

Perioperative Electrophysiology:  
*Special Programming:  
The Rate Response Mode*

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*I have no conflict of Interest*

## What do you need to know about the Rate Response Mode (RRM)?

1. Why patients need the RRM
2. How the RRM works
3. How to determine if the RRM is on
4. How to disable the RRM
5. How the RRM can affect patients in the perioperative period
6. How to manage the RRM in perioperative period

## Rate Response Mode Definition

A pacemaker function which helps increase the paced heart rate during exercise for those patients with chronotropic incompetence

## What is Chronotropic Incompetence?

Insufficient increase in HR during exercise or other activities of daily life which results in fatigue or SOB

## Patients with Pacemakers and Response to Exercise

- Some patients with a pacemaker are able to respond appropriately to exercise because they have an intact sinus node and are in sinus rhythm
- Other patients with a pacemaker are not able to respond appropriately to exercise—pts with SA dysfunction, Atrial fibrillation or those with a pacer in a non-tracking pacing mode, e.g., VVI

## Patients with a pacemaker and AV node disease?

- Sinus rate response to exercise is intact
- Pacer in a DDD mode can track the native sinus rate above the base pacing rate to respond to exercise
- Exercise leads to an increase in the sinus rate and the pacer follows 1:1 with ventricular pacing to keep up with demand
- Therefore patients with isolated AV node disease do not have CI

## Patients with a pacemaker and Sinus Node Disease

- Exercise may not reliably increase the sinus rate sufficiently to meet exercise demand
- A DDD pacemaker will not necessarily be sufficient as the base pacing rate does not change on its own
- This patient is "chronotropically incompetent"

## Patients with a pacemaker and in Atrial Fibrillation

- When a patient is in Afib, a tracking mode cannot be used, so the pacemaker must be changed to DDI or VVI
- Non-tracking modes have no way to increase the ventricular paced rate
- Patients with Afib are therefore also chronotropically incompetent

## Patients with a Non-tracking Pacing Mode

- If the pacemaker is in a non-tracking mode, the LRL is fixed.
- An increase in the atrial rate cannot be translated into an increase in the ventricular paced rate

## Summary of Patients with Chronotropic Incompetence

<u>Underlying Issue</u>	<u>Response to Exercise</u>
• Sick Sinus Syndrome	Chron Incomp
• A Fib with AV block	Chron Incomp
• DDI or VVI pacing mode	Chron Incomp

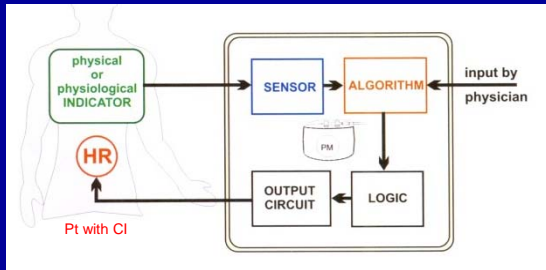
## Why do Patients Need RRM?

- And it is for these patients with Chronotropic Incompetence that the RRM was developed

## What do you need to know about the Rate Response Mode (RRM)?

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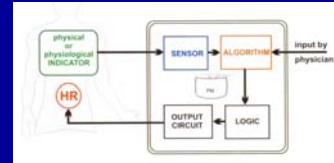
## Rate Response Mode Overview



Cardiac Pacemakers, SS Barold et al

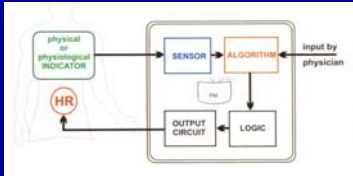
## Physical or Physiologic Indicators

- Body Movement
- Minute Ventilation
- RV contractility



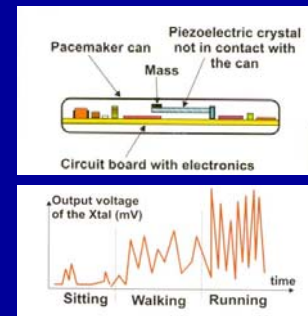
## Rate Response Mode (RRM) Sensors

1. Accelerometer (body movement)
2. Transthoracic Impedance (min. ventilation)
3. Myocardial Impedance (vent. contractility)



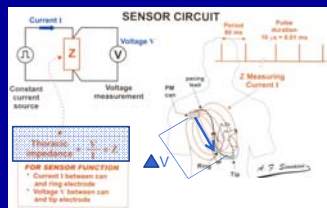
## Accelerometer

- A piezoelectric crystal with a small mass is attached to the circuit board of the pacemaker
- Patient movement in the A-P dimension leads to movement of the mass which deforms the piezoelectric crystal which then creates a voltage
- The voltage is detected by the pacer control system



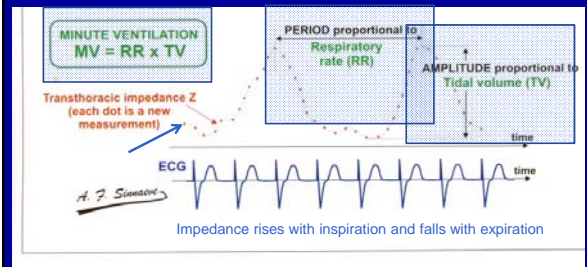
## Transthoracic Impedance Sensor

- Transthoracic impedance sensors measure the change of impedance across the chest during patient ventilation
- Rapid, ultra-short and subthreshold current impulses are emitted from the pulse generator and detected by one of the electrodes
- The voltage difference is measured
- Using  $V=IR$  the Resistance (Impedance) is determined



\* the current pulses I for impedance measurement are subthreshold, they have a low amplitude and are very short (pulse duration 5 to 15  $\mu$ s)  
 \*\* the measurement is frequently repeated (400 to 1200 times per minute)

## Minute Ventilation Sensor

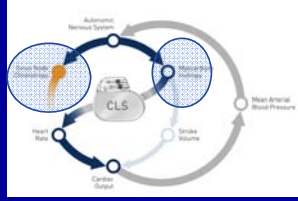


Increases in RR or TV can activate the sensor.

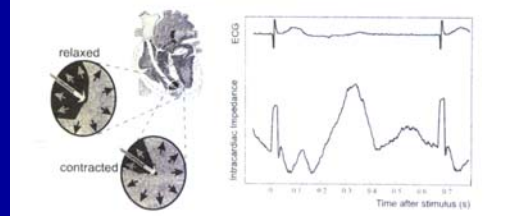
Cardiac Pacemakers, SS Barold et al

## Ventricular Impedance Sensor

- When the ANS detects a need to increase CO, it stimulates the SA Node and increases contractility
- Sinus Node dysfunction prevents the SA node contribution to increase CO
- The body compensates by increasing contractility further
- The "extra contractility" can be estimated by measuring myocardial impedance change at the RV lead's distal electrode



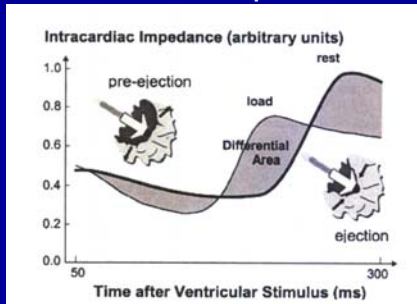
## INTRACARDIAC IMPEDANCE AND MYOCARDIAL CONTRACTILITY



$$\text{Myocardial Impedance (Z)} = \frac{\text{Measured V}}{\text{Injected I}}$$

Osswald S, et al, PACE 2000; 23:1502-1508

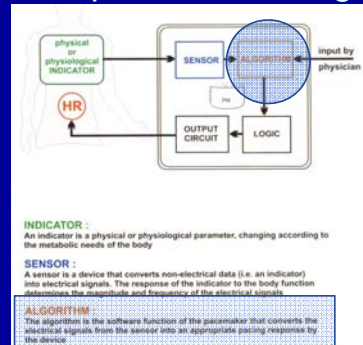
## Ventricular Impedance



The change in the RV impedance between rest and exercise is represented by the gray area. This information is used to adjust the heart rate

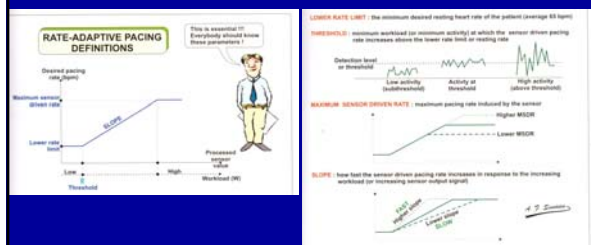
Griesbach L, et al, PACE 2003;26:1432-1437

