UT Southwestern Medical Center

INTRODUCTION TO EKGs

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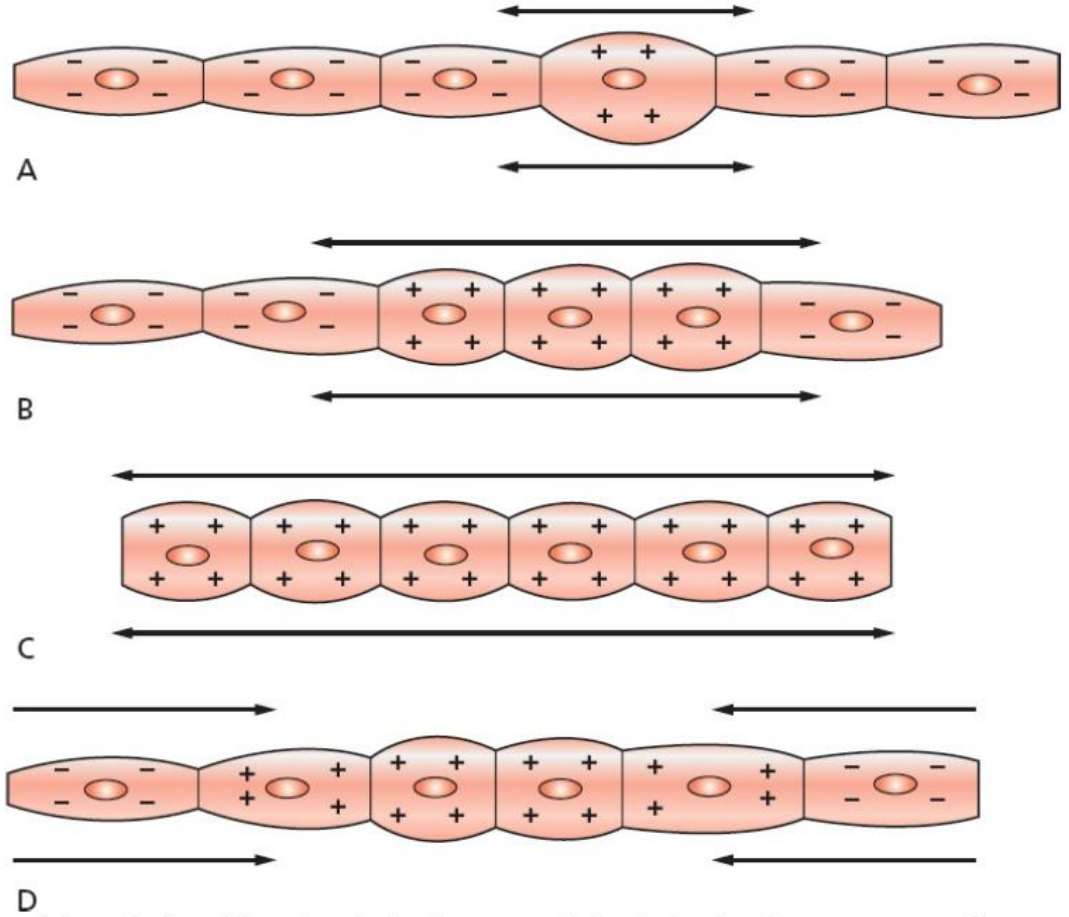
Cardiac Cells



In (*A*), a single cell has depolarized. A wave of depolarization then propagates from cell to cell (*B*) until all are depolarized (*C*). Repolarization (*D*) then restores each cell's resting polarity.

