sensitivity (mV)

Note that the atrial sensitivity threshold is less than the ventricular sensitivity threshold



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Key Concept #3

- Pacemakers programmed with unipolar sensing are more susceptible to cautery than those programmed with bipolar sensing

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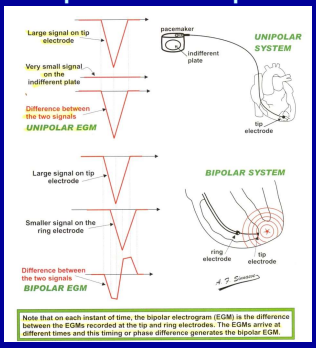
Unipolar vs Bipolar Sensing



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

Barold, Cardiac Pacemakers and Resynch., p. 46

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Key Concept #4

- Pacers are much more susceptible to monopolar cautery than to bipolar cautery

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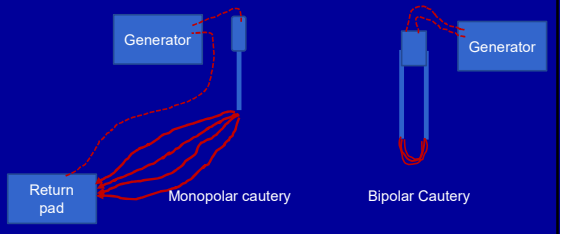
Key Concept #4

- Pacers are much more susceptible to monopolar cautery than to bipolar cautery



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Key Concept #5

- The likelihood that a pacer will detect cautery is very dependent on where the cautery is applied to the patient AND where the electrocautery return pad is placed

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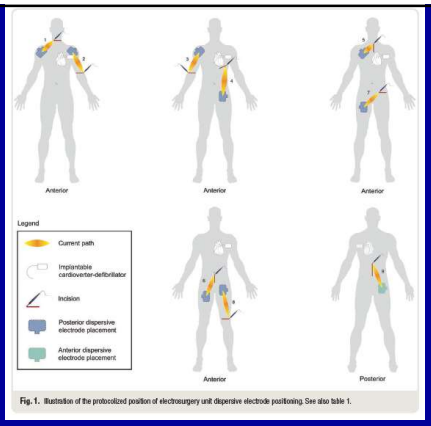

Schulman et al, Anesthesiology April 2019

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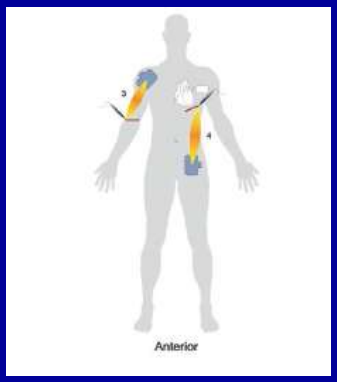

Schulman et al, Anesthesiology April 2019

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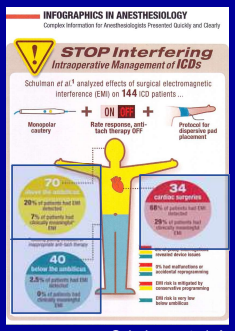
Electrocautery detection by ICDs



Schulman et al, Anesthesiology April 2019

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Concepts Encapsulated

- *Electrocautery is likely to be sensed by non-asynchronous pacers if the current path between the monopolar cautery instrument and the return pad travels near the pacing leads/pulse generator, especially if the pacer is sensing with a unipolar configuration; and cautery is more likely sensed on the atrial than the ventricular channel.*

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1. Asystole

- Monopolar cautery used in close proximity to the pacer's lead(s) is likely to inhibit pacemaker output
  - If the pacer is truly pacer dependent, asystole can occur

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Clinical Example

- Pt for thoracic surgery with significant CAD.
- Pt was pacer dependent and 100% AV-paced.
- Anesthesiologist did not want to use magnet (HR of 100 and CAD) and chose not to reprogram the pacer.
- Asked surgeon to use short bursts of cautery.

