Bradycardia and Cardiac Pacing

overview

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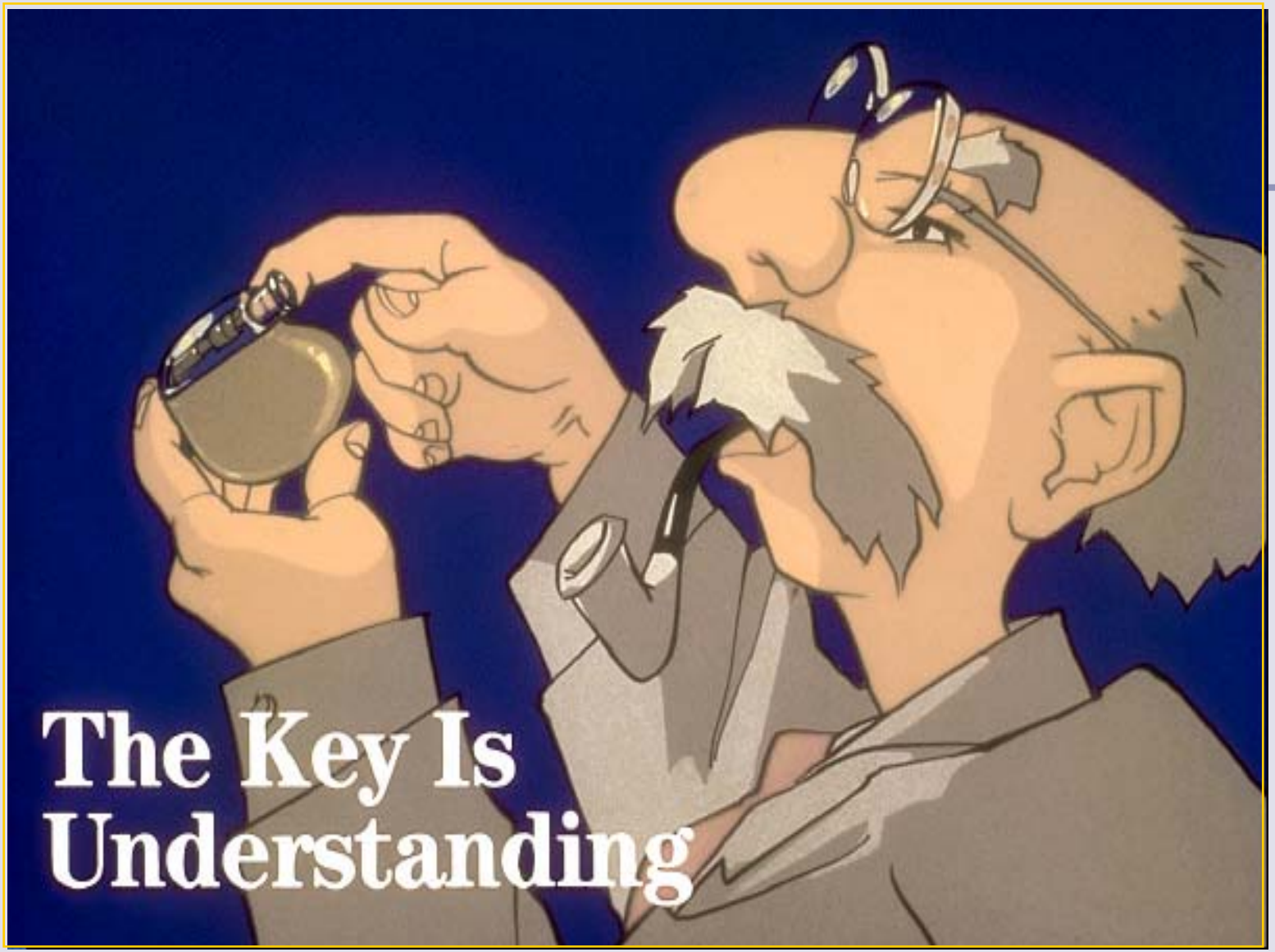
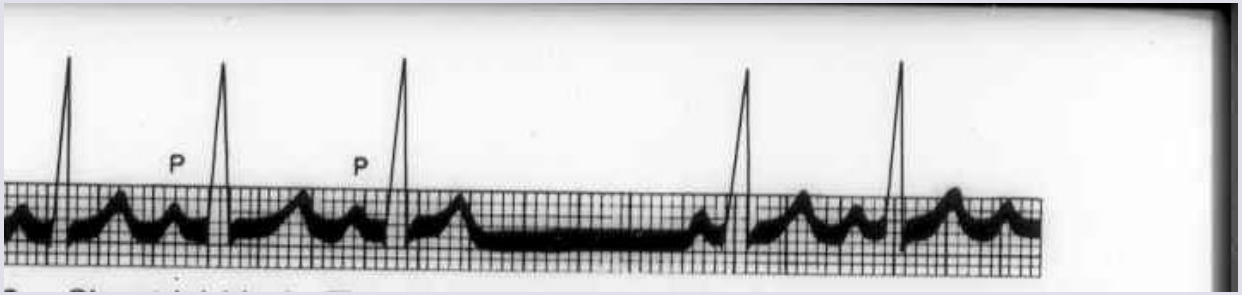

The Key Is
Understanding

Bradycardia

- Sinus node dysfunction
- AV node dysfunction(“block”)
- Neuro-cardiogenic reaction (VVS, CSH)

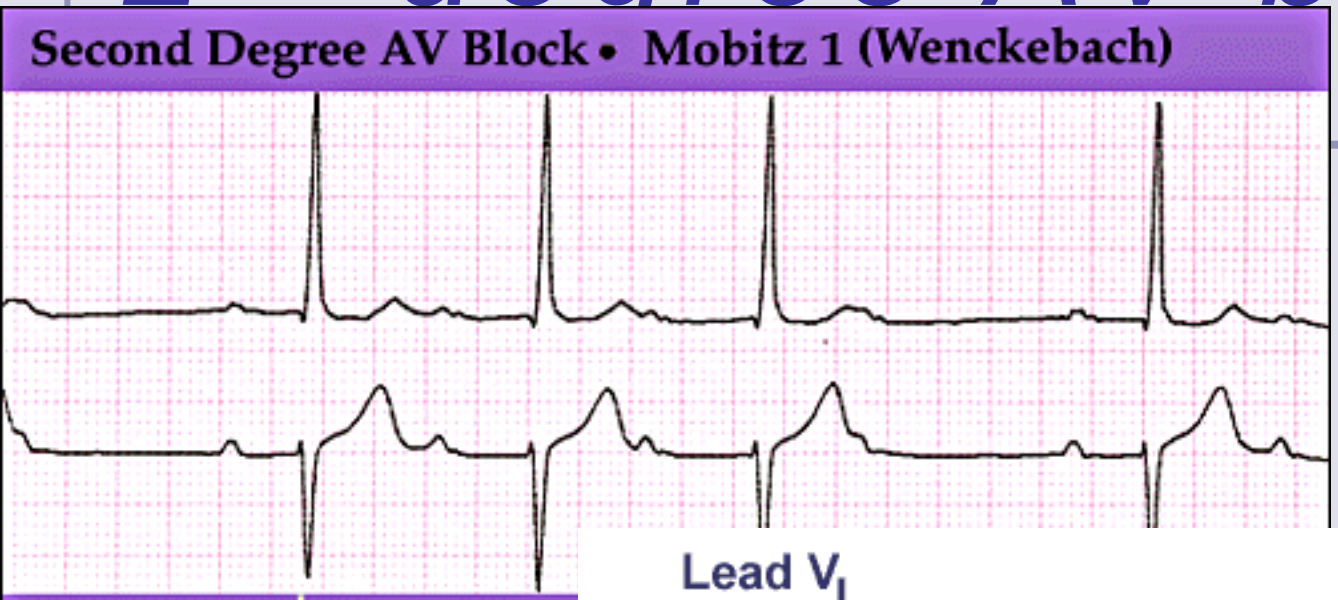
Sick Sinus Syndrome (SSS)

- Sinus bradycardia
- Sino-atrial block

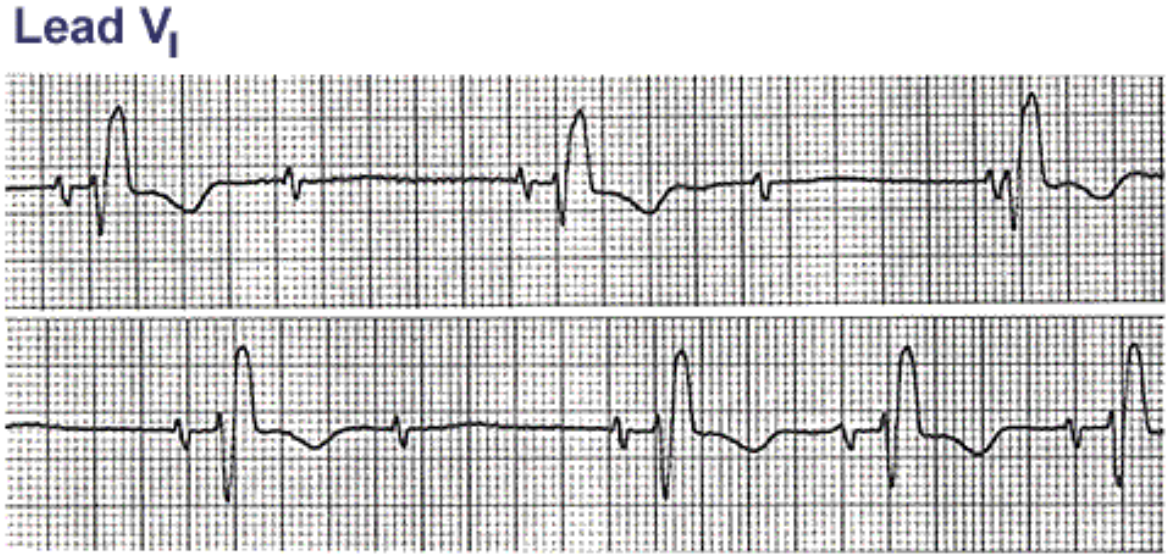


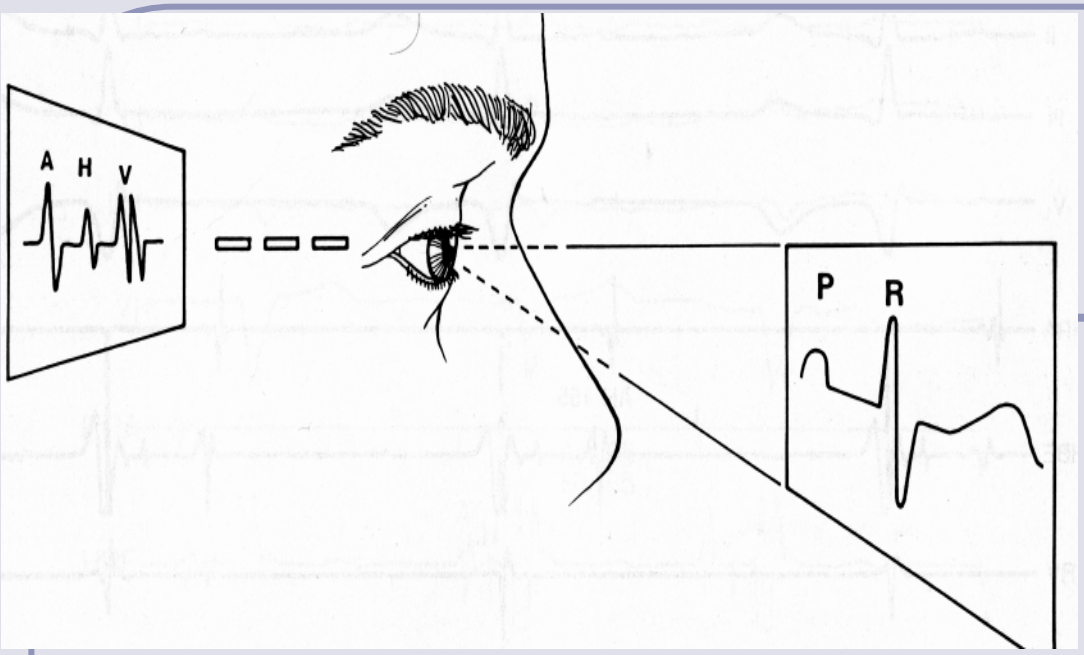
- Sinus pauses
- Chronothropic incompetence

