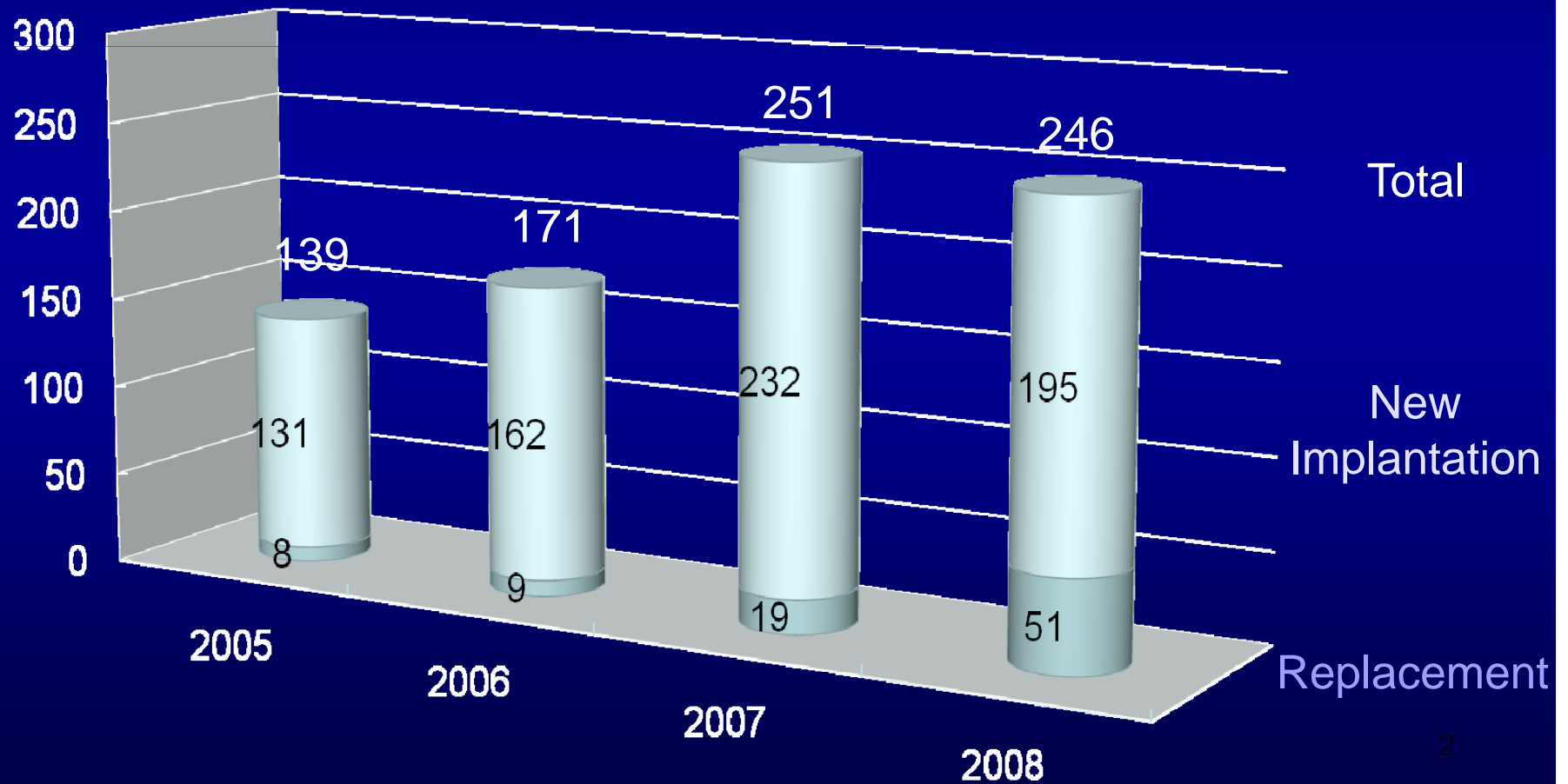


2010 춘계심장학회

ICD Troubleshooting

Kee-Joon Choi, MD / Ji-Hae Yun, RN
Asan Medical Center, Ulsan University

ICD Implantation in KOREA



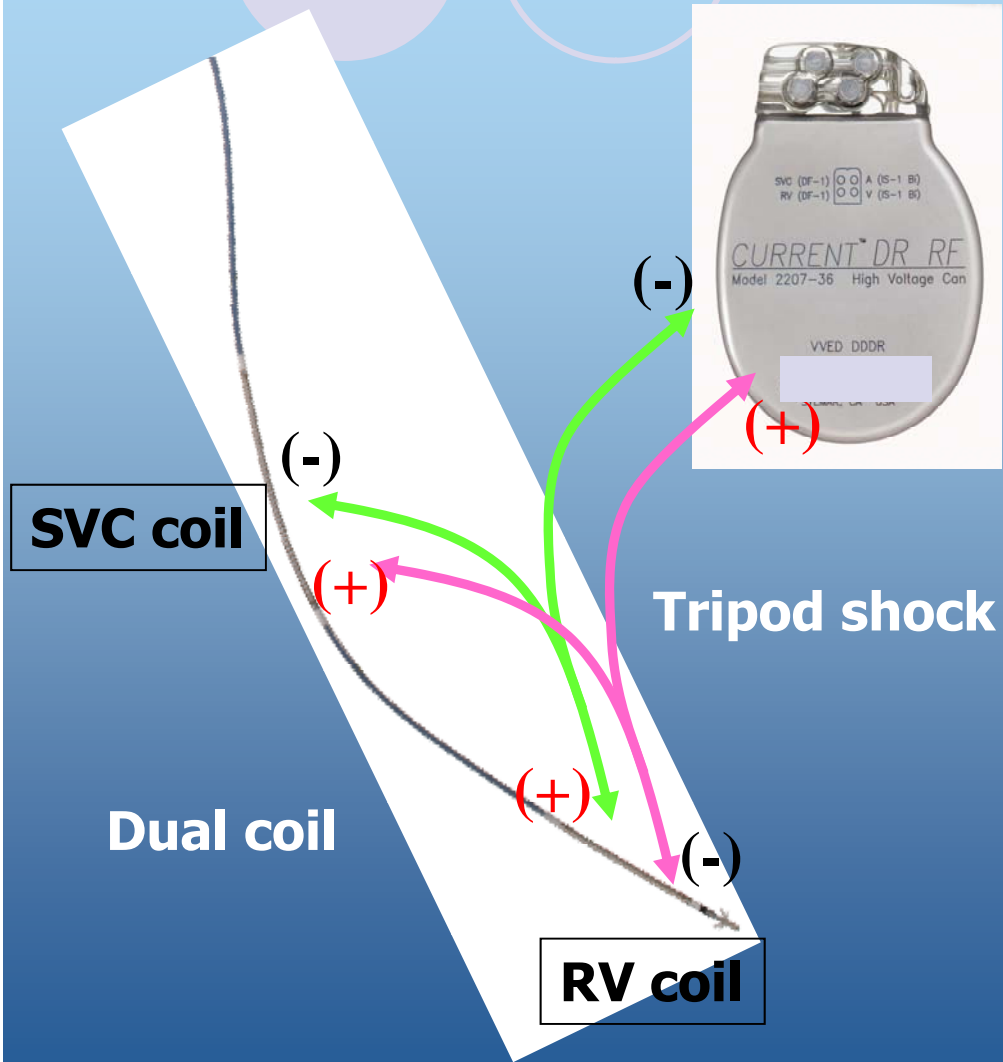
Troubleshooting Cases

- 1. High DFT during implantation**
- 2. Oversensing**
- 3. Electromagnetic Interference (EMI)**
- 4. Inappropriate shock**
- 5. Long charge time**

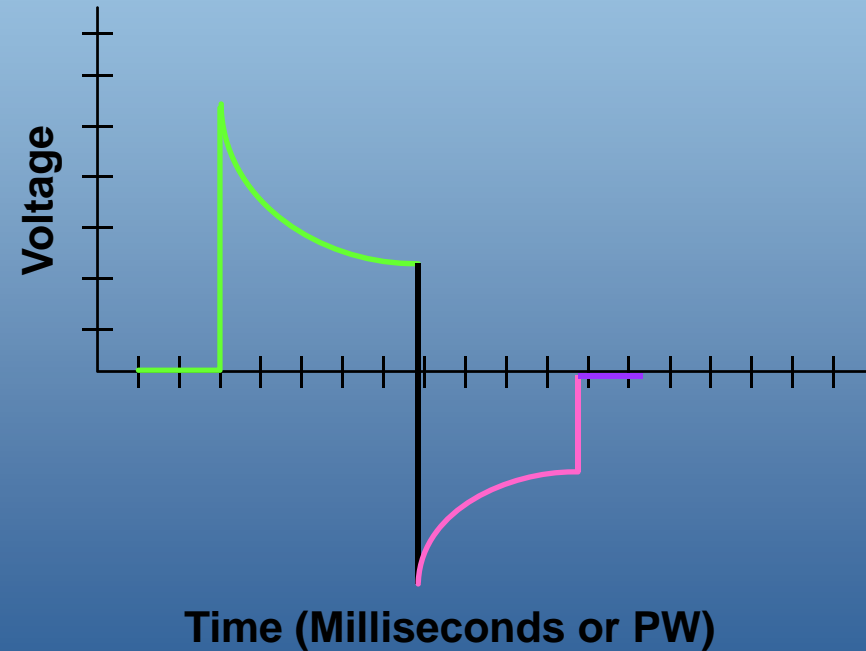
1. High DFT during ICD implant

- Lead position change
- Shocking vector change
 - Polarity change
 - SVC coil off
- Fixed tilt → Fixed pulse width (SJM)
- Separate coil in SVC or CS (Medtronic)
- (Surgical Patch)

ICD's shocking Vectors: Polarity change

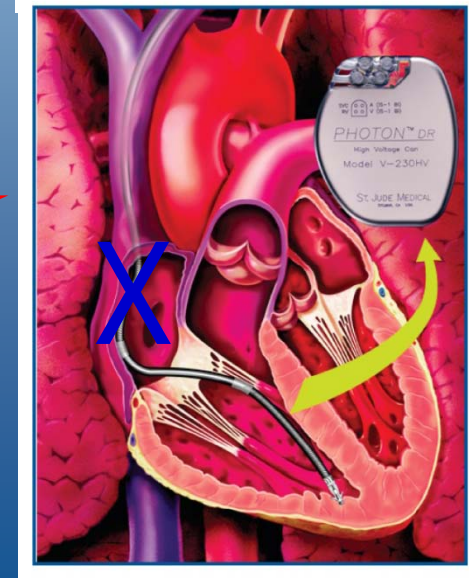
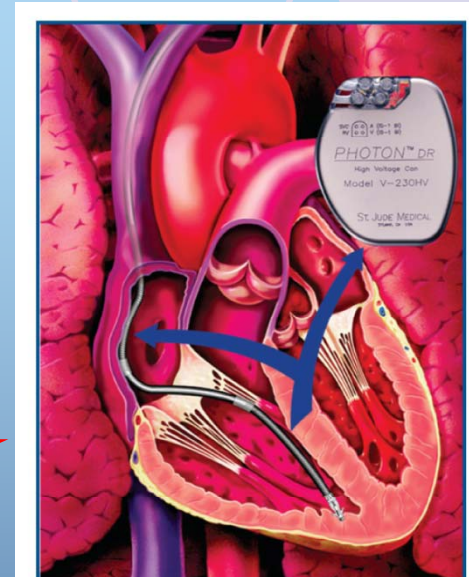


Bi-Phasic
SVC coil "ON"



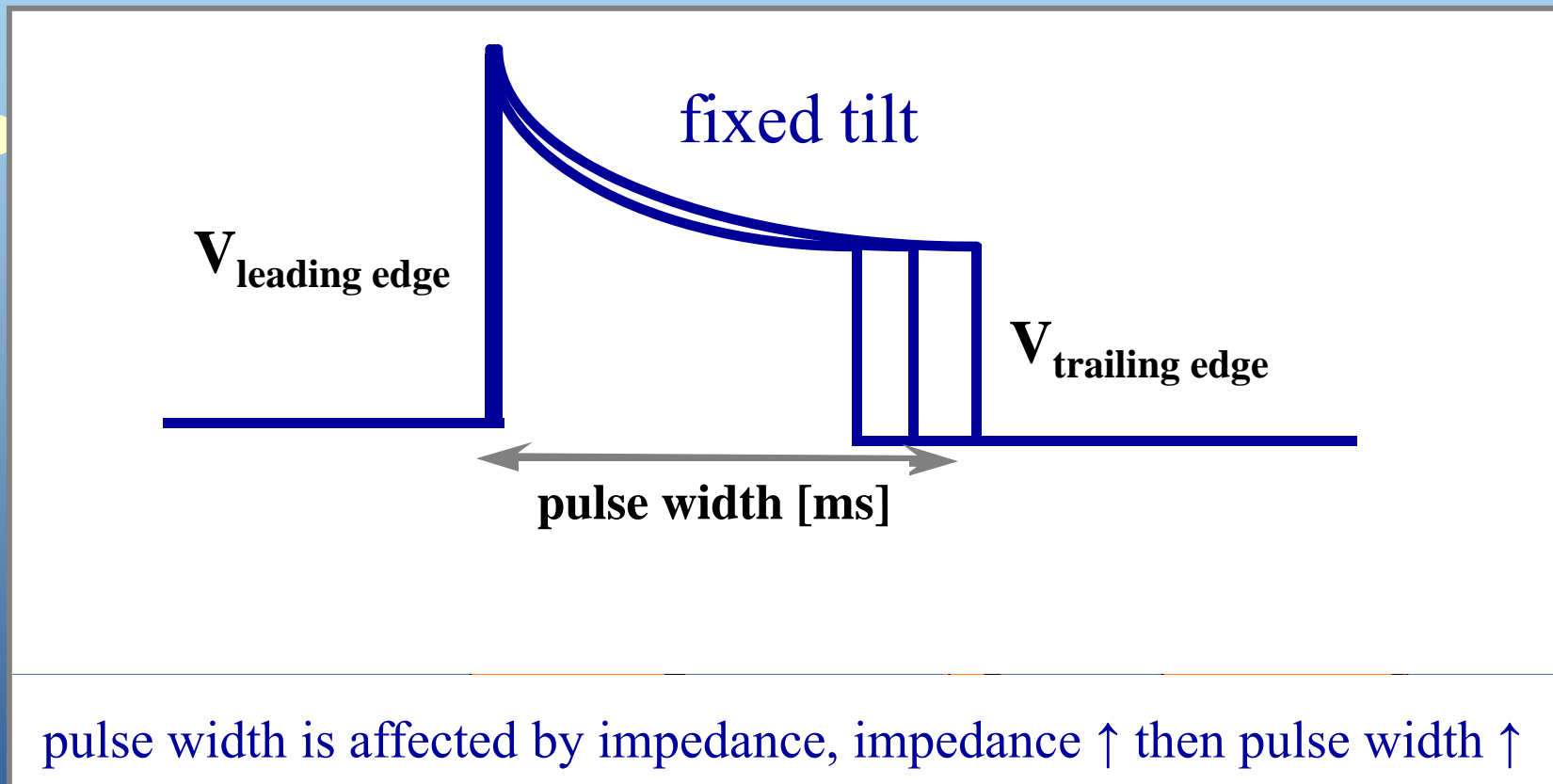
Programmable Shocking Vectors

- Requires dual-coil system
- SVC coil can be programmed ON or OFF
- **SVC coil ON**
 - Defibrillation energy travels from the **RV to either the coil on the lead or the can**
- **SVC coil OFF**
 - Defibrillation energy travels **from the RV to can only**



Waveform Programmability– **Fixed Tilt** (Biphasic)

