Approach to Telemetry

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HEALTH SCIENCES CENTRE

Telemetry

- Electrocardiographic monitoring (telemetry) allows for monitoring of life-threatening tachy or bradyarrhythmias for high risk cardiac patients.
- Improvement in technologies allow
  - automatically alert for abnormal ectopies
  - Automatic alerts for tachy or bradyarrhythmias/pauses
- Despite advancements, there still lies importance of skilled healthcare professionals to interpret these findings

Telemetry

- Monitor
  - Arrhythmia
  - Ectopic beats
  - ST segments
  - QT interval

Telemetry Indications

- Class I (Cardiac monitoring is indicated in most, if not all, patients in this group.)
  - Patients at risk of immediate, life-threatening arrhythmia
    - Survivors of Cardiac arrest
    - Acute coronary syndrome
    - Unstable angina
    - High risk coronary lesions
    - Post cardiac surgery
    - PCI with complications
    - Post PPM/ICD who is pacer-dependent
    - Patients with temporary pacemaker
    - AV block (Mobitz II, 3rd degree)
    - WPW and arrhythmia
    - Long QT syndrome/other channelopathies
    - Acute CHF

Circulation 2004

- Class II (Cardiac monitoring may be of benefit in some patients but is not considered essential for all patients.)
  - Post acute MI
  - Chest pain syndromes
  - Uncomplicated elective PCI
  - Antiarrhythmic drug therapy
  - Post PM implant in patient not dependent
  - Uncomplicated ablation for arrhythmia
  - Post coronary angiography
  - Subacute heart failure

- Class III (Cardiac monitoring is not indicated because a patient's risk of a serious event is so low that monitoring has no therapeutic benefit.)
  - Post-surgical in low-risk population
  - Stable controlled premature beats
  - Obstetric patients, unless with heart disease
  - Permanent, rate-controlled atrial fibrillation
  - Hemodialysis

3 Electrode Bipolar Lead System

- Positions: (Standard)
  - Positive electrode in V1 location
  - Negative electrode in left infraclavicular fossa
  - Reference electrode in V6 position

- Potential Leads recorded:
  - I, II, III, Modified chest lead (MCL)

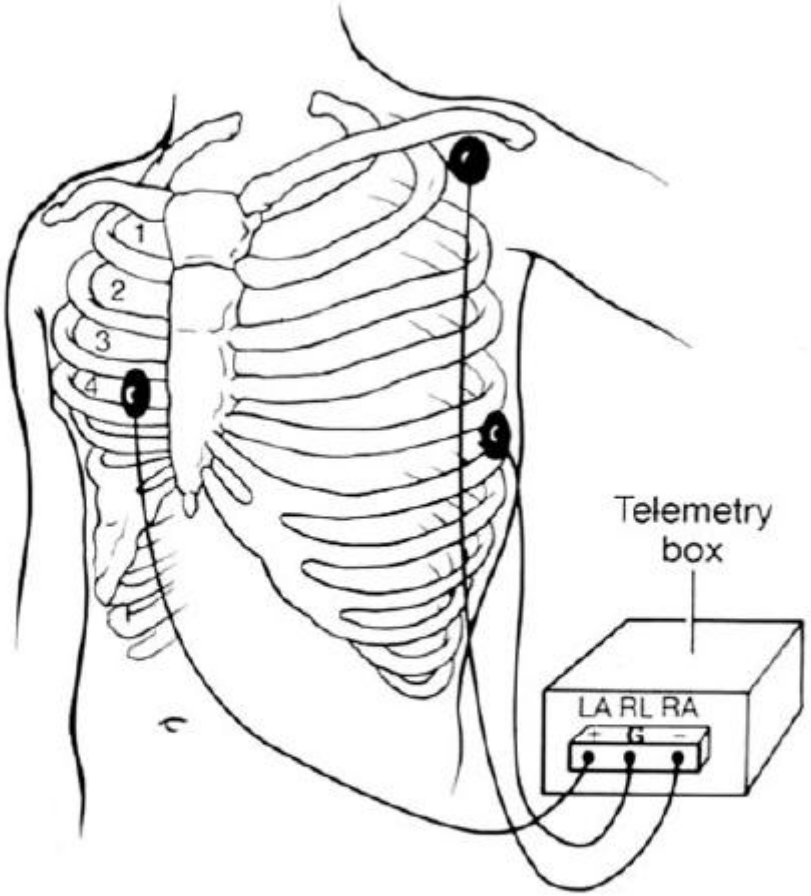


Figure 3. Simple 3-electrode bipolar lead system showing electrode placement for recording single MCL-1 lead. Positive electrode placed in V_1 location and negative electrode placed in left infraclavicular fossa. Reference (ground) electrode shown here in V_6 location; however, it can be placed in any convenient position.

3 Lead Systems

- Monitor heart rate
- Used for Synchronization during Cardioversions
- Useful to track simple arrhythmias
- Less accurate for complex arrhythmias
- MCL (bipolar substitute for V1) can differ >40% QRS morphology compared to standard V1. Therefore, not recommended to diagnose wide complex tachycardias.

5 lead electrode system

- LA, RA, LL, and RL positions
- Any of the 6 limb leads can be obtained (leads I, II, III,aVR, aVL, or aVF
- A fifth chest electrode placed on any of the standard V1 to V6 locations. (True unipolar)
- V1 is usually selected because of its value in arrhythmia monitoring.

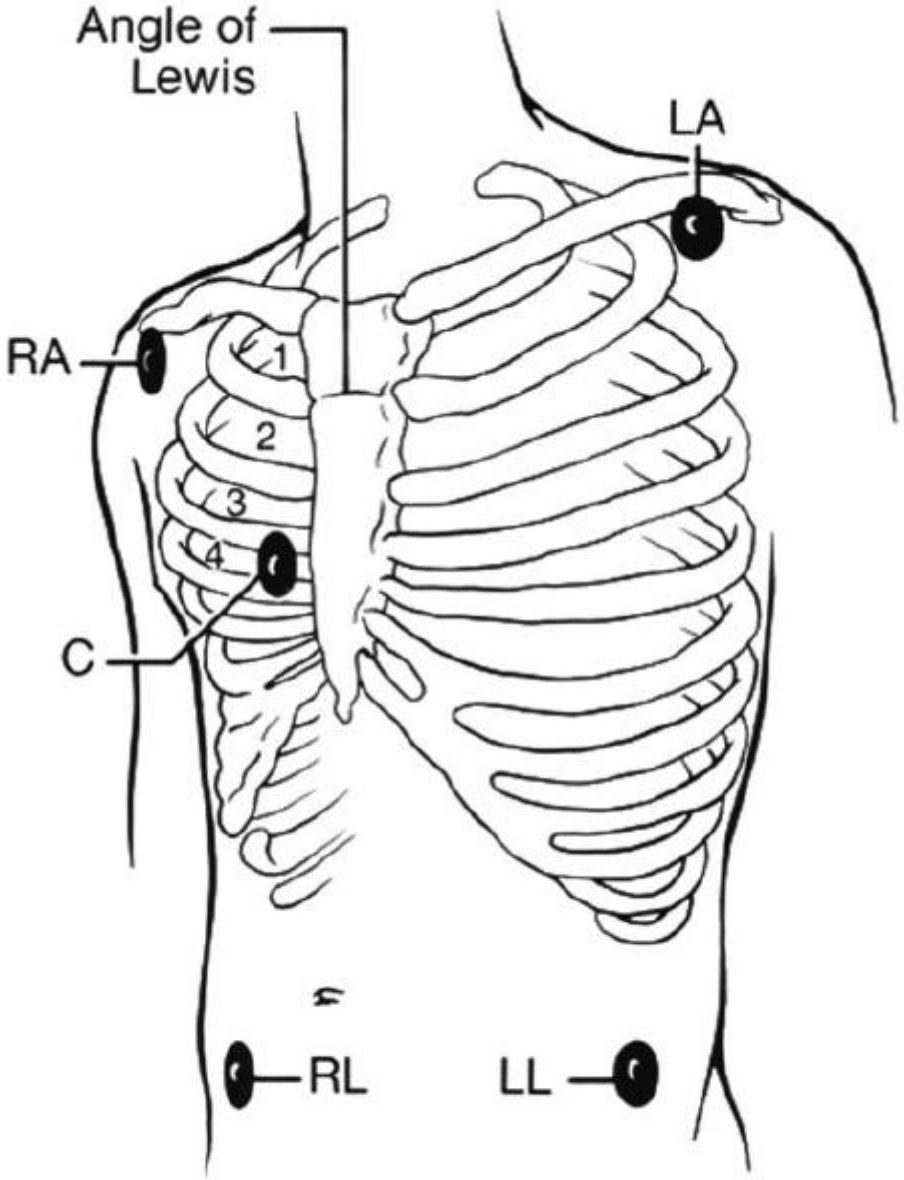
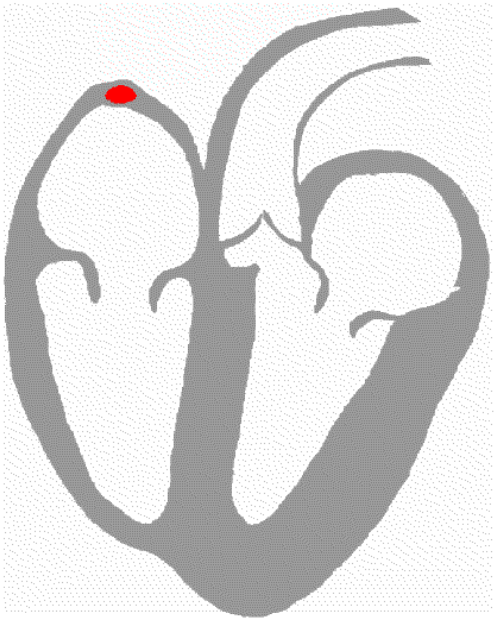
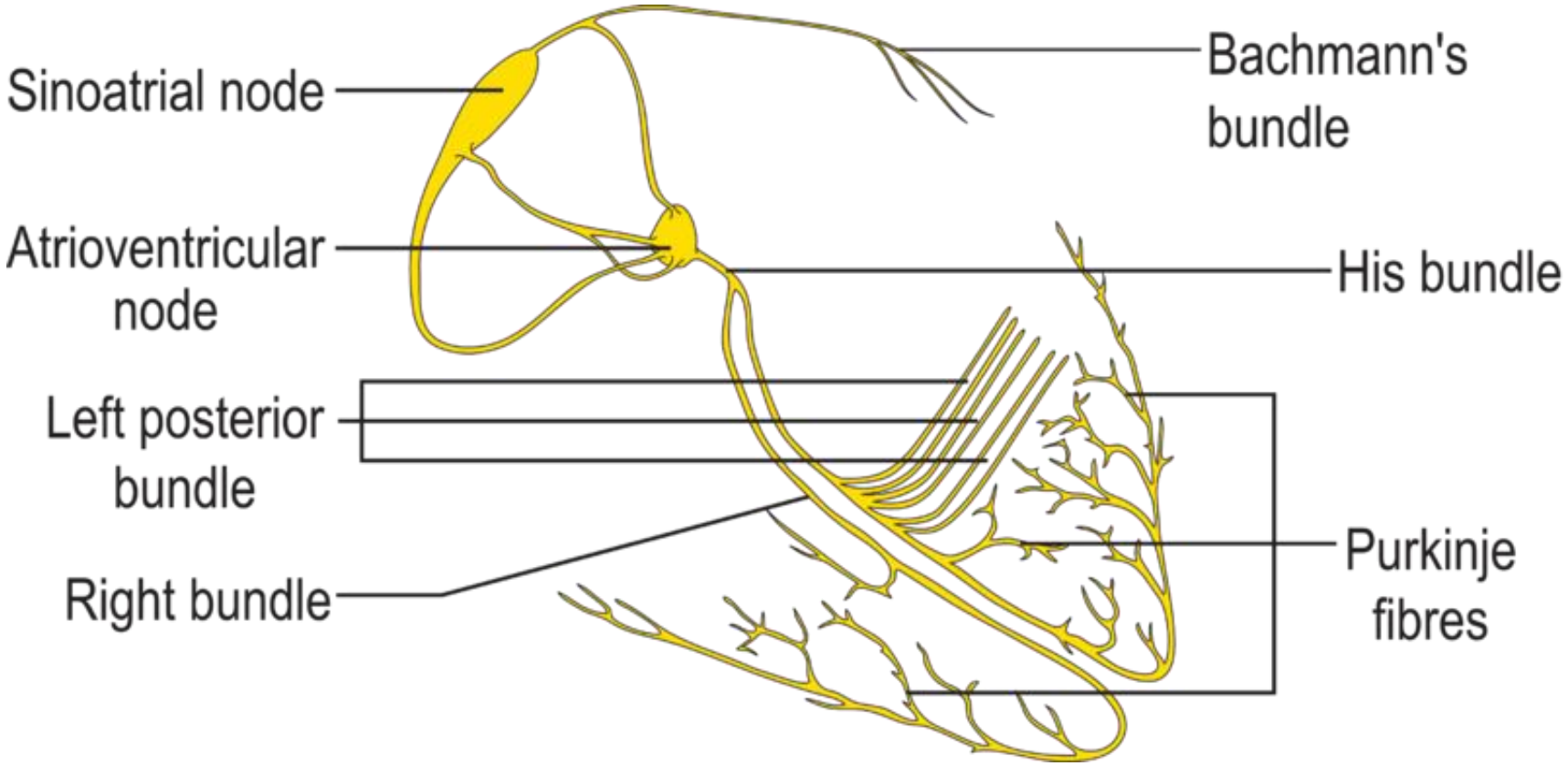
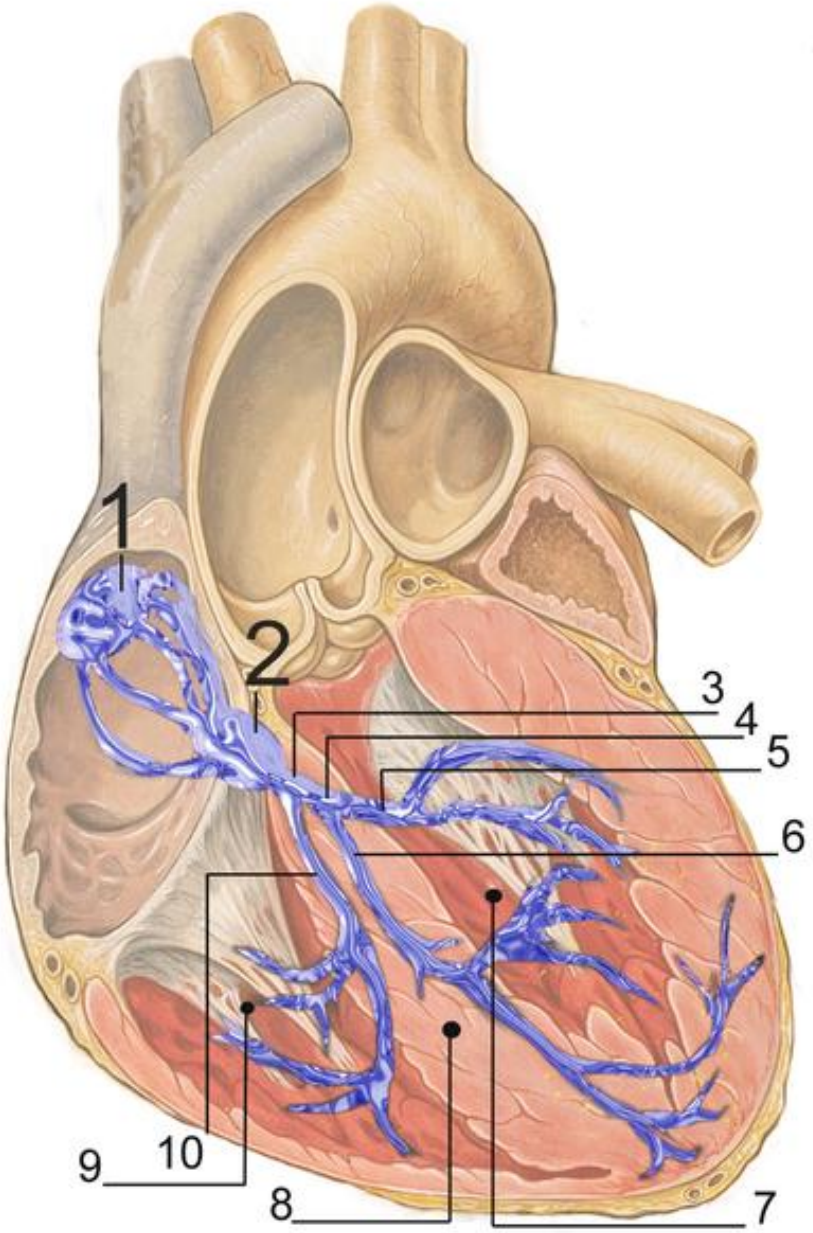
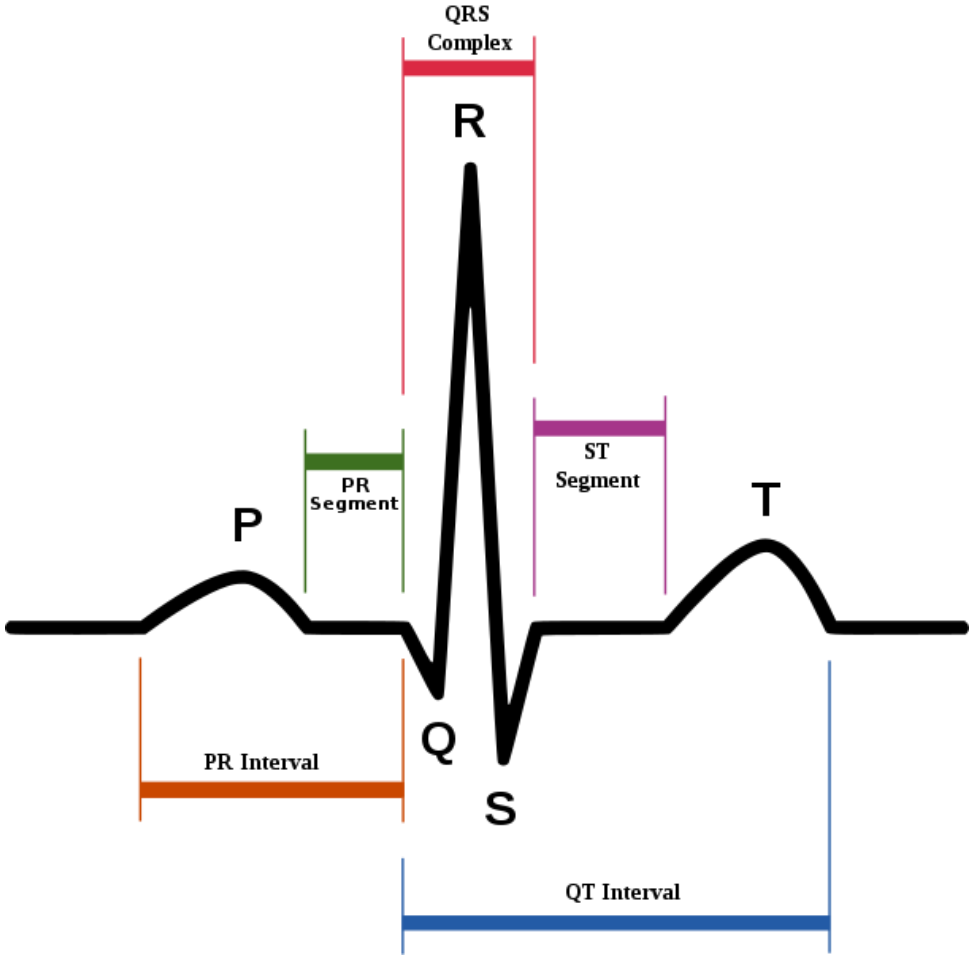


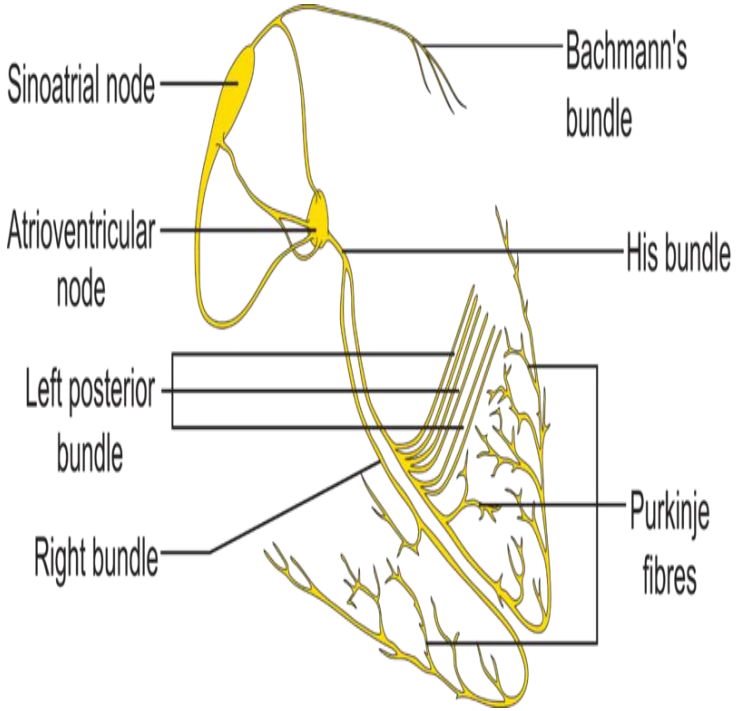
Figure 4. Commonly used 5-electrode lead system that allows for recording any of the 6 limb leads plus 1 precordial (V) lead. Shown here is lead placement for recording V_1. A limitation of this system is that only 1 precordial lead can be recorded.




Sinoatrial node
Atrioventricular node
Left posterior bundle
Right bundle
Bachmann's bundle
His bundle
Purkinje fibres

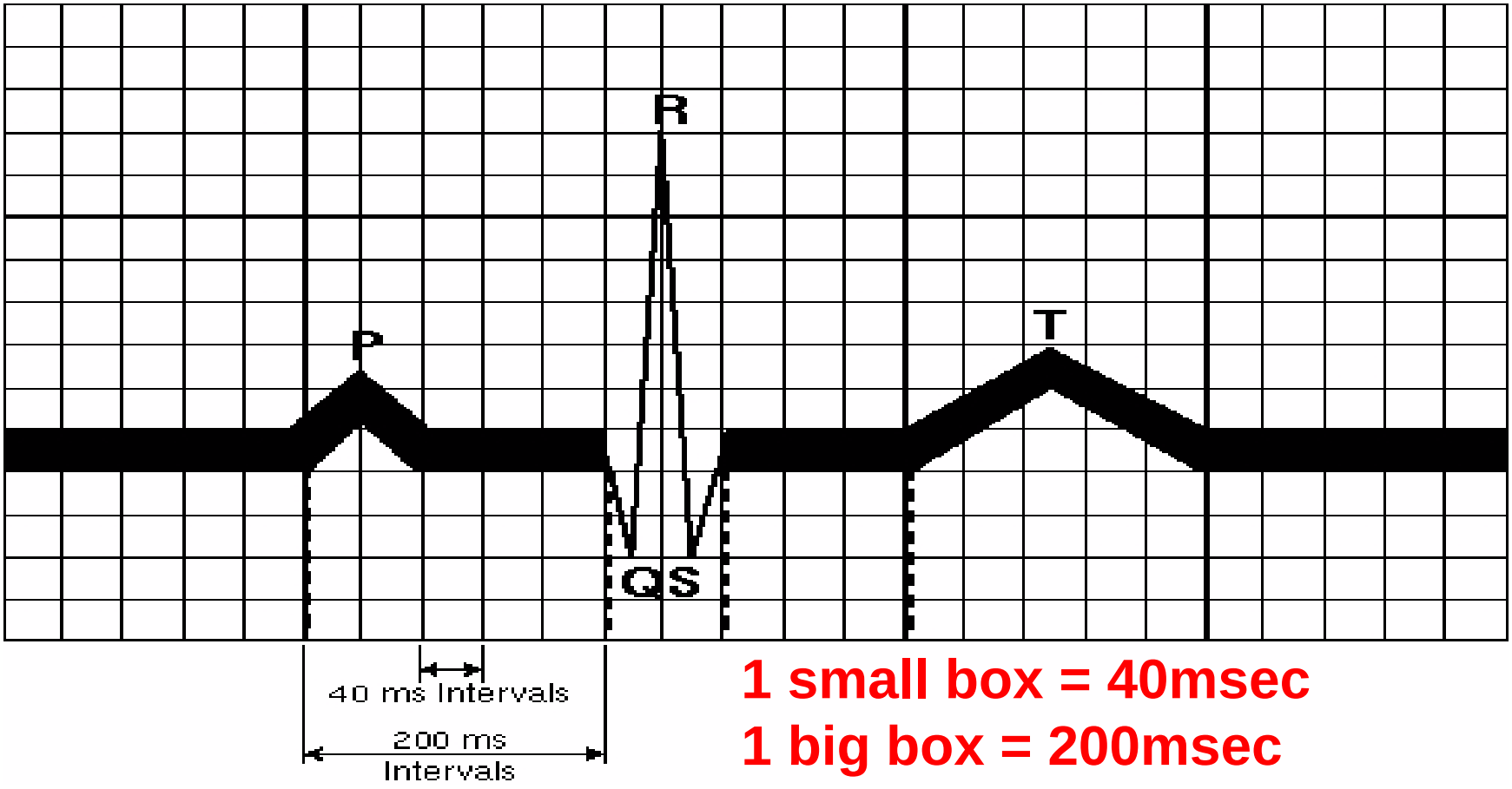

1
2
3
4
5
6
9
10
8
7


QRS
Complex
R
PR
Segment
ST
Segment
P
T
Q
S
PR Interval
QT Interval


Sinoatrial node
Bachmann's
bundle
Atrioventricular
node
His bundle
Left posterior
bundle
Purkinje
fibres
Right bundle