## Rate Response Mode Algorithm



Cardiac Pacemakers, SS Barold et al

## Rate Adaptive Definitions



## Rate Response HR Change



Cardiac Pacemakers, SS Barold et al

## Key Points of how the RRM works

- Pacers with an active RRM sense physiologic signals with one of three different sensors
- A physician adjusts the pacer algorithm that determines how the HR will respond to that stimulus
- The HR hopefully matches the demands of daily life and exercise

## What do you need to Know?

- How the RRM works
- **How to determine if the RRM is on and what the settings are**
- How to disable the RRM
- How the RRM can affect patients in the perioperative period
- How to manage the RRM in perioperative period

## How to Determine if the RRM is programmed ON

- If the active pacing mode has an "R" at the end, the RRM is ON
- Information about the RRM and whether or not it is activated can be found in 3 ways:
  - Cardiologist or EP's recent note
  - Programmer report
  - Programmer interrogation

## Rate Response Mode Company Specific Information

- Medtronic
- St Jude
- Boston Scientific
- Biotronik

## Medtronic

- Essentially all Medtronic pacers and ICDs use an accelerometer sensor

## Medtronic Programmer Report

Serial Number: NWL205534

**Final Report**

Modes		
	Initial	Final
Mode	DDI	> DDDR
Mode Switch		On
Detection Rate		175 bpm
Detection Duration		No Delay
Blanked Flutter Search		On

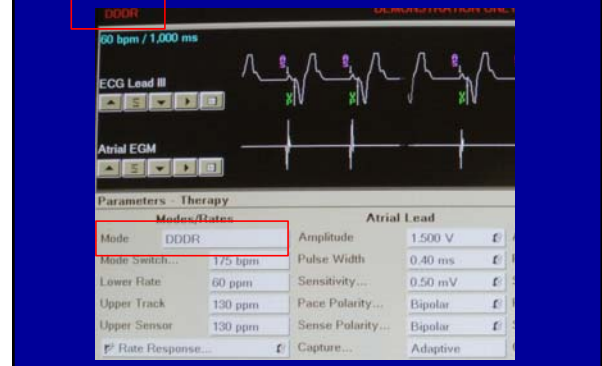
Rates		
	Initial	Final
Lower Rate	60 ppm	60 ppm
Upper Tracking Rate		130 ppm
Upper Sensor Rate		130 ppm
ADL Rate	95 ppm	95 ppm

**Intrinsic/AV**

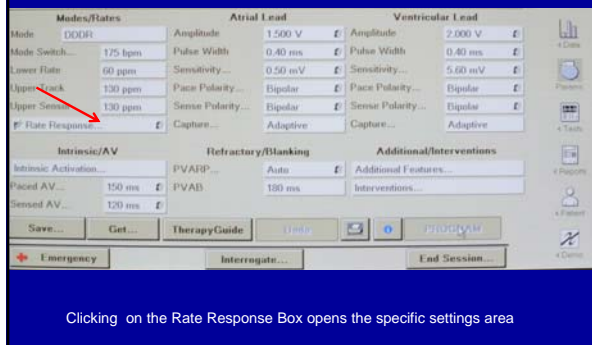
## Medtronic Programmer: Initial View



## Medtronic Initial View

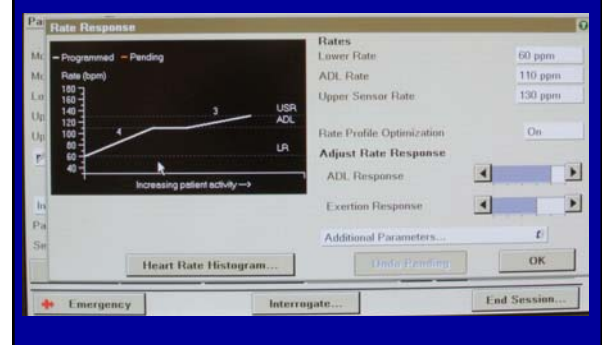


## Medtronic RRM Specific Settings

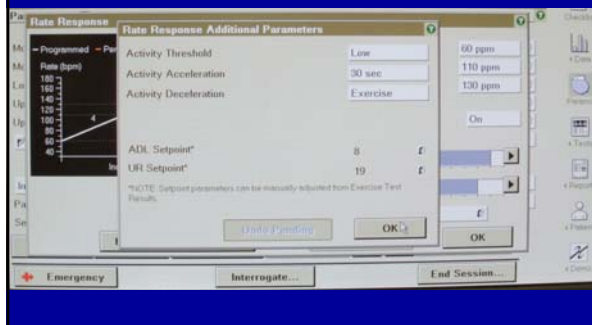


Clicking on the Rate Response Box opens the specific settings area

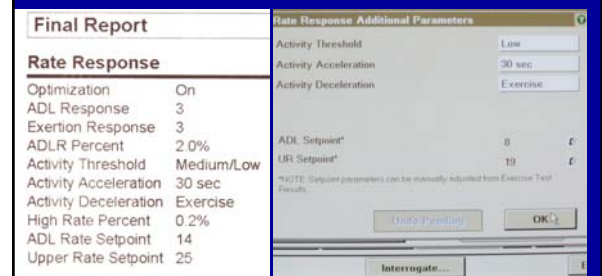
## Specific RRM Settings for Medtronic Devices



## Specific RRM Settings for Medtronic Devices



## Medtronic Comparison



Programmer Report

Programmer Screen



## St Jude RRM

- St Jude utilizes accelerometer technology only

## St Jude Programmer Report

Device	Manufacturer	Model	Serial	Implant Date
Pacemaker V Lead	St. Jude Medical St. Jude Medical	Accent® SR RP 1210 Tendril® STS 20687C / 53 cm	7455139 CAU155729	May 22, 2014 May 22, 2014

Battery	Voltage	3.01 V	Longevity estimate decreased due to activities this session
Longevity 4.6-5.0 yrs	Magnet Rate	100.0 ppm	
	Battery Current	12 uA	
	Remaining Capacity to ERI	>95%	

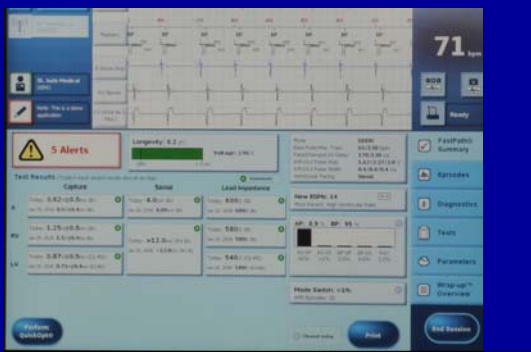
  

Test Results	Aug 4, 2015	Automatic
Capture	Sense	Lead Impedance
V 2.25V @ 0.5ms (B)	>12.0mV (B)	480 Ω (B)

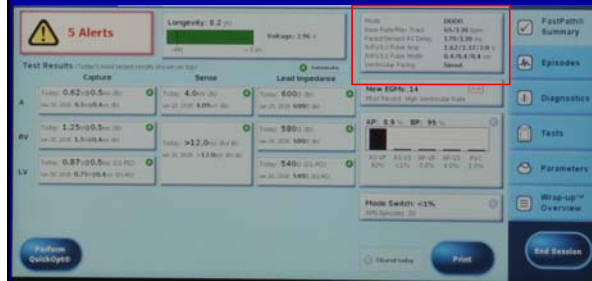
  

Parameters	Initial	Final
Mode	VVI	VVI
Base Rate	+80 bpm	+80 bpm
Programming Changes		
Base Rate	80 bpm	+80 bpm
Max Sensor Rate	110 bpm	%/n/a
Mode	VVI	+VVI
Reaction Time	Fast	%/n/a
Recovery Time	Medium	%/n/a
Sensor	On	+On
Slope	Auto (+2)	%/n/a
Threshold	Auto (-0.5)	%/n/a
V_Pulse Amplitude	2.5 V	+5.0 V

## St Jude Programmer



## Specific Settings for St Jude RRM



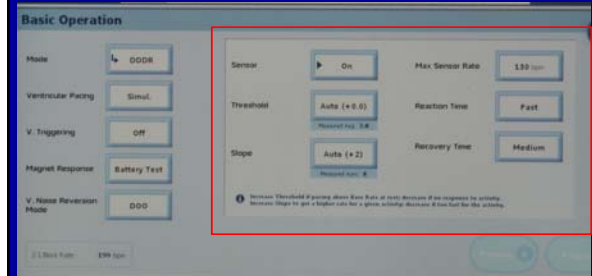
To get more information on the RRM settings click on the Mode Box or on the Parameters tab on the right

## St Jude Brady Parameters

Brady	Alert Notification	Episode Settings	Diagnostic Settings	Custom Sets
<b>Basic Operation</b>				
Mode	V DDDR			
Ventricular Pacing	Stimul			
V Trigg.ing	On			
Sensor, Magnet, Special Mode Settings...				
<b>Rates</b>				
Base Rate	65 bpm			
Fast Rate	On			
Max Sensor Rate	150 bpm			
Max Track Rate	130 bpm			
Hysteresis, Synchronization Settings...				
<b>Delays</b>				
Paced AV Delay	170 ms			
Sensed AV Delay	130 ms			
Negative AV Threshold/Search	On			
Additional Delays...				
<b>Capture &amp; Sense</b>				
Cap. Config	On			
Pulse Width	1.25 V			
Pulse Amplitude	2.375 V			
Pulse Width	0.4 ms			
Sensitivity	Auto			
Cap Config Settings, Sensitivity Settings...				
<b>Leads</b>				
Pulse Configuration	Diapolar			
Sense Configuration	Diapolar			
Lead Type, Lead Monitoring...				
<b>Refractory &amp; Blanking</b>				
PVBL	275 ms			
PVBL-vent. Atrial Blanking	150 ms			
V-Face Refractory	190 ms			
V-Face Refractory	250 ms			
PVC, PRT, Additional Settings...				
<b>AT/AP Detection &amp; Response</b>				
Auto Mode Switch	DDDR			
Arrhythmia Detection	100 bpm			
V-Face Refractory	190 ms			
AP Suppression	On			
Additional Settings...				

