
ВЫХОД
ЭКСКУРСИЙ
ИЗ ГРОТОВ

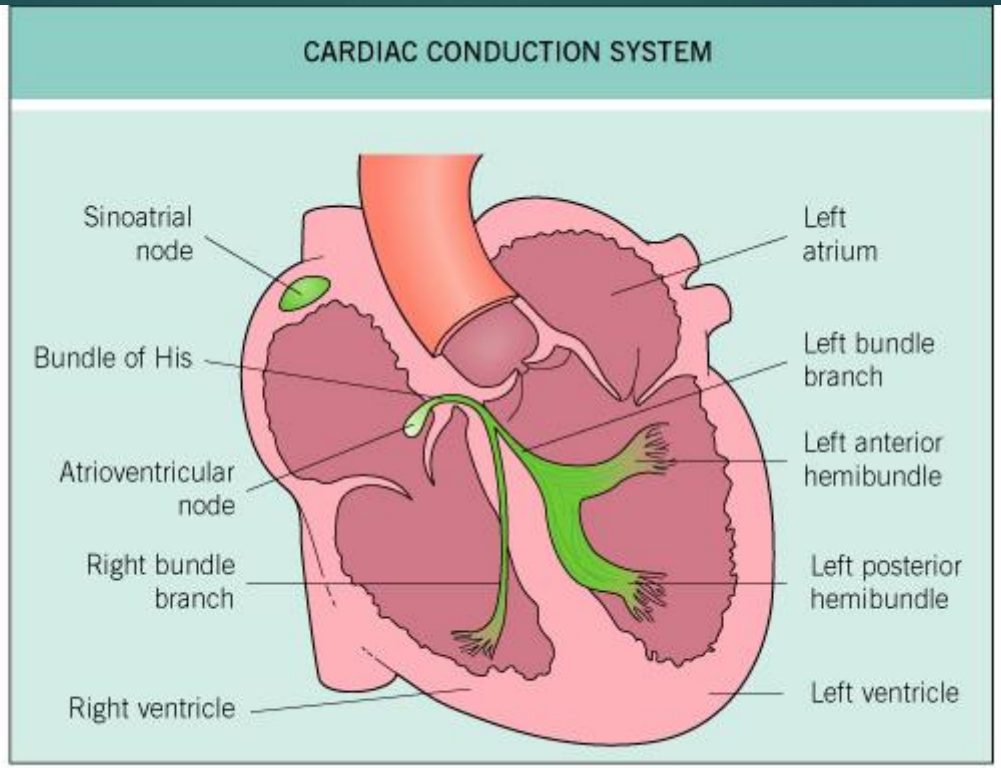
# ~~Fast &~~ Slow

## ~~Tachy &~~ Brady Arrhythmias & Pacemakers

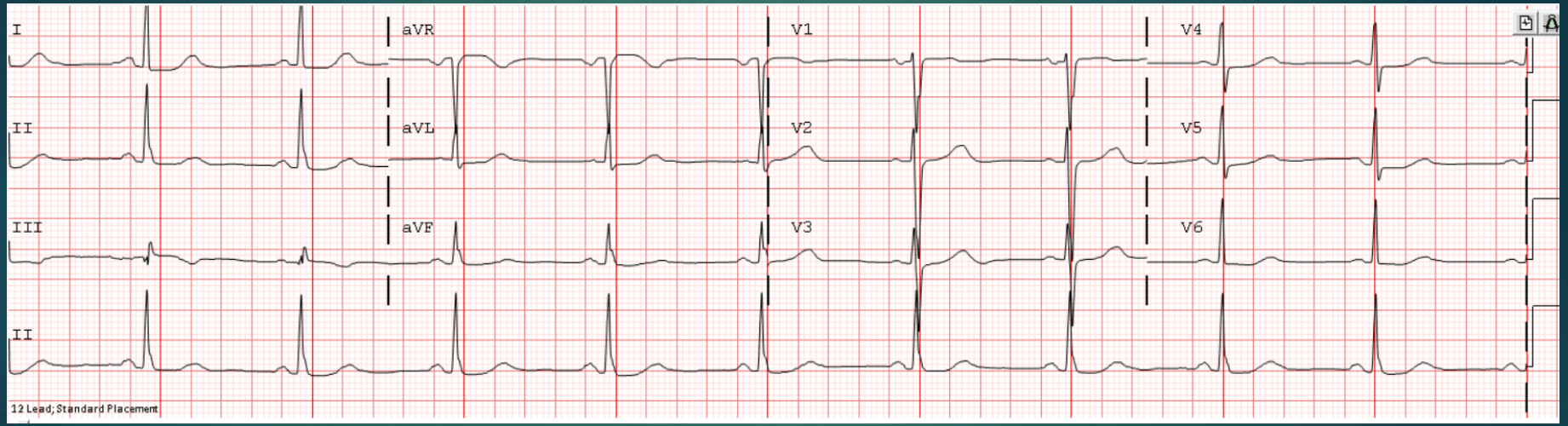

https://nypost.com/2020/09/30/shares-of-elon-musks-privately-held-spacex-soar-on-satellite-dreams/


https://techcrunch.com/2020/11/09/elon-musks-boring-company-is-setting-up-operations-in-austin/

DAVID STULTZ, MD, FACC
KHMG HEART & VASCULAR
AUGUST 25, 2021



# Normal EKG


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II
12 Lead; Standard Placement

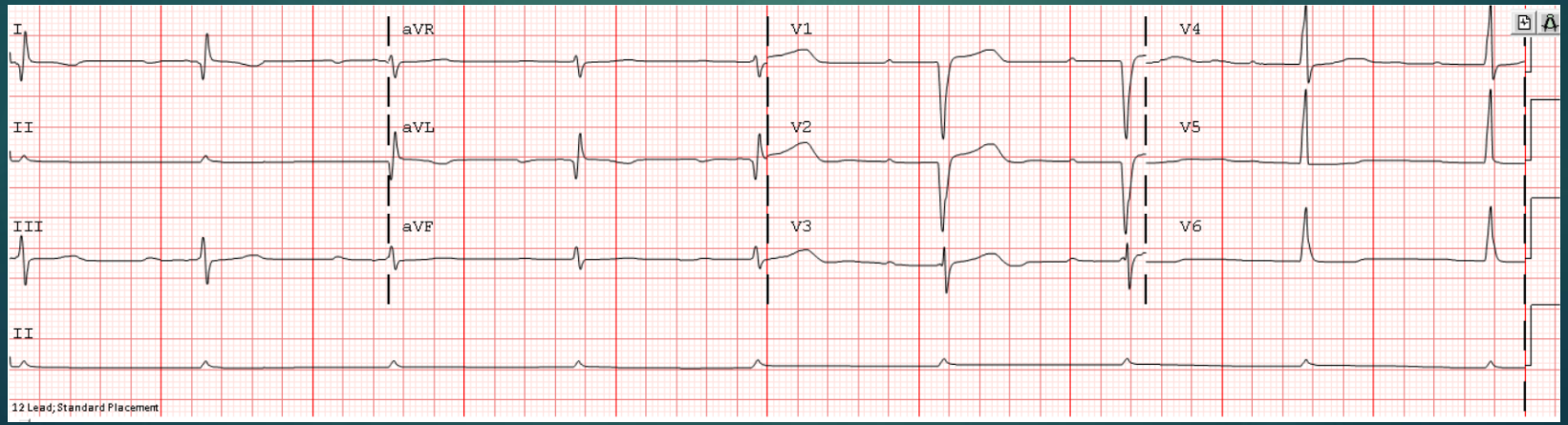
# EKG boxes

- Heart Rate
  - 1 big box = 200ms
  - 1 small box = 40ms

| Big Boxes<br>Between QRS complexes | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Heart Rate<br>(300/big boxes) | 300 | 150 | 100 | 75 | 60 | 50 | 42 |