- Pulse width will adjust based on shock



Tilt = 50%

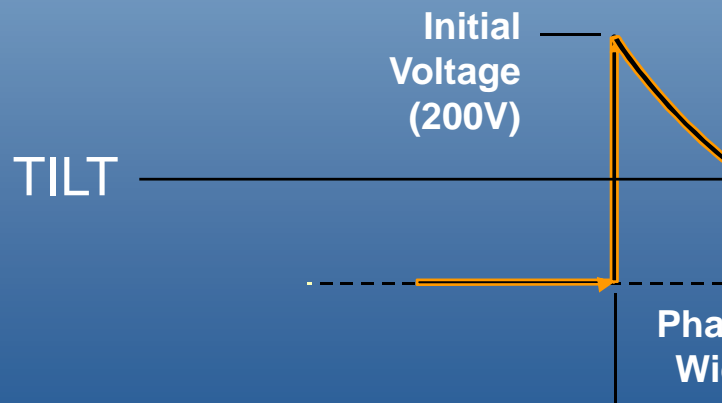
200 V

|||

Charge to 400 V (approx 10 J)

Waveform Programmability– **Fixed PW** (Biphasic)

- Fixed pulse width - shock therapy will be in volts (a joules reference is provided)
- Percent of the tilt and amplitude due to impedance
- Capacitor discharge is truncated at a programmed duration



4.0

Pulse width optimization card

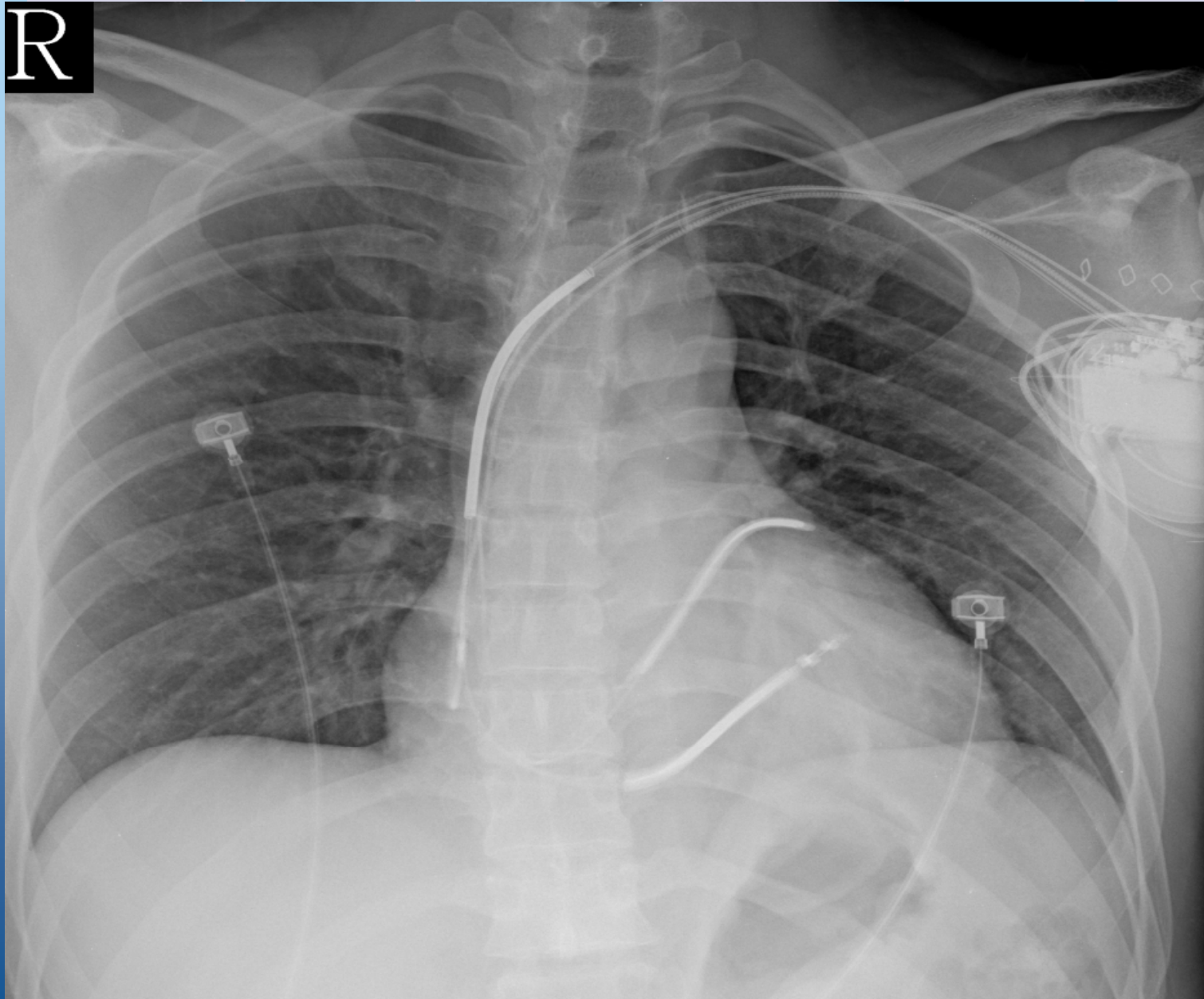
R (Ω)	Block #1				Block #2		Block #3	
	Typical patient (τ = 3,5 ms)				(τ = 2 ms)		(τ = 5 ms)	
	P1 (ms)	P1 tilt	P2 (ms)	P2 tilt	P1 (ms)	P2 (ms)	P1 (ms)	P2 (ms)
30	3,5	67%	3,5	67%	3,0	1,5	4,0	4,0
32	3,5	64%	3,5	64%	3,0	1,5	4,0	4,0
34	3,5	62%	3,5	62%	3,0	1,5	4,0	4,0
36	3,5	60%	3,0	54%	3,0	1,5	4,5	4,5
38	4,0	63%	3,5	58%	3,0	1,5	4,5	4,5
40	4,0	61%	3,5	56%	3,0	1,5	4,5	4,5
42	4,0	59%	3,0	49%	3,0	1,5	4,5	4,5
44	4,0	58%	3,0	47%	3,0	1,5	5,0	5,0
46	4,0	56%	3,0	46%	3,0	1,5	5,0	5,0
48	4,0	54%	3,0	45%	3,0	1,5	5,0	5,0
50	4,5	57%	3,0	43%	3,0	1,5	5,0	4,5
52	4,5	56%	3,0	42%	3,0	1,5	5,0	4,5
54	4,5	54%	3,0	41%	3,0	1,5	5,5	5,0
56	4,5	53%	3,0	40%	3,5	1,5	5,5	4,5
58	4,5	52%	3,0	39%	3,5	1,5	5,5	4,5
60	4,5	51%	3,0	38%	3,5	1,5	5,5	4,5

2008.10.01 implant (H-CMP with VT)

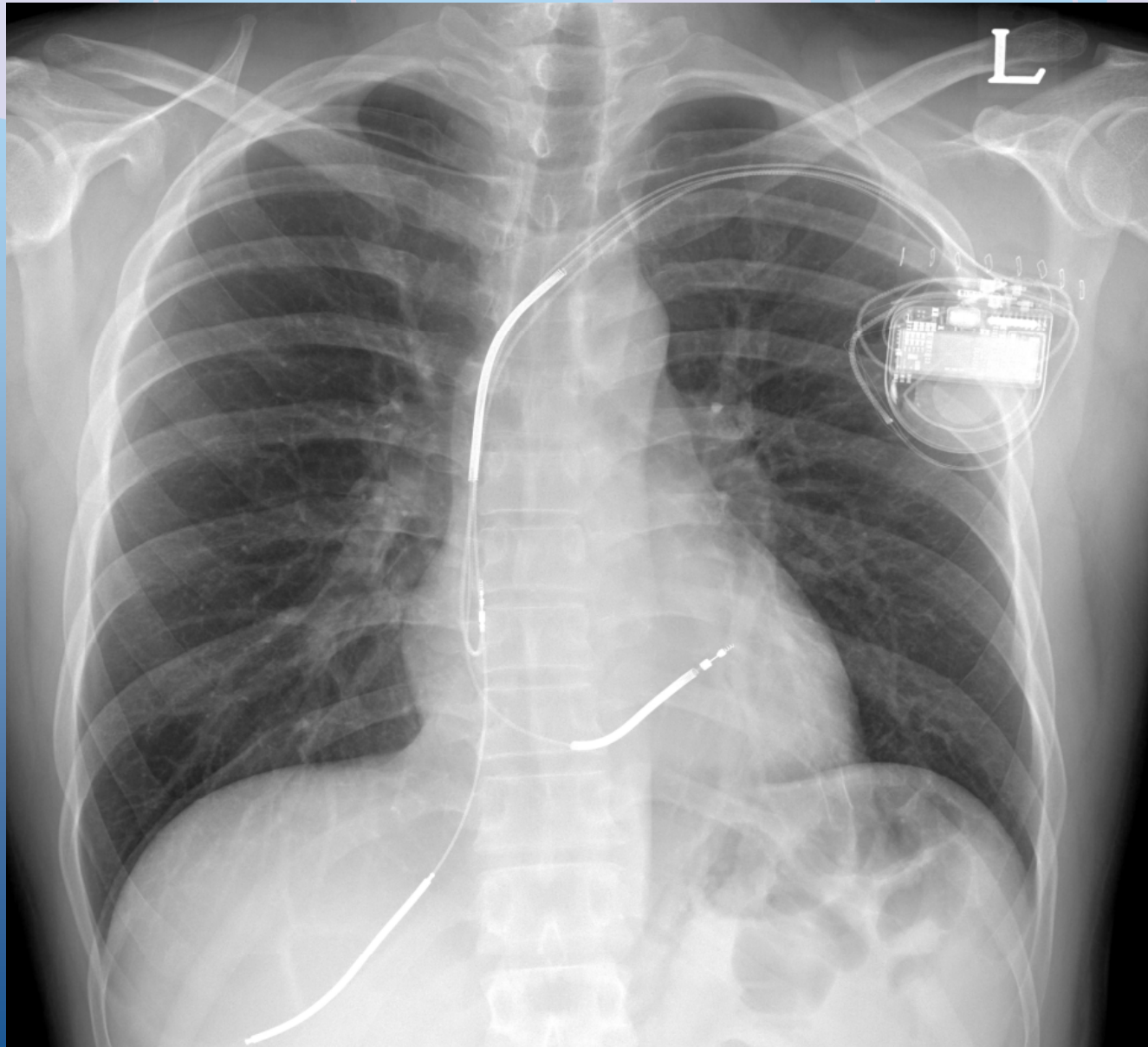
36J fail → with CS coil : 25J success



2009.08.10, D-CMP with SCD survivor 36J fail → with CS coil : 25J success



2009.08.11 (Post 1day)





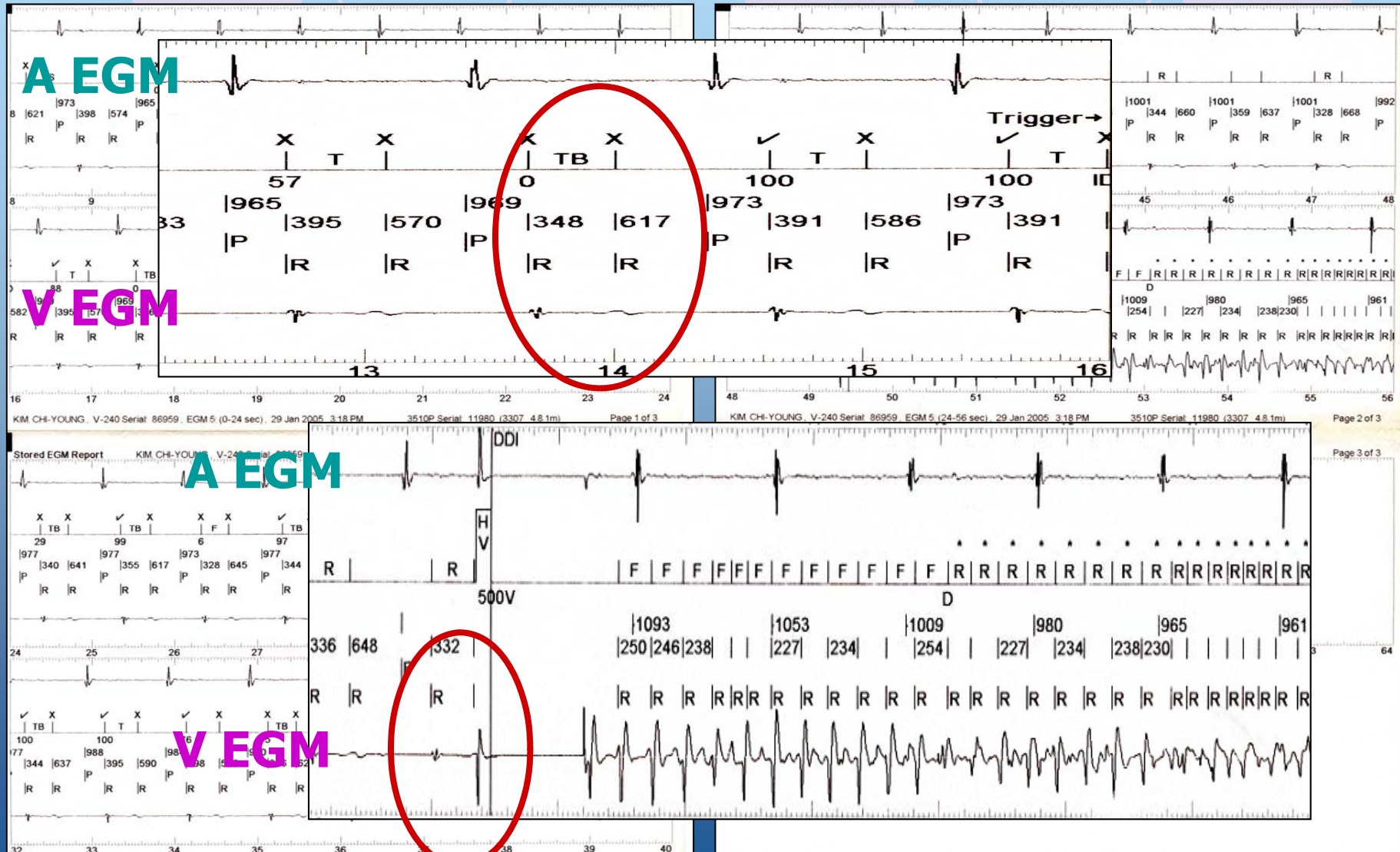
2. Oversensing

- **T-wave oversensing**
- **QRS double counting**
- **Lead fracture**
- **Lead insulation failure**
- **Loose setscrew**
- **Twiddler's syndrome**

