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Introduction to Pacemakers

- March 3, 2009
- David Stultz, MD
- Southwest Cardiology, Inc.

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Topics to be covered

- Indications
- Pacemaker nomenclature
- Insertion Technique
- Complications
- Orientation to “the box” (Pacemaker)
- Troubleshooting

- Questions?

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General indications for a temporary pacemaker

- Heart rate is slow, causing hemodynamic compromise
- Sick sinus syndrome
  - Sinus bradycardia or atrial fibrillation with slow heart rate response (generally <40 bpm)
- Heart block
  - 3rd degree
  - 2nd degree type 2 (Mobitz)
- Malignant Tachyarrhythmia caused by bradycardia
  - Torsades de Pointes

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Clinical settings for temporary pacemaker

- Syncope
- Myocardial infarction
  - Especially inferior
- Shock due to bradycardia
- Myocarditis
- Lyme disease

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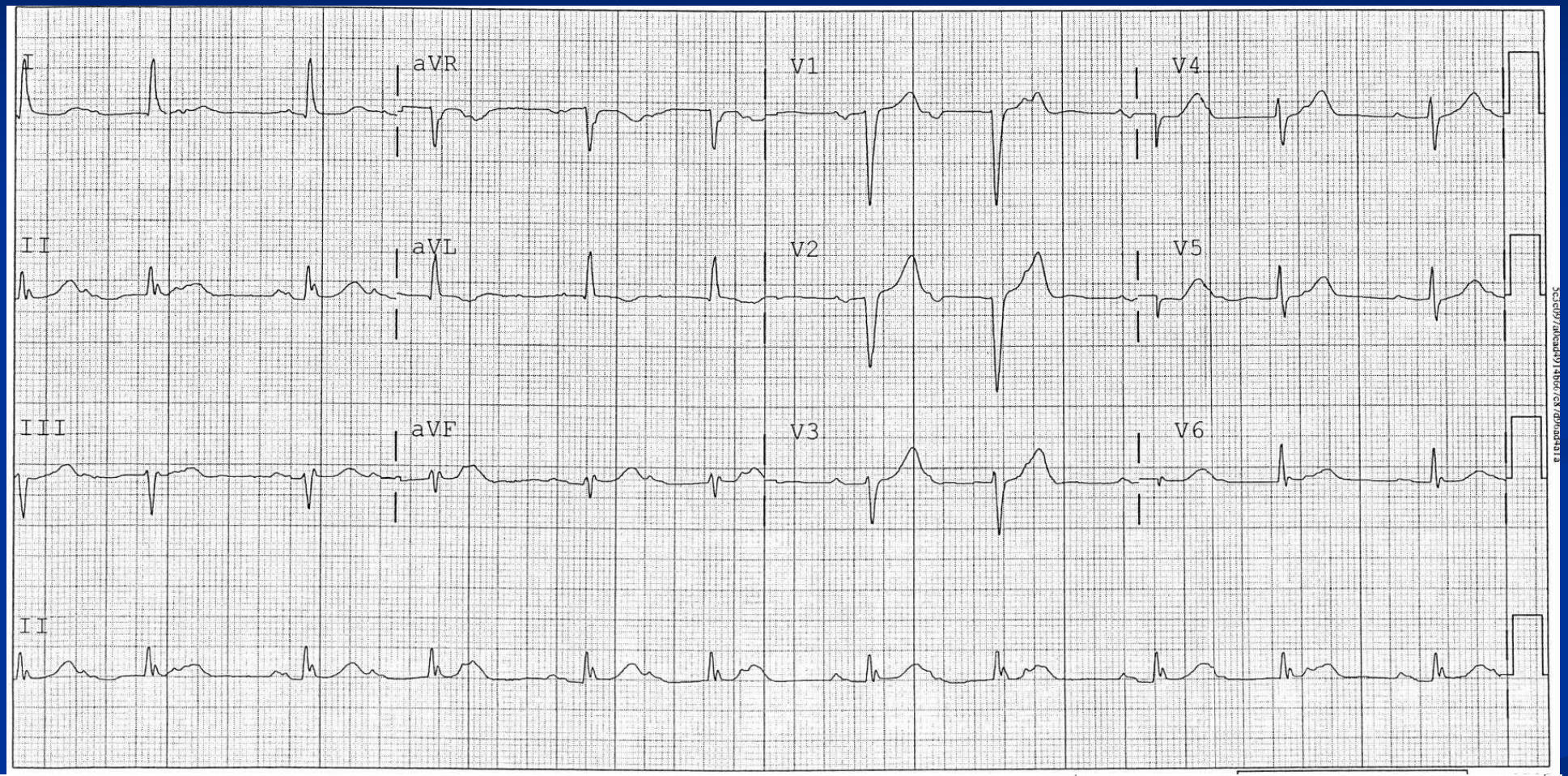
2nd Degree AV block type 1

Wenkebach – not a reason for pacemaker



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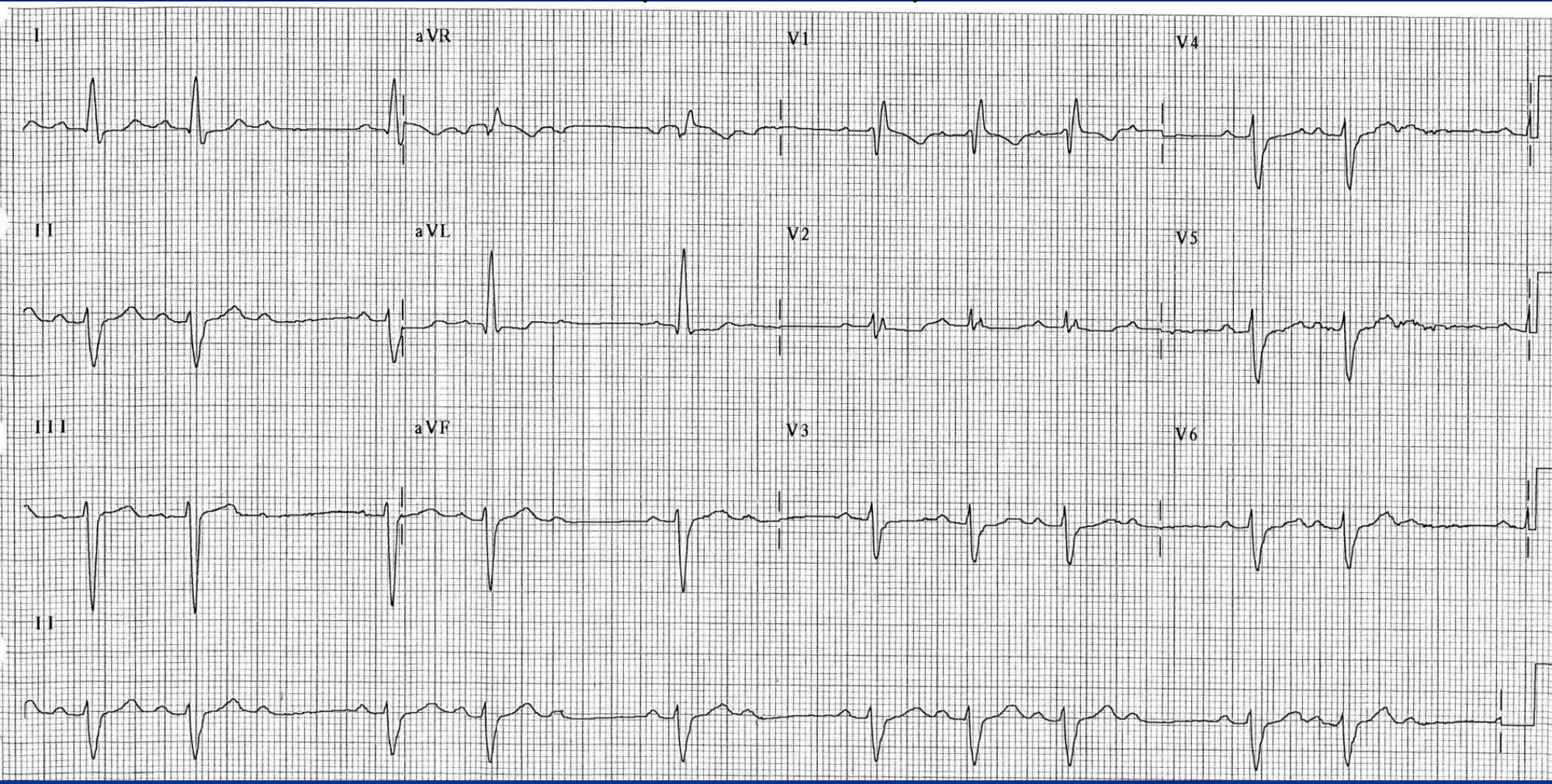
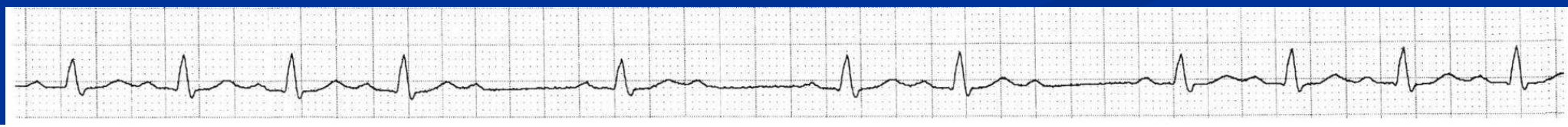
2nd Degree AV block type 2 (Mobitz)