Click on the "Basic Operation" section to get the Mode Options and "Sensor" Settings

## St Jude RRM Settings



The sensor is ON. The additional settings are included in this area as well. Electrophysiologists adjust these settings to improve the pacing efficiency. Anesthesiologists will not need to modify these settings and should ensure they are not changed.

## Boston Scientific RRM

- BS has three sensor options:
  - Minute Ventilation
  - Accelerometer
  - Combination

## Boston Scientific RRM

Settings			
<b>Ventricular Tachy Settings</b>			
Ventricular Tachy ECG Storage	On		
Conversion Rate	150 bpm		
<b>Atrial Tachy Settings</b>			
Atrial Mode Search	170 bpm - Off		
<b>Brady Settings</b>			
Mode	DDD	Output	
Lower Rate Limit	50 ppm	Atrial	2.5 V @ 0.4 ms
Maximum Tracking Rate	130 ppm	Ventricular	2.0 V @ 0.4 ms
Maximum Sensor Rate	130 ppm	Sensitivity	AGC 0.25 mV
Paced AV Delay	150 - 200 ms	Atrial	AGC 0.5 mV
Sensed AV Delay	135 - 180 ms	Ventricular	
A-Refractory (PVARP)	240 - 400 ms	Leads Configuration (Pace/Sense)	
V-Refractory (VRP)	230 - 250 ms	Atrial	Bipolar
		Ventricular	Bipolar
<b>Rate Adaptive Pacing</b>			
Minute Ventilation	On		
Accelerometer	Passive		

Notice that the Mode DDDR indicates that a rate response mode is active. In the Rate Adaptive Pacing section you can find out which sensor is active. Note the Minute Ventilation sensor is on, the accelerometer is passive (off).

## Bost Sci. Programmer Printout with Pacer in DDD mode

Brady Settings		Output	
Mode	DDD	● A	Trend 3.5 V @ 0.4 ms
RYTHMIO™	AAI With VVI Backup	● V	Trend 3.5 V @ 0.4 ms
Lower Rate Limit	50 ppm	Sensitivity	Fixed 0.75 mV
Maximum Tracking Rate	130 ppm	● A	Fixed 2.5 mV
Paced AV Delay	220 - 300 ms	● V	
Sensed AV Delay	220 - 300 ms	Leads	
A-Refractory (PVARP)	240 - 280 ms	● A	Pace Bipolar
V-Refractory (VRP)	230 - 250 ms	● V	Sense Bipolar
PVARP after PVC	400 ms	Sense Safety Switch	On
AV Search -	On	● A	Pace Bipolar
Search AV Delay	400 ms	● V	Sense Bipolar
Search Interval	400 ms	Sense Safety Switch	On
Blanking	32 cycles	● A	Pace Bipolar
A-Blank after V-Pace	125 ms	● V	Sense Bipolar
A-Blank after V-Sense	45 ms	Sense Safety Switch	On
V-Blank after A-Pace	65 ms	<b>Rate Adaptive Pacing</b>	
Magnet Response	Pace Async	Minute Ventilation	Passive
Noise Response	DOO	Accelerometer	Passive

Note that both sensors are Passive

## Boston Sci. Programmer Printout with both sensors on

Settings		Output	
Mode	DDDR	● A	Trend 3.5 V @ 0.4 ms
RYTHMIO™	AAI With VVI Backup	● V	Trend 3.5 V @ 0.4 ms
Lower Rate Limit	50 ppm	Sensitivity	Fixed 0.75 mV
Maximum Tracking Rate	130 ppm	● A	Fixed 2.5 mV
Maximum Sensor Rate	130 ppm	● V	
Paced AV Delay	220 - 300 ms	Leads	
Sensed AV Delay	220 - 300 ms	● A	Pace Bipolar
A-Refractory (PVARP)	240 - 280 ms	● V	Sense Bipolar
V-Refractory (VRP)	230 - 250 ms	Sense Safety Switch	On
PVARP after PVC	400 ms	● A	Pace Bipolar
AV Search -	On	● V	Sense Bipolar
Search AV Delay	400 ms	Sense Safety Switch	On
Search Interval	400 ms	● A	Pace Bipolar
Blanking	32 cycles	● V	Sense Bipolar
A-Blank after V-Pace	125 ms	Sense Safety Switch	On
A-Blank after V-Sense	45 ms	<b>Rate Adaptive Pacing</b>	
V-Blank after A-Pace	65 ms	Minute Ventilation	On
Magnet Response	Pace Async	Response Factor	6
Noise Response	DOO	Pace Level	Active
		Ventricular Threshold	130 ppm

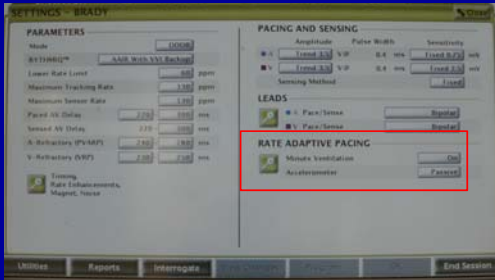
## Boston Scientific Programmer

## Boston Scientific Programmer

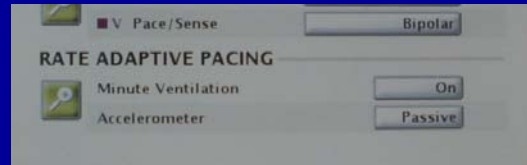
You can see that the mode indicates that RRM is ON. You also can see that the sensor is Minute Ventilation. To get more detail, click on the zoom box.



## Minute Ventilation On

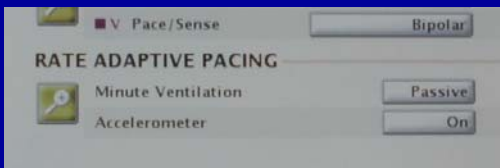


## Minute Ventilation On

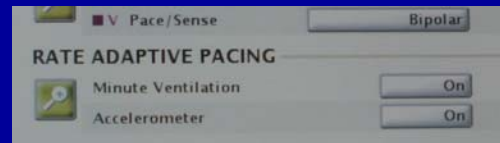


Notice that the Minute Ventilation is ON; the Accelerometer is PASSIVE. For our purposes, PASSIVE is OFF.

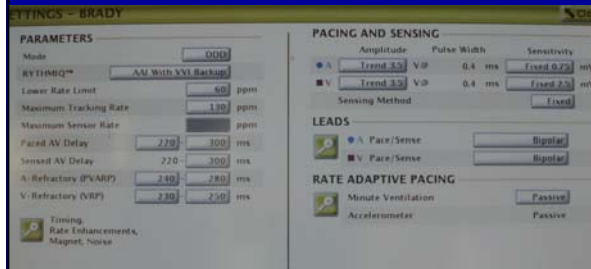
## It could also be set as: Accelerometer On



## or Both On

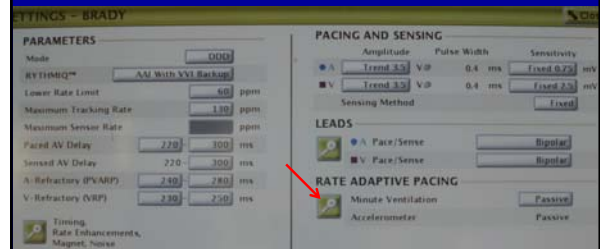


## or Both Off--DDD

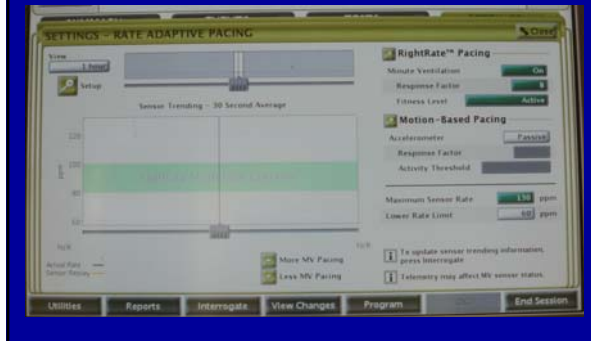


When the pacer is programmed in a DDD mode, both sensors will be Passive or Off.