T-wave oversensing

→ shock on T → ventricular fibrillation induced

Case 1



* Rhythm acceleration : VT → VF by ATP (anti-tachy pacing) or shock

Case 1

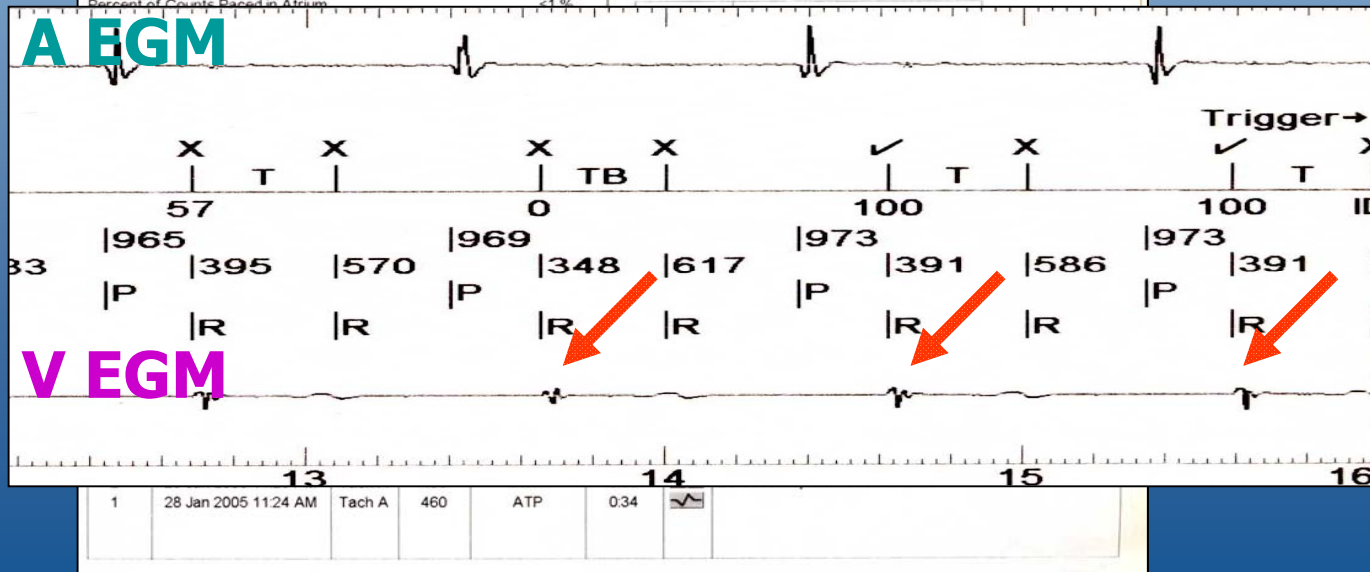
Caused by
Decrease R
 wave amplitude

Atlas™ DR Model V-240, Serial: 86959 Report Date/Time: 2 Feb 2005 12:14 PM

Battery and Charge Information		Status: 2 Alerts	
Implant Date	20 Dec 2004	Episodes with alert conditions	6
Battery Voltage	3.2 V	PMT Detections	6
Last Max Charge	N/A		

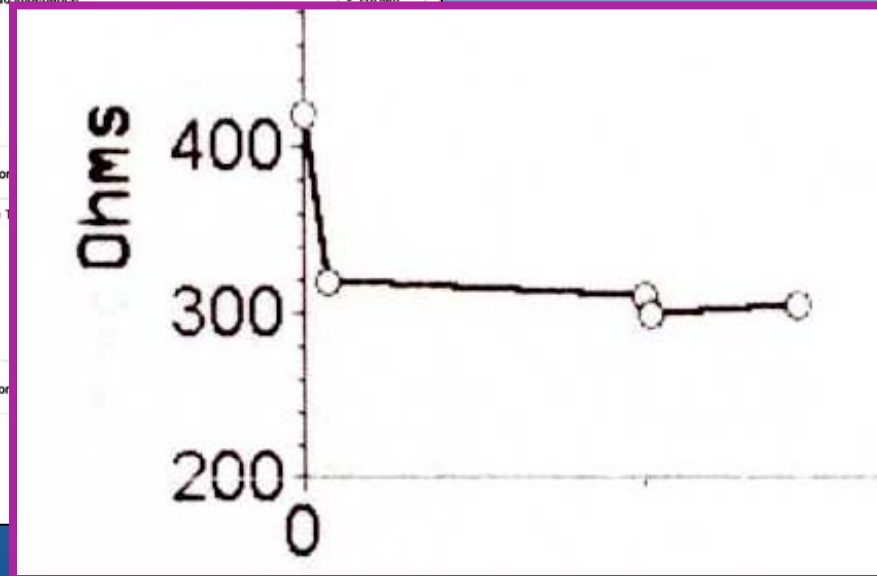
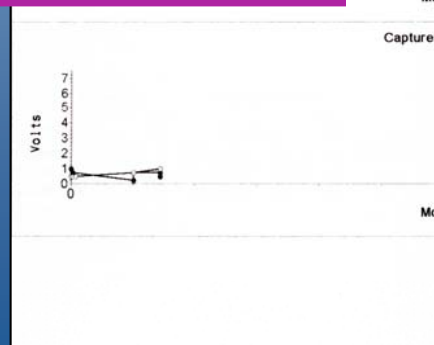
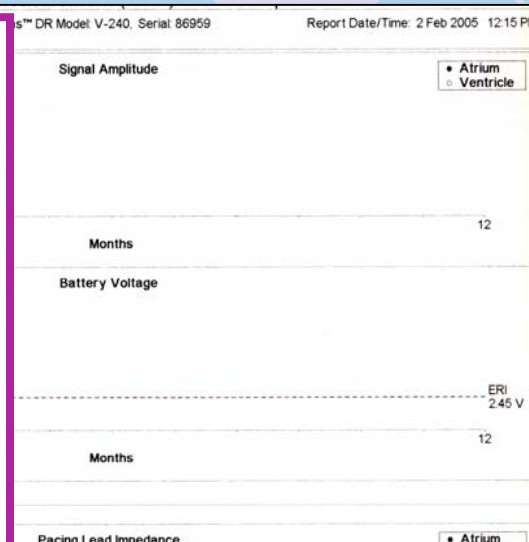
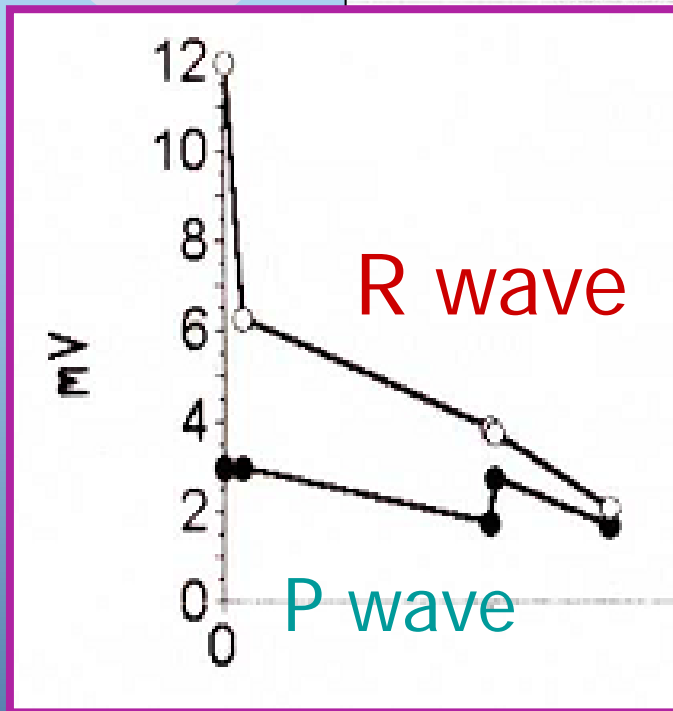
Lead Analysis (Last session: 20 Jan 2005)				
	Atrium		Ventricle	
Capture Threshold	Today 1.0 V	Last session 0.75 V	Today 1.0 V	Last session 0.75 V
Signal Amplitude	Today 2.1 mV		Last session 3.8 mV	
Pacemaker Impedance	Today 40 Ω		Last session 40 Ω	

Brady Diagnostics Summary		Tachy Diagnostics Summary	
Since 20 Jan 2005 11:33 AM		Since 20 Jan 2005 11:33 AM	



R wave trend during 2m
Decrease R wave amplitude
: 12mv → 6mv → 3.8mv → 2.1mv

Case 1

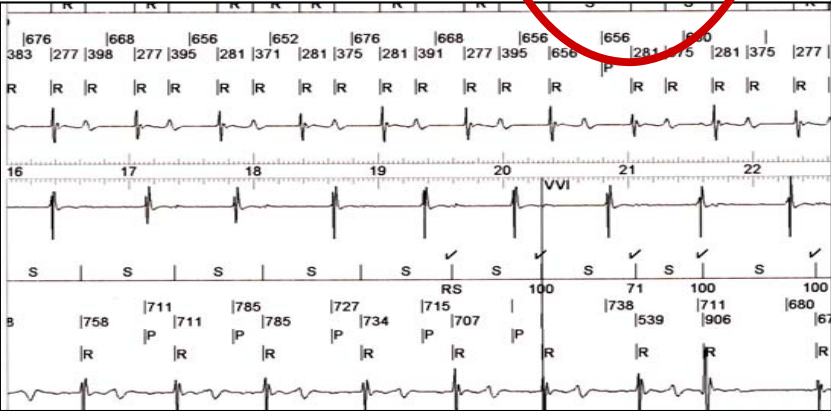
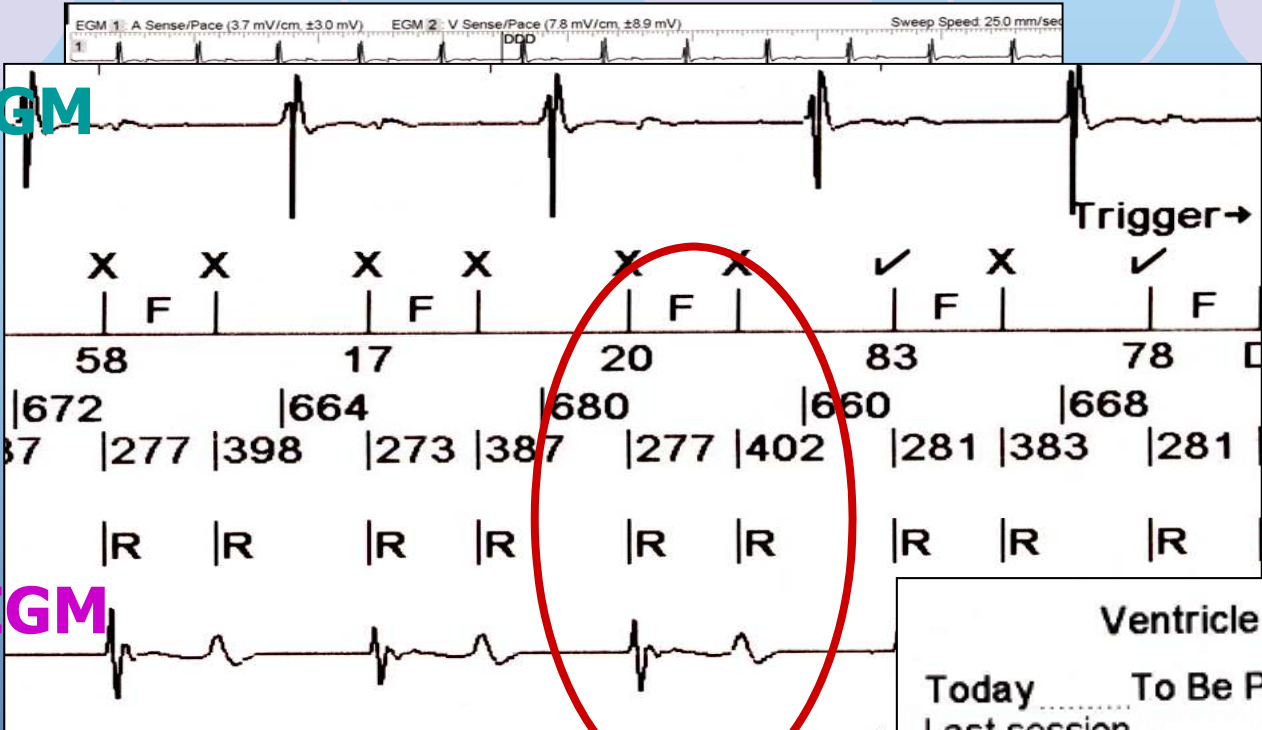


T-wave oversensing of Sinus rhythm

Case 2

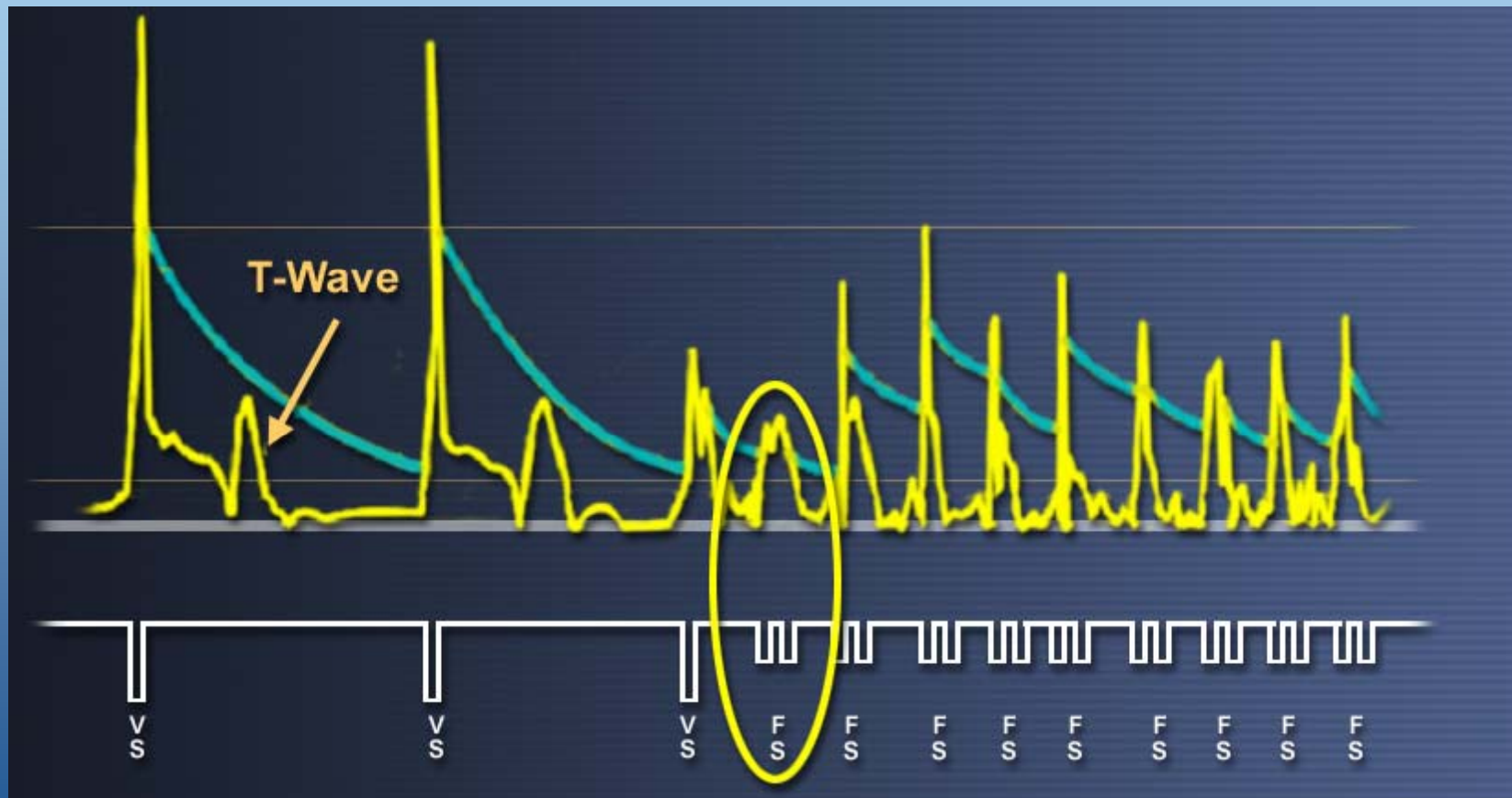
A EGM

V EGM



Ventricle	
Today	To Be Performed
Last session	1.0 V
Today	3.8 mV
Last session	3.4 mV
Today	335 Ω
Last session	330 Ω

T-wave oversensing during low R-wave amplitude



How to resolve T-wave oversensing?

Special Sensing

V. Sensitivity	Automatic, Max <u>0.2 mV</u>
V. Sense Refractory	157 ms
V. Post-Sensed Threshold Start	50 %
V. Post-Sensed Decay Delay	0 ms

Surface
ECG

EGM



How to resolve T-wave oversensing?