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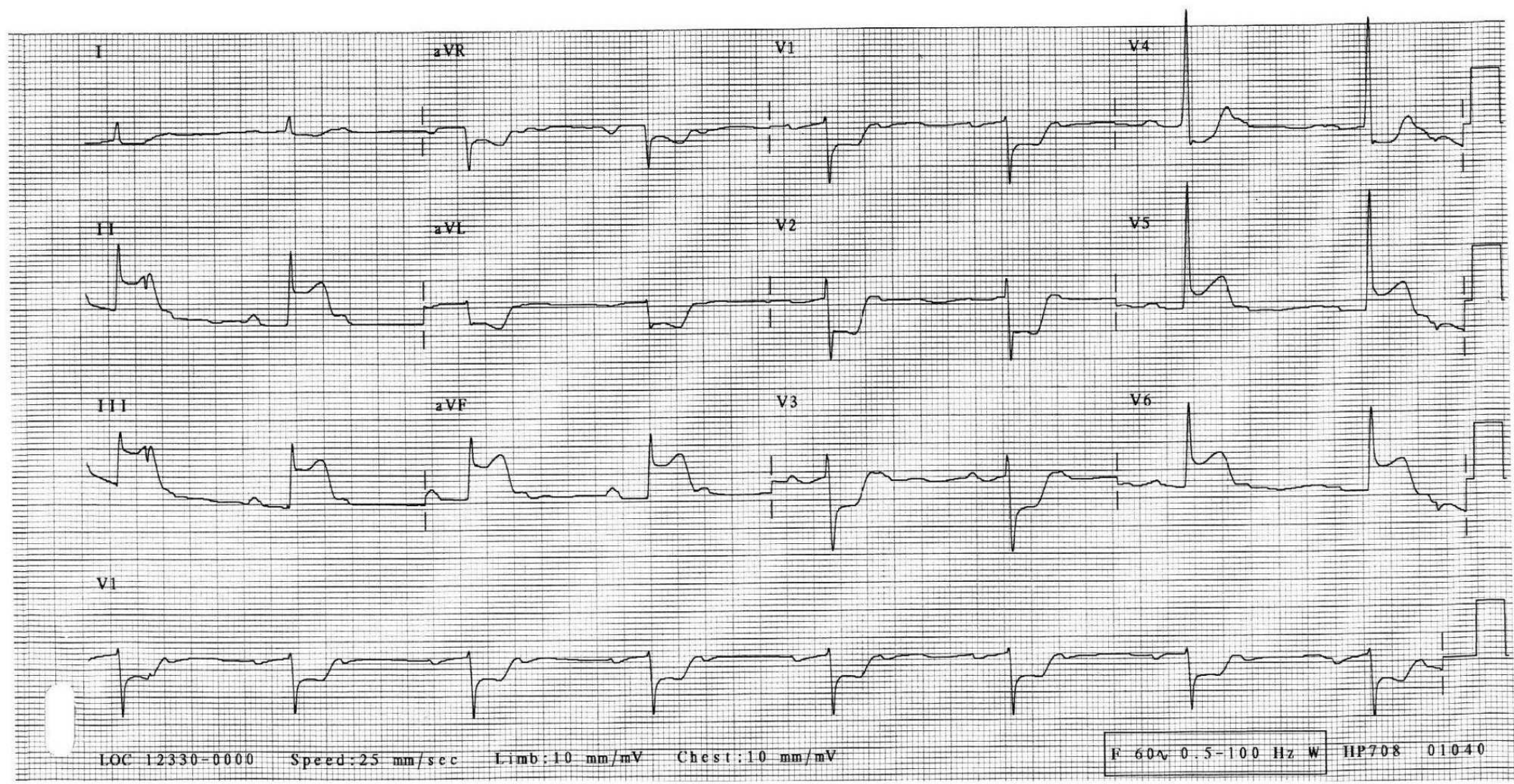
Inferior/Lateral/Posterior Infarct with 2:1 block



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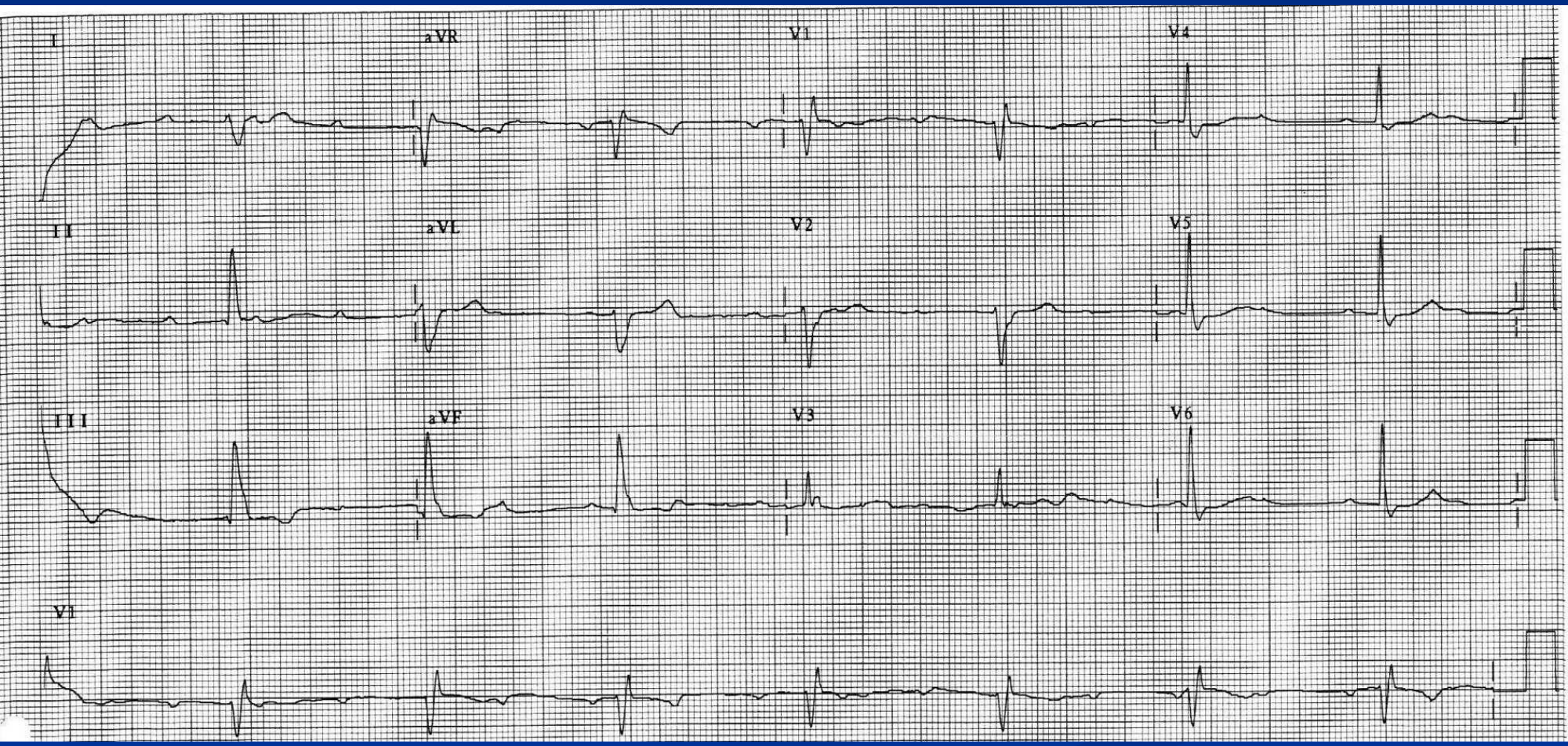
3rd degree heart block



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Another 3rd degree heart block

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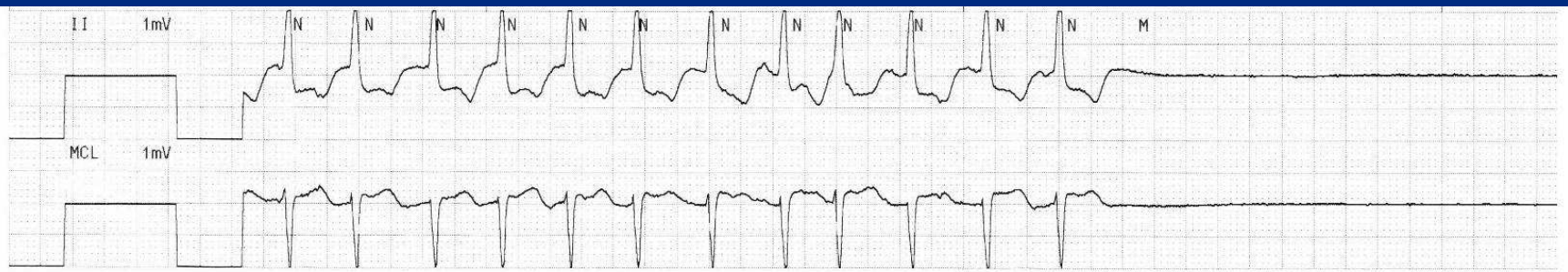
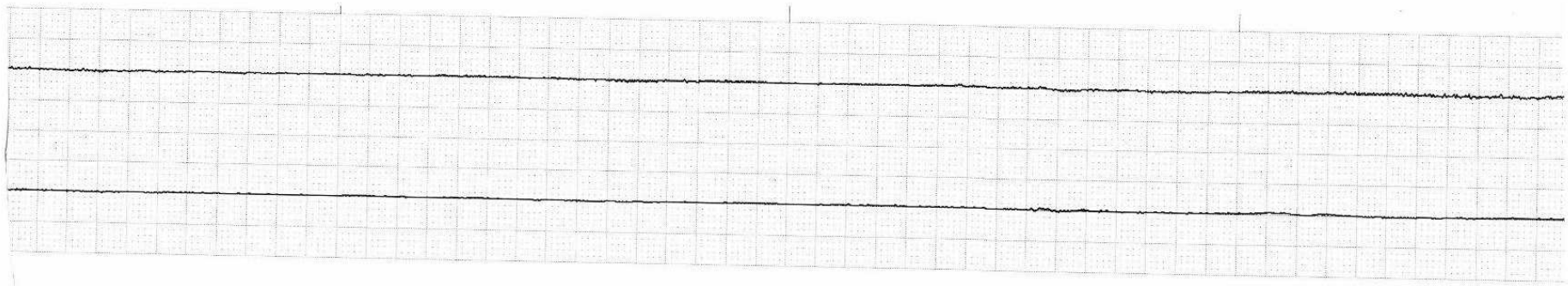
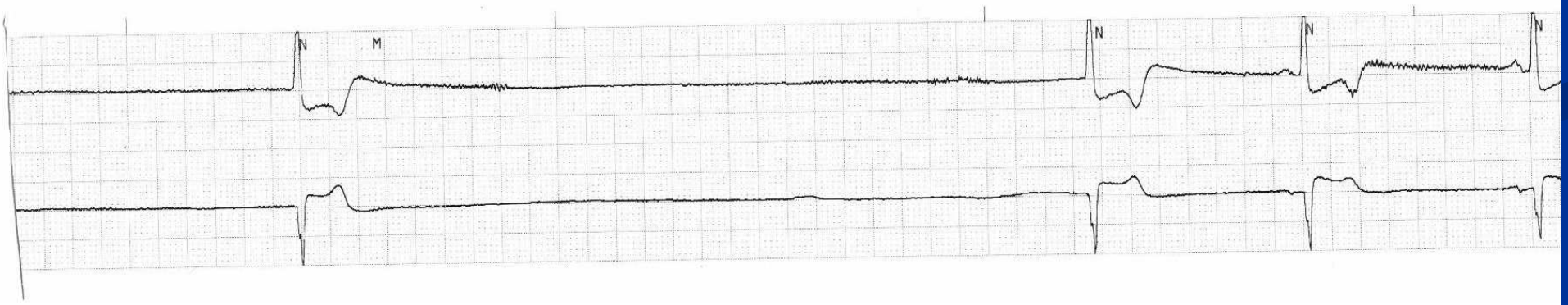
Atrial fibrillation → Asystole