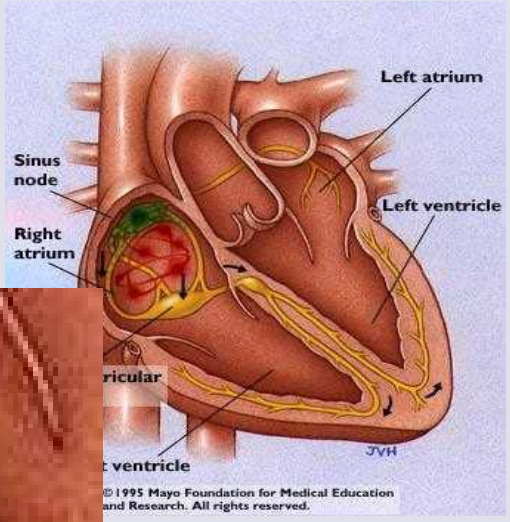
2nd degree AV block

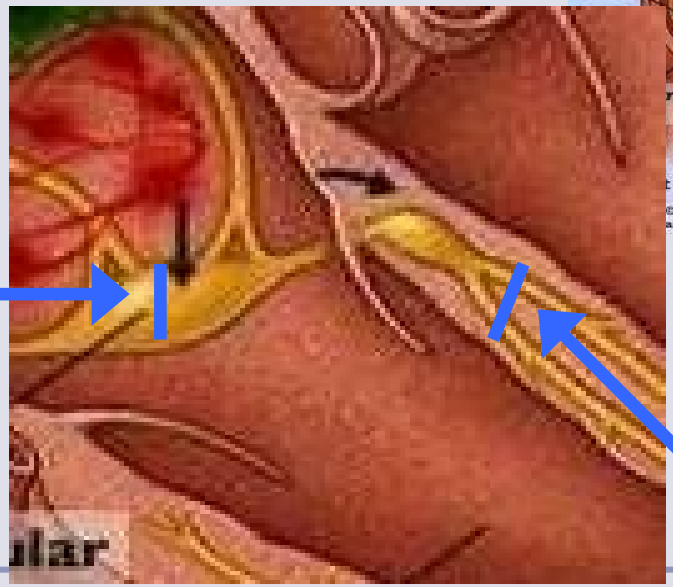


P Wave	PR Interval (in seconds)
Conduction intermittant	Increasingly Prolonged



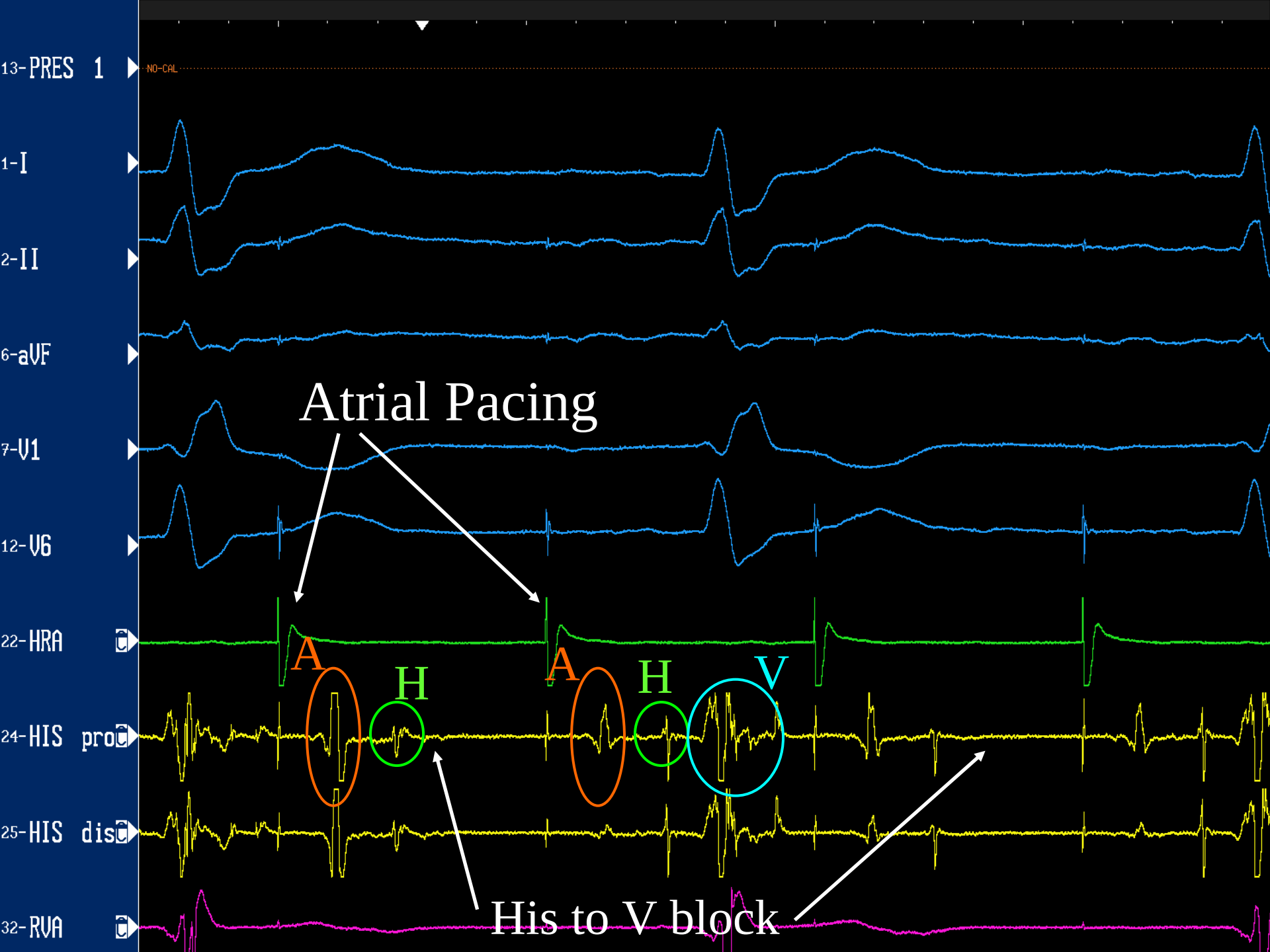






MOBITZ I
(AH block)

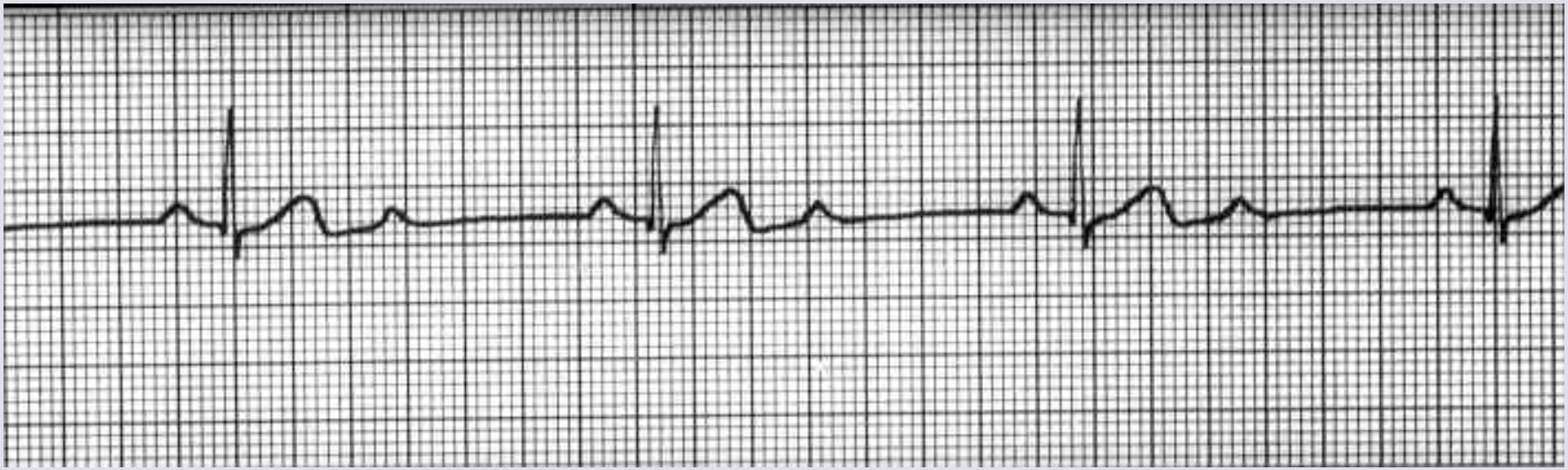
MOBITZ II
(HV block)


13-PRES 1
NO-CAL
1-I
2-II
6-aVF
7-V1
12-V6
22-HRA
24-HIS pro
25-HIS dis
32-RVA
Atrial Pacing
A
H
A
H
V
His to V block

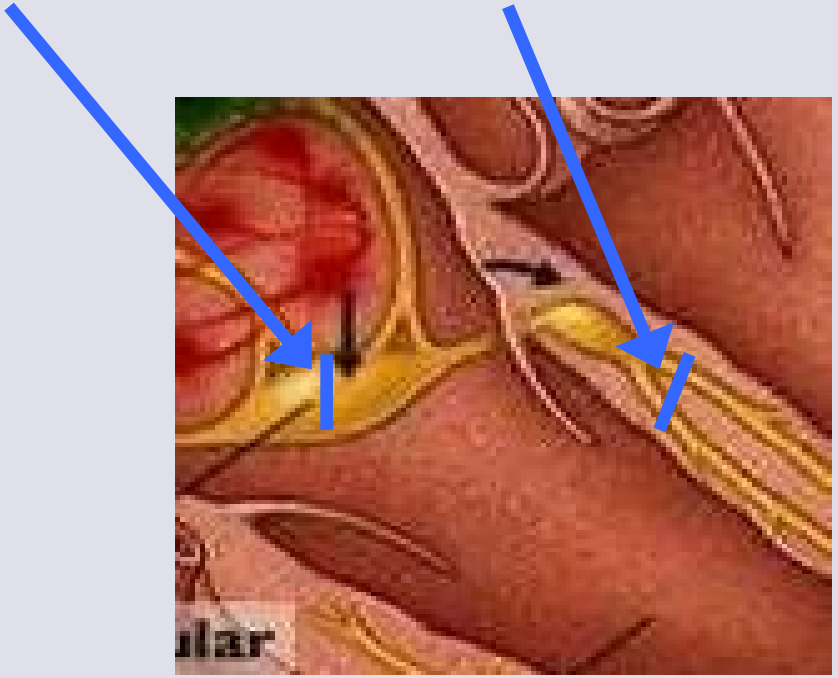
Prognostic implications

- MOBITZ I
  - Usually did not progress to Complete AVB
  - CAVB with nodal escape rhythm
- MOBITZ II
  - Progress to CAVB is a rule
  - CAVB with ventricular (very slow) escape: syncope and SCD can occur

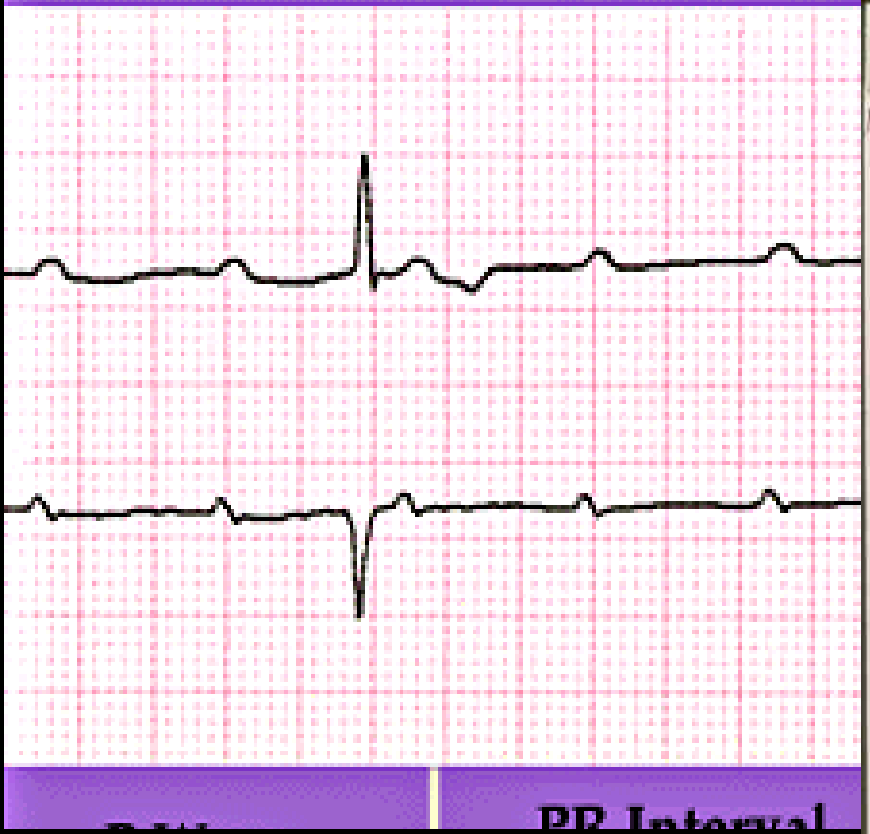
Is It Mobitz I or Mobitz II?



- Differential diagnosis of 2:1 AV block
  - Rest ECG
    - QRS width
    - PR interval
  - Stress ECG
    - Exersise/atropine
    - Carotid sinus massage
  - EPS
    - HV interval
    - Atrial pacing



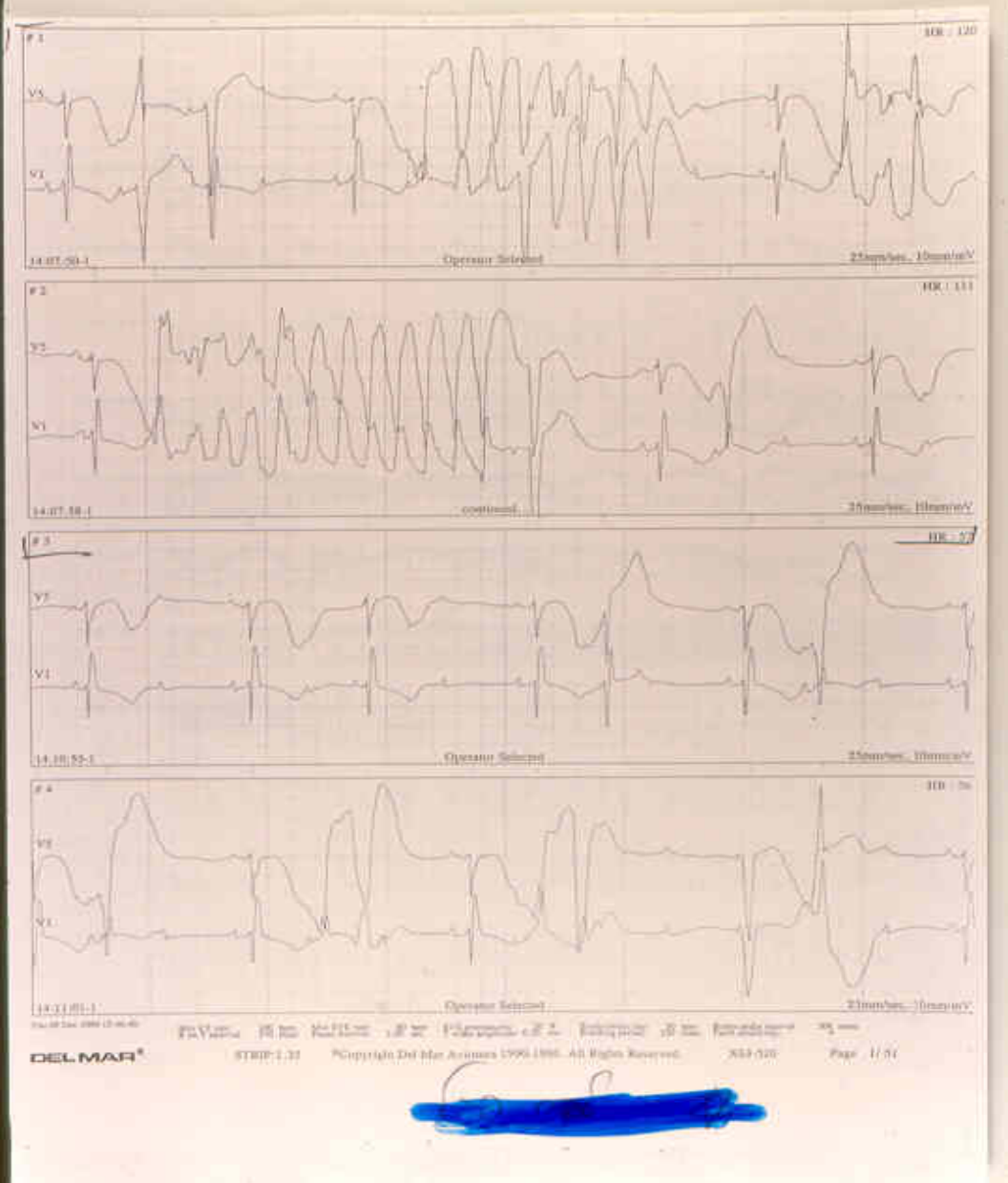
Third Degree (complete) AV Block



PR Interval

Could be less good…

Or even worse…



AHA/ACC Guidelines for PM implantation in patients with SA disease (2008)

Class I Indications

- Sinus node dysfunction with documented symptomatic sinus bradycardia & sinus pauses
- Symptomatic chronotropic incompetence

Class II Indications

- Class IIa: Symptomatic patients with SND and HR<40 but with no clear association between symptoms and bradycardia
- Class IIb: Chronic heart rate < 40 bpm while awake, in minimally symptomatic patients