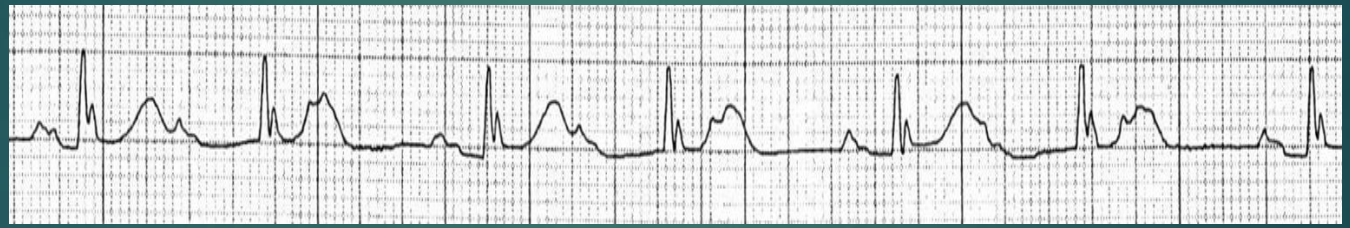
# 1st Degree AV Block

- >200 ms from onset of P wave to onset of QRS

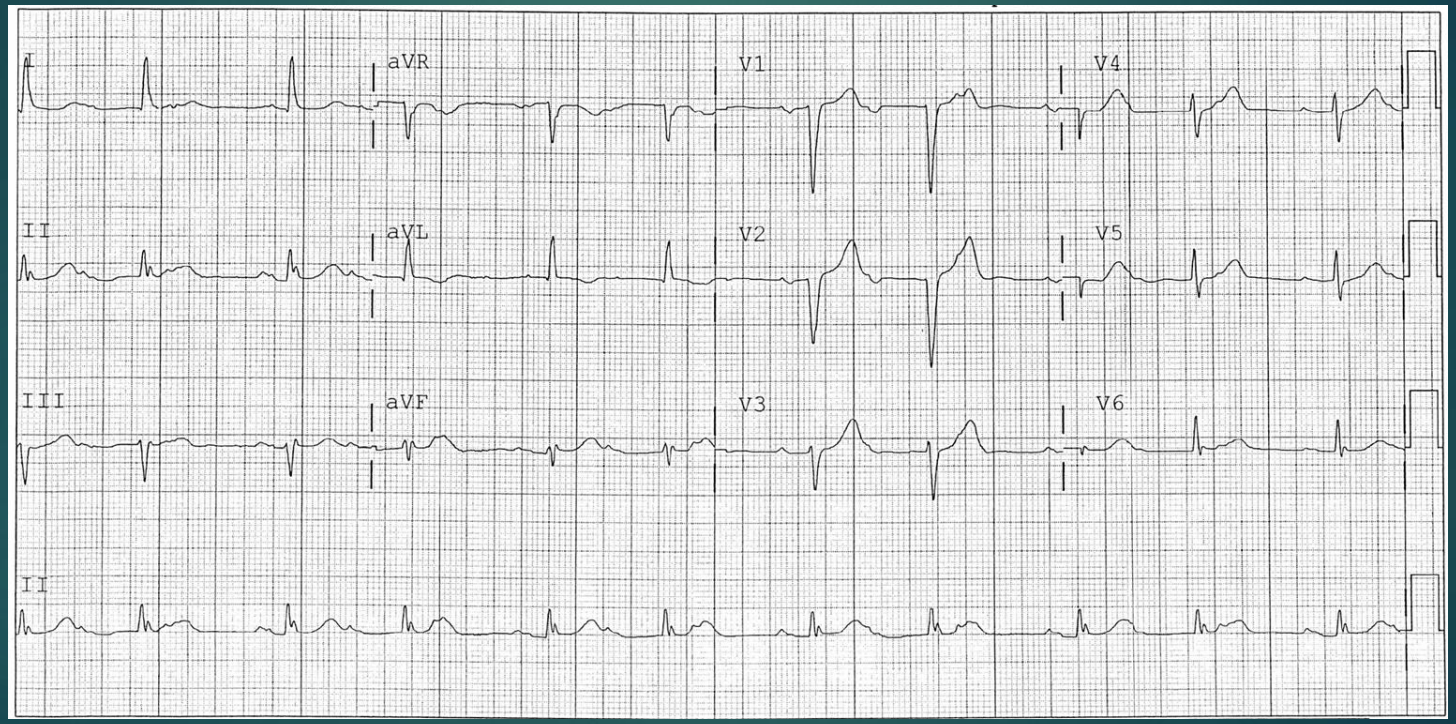


# 2nd Degree AV Block Type 1 - Wenckebach

- P-R interval prolongs until QRS is dropped

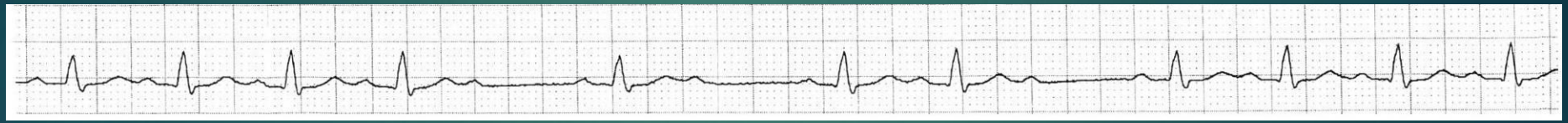


# 2nd Degree AV Block
# Type 1 - Wenckebach

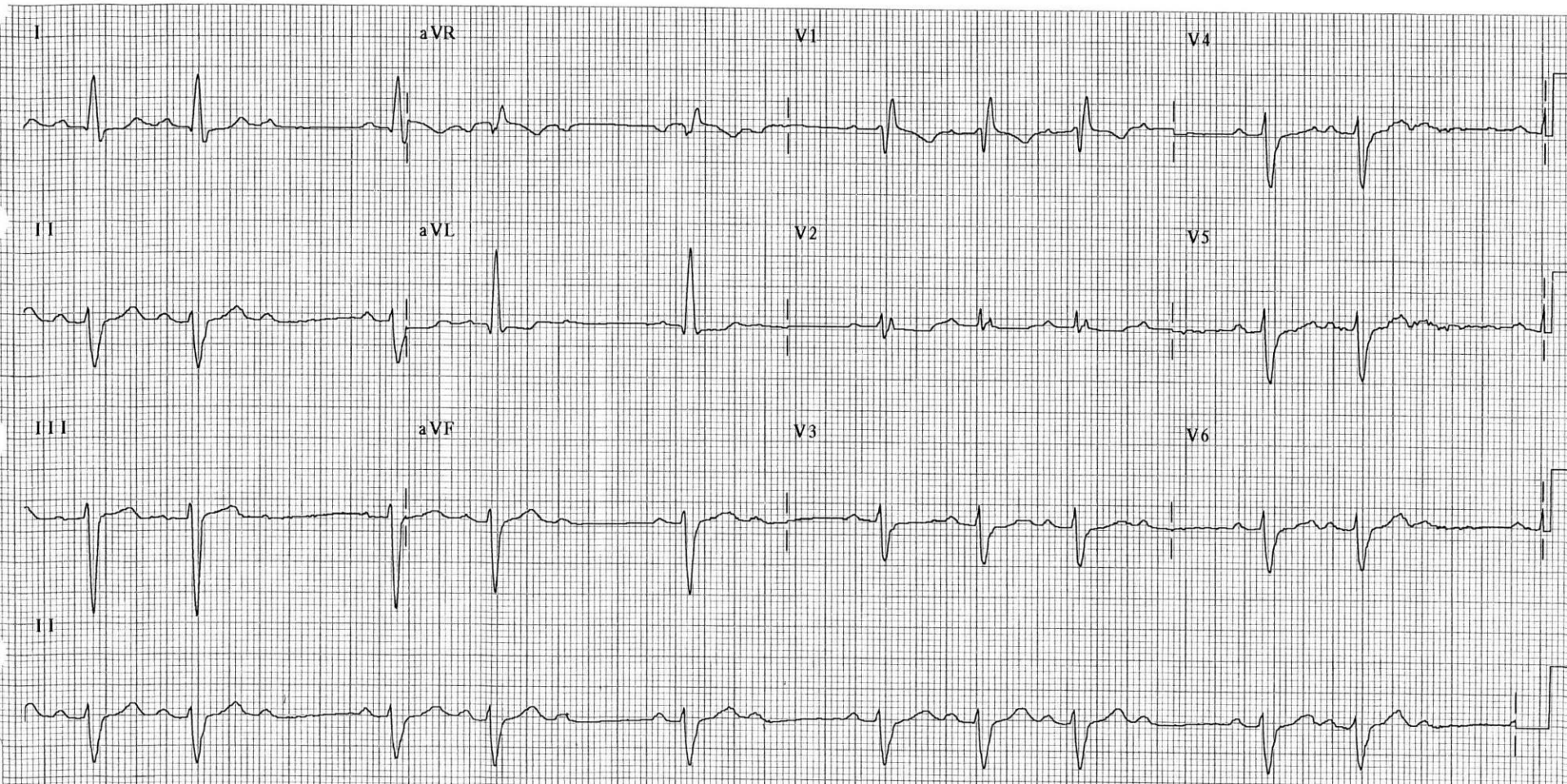


# 2nd Degree Heart Block Type 2

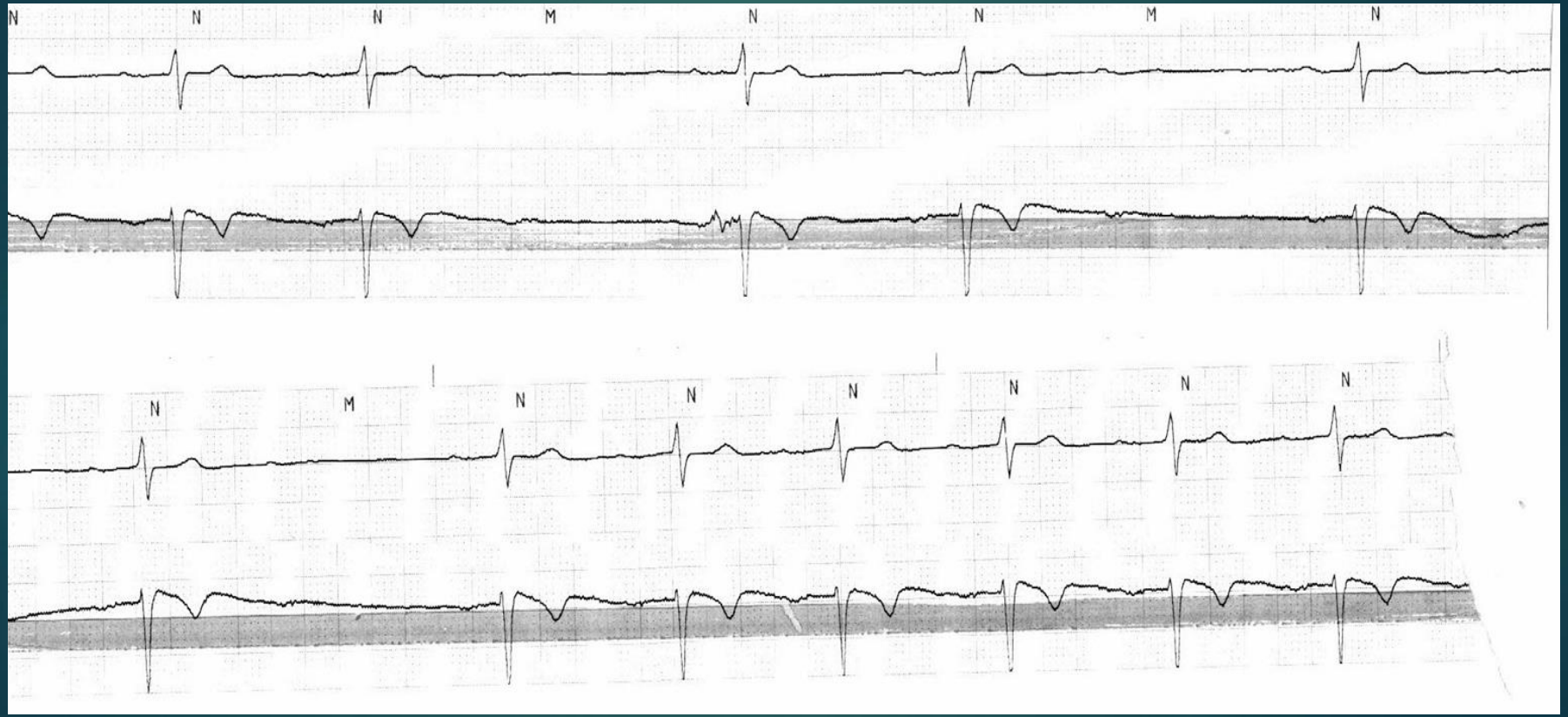
- PR interval remains constant, QRS drops unexpectedly



# 2nd Degree Heart Block Type 2

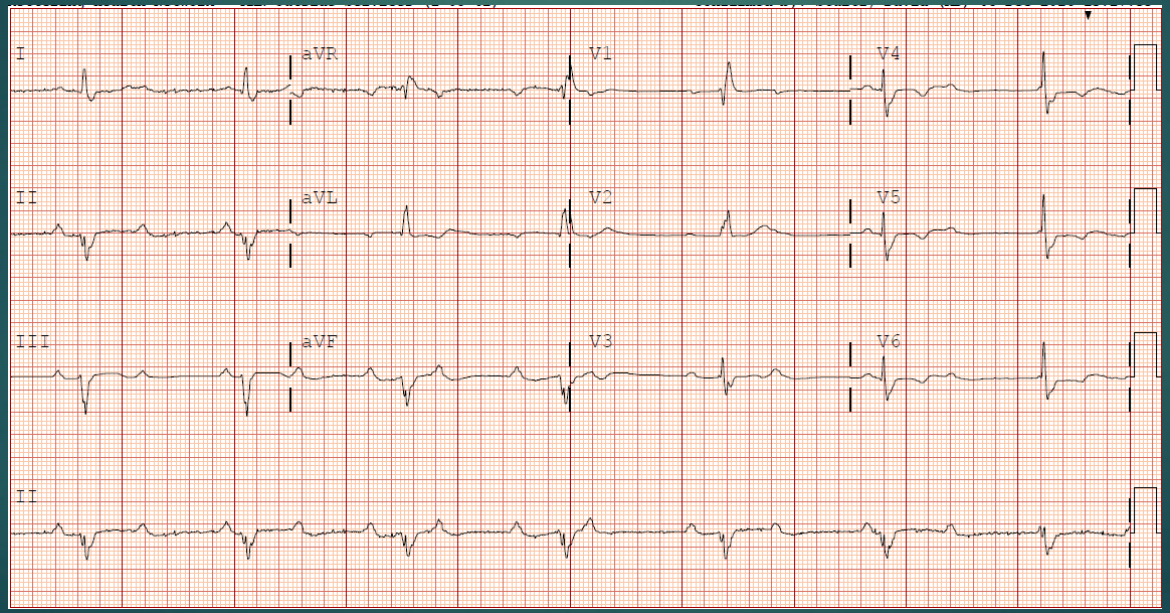


# 2nd Degree Heart Block Type 2



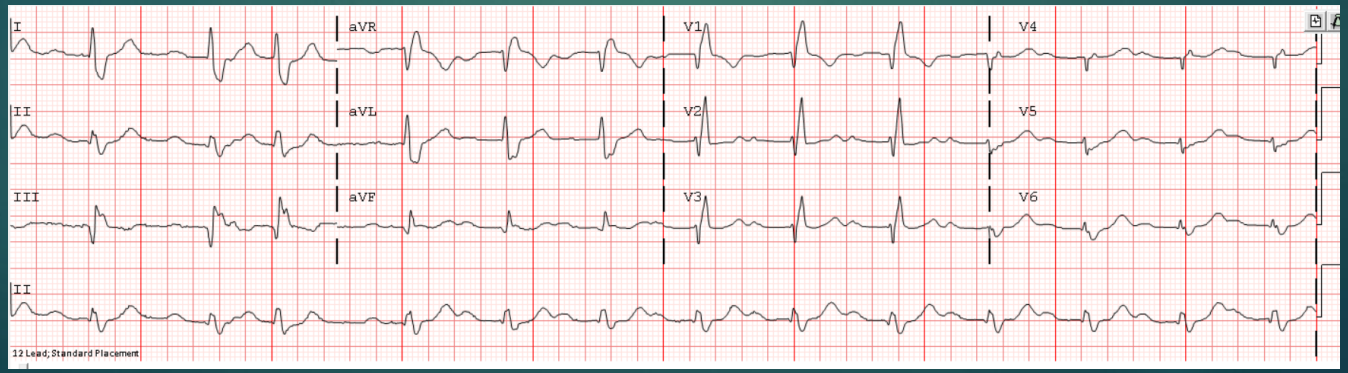
# 3rd degree Heart Block

- P rate faster than QRS rate
- No correlation between P's and QRS



# Bundle Branch Blocks

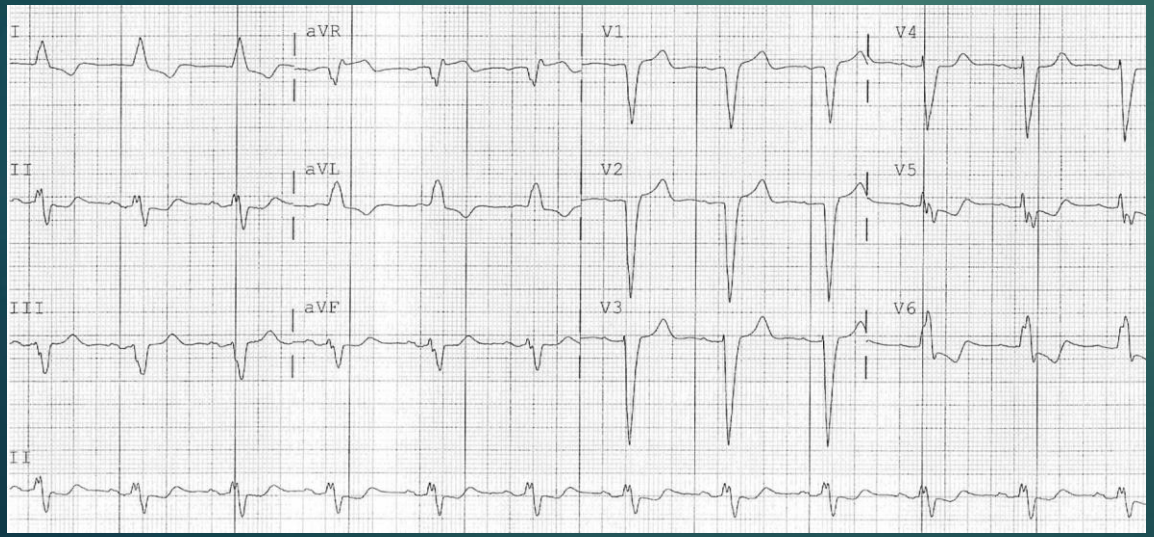

- Right Bundle Branch Block
  - QRS duration >120ms (3 small boxes)
  - rsR' in V1
  - 'Rabbit Ears'