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NSR → 20 second asystole

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Pacemaker Nomenclature

- Common Modes
  - VVI – Single chamber (ventricle)
  - DDD – Dual chamber
  - AAI (uncommon) – Single chamber (atrium)
- 1st Letter is chamber PACED
- 2nd Letter is chamber SENSED
- 3rd Letter is response
  - I = Inhibit
  - T = Triggered (Unusual)
  - D = Dual (Inhibit or Pace)
- 4th Letter – R = Rate responsive (permanent pacers)

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Components of a pacemaker system

- Lead
  - Wire connects to heart
    - Percutaneous
      - Ventricular wire sits in RV apex
    - Epicardial (post surgery)

http://www.oscor.com/images/lead%20pics/RU-STR-Polaris%20lead2%20copy.jpg

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The Can

AKA "Pulse Generator," "Battery"

Temporary

Single chamber

http://www.staff.vu.edu.au/CriticalCare/Critical%20Care/Images%20_l1/spacer.gif

Dual chamber

http://intensivecare.hsnet.nsw.gov.au/five/images/generator.jpg

Permanent single chamber

http://upload.wikimedia.org/wikipedia/commons/thumb/b/b1/Pacemaker_GuidantMeridianSR.jpg/549px-Pacemaker_GuidantMeridianSR.jpg

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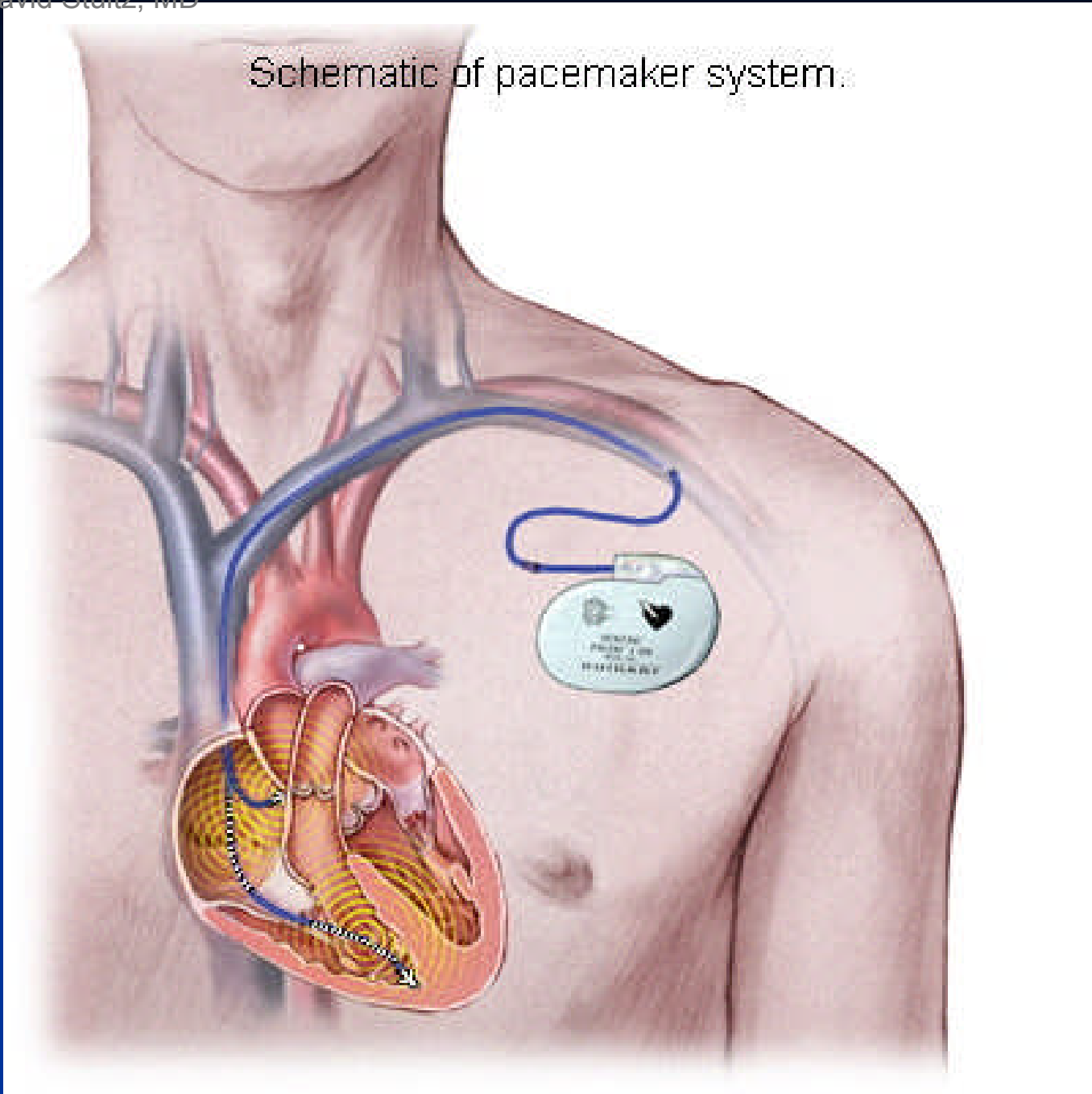

http://www.hgcardio.com/HRhythm/Treatments/a_pacemaker_schematic.jpg

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Sites of insertion for a temporary pacemaker

- Right internal jugular
- Left subclavian vein
- Right subclavian vein
- Either femoral vein (Fluoroscopy required)
- Left IJ is possible but very difficult

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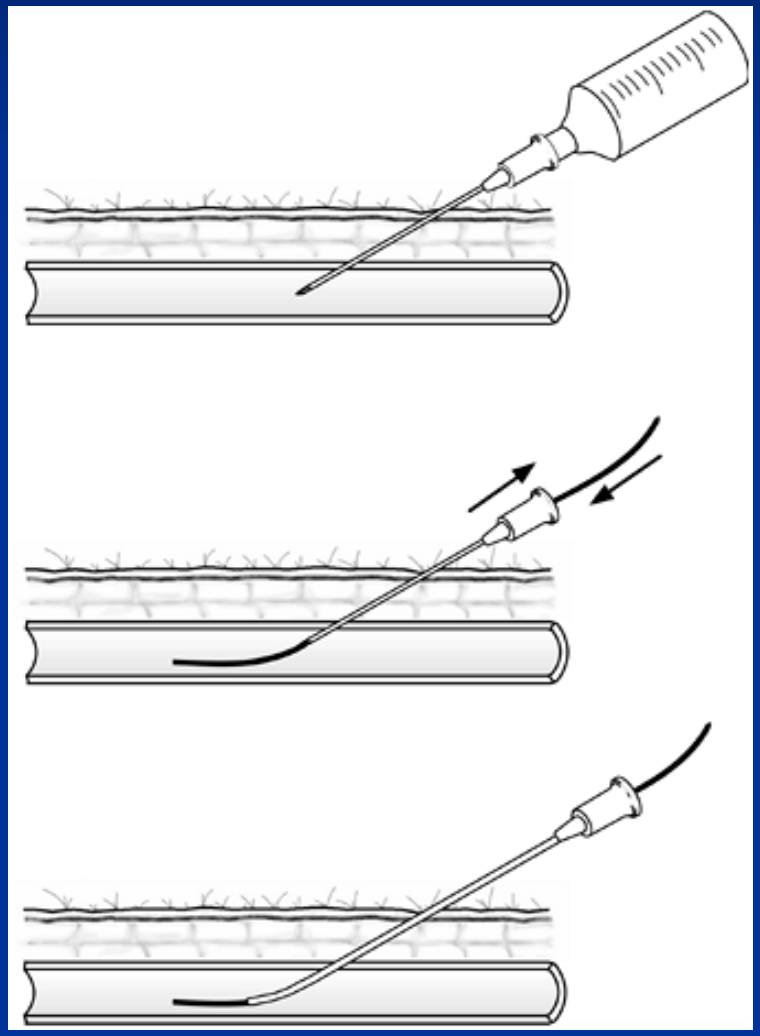
Seldinger technique for percutaneous vascular access



ICU Book (Marino)

General steps

- Trendelenberg position or leg elevation can facilitate access to IJ and subclavian veins
- Sterile Field
- Anesthetize skin with lidocaine
- Access vein with Cook needle
- Insert guidewire
- Remove needle
- Consider making a skin nick with scalpel
- Insert 6-8F introducer sheath with dilator over guidewire
- Remove dilator and guidewire
- Flush sheath using side port
- Advance temporary pacemaker to right ventricle

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Complications of temporary pacemaker insertion

- Blood loss/hematoma
- Infection
- Arrhythmia (especially during insertion)
  - PVC's are common
  - Heart block
    - Especially in patients with underlying LBBB
  - Bundle branch block
- Pneumothorax (about 1+% when subclavian access used)
- Cardiac perforation → Tamponade

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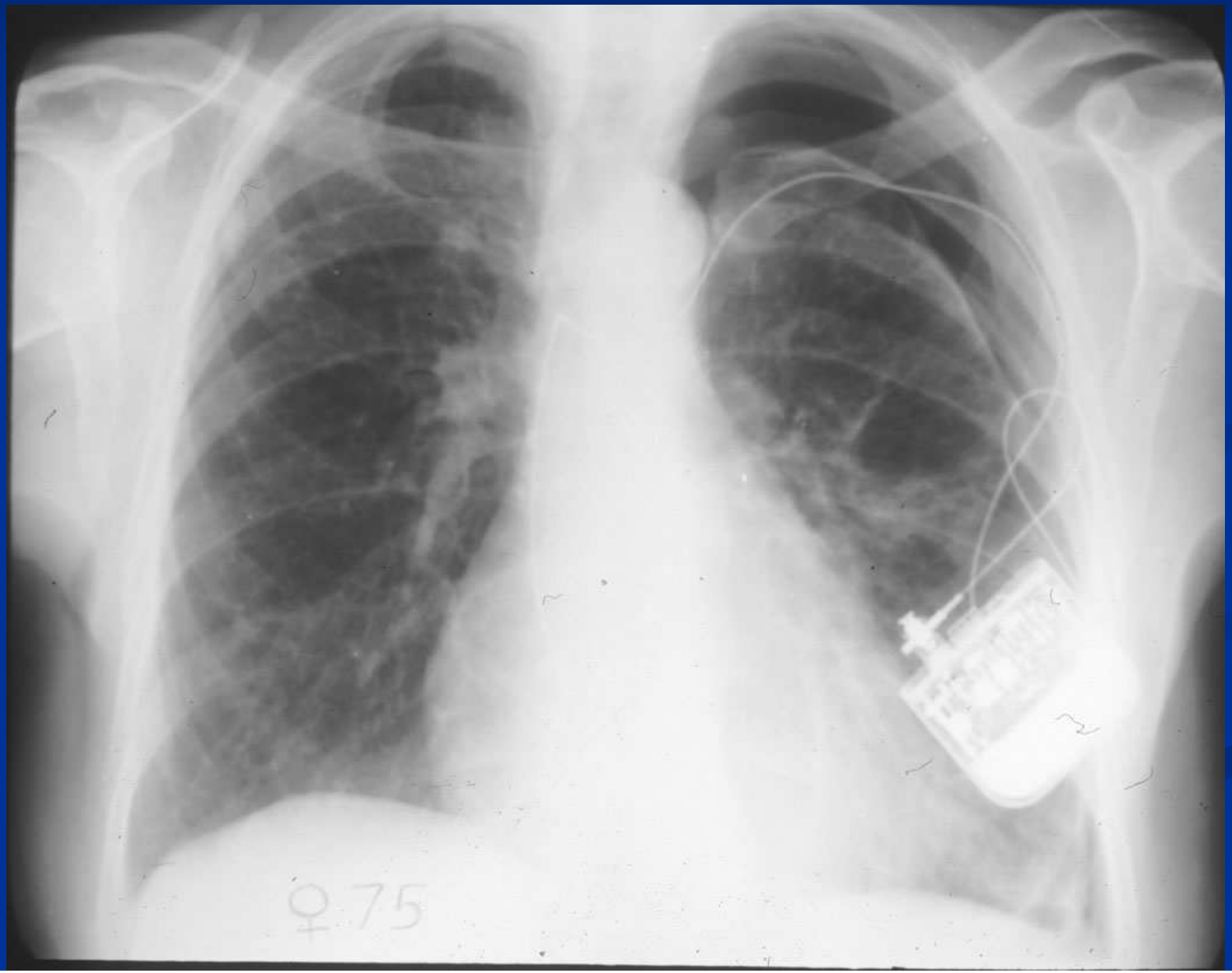
Pneumothorax of Left Lung