Intervals Are Often Expressed in Milliseconds

- One millisecond = 1 / 1,000 of a second



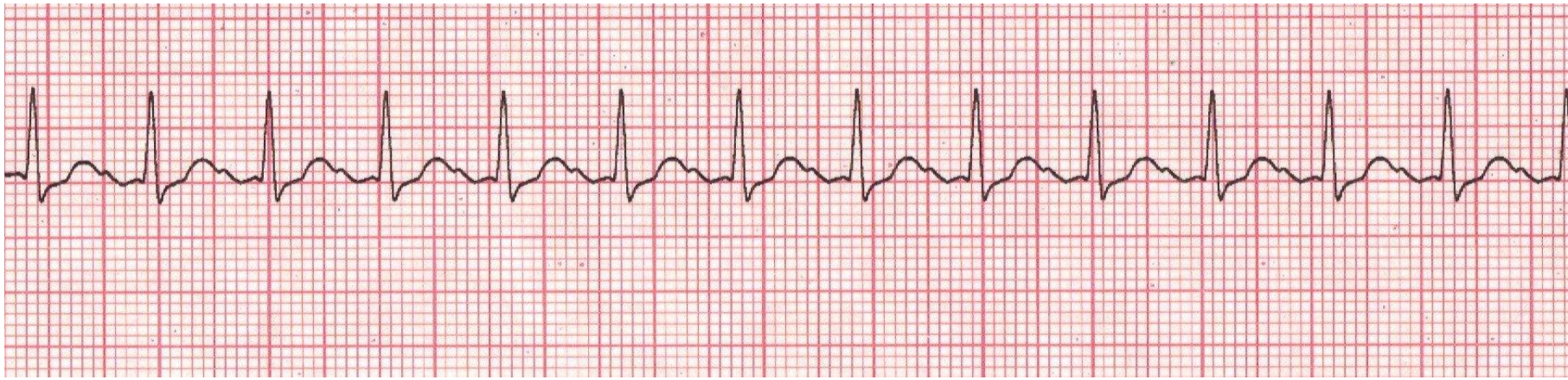
1 small box = 40msec
1 big box = 200msec
Five big boxes = 1 second

- 1 small box = 40 msec
- 1 big box (5 small boxes) = 200 msec
- 5 big boxes = 1 second

How to calculate Heart Rate

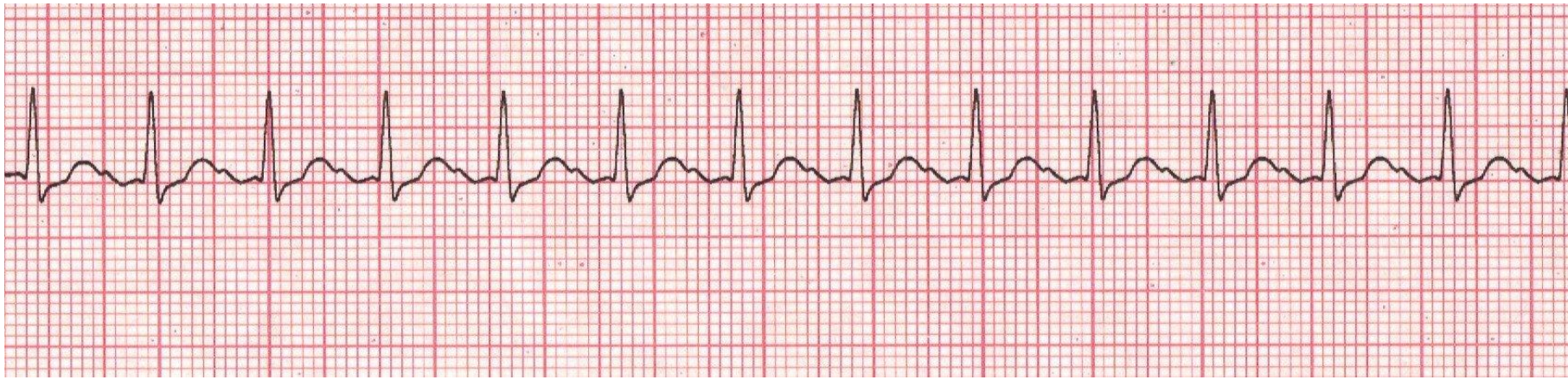
- Count number of big boxes between each QRS
  - 1 box = 300bpm
  - 2 boxes = 150bpm
  - 3 boxes = 100 bpm
  - 4 boxes = 75 bpm
  - 5 boxes = 60bpm

What is the Heart Rate?

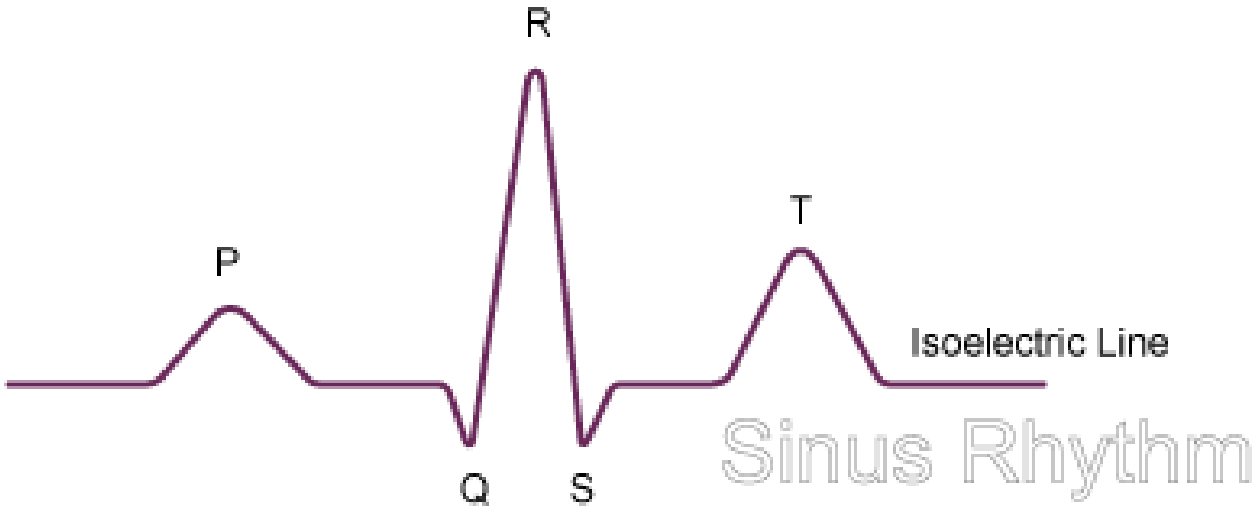


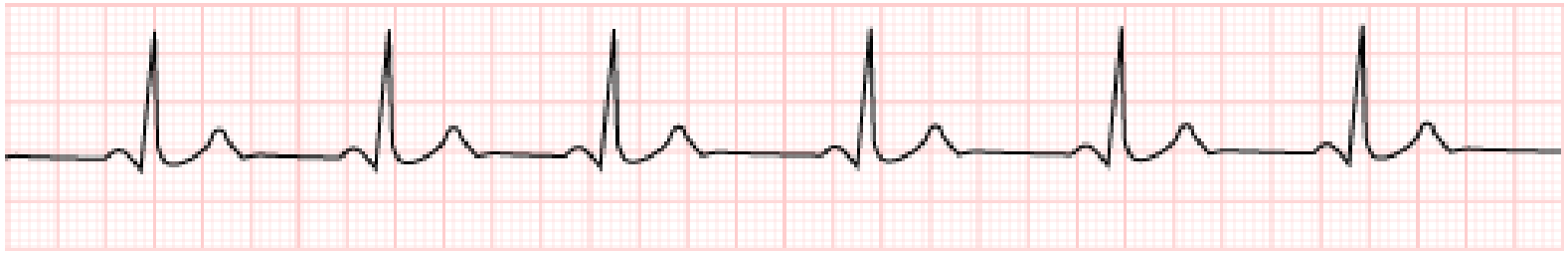
300/150/100/75/60

What is the Heart Rate?



Heart Rate = ~ 150 bpm





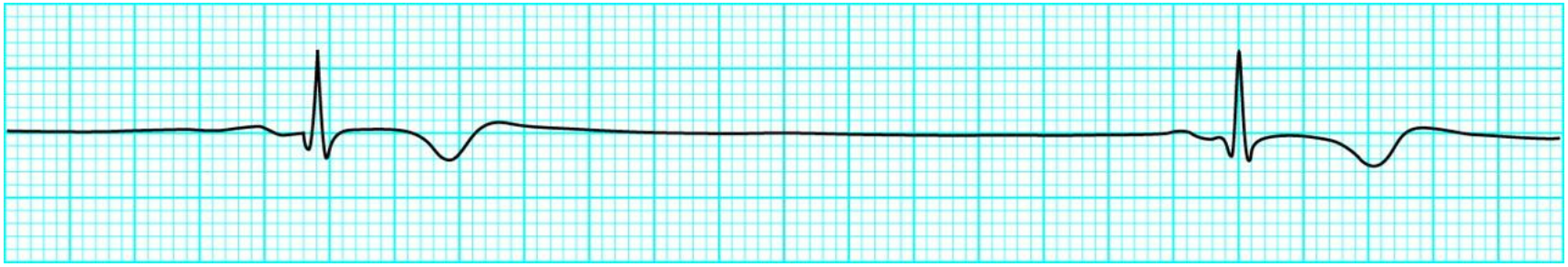
300/150/100/75/60

What is the Heart Rate

- Measure the cyclelength
  - ?The duration between each QRS in msec
  - Has to be a regular rhythm

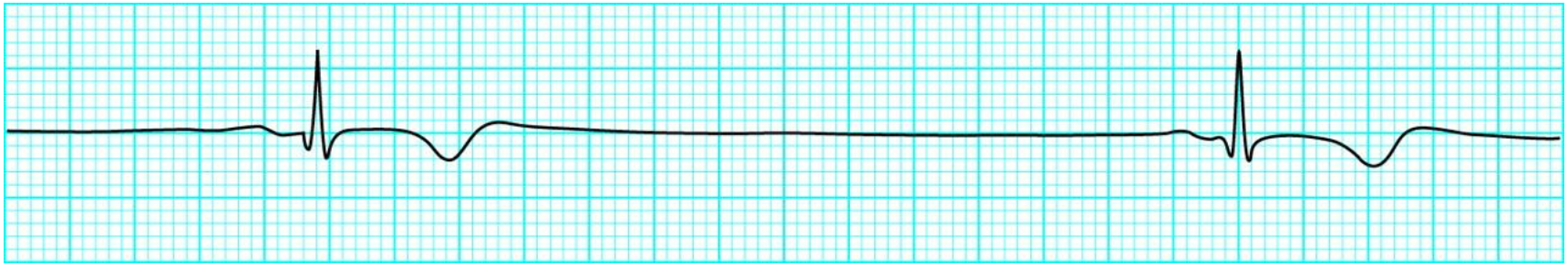
- Heart rate = 60,000 / Cyclelength bpm

What is the heart rate?



How many boxes between each QRS?

What is the heart rate?



How many boxes between each QRS?

14 Big boxes

Cyclelength = 14 x 200msec = 2800 msec

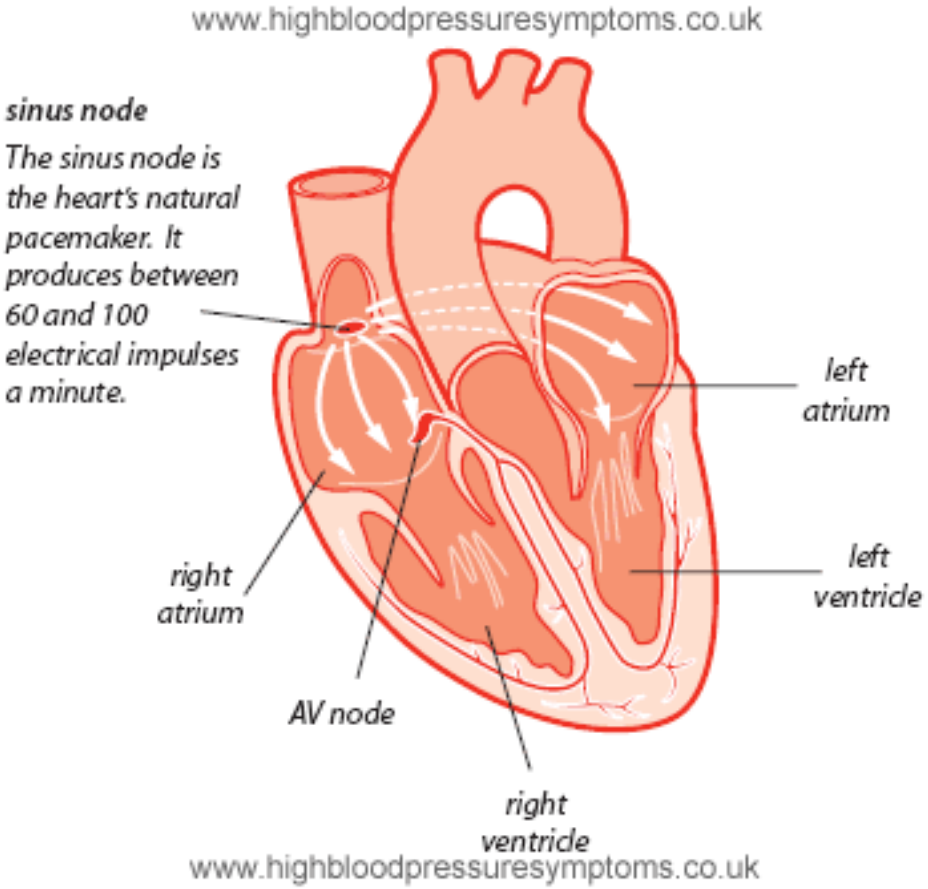
Heart rate = 60,000/2800 = 21 bpm.

Intervals

- PR
  - Time for atrioventricular conduction
  - < 200msec
- QRS
  - > 120 msec signifies distal conduction disease (Left vs Right bundle branch block)

- QT
  - Signifies duration of repolarization.
  - Prolonged or very short QT can lead to lethal ventricular arrhythmias
- Clinical Pearl
  - QT interval should NOT be > 50% R-R interval.

Natural Pacemaker



Sinus: 60-100bpm

Junctional: 40-60 bpm

Ventricular: 30-40 bpm

Normal Sinus Rhythm

- P before QRS. QRS follows a P wave.
- Atrial rate: 60-100 bpm
  - PR interval: 120-200 ms (.12-.20 seconds)
  - QRS interval: 60-100 ms (.06-.10 seconds)
  - QT interval: 360-440 ms (.36-.44 seconds)

Junctional Rhythm

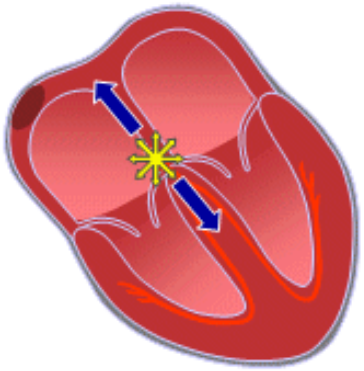
Junctional Rhythm

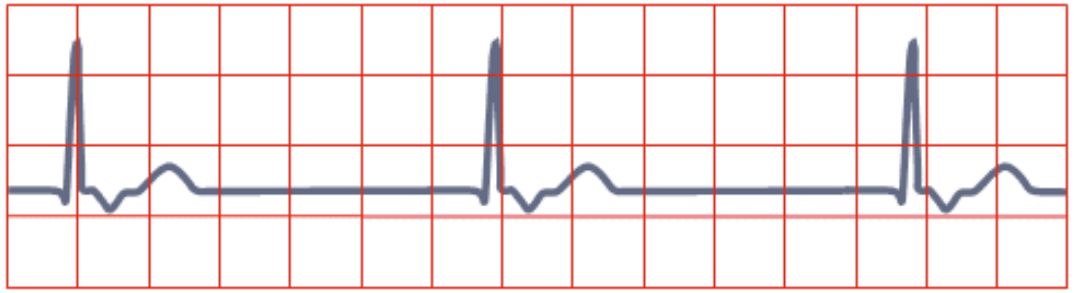
Narrow complex rhythm
No p wave prior to QRS
May see inverted p wave in QRS/ST segment

Junctional Rhythm

JUNCTIONAL RHYTHM

Impulses originate at AV node with retrograde and antegrade direction





P-wave is often inverted, may be under or after QRS complex
Heart rate is slow

Idioventricular Rhythm

Idioventricular Rhythm

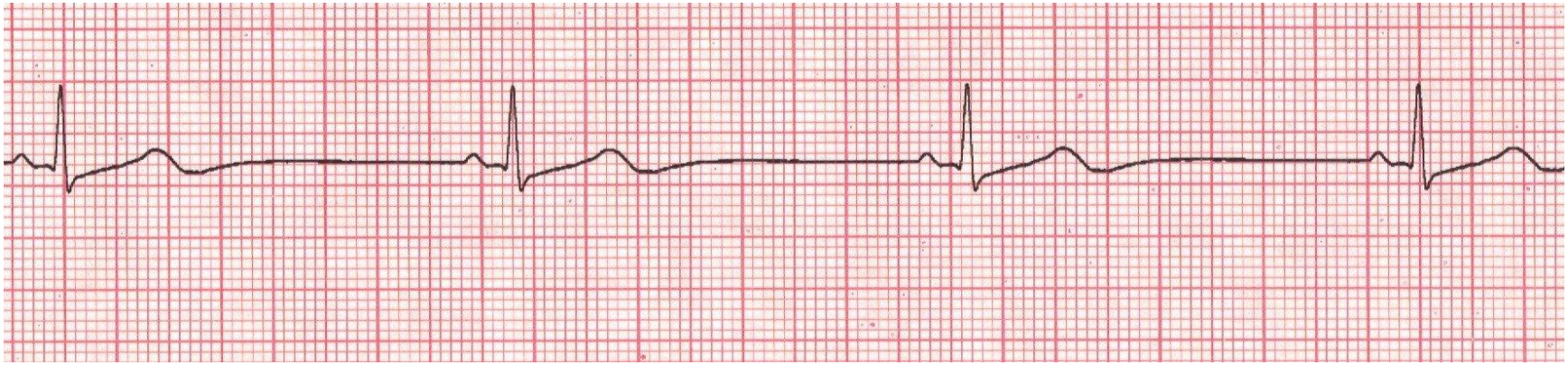
Ventricular Escape rhythm
Wide QRS rhythm without any p waves
May have p waves imbedded in QRS
(retrograde p)

BRADYCARDIA

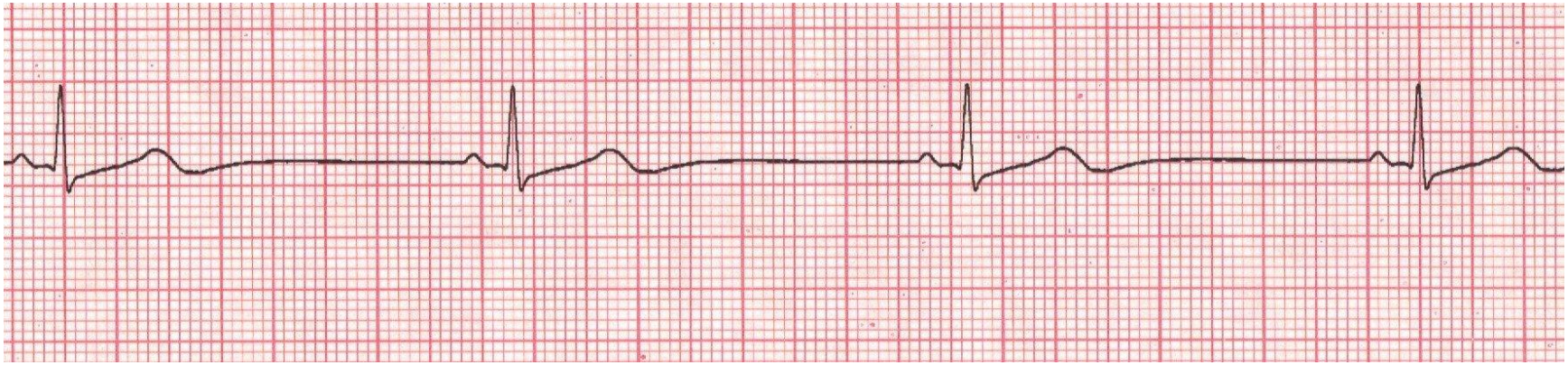
Bradycardia

- Heart Rate < 60bpm

Sinus Bradycardia

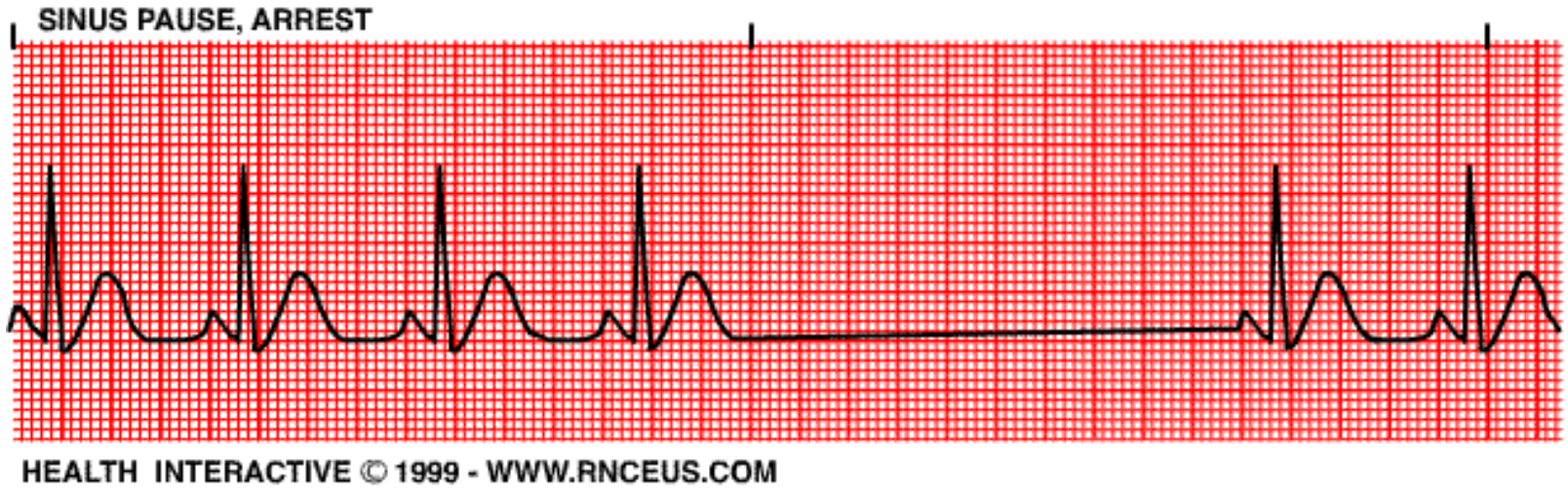


Sinus Bradycardia

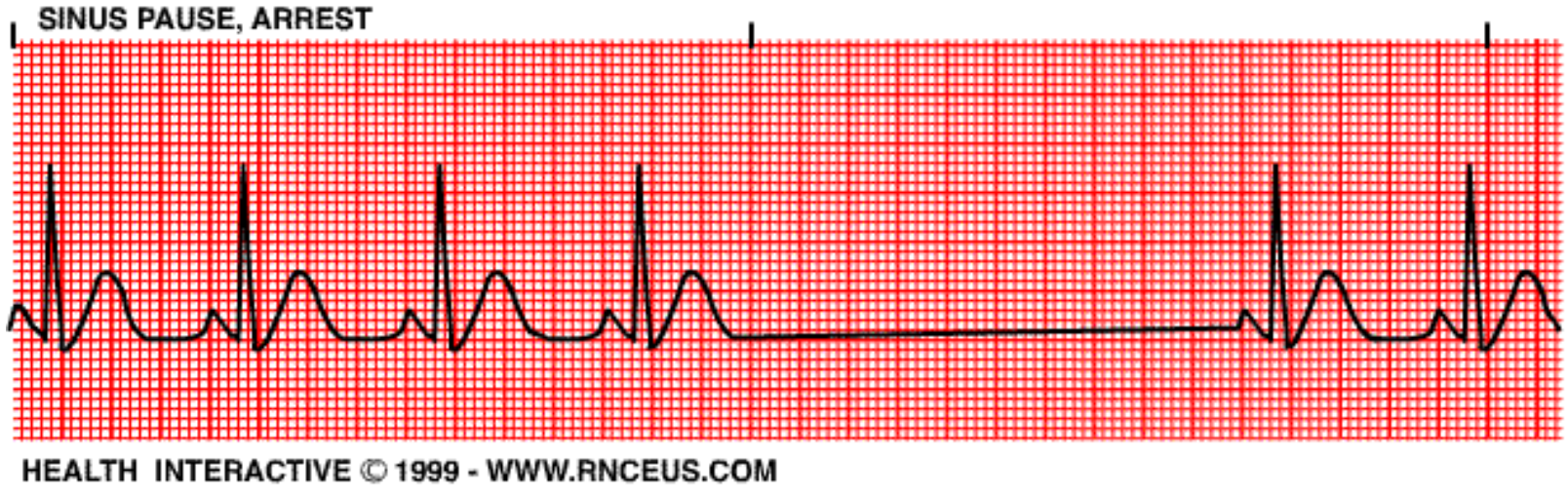


P wave before each QRS
HR < 60bpm

Sinus Pause

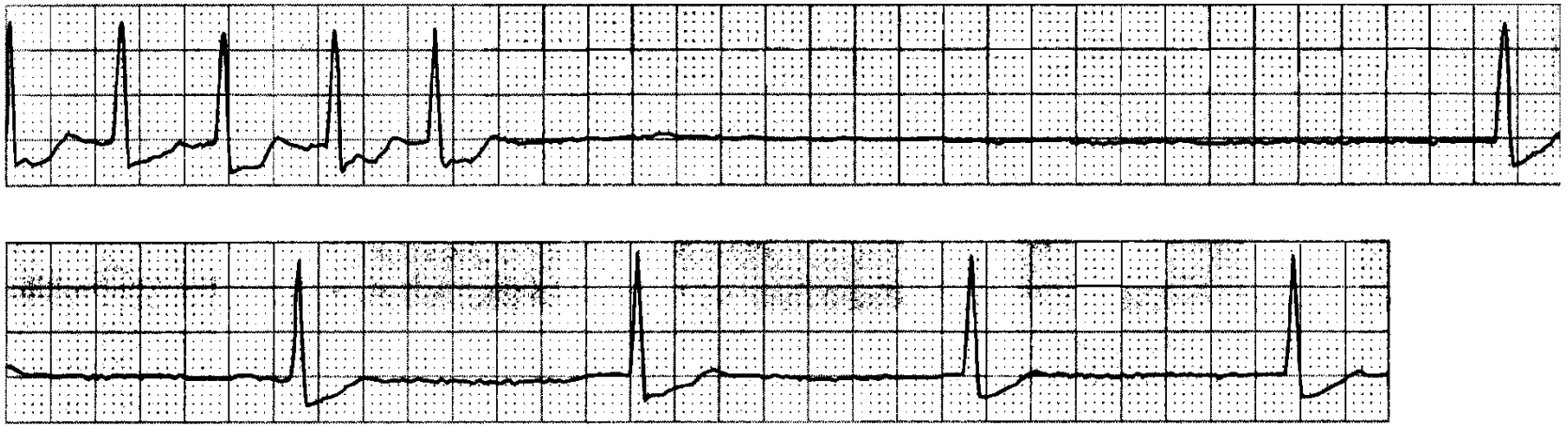


Sinus Pause



Sudden pause in sinus activity leading to NO cardiac output.