Class III Indications

- Asymptomatic sinus node dysfunction

AHA/ACC Guidelines for PM implantation in patients with AV node disease

Class I Indications

- 3rd degree and advanced 2nd degree AV block associated with:
  - Symptomatic bradycardia
  - Documented periods of asystole ≥ 3 seconds in SR or ≥ 5 sec in AF
  - Escape rate < 40 bpm in SR in awake, symptom free patients
  - Escape rate >40 with LV dilatation/dysfunction or escape below his
  - Post AV junction ablation & Post-operative AV block
- Second degree AV block with associated symptomatic bradycardia
- Second degree AV block exercise induced
- Asymptomatic Type II 2nd degree AV block with wide QRS

AHA/ACC Guidelines for PM implantation in patients with AV node disease

Class II Indications

- Class IIa:
  - Asymptomatic CHB with a ventricular rate > 40 bpm and normal LV
  - Asymptomatic Type II 2nd degree AV block with narrow QRS.
  - Asymptomatic Type I 2nd degree AV block within the His-Purkinje system found incidentally at EP study
  - First or second degree AV block with symptoms similar to those of pacemaker syndrome or hemodynamic compromise

AHA/ACC Guidelines for PM implantation in patients with neuro-cardiogenic syncope

Class I Indications

- Recurrent syncope caused by spontaneouse carotid sinus stimulation and carotid sinus pressure induces a period of asystole > 3 seconds

AHA/ACC Guidelines for PM implantation in patients with neuro-cardiogenic syncope

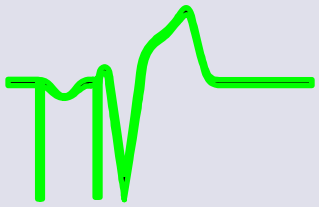
Class II Indications

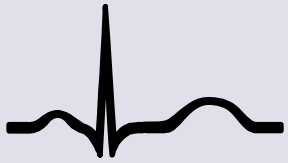
- Class IIa:
  - Syncope without clear, provocative events and with a hypersensitive cardioinhibitory response (> 3 sec)

- Class IIb:
  - Significant symptomatic neurocardiogenic syncope associated with bradycardia documented spontaneously or at the time of tilt-table testing

Pacing Technology "Secret"

- Pacemakers do *only* 2 things:

Pace 

Sense 

Pacing Rate/Low Rate Limit

- **The rate at which the pacemaker will pace if the patient does not have their own rhythm**

Capture

- **The depolarization of the Atria or Ventricles in response to a pacemaker stimulus**

Sensing

- **The ability of the pacemaker to sense an intrinsic electrical signal**

Inhibition

- **Suppression of the pacemaker stimulus by spontaneous (sensed) intrinsic event**

Pacemaker malfuncture

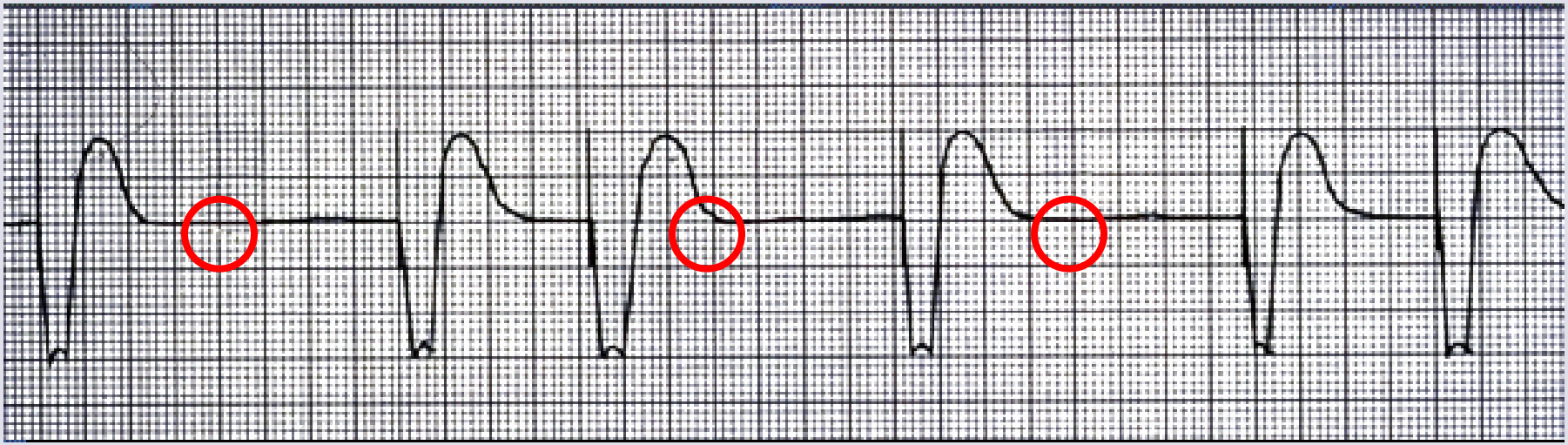
- Oversensing
- Undersensing
- Loss of capture

Oversensing

- **Definition: The sensing of events other than P or R-waves by the pacemaker circuitry**

- **Oversensing leads to Underpacing**

Ventricular Oversensing



Pacing interval

Pacing interval

Pacing interval

Pacing interval

Pacing interval

Oversensing Causes

- **Normal signals oversensing**
  - repolarization (“T wave”)
  - opposite chamber activity or pacing stimulus (cross-talk)

- **Lead failure**
  - Insulation Break
  - Conductor Fracture

- **External noise**
  - Myopotentials
  - EMI

Undersensing

- **Definition:** **Failure of the pacemaker to sense intrinsic P- or R-waves**

- **Undersensing leads to Overpacing**

Ventricular Undersensing

Undersensing Causes

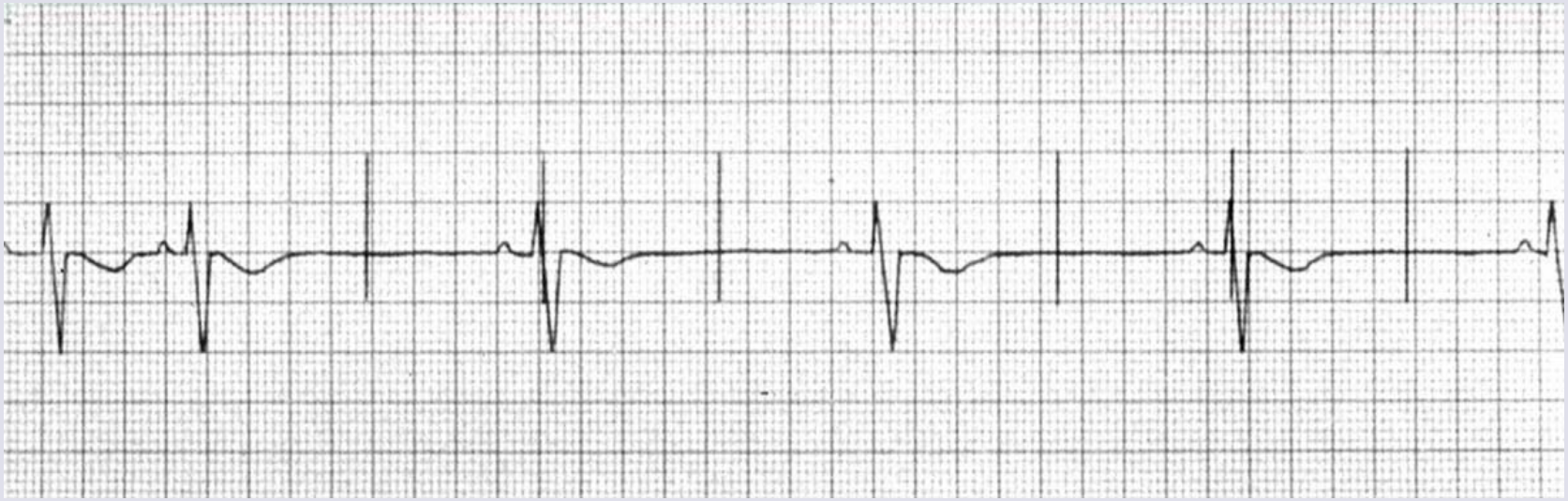
- **Inadequate cardiac signal or programmed sensitivity**
- **Lead failure:**
  - **Insulation break**
  - **conductor fracture**
- **Lead dislodgment**

Loss of Capture

- **Definition:** **The emitted pacemaker stimulus does not cause depolarization**
- **Loss of capture occurs when the pacemaker's programmed energy is less than the stimulation threshold**

Loss of Capture

No evidence of depolarization after pacing artifact



Loss of Capture Causes

- **Increased pacing threshold**
  - **Hyperkalemia**
  - **Antiarrhythmic drugs**
  - **Exit block**

- **Decreased effective output**
  - **Dislodged lead (Perforation)**
  - **Lead failure (Insulation break, fracture)**
  - **PM end of life**

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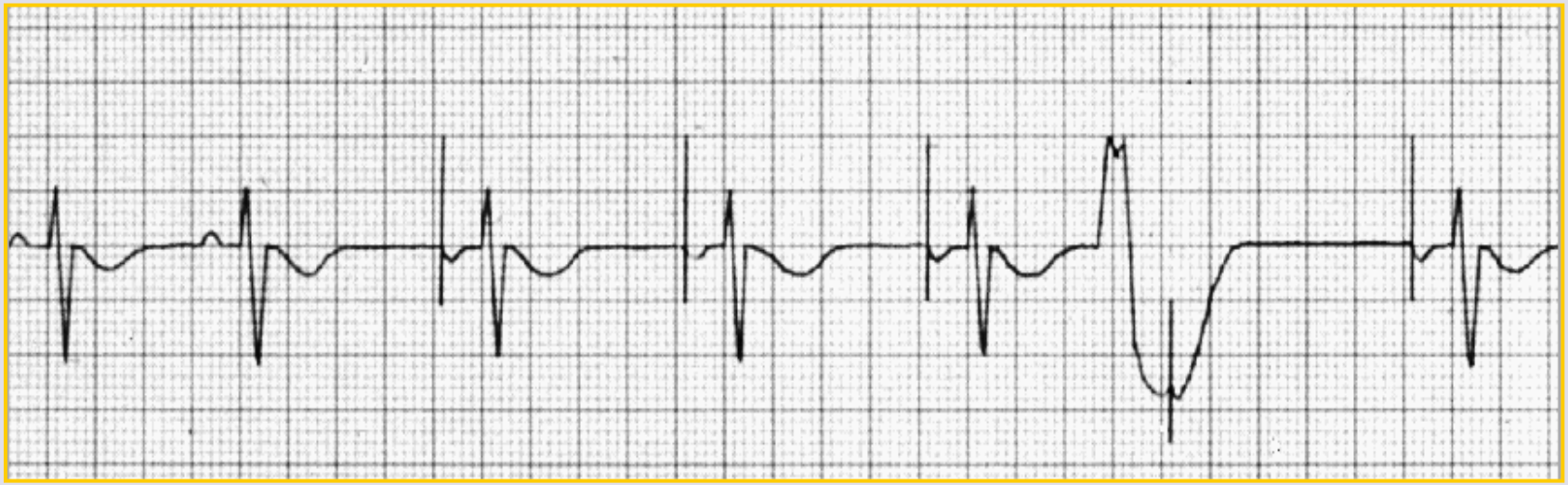

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PACING KOD

PACING CHAMBER	SENSING CHAMBER	PACING MODE response to "sensed event "
O = None	O = None	O = None
A = Atrium	A = Atrium	I = inhibited
V = Ventricle	V = Ventricle	T=triggered
D = Dual	D = Dual	D = Dual

Asynchronous Pacing – VOO/AOO/DOO

PACING CHAMBER	SENSING CHAMBER	PACING MODE response to "sensed event "
O = None	O = None	O = None
A = Atrium	A = Atrium	I = inhibited
V = Ventricle	V = Ventricle	T=triggered
D = Dual	D = Dual	D = Dual

- **Pacing without sensing**
- **Oldest mode of pacing**
- **Magnet mode for most pacemakers**

VOO

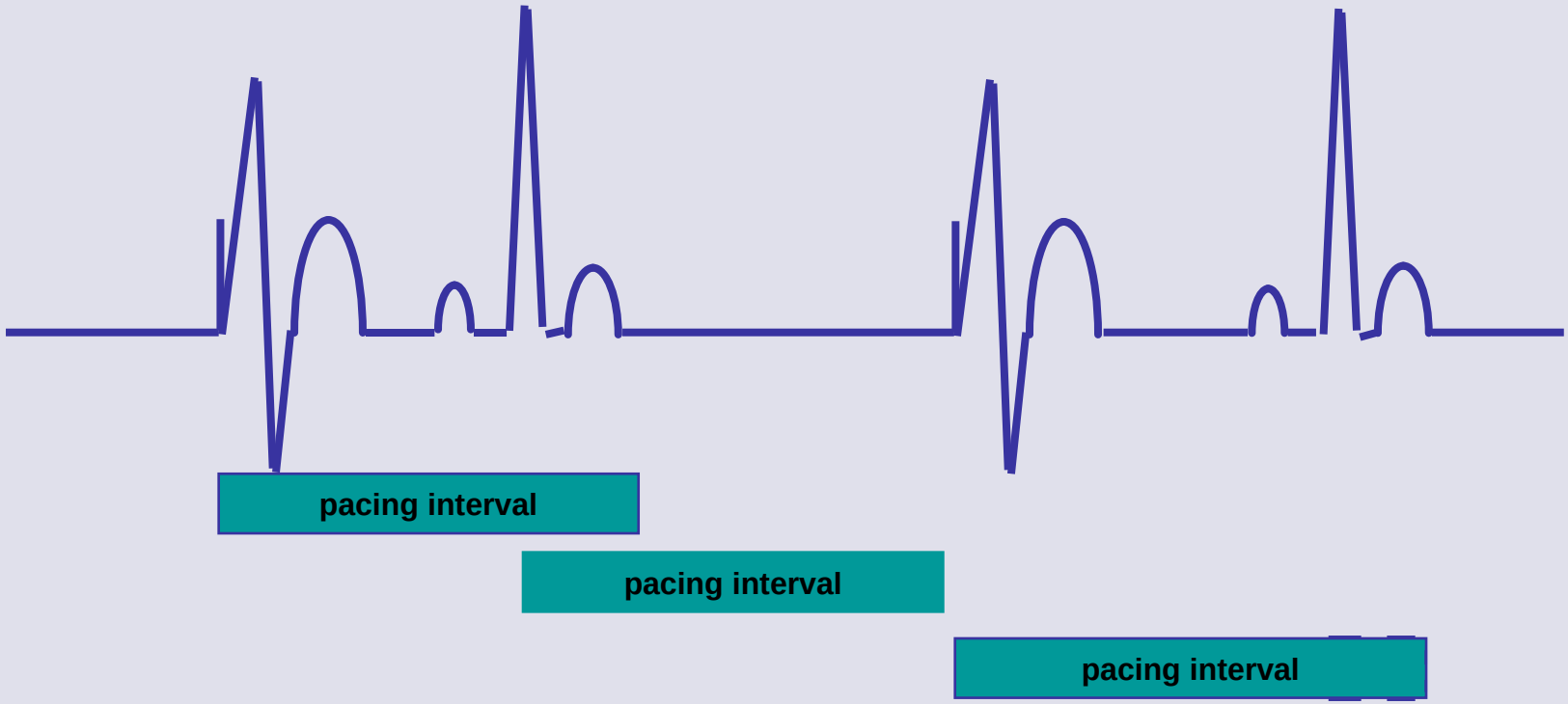
Demand Pacing (VVI/AAI)