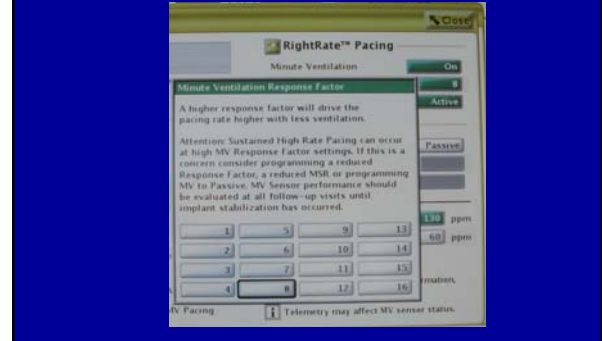
## To Get More Information on the Specific RRM settings click on the Zoom Box



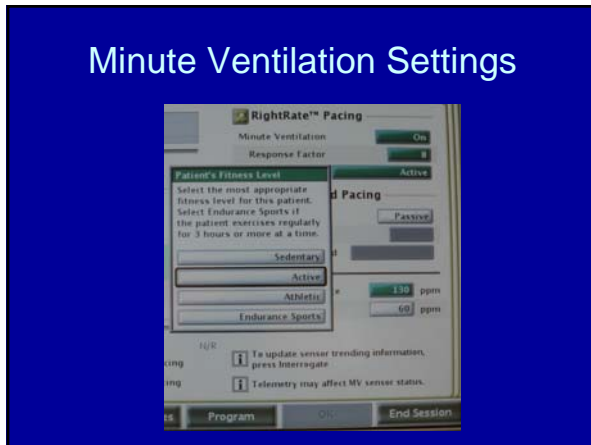
## RRM Specific Settings



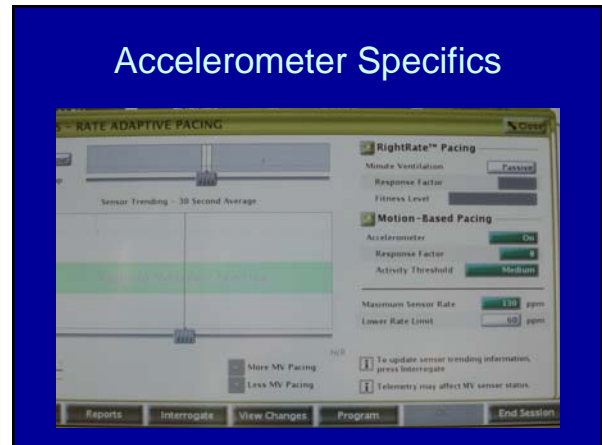
## Minute Ventilation Settings



## Minute Ventilation Settings



## Accelerometer Specifics



## Biotronik RRM

- Biotronik has two types of sensors
  - Accelerometer (appears as DDDR)
  - Ventricular Impedance (appears as DDD-CLS)
    - "CLS" is closed loop stimulation algorithm

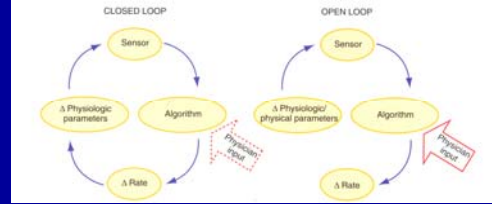
## Biotronik Programmer Report DDDR

<b>Bradycardia</b>	
Mode	DDDR
Basic rate/night rate [bpm]	60/OFF
Night begins	.....
Night ends	.....
Hysteresis [bpm]	OFF
Repetitive cycles	.....
Scan cycles	.....
Sensor/Rate fading [bpm]	120/OFF
Sensor gain	4
Automatic gain	ON
Sensor threshold	Medium
Rate fading	OFF
Rate increase [bpm/cycle]	4
Rate decrease [bpm/cycle]	0.5
Upper rate response [bpm]	120/WKB
Wenckebach response of [bpm]	120-156
Atrial upper rate [bpm]	240
Mode switching [bpm]	160/DDDR
Intervention rate [bpm]	160
Switch to	DDDR
Onset criterion [out of 8]	5
Resolution criterion [out of 8]	5
Change of basic rate [bpm]	+10
Rate stabilization during mode switching	OFF
2:1 Lock-in protection	ON
Vp suppression	OFF

# Biotronik Programmer Report DDD CLS

Bradycardia	Previous	Current
Mode	DDD-CLS	DDD-CLS
Basic rate/night rate [bpm]	60/----	60/----
Night begins	----	----
Night ends	----	----
Hysteresis [bpm]	OFF	OFF
Repetitive cycles	----	----
Scan cycles	----	----
CLS [bpm]	120	120
CLS response	Medium	Medium
CLS resting rate control [bpm]	+20	+20
Vp required	No	No
Sensor/Rate fading [bpm]	120	120
Sensor gain	4	4
Automatic gain	ON	ON
Sensor threshold	Medium	Medium
Rate fading	----	----
Rate increase [bpm/cycle]	4	4
Rate decrease [bpm/cycle]	0.5	0.5
Upper rate response [bpm]	130/WKB	130/WKB
Wenckebach response of [bpm]	130-150	130-150
Atrial upper rate [bpm]	240	240
Mode switching [bpm]	160/DDIR	160/DDIR
Intervention rate [bpm]	160	160
Switch to	DDIR	DDIR
Onset criterion [out of 8]	5	5
Resolution criterion [out of 8]	5	5

# What does CLS mean?



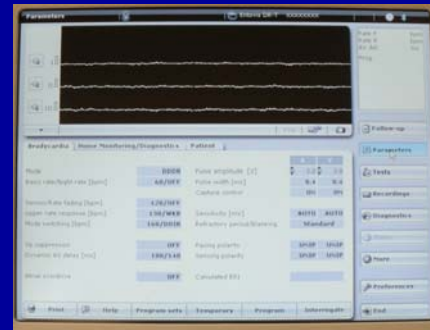
CLS=Closed Loop Stimulation

# DDD Mode

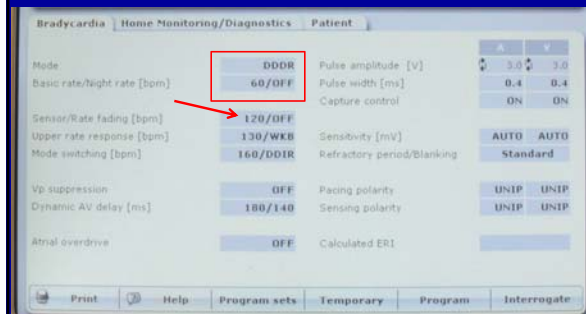
Bradycardia	Previous	Current
Mode	DDD	DDD
Basic rate/night rate [bpm]	60/OFF	60/OFF
Night begins	----	----
Night ends	----	----
Hysteresis [bpm]	OFF	OFF
Repetitive cycles	----	----
Scan cycles	----	----
Sensor/Rate fading [bpm]	120/OFF	120/OFF
Sensor gain	4	4
Automatic gain	ON	ON
Sensor threshold	Medium	Medium
Rate fading	OFF	OFF
Rate increase [bpm/cycle]	4	4
Rate decrease [bpm/cycle]	0.5	0.5
Upper rate response [bpm]	130/WKB	130/WKB
Wenckebach response of [bpm]	130-150	130-150
Atrial upper rate [bpm]	240	240
Mode switching [bpm]	160/DDIR	160/DDIR
Intervention rate [bpm]	160	160
Switch to	DDIR	DDIR
Onset criterion [out of 8]	5	5
Resolution criterion [out of 8]	5	5
Change of basic rate [bpm]	+10	+10
Rate stabilization during mode switching	OFF	OFF
7-1 loop-in protection	ON	ON

Even though the RRM is off, the settings for the RRM are listed in the programmer report