http://myweb.lsbu.ac.uk/dirt/museum/margaret/66--732-1160120.jpg

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Functions of a pacemaker

- Sensing
  - The device ‘sees’ a native heart beat
- Pacing
  - The device delivers a shock to stimulate a heart beat

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VVI Explained

- A VVI pacemaker
  - Paces the ventricle
  - Senses the ventricle
  - In response to a sensed event it INHIBITS the pacing response
    - So if it doesn't SENSE a native heart beat in a specified period, it will deliver a pace.

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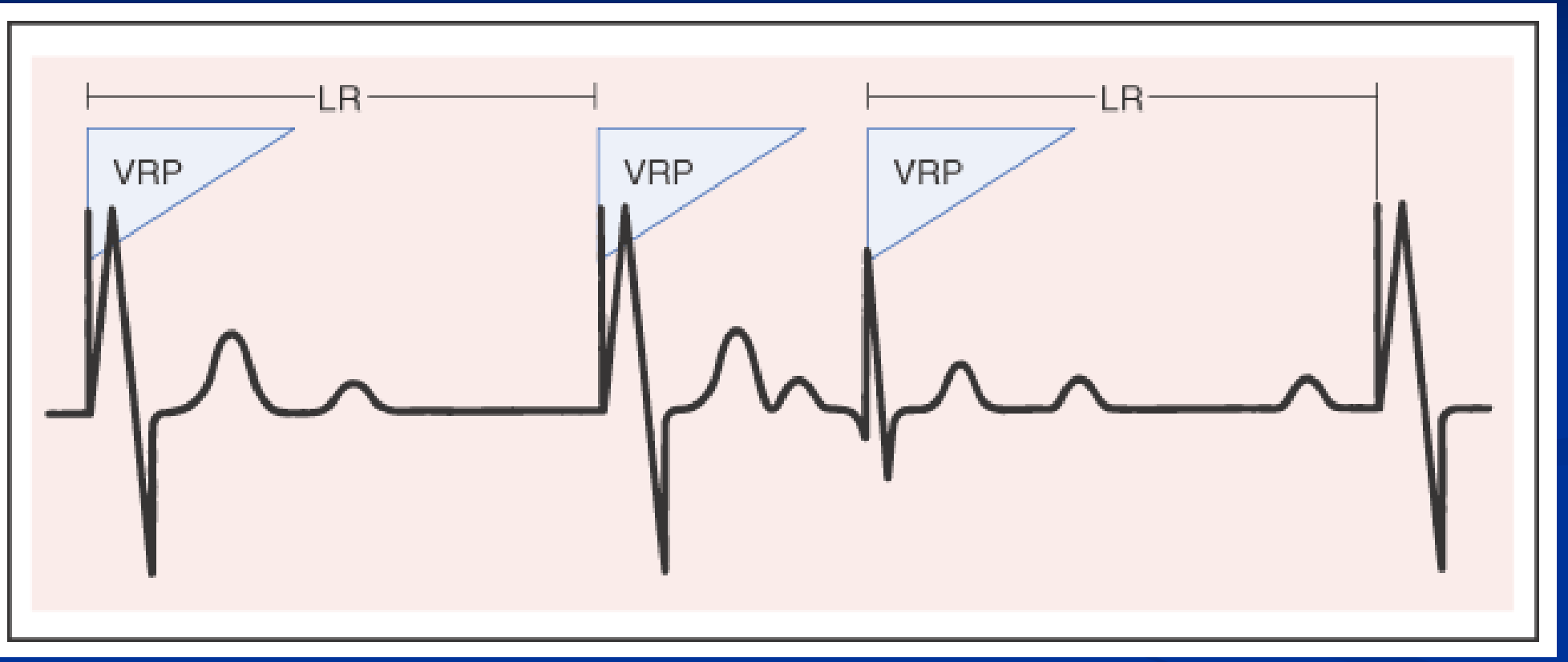
Timing cycles



Braunwald, 7th ed.

VVI pacemaker
LR = lower rate limit
VRP = ventricular refractory period
Note that a sensed QRS starts the VRP and resets the LR

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The dials on the Temporary pacemaker

- Rate
  - Determines the lower rate limit of the device
  - Heart rate should not go lower than the set rate
- Output
  - In milliamps, the amount of 'juice' the device outputs with each pacer spike

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Sensitivity

- Sensitivity → asynchronous
  - In millivolts, the amount of energy that has to be detected in order for the device to 'sense' a beat
  - Higher millivolts = less sensitive
    - More likely for the pacemaker to pace at the lower rate regardless of what the heart does on its own
  - Lower millivolts = more sensitive
    - More likely to pick up noise, and 'sense' a ventricular beat even though nothing actually happened

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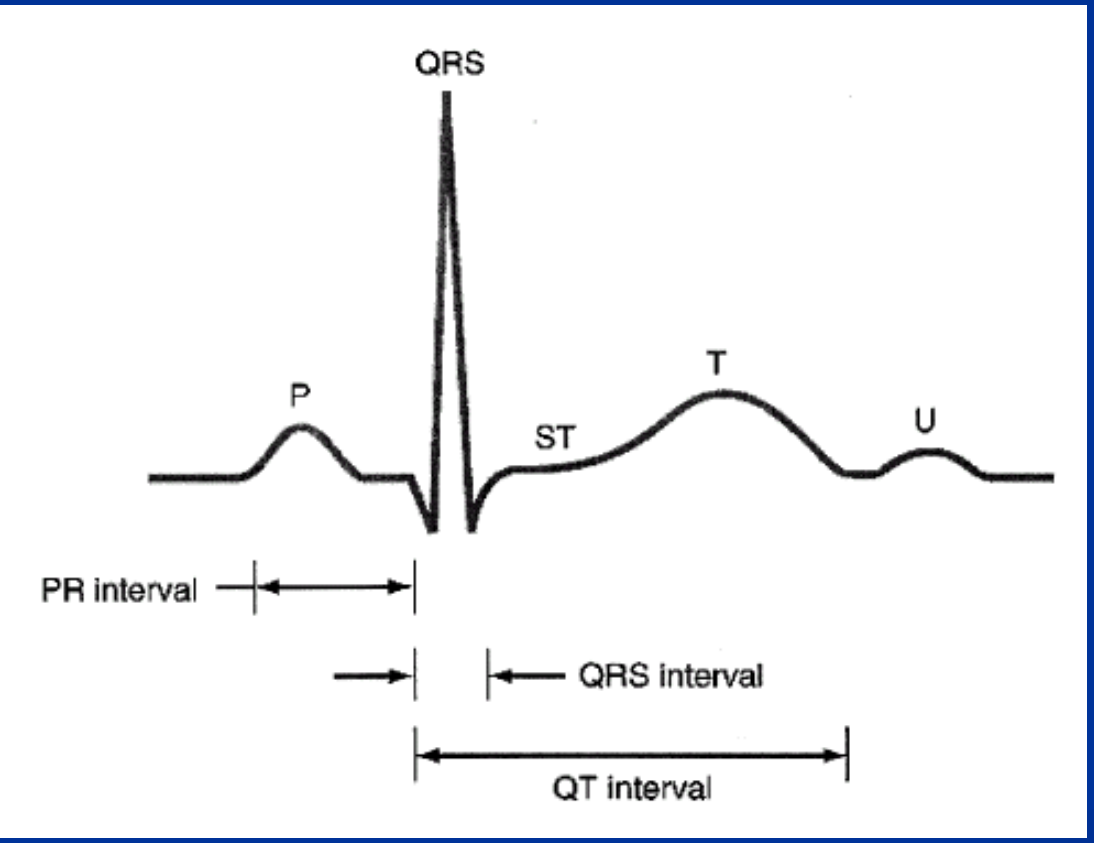
Sensitivity