Sinus Pause



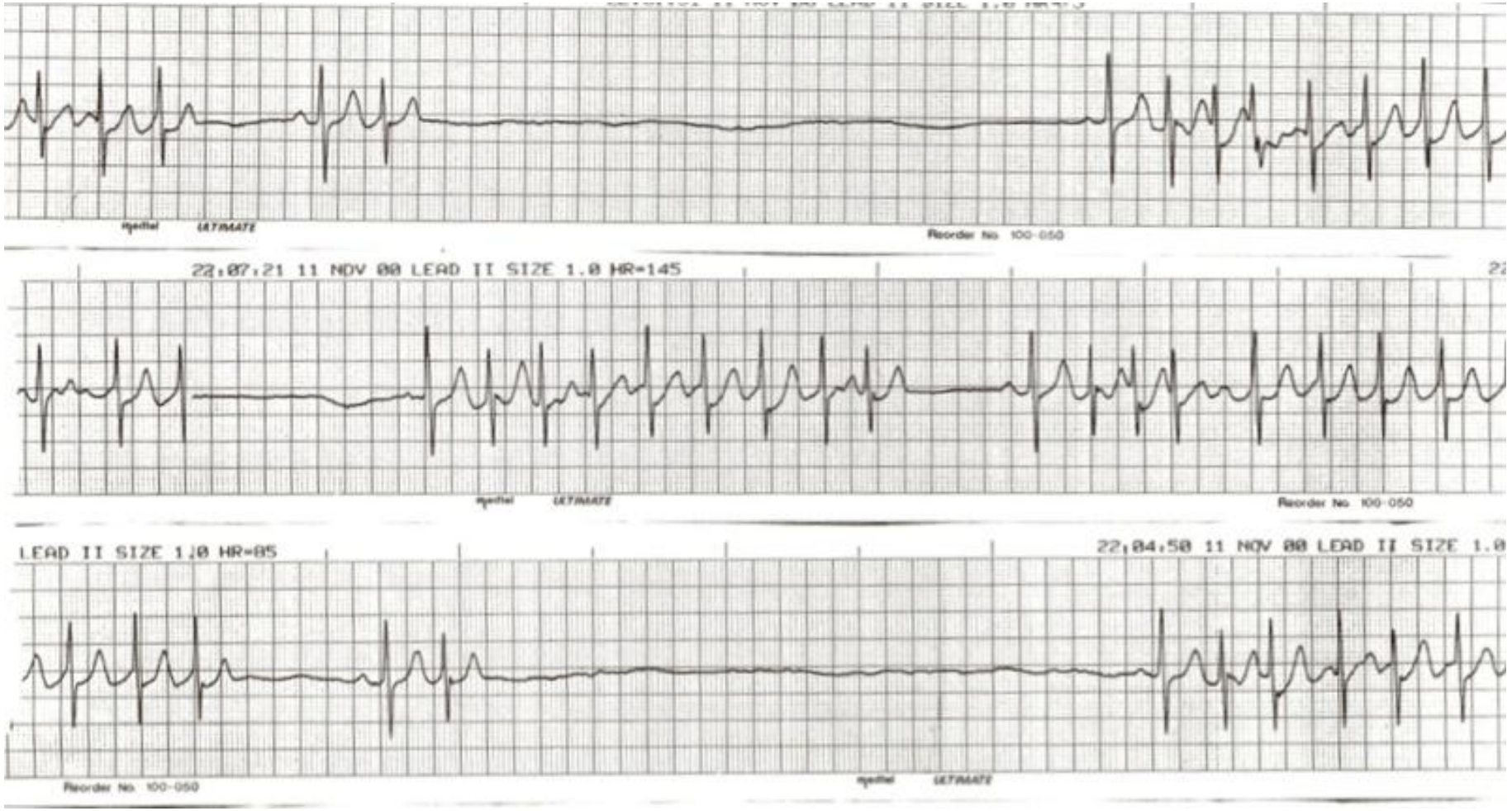
Sinus Node Disease

Types of Pauses

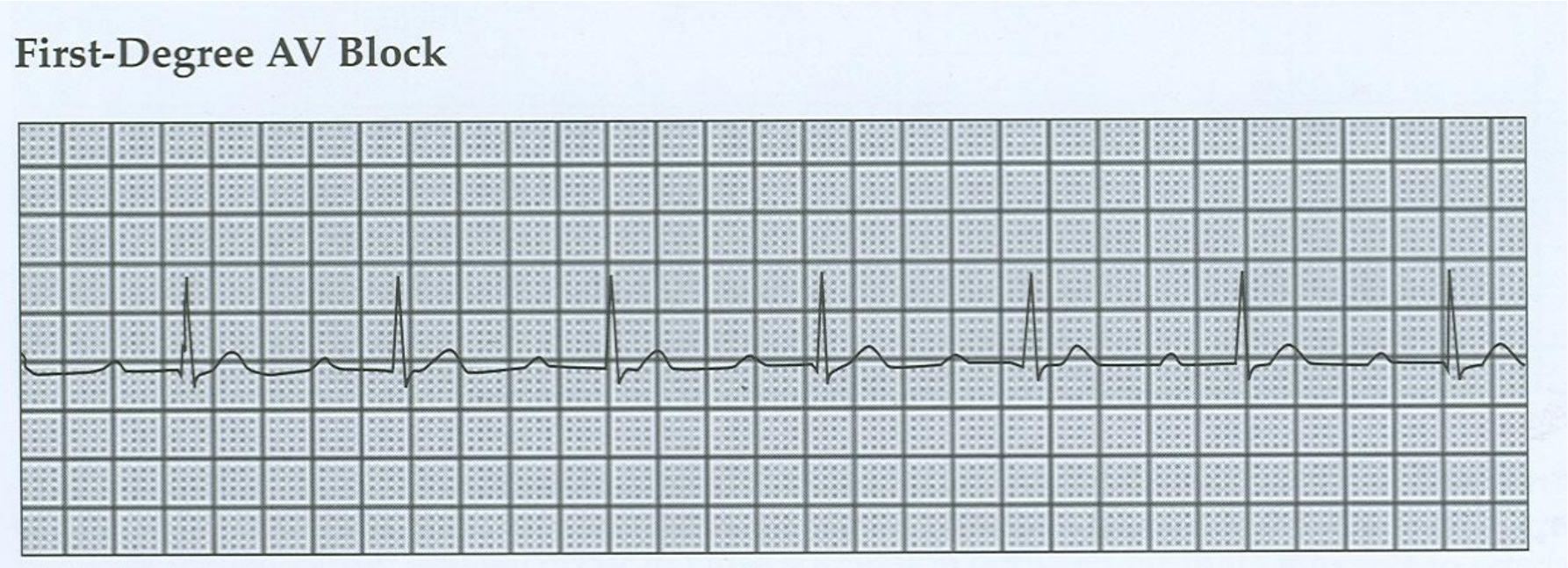
- Sinus arrest/pause
- Post-conversion pause (Afib to sinus)

What is a significant pause?

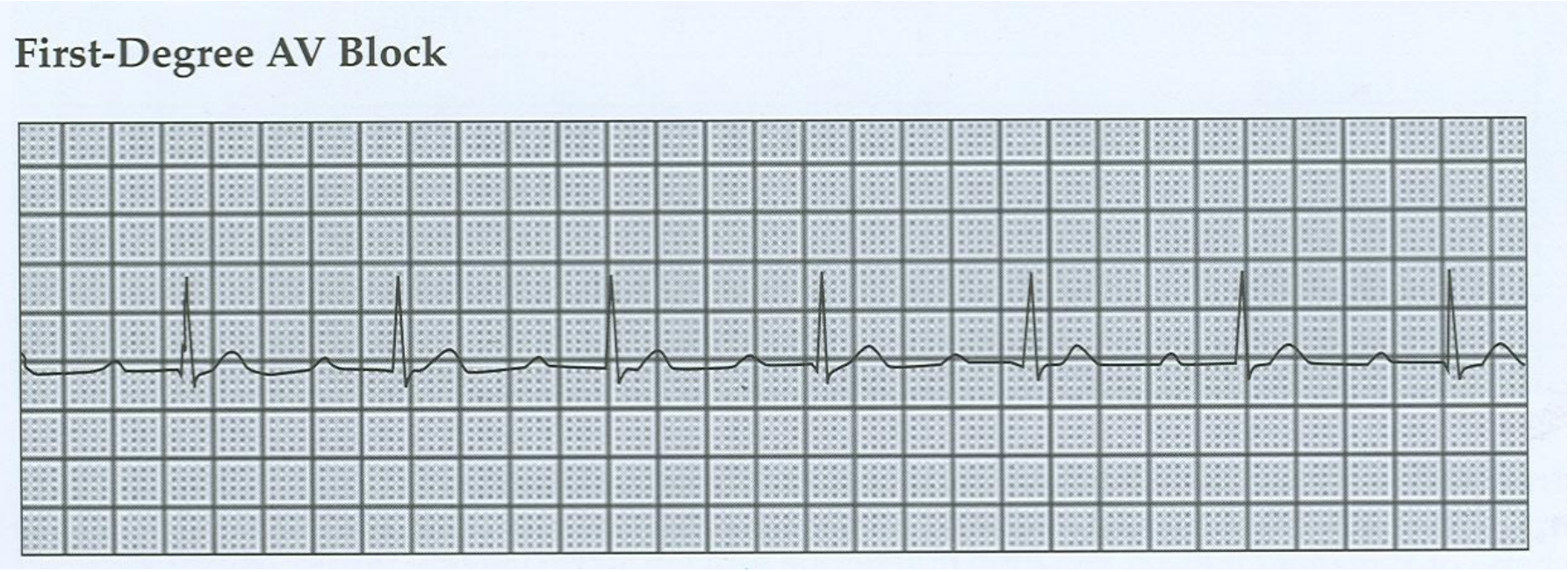
How Long is the Pause?



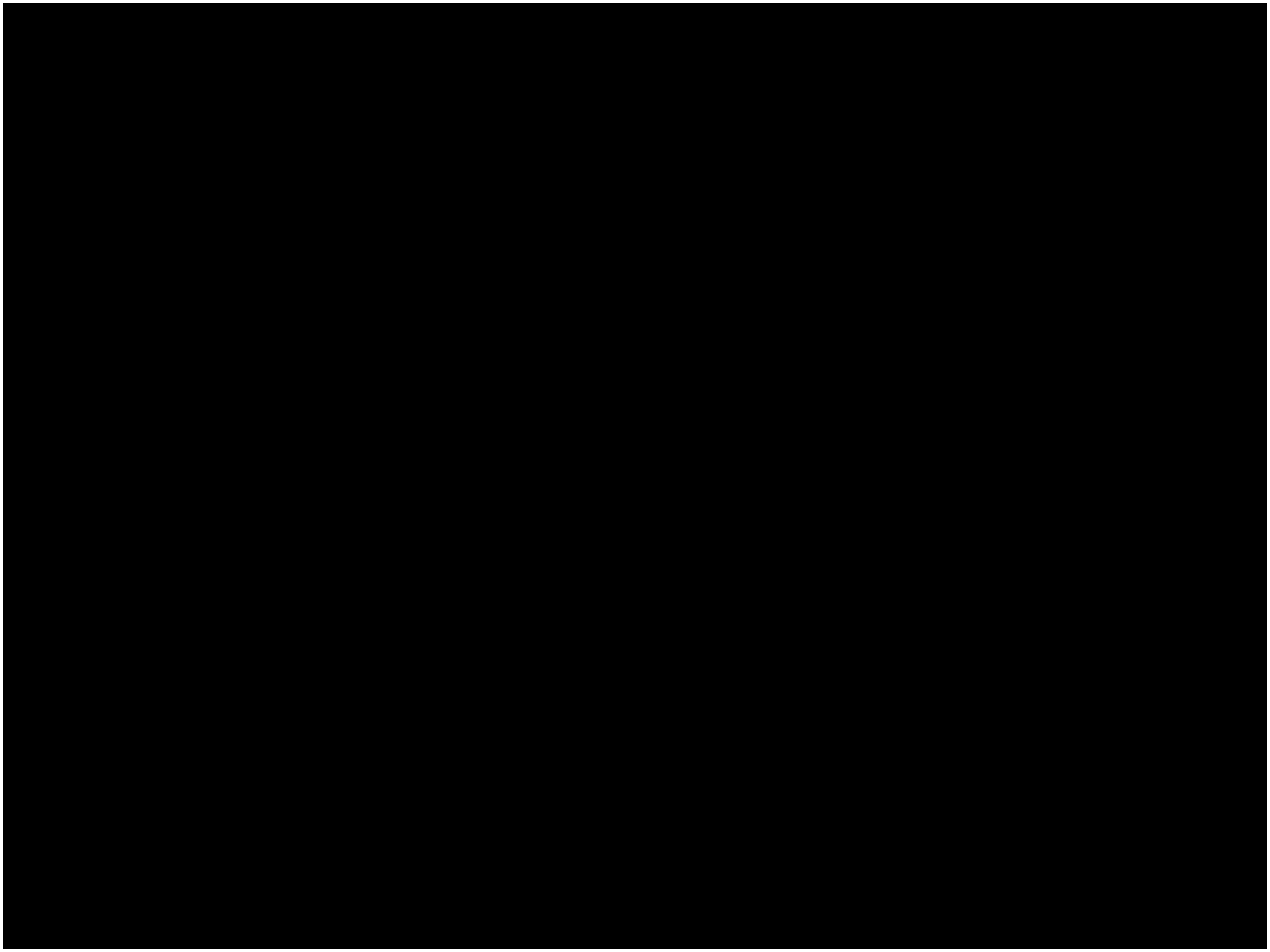
First Degree AV Block



First Degree AV Block



P before every QRS
Constant PR interval
PR interval prolonged > 200 msec



Second Degree AV Block
Mobitz I - Wenchebach

Second Degree Mobitz I Wenchebach

P>QRS
A-V association

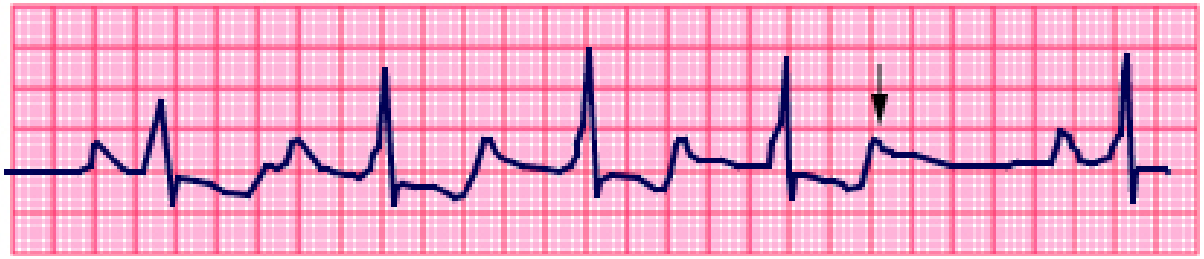
Second Degree AV Block Mobitz I

- Associated with diseased AV node
- AV node has decremental conduction properties
- Constant atrial/sinus rate
- Each successive atrial beat leads to more prolonged conduction through the AV node, until one atrial beat is BLOCKED, and DOES NOT REACH the ventricle.
- Usually benign, not requiring pacemaker.

Second Degree Mobitz I Wenchebach

- P>QRS
- Progressive prolongation of PR interval followed by dropped beat
- The PR interval is shortest in the first beat in the cycle
- Largest absolute increase in delay occurs in the second beat
- R-R interval decreases with each beat of the cycle
- Group beating

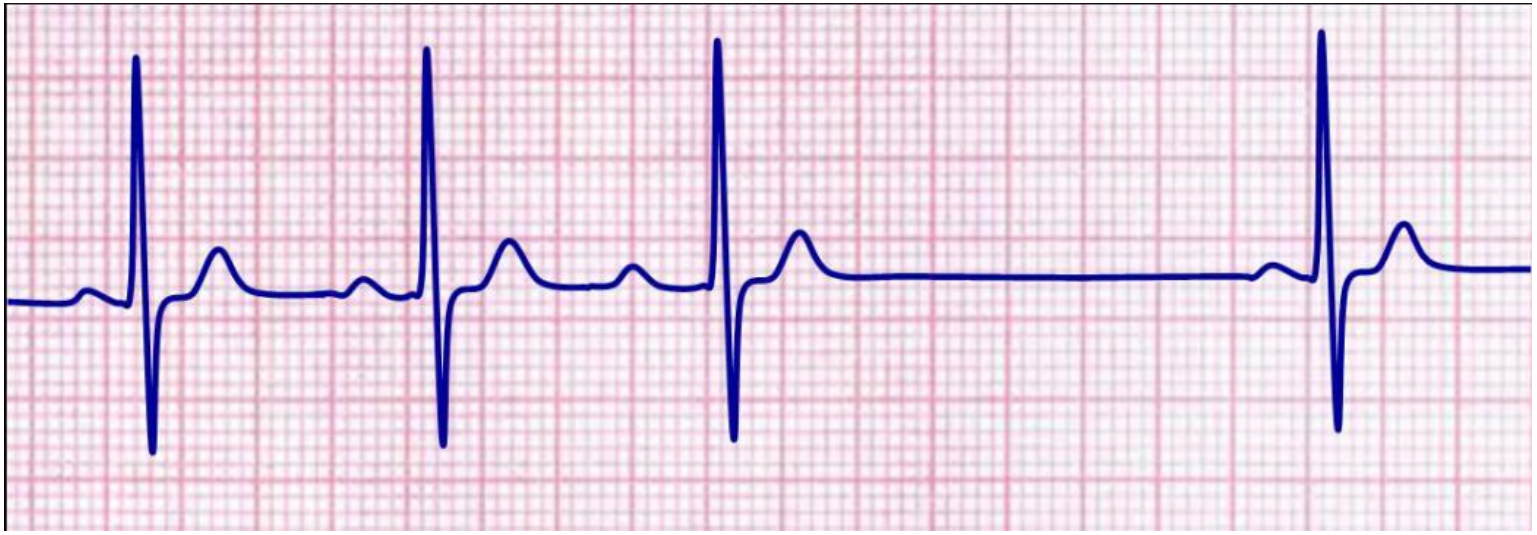
Mobitz type I (Wenckbach) AV block



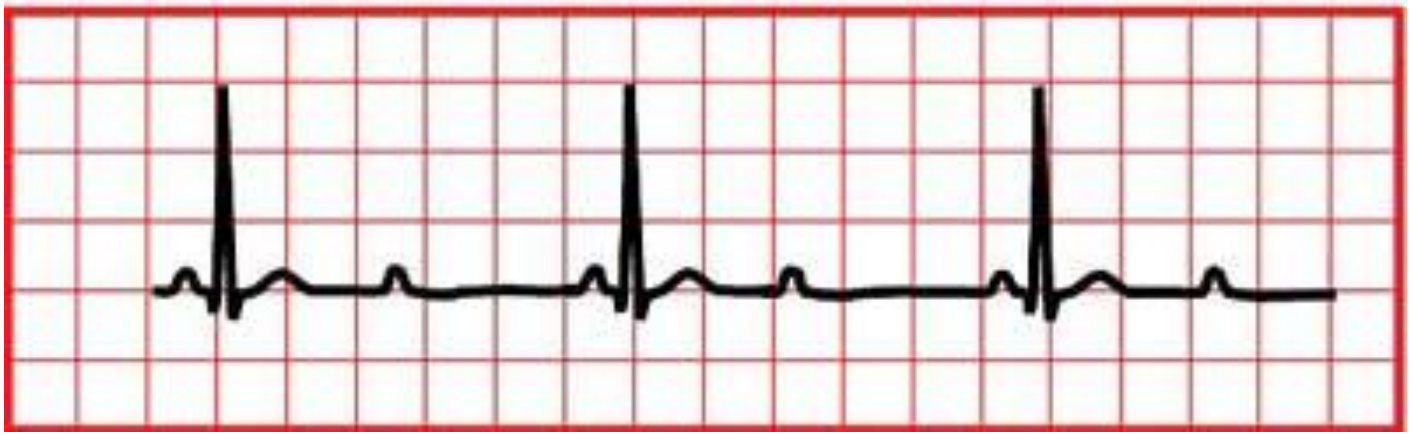
PR	.18	.23	.26	.27	.18
Increment		.05	.03	.01	
RR	.57	.54	.53	.96	

Electrocardiogram showing Mobitz type I (Wenckebach) second degree AV block with 5:4 conduction. The characteristics of this arrhythmia include: a progressively increasing PR interval until a P wave is not conducted (arrow); a progressive decrease in the increment in the PR interval; a progressive decrease in the RR interval; and the RR interval that includes the dropped beat (0.96 sec) is less than twice the RR interval between conducted beats (0.53 to 0.57 sec).

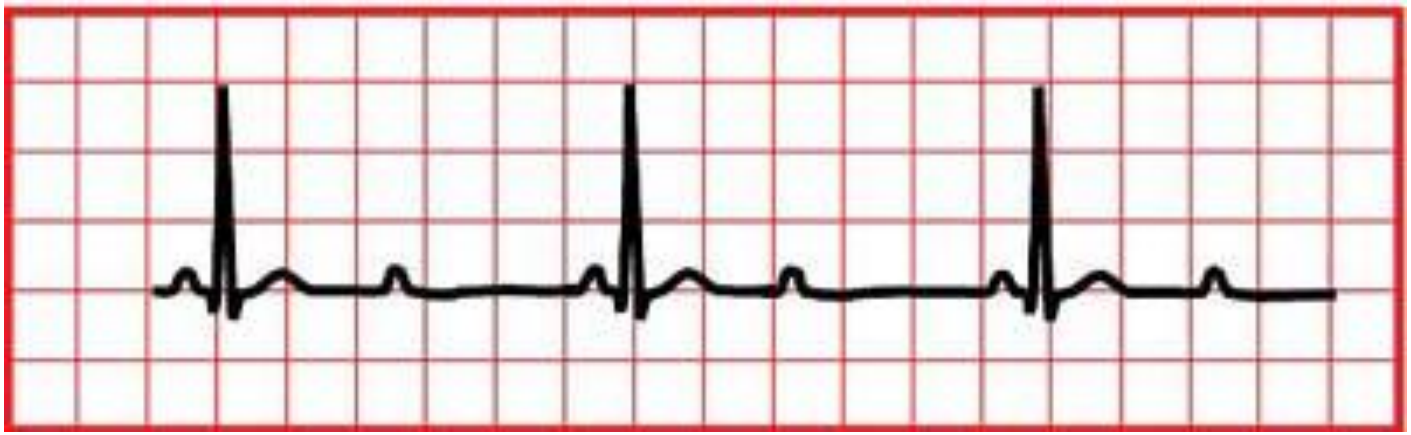
Courtesy of Morton Arnsdorf, MD.