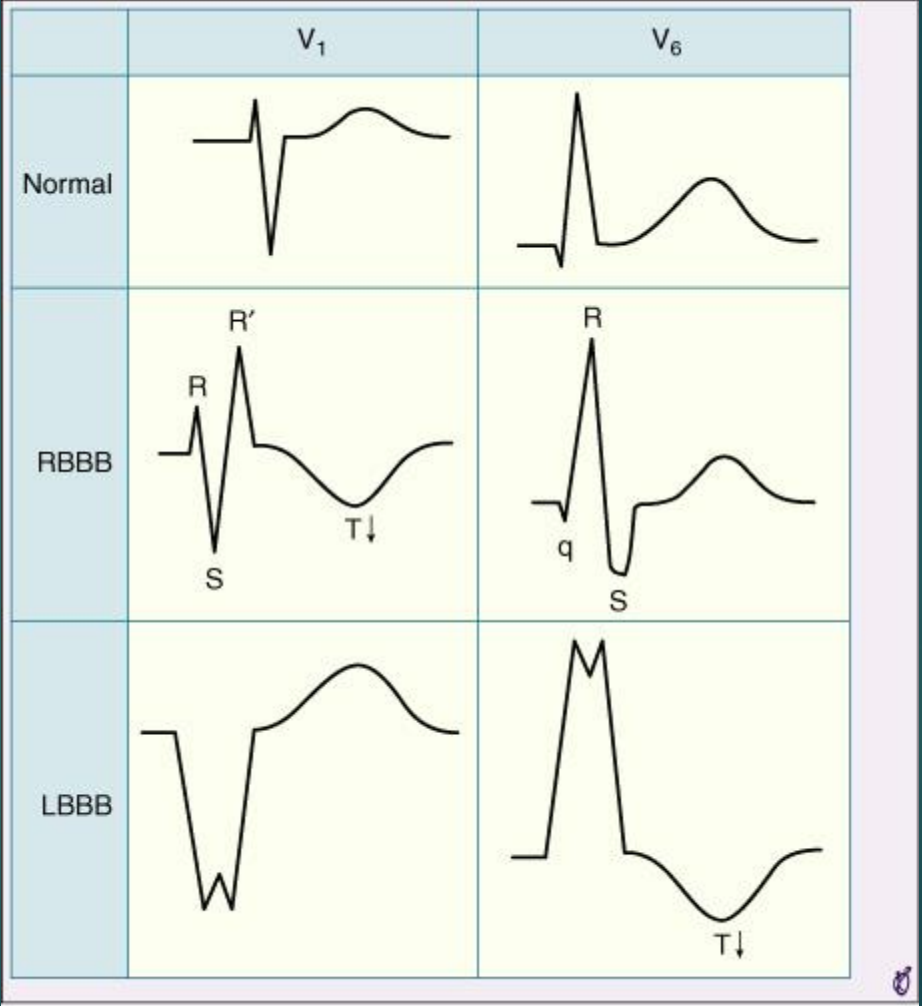


# Bundle Branch Blocks

- Left Bundle Branch Block
  - QRS duration >120ms (3 small boxes)
  - R in V6





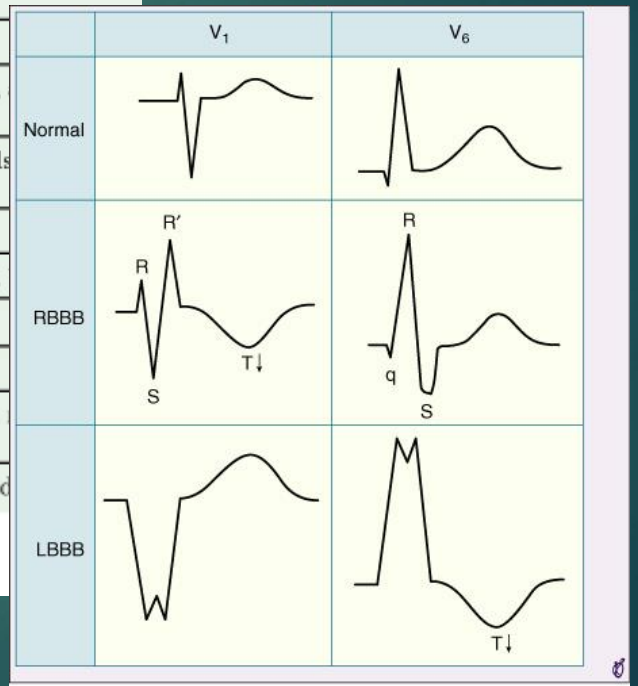


# Bundle Branch Block Criteria

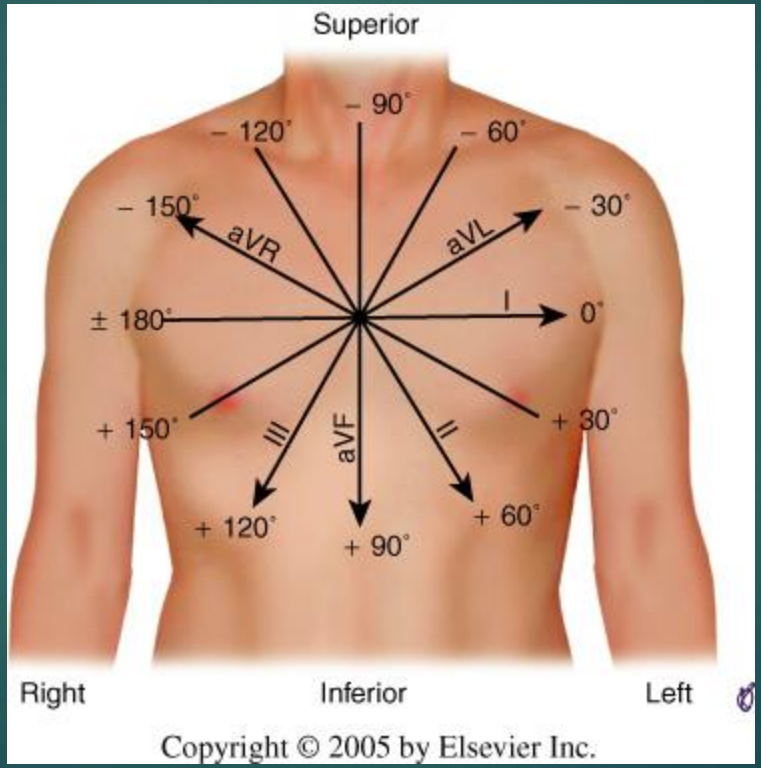
| TABLE 9–7 | Common Diagnostic Criteria for Bundle Branch Blocks |
|---|---|
| ***Complete left bundle branch block*** | |
| QRS duration ≥120 msec | |
| Broad, notched R waves in lateral precordial leads ($V_5$ and usually leads I and $aV_L$ | |
| Small or absent initial r waves in right precordial leads $V_2$) followed by deep S waves | |
| Absent septal q waves in left-sided leads | |
| Prolonged intrinsicoid deflection (>60 msec) in $V_5$ and | |
| ***Complete right bundle branch block*** | |
| QRS duration ≥120 msec | |
| Broad, notched R waves (rsr′, rsR′, or rSR′ patterns) in precordial leads ($V_1$ and $V_2$) | |
| Wide and deep S waves in left precordial leads ($V_5$ and | |

*Criterion required by some authors.



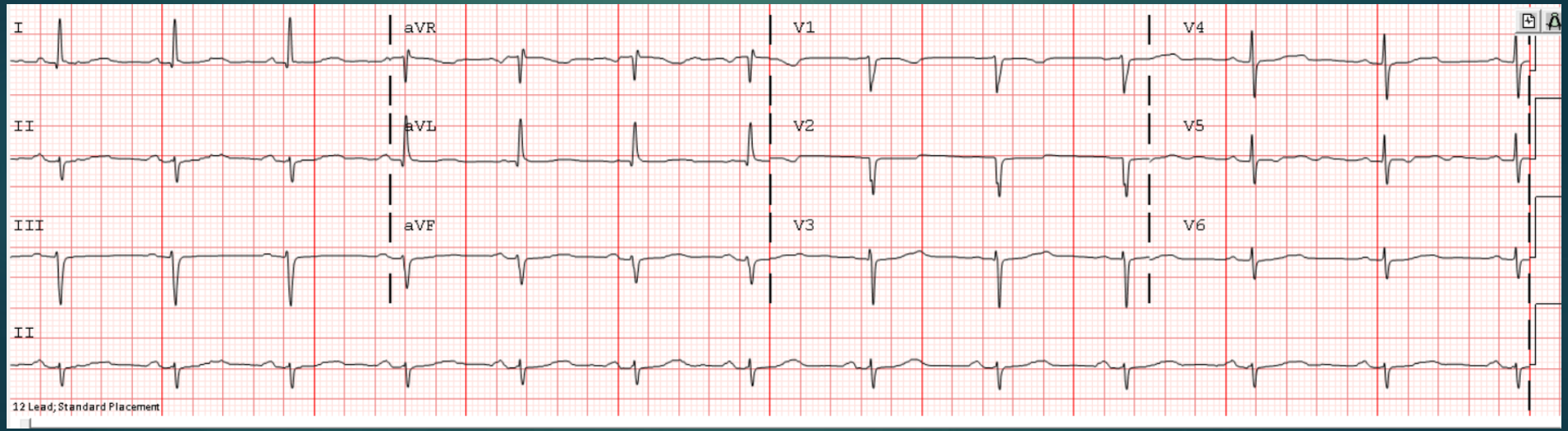


# Axis

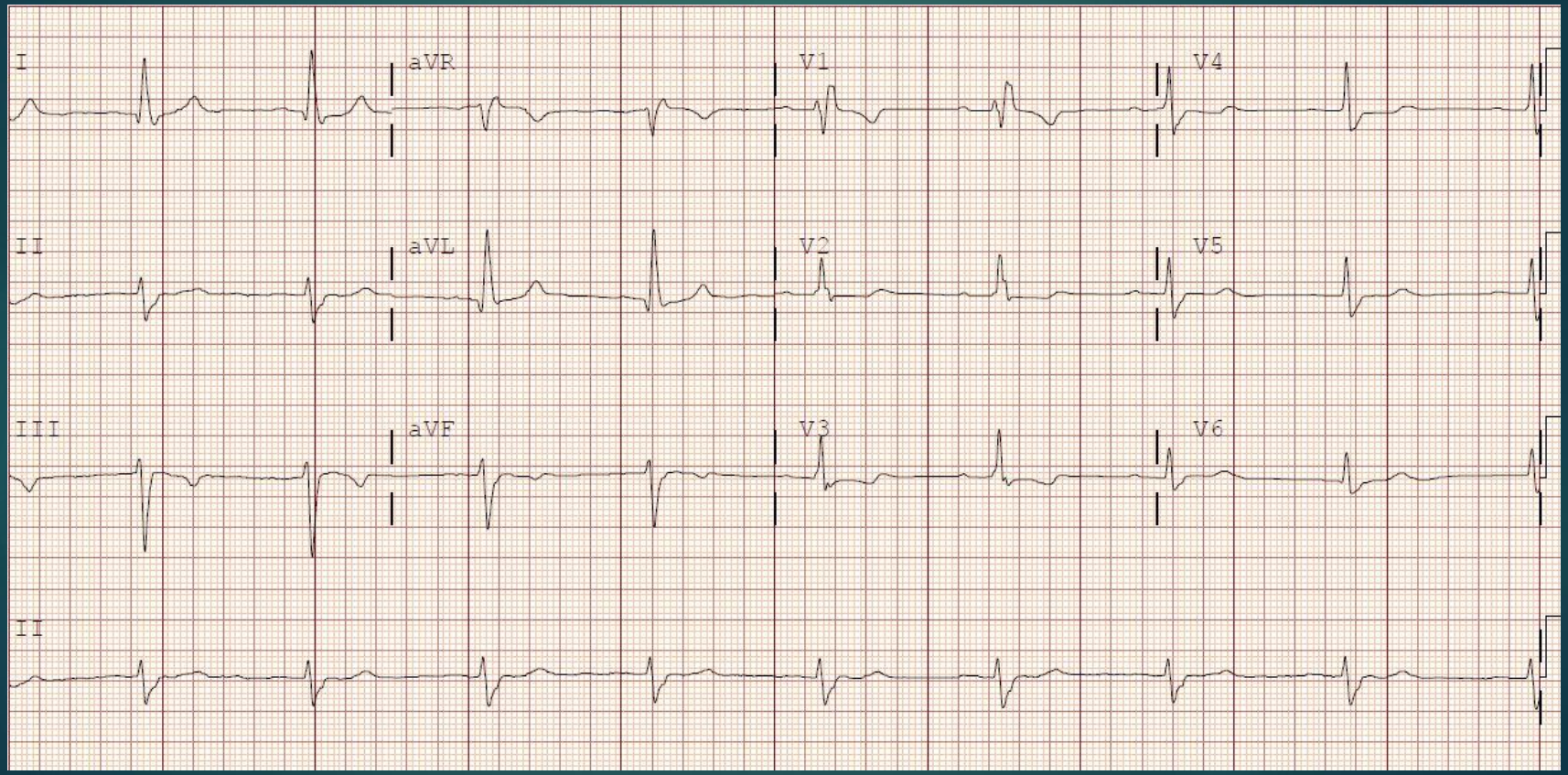

Superior
– 90°
– 120°
– 60°
– 150°
aVR
aVL
– 30°
± 180°
I
0°
+ 150°
III
aVF
II
+ 30°
+ 120°
+ 90°
+ 60°
Right
Inferior
Left
Copyright © 2005 by Elsevier Inc.

# Left Anterior Fascicular Block

- Frontal Axis -45 to -90 degrees
- QRS <120ms
- rS pattern in II, II, aVF (inferior leads)

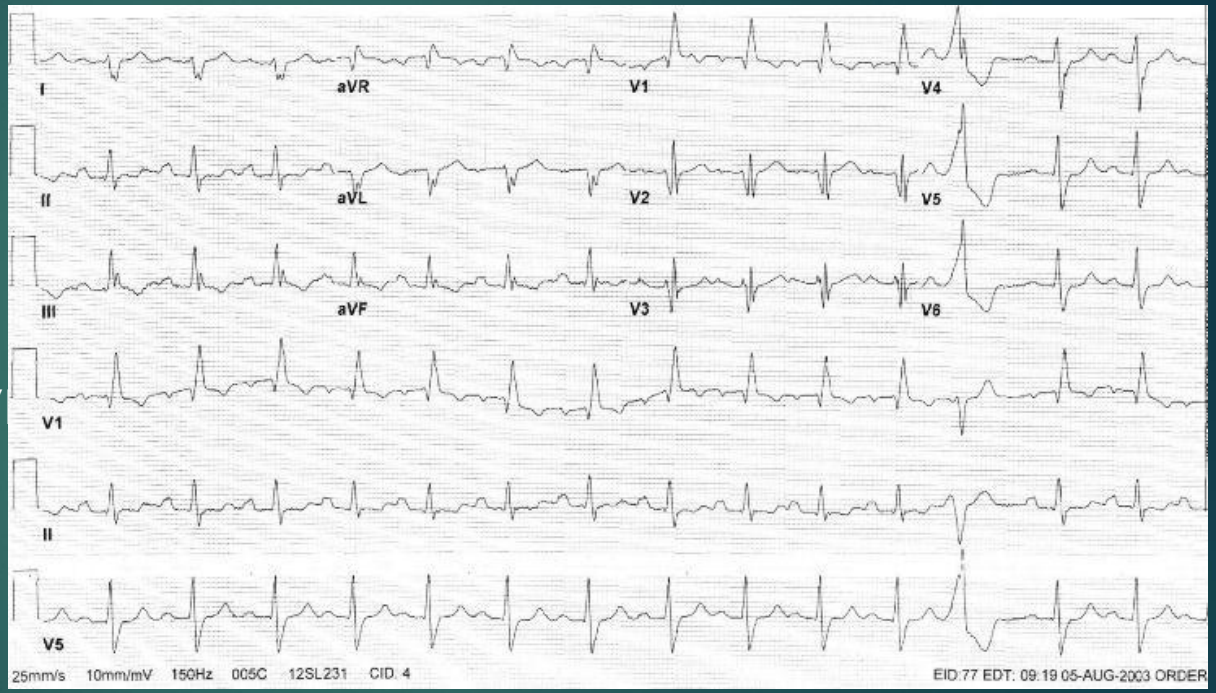


# NSR with 1st AVB, RBBB, LAFB



# Left Posterior Fascicular Block

- Frontal Axis +/-120 degrees (typically right axis deviation)
- QRS <120ms
- RS pattern I
- qR pattern in II, II, aV (inferior leads)