PACING CHAMBER	SENSING CHAMBER	PACING MODE response to "sensed event "
O = None	O = None	O = None
A = Atrium	A = Atrium	I = inhibited
V = Ventricle	V = Ventricle	T=triggered
D = Dual	D = Dual	D = Dual

- **Pacing with sensing**
- **Pacing pulse is inhibited by intrinsic "P" or "R-waves"**
- **Sensed events reset the pacing interval**

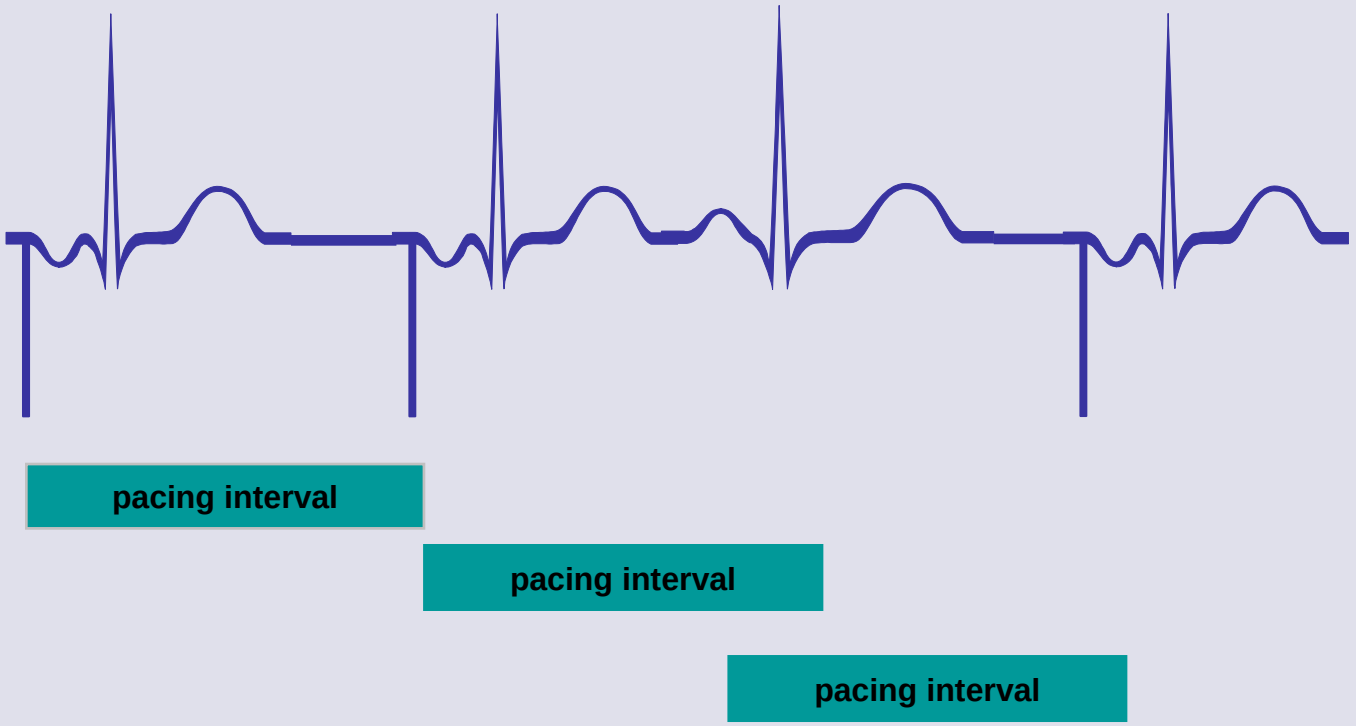
Ventricular Sensing / Inhibition

- **Sensed R-waves re-start the pacing interval**



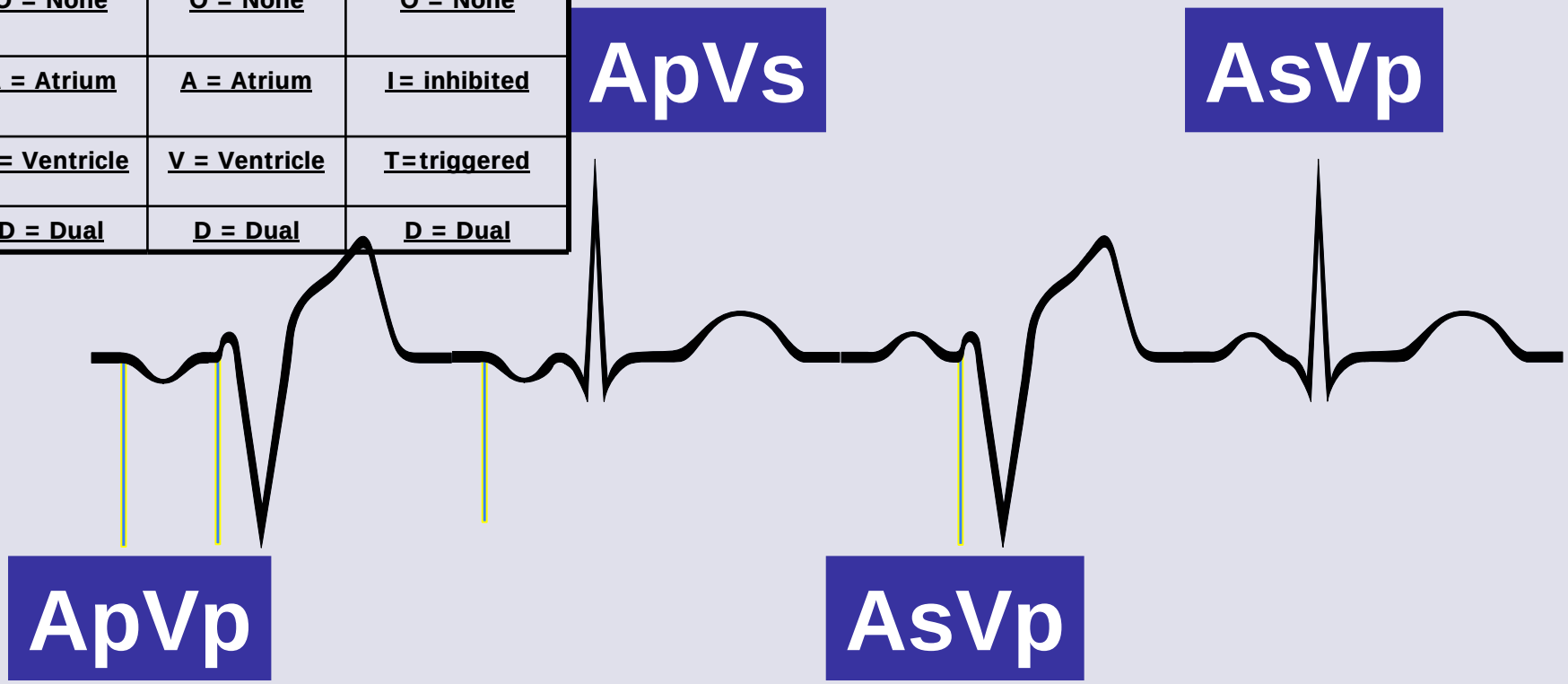
Atrial Sensing / Inhibition

- **Sensed P-waves re-start the pacing interval**



Four States Of Dual Chamber Pacing (DDD)

PACING CHAMBER	SENSING CHAMBER	PACING MODE response to "sensed event"
O = None	O = None	O = None
A = Atrium	A = Atrium	I= inhibited
V = Ventricle	V = Ventricle	T=triggered
D = Dual	D = Dual	D = Dual



Atrial event **HAVE TO** followed by ventricular event

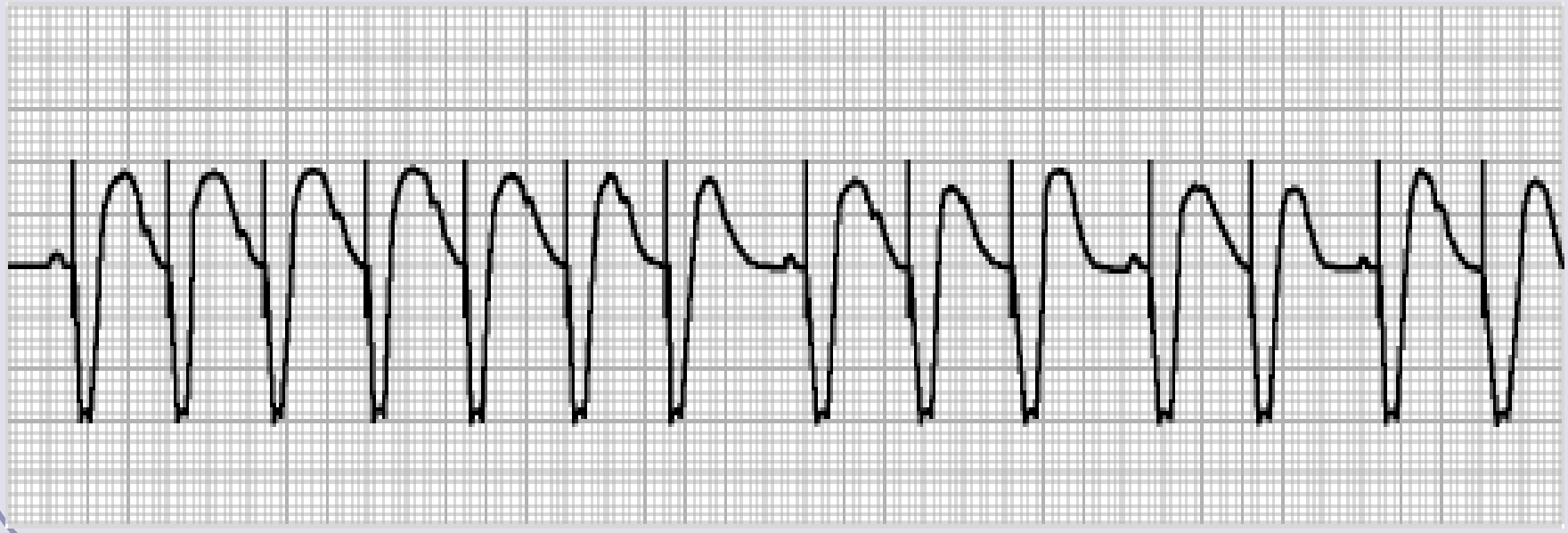
Maximum Tracking Rate (Upper Rate Limit)

- The fastest rate the Ventricular channel can track intrinsic P-waves
- Goal:

  Prevent of tracking inappropriate fast atrial rhythms (AT/ AFL)

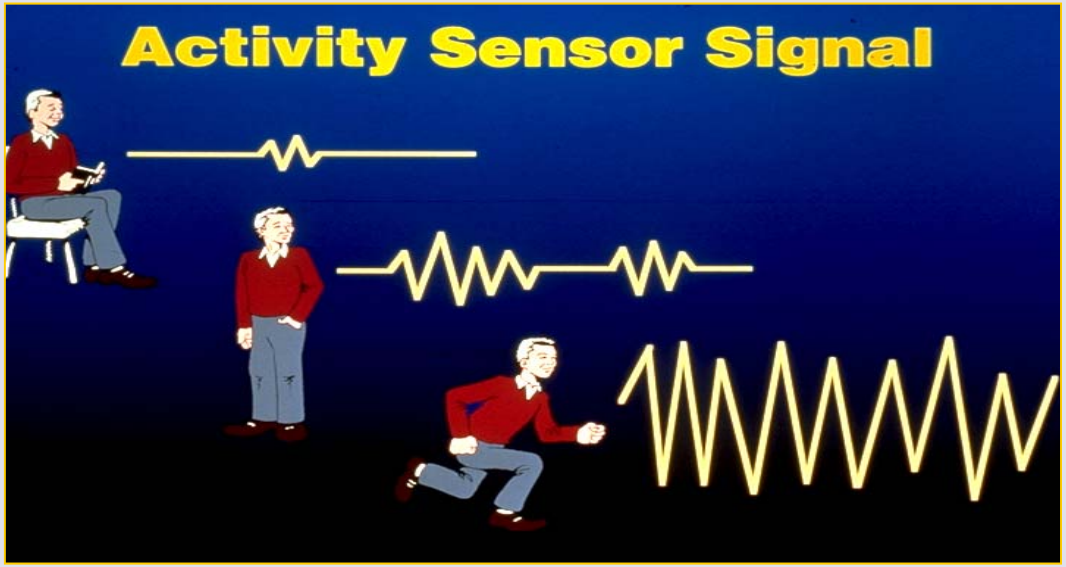
Upper Rate Behaviors

- **Fixed-Ratio block (2:1, 3:1, etc)**
- **Wenckebach behavior**

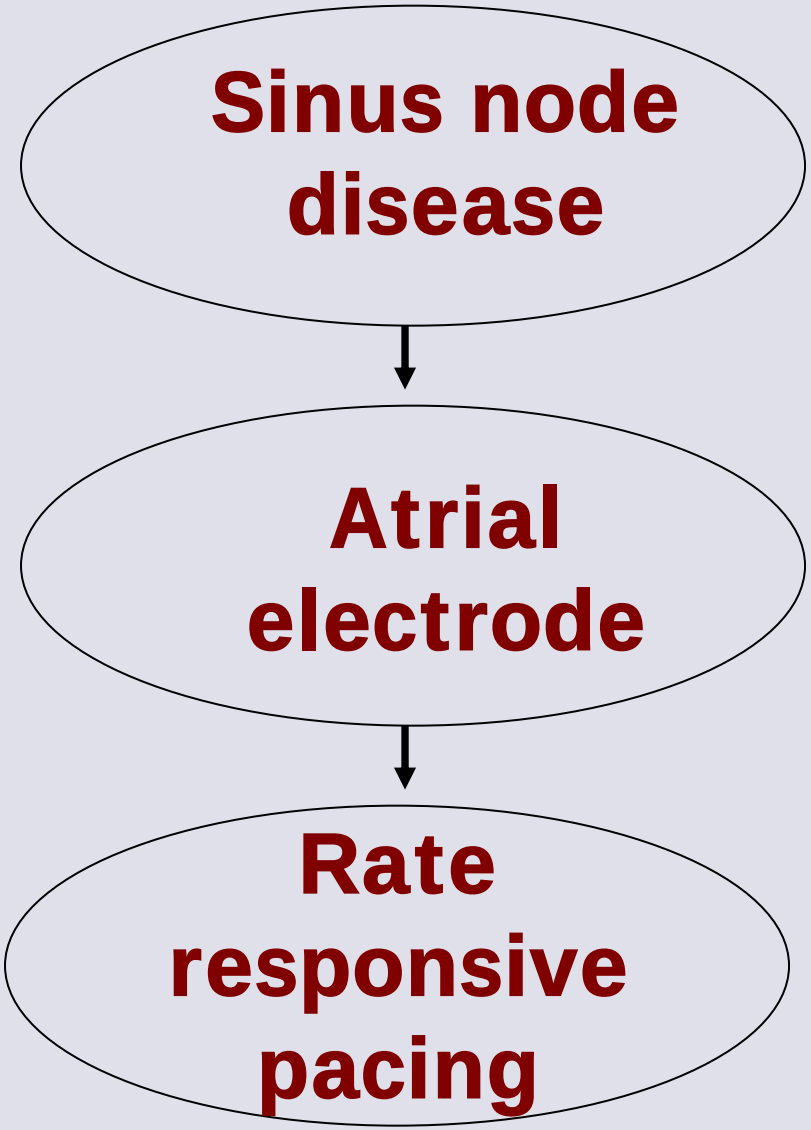


Rate Responsive Pacing (AAIR, VVIR, DDDR)