Second Degree AV Block Mobitz II

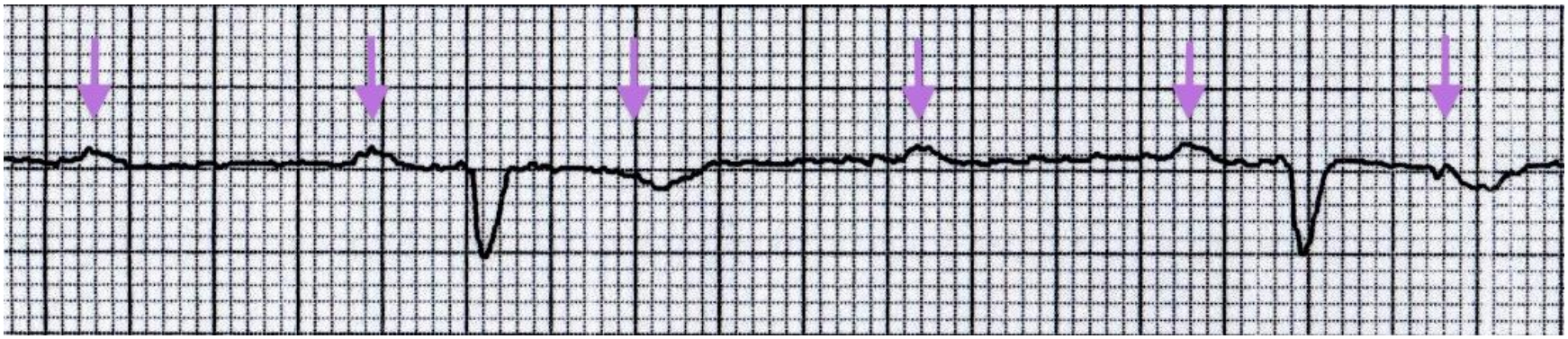


Second Degree AV Block Mobitz II



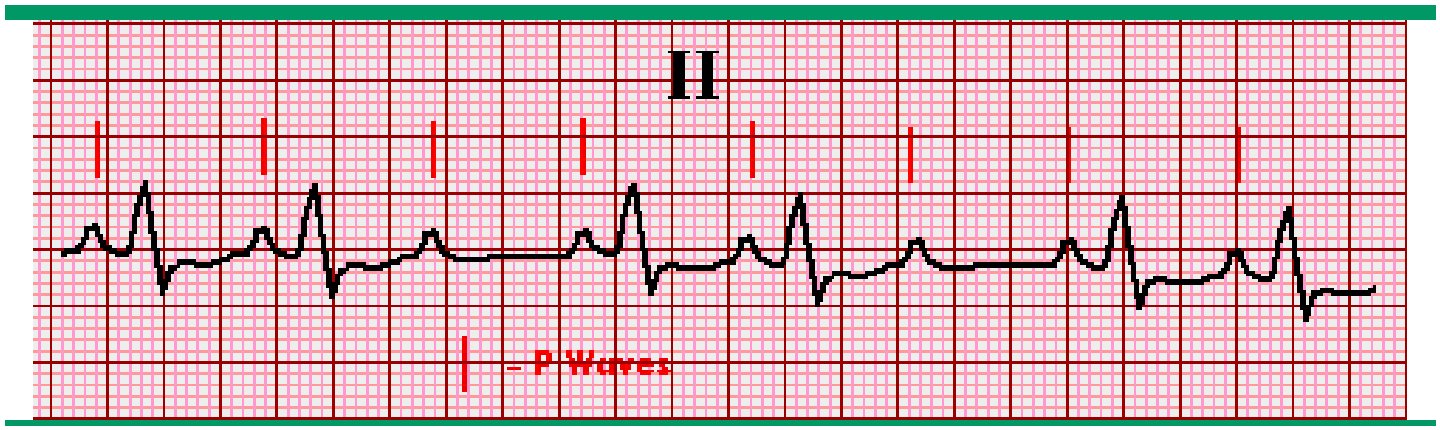
P>QRS. A-V association
P suddenly fails to conduct to V
Stable PR Interval
Patterns→ 2:1, 3:1, variable

Mobitz II

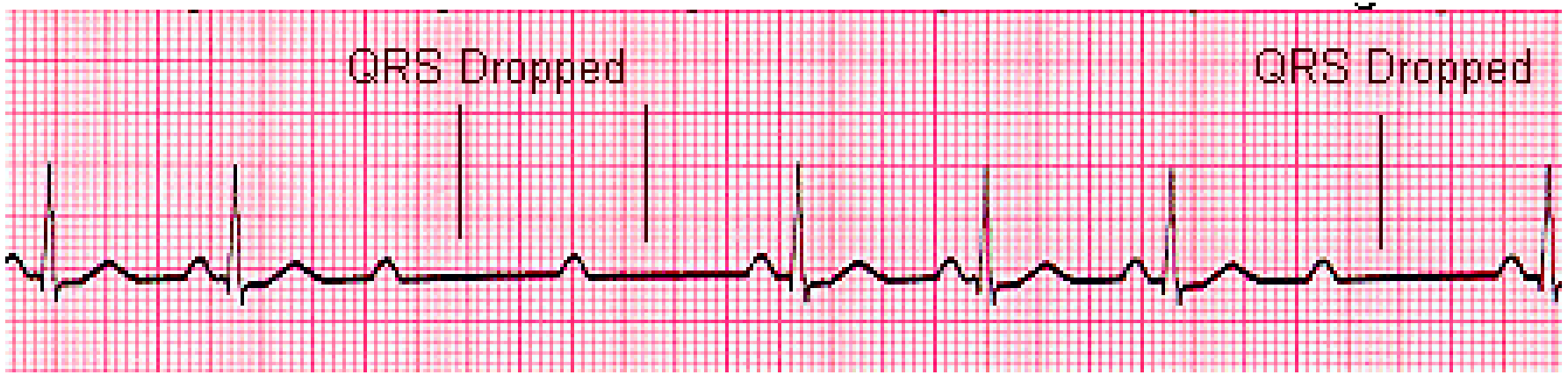


- 3:1 AV block

Mobitz type II second degree atrioventricular (AV) block



The third and sixth P waves are not conducted through the AV node (there is no associated QRS complex). The PR interval is constant prior to and after the non-conducted beats.

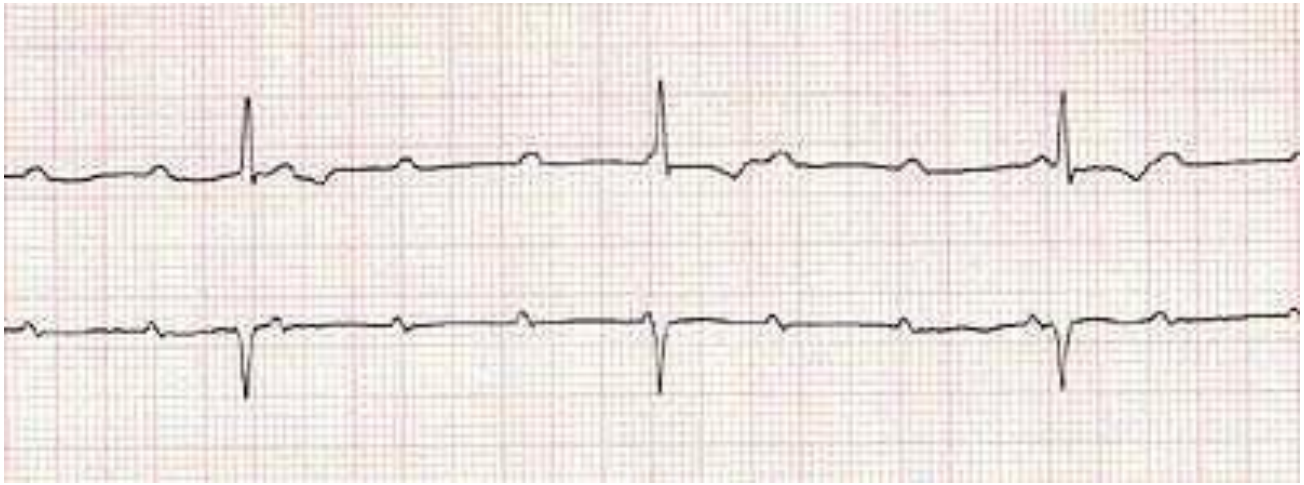

QRS Dropped
QRS Dropped

Mobitz I vs Mobitz II

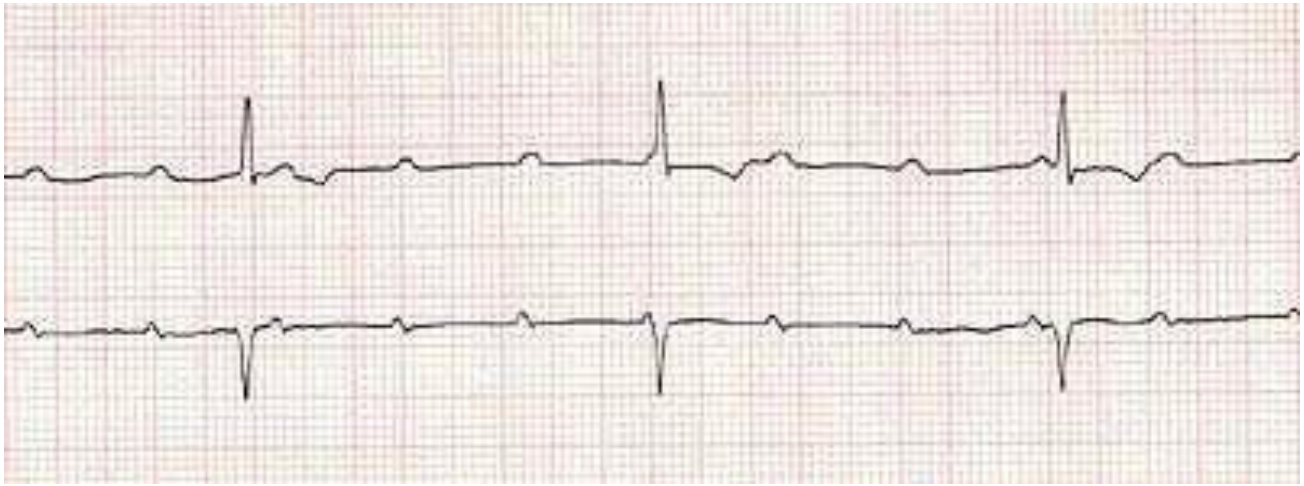
- Mobitz I (Wenchebach) signifies diseased AV node, which usually has benign outcome

- Mobitz II signifies diseased distal HIS/Purkinjae system. Higher risk of complete heart block, and usually requires permanent pacemaker.

Complete Heart Block

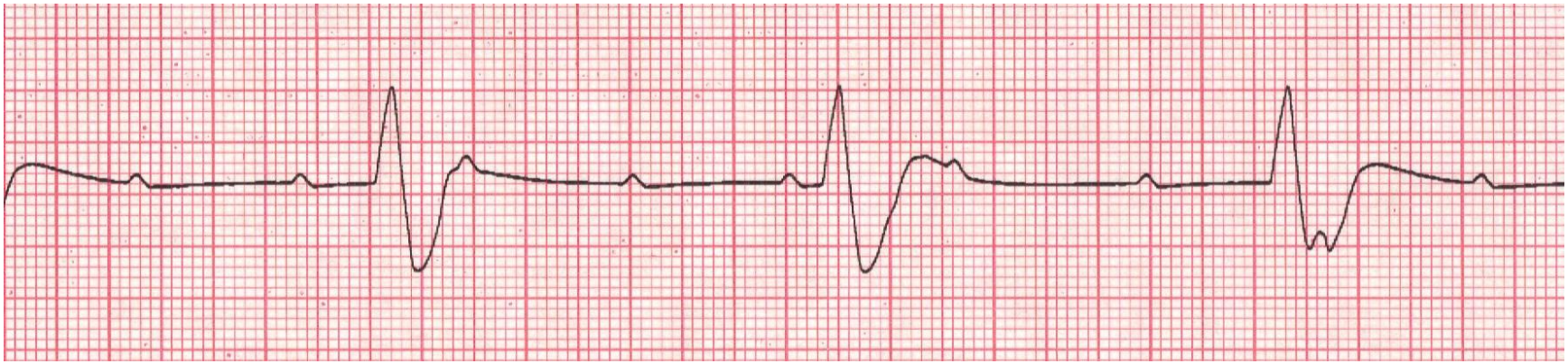


Complete Heart Block



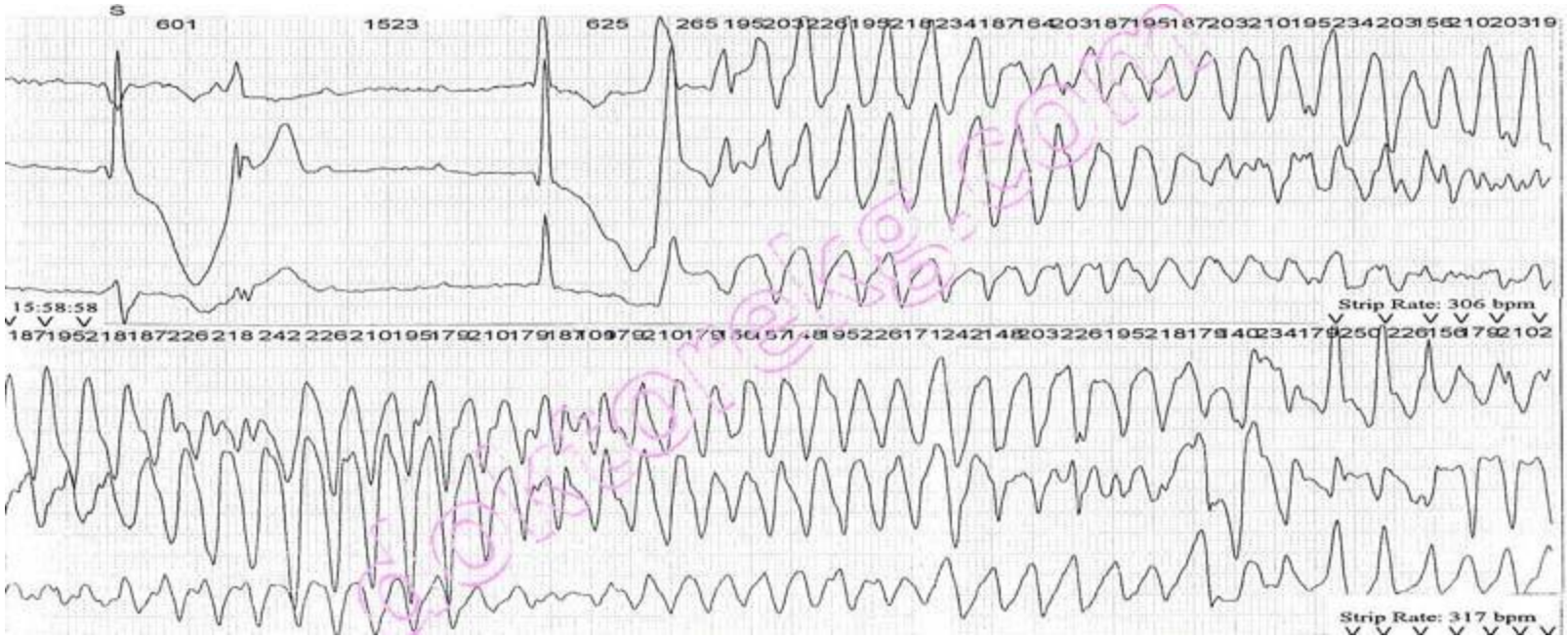
More p waves than QRS
AV Disassociation
Escape rhythm- Junctional (narrow) vs Ventricular (wide)

P rate is faster than that V rate

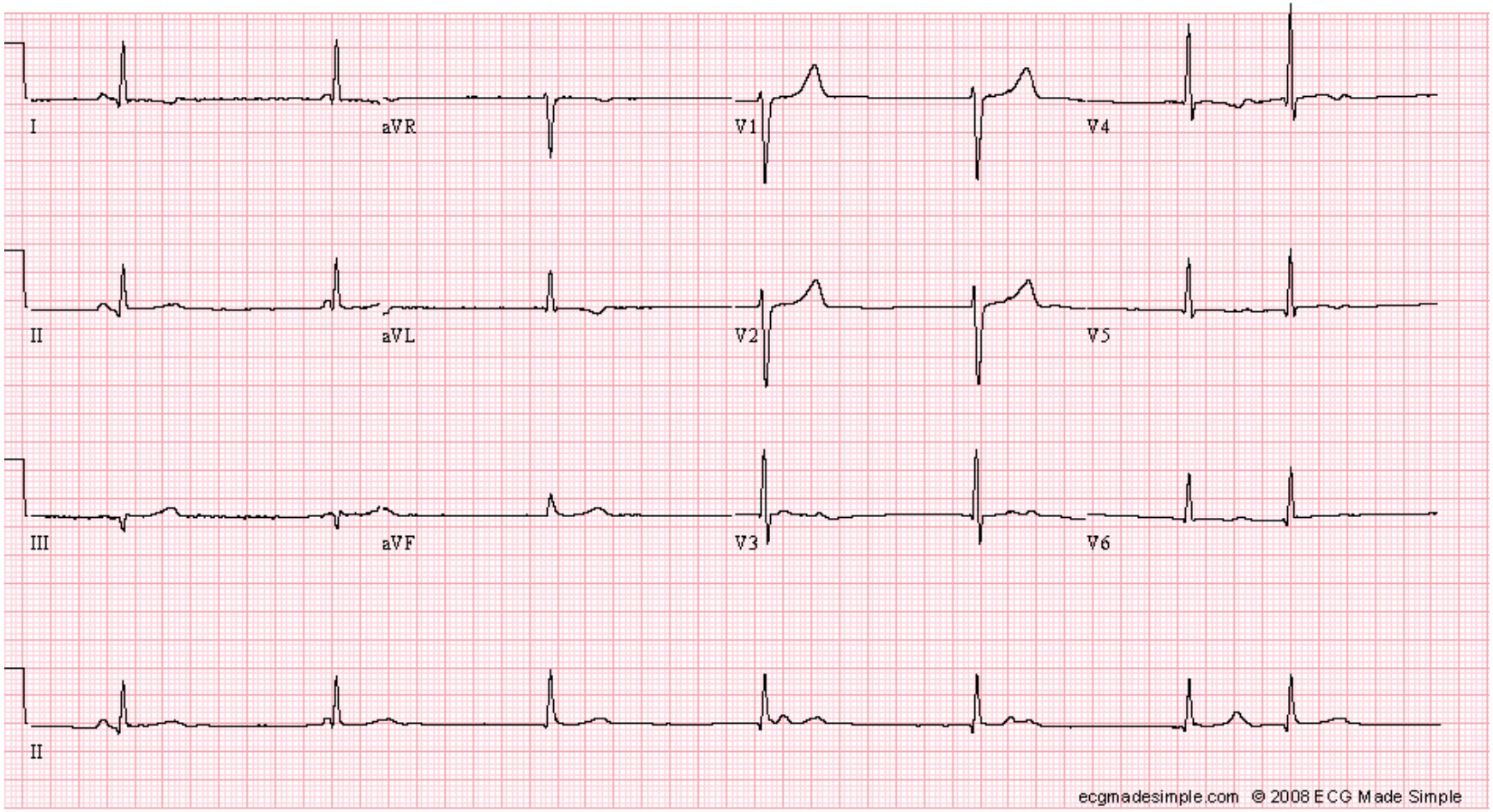


Complete Heart Block

- High risk
  - Ventricular escape (Wide QRS)
  - Bradycardia
  - Ventricular ectopy
  - Long QT


S
601
1523
625
15:58:58
Strip Rate: 306 bpm
Strip Rate: 317 bpm

Isorhythmic Dissociation



AV Dissociation
QRS rate > p rate

- Complete Heart Block
  - Atrial rate > Ventricular rate
- Isorrhythmic Disassociation
  - Ventricular rate > Atrial rate
  - Overriding Junctional/Ventricular escape rhythm over slower sinus rate.

Approach to Bradycardia

- P before every QRS? (1:1 ratio)
  - Sinus bradycardia
    - PR interval >200msec → First Degree AV Block
- More P than QRS?
  - Is there association between P and QRS?
    - YES
      - Prolonging PR segment, Grouped beating?
        - » **Second Degree AV block Mobitz I (Wenchebach)**
      - Stable PR segment, dropped p waves.
        - » **Second Degree AV block Mobitz II**
    - **No**
      - **P rate > QRS rate → Consider complete Heart Block!**

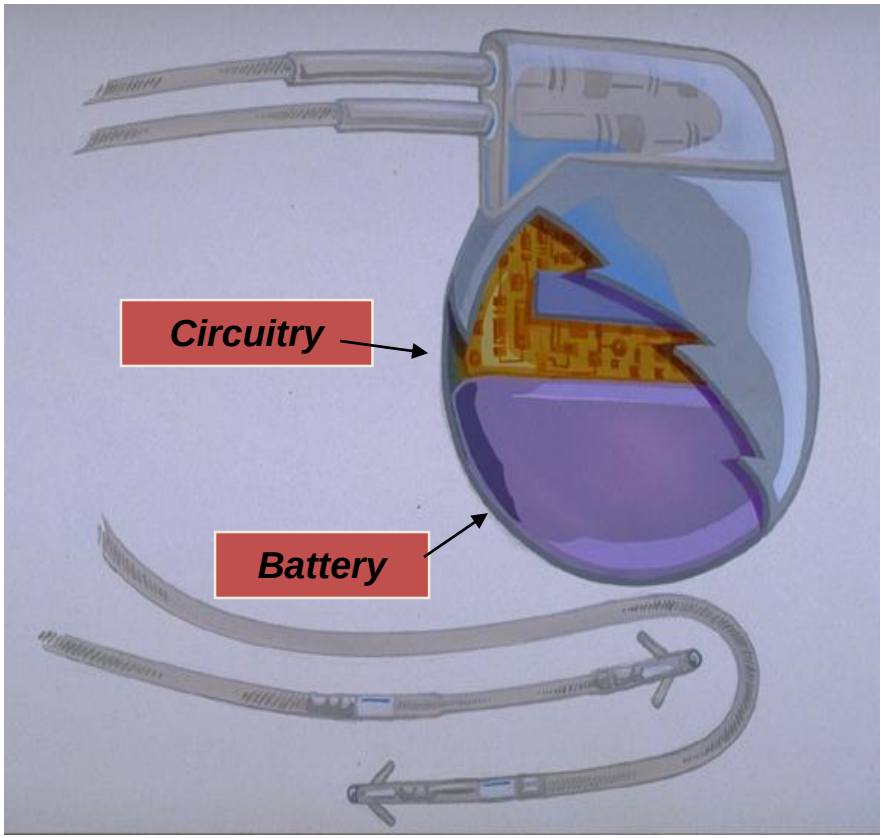
QUESTIONS?