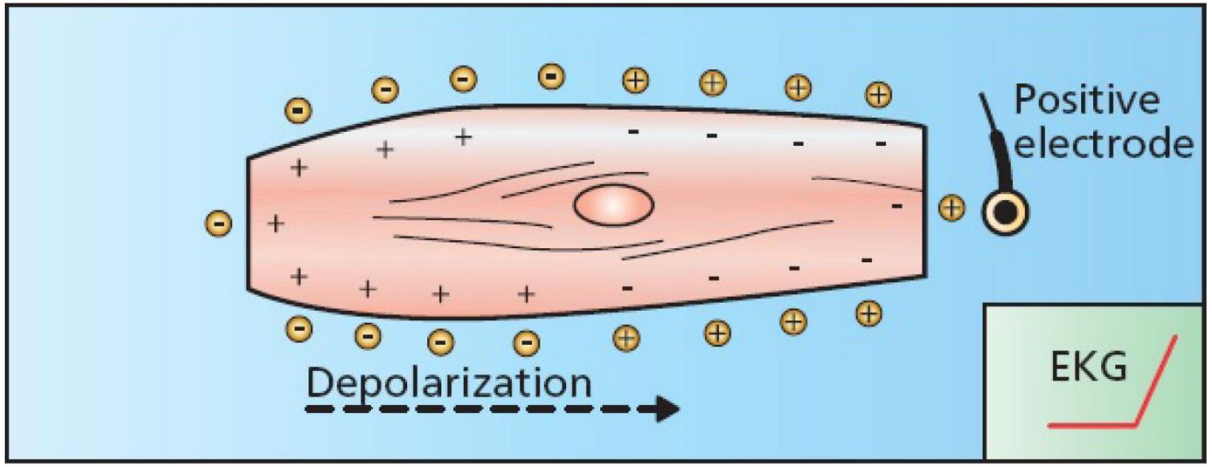
Cell Depolarization

Propagation of depolarization

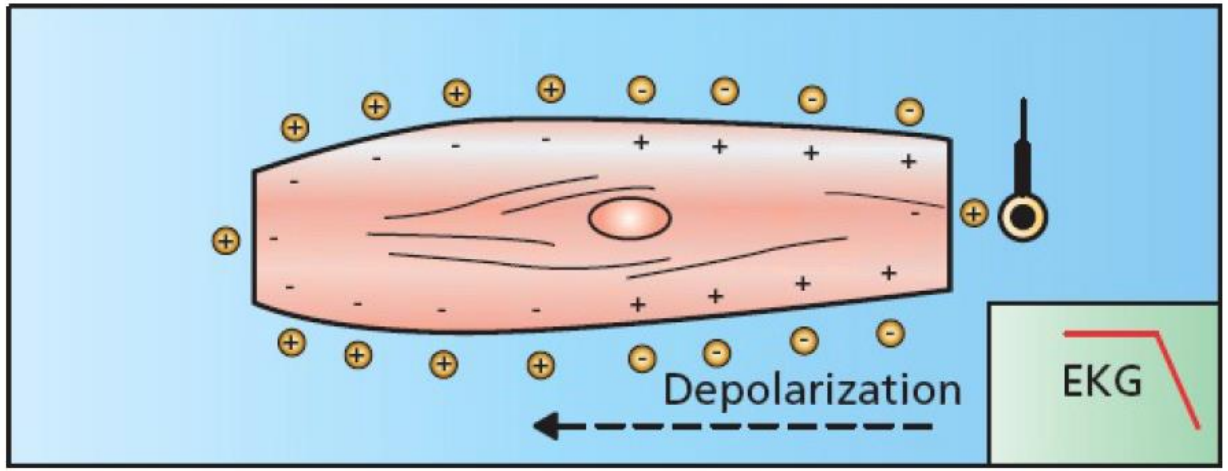
Repolarization

Thaler. *The Only EKG Book You'll Ever Need.* 2019.

EKG Deflections



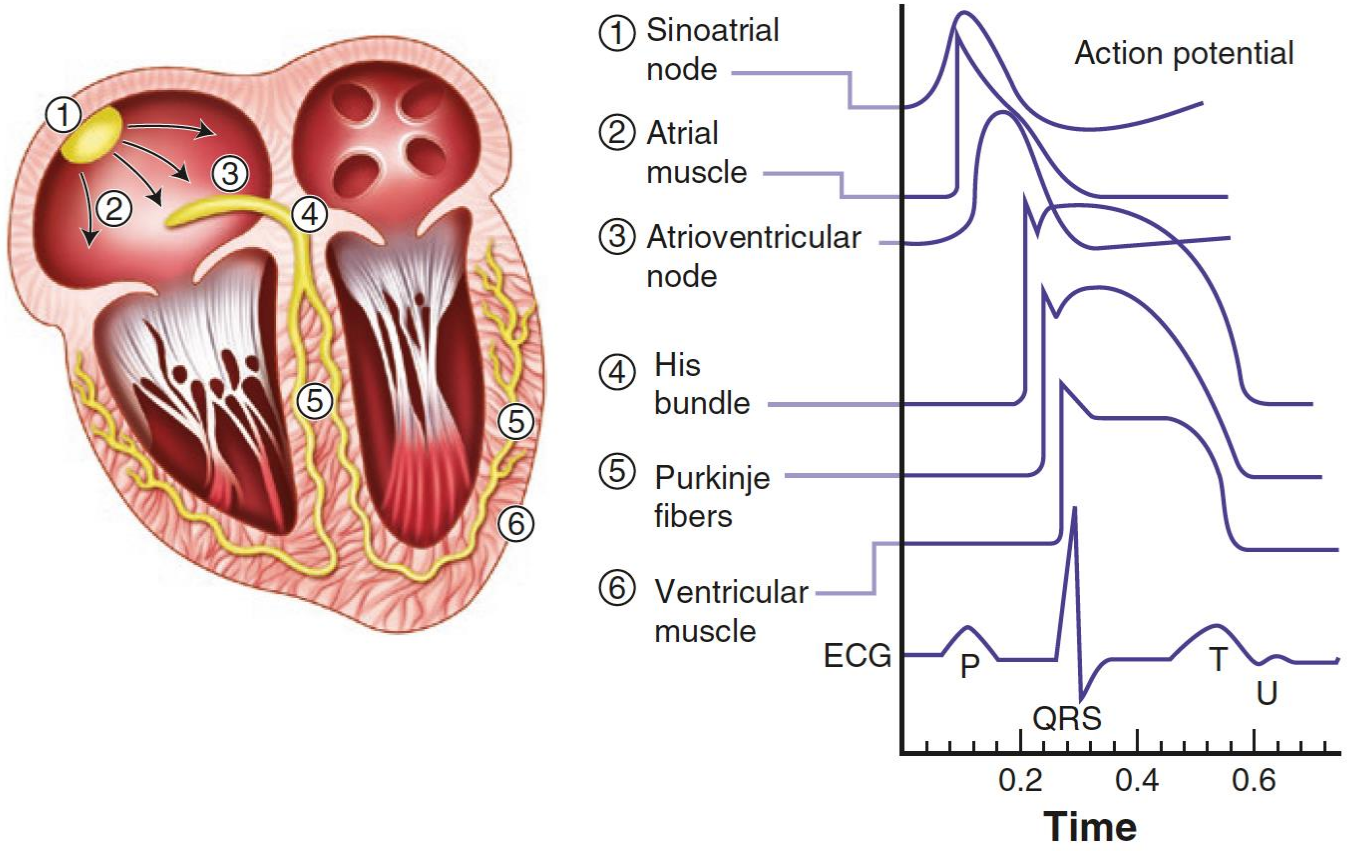
Positive deflection: Wave front moving towards the electrode