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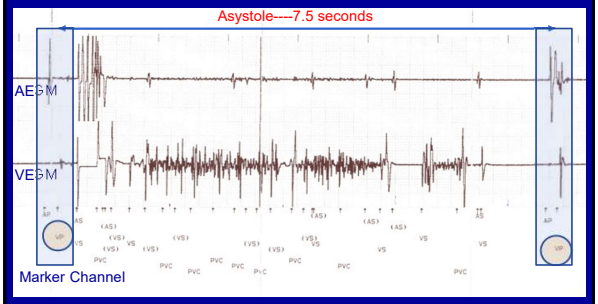
EMI-induced Asystole



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2. Accelerated/Erratic Tracking

- Cautery detected by the atrial lead triggers ventricular pacing in DDD pacers
  - Atrial lead senses the cautery, ventricular does not
  - Paced HR can theoretically increase up to the max tracking rate
  - More often, the ventricular pacing is erratic

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Max Tracking Rate

Basic Operation		**Refractories & Blanking**	
Mode	DDD	PVARP	275 ms
V. Triggering	Off	Post-Vent. Atrial Blanking	100 ms
Magnet Response	Battery Test	Rate Responsive PVARP/V Ref	High
V. Noise Reversion Mode	VOO	Shortest PVARP/V Ref	175 ms
Sensor	Off	A/V Pace Refractory	190/250 ms
		A/V Sense Refractory	93/250 ms
Rates		Ventricular Blanking	Auto
Base Rate	60 bpm	Ventricular Safety Standby	On
Rest Rate	Off	PVC Response	Off
Max Track Rate	130 bpm	PMT Response	Atrial Pace
Hysteresis Rate	Off	PMT Detection Rate	110 bpm
2:1 Block Rate	216 bpm		
Delays		**AT/AF Detection & Response**	
		Auto Mode Switch	DDI
Paced AV Delay	200 ms		
Sensed AV Delay	150 ms	A. Tachycardia Detection Rate	180 bpm
Rate Responsive AV Delay	Medium	AMS Base Rate	80 bpm
Shortest AV Delay	100 ms	AF Suppression™	Off
Ventricular Intrinsic Preference (VIP®)	On		
VIP® Extension	200 ms		
Search Interval	1 min		
Search Cycles	1		
Neg. AV Hysteresis/Search	Off		

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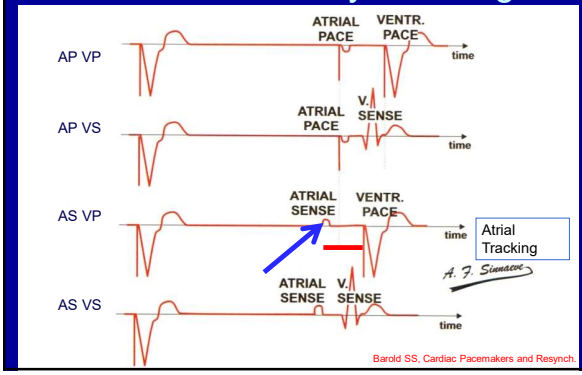
What do I mean by Tracking?



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What is Happening Here?

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Clinical Example of Ventricular Tracking of Electrocautery

- 50 yo W scheduled for a Belt Lipectomy
- SSS
- DDD pacemaker
- Not pacer dependent

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What do you see?

A. Electrocautery artifact
B. Abnormal rhythm
C. Not sure

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Without the electrocautery

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With the Cautery

Pulse Ox curve consistent with dysrhythmia
Wide QRS consistent with pacing
Brought in a programmer

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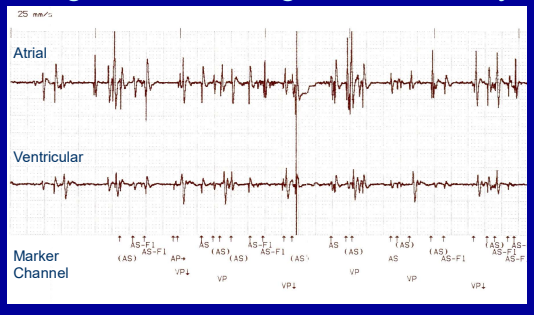
Programmer during electrocautery