# Fascicular Blocks

QRS Duration <120ms

LAHB (LAFB)

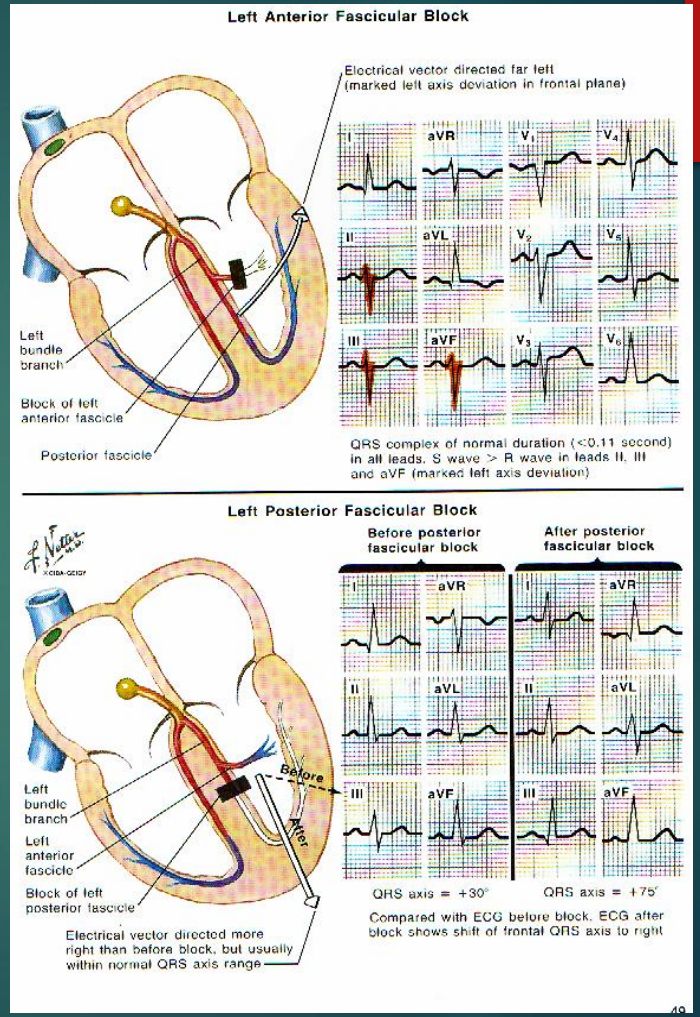
*Severe LAD without explanation*

- Deep S waves in II, III, aVF
- Frontal Axis <-45 to -60 degrees
- Positive in I, Negative in aVF
- Not explained by LBBB, LVH, inferior infarct

LPHB (LPFB)

*Opposite of LAFB, **Rare***

- Usually Right Axis deviation
- Negative in I, Positive in aVF
- Positive in II, III, aVF
- Not explained by RVH, anterolateral infarct




Schedit, S. Basic Electrocardiography. CIBA-GEIGY Pharmaceuticals, USA, p 49.

# Fascicular Block Criteria

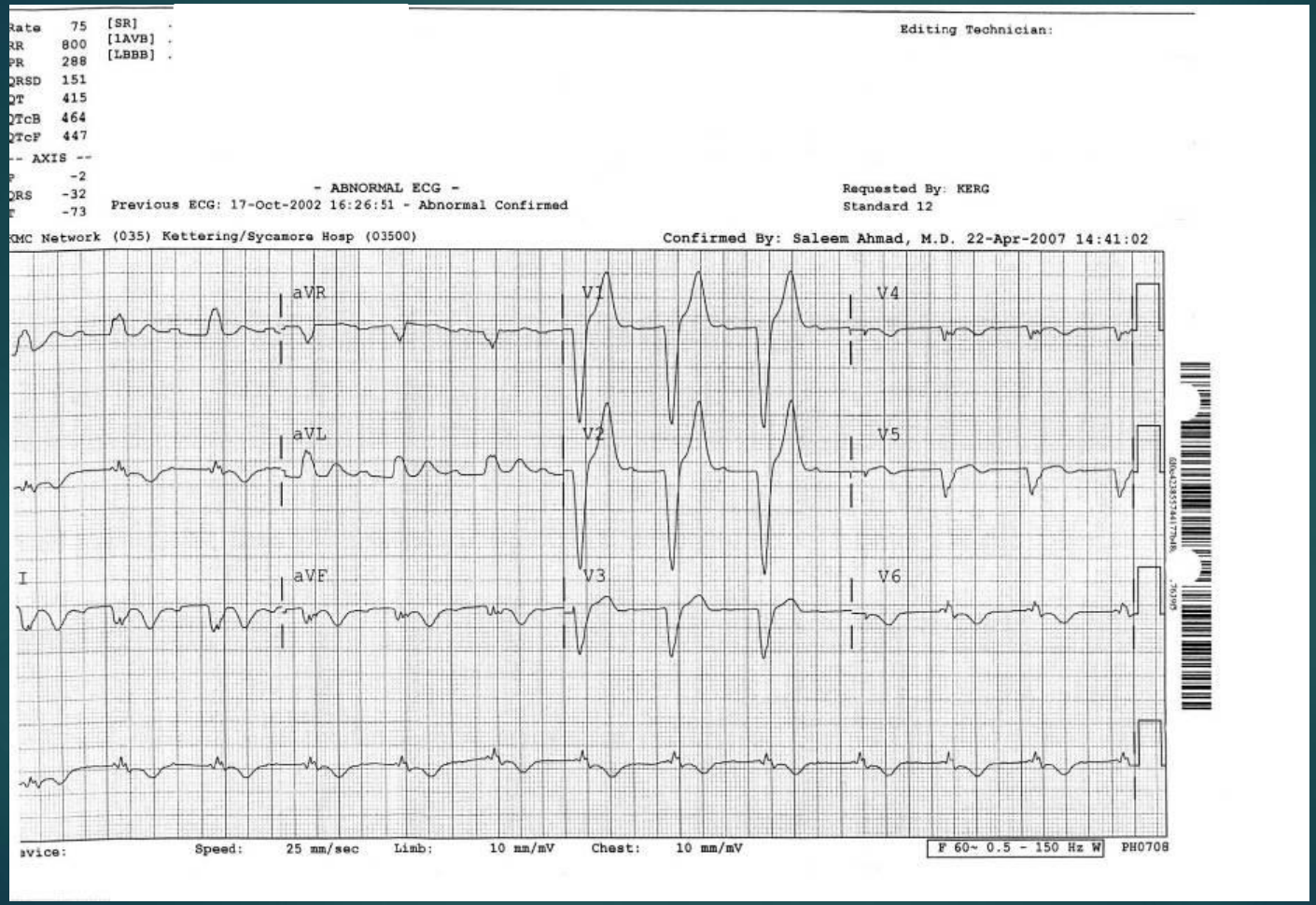
| TABLE 9–6 | Common Diagnostic Criteria for Unifascicular Blocks |
|---|---|
| ***Left anterior fascicular block*** | |
| Frontal plane mean QRS axis of –45 to –90 degrees with rS patterns in leads II, III, and $aV_f$ and a qR pattern in lead $aV_l$ | |
| QRS duration less than 120 msec | |
| ***Left posterior fascicular block*** | |
| Frontal plane mean QRS axis of ±120 degrees | |
| RS pattern in leads I and $aV_l$ with qR patterns in inferior leads | |
| QRS duration of less than 120 msec | |
| Exclusion of other factors causing right axis deviation (e.g., right ventricular overload patterns, lateral infarction) | |

| COMMON CAUSES OF ATRIOVENTRICULAR AND INTRAVENTRICULAR CONDUCTION DISTURBANCE | |
|---|---|
| Intrinsic causes | Congenital<br>Sclerodegenerative<br>Ischemia<br>Trauma (surgical)<br>Connective tissue disorders<br>Tumors<br>Sarcoidosis |
| Extrinsic causes | Drugs<br>Autonomic disorders<br>Hypothyroidism |

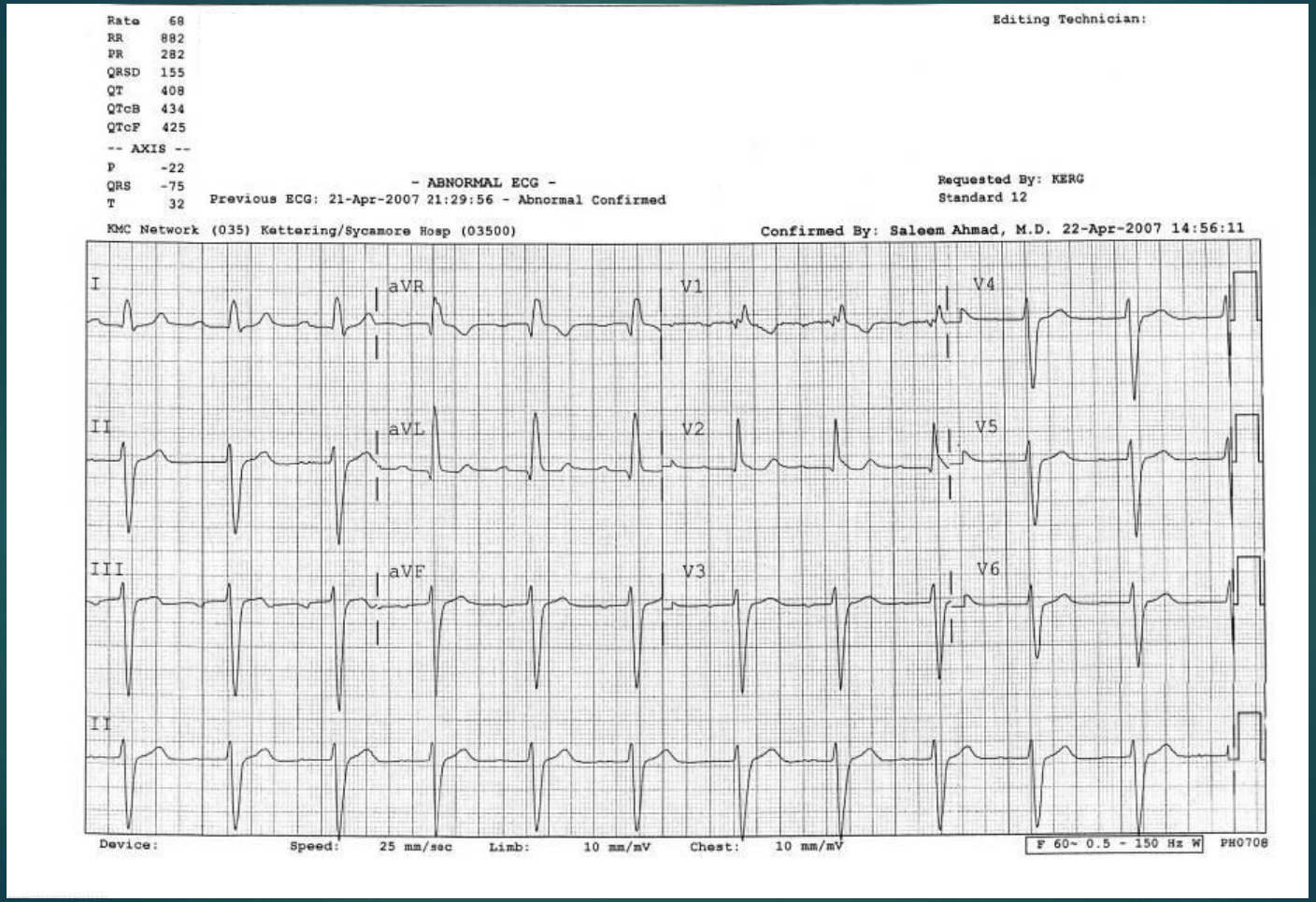
# Case Presentation

- 50ish year old white female
- No cardiac history
- Admitted 2 weeks ago at outside hospital for syncope
- Watched for 2 days, diagnosed with possible seizures, had “negative” echo
- Recurrent syncope, admitted to KMC

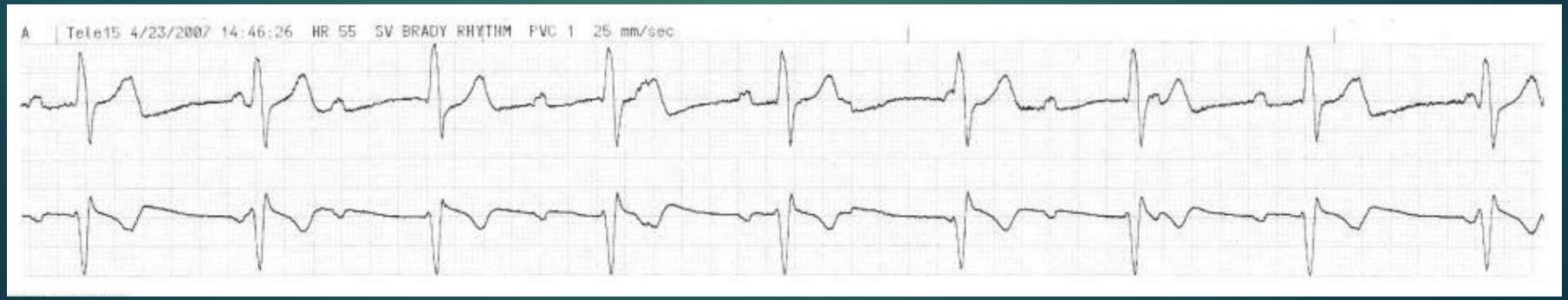
4/21/07 21:30


Rate 75
RR 800
PR 288
QRSD 151
QT 415
QTcB 464
QTcF 447
-- AXIS --
P -2
QRS -32
T -73
[SR]
[1AVB]
[LBBB]
Editing Technician:
- ABNORMAL ECG -
Previous ECG: 17-Oct-2002 16:26:51 - Abnormal Confirmed
Requested By: KERG
Standard 12
KMC Network (035) Kettering/Sycamore Hosp (03500)
Confirmed By: Saleem Ahmad, M.D. 22-Apr-2007 14:41:02
aVR
V1
V4
aVL
V2
V5
I
aVF
V3
V6
Speed: 25 mm/sec
Limb: 10 mm/mV
Chest: 10 mm/mV
F 60~ 0.5 - 150 Hz W
PH0708