APPROACH TO PACEMAKERS

Pacemaker

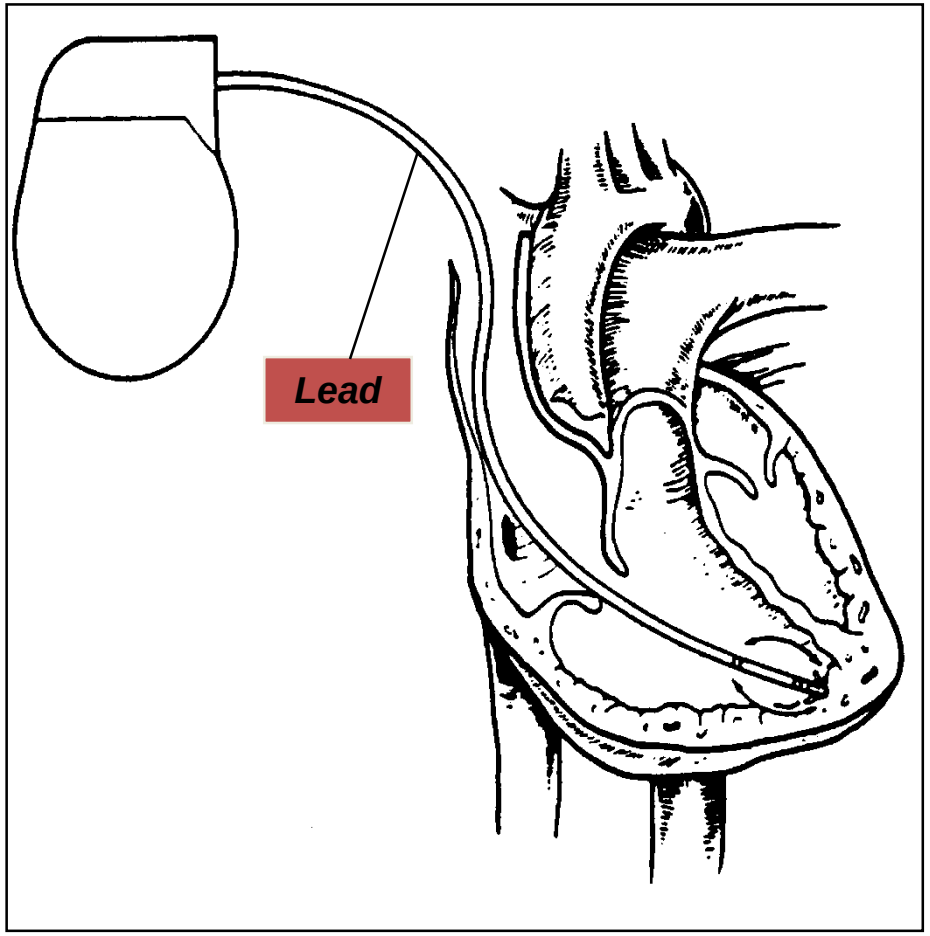
The Pulse Generator:

- Contains a battery that provides the energy for sending electrical impulses to the heart
- Houses the circuitry that controls pacemaker operations



Leads Are Insulated Wires That:

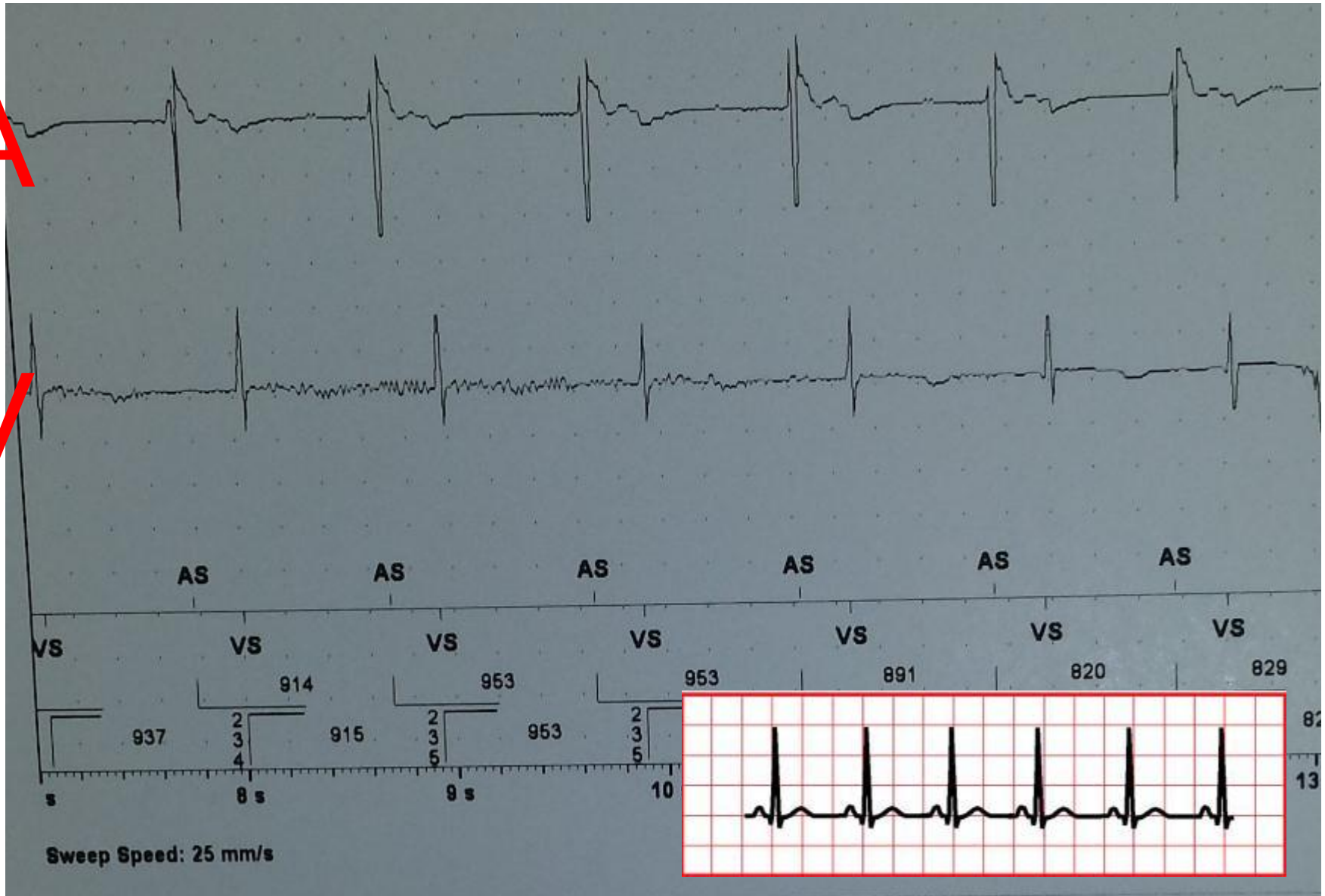
- Deliver electrical impulses from the pulse generator to the heart
- Sense cardiac depolarization



Sensing

- Sensing is the ability of the pacemaker to “see” when a natural (intrinsic) depolarization is occurring

What does the pacemaker see?

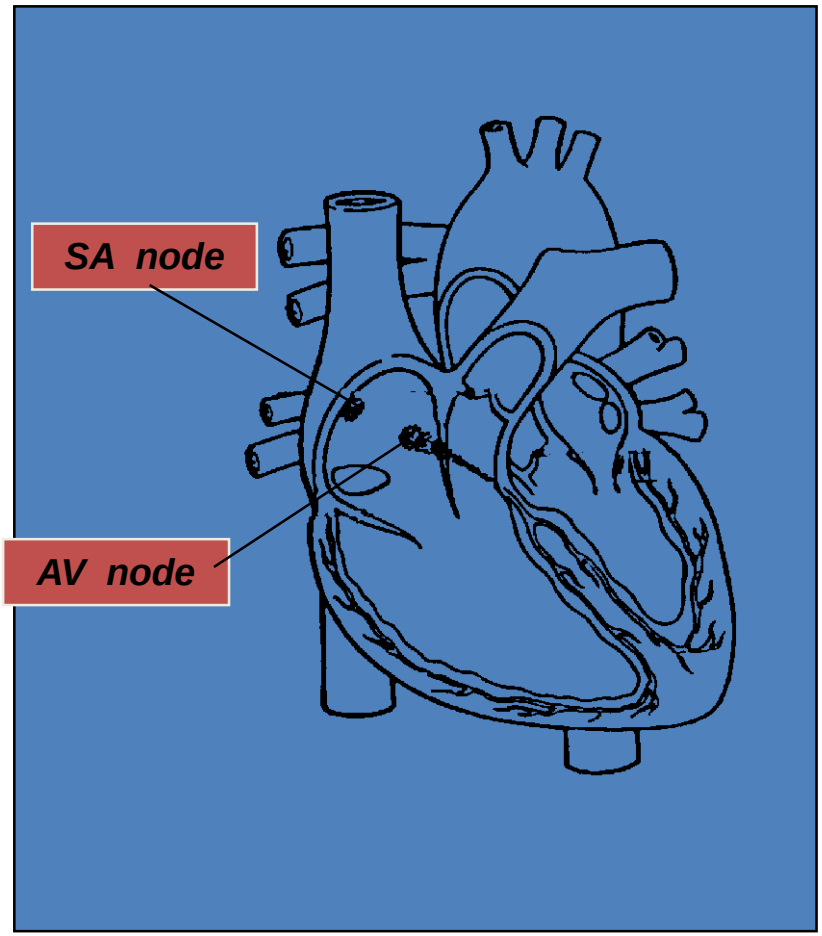


A Pacemaker Must Be Able to **Sense** and Respond to Cardiac Rhythms

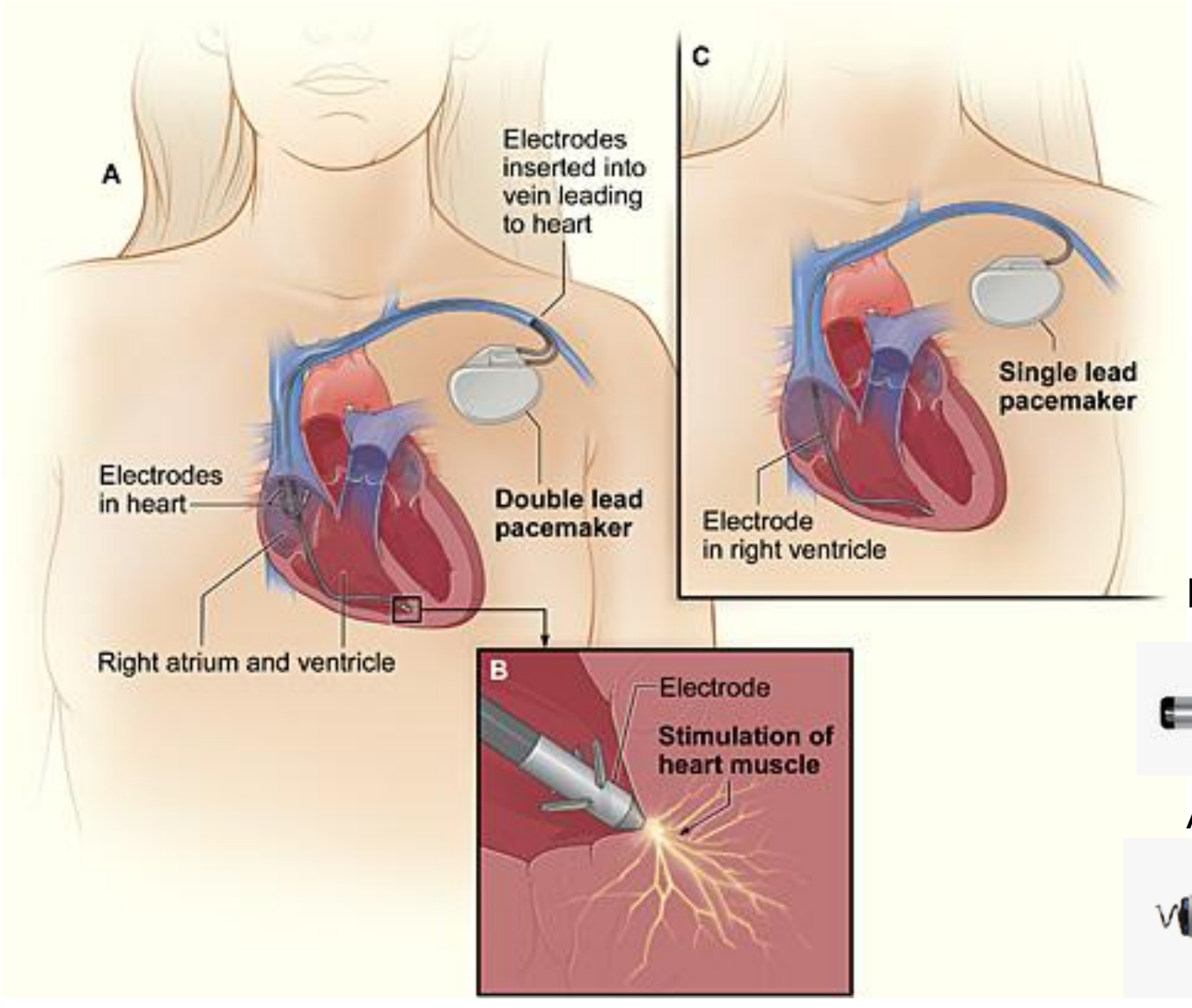
- Accurate **sensing** enables the pacemaker to determine whether or not the heart has created a beat on its own
- The pacemaker is usually programmed to respond with a **pacing** impulse only when the heart fails to produce an intrinsic beat

Indications for PPM

- Failure of impulse generation in the SA node (Sinus node disease)
- AV conduction disease

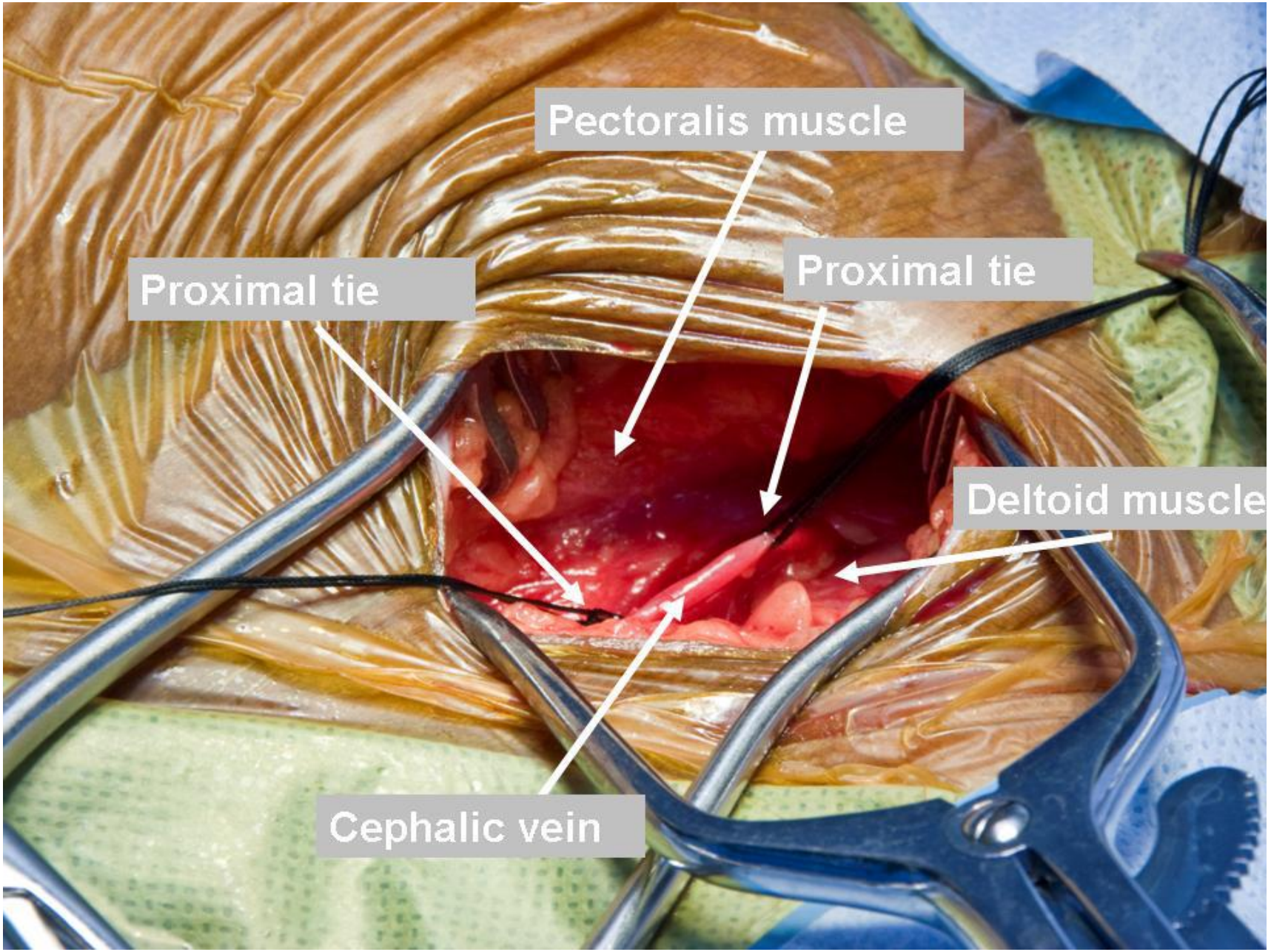


Implantation



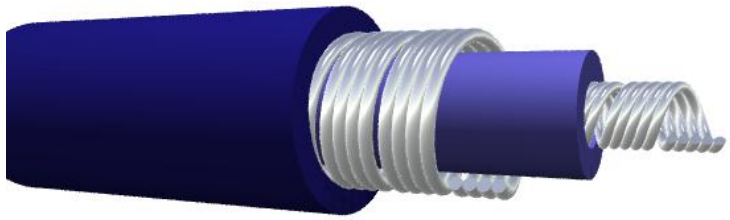
Passive Lead

Active Lead


Pectoralis muscle
Proximal tie
Proximal tie
Deltoid muscle
Cephalic vein

Bipolar leads

- Less susceptible to oversensing noncardiac signals (myopotentials)



Coaxial Lead Design

Pacemaker Brands

Medtronic

BIOTRONIK
excellence for life

Boston Scientific
Delivering what's nex

ST. JUDE MEDICAL
MORE CONTROL. LESS RISK.

SORIN GROUP
AT THE HEART OF MEDICAL TECHNOLOGY

NBG Code Review

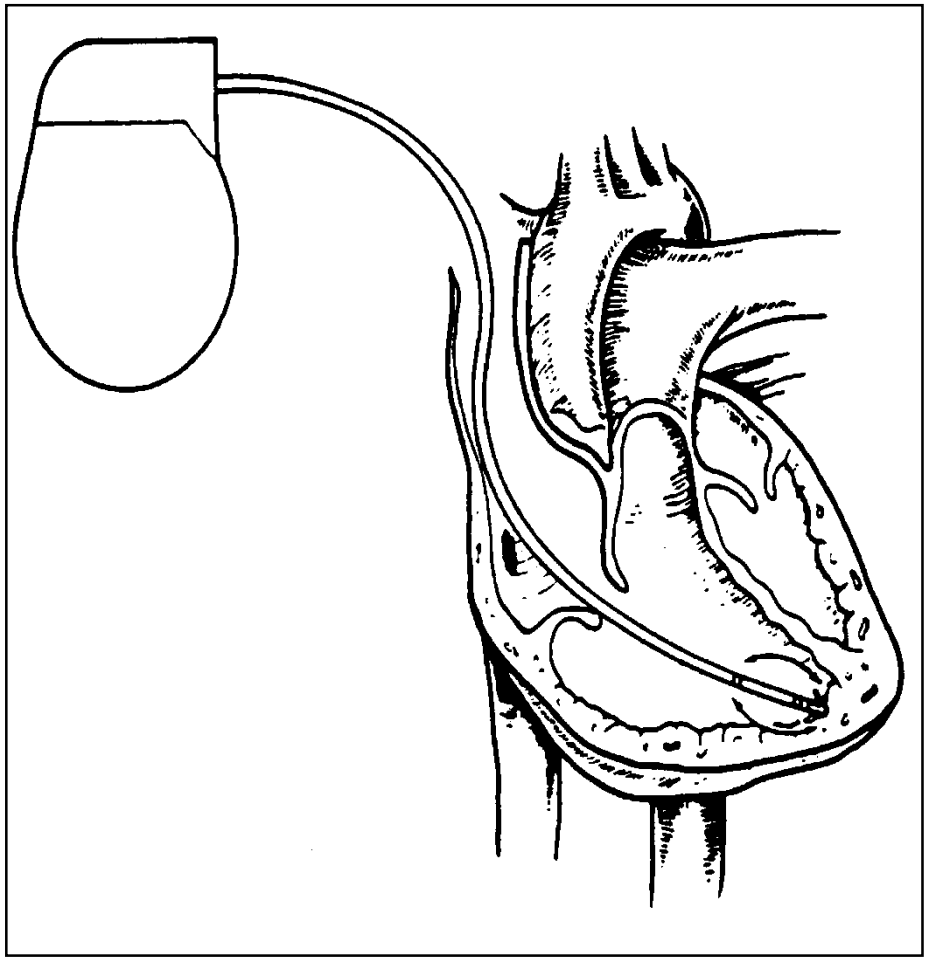
I Chamber Paced	II Chamber Sensed	III Response to Sensing	IV Programmable Functions/Rate Modulation	V Antitachy Function(s)
V: Ventricle	V: Ventricle	T: Triggered	P: Simple programmable	P: Pace
A: Atrium	A: Atrium	I: Inhibited	M: Multi-programmable	S: Shock
D: Dual (A+V)	D: Dual (A+V)	D: Dual (T+I)	C: Communicating	D: Dual (P+S)
O: None	O: None	O: None	R: Rate modulating	O: None
S: Single (A or V)	S: Single (A or V)		O: None	

Most Common Pacemaker Algorithms

- VVI
- DDD
- VOO (surgery)

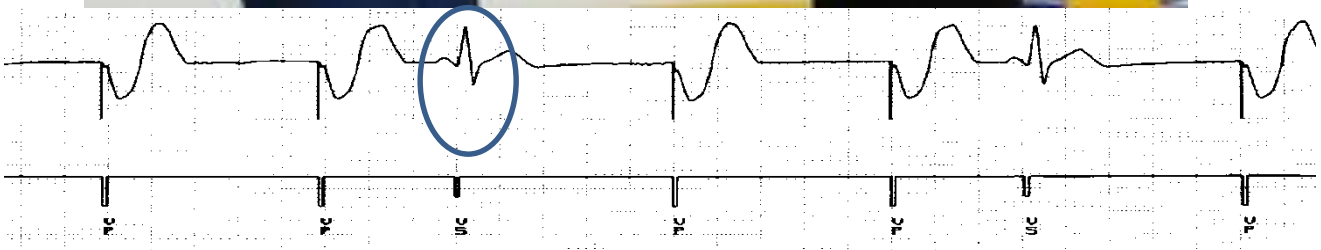
Single-Chamber System
VVI

- The pacing lead is implanted in the ventricle
- It inhibits pacing when sensed intrinsic beats