1. Notice the multiple atrial sensing events (AS)
2. Notice absence of V sensing; only many Vent tracking (VP) events
3. Patient loses effective atrial kick

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Management: Convert to DDI

		Initial Value	Present Value
Mode		DDD -->	DDI
Lower Rate Limit		40	40 ppm
Max Tracking Rate		120 -->	-- ppm
Max Sensor Rate		120 -->	-- ppm
AV Delay (paced)	DYN	-- -->	150 ms
ATRIAL			
Pulse Width		0.40	0.40 ms
Amplitude		2.0	2.0 V
Sensitivity		0.50	0.50 mV
Refractory (PVARP)		280	280 ms
VENTRICULAR			
Pulse Width		0.50	0.50 ms
Amplitude		2.0	2.0 V
Sensitivity		1.5	1.5 mV
Refractory		250	250 ms

AV Delay

	Initial Value	Present Value
Dynamic AV Delay	ON -->	--
Maximum Delay	300 -->	-- ms
Minimum Delay	200 -->	-- ms
Sensed AV Offset	-30 -->	-- ms
AV Search Hysteresis		
Search Interval	OFF	OFF cycles
AV Increase	--	-- %

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2 Key Concepts

- DDI and VVI are non-tracking modes that are useful in the setting of electrocautery use close to the pacemaker in a patient who is not typically pacing
- If you choose to keep the pacer in DDD, you should monitor for erratic tracking in addition to asystole

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3. Noise Reversion Mode Activation

- Temporary asynchronous pacing mode activated during EMI that prevents asystole in pacemaker dependent patients

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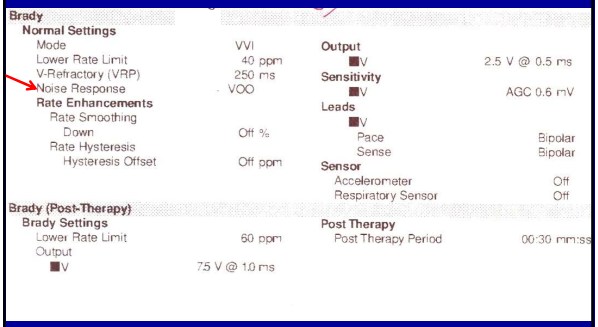
Noise Reversion Mode: VOO



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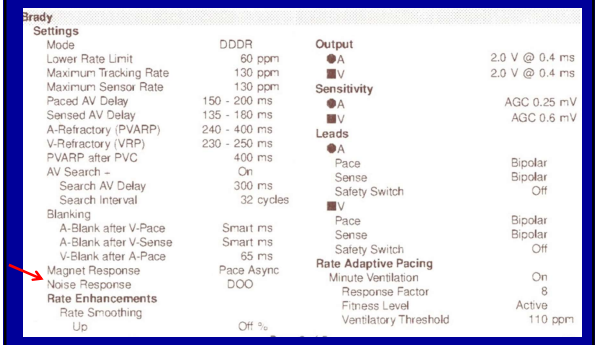
Noise Response Mode: DOO



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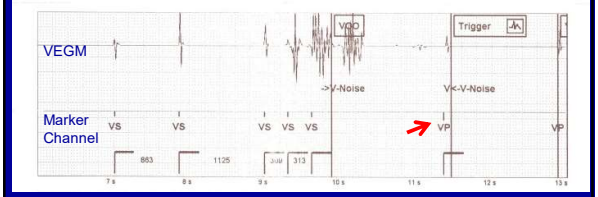
Noise Reversion Mode Example: VOO



This patient was not pacing at all—then all of sudden he started to pace after a short burst of cautery---Is it a malfunction?