4/21/07 23:45

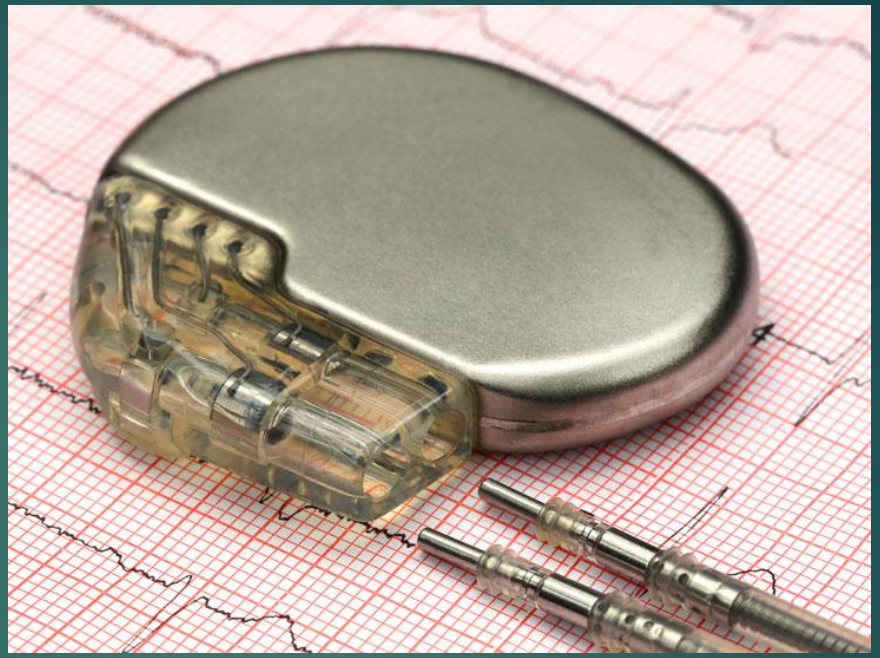

Rate 68
RR 882
PR 282
QRSD 155
QT 408
QTcB 434
QTcF 425
-- AXIS --
P -22
QRS -75
T 32
Editing Technician:
- ABNORMAL ECG -
Previous ECG: 21-Apr-2007 21:29:56 - Abnormal Confirmed
Requested By: KERG
Standard 12
KMC Network (035) Kettering/Sycamore Hosp (03500)
Confirmed By: Saleem Ahmad, M.D. 22-Apr-2007 14:56:11
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II
Device:
Speed: 25 mm/sec
Limb: 10 mm/mV
Chest: 10 mm/mV
F 60~ 0.5 - 150 Hz W
PH0708

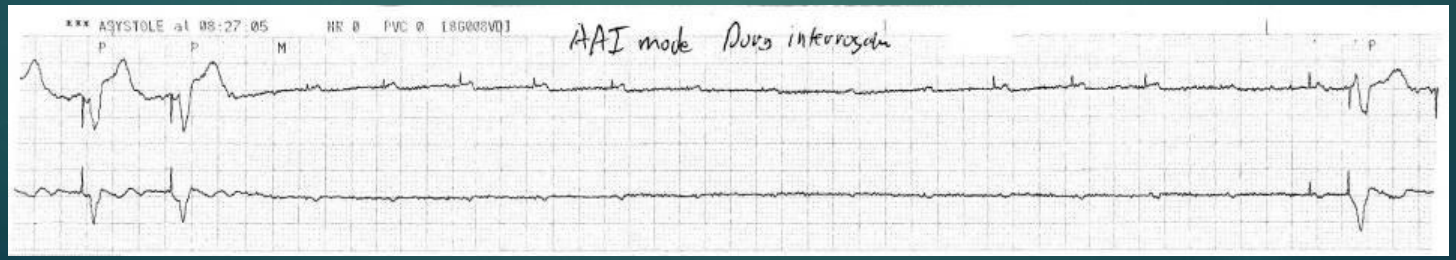
# Later that night….



# Treatment?

Pacemaker

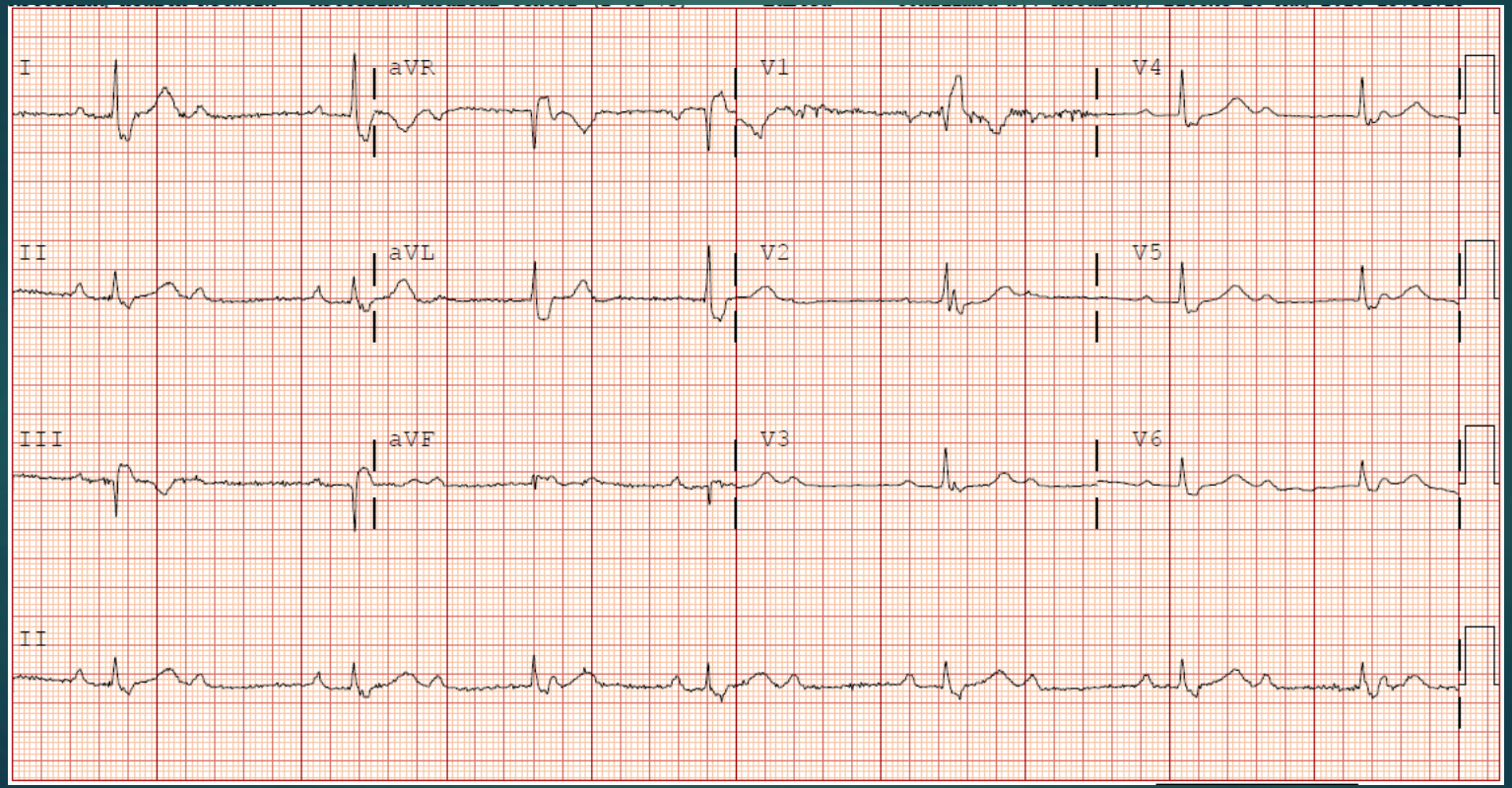




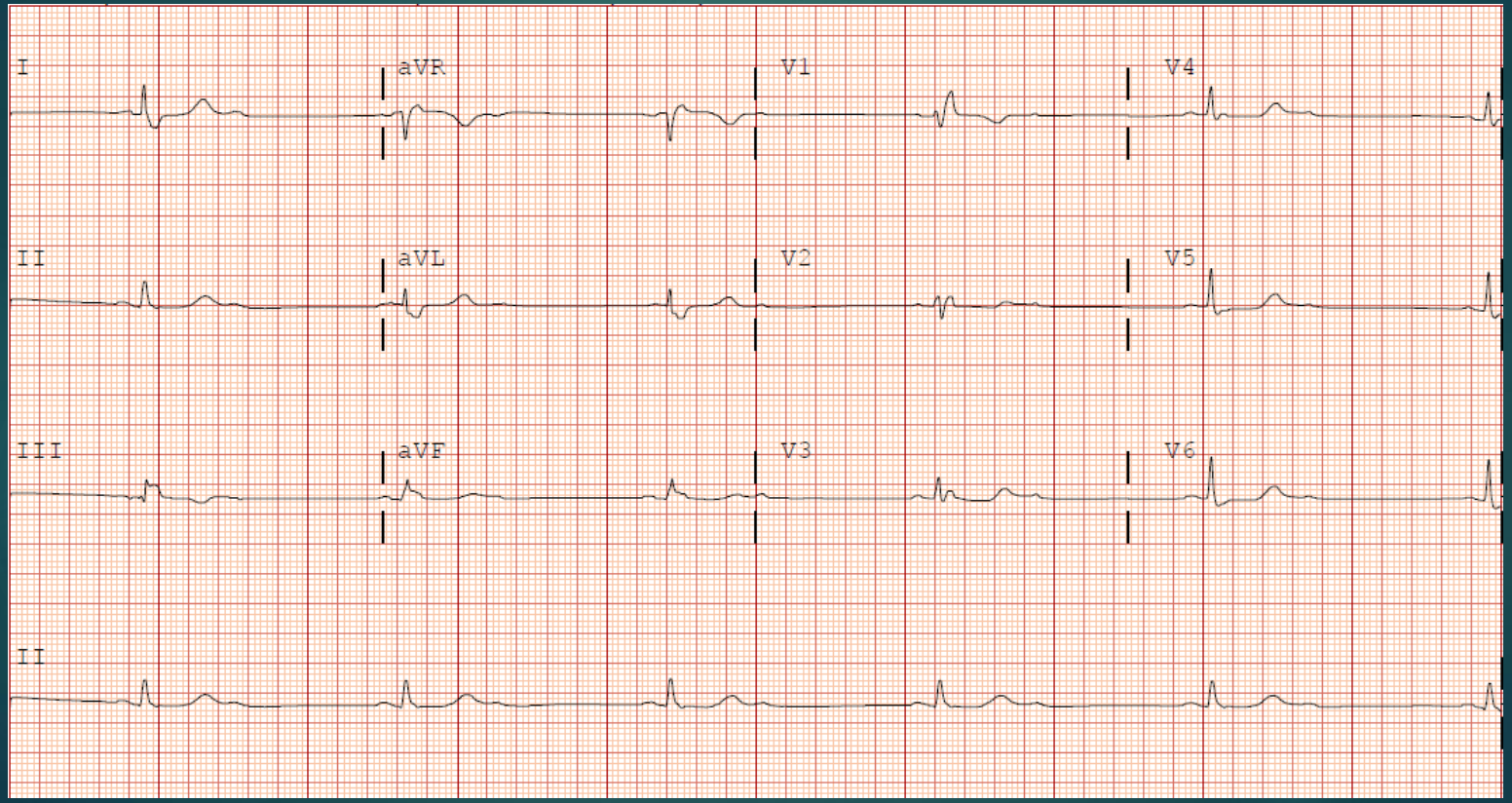
# Board Pearls for Heart Block

- Think of potential causes of heart block
  - Lyme disease
  - Sarcoidosis
  - Drug overdose
  - Hyperkalemia
  - Hypothyroidism

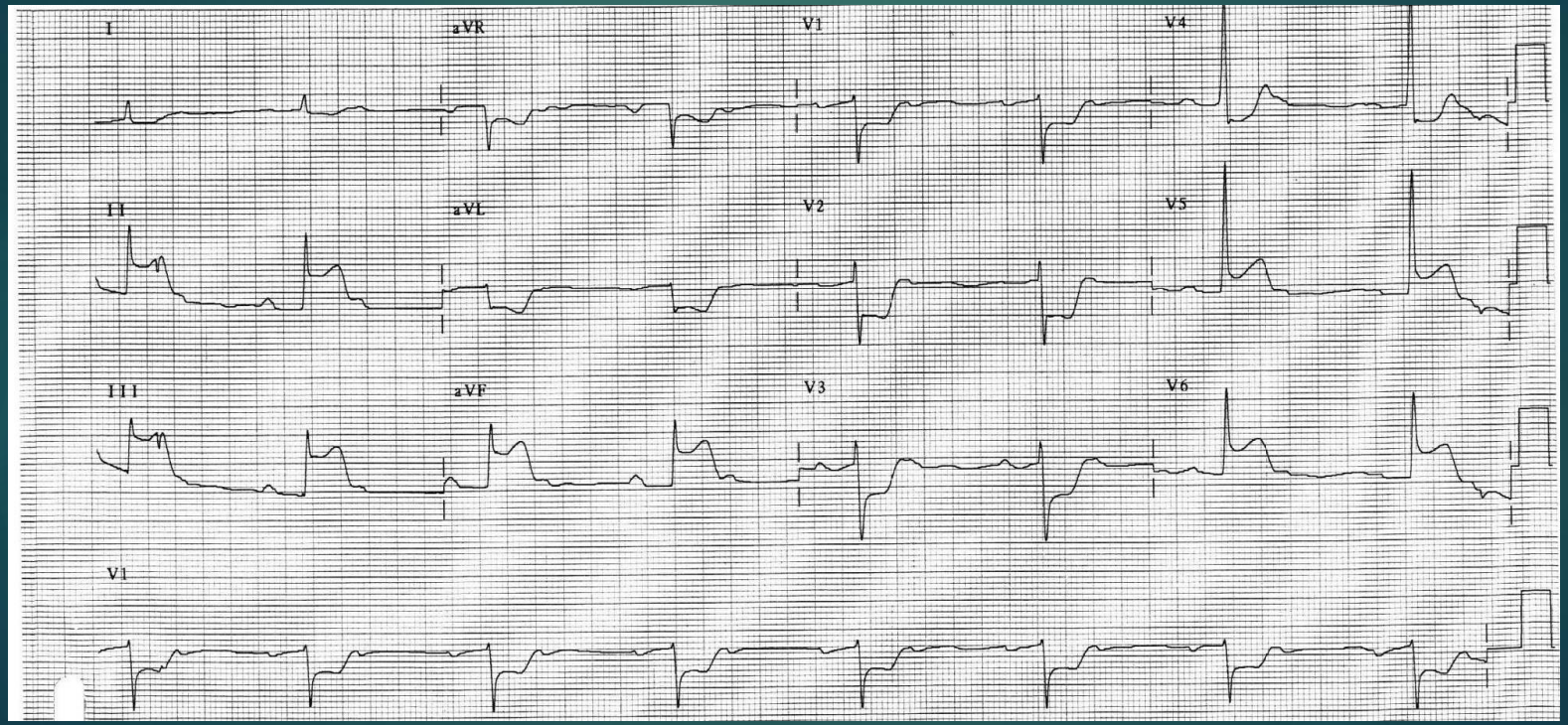
# Sometimes heart blocks don't easily fit into a defined category…