VVI Pacemaker

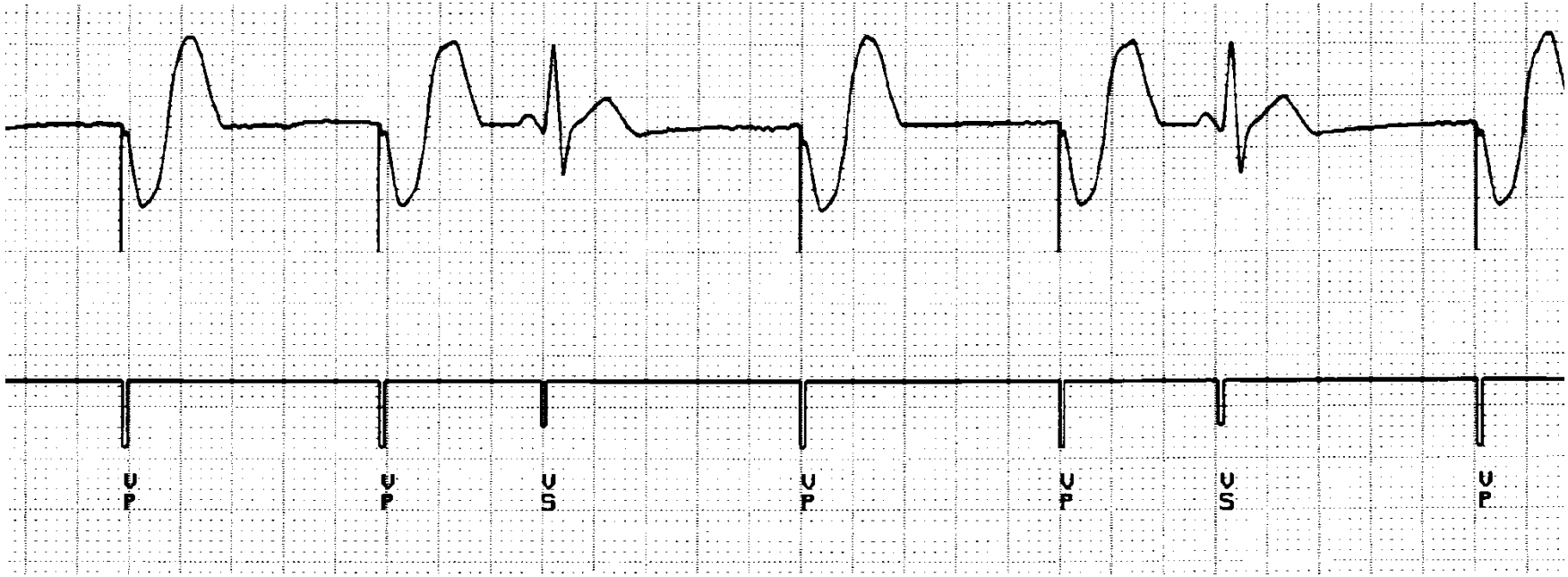
- Ventricular sensing = Inhibition



VVI Pacemaker

- No sensing-> Inhibition lifted → Paced

Paced Rhythm Recognition

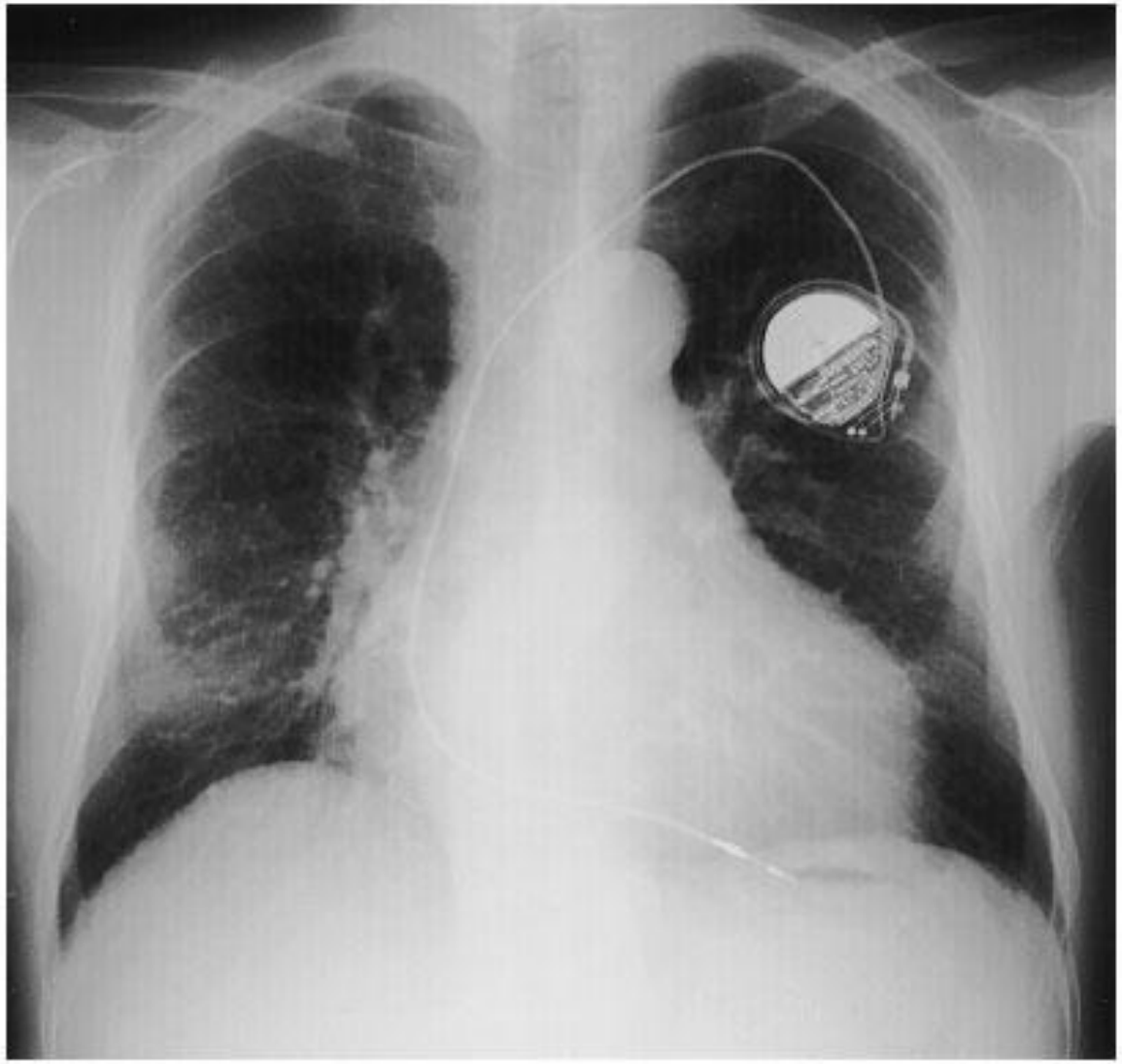


VVI /

60

RR = 1000ms

Chest X-ray on re-admission



I

II

III

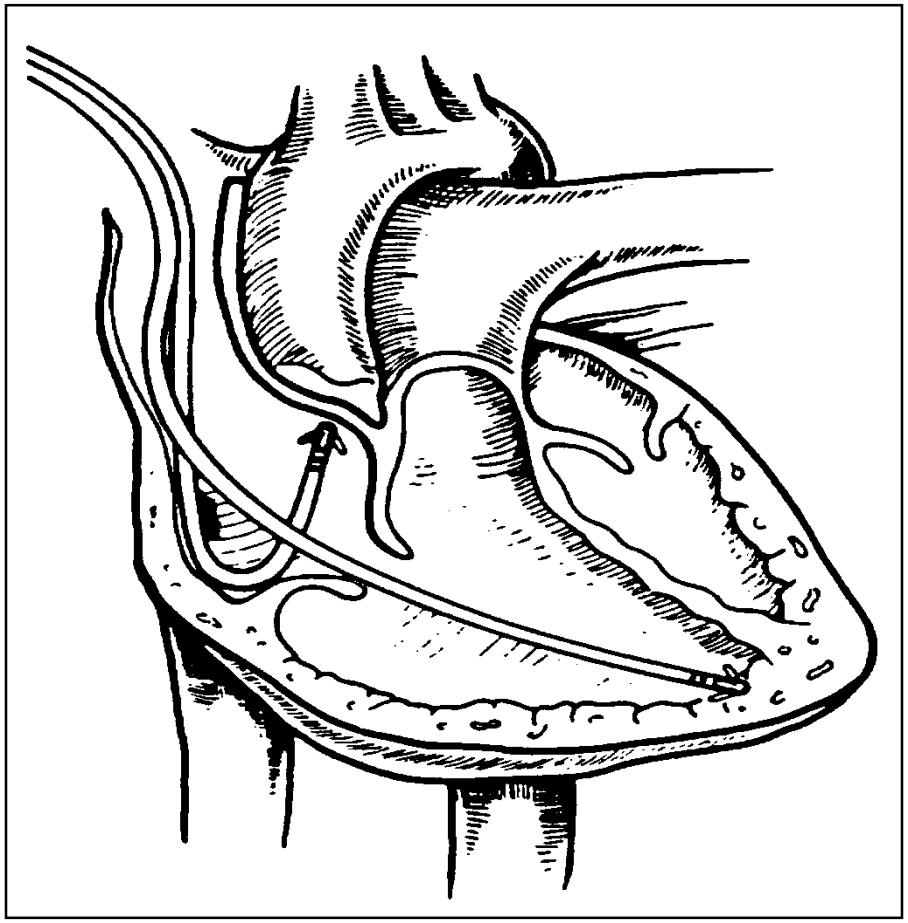
$_{a}V_{R}$

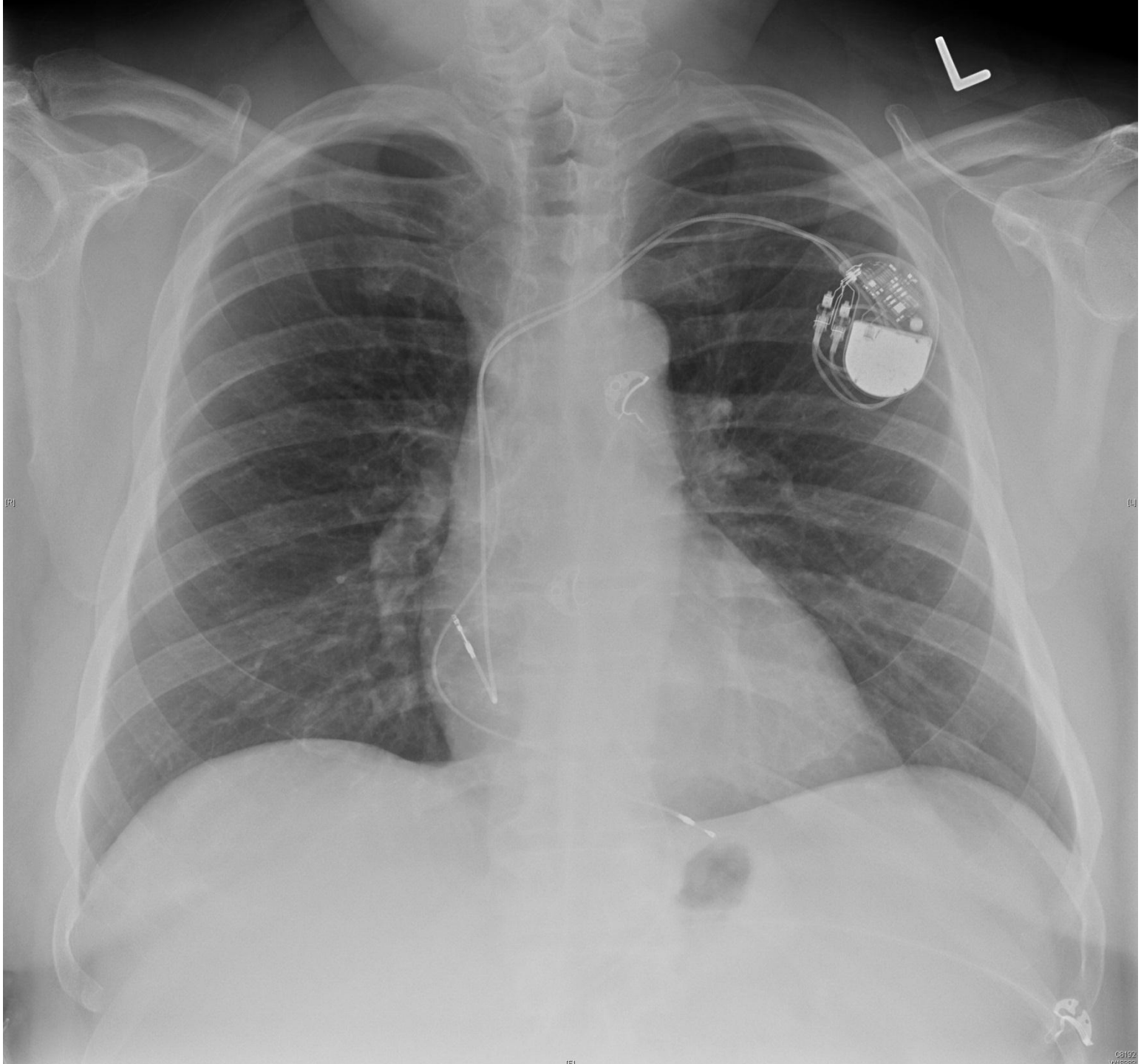
$_{a}V_{L}$

Dual-Chamber Systems Have Two Leads:

- One lead implanted in both the atrium and the ventricle

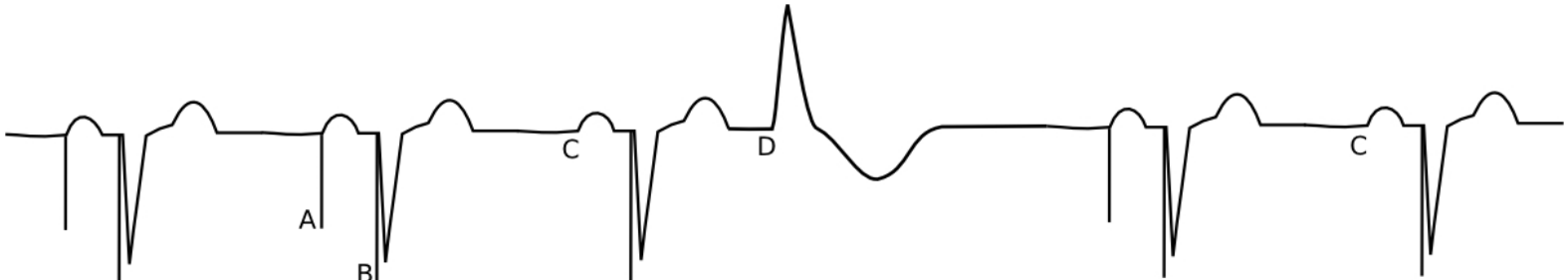
- (D) Dual chamber pace
- (D) Dual chamber sense
- (D) Inhibit and trigger



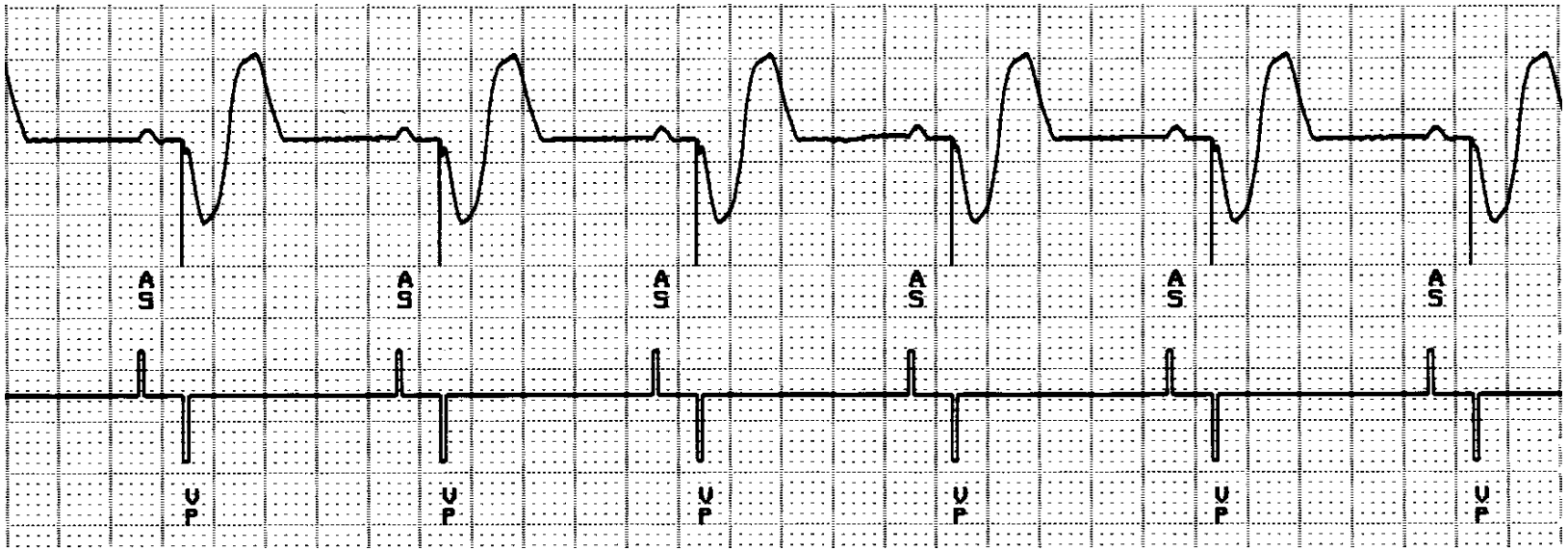

L

DDD

- 1. Sensed Atrial impulse?
  - (YES) Inhibit atrial pacing.
  - (No) pace atrium
- 2. AV delay
- 3. Sensed Ventricular impulse?
  - (Yes) Inhibit ventricular pacing
  - (No) pace ventricle

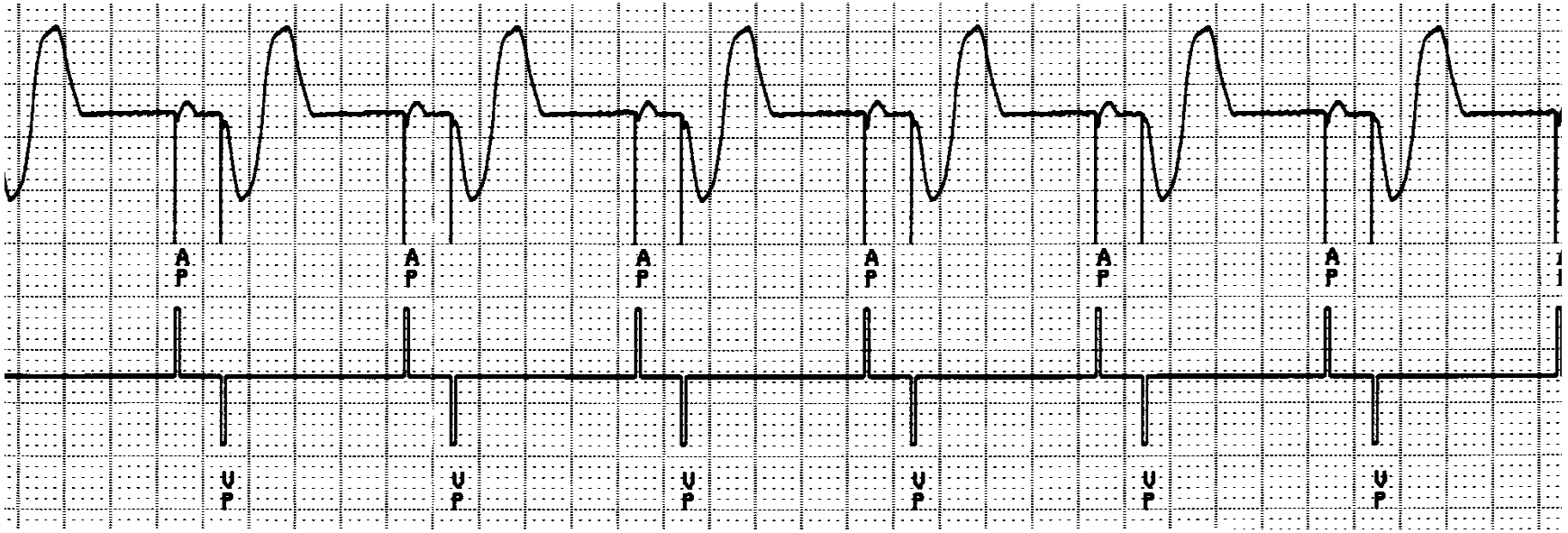


DDD



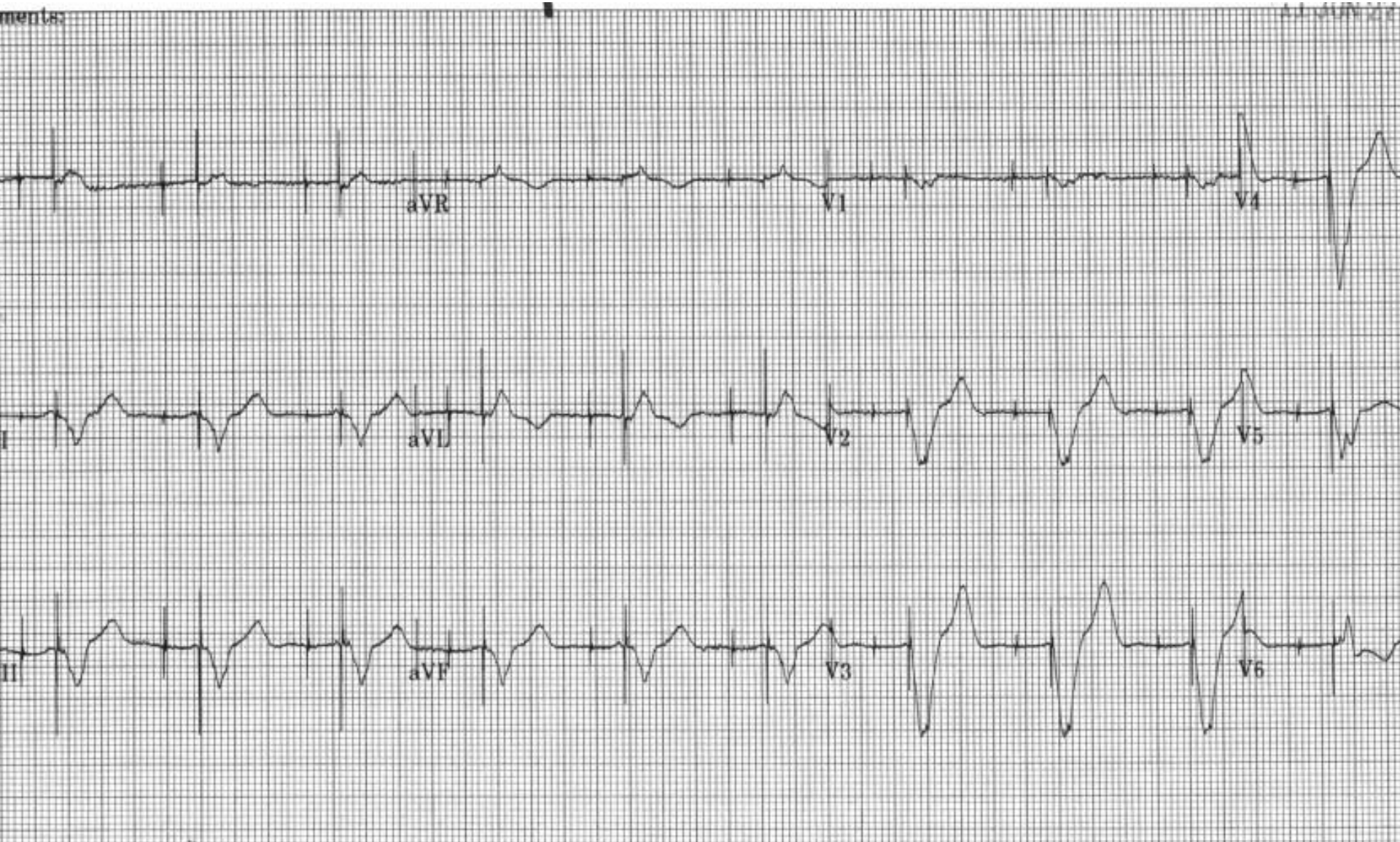
DDD / 60 / 120

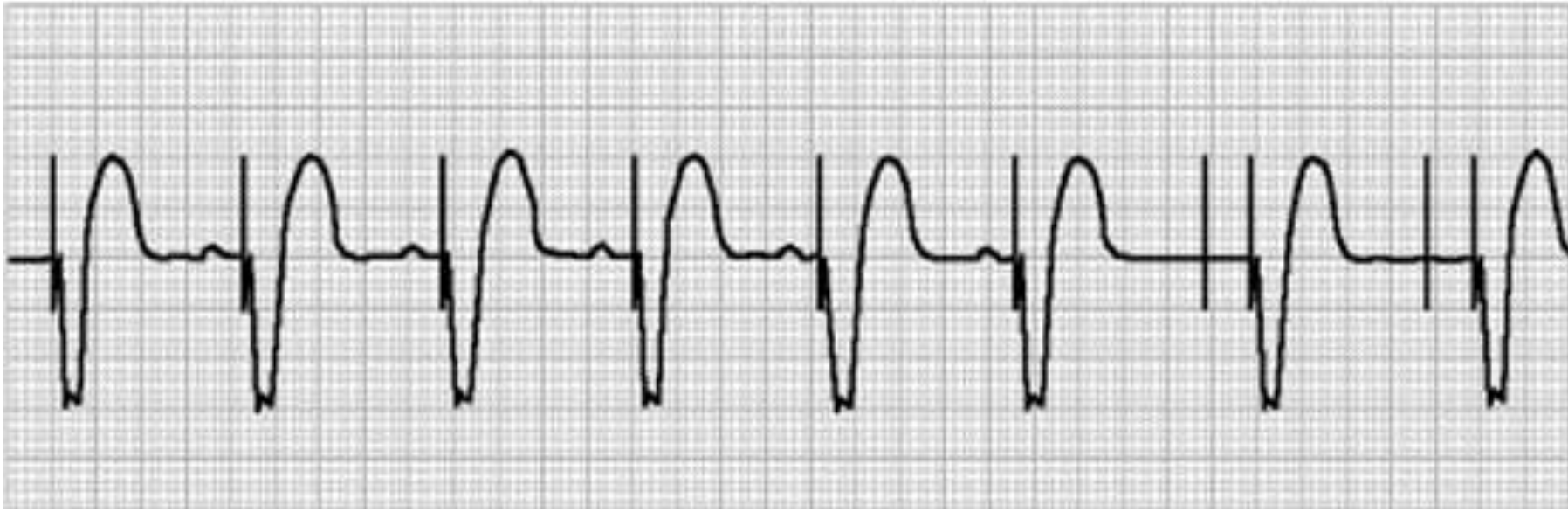
Paced Rhythm Recognition



DDD / 60 / 120

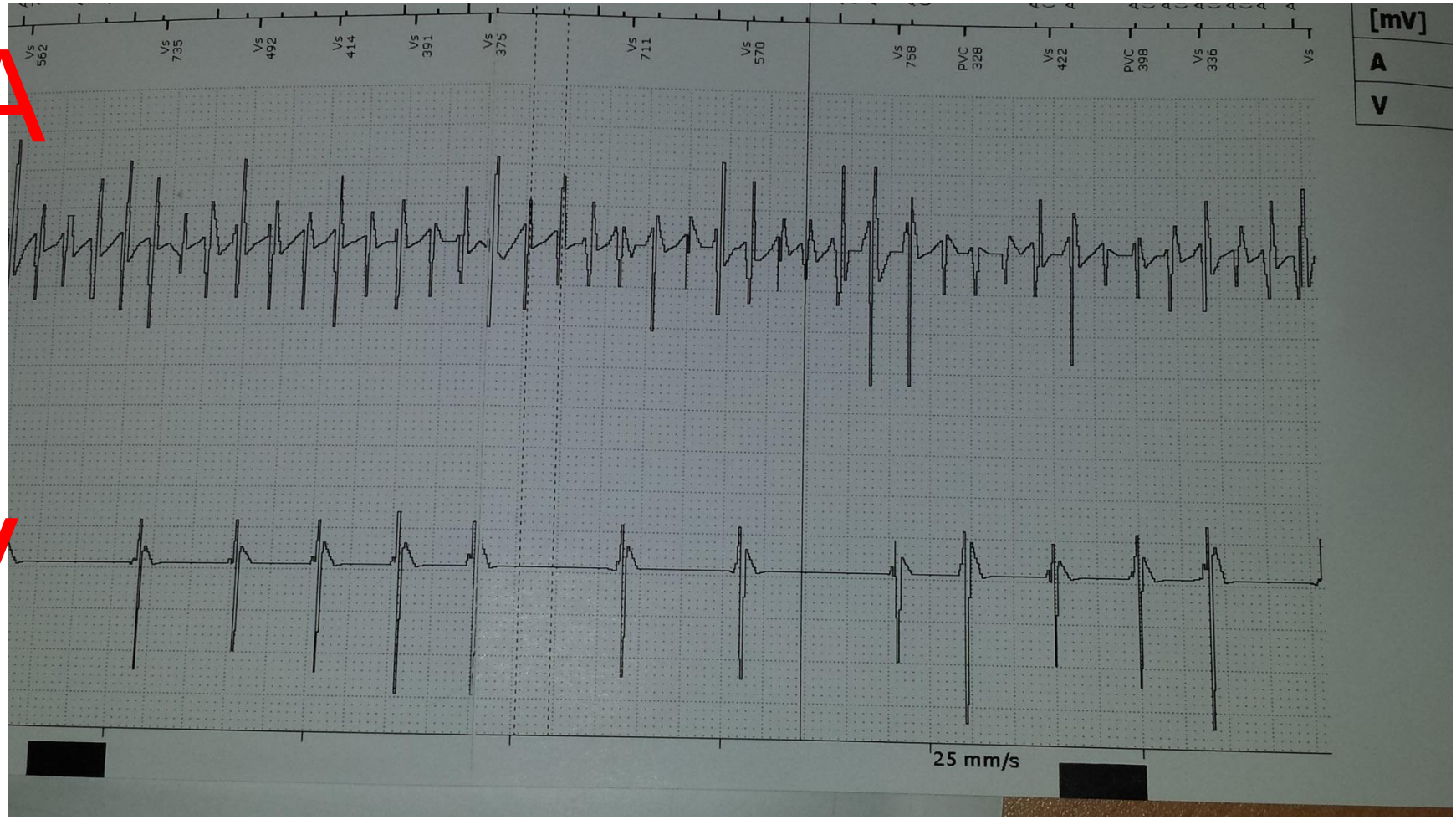
DDD





Other Pacemaker features

- Holter monitor
  - Ability to record arrhythmias (?Afib, VT)


A
V
Vs 562
Vs 735
Vs 492
Vs 414
Vs 391
Vs 375
Vs 711
Vs 570
Vs 758
PVC 328
Vs 422
PVC 398
Vs 336
Vs
[mV]
A
V
25 mm/s