Sensitivity low – Everything (QRS, T, U) can be sensed by the pacemaker as a QRS

http://www.univie.ac.at/cga/courses/BE513/EKG/qrs.gif

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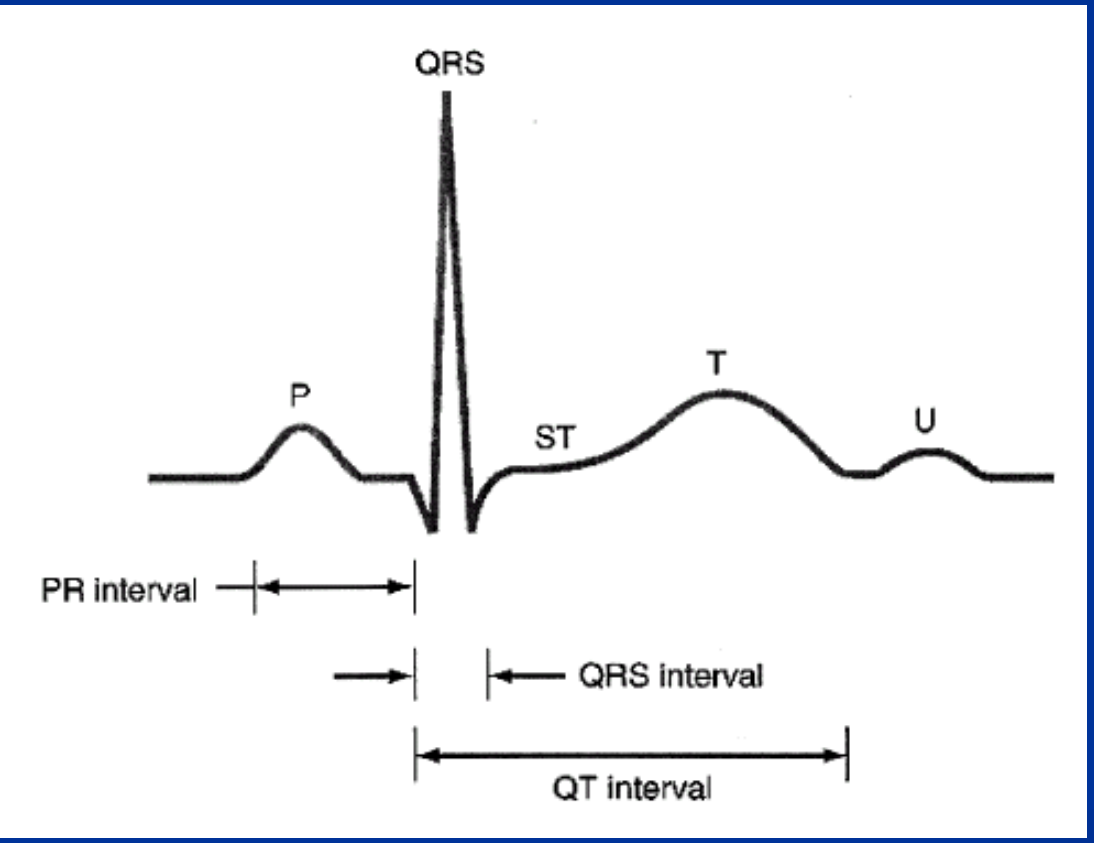
Sensitivity



Async

0 mV

Sensitivity low –
QRS and some T waves will be sensed by pacemaker as a QRS

http://www.univie.ac.at/cga/courses/BE513/EKG/qrs.gif

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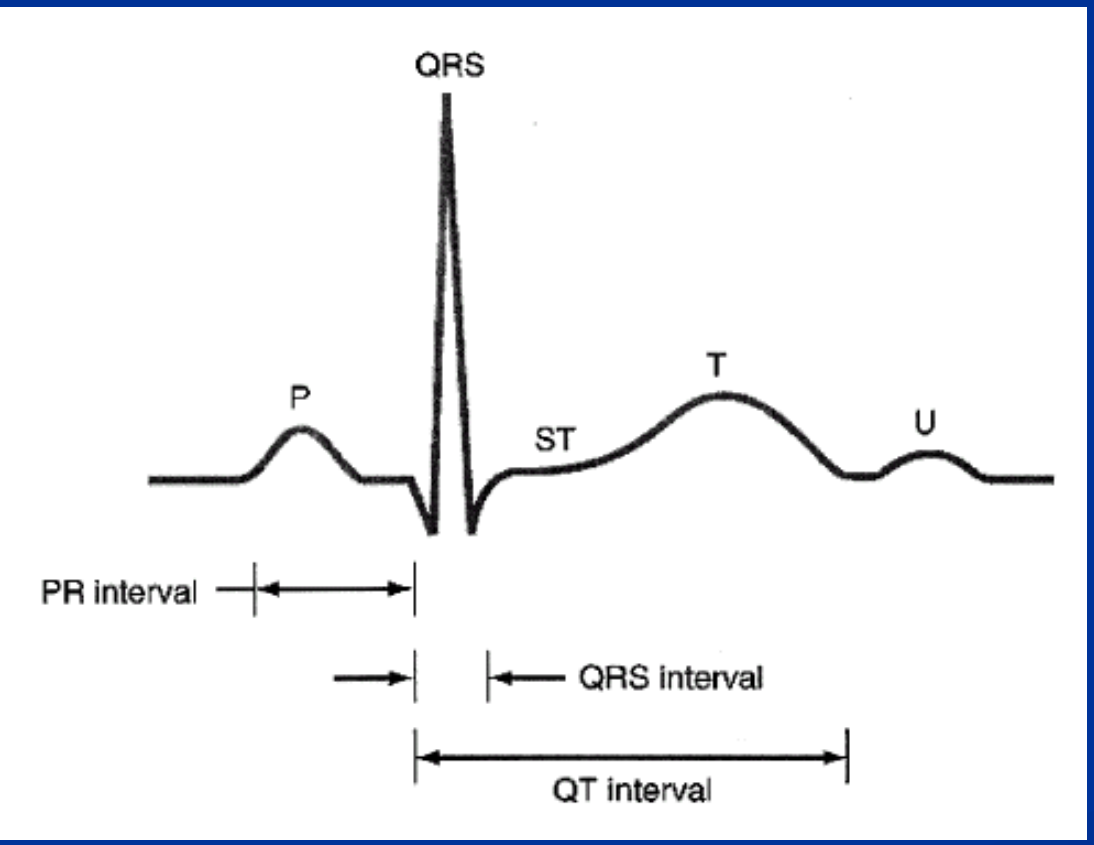
Sensitivity



Sensitivity just right
QRS will be sensed,
T waves will not

http://www.univie.ac.at/cga/courses/BE513/EKG/qrs.gif

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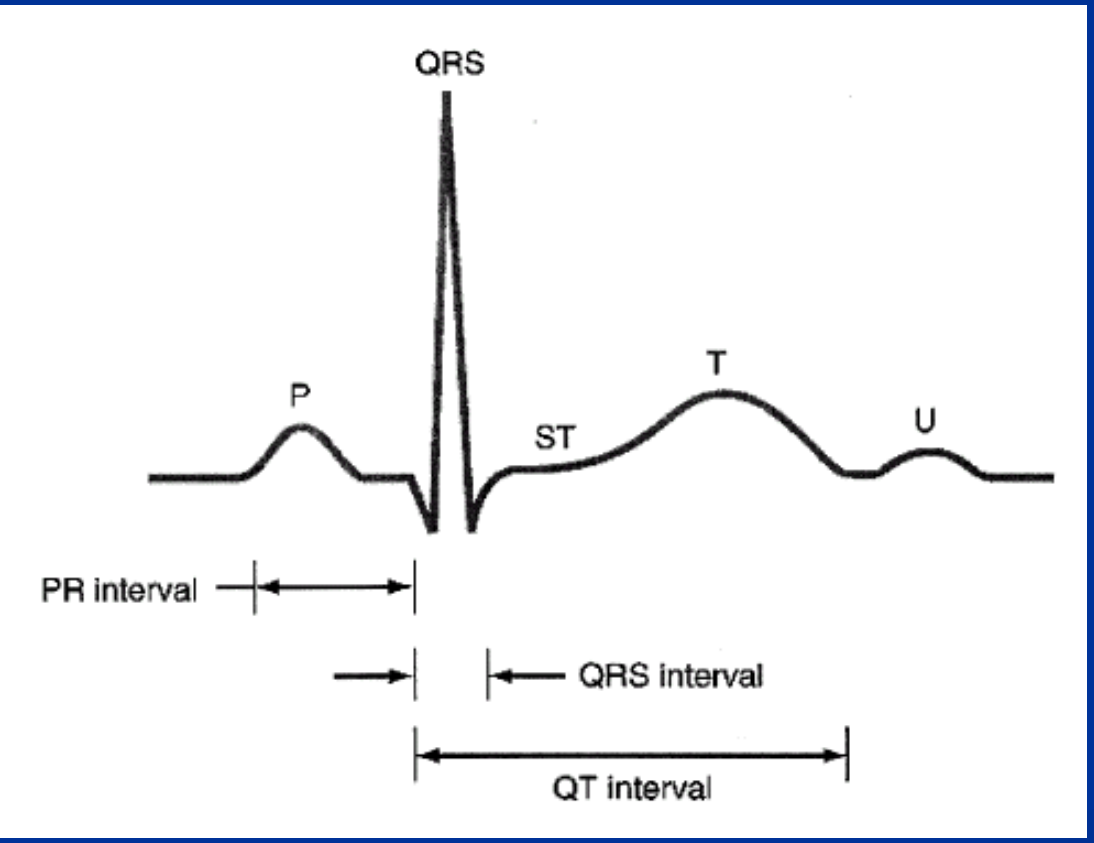
Sensitivity



Sensitivity too high
Nothing will be sensed

Async

0 mV

http://www.univie.ac.at/cga/courses/BE513/EKG/qrs.gif

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Testing thresholds

- Output Threshold
  - Set Sensitivity to 'asynchronous'
  - Set Rate just above the native heart rate
    - 60-80 bpm
  - Start output at 5-10 mA, and gradually turn down until ventricular capture is lost
  - The last point before losing capture is the threshold
  - Pacemaker output should be set at 2-3x the threshold

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Testing Thresholds

- Sensitivity Threshold
  - Not always necessary
  - Testing the amplitude of native QRS complexes as seen by the can
  - Set Rate just below native heart rate
  - Set Output at 2-3x the Pacing threshold
  - Start asynchonrous, then slowly turn dial down. Pacemaker spikes will disappear when the sensitivity threshold is reached. The pacemaker can now ‘see’ the native QRS complexes.
  - The pacemaker should be set at a sensitivity 1/3 to 1/2 the sensitivity threshold

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Troubleshooting Pacemakers

- Normal behavior that looks strange
- Failure to Capture
- Undersensing
- Oversensing
- Cross Talk (Dual Chamber only)