# 2:1 AV Block

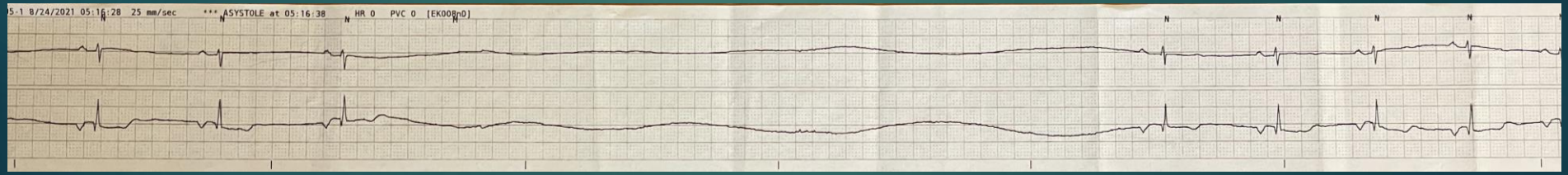


# Inferior/Lateral/Posterior Infarct with 2:1 block



# While Sleeping….

- 30 YOM admitted with alcohol withdrawal
- No Cardiac History
- No Symptoms
- Echo unremarkable

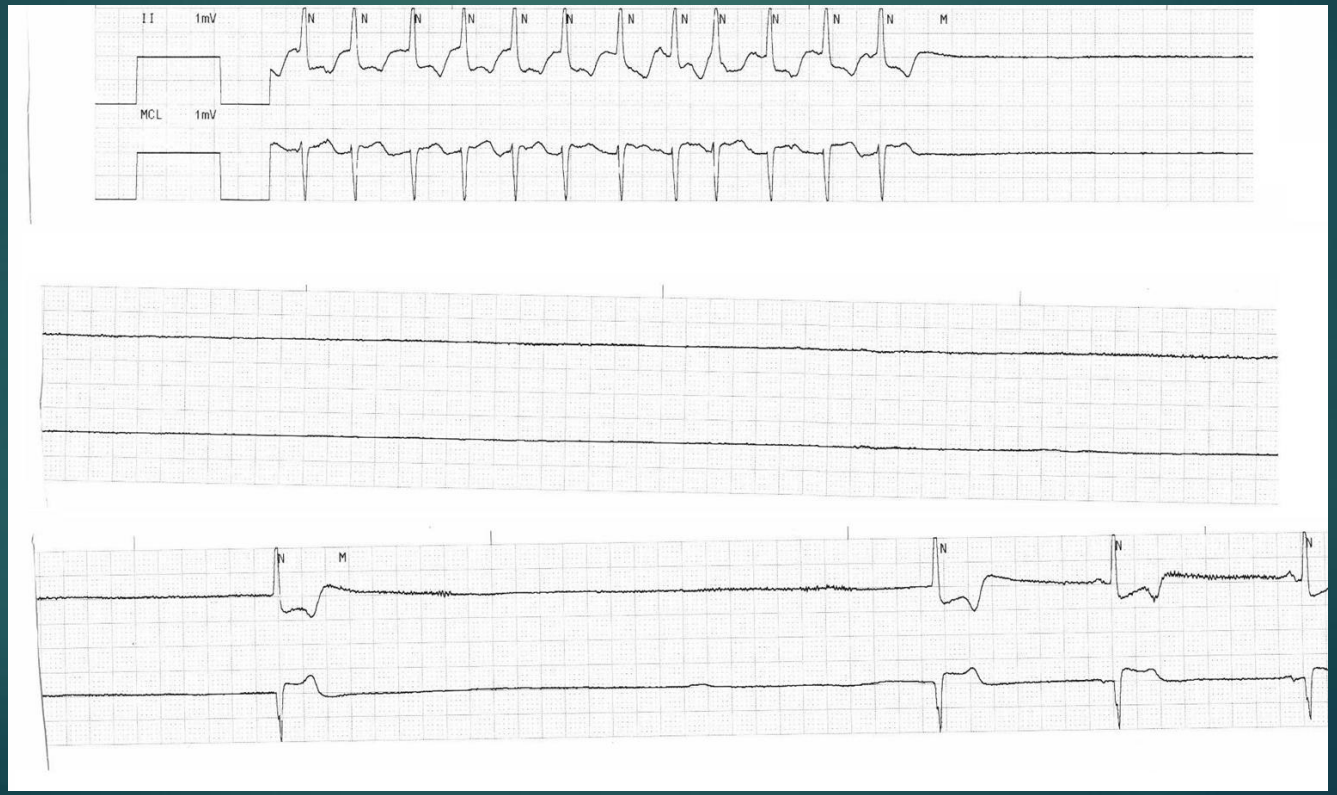


# Another case…

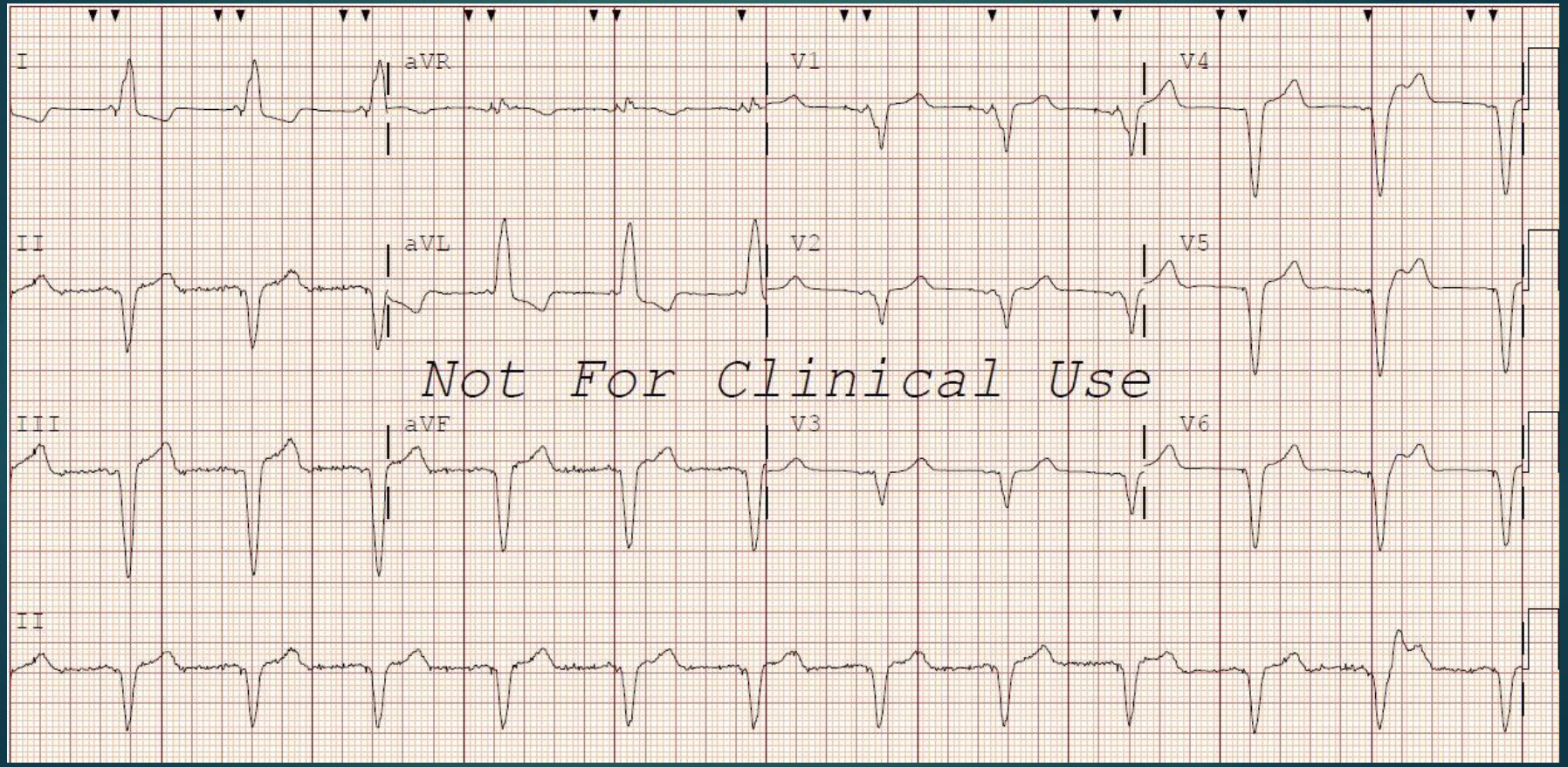
- 75 year old male admitted with syncope
- No significant past medical history or medications
- Nothing on telemetry overnight…

# NSR → 20 second asystole

# Atrial fibrillation → Asystole



# AV Dual Chamber Pacing



# Why Do We Do Pacemakers?

- Symptomatic Bradycardia!
- 3rd degree heart block
- 2nd degree heart block (Mobitz type 2)
- Sick sinus syndrome
- Tachy-Brady syndrome
- Chronotropic Incompetence

# 2018 Pacemaker Guidelines Selected Take Home Points

- Sinus node dysfunction is most often related to age-dependent progressive fibrosis of the sinus nodal tissue and surrounding atrial myocardium leading to abnormalities of sinus node and atrial impulse formation and propagation and will therefore result in various bradycardic or pause-related syndromes.

- Both sleep disorders of breathing and nocturnal bradycardias are relatively common, and treatment of sleep apnea not only reduces the frequency of these arrhythmias but also may offer cardiovascular benefits. The presence of nocturnal bradycardias should prompt consideration for screening for sleep apnea, beginning with solicitation of suspicious symptoms. However, nocturnal bradycardia is not in itself an indication for permanent pacing.

**2018 ACC/AHA/HRS Guideline on the Evaluation and Management of Patients With Bradycardia and Cardiac Conduction Delay: Executive Summary: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines, and the Heart Rhythm Society** https://doi.org/10.1161/CIR.0000000000000627Circulation. 2019;140:e333–e381

# 2018 Pacemaker Guidelines Selected Take Home Points

- In sinus node dysfunction, there is no established minimum heart rate or pause duration where permanent pacing is recommended. Establishing temporal correlation between symptoms and bradycardia is important when determining whether permanent pacing is needed.

- In patients with acquired second-degree Mobitz type II atrioventricular block, high-grade atrioventricular block, or third-degree atrioventricular block not caused by reversible or physiologic causes, permanent pacing is recommended regardless of symptoms. For all other types of atrioventricular block, in the absence of conditions associated with progressive atrioventricular conduction abnormalities, permanent pacing should generally be considered only in the presence of symptoms that correlate with atrioventricular block

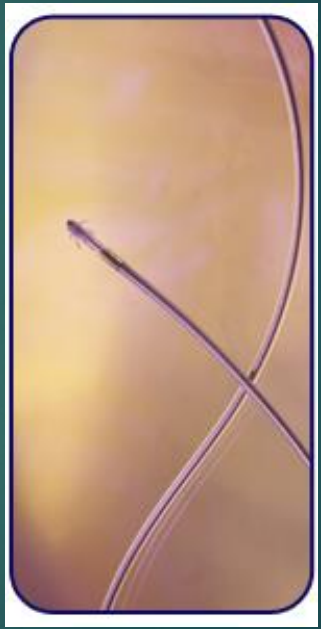
**2018 ACC/AHA/HRS Guideline on the Evaluation and Management of Patients With Bradycardia and Cardiac Conduction Delay: Executive Summary: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines, and the Heart Rhythm Society** https://doi.org/10.1161/CIR.0000000000000627Circulation. 2019;140:e333–e381

# 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)

# 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

# The Can

## AKA "Pulse Generator," "Battery"

Temporary

Single chamber

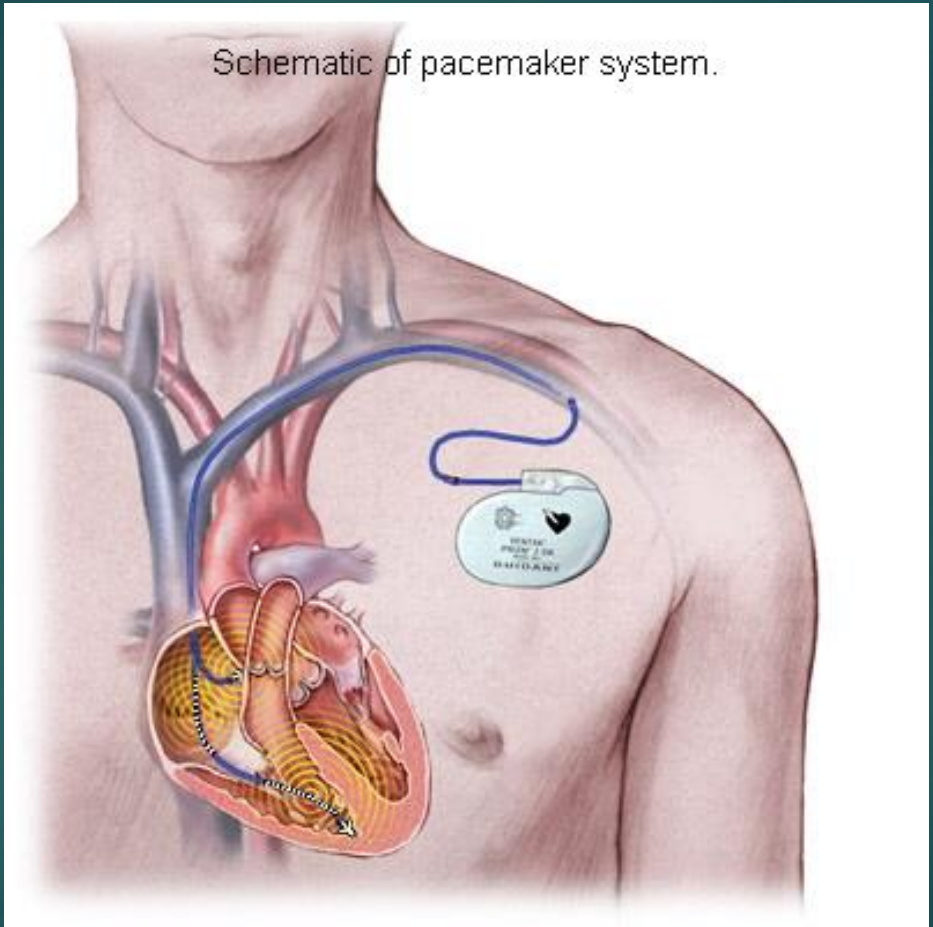
http://www.staff.vu.edu.au/CriticalCare/Critical%20Care/Images%20_l1/spacer.gif