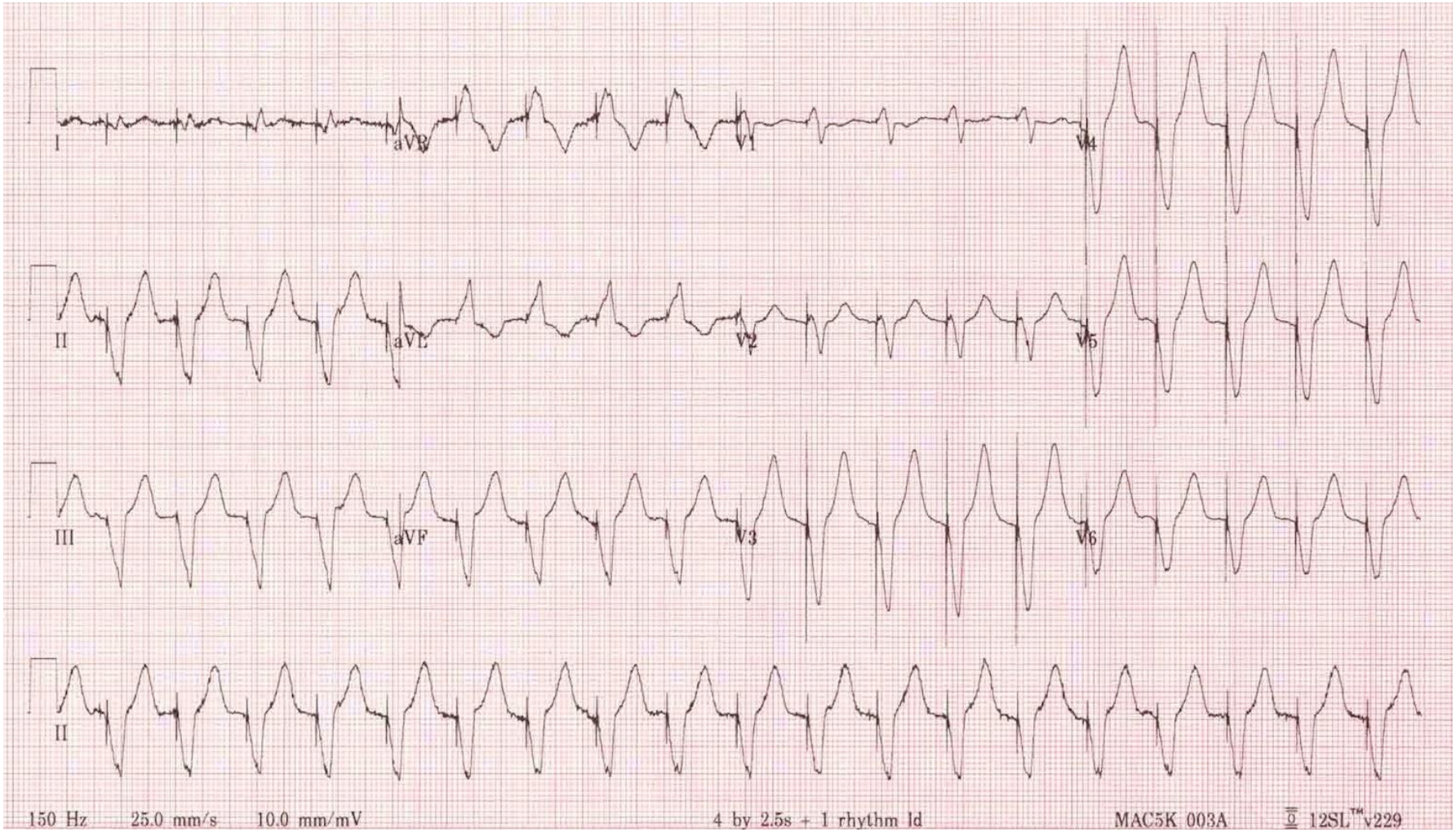
A

V

Other Pacemaker features

- Holter monitor
  - Ability to record arrhythmias (?Afib, VT)
- Mode switching (favorable pacing mode during paroxysmal Afib)
- Algorithms to reduce pacing/conserve battery

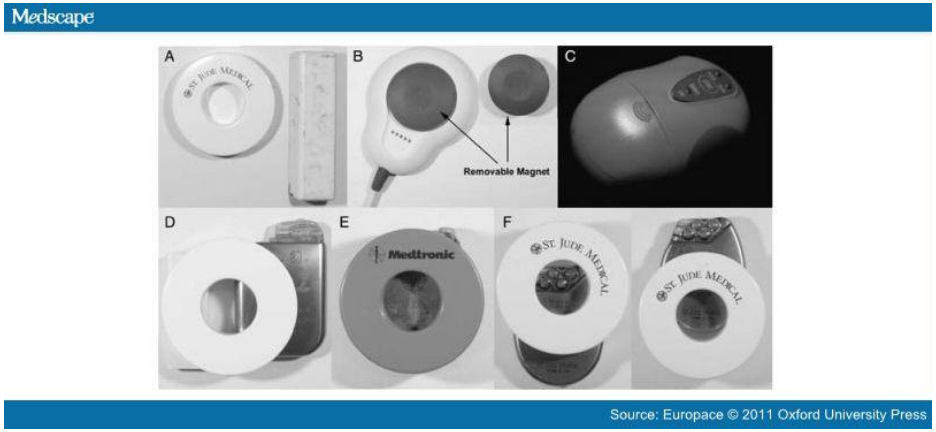
Pacemaker induced tachycardia (DDD)



PMT

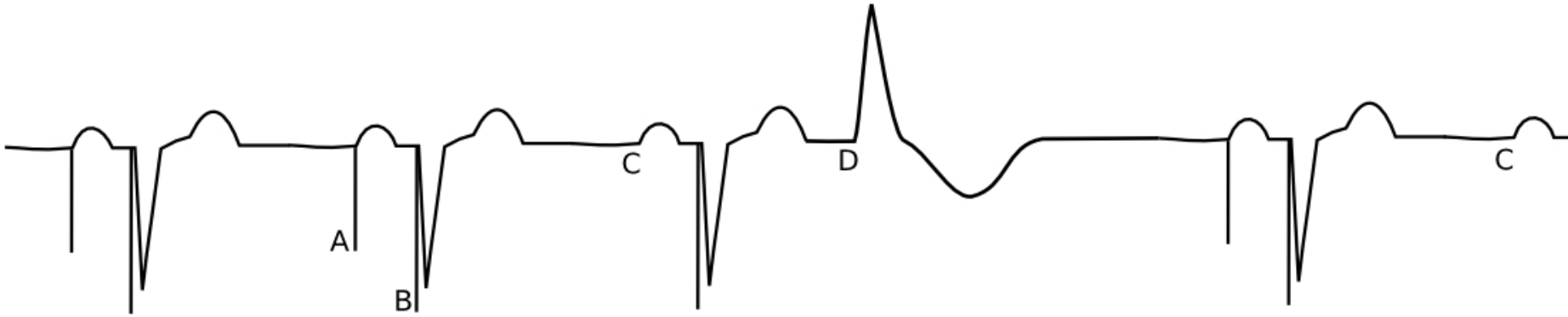

AS 668
AS 515
PAC 503
AS 500
AS 503
AS 500
AS 500
AS 500
AS 503
AS 500
AS 500
AS 500
AS 503
-MT
RVP-MT 500
RVP-MT 500
RVP-MT 500
RVP-MT 500
RVP-MT 500
RVP-MT 500
RVP-MT 500
RVP-MT 500
RVP-MT 500
RVP-MT 500
RVP-MT 500

Magnet



- Changes to asynchronous pacing mode (Non sensing) ie. VOO, DOO
- Good for surgeries, PMT.
- Paces at max output (some vendors)
- DOES NOT TURN OFF PACEMAKER

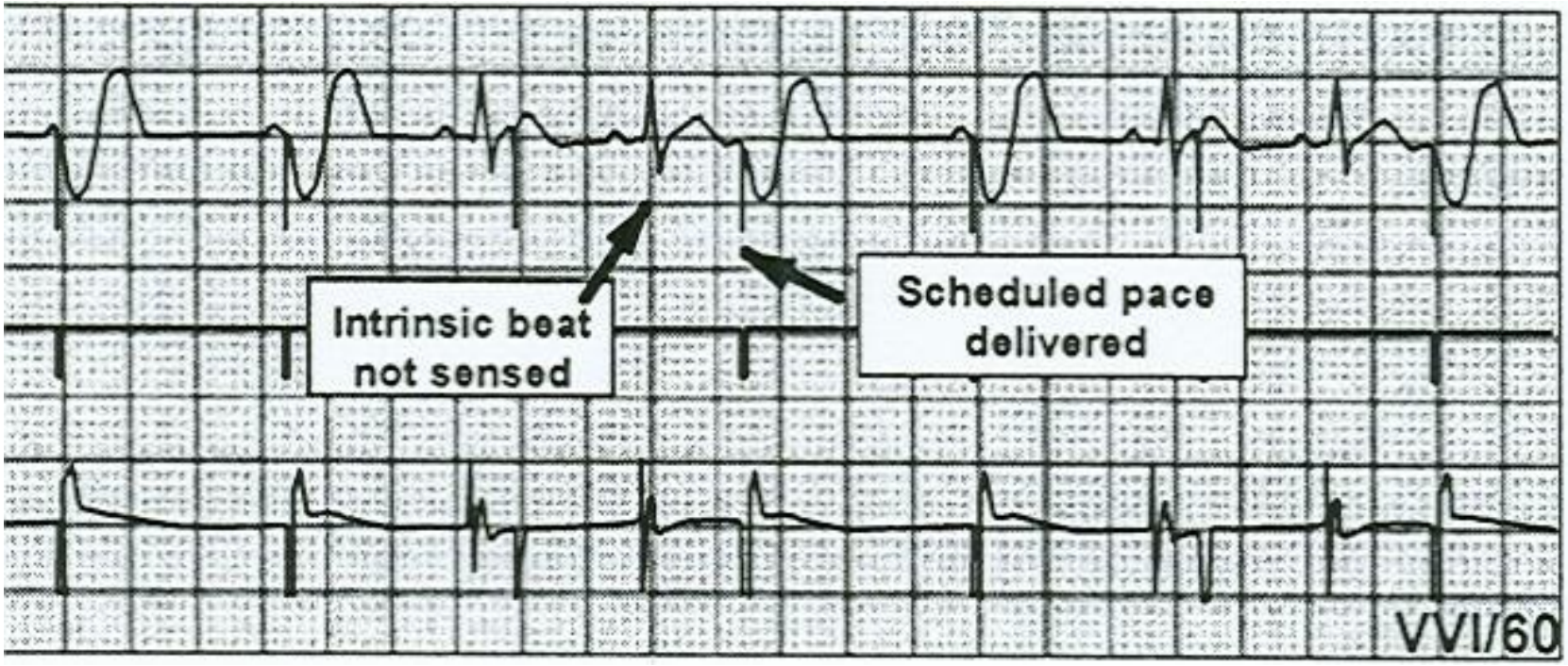
DDD



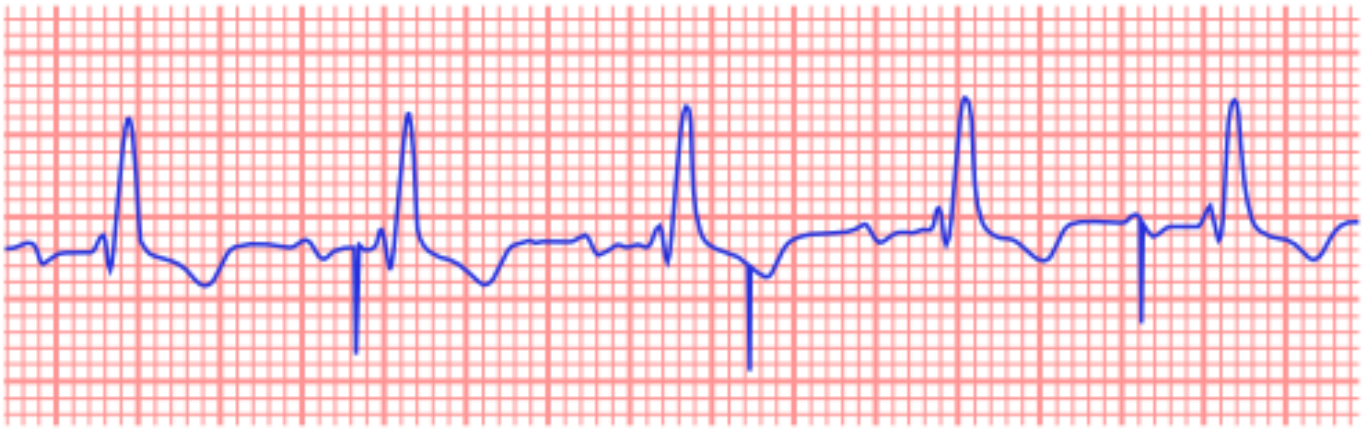
- A = Atrial paced beat
- B = Ventricular paced beat
- C = Atrial sensed beat (inhibiting the PM)
- D = Ventricular sensed beat (inhibiting the PM)

PACEMAKER TROUBLESHOOTING

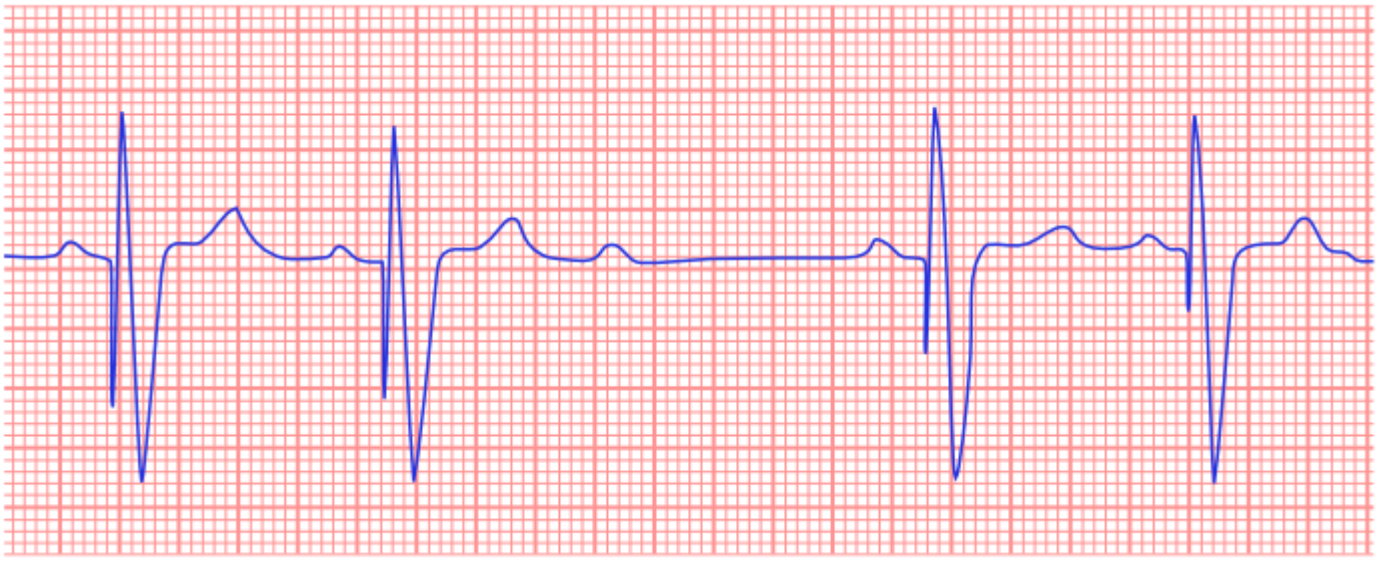
Pacemaker undersensing



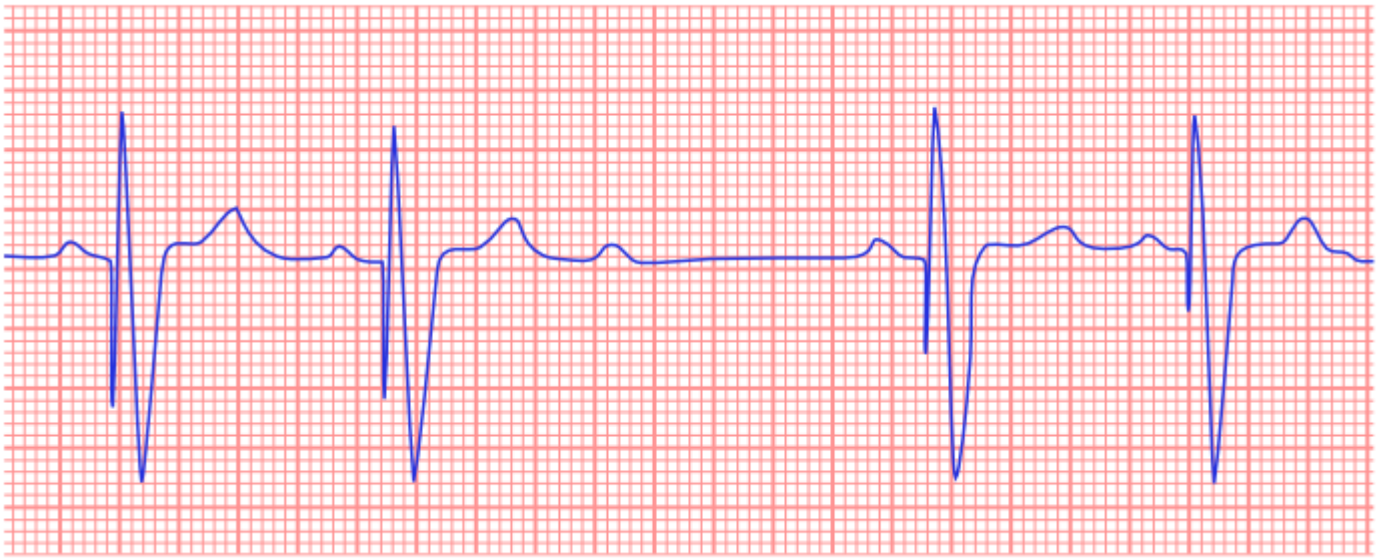
Pacemaker undersensing



Pacemaker Oversensing

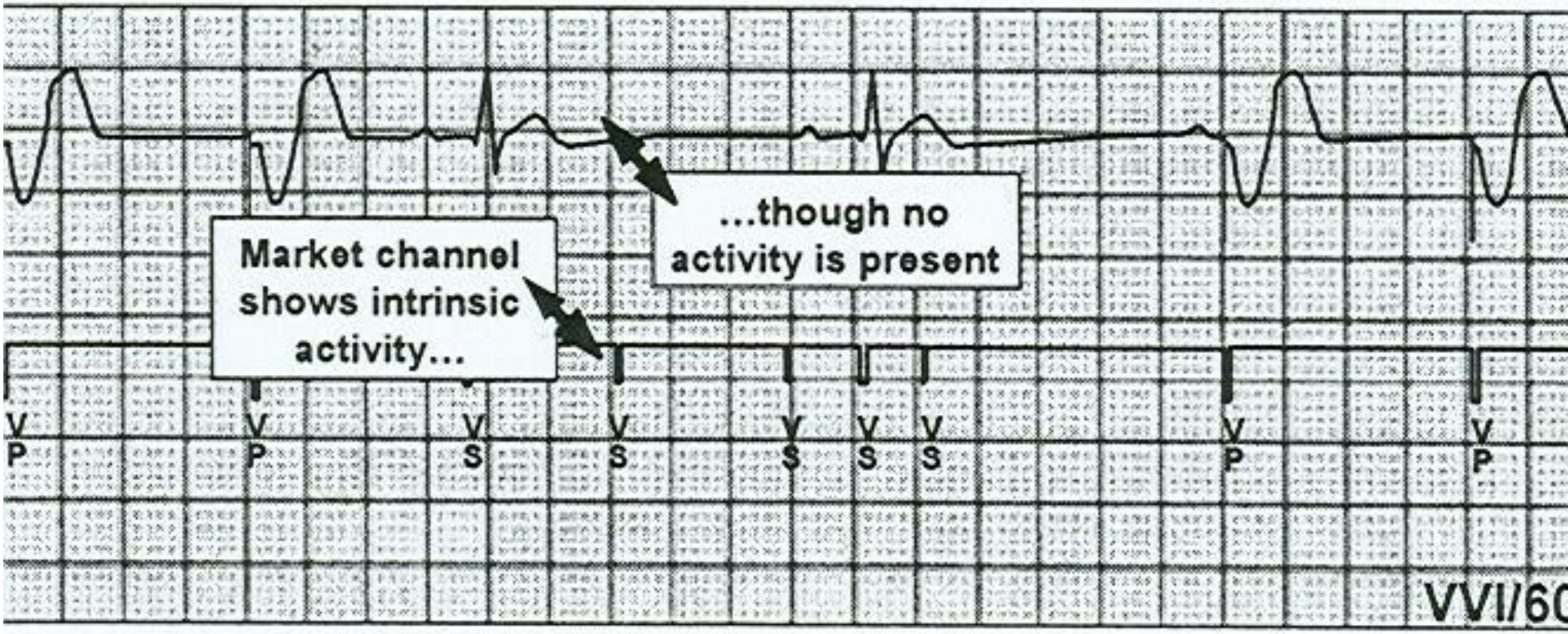


Pacemaker Oversensing

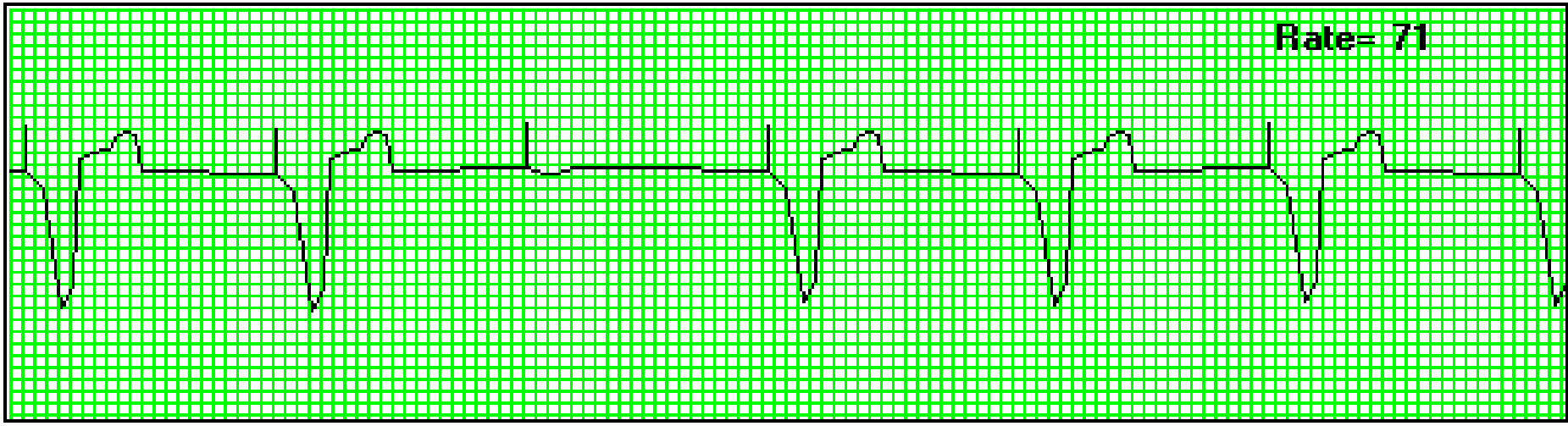


Pacemaker inhibits (ie does not pace)
Over senses noise- which confuses device as intrinsic rhythm