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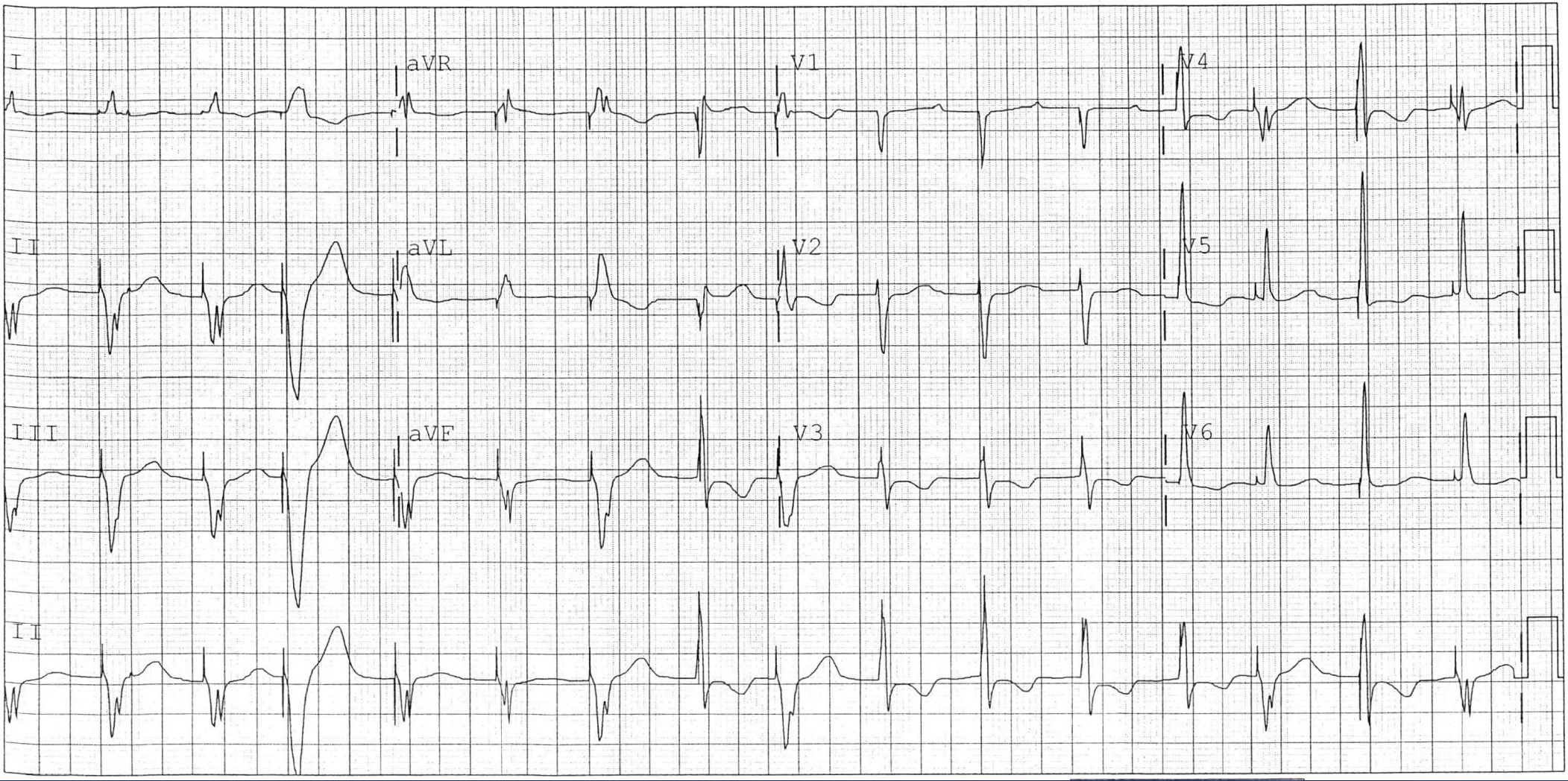
Normal behavior of VVI pacemaker



Native QRS

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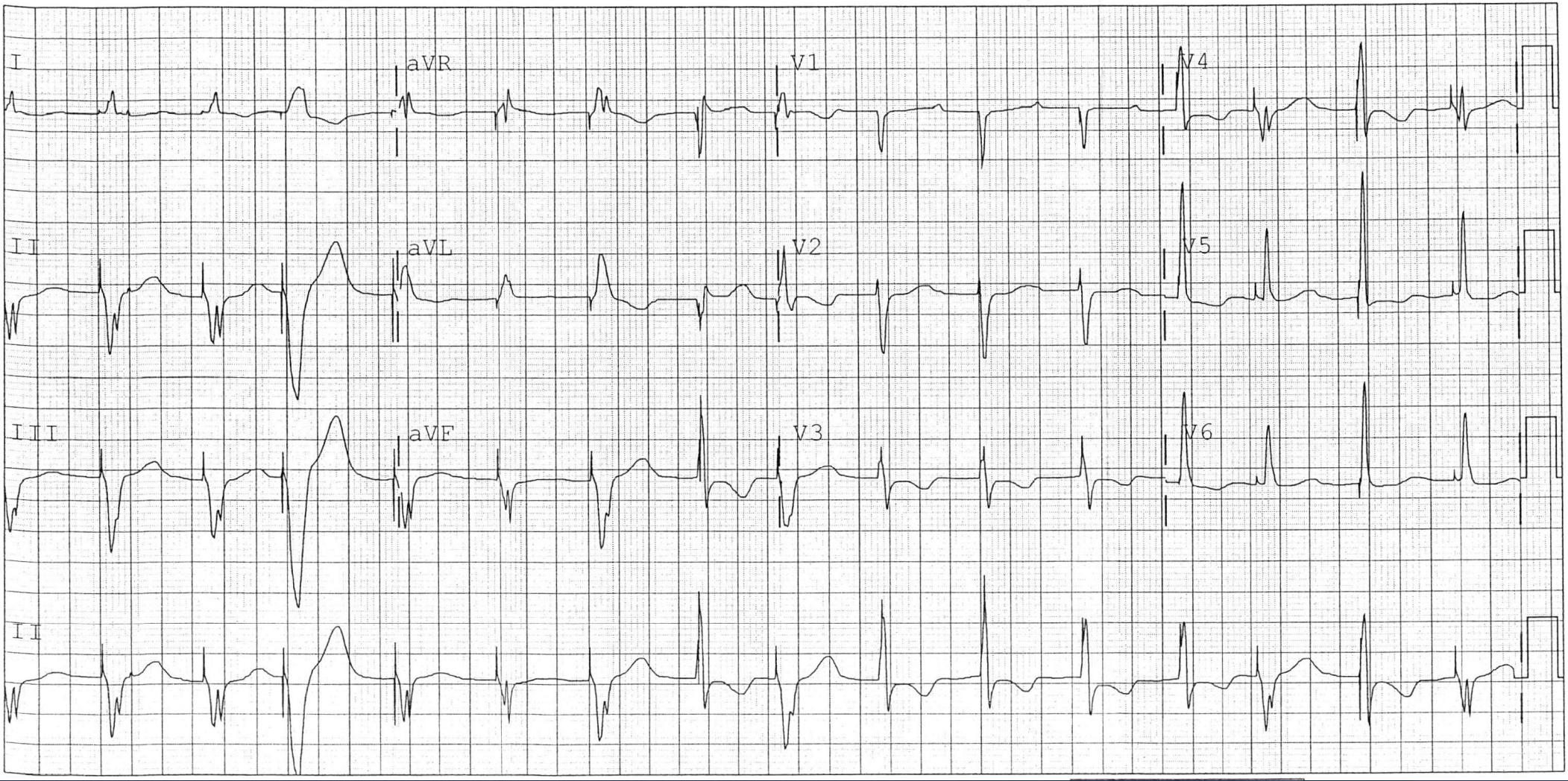
Normal behavior of VVI pacemaker



Paced beat with capture

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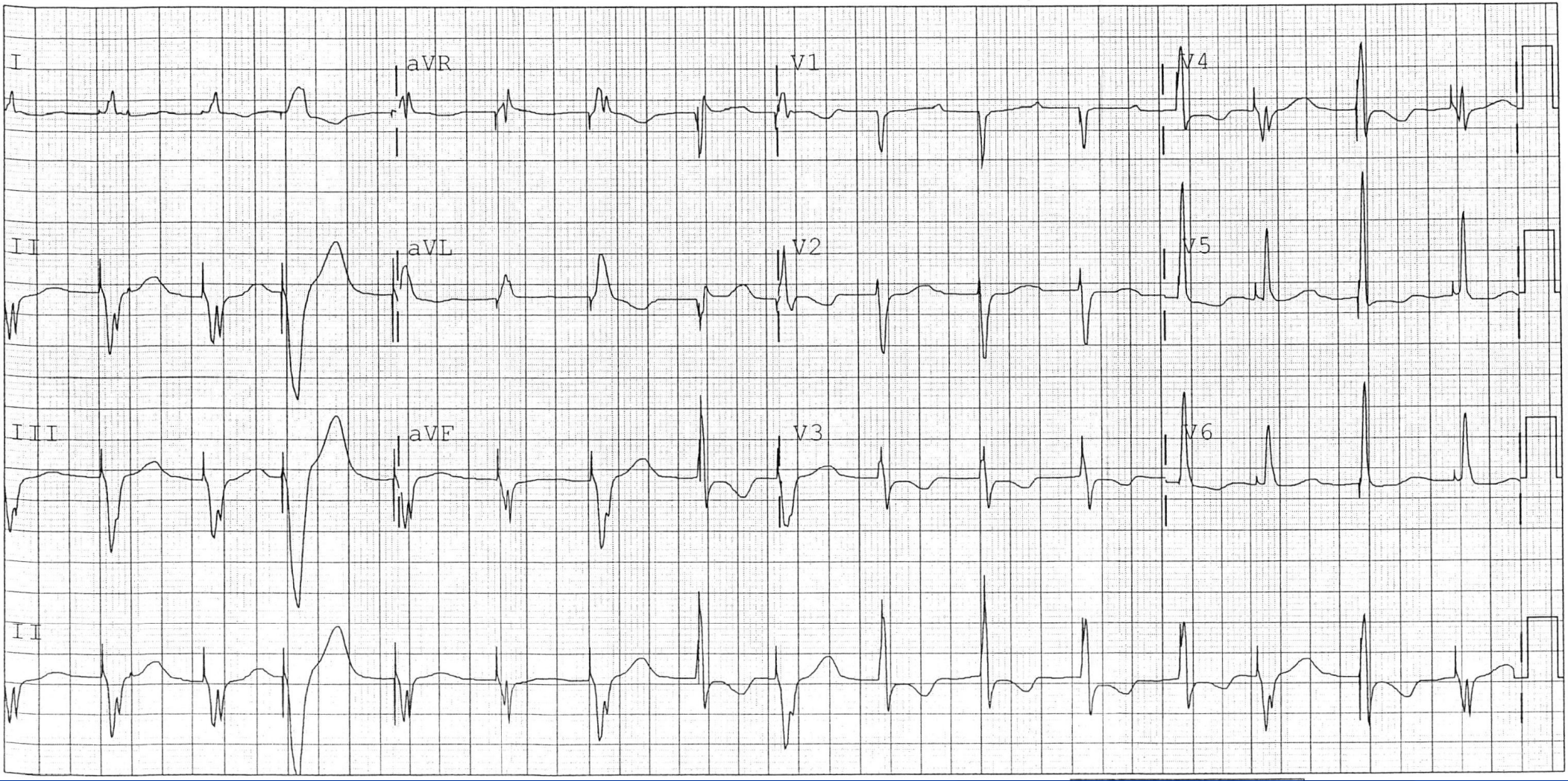
Normal behavior of VVI pacemaker