Do a full analysis of the electrogram
1. What do we see on the strip?
2. Notice how the V-Noise activates and VP ensues

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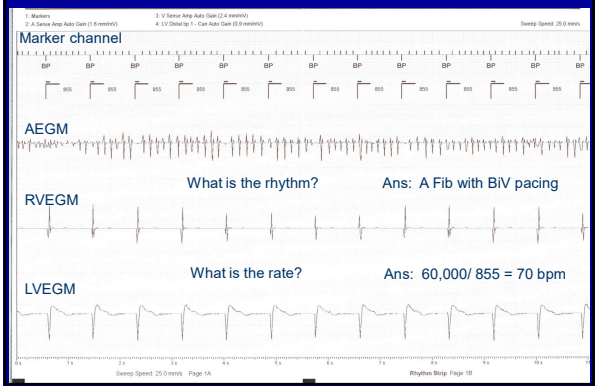
Noise Reversion Mode DOO



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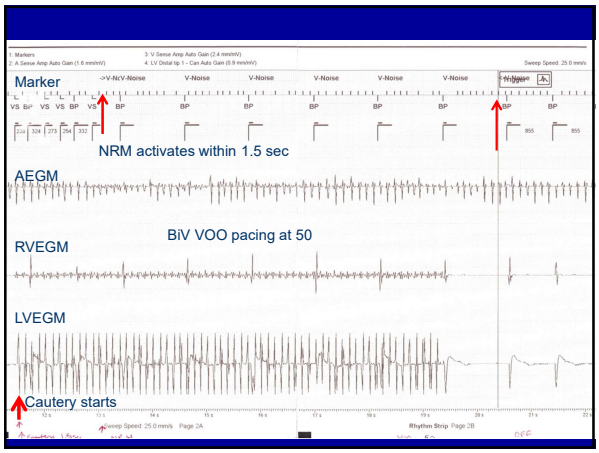

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Noise Reversion Mode Example

- In this case the pacer rate change from 70 to 50 was the sign that the pacer went into the NRM
- The pacer is not malfunctioning—just another PSEUDOMALFUNCTION

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4. Pacemaker Reset

- Typically caused by a surge of energy coursing through the pulse generator
- Converts pacer to a fixed VVI mode at a specific rate
  - Medtronic 65
  - Boston Sci 65
  - St Jude 67.5
  - Biotronik 70
- NOT temporary---Must reprogram

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MRI causes Pacer Reset

- 83 yo Cantonese speaking patient to OSH
- Had acute pancreatitis
- An MRI was performed
- When patient transferred to the MGH, the patient was hypotensive and the pacemaker was “malfunctioning”

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MRI converts Pacer to VVI

- Dec 2012 interrogation (1 year ealier):
  - DDD mode
  - 97% atrial pacing with intact ventricular conduction
- At MGH, she was in VVI mode due to pacer reset
  - Lost the effective atrial kick

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5. Rate Response Mode Activation

- If the rate response mode sensor misinterprets the electrocautery as a sign that the patient is increasing his or her activity level, the paced rate will increase
  - More likely with the minute ventilation sensor
  - This is more theoretical than practical in my experience

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6. Lead or Circuitry Damage

- RARE
- Occasionally after cardiac surgery I will see a "Lead Impedance Warning" that resolves
- I have not seen permanent lead or pulse generator damage related to cautery alone
- If it is going to occur—it will likely be related to direct radiation exposure or with cautery used very close to the device (e.g., PVI or VT ablation)

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Let's Summarize

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Electrocautery in patients with a Pacemaker may cause:

- Temporary asystole
- Elevated/erratic pacing rates due to ventricular tracking of cautery seen by the atrial lead
- Reversion to temporary asynchronous pacing (NRM)
- Permanent (pacer reset) VVI pacing
- Elevated pacing rates due to a inappropriate rate response mode activation
- Damage the lead-tissue interface or damage the pacemaker circuitry

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5 Ways to Reduce Cautery Issues:

- Avoid unipolar pace sensitivity settings when possible
- If bipolar cautery an option, use it
- Place cautery return pads strategically
- Minimize cautery output levels
- If inappropriate tracking occurs, convert to a non-tracking pacing mode if possible

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