# Biotronik RRM—DDDR Accelerometer

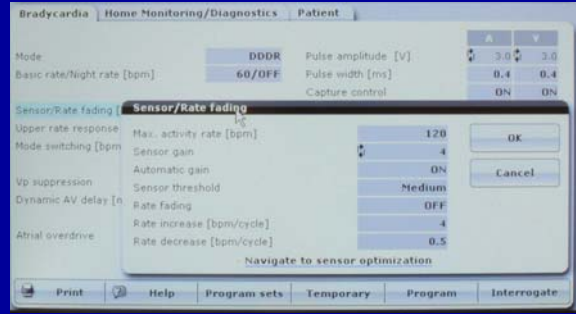


# Biotronik RRM—DDDR Accelerometer



To see the specific Accelerometer Settings click on "Sensor/Rate Fading"

# Patient Specific Settings--DDDR



## DDDR as seen on the Programmer Report

**Bradycardia**

Mode: **DDDR** (Current)

Basic rate/Night rate [bpm]: 60/OFF

Night begins: OFF

Night ends: OFF

Hysteresis [bpm]: OFF

Repetitive cycles: OFF

Sen cycles: OFF

**Sensor/Rate fading [bpm]**

Sensor gain: 4

Automatic gain: ON

Sensor threshold: Medium

Rate fading: OFF

Rate increase [bpm/cycle]: 4

Rate decrease [bpm/cycle]: 0.5

Upper rate response [bpm]: 120/OFF

Winckelbach response of [bpm]: 120/156

Atrial upper rate [bpm]: 240

Mode switching [bpm]: 160/DDDR

Intervention rate [bpm]: 160

Switch to: DDDR

Onset criterion [out of 8]: 5

Resolution criterion [out of 8]: 5

Change of basic rate [bpm]: +10

Rate stabilization during mode switching: OFF

2:1 Lock-in protection: ON

Vp suppression: OFF

**Sensor/Rate Fading**

Max. activity rate [bpm]: 120

Sensor gain: 4

Automatic gain: ON

Sensor threshold: Medium

Rate fading: OFF

Rate increase [bpm/cycle]: 4

Rate decrease [bpm/cycle]: 0.5

Rate of sensor adaptation: 0.5

The specific settings from the programmer are listed in the programmer printout

## Biotronik RRM--CLS

**Bradycardia** | Home Monitoring/Diagnostics | Patient

Mode: **DDD-CLS** (Current)

Basic rate/Night rate [bpm]: 60/----

CLS [bpm]: 120

Sensor/Rate fading [bpm]: 120/----

Upper rate response [bpm]: 130/W/B

Mode switching [bpm]: 160/DDIR

Vp suppression: OFF

Dynamic AV delay [ms]: 150/120

Atrial overdrive: OFF

Pulse amplitude [V]: 3.0

Pulse width [ms]: 0.4

Capture control: ON

Sensitivity [mV]: AUTO

Refractory period/Blanking: Standard

Pacing polarity: UNIP

Sensing polarity: UNIP

Calculated ERI: OFF

Print | Help | Program sets | Temporary | Program | Interrogate

## What do you need to Know?

- How the RRM works
- How to determine if the RRM is on and what the settings are
- **How to disable the RRM**
- How the RRM can affect patients in the perioperative period
- How to manage the RRM in perioperative period

## How to Turn Off the RRM

- You should know how to turn off the RRM modes of each of the 4 major manufacturers
  - Magnet-temporary
  - Programmer

## How to Turn off RRM in Medtronic Devices

- Very simple
- Use the programmer to change the mode to one without the "R"

## How to Turn off RRM in Medtronic Devices

ECG Level II

Atrial ECG

Parameters - Therapy

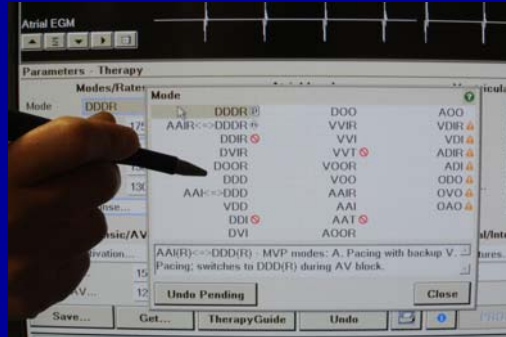
	Atrial Lead	Ventricular Lead
Mode	ECDD	ECDD
Max. Sensitivity	1.75 ppm	1.75 ppm
Lower Rate	60 ppm	60 ppm
Upper Limit	130 ppm	130 ppm
Upper Sensor	130 ppm	130 ppm
R Rate Response	Adaptive	Adaptive
Intrinsic/AV	PVARP: Auto	PVARB: 100 ms
Additional Interventions	Additional Interventions	Additional Interventions

Emergency | Interrogate | End Session

## How to Turn off RRM in Medtronic Devices



## Select the Desired Mode



## Click Program



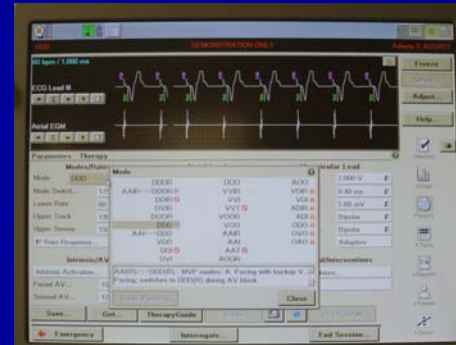
## Confirm Change



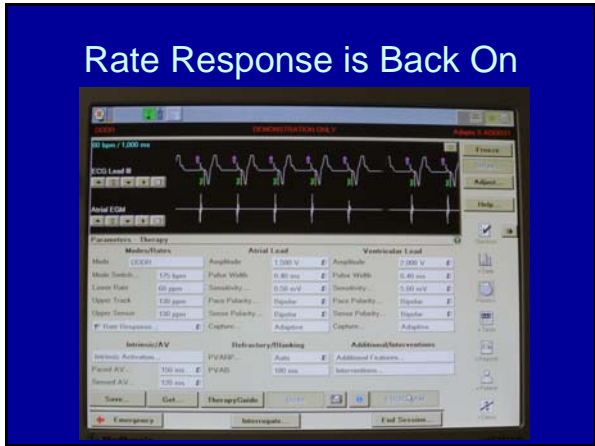
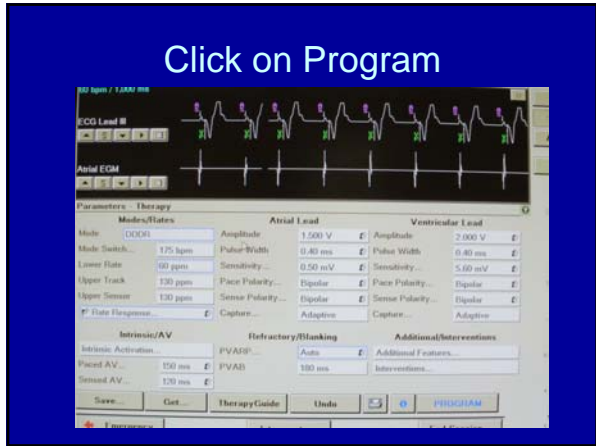
## To Resume Medtronic RRM



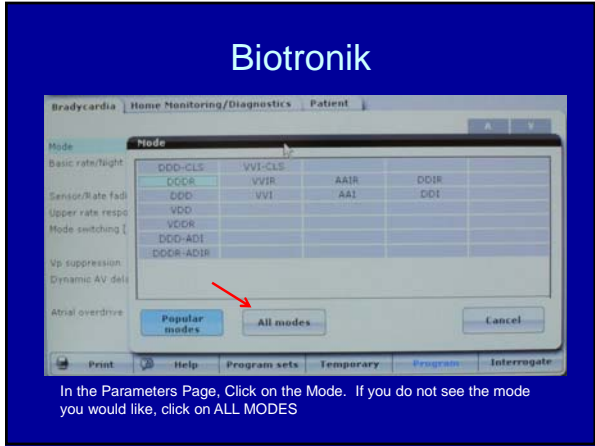
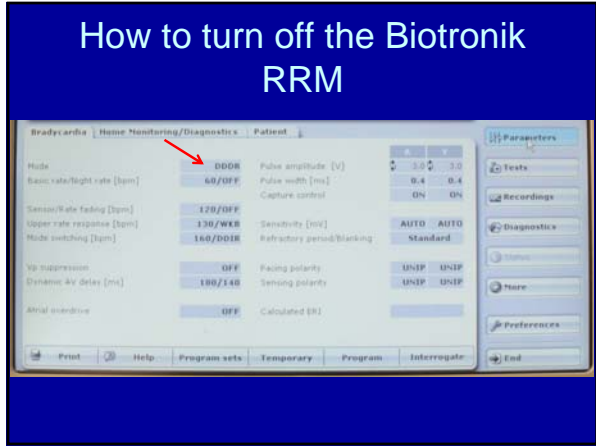
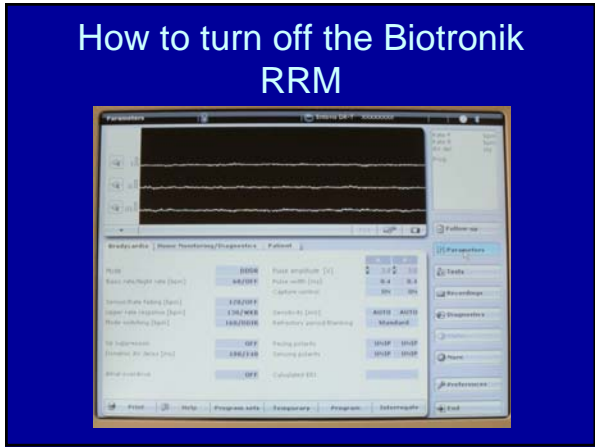
## Click on DDDR