Fusion beat – combination of native QRS and paced beat

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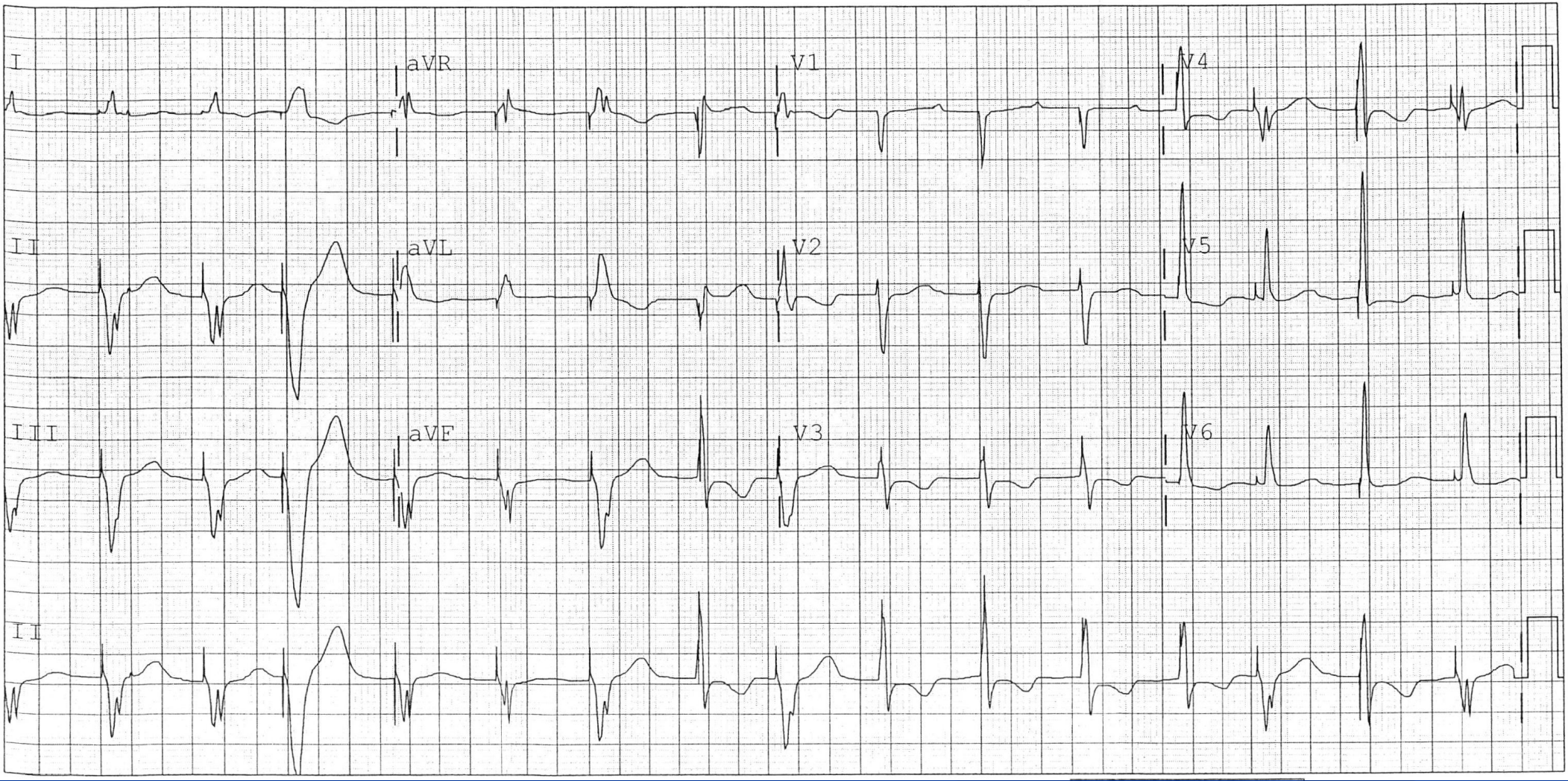
Normal behavior of VVI pacemaker



Pseudofusion – pacing spike, normal QRS

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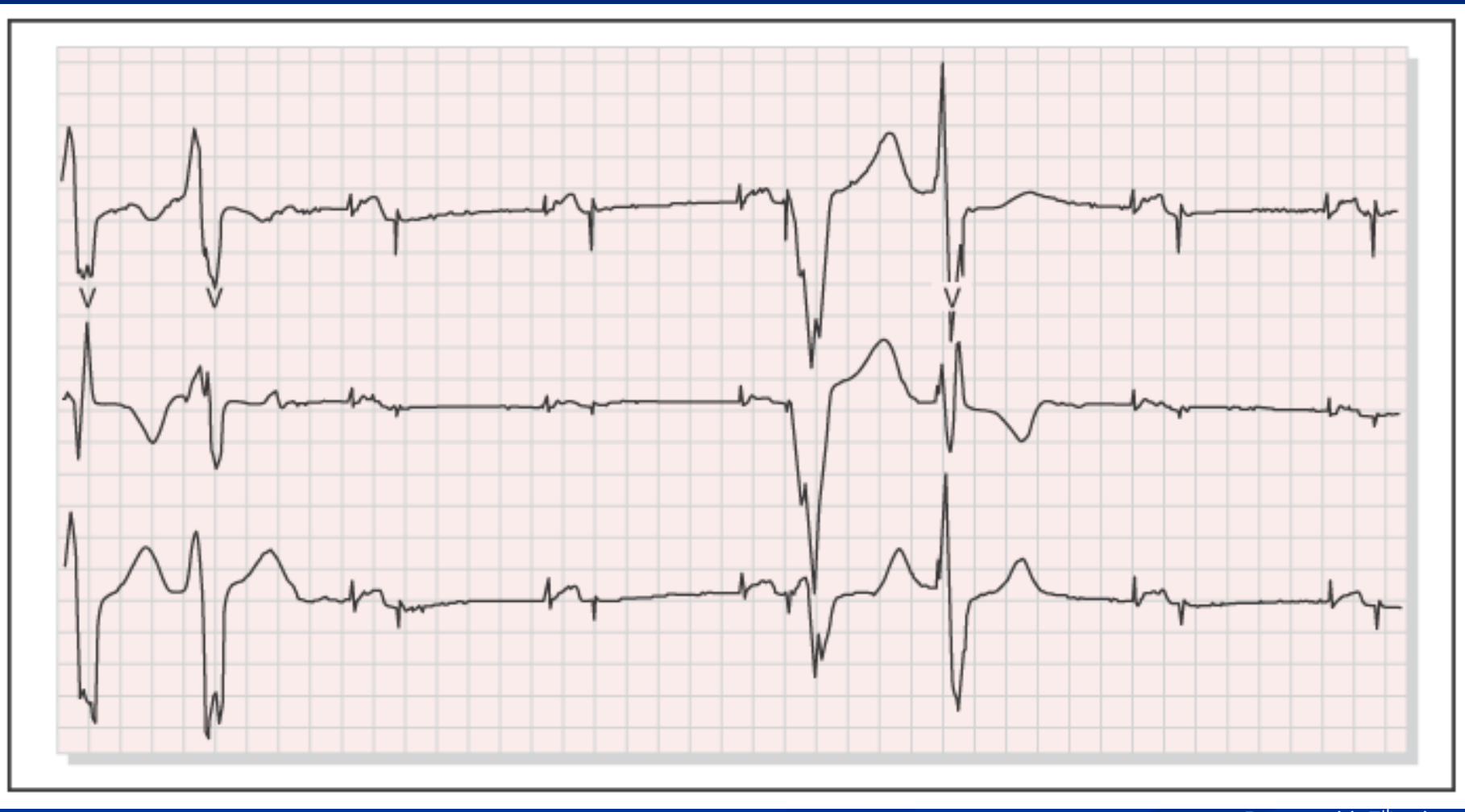
Failure to Capture



Braunwald, 7th ed.

Atrial pacing with intermittent ventricular capture

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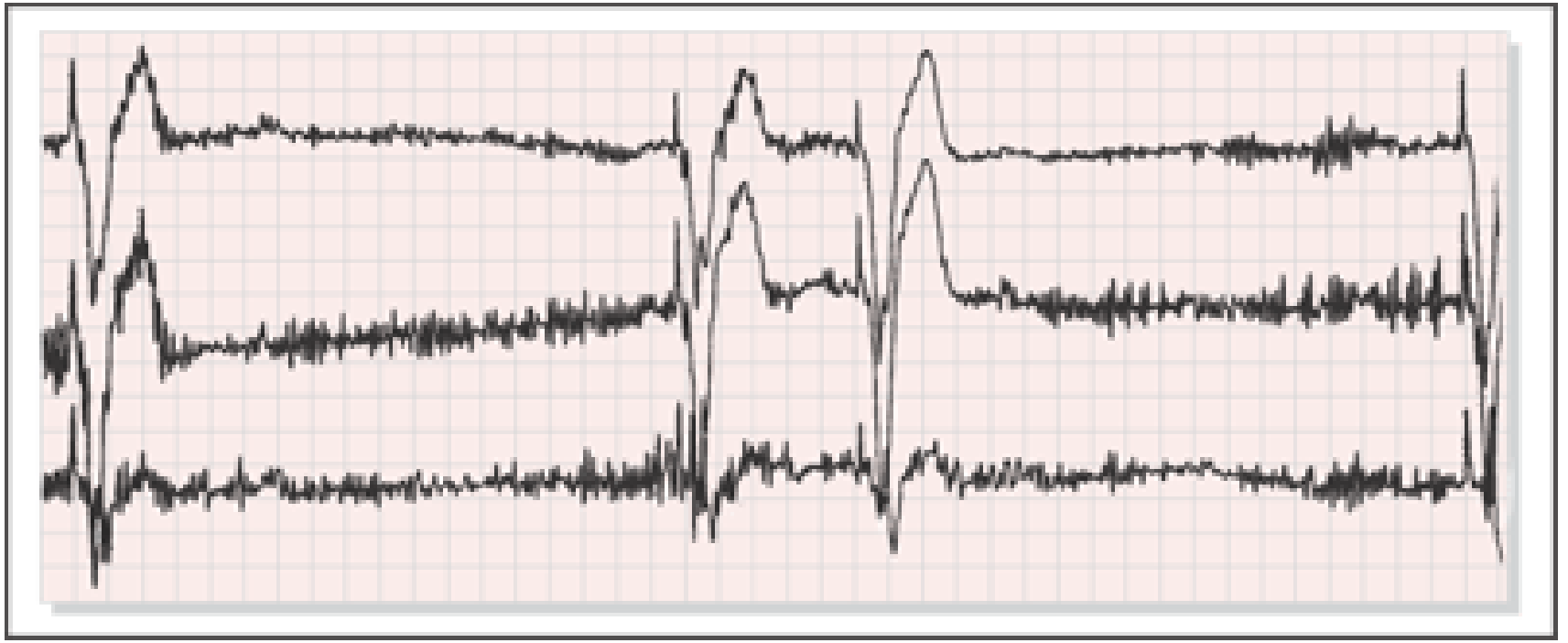
Failure of output (oversensing)



Braunwald, 7th ed.