Special sensing program (SJM)

Patient: MOON, NEUNG-JA			Atlas® DR Model V-240, Serial: 87319			Report Date/Time: May 3, 2007 9:26 AM		
Tachyarrhythmia Configuration			Shock Waveform			Stored EGM		
Biphasic, Fixed Tilt 152 bpm 12 intervals			Biphasic, Fixed Tilt 200 bpm 12 intervals			EGM #1 A Sense/Pace, ± 3.0 mV V Sense/Pace, ± 8.9 mV First AMS Entry & Exit VF, SVT Timeout, VT SVT & VT/VF Diagnosis 16 sec/1 min		
SVT			VT ATP					
ATP x3 10.0 J (429 V) 22.5 J (642 V) 36.0 J x2 (801 V)			25.0 J (676 V) 36.0 J (801 V) 36.0 J x4 (801 V)			Output: 7.5 V, 1.0 ms BCL: 85 % (Readaptive) (Min 200 rns) No Bursts: 3 bursts Stimuli: 8 stimuli Scanning: Off Ramp: Off		
Timeouts			SVT Discrimination			SVT Criteria		
SVT Discrimination Timeout: 40 sec (VF Therapy) VT Therapy Timeout: VT for 50 sec			SVT Discrimination: Dual Chamber VT: On AF/AFI (V < A Rate Branch) Morphology: Passive (60 %, 5 of 8) Interval Stability: On (80 ms), 12 intervals AV Association Delta: Passive (60 ms)					

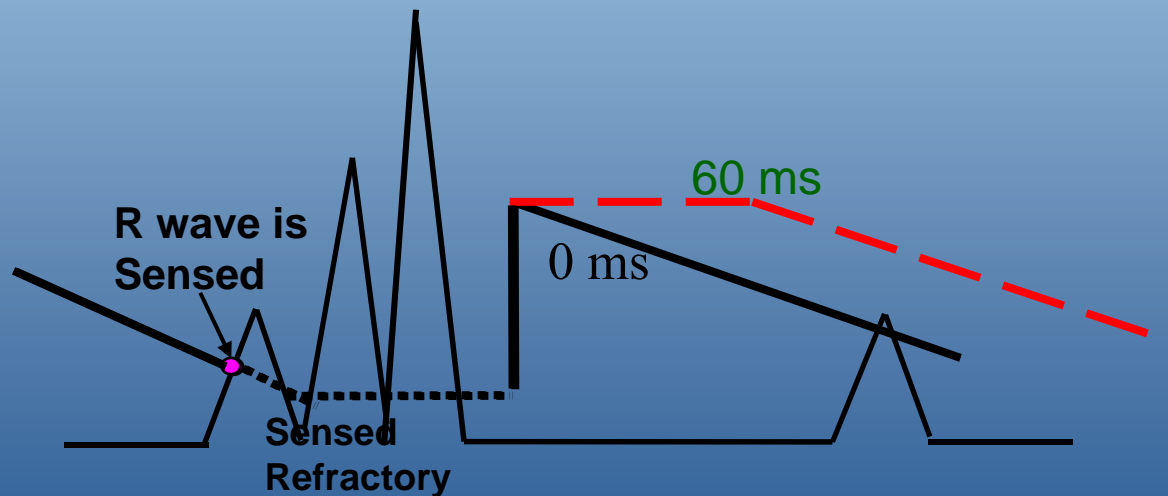
Special Sensing	
A. Sensitivity	Automatic, Max 0.2 mV
V. Sensitivity	Automatic, Max 0.3 mV
A/V Post-Sensed <u>Threshold Start</u>	50 % / 62.5 % *
A/V Post-Sensed <u>Decay Delay</u>	0 ms / 60 ms *

AMS	DDI	Post-Shock V. Output	7.5 V, 1.0 ms
Atrial Tachycardia Detection Rate	225 bpm / 267 ms	Special Sensing	
PVC Options	Off	A. Sensitivity	Automatic, Max 0.2 mV
PMT Options	Passive (Detect: 90 bpm)	V. Sensitivity	Automatic, Max 0.3 mV
Ventricular Noise Reversion Mode	Pacer Off	A/V Post-Sensed Threshold Start	50 % / 62.5 % *
Ventricular Safety Standby	On	A/V Post-Sensed Decay Delay	0 ms / 60 ms *
Episodic Pacing Mode	DDI	Special Functions	
		Capacitor Maintenance Charge Interval	1 month (800 V)
		Ventricular Blanking	32 ms

Decay delay

Special sensing program

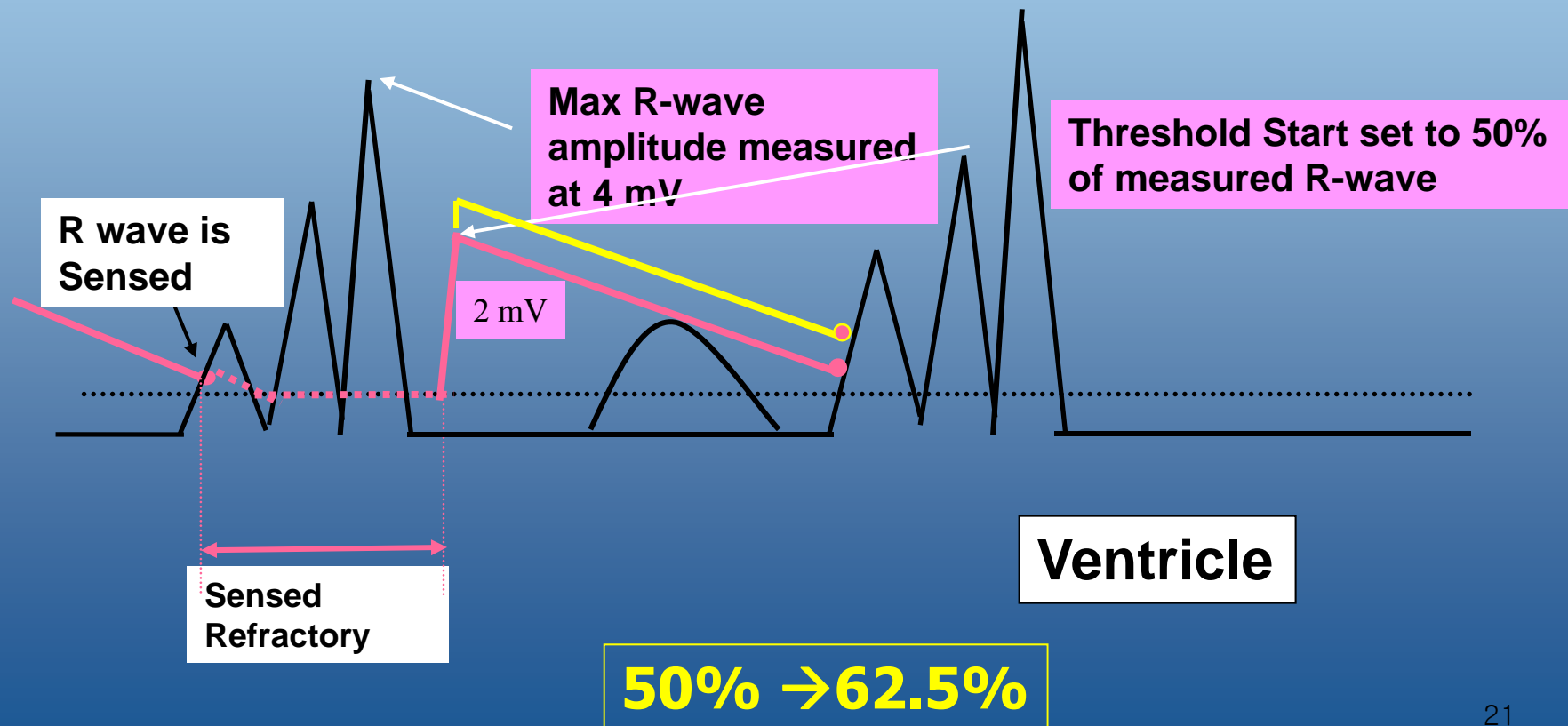
- The Decay Delay holds the sensitivity threshold at the starting value for a programmable amount of time



Threshold start

Special sensing program

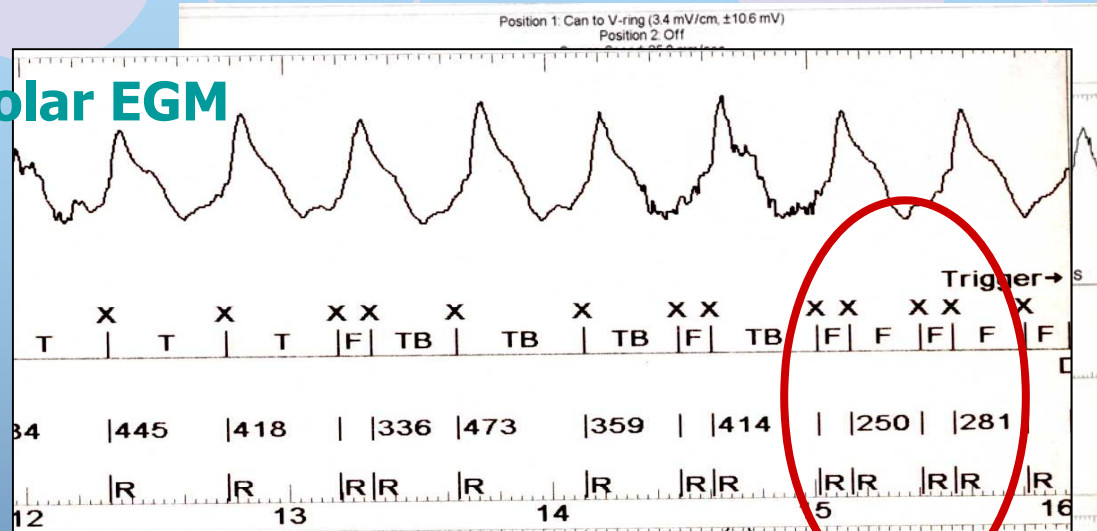
- A percentage of maximum peak amplitude sensed during the Sensed Refractory Period used to begin the linear decay



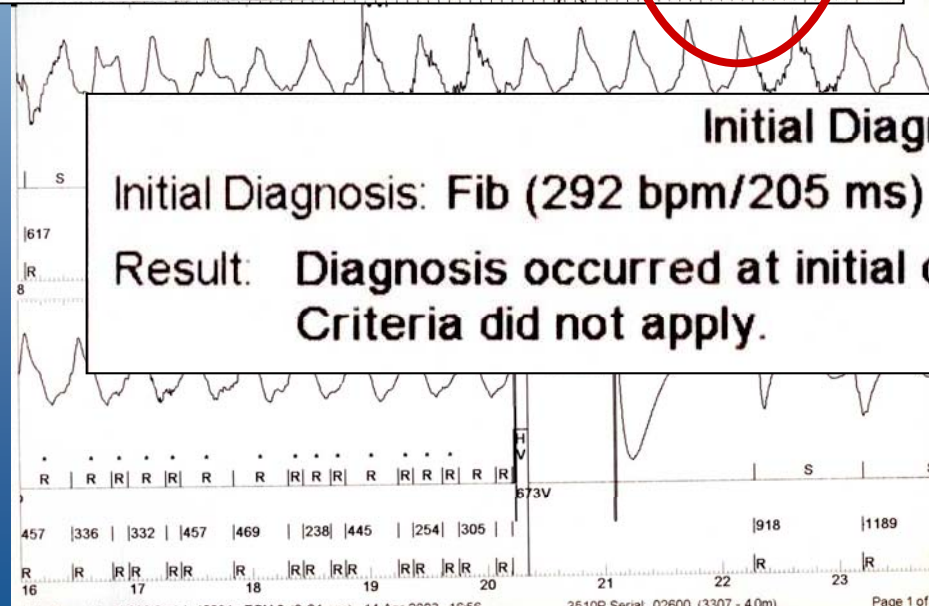
QRS double counting of slow VT

Case 3

V unipolar EGM



Initial Diagnosis
Initial Diagnosis: Fib (292 bpm/205 ms)
Result: Diagnosis occurred at initial detection; SVT Criteria did not apply.

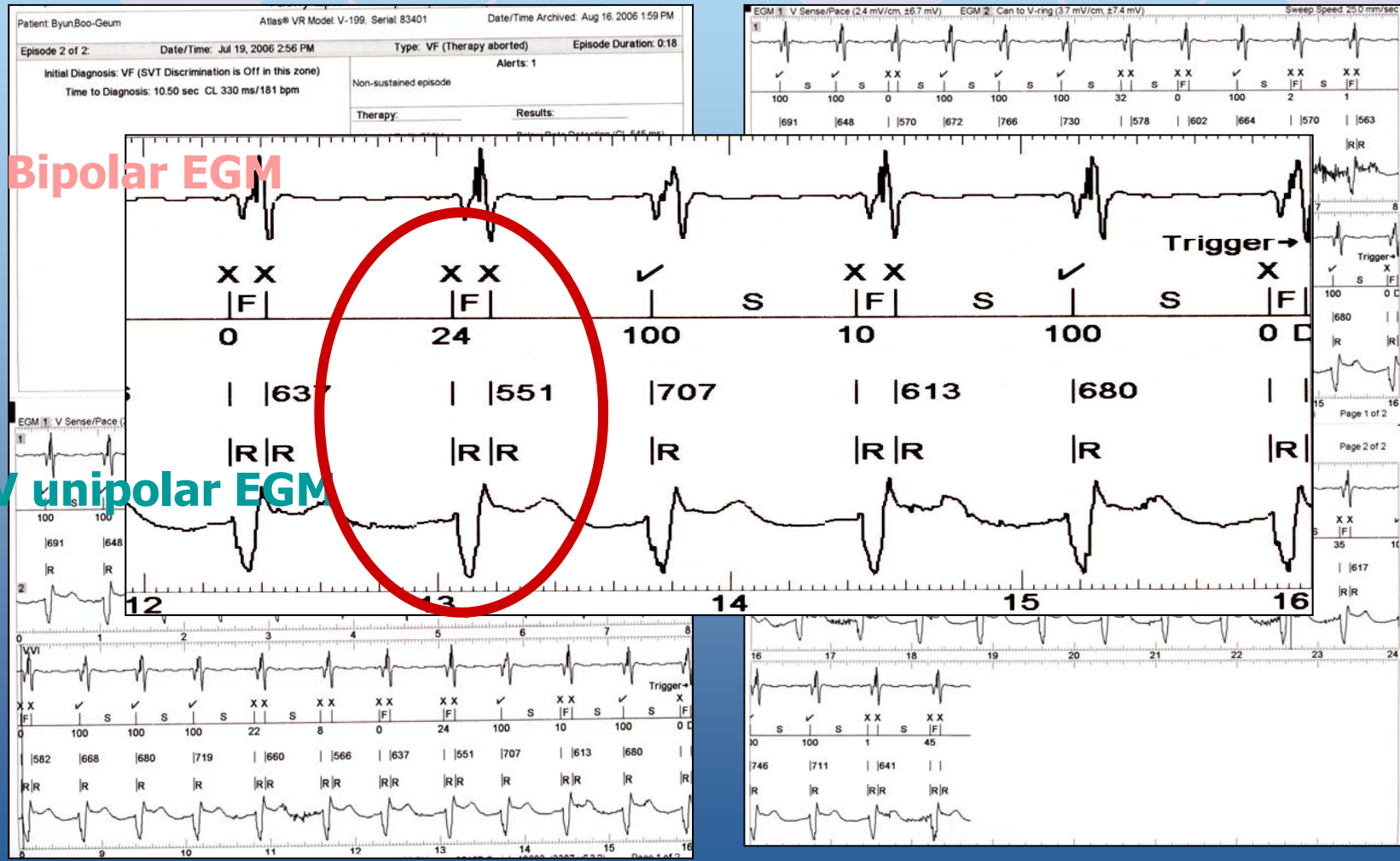


QRS double counting

Case 4

V Bipolar EGM

V unipolar EGM



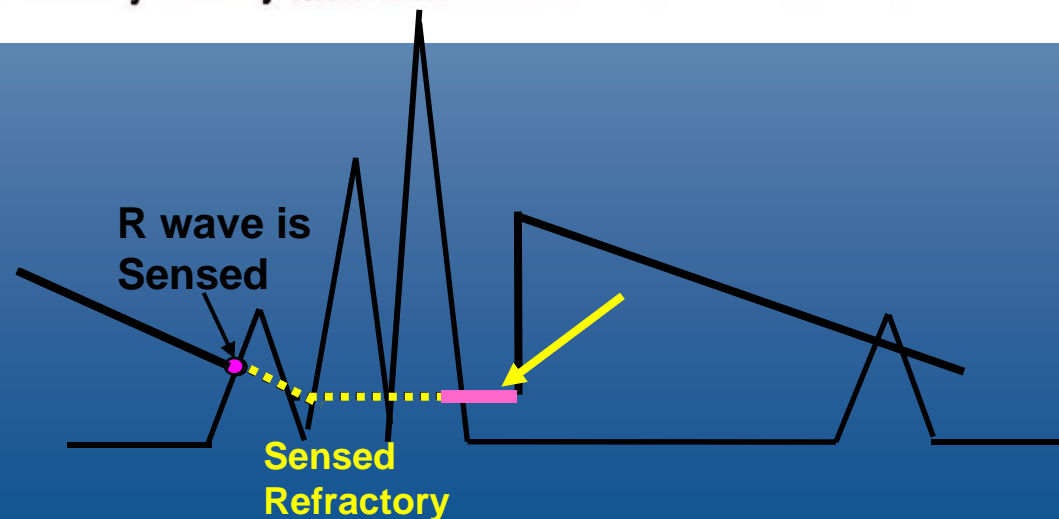
How to resolve QRS double-counting?