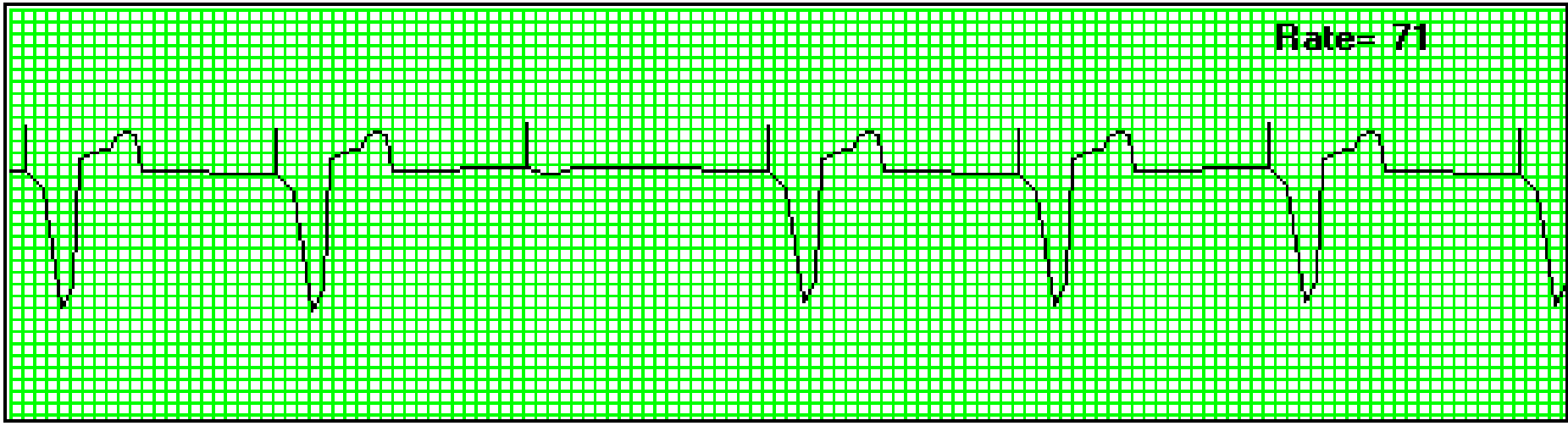
Oversensing



Failure to capture

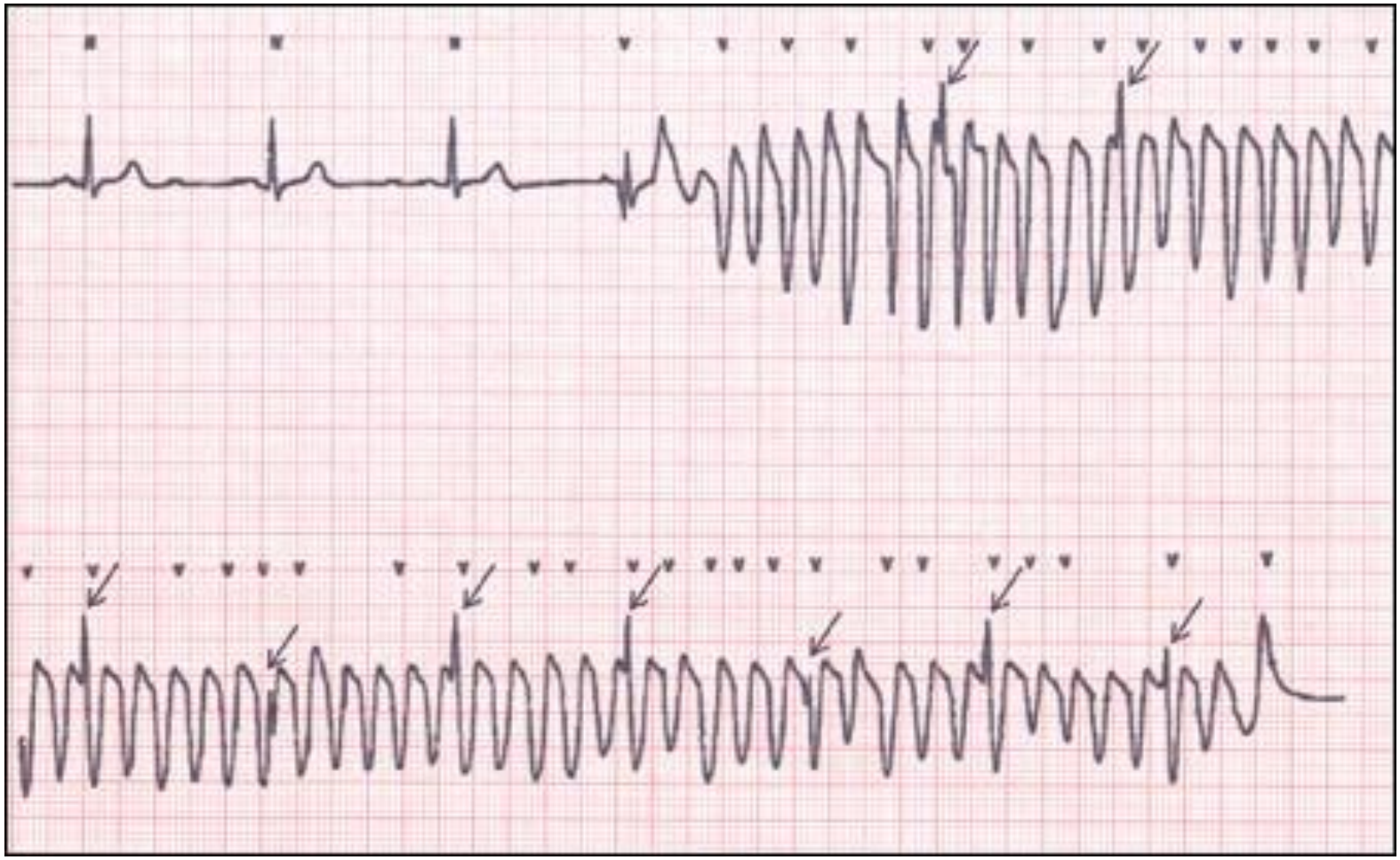


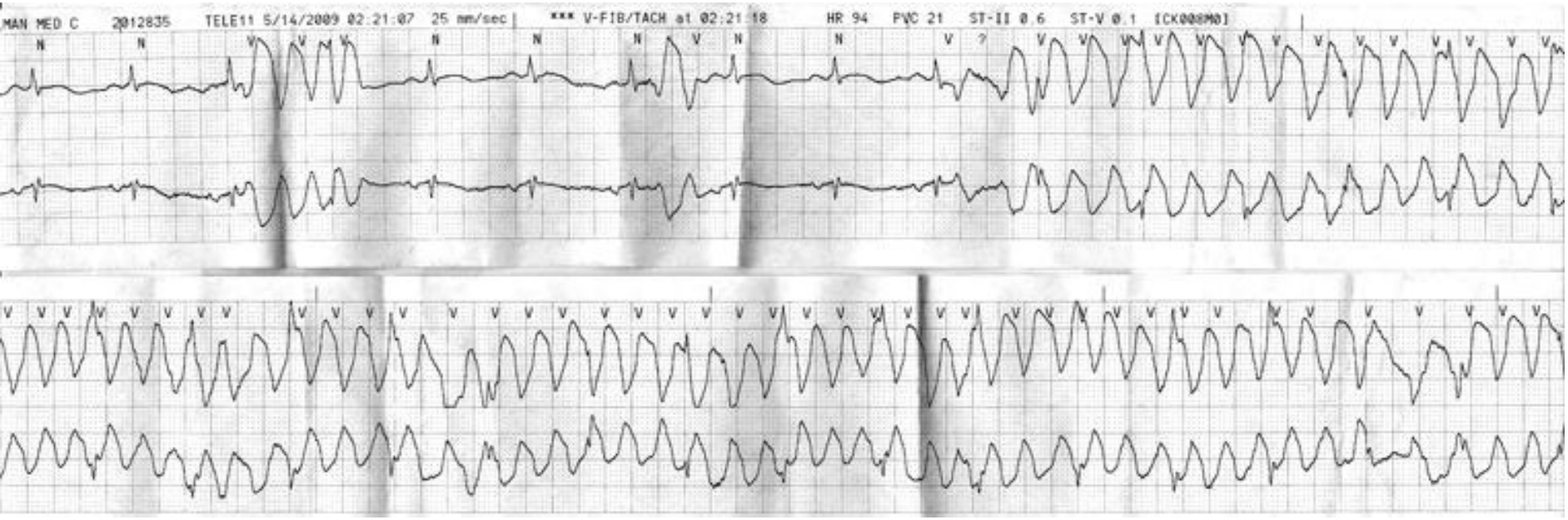
Failure to capture



Pacemaker spike, but NO QRS or p wave

- Is it real?
  - Does it make sense?
  - Are QRS marching through?
    - Hint- find onset and offset of arrhythmia
  - What was the patient doing
  - Were there any symptoms?



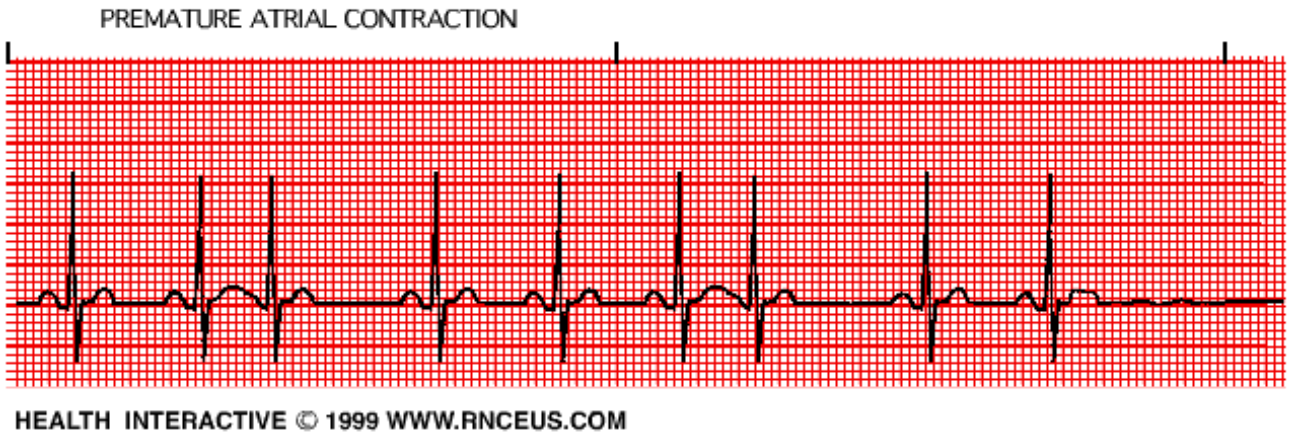

MAN MED C 2012835 TELE11 5/14/2009 02:21:07 25 mm/sec
*** V-FIB/TACH at 02:21:18
HR 94 PVC 21 ST-II 0.6 ST-V 0.1 [CK000M0]

ECTOPY

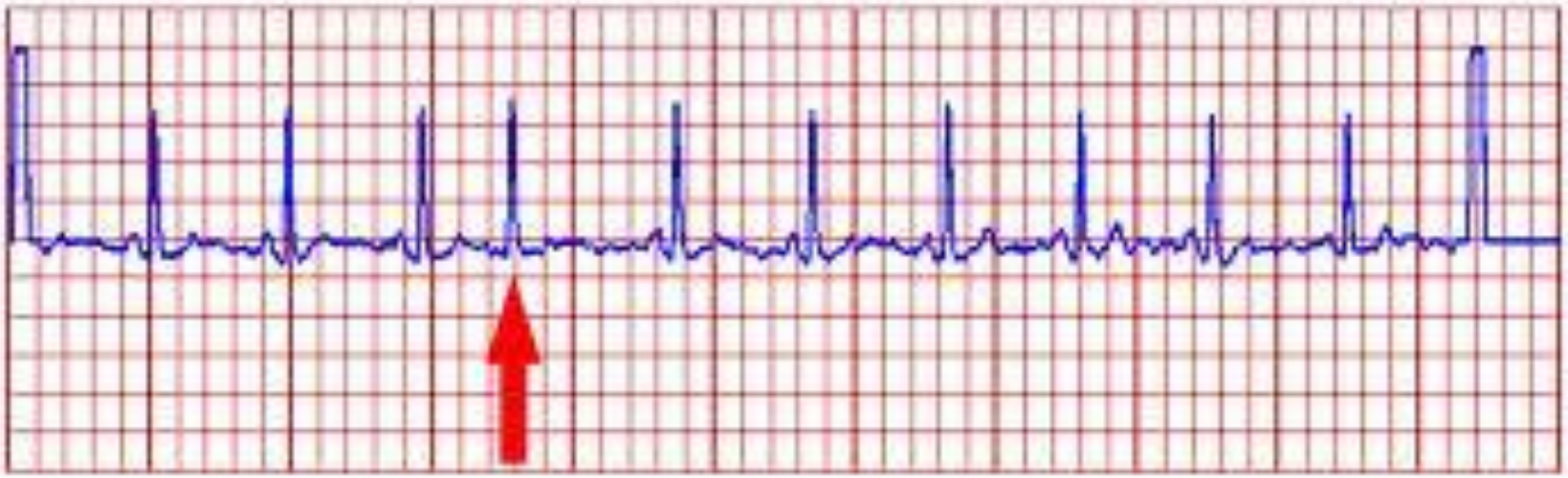
Significance

- PACs
  - Can trigger arrhythmia (SVT, Afib)
  - Can be symptomatic
- PVCs
  - Can trigger VT, Torsade
  - Can signify ischemia
  - Can cause LV dysfunction over time (if very frequent)
  - Can be symptomatic

PREMATURE ATRIAL CONTRACTION



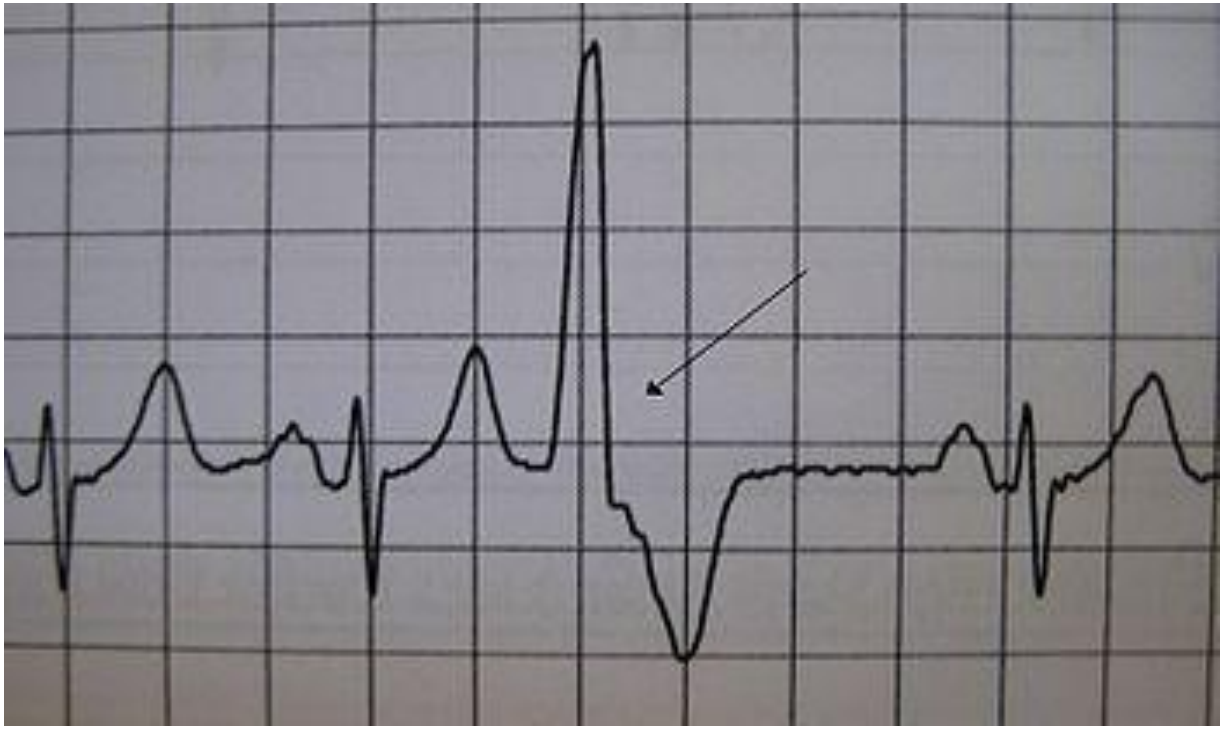
Premature QRS preceded by p wave
May have different p wave morphology
May reset sinus/compensatory pause

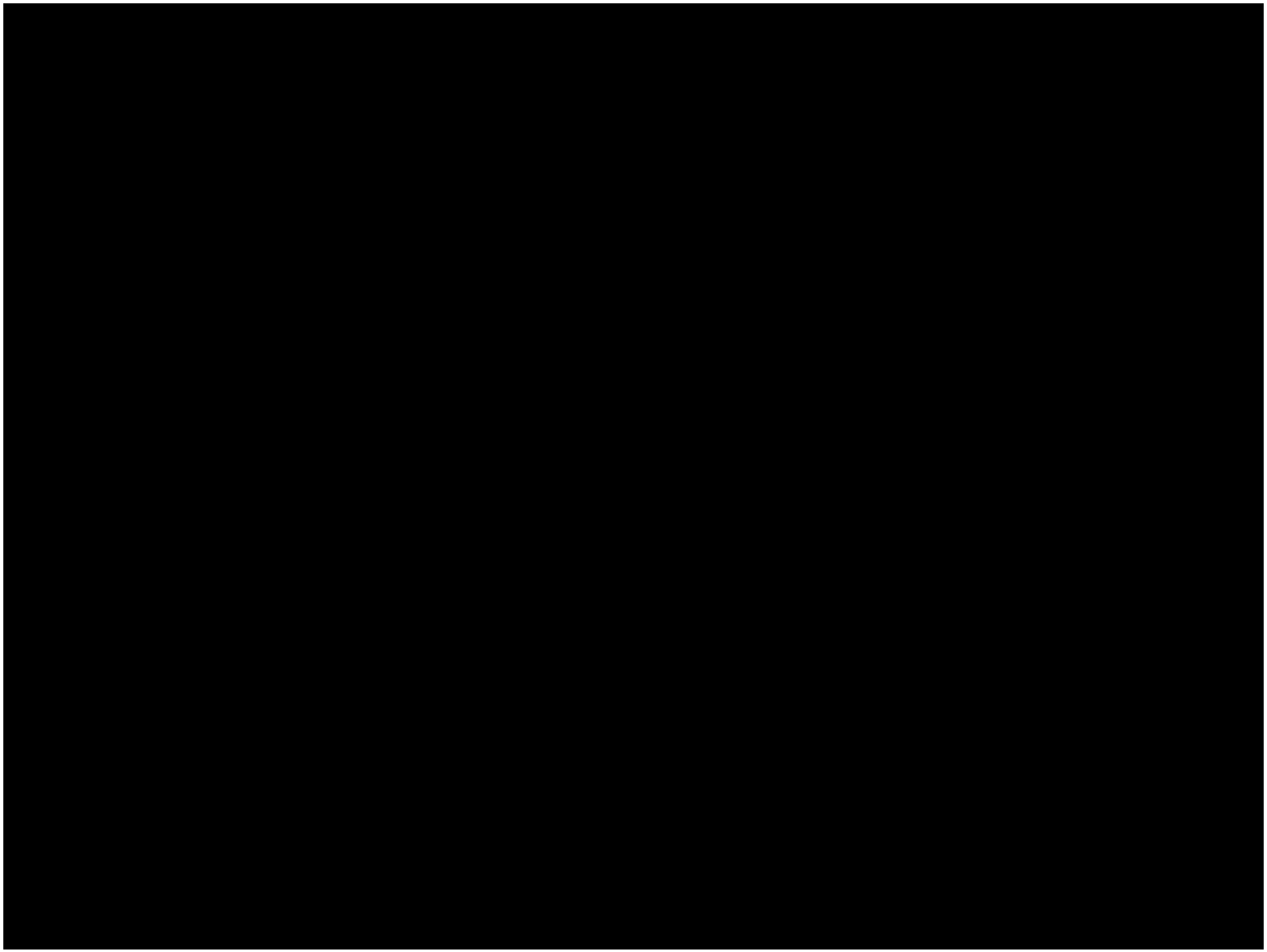


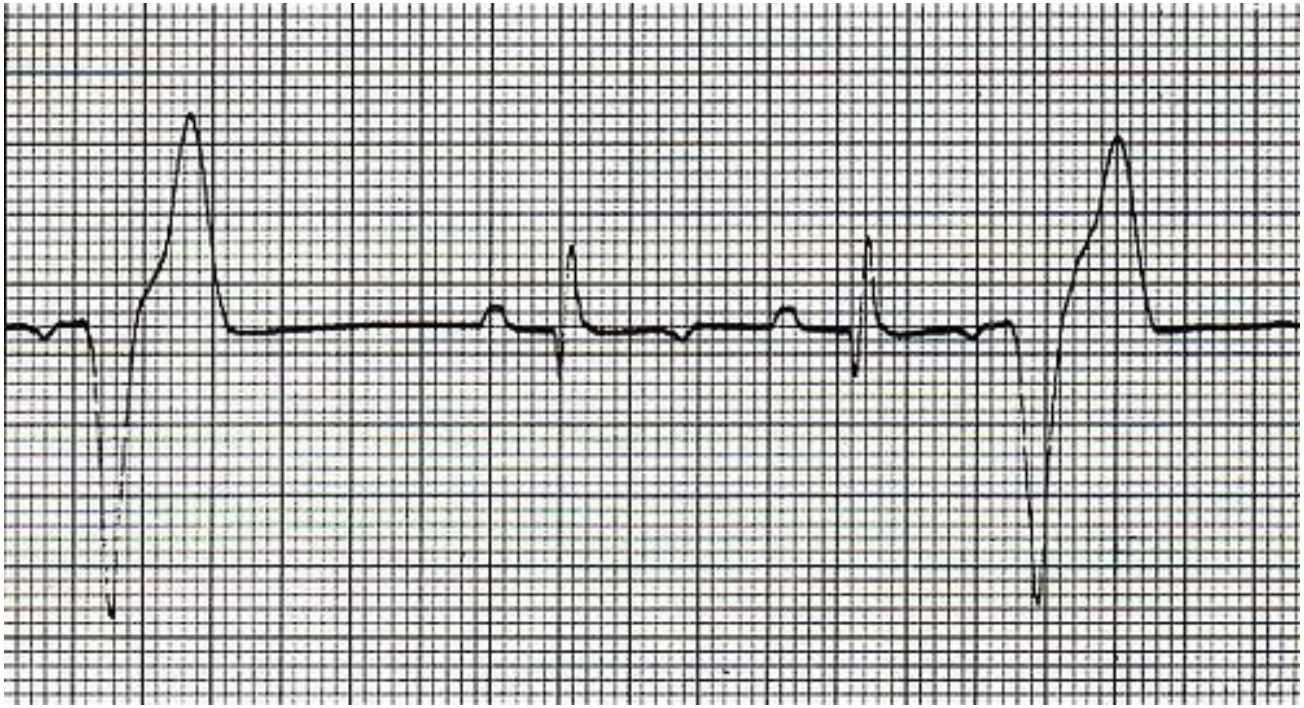
Scale: 200ms/div || R-R Time (min/ave/max): 636 / 940 / 1168ms || St. Dev: 135ms || Pulse (10 sec. ave.): 64bpm

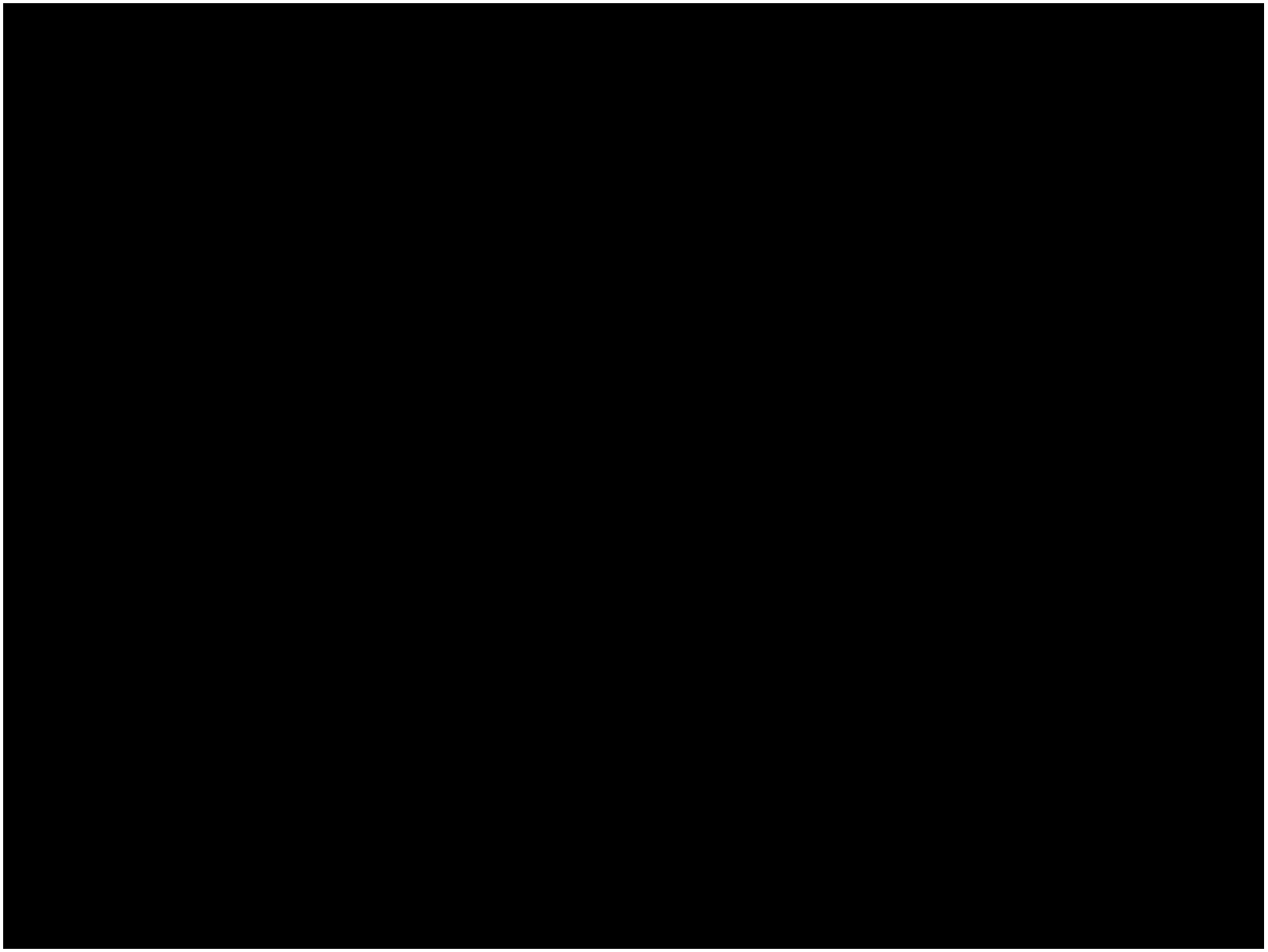
PVC

- Premature, occurring before & next expected beat
- No P wave before the PVC.
- Compensatory pause
- QRS widened (0.12 or wider)
- T wave is usually oppositely directed from QRS complex.









Thank you for your attention. Please enjoy your day!