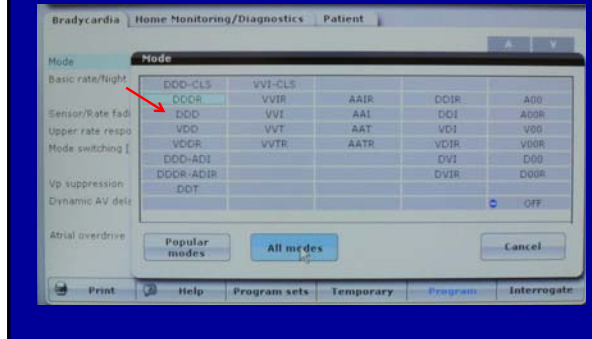


- ### Summary Medtronic RRM
- Turning the Medtronic RRM off and on is very simple
    - When turning off the Medtronic RRM, the patient specific RRM settings are retained
    - When you turn the RRM on at the end of the case, the patient specific RRM settings will automatically resume

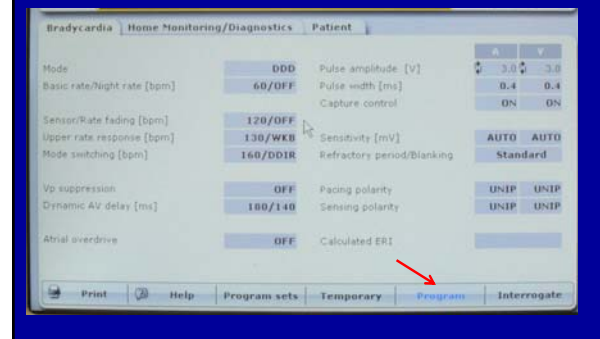




## Select DDD



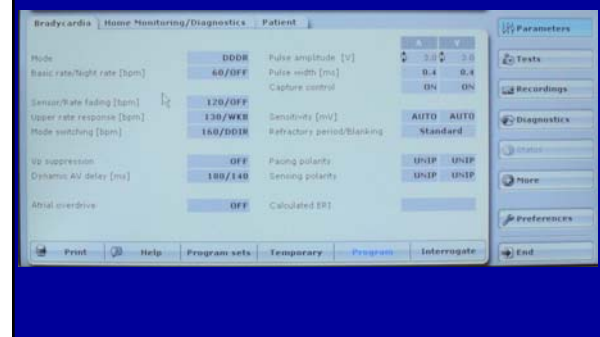
## Click Program



## Resume the Biotronik RRM

1. Open parameters page and click on the DDD mode to open the Mode Option Box
2. Click on DDDR
3. Click the blue Program box

## Confirm DDDR mode



## Key Biotronik Concept

- All the patient specific settings remain as they were before you turned the RRM off
- You do not have to go into the specific programming for the RRM to ensure that the patient specific settings are back to baseline

## Biotronik Summary

- Rate response mode can appear as DDDR (VVIR etc) or DDD-CLS
- R represents an accelerometer
- CLS represents a ventricular impedance sensor
- Both are turned off simply by clicking on the present mode and choosing the pacing mode without the rate response mode and programming the change

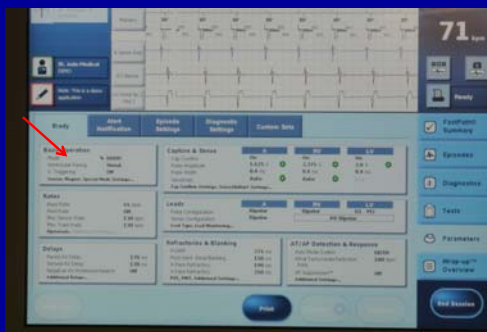
## Biotronik Summary

- Like the Medtronic devices, when you turn the Biotronik RRM back on, the patient specific settings automatically resume

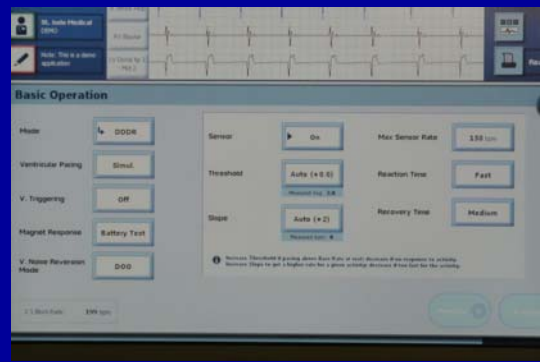
## How to turn off the RRM in a St Jude Device

- Less intuitive than Medtronic and Biotronik
- Not so simple as just changing the pacing mode
- Must turn SENSOR to Passive

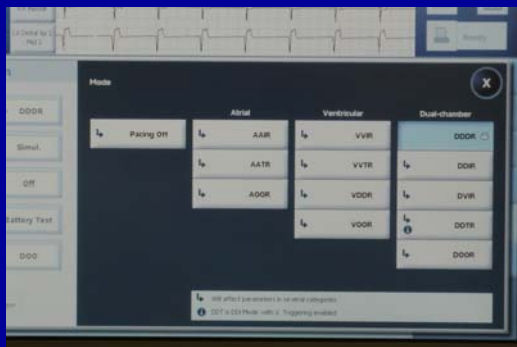
## How to turn off the St Jude RRM



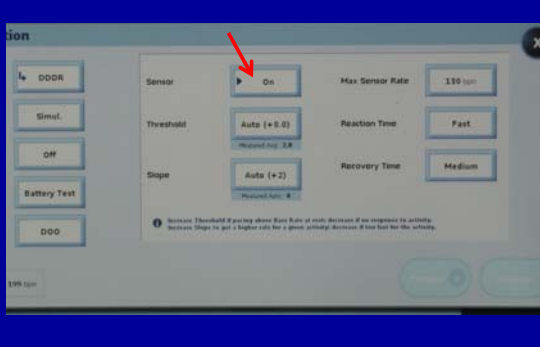
## Intuition Says Click on Mode



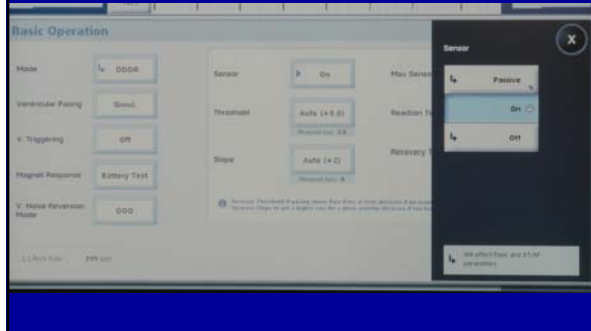
## Note that all Modes have an R



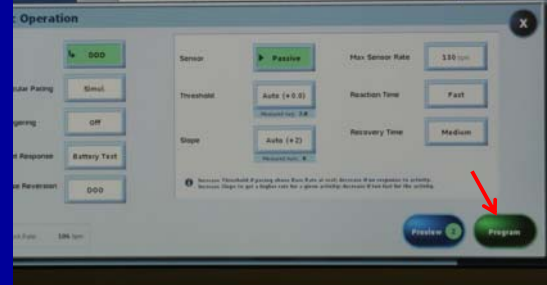
## Must Click on Sensor



## Turn to Passive to maintain patient-specific settings



## Must Click Program to Activate the Change



Notice that the mode changes to DDD automatically.