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

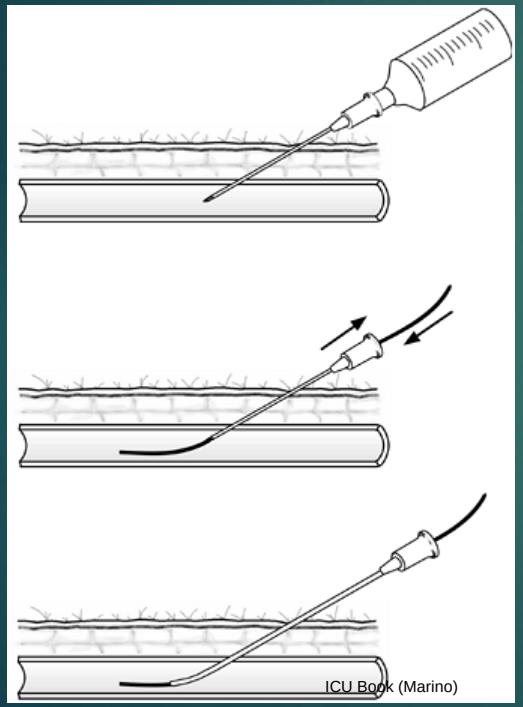



http://www.hgcardio.com/HRhythm/Treatments/a_pacemaker_schematic.jpg

# 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

# Seldinger technique for percutaneous vascular access



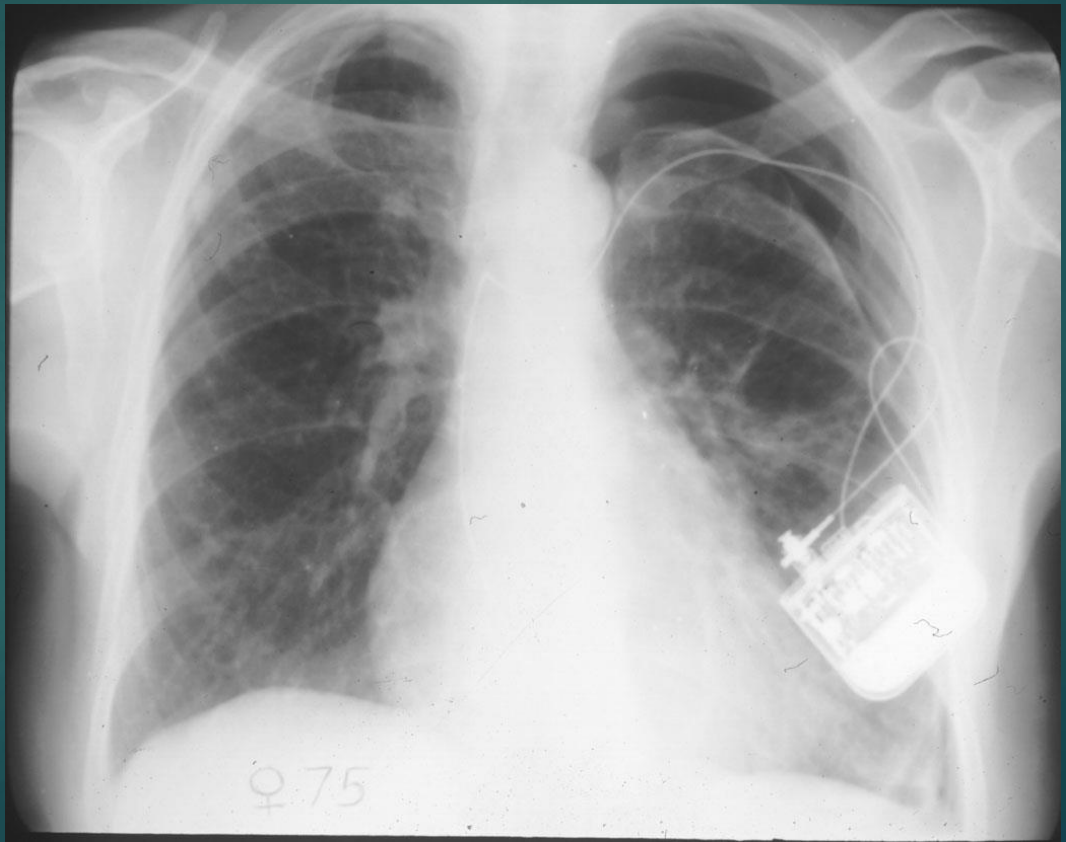

General steps

- 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

# 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

# Pneumothorax of Left Lung




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

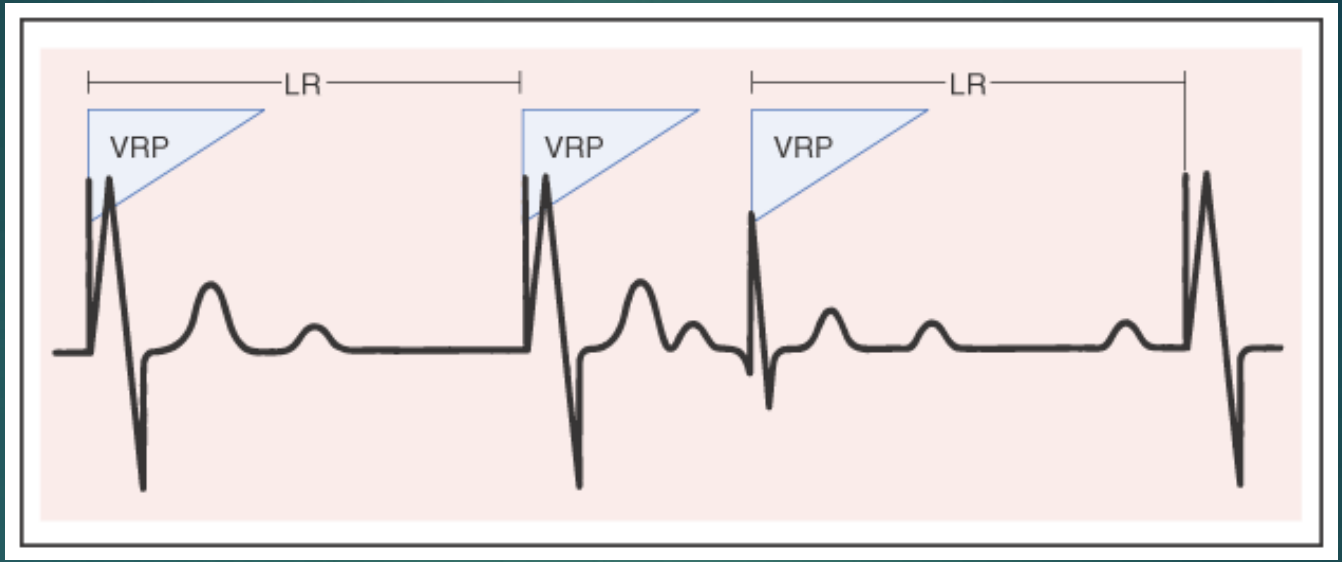
# Functions of a pacemaker

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

# 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.

# 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

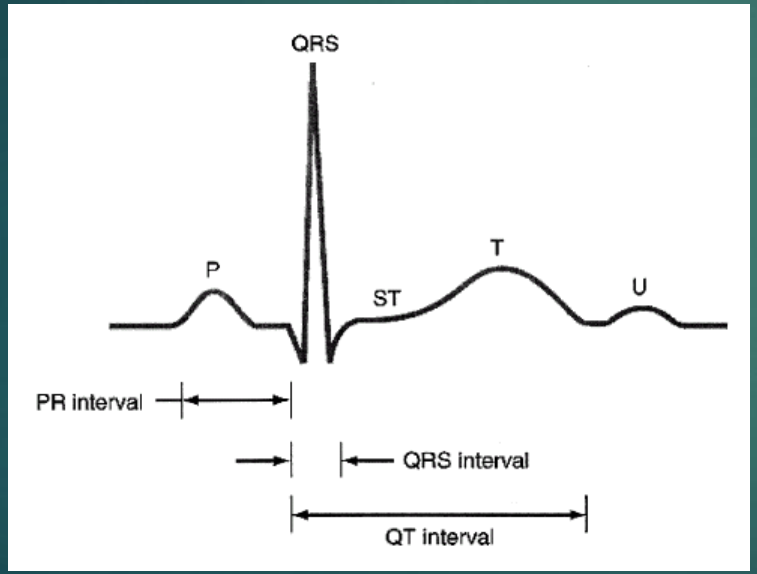
# The dials on the Temporary pacemaker

- 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

# 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

# Sensitivity

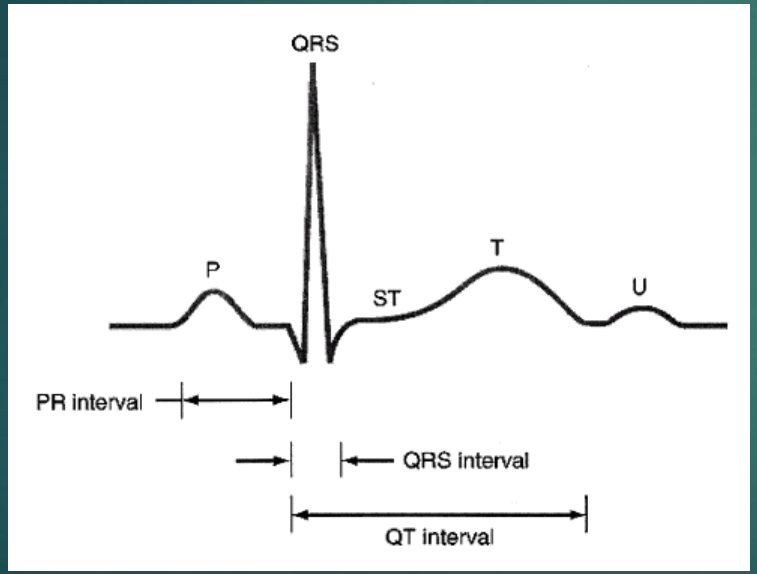


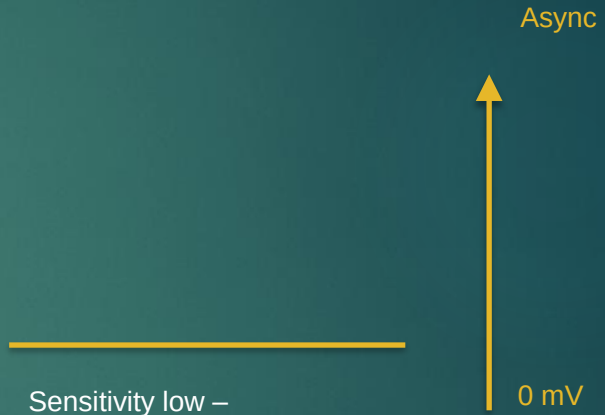


Sensitivity low – Everything (QRS, T, U) can be sensed by the pacemaker as a QRS

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

# Sensitivity

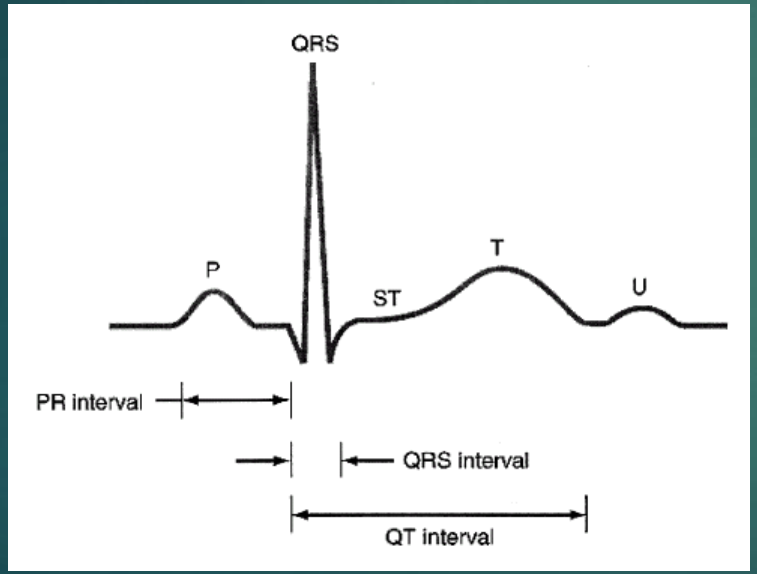



Sensitivity low –
QRS and some T waves will be sensed by pacemaker as a QRS

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

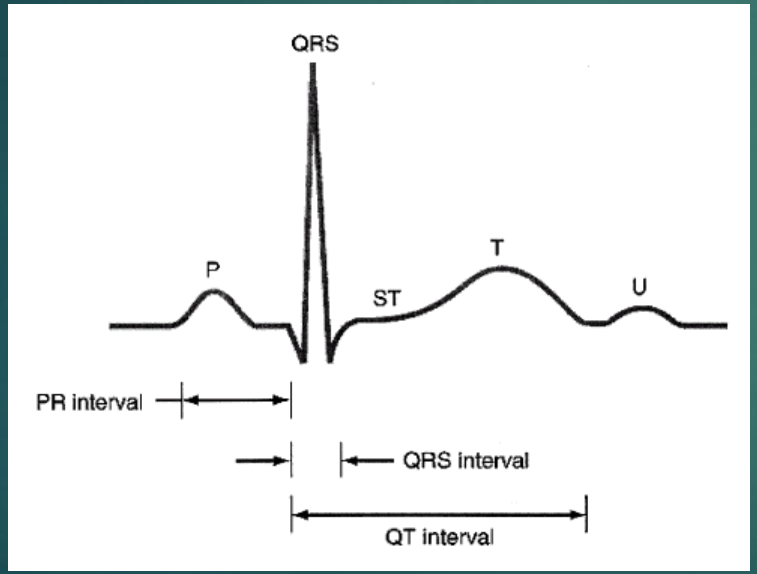
# Sensitivity




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


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