Changing sensed refractory interval

Ventricular Sense Refractory 125ms → 157ms

Special Sensing

V. Sensitivity	Automatic, Max 0.2 mV
V. Sense Refractory	<u>157 ms</u>
V. Post-Sensed Threshold Start	50 %
V. Post-Sensed Decay Delay	0 ms



Case 5

QRS Double counting and T-wave oversensing

ST JUDE MEDICAL
Tachycardia Diagnostic Summary Report
Patient: Song Ock Hee
Atlas™ VR Model V-199, Serial 88928
Report Date/Time: 11 Aug 2005 12:14 PM
Page 1 of 1
Episodal Diagnostics

ST JUDE MEDICAL
Stored EGM Report
Patient: Song Ock Hee
Atlas™ VR Model V-199, Serial 88928
Episode Date/Time: 11 Aug 2005 10:04 AM
EGM 3 (0-24 sec)
Summary: Fib Detection
Template Date/Time: 11 Aug 2005 7:00 AM
Page 1 of 2
Position 1: V Sense/Pace (5.5 mV/cm, 18.9 mV)
Position 2: Can to V-ring (8.3 mV/cm, 110.6 mV)
Sweep Speed: 25.0 mm/sec

Initial Diagnosis
Initial Diagnosis: Fib (196 bpm/305 ms)
Result: Diagnosis occurred at initial detection; SVT Criteria did not apply.



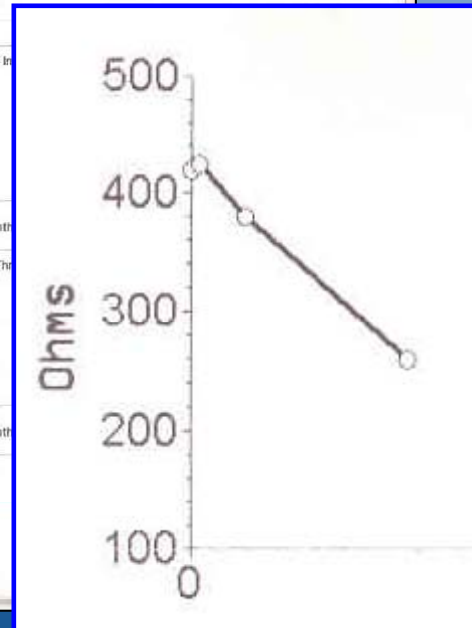
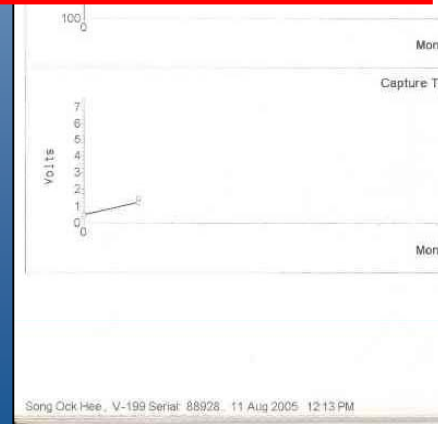
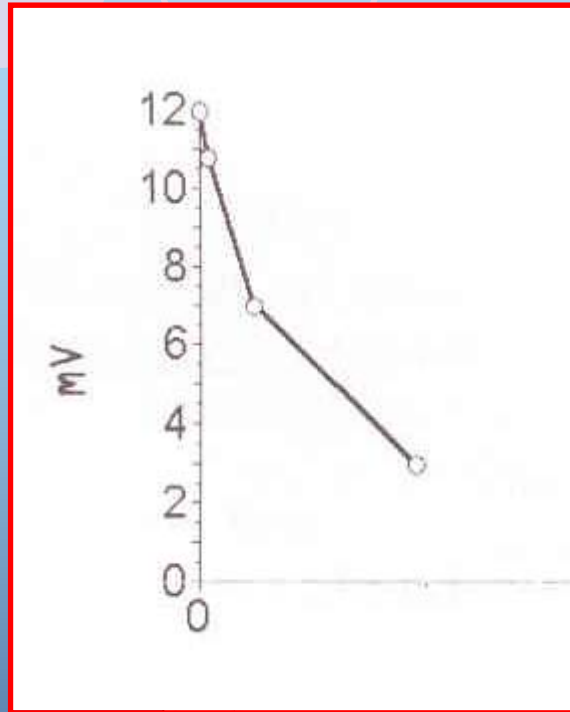
V Bipolar EGM

V Unipolar EGM



Decreased Impedance : $400\Omega \rightarrow 250\Omega$
Decreased R wave amplitude : $12\text{mv} \rightarrow 3.0\text{mv}$

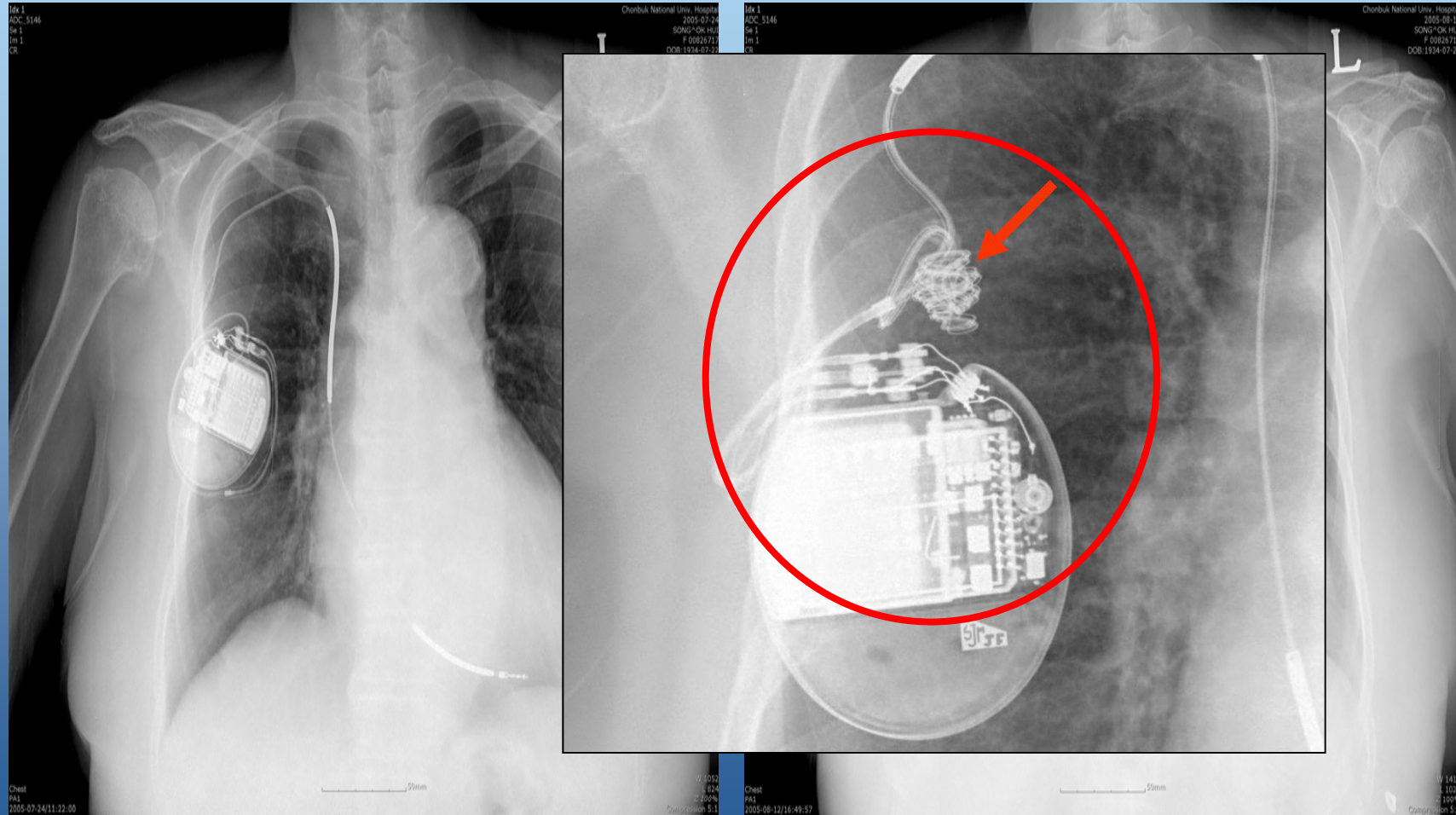
Case 5



Case 5

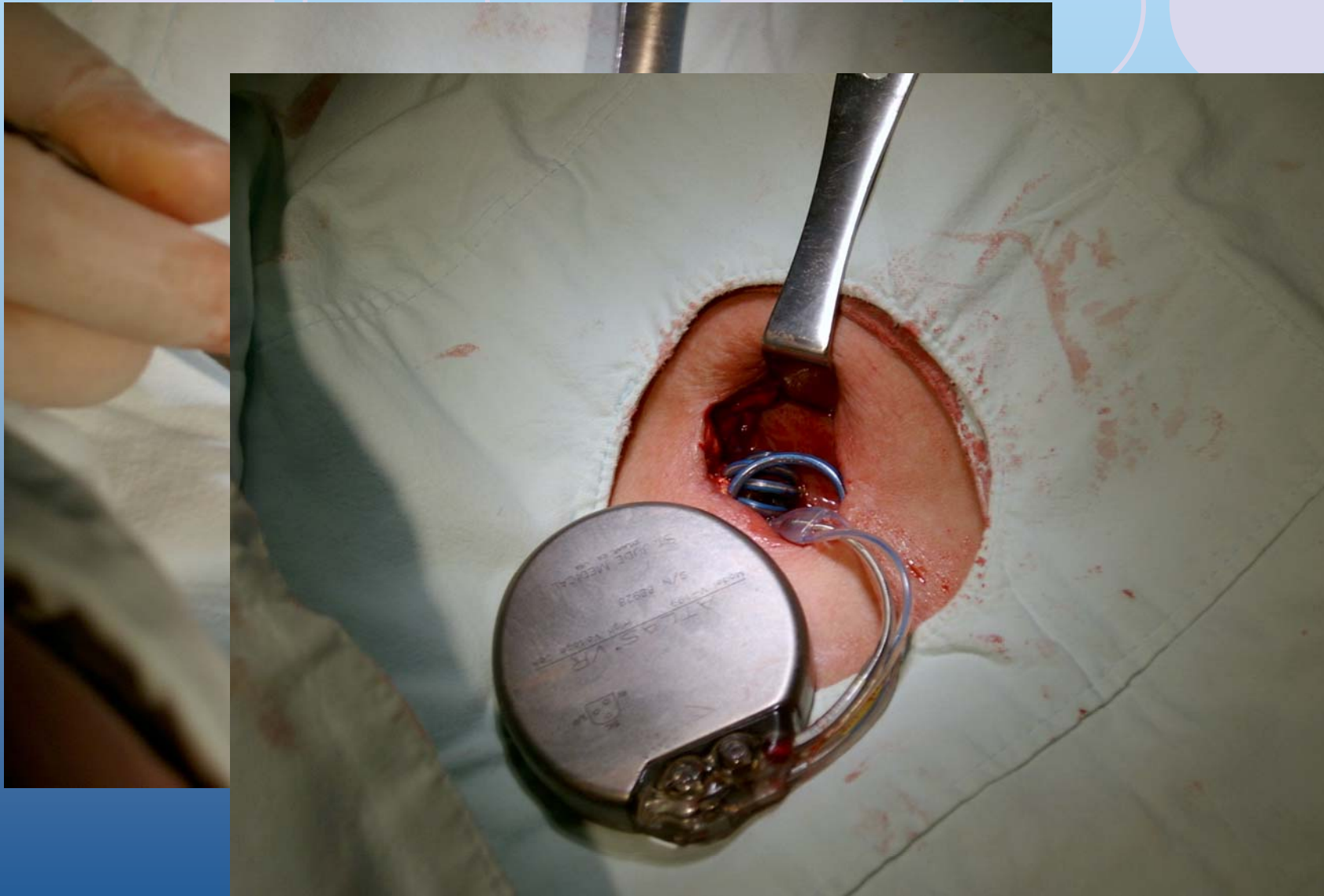
2005.7.24-The day of implantation

2005.8.12 Twiddler's syndrome



Twiddler's syndrome

Case 5





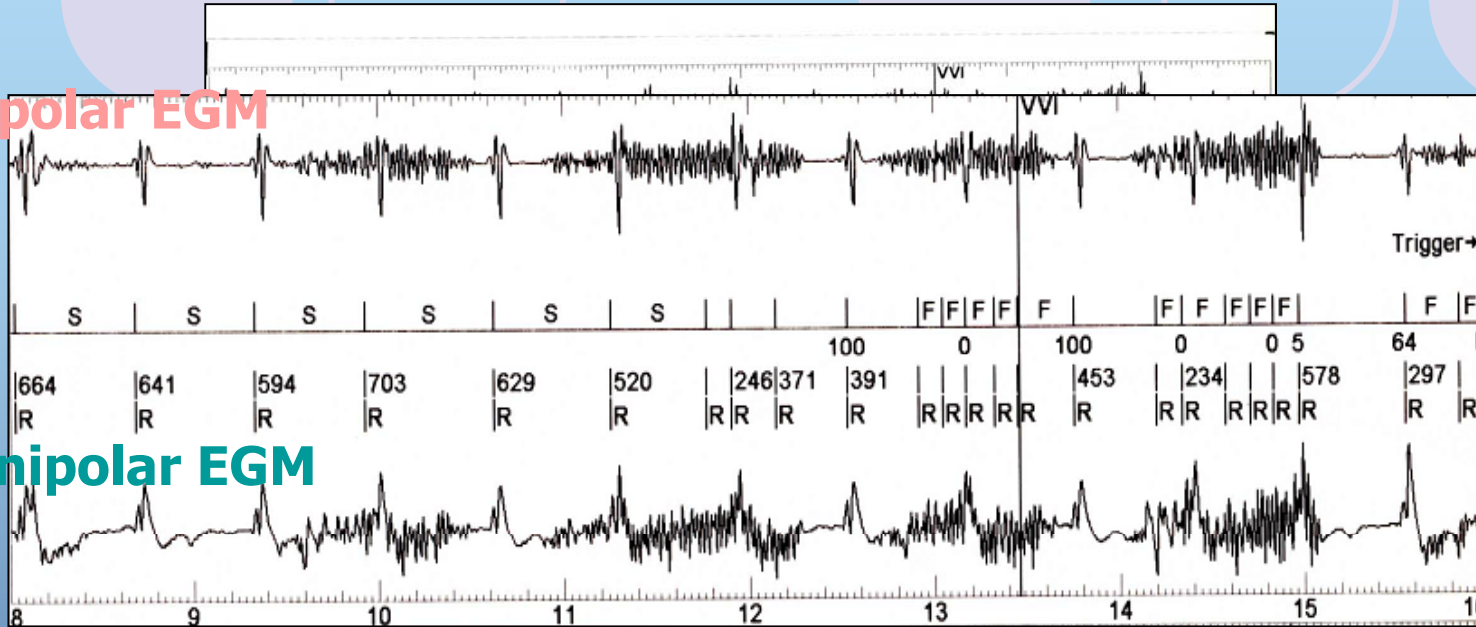
Twiddler's syndrome

- **Twiddler's syndrome is excessive unintentional or intentional coiling and knotting of the leads.**
- **It may occur because of a large generator pocket or loose, fatty subcutaneous tissue, allowing **rotation or repeated flipping** of the pulse generator with physical activity or from patient manipulation.**
- **Such excessive coiling and knotting of the leads can lead to lead fracture, insulation breaks, or inappropriate shocks.**