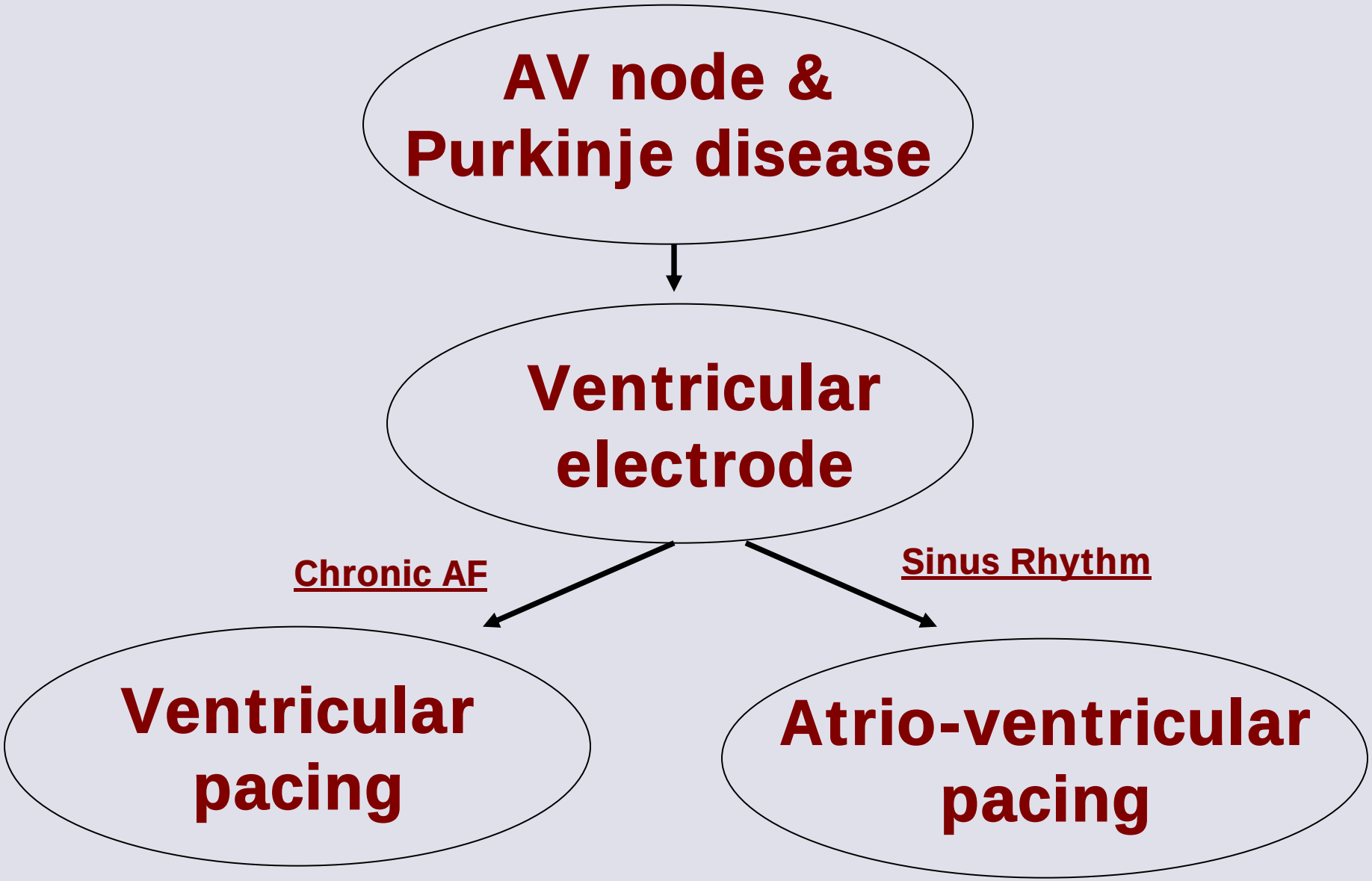
- The use of activity sensor to adjust the pacing rate (LRL) to patient's metabolic needs
- Indication: Chronothopic Incompetence



Mode Selection Decision Tree



Mode Selection Decision Tree



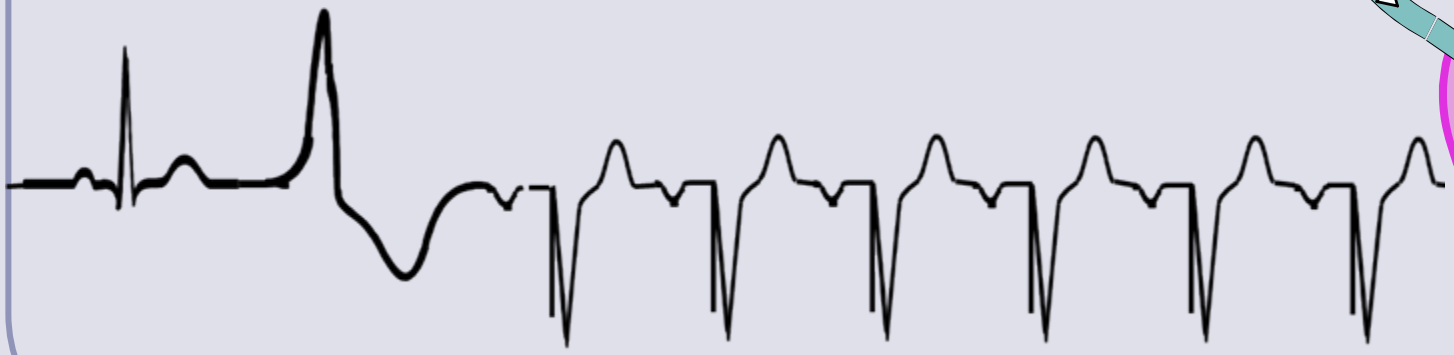
Pacemaker Mediated Tachycardia

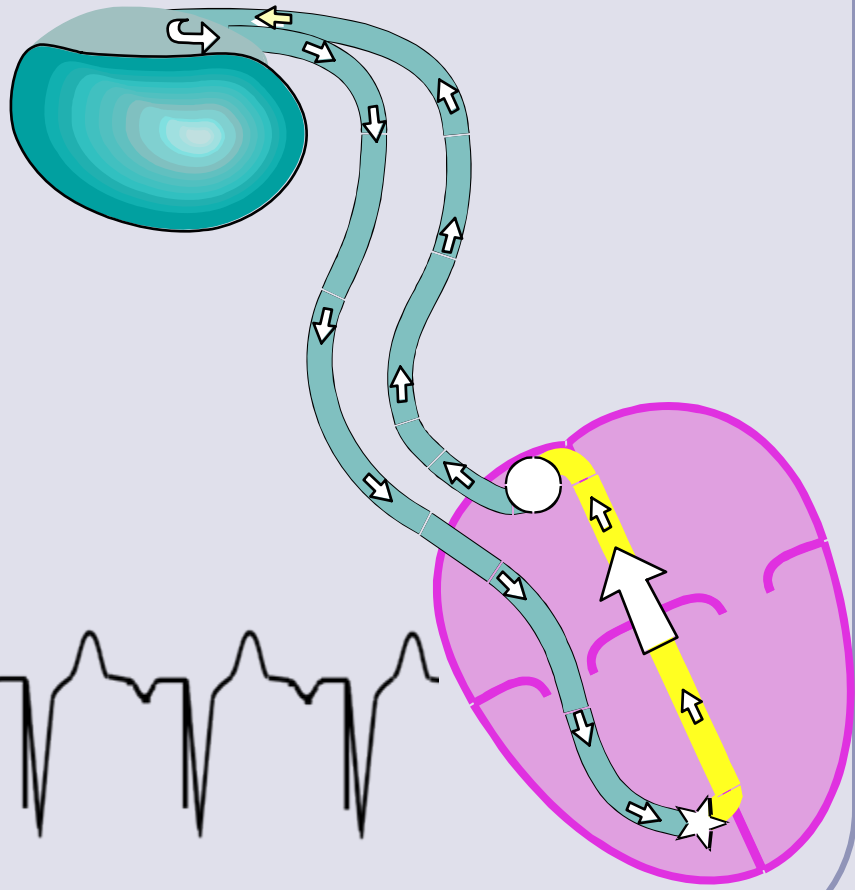
Tachycardia cycle time =

VA conduction time +

functional PV-Delay

(usually PMT rate close to URL)





Advanced pacing features

- Mode Switch (DDD to VVI; DDD to AAI)
- PMT termination
- Autocapture
- Rate Drop Response
- Left ventricular pacing

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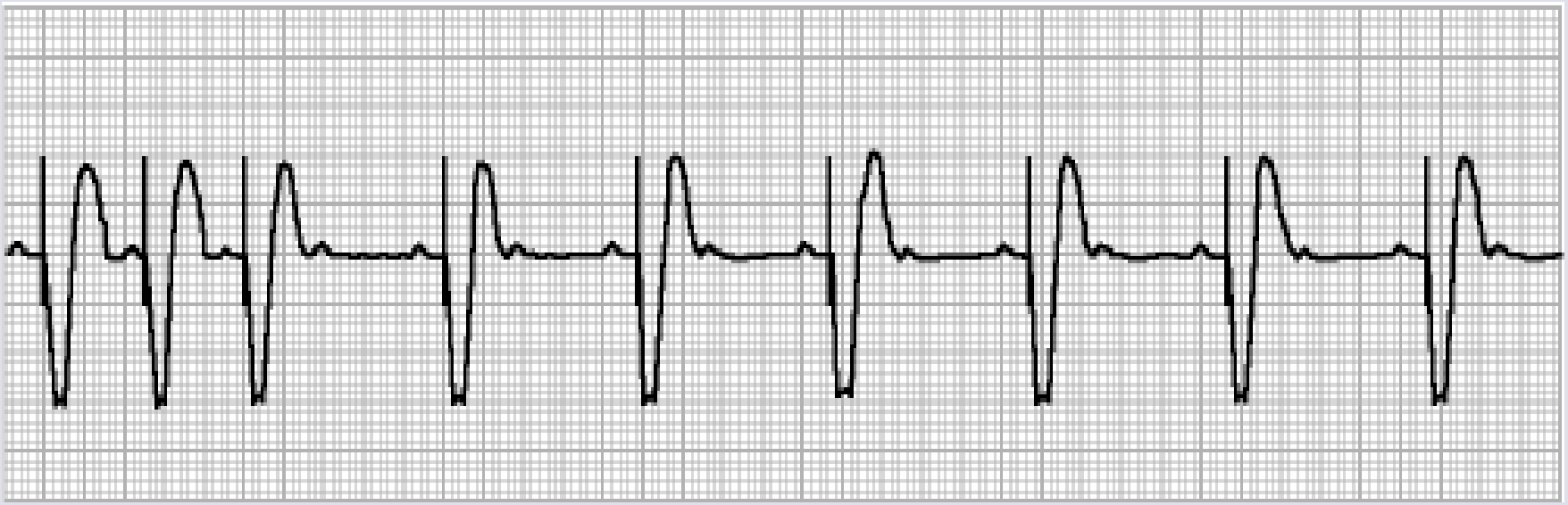

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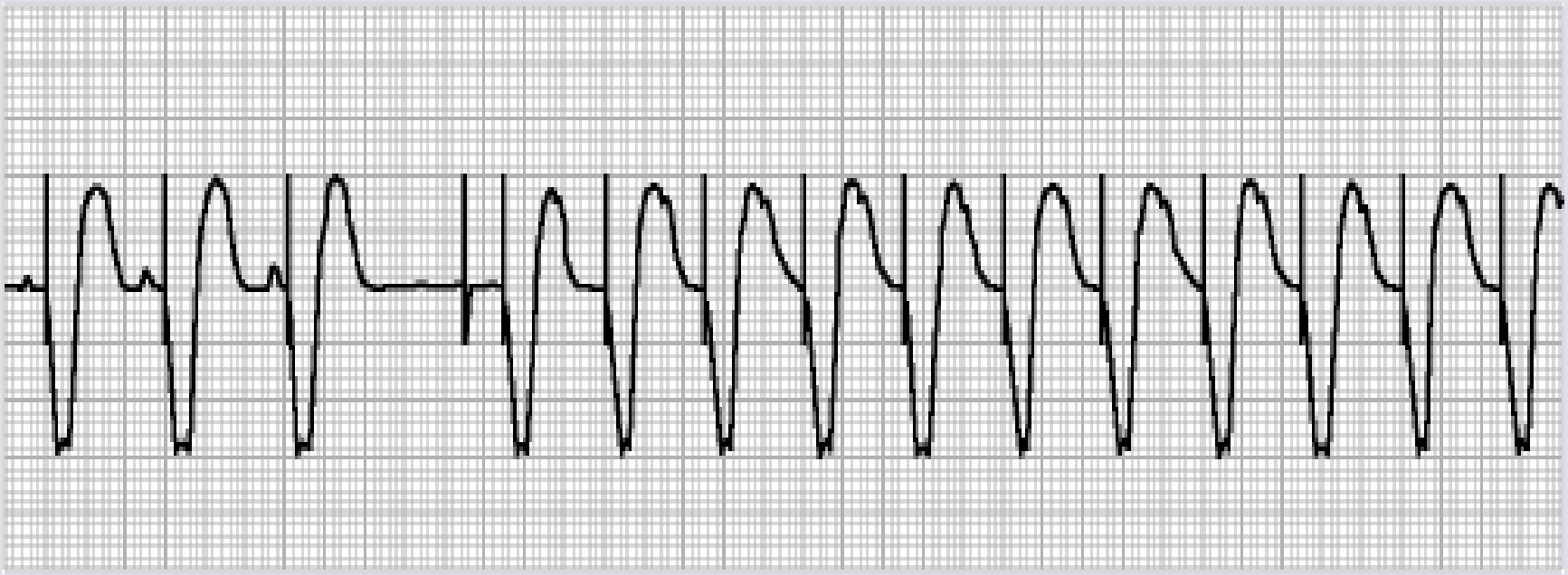
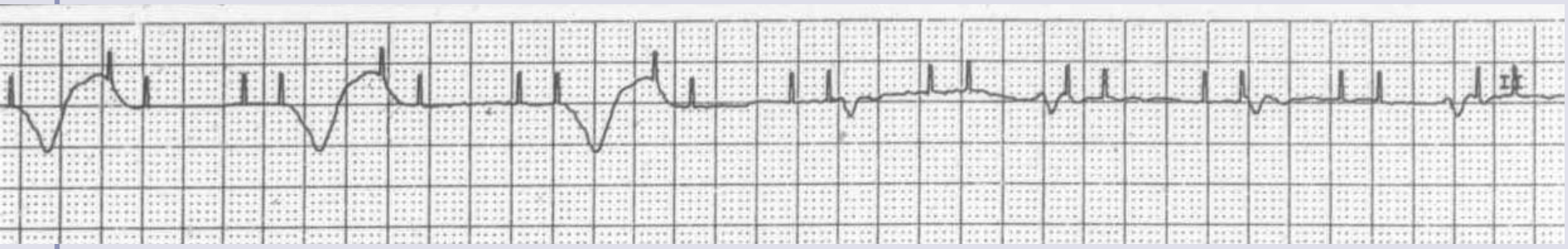