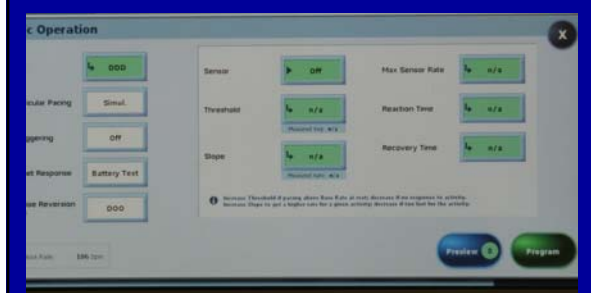
## Programmer Report BEFORE turning RRM off

Basic Operation	
Mode	DDDR
Ventricular Pacing	Simul.
V. Triggering	Off
Magnet Response	Battery Test
V. Noise Reversion Mode	DOO
Sensor	On
Threshold (Measured Avg.)	Auto (+0.0) (2.0)
Slope (Measured Auto)	Auto (+2) (8)
Max Sensor Rate	130 bpm
Reaction Time	Fast
Recovery Time	Medium

## St Jude Programmer Report after turning RRM to Passive

Basic Operation	
Mode	DDD
Ventricular Pacing	Simul.
V. Triggering	Off
Magnet Response	Battery Test
V. Noise Reversion Mode	DOO
Sensor	Passive
Threshold (Measured Avg.)	Auto (+0.0) (2.0)
Slope (Measured Auto)	Auto (+2) (8)
Max Sensor Rate	130 bpm
Reaction Time	Fast
Recovery Time	Medium

## Example of Turning St Jude RRM Off



NEVER turn the RRM OFF—always use Passive instead

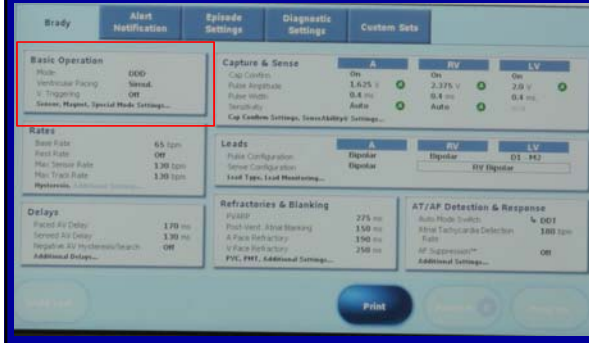
## St Jude Programmer Report when turning RRM Off

Basic Operation	
Mode	DDD
Ventricular Pacing	Simul.
V. Triggering	Off
Magnet Response	Battery Test
V. Noise Reversion Mode	DOO
Sensor	Off

Rates	
Base Rate	65 bpm
Rest Rate	Off
Max Track Rate	130 bpm
Hysteresis Rate	Off
2.1 Block Rate	186 bpm

## St Jude RRM now Passive/Off



## Turning RRM Back On

- Follow same procedure and turn RRM ON from either Passive or Off
- Check to make sure the baseline patient specific settings have not changed
  - Passive—no change in parameters
  - Off—may see a change in parameters

## RRM Active Again



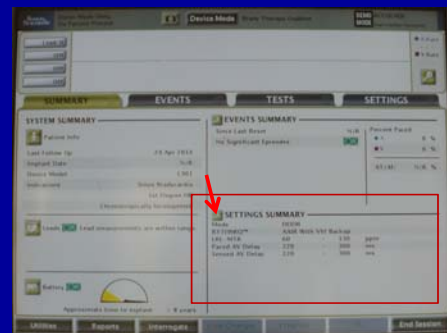
## St Jude Summary

- Unlike the Medtronic and Biotronik devices, you have to actually change the RRM setting in a location separate from the mode settings.
- Choose the PASSIVE setting, not the OFF setting to inactivate the RRM
- Reactivation of the RRM is easy
- Confirm that the patient-specific settings have not changed

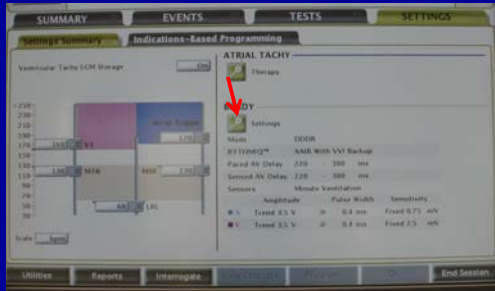
## How to turn off the Boston Scientific RRM

- Boston Scientific has two sensors and three possible sensor programming options

## How to turn off the Boston Scientific RRM

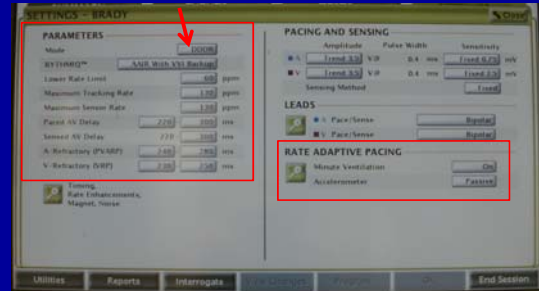


## How to turn off the Boston Scientific RRM



The rate limits are on the left—LRL, MTR, MSR, Mode Switch rate  
On the right you see the mode again as DDDR—click on magnifying glass again

## How to turn off the Boston Scientific RRM

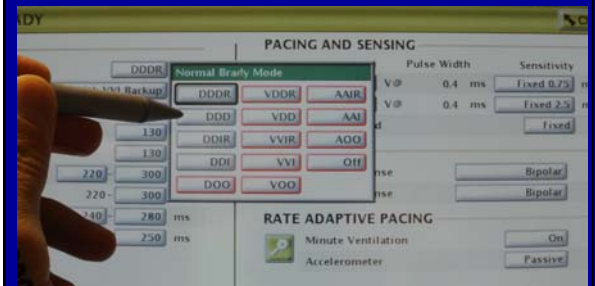


Now you can see the mode with a box around it; note the Rate Adaptive Pacing section  
Click on the DDDR box to open Mode Options

## How to turn off the Boston Scientific RRM

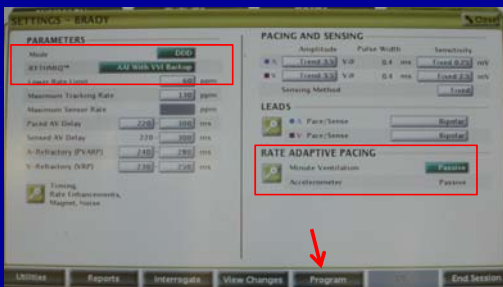


## How to turn off the Boston Scientific RRM



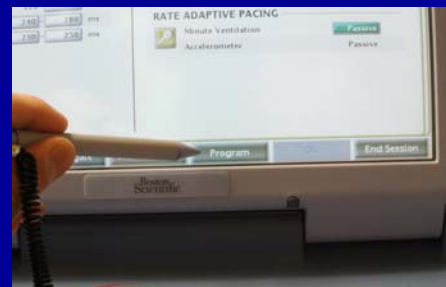
Click on the DDD mode to inactivate the RRM

## How to turn off the Boston Scientific RRM



Note the change in the Modes and the change from Min Vent on to Min Vent Passive  
All changed boxes are GREEN—you must push program to activate the change

## How to turn off the Boston Scientific RRM



You have two options to program your changes: click on screen as seen here

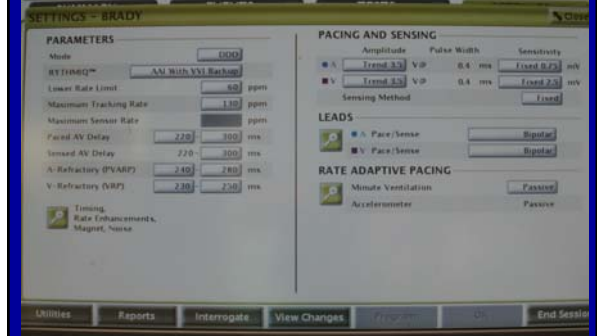


## How to turn off the Boston Scientific RRM

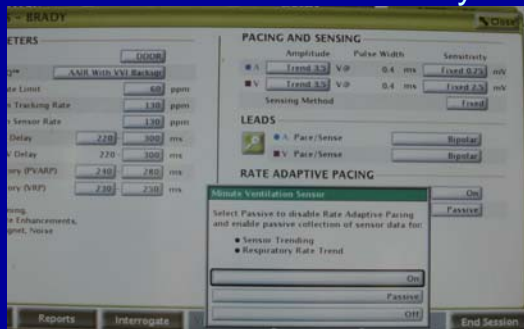


You have two options to program your changes: click on lower panel of programmer

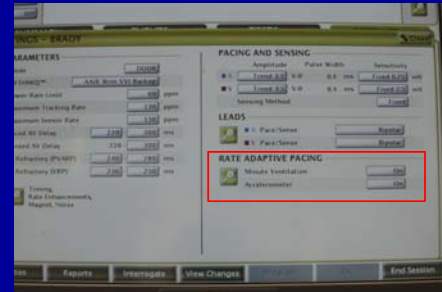
## Confirm that RRM "Off" by seeing DDD mode



## Can also convert the Min Ven Sensor to Passive Directly

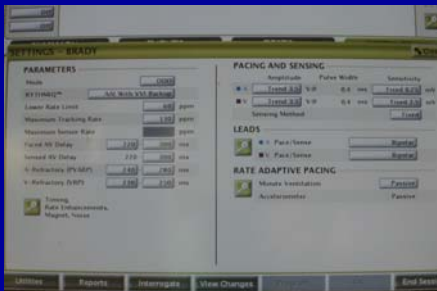


## Tricky Situation



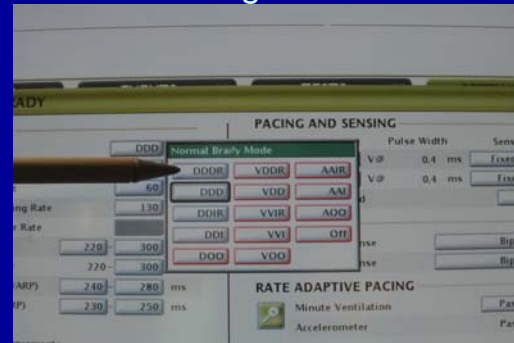
If Min Ven and Accel are on, and you turn off the RRM, you have to be vigilant when reactivating the RRM—Min Vent will come on, but the accel may not.