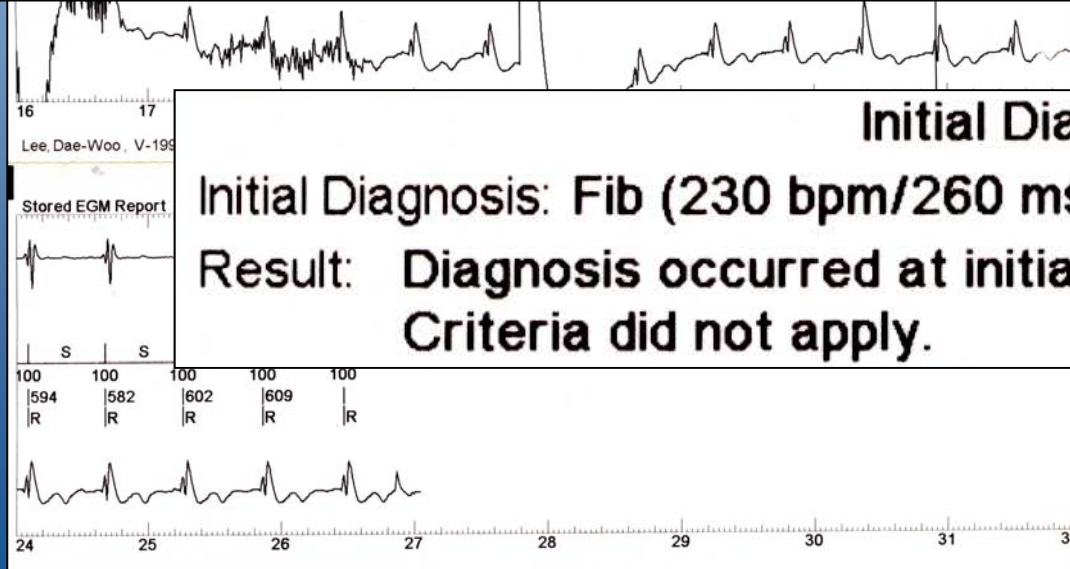
Oversensing cause of lead fracture

Case 6

V Bipolar EGM



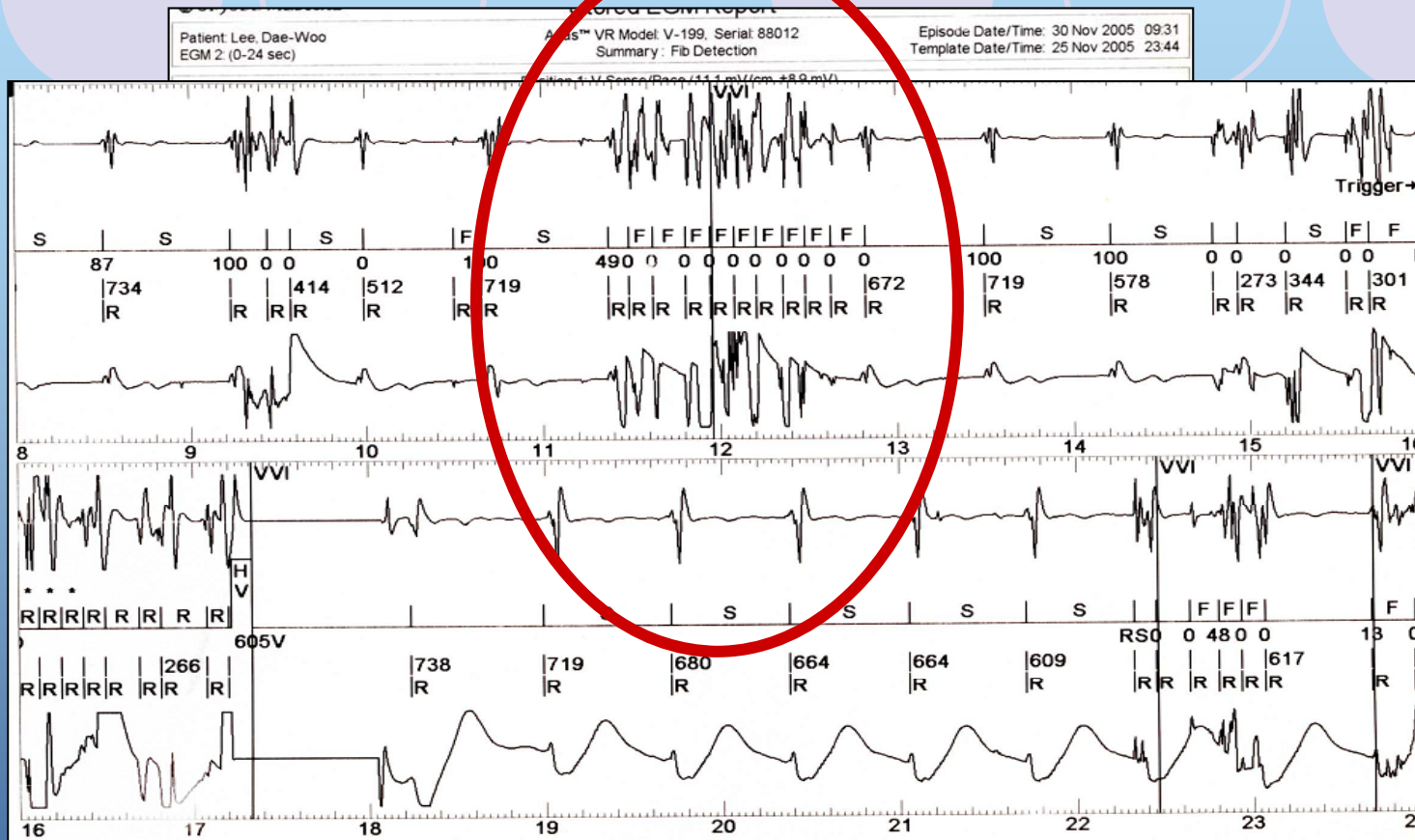
V unipolar EGM



Initial Diagnosis
Initial Diagnosis: Fib (230 bpm/260 ms)
Result: Diagnosis occurred at initial detection; SVT Criteria did not apply.

Oversensing caused by lead fracture

Case 6



Initial Diagnosis: Fib (CL 285 ms)	Diagnosis Time:
Therapy	Results
Aborted Defib 20.0J (605V)	Below Rate Detection (CL 560 ms)

Case 6

ICD lead measure by PSA

ICD lead measure	
Rwave :	2.6 mV
Threshold:	2.0
Impedance:	> 2000 Ω

Lead Fracture

Oversensing caused by lead insulation failure

Case 7

ST JUDE MEDICAL Tachy Episode Report (Archive) Page 1 of 2
 Patient: Min, Chang-Geun Atlas® VR Model V-199, Serial: 79268 Date/Time Archived: Aug 22, 2007 8:04 AM

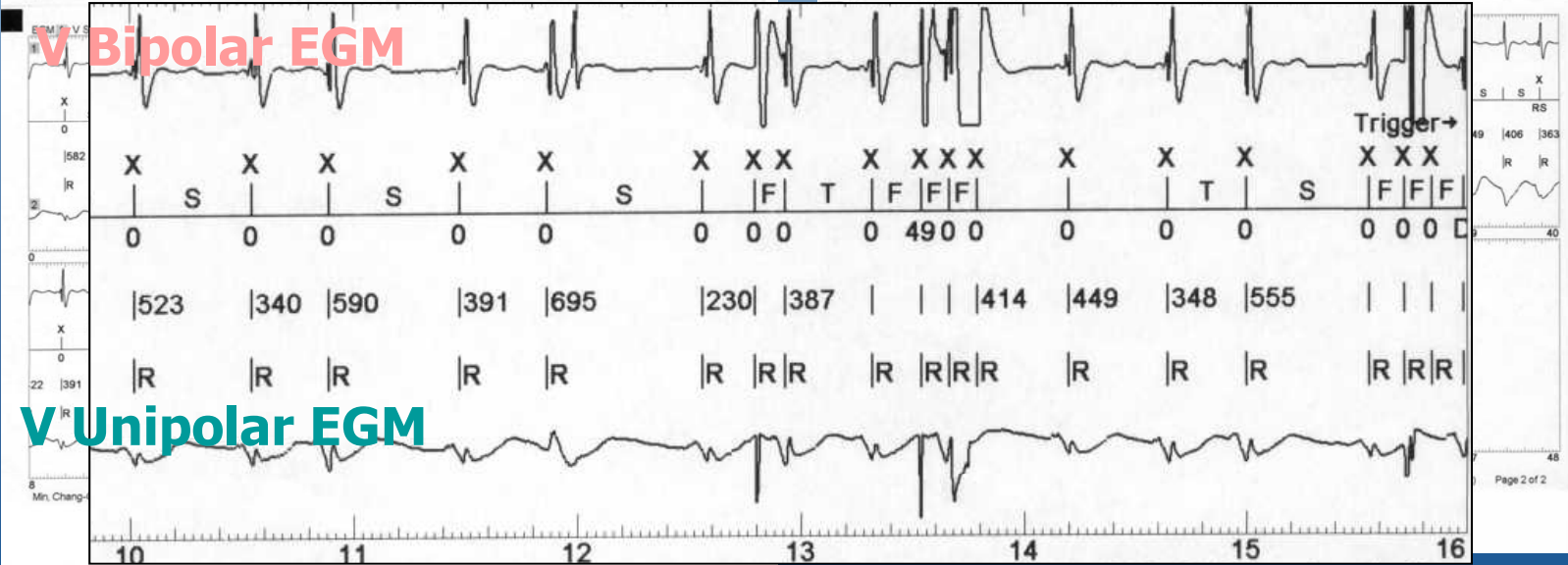
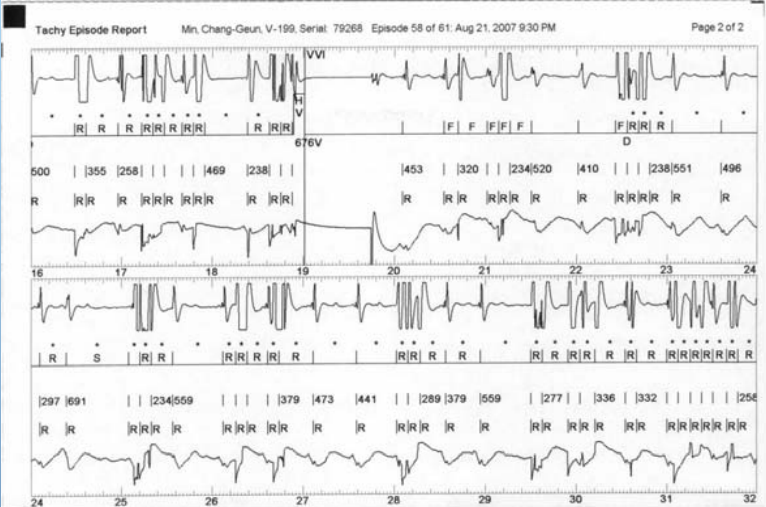
Episode 58 of 61: Date/Time: Aug 21, 2007 9:30 PM Type: VF (Therapy Delivered) Episode Duration: 0:34

Initial Diagnosis: VF (SVT Discrimination is Off in this zone)
 Time to Diagnosis: 10.75 sec CL 245 ms/244 bpm

Alerts: 2
 At least one shock unsuccessful, ≥3 VT/VF episodes in 24 hours

Therapy	Results
Defib 250J (676V)	VF
Defib 360J (501V)	Below Rate Detection (CL 465 ms)

High Voltage Therapy Details
 First Charge Time: 2.5 s
 Last Charge Time: 11.5 s
 Last Lead Impedance: 49Ω
 Delivered PW: +6.0 ms, -6.0 ms



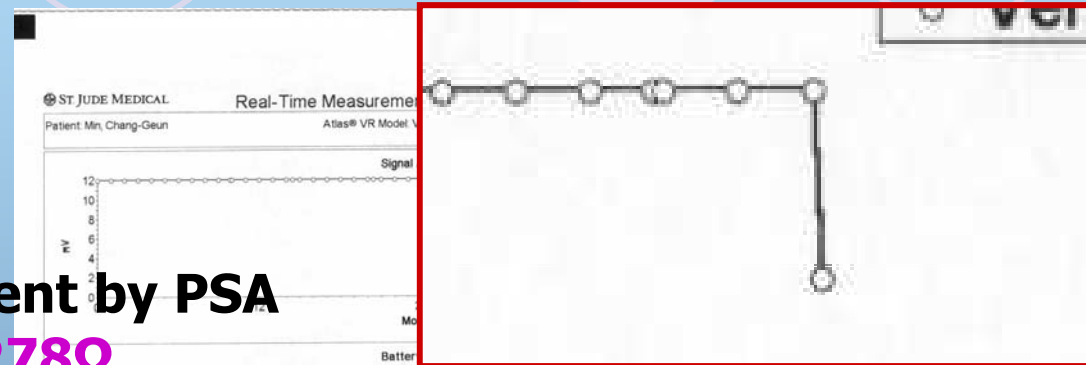
Case 7

Decreased impedance : $560\Omega \rightarrow 305\Omega$

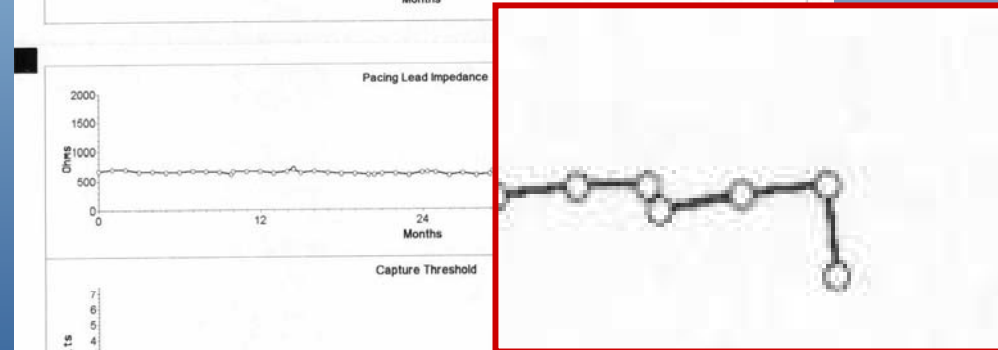
Decreased R wave amplitude : $>12\text{mv} \rightarrow 8.0\text{mv}$

Lead measurement by PSA

- Impedance : 278Ω
- R wave amplitude : 9.8mv
- Output Threshold : $5.0\text{v} / 0.5\text{ms}$



R amplitude



V impedance

Lead Insulation break

Episodes data of Loose setscrew (CRT-D case)