Paced Tachycardia - DD

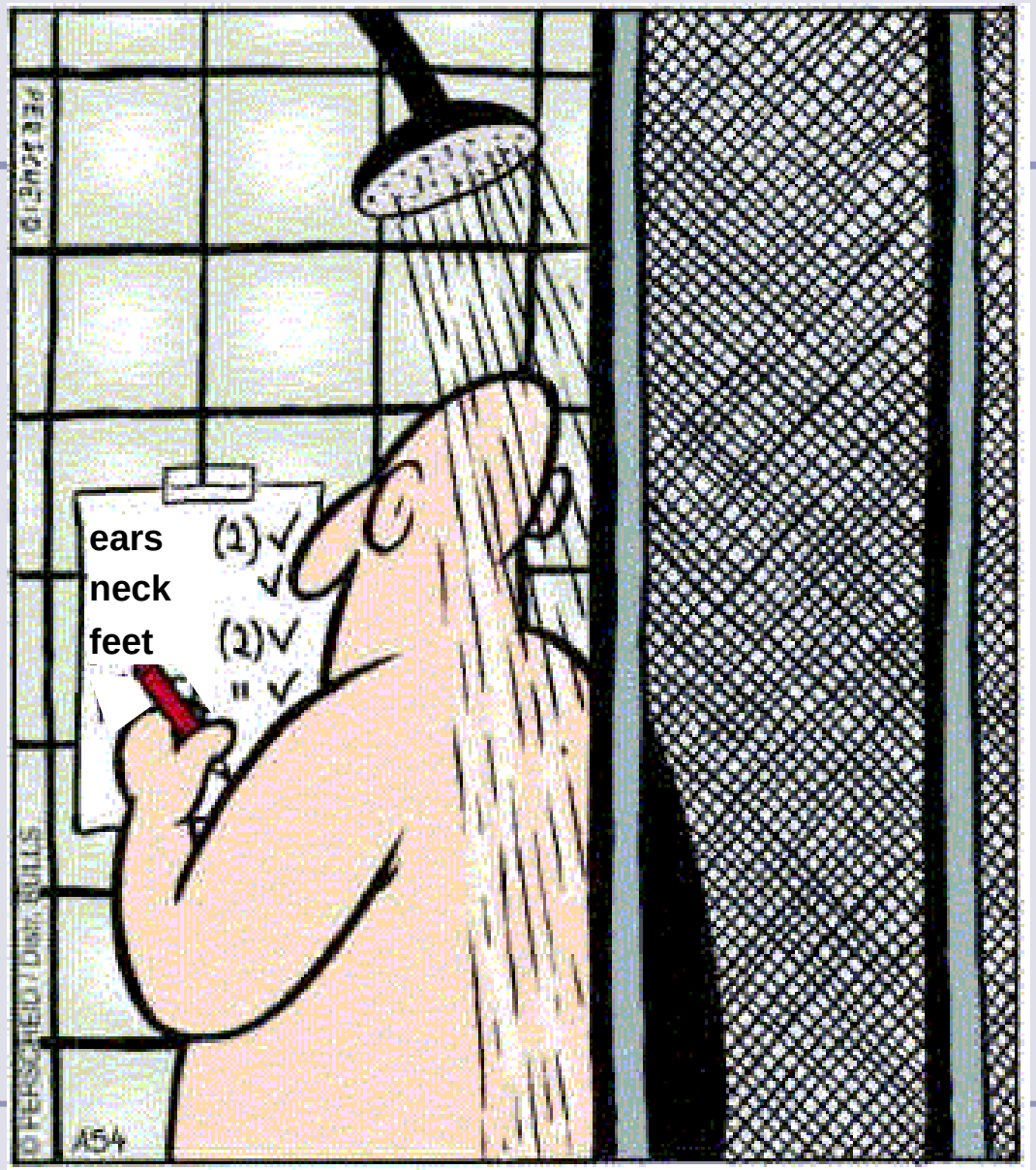
- PMT
- Tracking of atrial tachyarrhythmia
- Sensor mediated tachycardia
- Atrial lead oversensing
- Component failure/ runaway tachycardia

A patient with severe CHF and a new DDD pacemaker developed bradycardia



1. Ventricular noncapture , atrium OK
2. Crosstalk
3. A+V lead dislodgment
4. Hyperkalemia

Be methodical – and you'll succeed

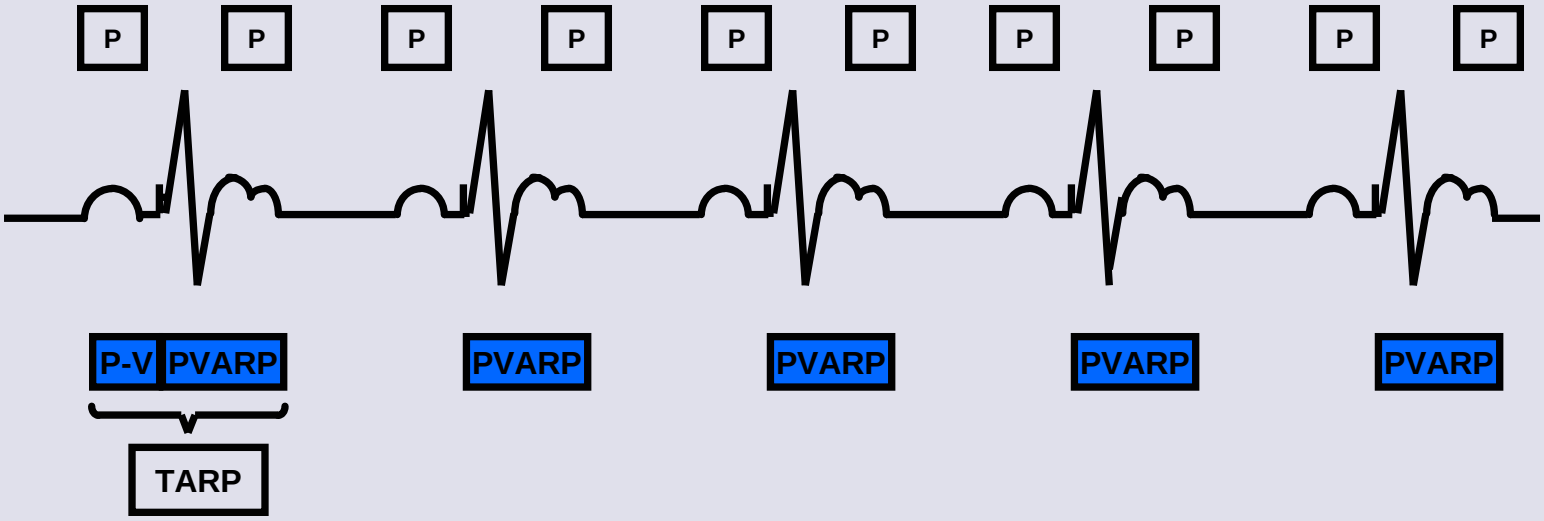


BACK UP SLIDES

Fixed-Ratio Block

- **2:1 Block**

(one v-paced event per two p-waves)

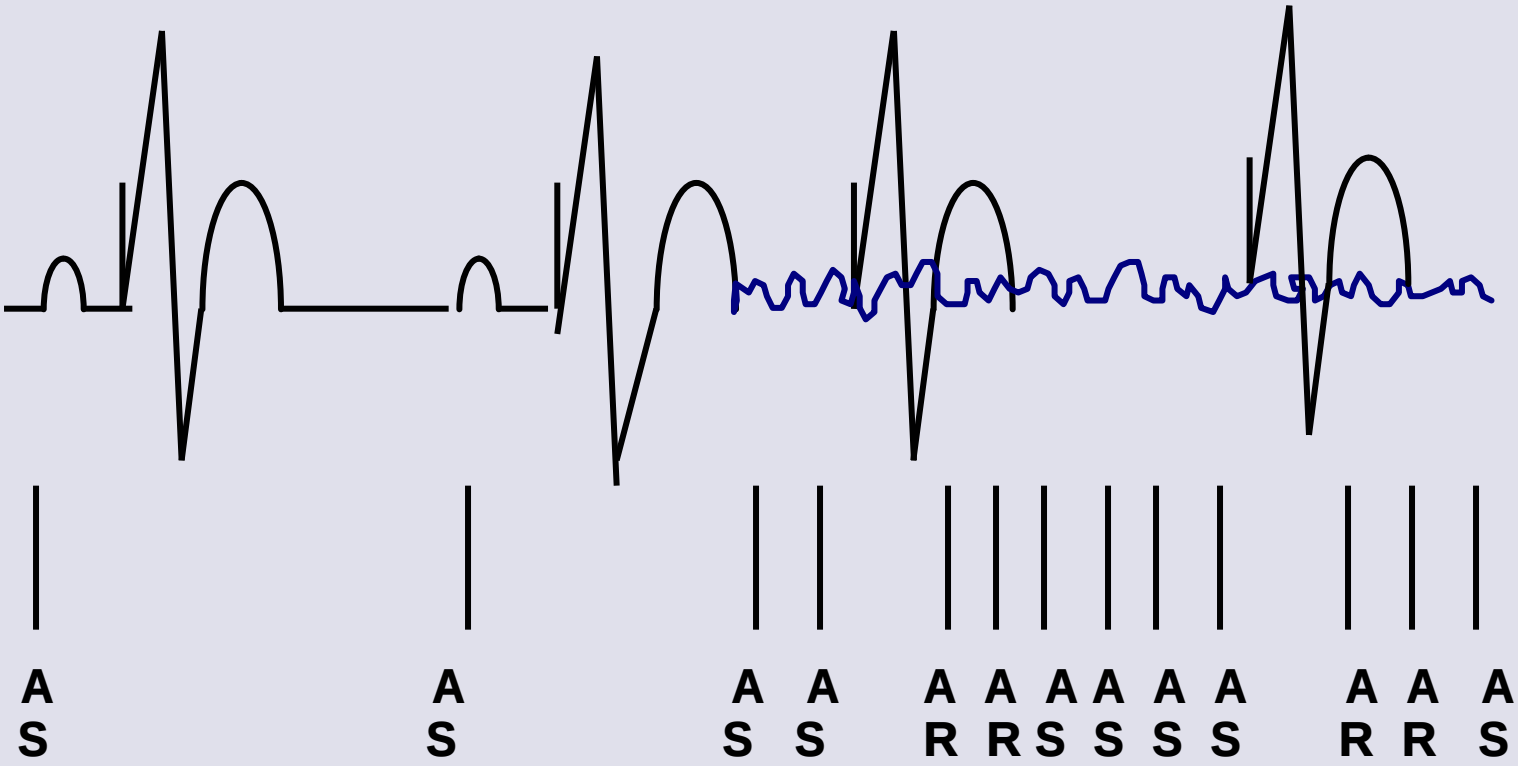


Post Ventricular Atrial Refractory Period (PVARP)

Atrial channel refractoriness after ventricular paced/sensed event

PVARP

Automatic Mode Switching
DDD to VVI



Automatic Mode Switching (AMS)

Reversion to tracking mode

Uses of PVARP

- Prevent the Atrial channel from sensing:
  - **Far-field Ventricular signals**
  - **Atrial Premature Contractions**
  - **Retrograde P-waves**

Pacemaker Mediated Tachycardia

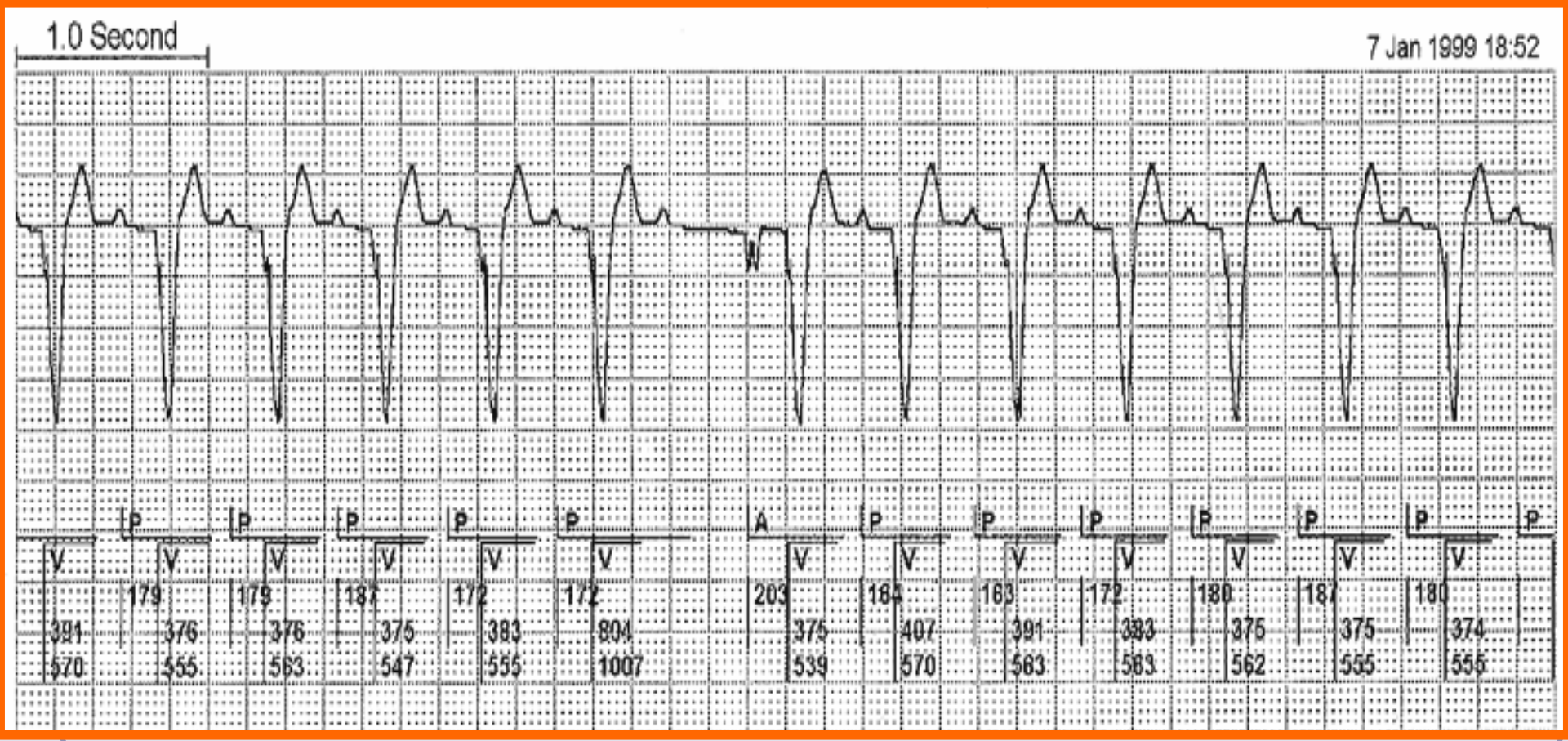
- **Initiated by a loss of AV synchrony**
  - **PVC most common cause**
  - **Atrial loss of capture and undersensing, APC, magnet removal**
- **Pacemaker acts like a re-entrant pathway**