## Bost Sci RRM turned off now with RRM's in Passive mode



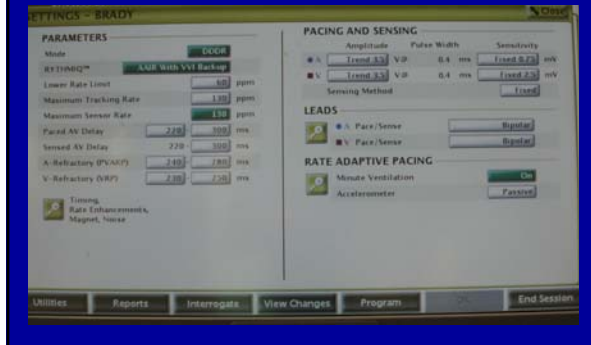
By converting the pacing mode from DDDR to DDD using the MODE option, MV and Accel. both convert to PASSIVE

## Post op, you choose DDDR again





Note that the Accelerometer is still Passive



## Key Concept

- Pacer and ICD programming is not always intuitive.
- Always print the baseline settings before making any programming changes
- Always make sure the post-op settings are the same as the pre-op settings if you make any programming changes

When turning off RRM make sure to use the passive option if available so as to not lose the baseline settings

## What do you need to Know?

- How the RRM works
- How to determine if the RRM is on
- How to disable the RRM
- **How the RRM can affect patients in the perioperative period**
- **How to manage the RRM in perioperative period**

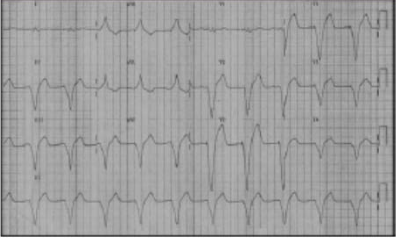
## Accelerometers and Anesthesia

- Environmental interference can cause unwanted HR increases:
  - Succinylcholine fasciculations
  - Shaking the patient during prepping
  - Electrocautery
  - Post op shivering

## Minute Ventilation Sensors and Anesthesia

- Increased RR or TV can produce a substantial increase in paced HR
- Electrocautery may provoke changes in the impedance and thus increase the pacer to the upper rate limit
- Respiratory monitoring systems in the ICU or recovery room can accelerate the paced HR

**P. R. E. W. E. P. r. m. h. m. h. c. r. e. c. m.**



**B**

connected to monitor in the operating

- 71 yo M with ICM and a St Jude pacemaker presented to ER with CP
- Connected to EKG monitor in ER and he subsequently developed WCT at 130—conscious and feeling OK, BP 120/70
- IV amio→hypotension→amio, mg, sotalol, 11 shocks
- BP unrecordable→Epi→transferred to tertiary center
- Arrived in stable paced rhythm at 70 bpm, intubated and unconscious

PACE 2006;29:438-40

### Ventricular Impedance Sensors (Biotronik CLS) and Anesthesia

- According to company technicians and reps, we do not have to be concerned about electrocautery negatively impacting the CLS (ventricular impedance) sensor
- I think it is therefore safe to not change the mode (e. g., from DDD-CLS to DDD) during surgery
- Nevertheless, maintain vigilance

### What do you need to Know?

- How the RRM works
- How to determine if the RRM is on
- How to disable the RRM
- **How the RRM can affect patients in the perioperative period**
- **How to manage the RRM in perioperative period**

### Rate Response Mode Recommendations

- Intrathoracic impedance (minute ventilation) sensors should be suspended for all surgery
- Accelerometers should be suspended if the surgery is in the High Risk Zone (above the waist)
- Ventricular impedance sensor (Biotronik CLS) can remain on

### Rate Response Mode Recommendations

- If the rate response mode is not turned off, the heart rate may increase transiently due to:
  - Increased patient motion or manipulation of the pacer or ICD
  - Increased ventilation
  - Electrocautery

### Special Consideration for Boston Scientific Devices

- If the patient has a Boston Scientific pacer or ICD and the mode indicates a RRM is active, you must find out which of the two sensors is/are active before you can determine how to manage the device

## Case Example Pt having Pelvic Surgery

**Impression & Recommendations:**

**Problem # 1: PACEMAKER, PERMANENT - BSCI ADVANTIO DUAL (ICD-VAS.01) (CD10-236 6)**  
normal pacemaker function with today. Patient continues to be pacemaker dependent. Atrial and ventricular output today were decreased to 2.0 volts. Patient will continue to follow him in the device clinic. Return to clinic in 6 months.

**Medications Added to Medication List This Visit:**  
1) Ofloxacin 0.3 % Soln (Ofloxacin) ... (patient not taking) 5 drops left ear twice daily for 7-10 days.

**Pacemaker/Defibrillator Device Interrogation**  
EKG with and without magnet on file.  
Chief Complaint: device check

**Device Information**  
Manufacturer: Boston Scientific  
Device Type: pacemaker  
Model: DDDR  
Model Name: Advantio  
Model #: K253 318 - 182126  
Atrial Lead #: 4136 29457040 Guidant  
RV Lead #: 4137 29467684 Guidant

**Battery Status**

**Lead Characteristics**  
P Waves: 4.0 mV  
Atrial (V @ ms): V @ 0.4ms@0.6  
Atrial: 7.2 Ohms

The patient has a Boston Scientific Pacemaker in the DDDR mode. Given that the procedure is below the waist, one might consider leaving the pacing mode unchanged

## Boston Scientific Adventio Pacer

Settings			
<b>Ventricular Tachy Settings</b>			
Ventricular Tachy RGM Storage	On		
Resync Rate	100 bpm		
<b>Atrial Tachy Settings</b>			
ATN Mode Switch: 120 bpm DDI			
<b>Brady Settings</b>			
Mode	DDDR	Pacing Output	
Lower Rate Limit	60 ppm	Atrial	2.0 V @ 0.4 ms
Maximum Tracking Rate	130 ppm	Ventricular	2.0 V @ 0.4 ms
Maximum Sensor Rate	130 ppm	Sensitivity	AGC 0.25 mV
Paced AV Delay	150 - 200 ms	Atrial	AGC 0.5 mV
Sensed AV Delay	135 - 180 ms	Ventricular	
A-Refractory (PVARP)	240 - 400 ms	Leads Configuration (Pace/Sense)	
V-Refractory (VRP)	230 - 250 ms	Atrial	Bipolar
		Ventricular	Bipolar
		Rate Adaptive Pacing	On
		Minute Ventilation	On
		Accelerometer	On

By checking the settings with a programmer, you note that a Min Vent sensor is on. You would be well to have the RRM turned off by converting to a DDD mode instead.

### Summary 1/4

1. Pts who are chronotropically incompetent depend on the RRM
2. There are three different sensors
3. You may determine which sensor is active by getting a programmer report or using a programmer to interrogate the device

### Summary 2/4

1. Medtronic and St Jude only have accelerometers
2. Boston Scientific has accelerometers and minute ventilations sensors
3. Biotronik has accelerometers and ventricular impedance sensors (CLS)

### Summary 3/4

1. A Magnet inhibits the RRM in pacemakers
2. A Magnet does not inhibit the RRM in ICDs
3. A Programmer can always turn off the RRM

### Summary 4/4

1. Suspend Min Ventilation RRM on all cases
2. Suspend Accelerometer RRM if in HRZ
3. If you leave rate response on, HR will likely increase in response to:
  - Increased patient motion/pressure on pacer
  - Increased ventilation rate
  - Electrocautery

THE END