Case 8

Lee, Won-Ryul 29038549 ICD Model: InSync ICD 7272 Serial Number: PJP230187S	Aug 30, 2003 11:17:30 9969 Software Version 4.0 Copyright Medtronic, Inc. 2000	Lee, Won-Ryul 29038549 ICD Model: InSync ICD 7272 Serial Number: PJP230187S	Aug 30, 2003 11:17:41 9969 Software Version 4.0 Copyright Medtronic, Inc. 2000
VT/VF Episode #7 Report Episode #7 - Aug 29, 2003 10:18:36 Page 1		VT/VF Episode #7 Report Page 2	
Episode Summary		Parameter Settings	
SVT Criteria Triggered Prior to VT/VF Detection		VF On 300 ms (200 bpm) FVT via VT 340 ms (176 bpm) VT On 380 ms (158 bpm)	

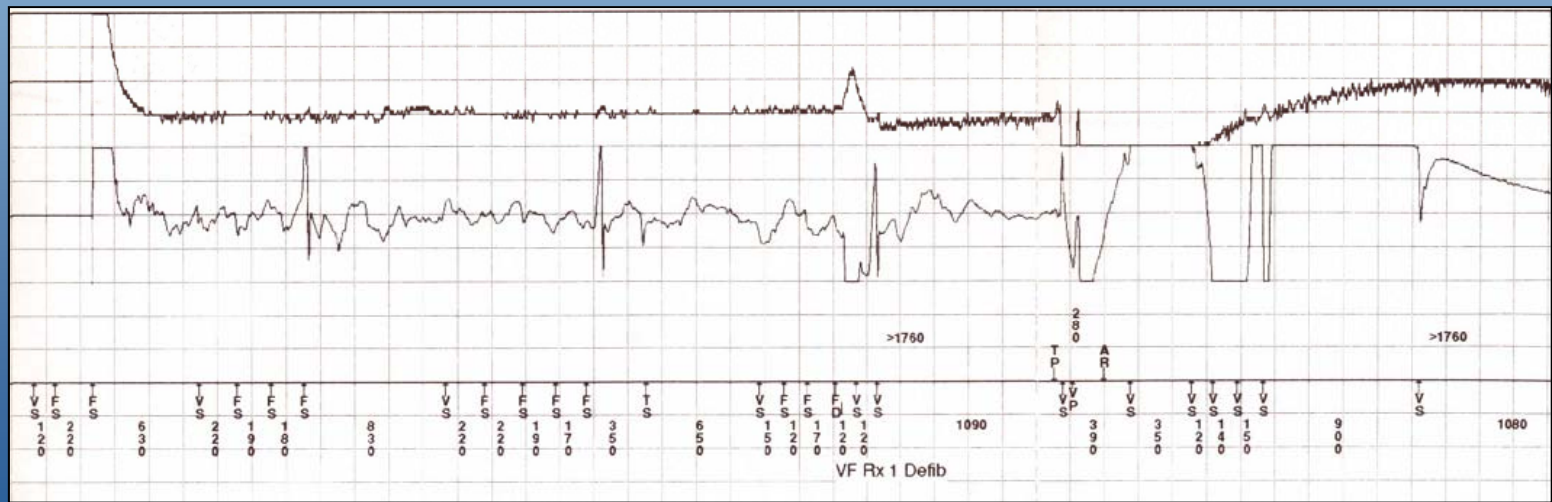
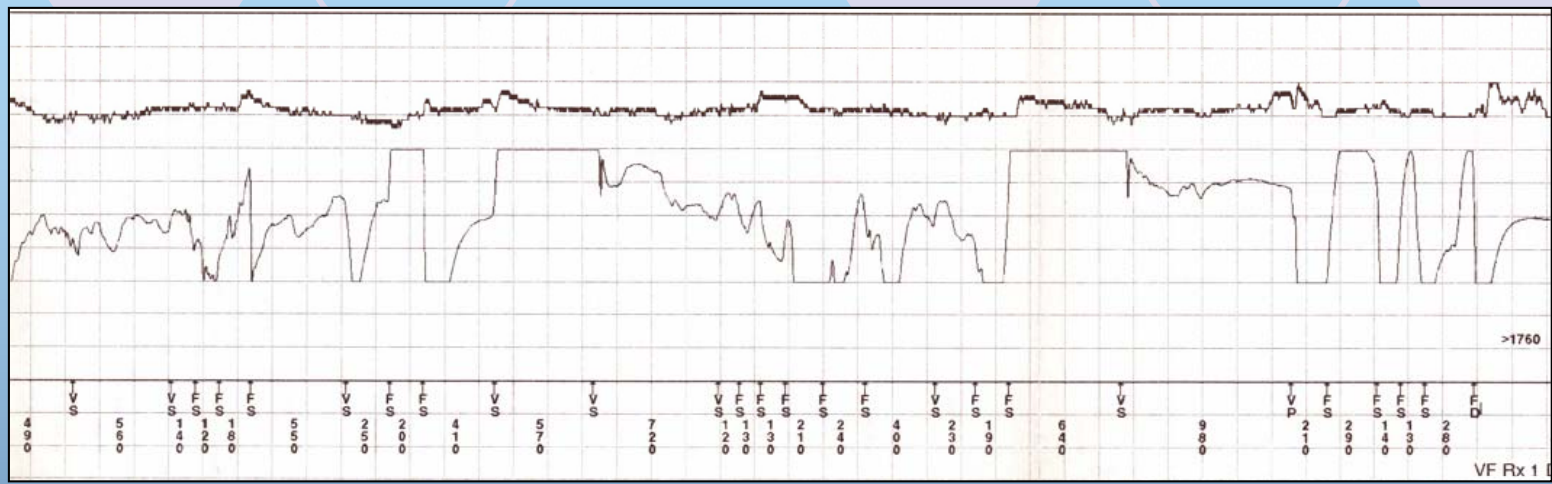
VF Rx 1 Defib	Energy	0.0 - 26.0 J	Aborted
	Charge Time	4.73 sec	

Therapy Sequence One or more therapies aborted due to inability to confirm VF or synchronize a CV therapy.				Dual Chamber SVT Criteria		Ventricular SVT Criteria	
VF Rx 1 Defib	Energy	0.0 - 26.0 J	Aborted	AFib/AFflutter	On	VT Stability	Off
	Charge Time	4.73 sec		Sinus Tach	On		
				Other 1:1 SVTs	Off		
				SVT Limit	320 ms		

Lee, Won-Ryul 29038549 ICD Model: InSync ICD 7272 Serial Number: PJP230187S	Aug 30, 2003 11:17:57 9969 Software Version 4.0 Copyright Medtronic, Inc. 2000														
VT/VF Episode #7 Report Page 1															
<table border="1"> <thead> <tr> <th>ID#</th> <th>Date/Time</th> <th>Type</th> <th>V. Cycle</th> <th>Last Rx</th> <th>Success</th> <th>Duration</th> </tr> </thead> <tbody> <tr> <td>7</td> <td>Aug 29 10:18:36</td> <td>VF</td> <td>210 ms</td> <td>(No Rx Delivered)</td> <td></td> <td>30 sec</td> </tr> </tbody> </table>		ID#	Date/Time	Type	V. Cycle	Last Rx	Success	Duration	7	Aug 29 10:18:36	VF	210 ms	(No Rx Delivered)		30 sec
ID#	Date/Time	Type	V. Cycle	Last Rx	Success	Duration									
7	Aug 29 10:18:36	VF	210 ms	(No Rx Delivered)		30 sec									

EGM of noise sensing cause of Loose setscrew Episode usually provoke by changing position

Case 8



*** Confirmed by manual manipulation**

Oversensing : Causes and Solutions

- **Oversensing of physiologic but non-QRS signals**

- T-wave or oversensing →
- Myopotential oversensing

Changing ventricular sensitivity and sensing parameter

- **QRS double counting** →

- Wide QRS complex
- Low ventricular sensing signal during sinus rhythm

Changing sensed refractory interval

- **Mechanical system malfunction**

- Lead dislodgement ↴
- Lead fracture
- Lead insulation failure
- Loose setscrew connection

Lead revision

3. ElectroMagnetic Interference

- **High Intensity Electromagnetic Fields**

- TV/Radio transmitting towers (>100,000 volts)
- Power plants/ power lines
- Large generators

- **Heavy Electrical Equipment**

- Chain saw, Arc welding equipment
- Electric steel furnaces

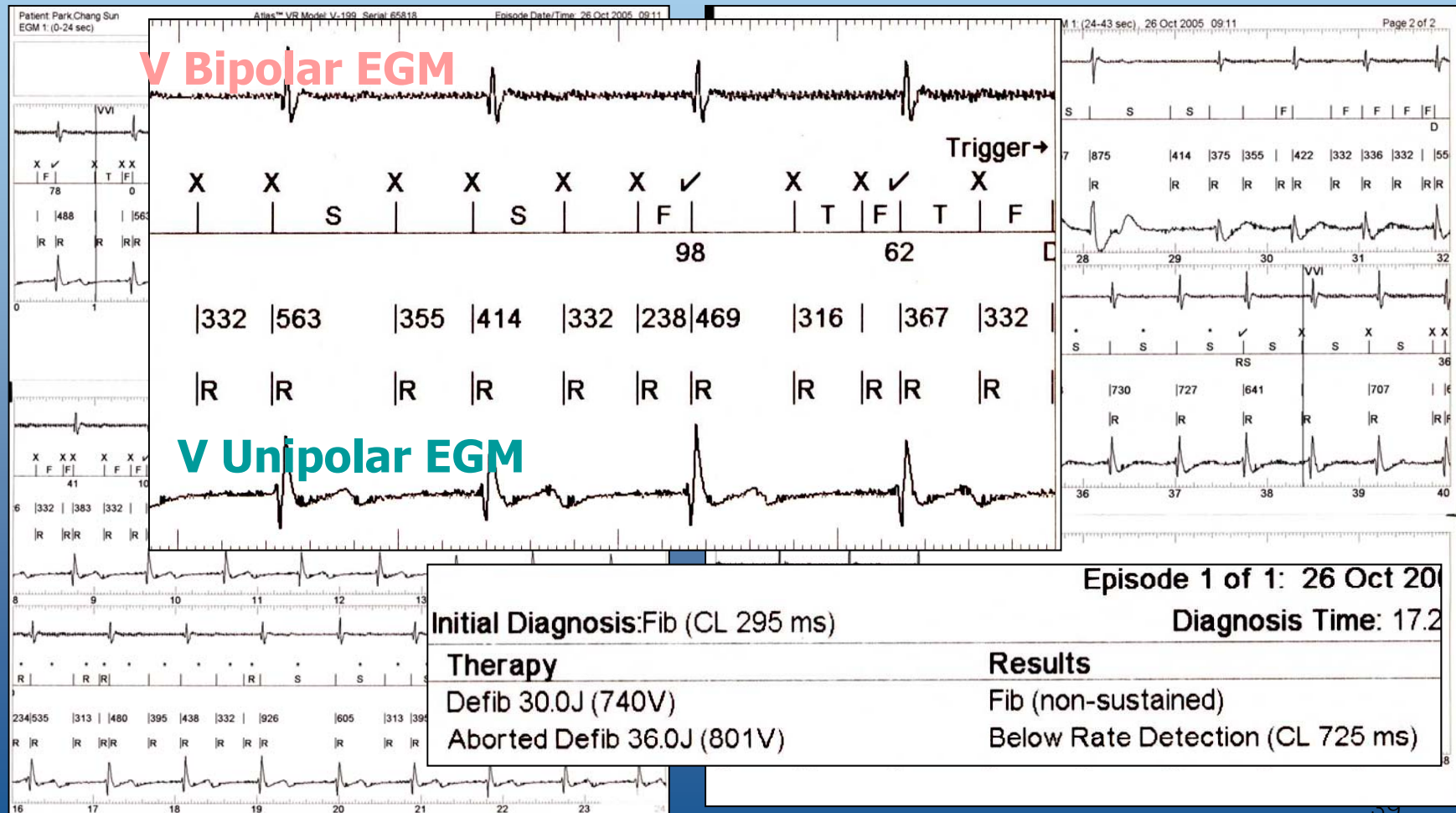
- **Industrial Magnets**

- **Surgical/Therapeutic equipment**

- Electrocautery, RF ablation, TENS
- Extracorporeal shock-wave lithotripsy
- Therapeutic radiation, Heat Diathermy
- MRI