Pacemaker Mediated Tachycardia

- **Prevention**
  - **Extend PVARP**

    (Program PVARP 50 ms longer than measured RVAC)
  - **Fix atrial lead function**
- **Therapy**
  - **Magnet application**
  - **PVC option or PMT option**

PMT Termination by pacemaker



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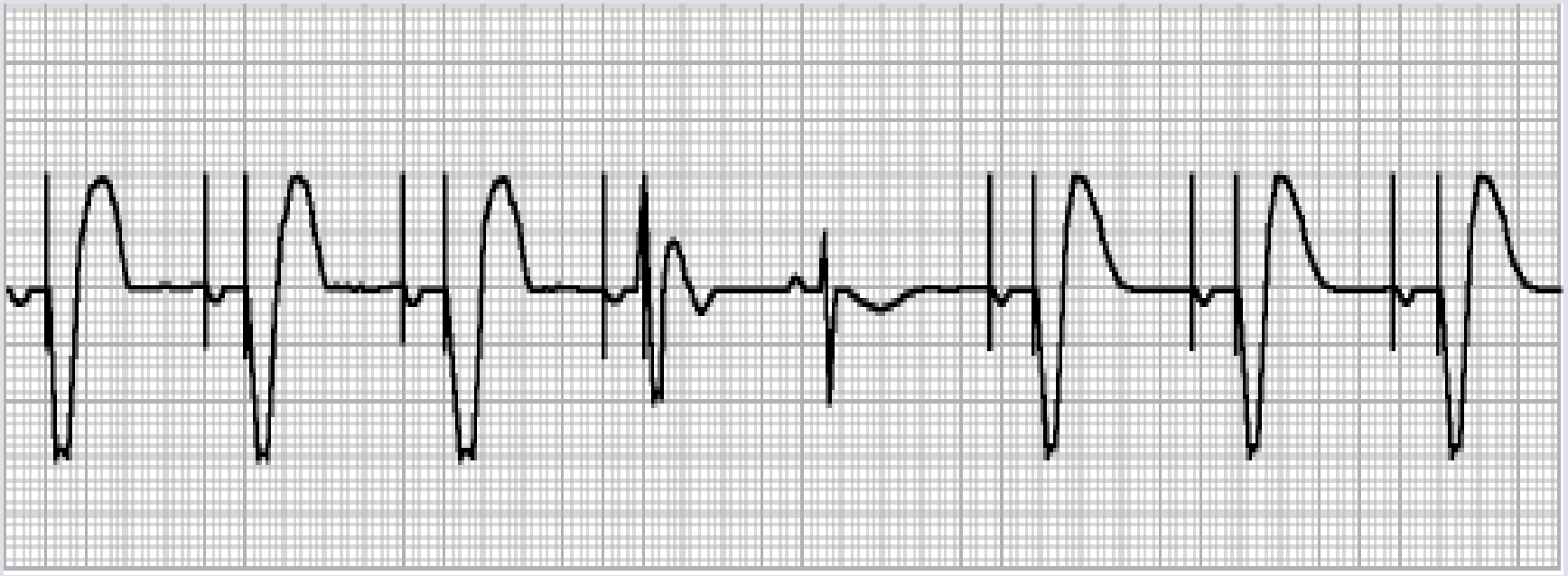

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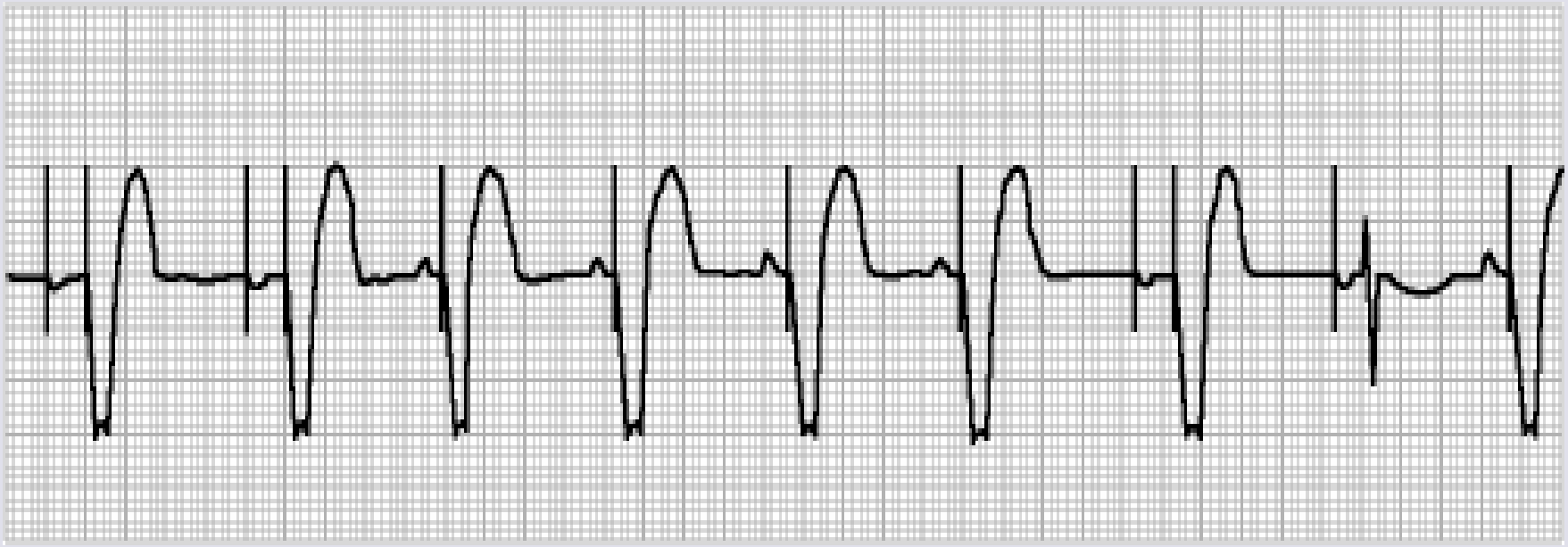

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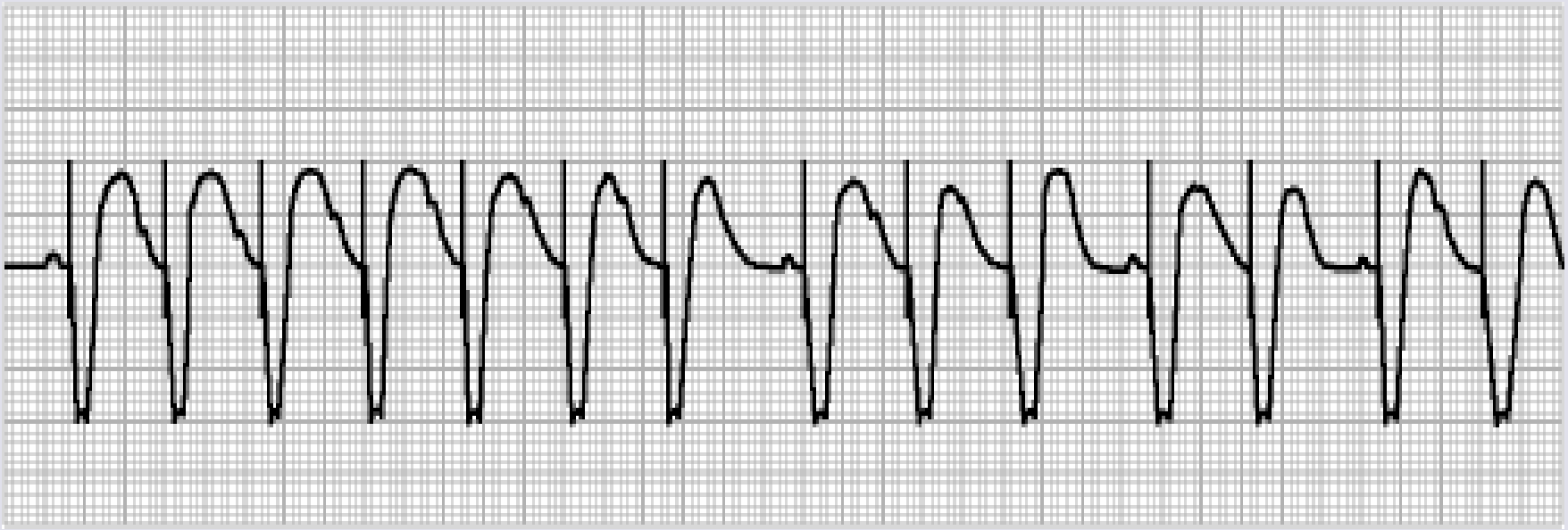

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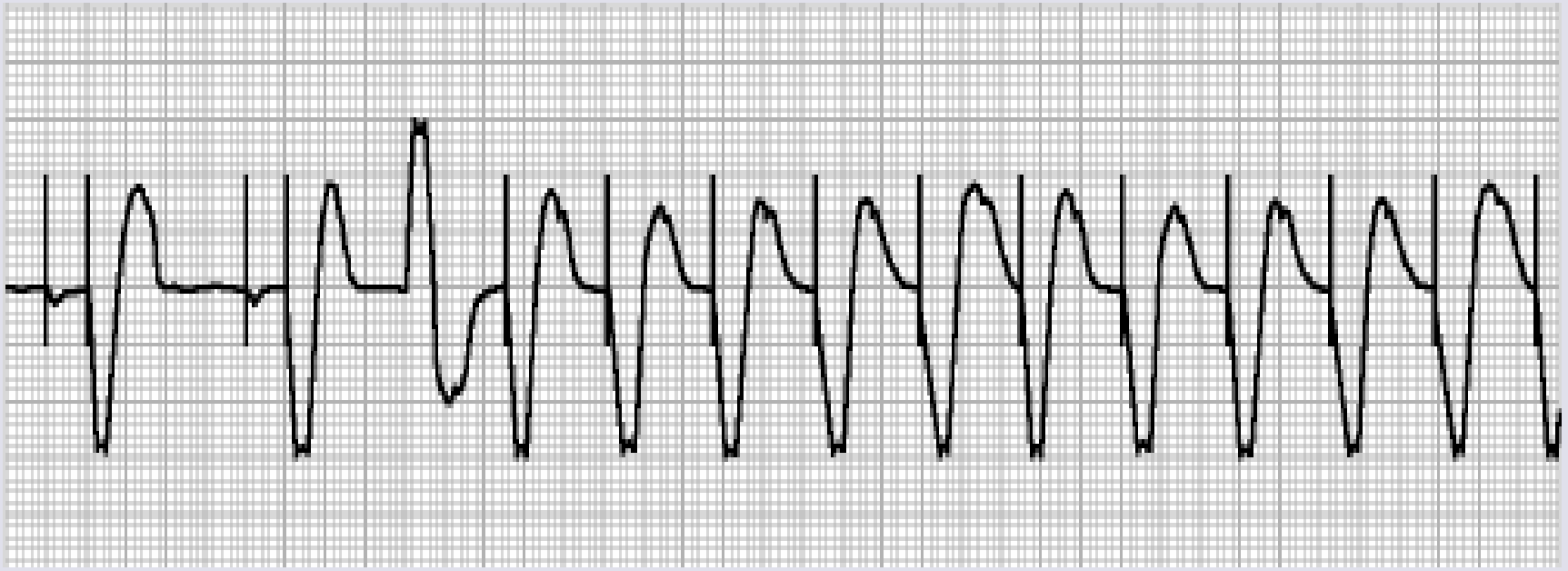

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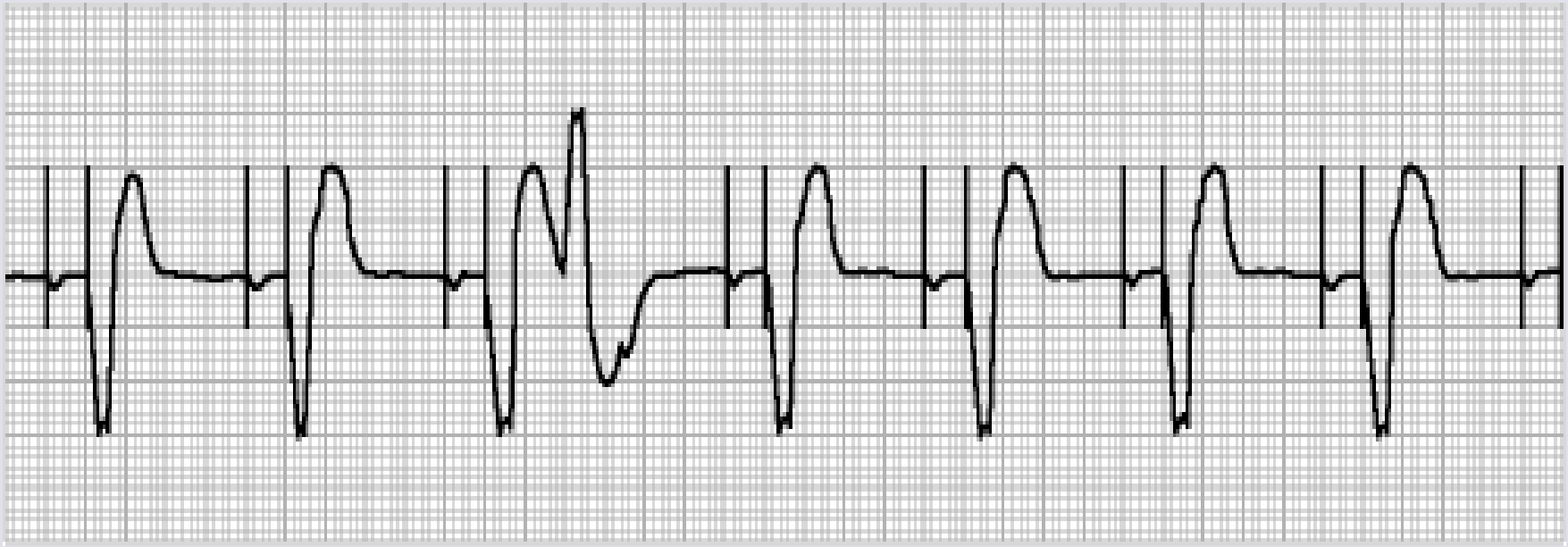