# Sensitivity




Sensitivity too high
Nothing will be sensed

Async

0 mV

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

# 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

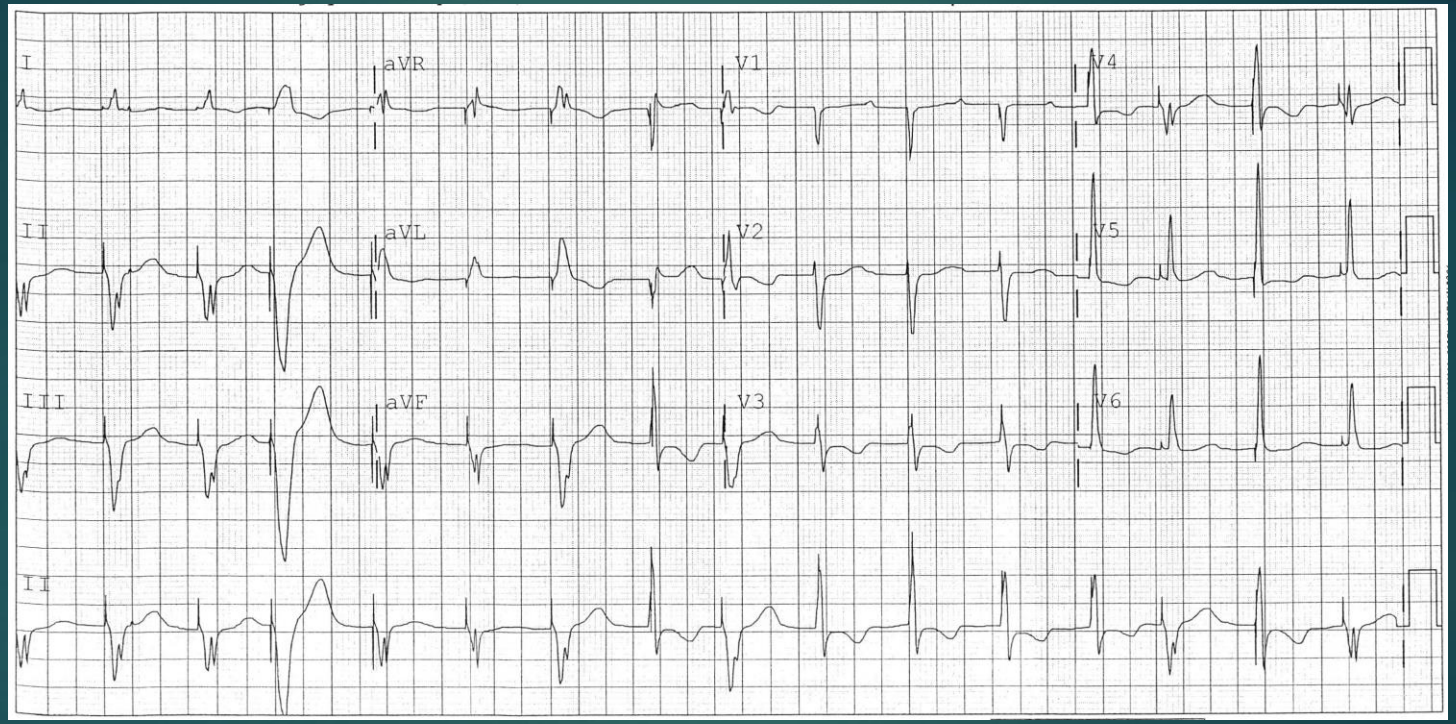
# Testing Thresholds

- 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

# Troubleshooting Pacemakers

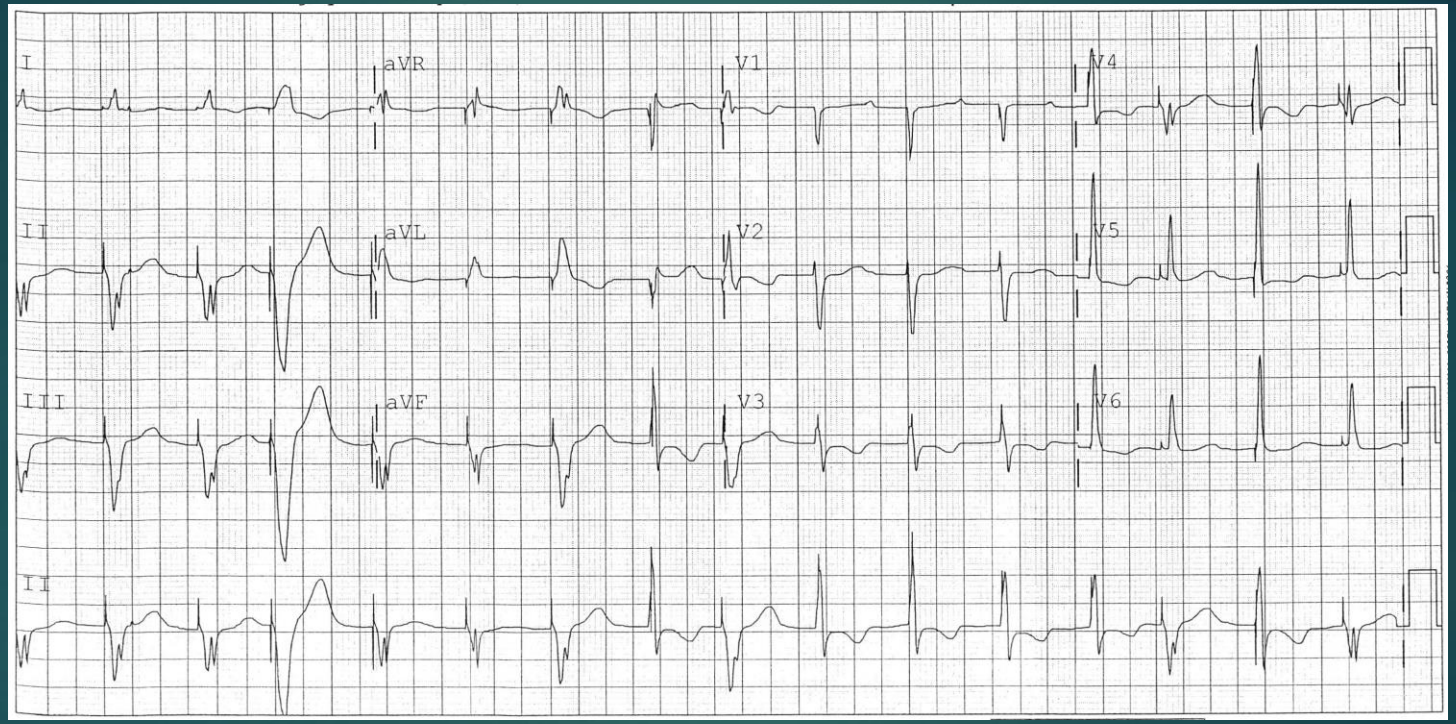
- Normal behavior that looks strange
- Failure to Capture
- Undersensing
- Oversensing
- Cross Talk (Dual Chamber only)

# Normal behavior of VVI pacemaker



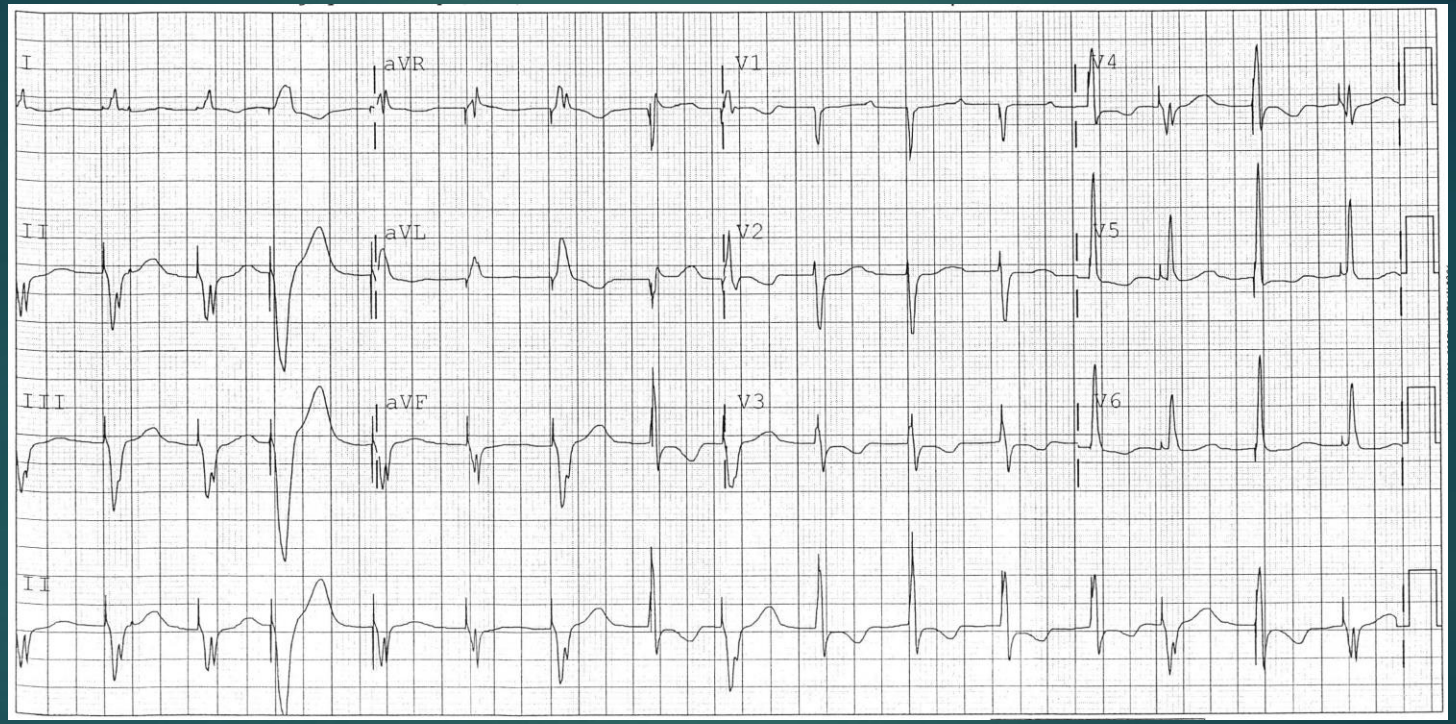

Native QRS

# Normal behavior of VVI pacemaker



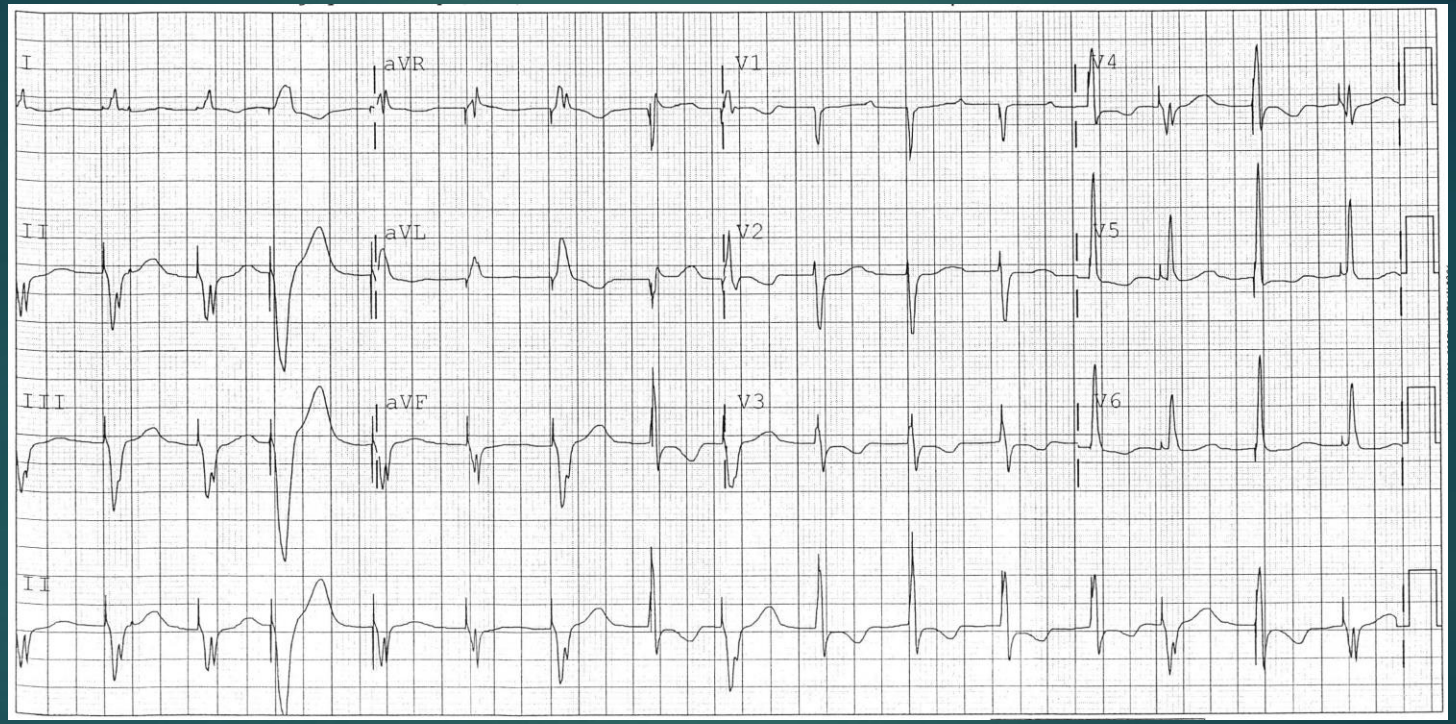

Paced beat with capture

# Normal behavior of VVI pacemaker




Fusion beat – combination of native QRS and paced beat

# Normal behavior of VVI pacemaker




Pseudofusion – pacing spike, normal QRS

# Failure to Capture

Braunwald, 7th ed.

Atrial pacing with intermittent ventricular capture

# Failure of output (oversensing)

Braunwald, 7th ed.

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

# 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

# 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

# References


- Goldberger AL,  Goldberger ZD, Shvilkin A. Goldberger's Clinical Electrocardiography, Chapter 14, 130-143
- Chauhan VS, Krahn AD, Klein GJ, Skanes AC, Yee R. Supraventricular tachycardia. Med Clin North Am. 2001 Mar;85(2):193-223, ix.
- Ganz LI, Friedman PL. Supraventricular tachycardia. N Engl J Med. 1995 Jan 19;332(3):162-73.