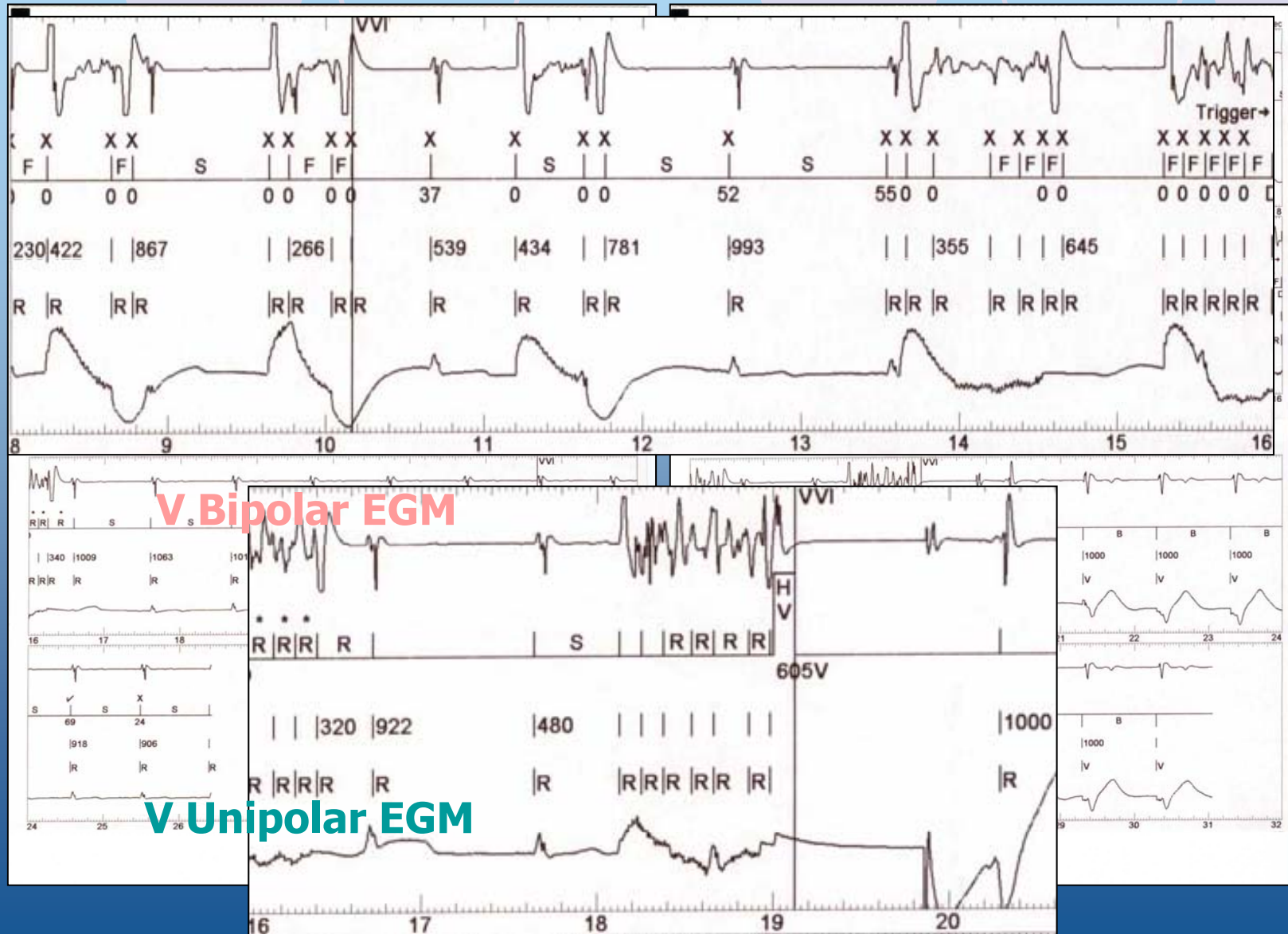
TENS on back

Case 1



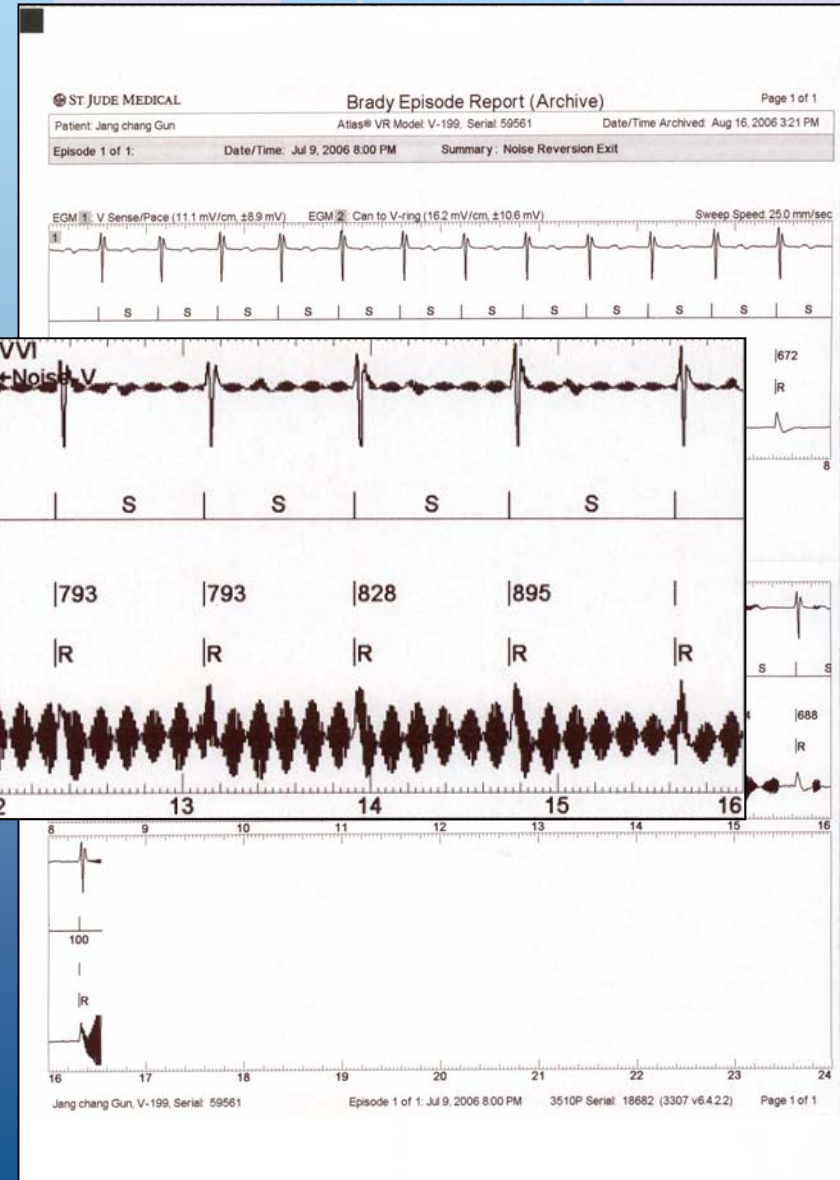
GI Bleeding → Argon plasma coagulation (APC) Thermo-coagulation Therapy

Case 2



Unknown origin on the ship

Case 3



Noise Reversion

**Absolute
Sensed
Refractory
Period**

110ms

**Noise
Detection
Time**

**25ms
(40Hz)**

**Number of
Noise
Events for
Noise
Detection**

12

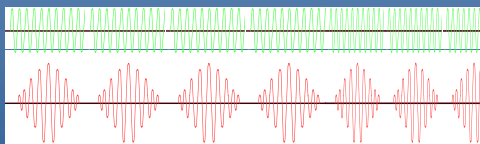
Noise Reversion Results:

**Cessation of all
sensing for one
brady escape
interval**

**Cessation of
charging and
therapy delivery**

**Detection counters
reset to at least 6
intervals**

Then normal sensing resumes



Shown Noise Reversion episodes

Case 3

ST JUDE MEDICAL Tachy and Lifetime Diagnostic Summary Report (Archive) Page 1 of 2
Patient: Jang chang Gun Atlas® VR Model: V-199, Serial: 59561 Date/Time Archived: Jun 28, 2007 10:56 AM

Diagnostic Summary (Since Last Cleared)
Diagnostics Last Cleared: Mar 22, 2007 10:45 AM

VT	VF
Off	320 ms 188 bpm

No Tachyarrhythmia Episodes Detected

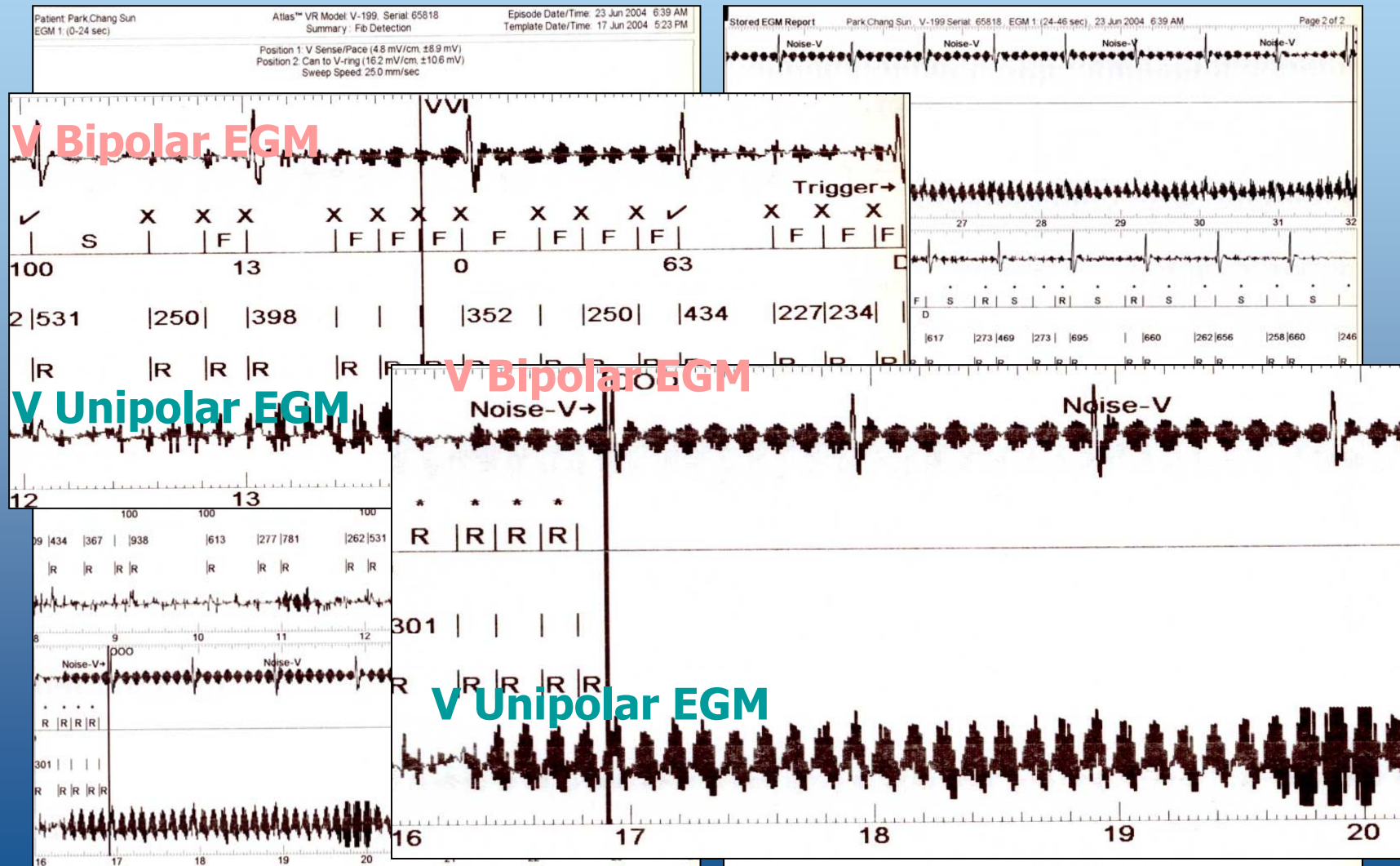
High Voltage Charging	High Voltage Therapy Summary
Total No. Charges: 1 No. of Manual Charges: 0 26 - 125 V: 0 126 - 225 V: 0 226 - 325 V: 0 326 - 425 V: 0 426 - 525 V: 0 526 - 625 V: 0 626 - 725 V: 0 726 - 801 V: 1	No High Voltage Tachyarrhythmia Therapies Delivered

Noise Reversions:
Ventricular: 86

Jang chang Gun, V-199, Serial: 59561 Sep 17, 2007 3:23 PM 3510P Serial: 18682 (3307 v6.4.2.2) Page 1 of 2

Using a industrial grinder

Case 4



4. Inappropriate shocks

Oversensing

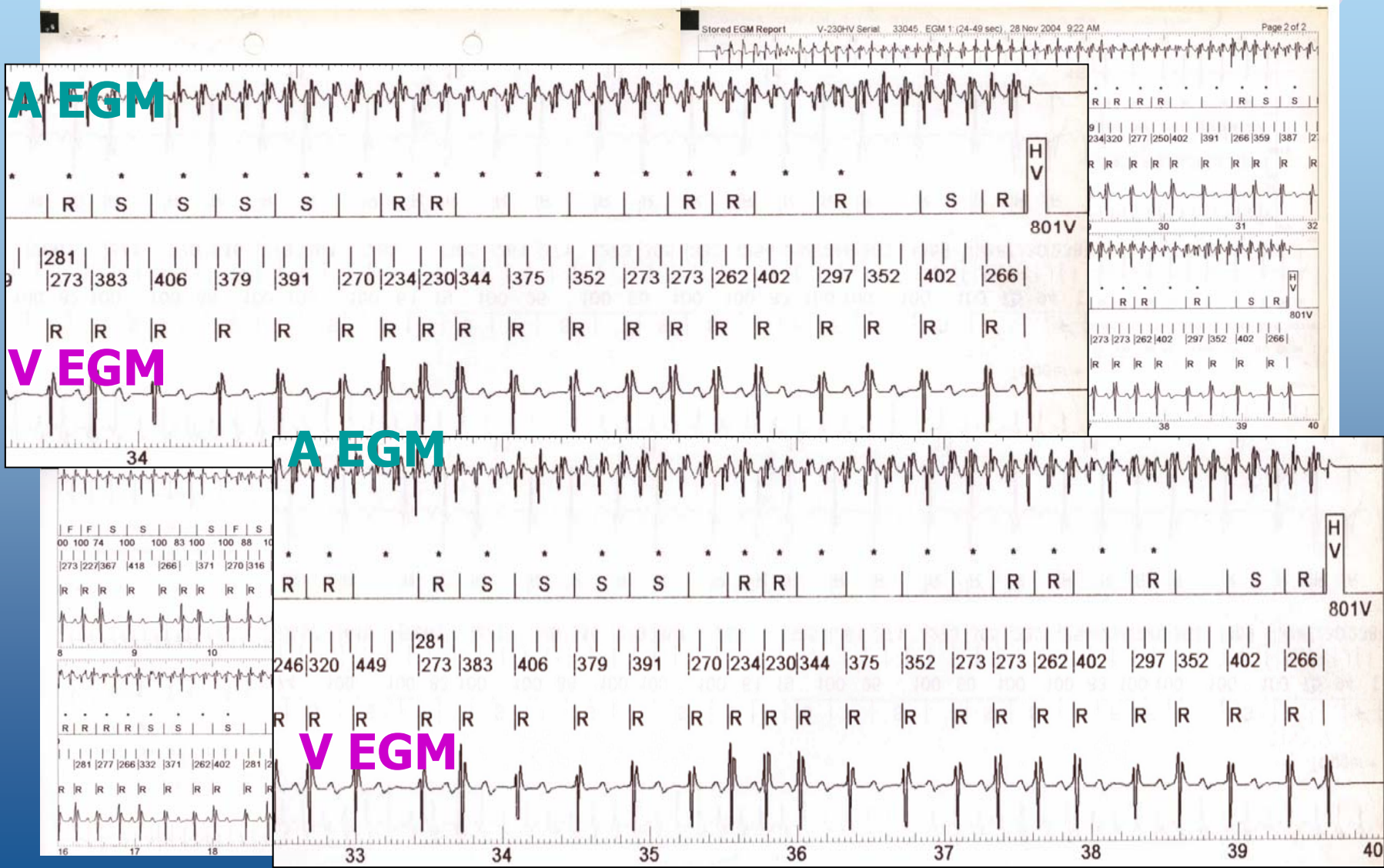
A. Fibrillation with fast ventricular resp.

Sinus Tachycardia

Atrial Tachycardia

EGM of A.Fib with fast ventricular response

Case 1



How to resolve inappropriate shock

- Discrimination : dual chamber ICD
 - regularity, onset mode, morphology --
 - PR logic[®] (Medtronic), rate branch (SJM)
- Anti-arrhythmic agent for A.fib or AT prevention
- Beta-blocker for sinus tachy.

Long charge time

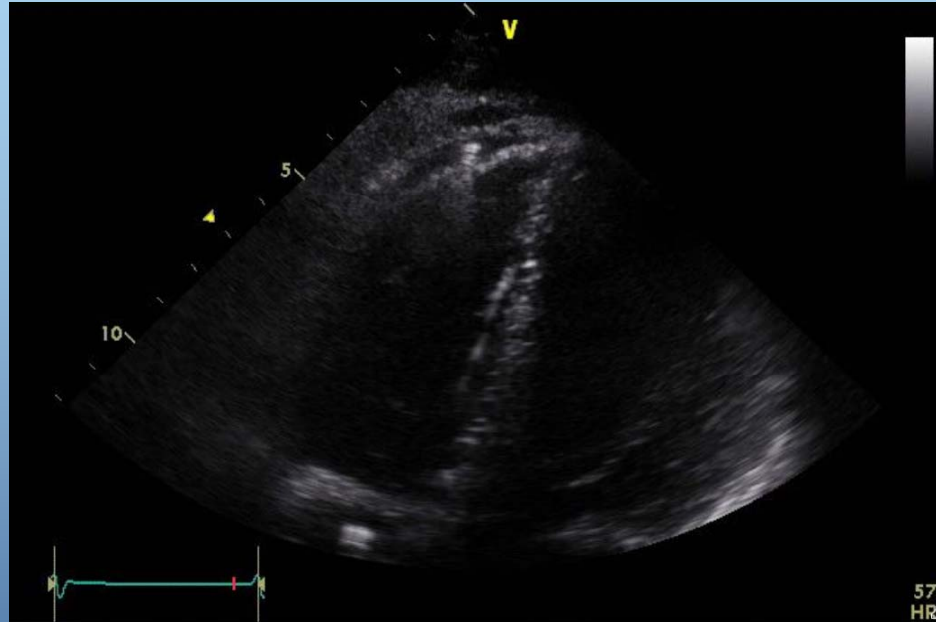
Possible Causes:

1. Capacitor(s) not reformed : reform $\bar{\bar{r}}$ re-check
 - * "automatic reforming"
2. Battery depletion / Elective replacement point
3. Component failure (uncommon)
 - Battery
 - Capacitor



Stronger ICD lead than pacemaker...

Case 1 : 09.9.30, raising threshold, and pericardial effusion



Case 2 : 09.10.13 ICD implant d/t DCMP with SCD
09.10.14 decreased R wave, Capture failure
=> lead revision
=> two hours later, shock & massive PE 51



Thank You !