VVI pacemaker sensing artifact as ventricular contractions (oversensing)
As a result, the pacemaker does not output

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Undersensing

Braunwald, 7th ed.

VVI pacemaker

3rd ventricular beat is a PVC, but it is followed by a pacemaker spike

4th beat is a probably a normal ventricular beat, but it is also followed by a pacer spike

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Cross Talk

Braunwald, 7th ed.

Dual chamber pacemaker in DDD mode
3rd atrial pacing spike is not followed by ventricular spike
Ventricular lead detects the atrial spike as a ventricular depolarization,
So the pacemaker fails to deliver a ventricular spike

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Pacemaker interrogation

Boston Scientific — ALTRUA 60

12-FEB-2009 10:00

Institution \ Kettering Hospital - 3rd Floor
Patient — Programmer 065046
Model S603 Serial 122305 — 2892 Software 4.00

Patient Data File

Patient Name

Pulse Generator Data

Model	S603
Serial	122305
PG Implant Date	11 FEB 2009
Last Interrogation Date	11-FEB-2009

Indications

Atrial	N.R.
AV Nodal	2nd Degree HB Mobitz II
Ventricular	N.R.

Lead Data

	Atrium	Ventricle	
Lead Implant Date	FEB 2009	FEB 2009	
Lead Manufacturer	Guidant	Guidant	
Lead Model	4136	4137	
Connector Type	IS-1 Bipolar	IS-1 Bipolar	
Lead Serial Number	28372183	28337873	
Impedance at PG Implant	700	600	Ω
Threshold at PG Implant	0.75	1.50	V
Wave Amplitude at PG Implant	3	7	mV
Slew Rate at PG Implant	N.R.	N.R.	V/s

Physician

Physician	STULTZ, DAVE
Hospital	Kettering Hospital EP Lab
Phone	937-312-9890

Notes

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Lead data and settings

Boston Scientific ALTRUA 60

12-FEB-2009 10:00

Institution \ Kettering Hospital - 3rd Floor
Patient
Model S603 Serial 122305 Programmer 065046
2892 Software 4.00

Measured Data- Lead Impedance

	Atrial Previous	Atrial Present	Ventricular Previous	Ventricular Present	
Date of last test	11-FEB-2009		11-FEB-2009		
Impedance	590	530	700	660	Ω
Amplitude	3.5	3.5	3.5	0.9	V
Pulse Width	0.50	0.50	0.40	0.40	ms
Current	6	7	5	1	mA
Lead Config. (paced)	Bipolar	Bipolar	Bipolar	Bipolar	
Energy	10.4	11.6	7.0	0.5	µJ

Measured Data- Intrinsic Amplitude

	Previous	Present	
Date of last test	11-FEB-2009		
Chamber Tested	Atrium		
Measured Amplitude	2.1	2.3	mV
Lead Configuration (sensed)	Bipolar	Bipolar	

Measured Data- Intrinsic Amplitude

	Previous	Present	
Date of last test	11-FEB-2009		
Chamber Tested	Ventricle		
Measured Amplitude	5.6	5.7	mV
Lead Configuration (sensed)	Bipolar	Bipolar	

End of Report

Boston Scientific ALTRUA 60

12-FEB-2009 10:00

Institution \ Kettering Hospital - 3rd Floor
Patient
Model S603 Serial 122305 Programmer 065046
2892 Software 4.00

Threshold Test Report

Chamber Tested: Atrium

Threshold Test Results

Test	Type	Mode	Rate	AV Delay	Ampl	PW	Configuration
1	A-Ampl	AAI	90	--	1.0	0.50	Bipolar
2	A-Ampl	AAI	90	--	1.6	0.50	Bipolar
3	A-Ampl	AAI	75	--	0.7	0.50	Bipolar
4							
5							
6							

Threshold Test Report

Chamber Tested: Ventricle

Threshold Test Results

Test	Type	Mode	Rate	AV Delay	Ampl	PW	Configuration
1	V-Auto	VVI	90	--	0.4	0.40	Bipolar
2							
3							
4							
5							
6							

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Bradycardia settings

Boston Scientific — ALTRUA 60

12-FEB-2009 10:00

Institution \ Kettering Hospital - 3rd Floor
Patient
Model S603 Serial 122305 — Programmer 2892 Software — 065046 — 4.00

Brady Parameters

		Initial Value		Present Value	
Mode		DDDR		DDDR	
Lower Rate Limit		55		55	ppm
Max Tracking Rate		120		120	ppm
Max Sensor Rate		120		120	ppm
AV Delay (paced)	DYN	--	DYN	--	ms
Atrial					
Pulse Width		0.50		0.50	ms
Amplitude		3.5		3.5	V
Sensitivity		0.50		0.50	mV
Refractory (PVARP)	DYN	--	DYN	--	ms
Ventricular					
Pulse Width		0.40		0.40	ms
Amplitude	AUTO	0.9	AUTO	0.9	V
Sensitivity		2.5		2.5	mV
Refractory		250		250	ms

AV Delay

	Initial Value		Present Value	
Dynamic AV Delay	On		On	
Maximum Delay	350		350	ms
Minimum Delay	200		200	ms
Sensed AV Offset	-30		-30	ms
AV Search Hysteresis				
Search Interval	Off	-->	64	cycles
AV Increase	--	-->	30	%

Sensor(s)

	Initial Value		Present Value	
Accelerometer	On		On	
Activity Threshold	Medium		Medium	
Reaction Time	30		30	sec
Response Factor	8	-->	Passive	
Recovery Time	2		2	min
Minute Ventilation	Off	-->	On	
MV Lead	--	-->	Ventricle	
Response Factor	--	-->	3	
High Rate Response Factor	--	-->	70	%
High Rate Break Point	--	-->	110	ppm
Age	60		60	
AutoLifestyle	--	-->	Off	
with Exercise	--		--	
Time Dependent Blend	--	-->	On	

Refractory

	Initial Value	Present Value	
Dynamic PVARP	On	On	
Maximum PVARP	250	250	ms
Minimum PVARP	240	240	ms
PVARP after PVC/PAC	400	400	ms
V-Blanking after A-Pace	40	40	ms
A-Blanking after V-Pace	120	120	ms

A-Tachy Response

	Initial Value		Present Value	
A-Tachy Response	On		On	
Trigger Rate	170		170	bpm
Duration	8		8	cycles
Entry Count	8		8	cycles
Exit Count	8		8	cycles
Fallback Mode	DDIR	-->	DDI	
Fallback Time	30		30	sec
Lower Rate Limit	70		70	ppm
Atrial Flutter Response	Off		Off	bpm
PMT Termination	On		On	
Ventricular Rate Regulation	On		On	
Max Pacing Rate	110		110	ppm

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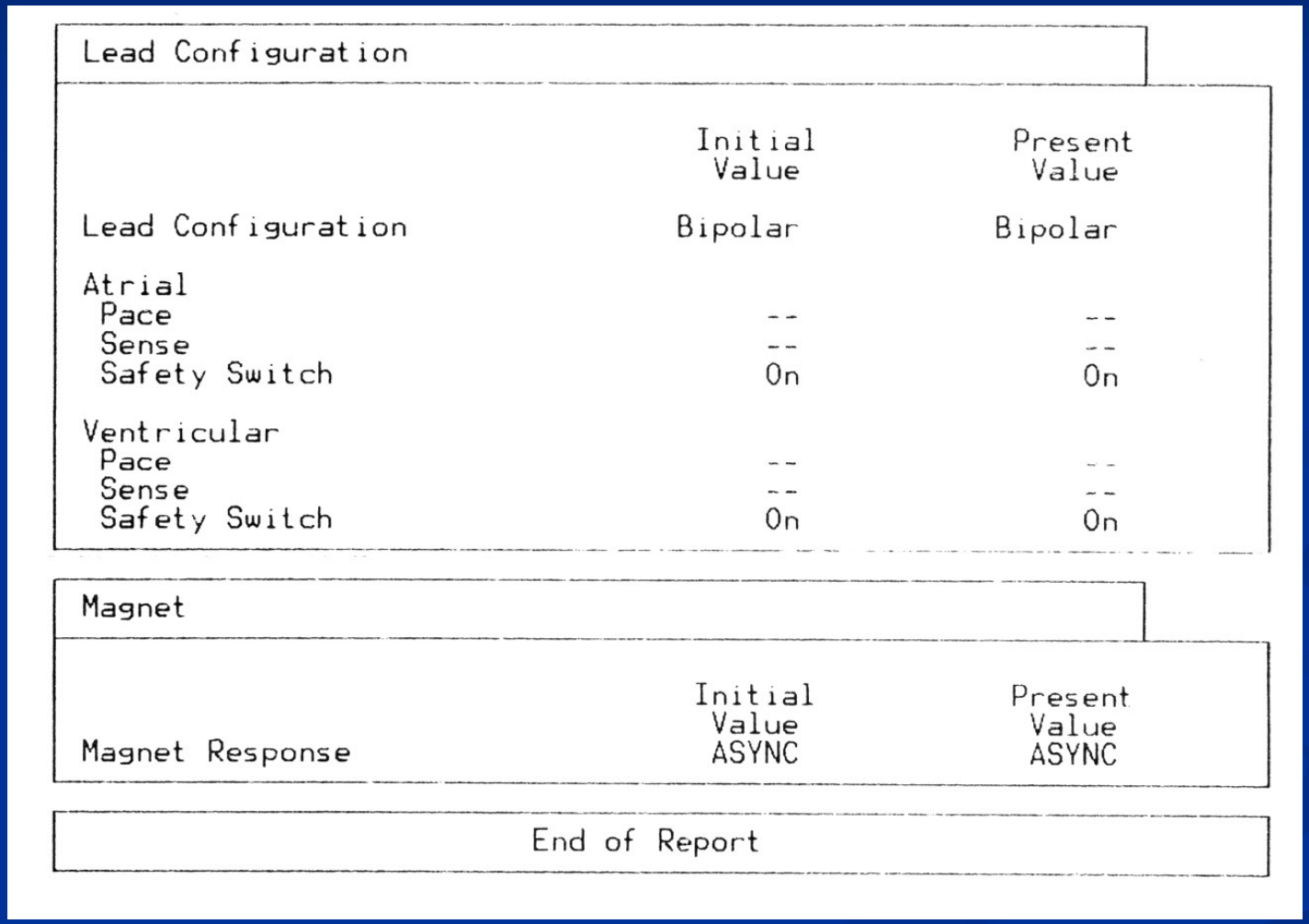
Lead configuration



Lead Configuration

	Initial Value	Present Value
Lead Configuration	Bipolar	Bipolar
Atrial		
Pace	--	--
Sense	--	--
Safety Switch	On	On
Ventricular		
Pace	--	--
Sense	--	--
Safety Switch	On	On

Magnet

	Initial Value	Present Value
Magnet Response	ASYNC	ASYNC

End of Report