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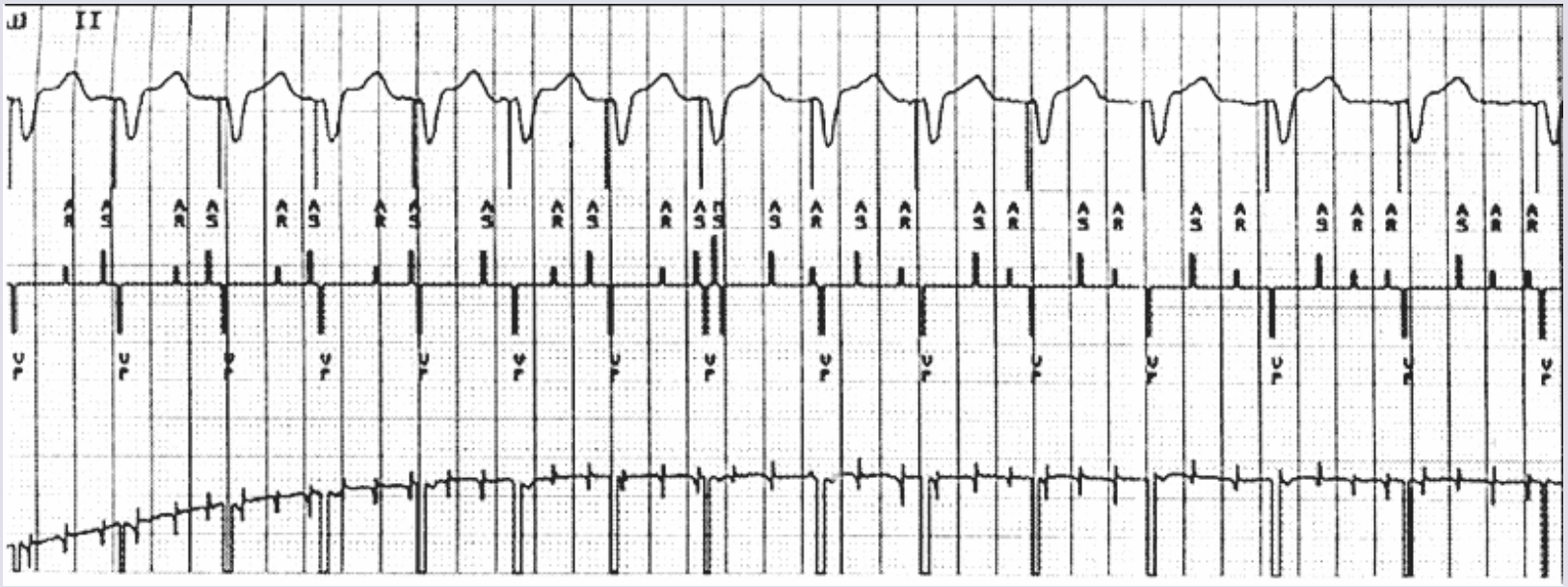
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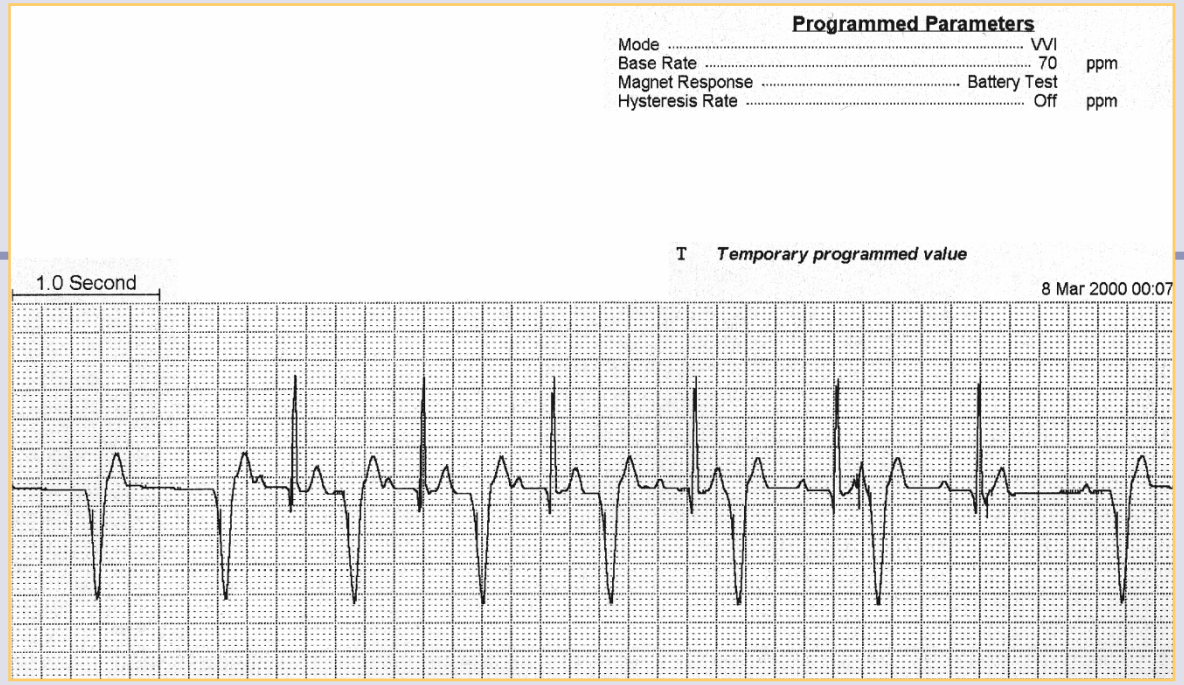
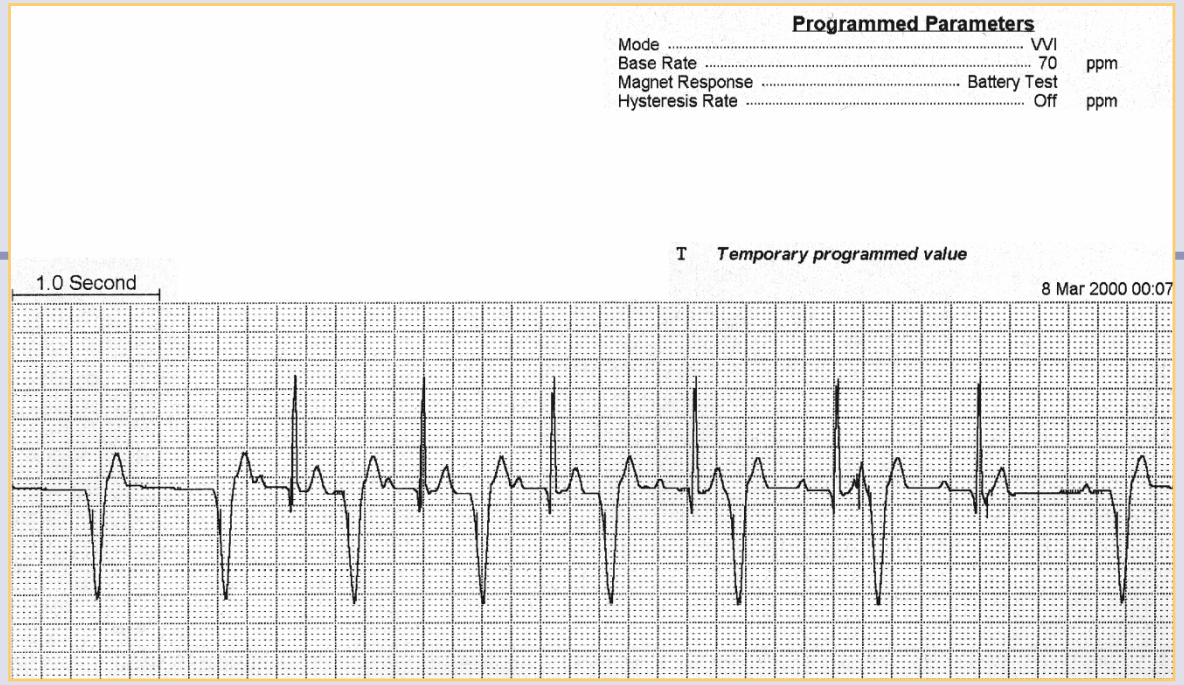


1. Ventricular noncapture
2. Normal pacemaker function
3. Ventricular undersensing
4. Multiple VPCS

DDD mode
60 ppmBase Rate
120 ppm MTR
150 ms AVD
350 ms PVARP

1. Atrial undersensing
2. Normal upper rate response then 2:1 tracking
3. Tracking of short atrial tachycardia
4. PMT



1. Ventricular noncapture
2. Normal pacemaker function
3. Ventricular undersensing
4. Multiple VPCS

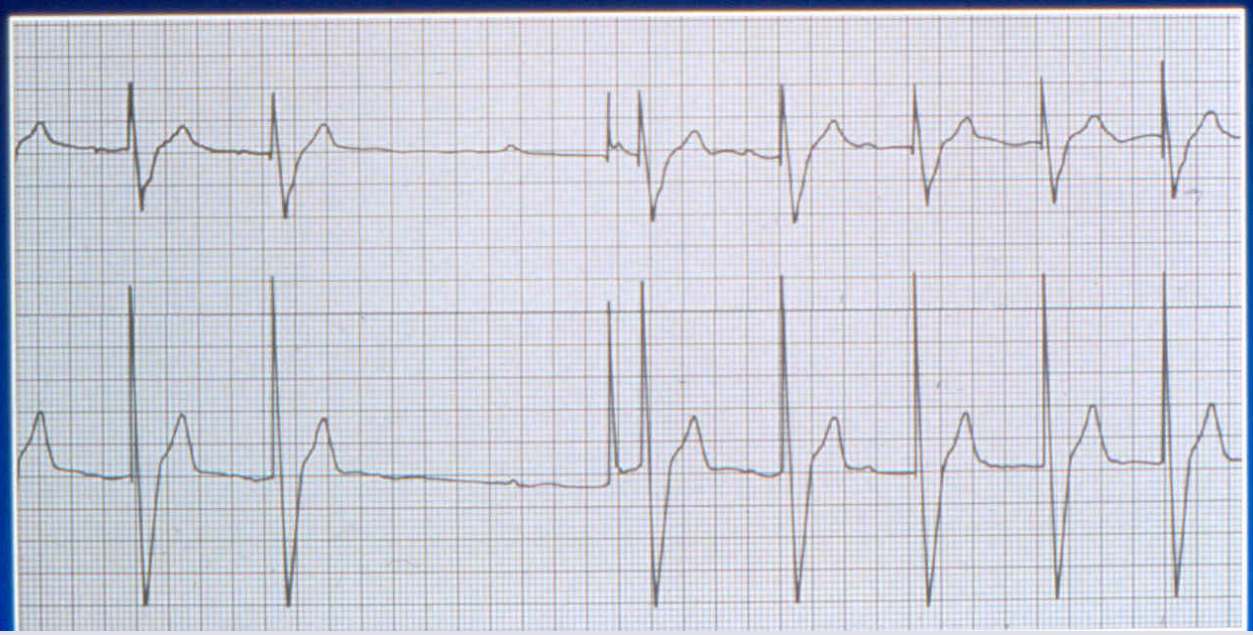
CASE STUDY

A DDD pacemaker was implanted in a 60-year-old male due to intermittent CHB. About four months later he returned complaining of palpitations interspersed with abrupt, short durations of fast heart rate associated with lightheadedness and shortness of breath. He also mentioned that he didn't think the pacer was consistently increasing his pacing rate during exercise. As a result he felt more fatigued. The following ECG was recorded. What is your diagnosis?

1. Atrial undersensing
2. Ventricular noncapture
3. Atrial fibrillation
4. PMT

CASE STUDY 13

The tracing shown below is the Holter monitor of a 56-year-old plumber with complete AV block. He complained to his physician that sometimes when he was working he would feel lightheaded and faint.



Myopotential inhibition

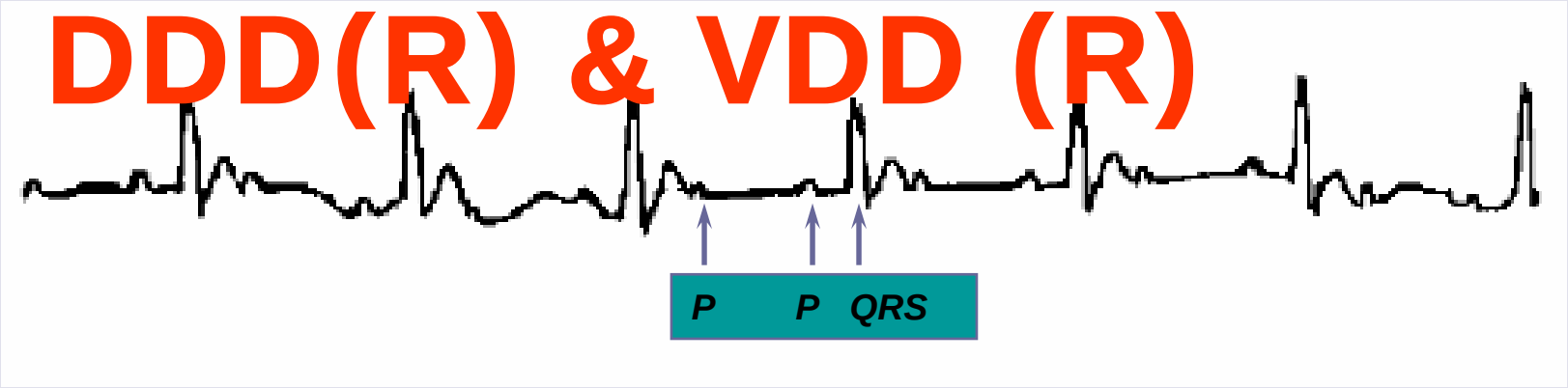
Determining the Optimal Pacing Mode -1

- Patient information:
  - Pt has chronic atrial fibrillation with an irregular ventricular rate
  - Pt's heart rate does not reach 100 bpm in response to an exercise stress test

Determining the Optimal Pacing Mode 1

- Patient information:
  - Documented symptomatic sinus bradycardia
  - When exercise tested, rate does not increase appropriately with increasing work loads
  - At present, AV conduction is intact

Determining the Optimal Pacing Mode - 2



- Patient information:
  - Pt has intermittent 2nd degree Type II AV block with symptoms
  - Pt's atrial rate responded appropriately (or not) to an exercise test