Negative deflection: Wavefront moving away from the electrode

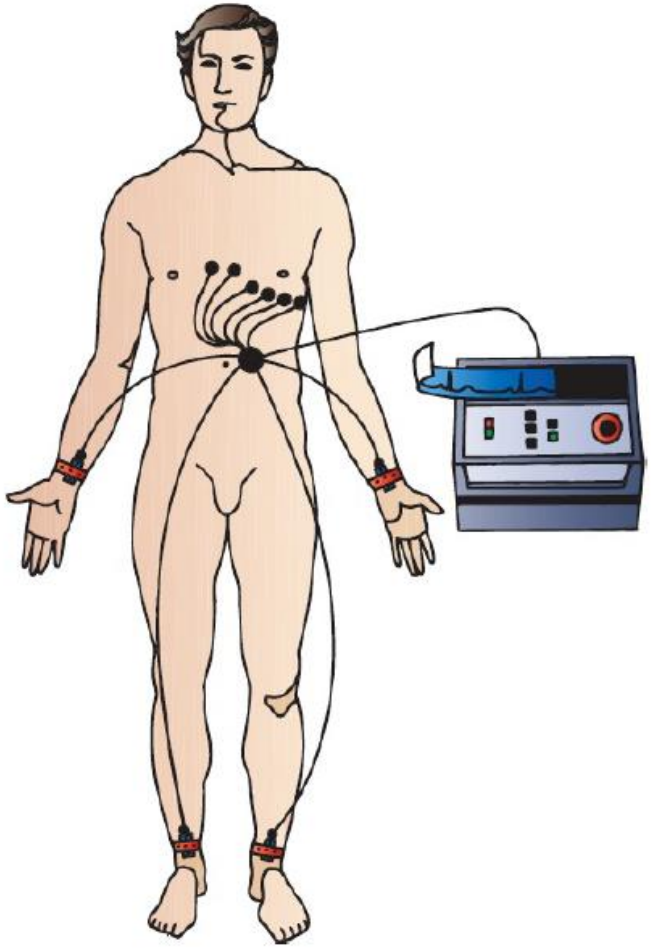
Thaler. *The Only EKG Book You'll Ever Need.* 2019.

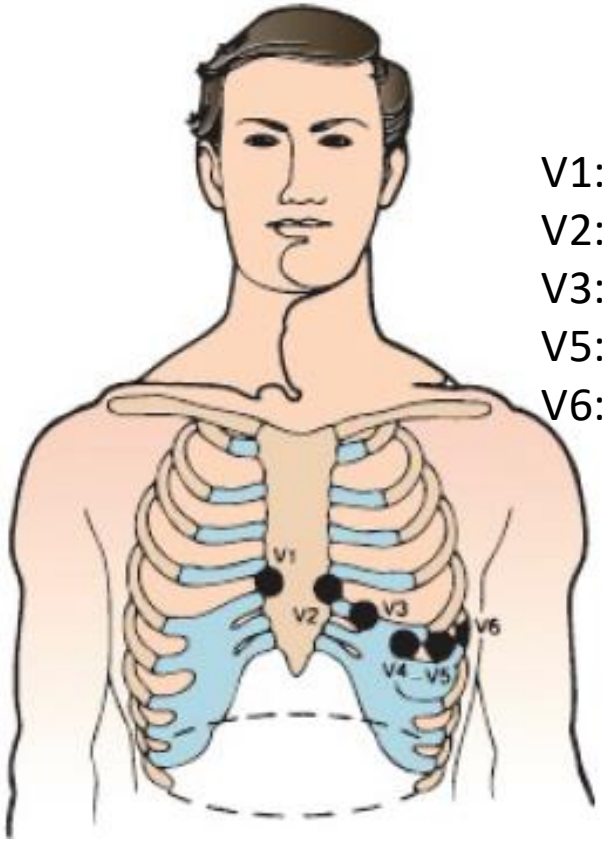
Activation of the Heart



Kusomoto. *ECG Interpretation: From Pathophysiology to Clinical Application.* 2019.

12 Lead EKG

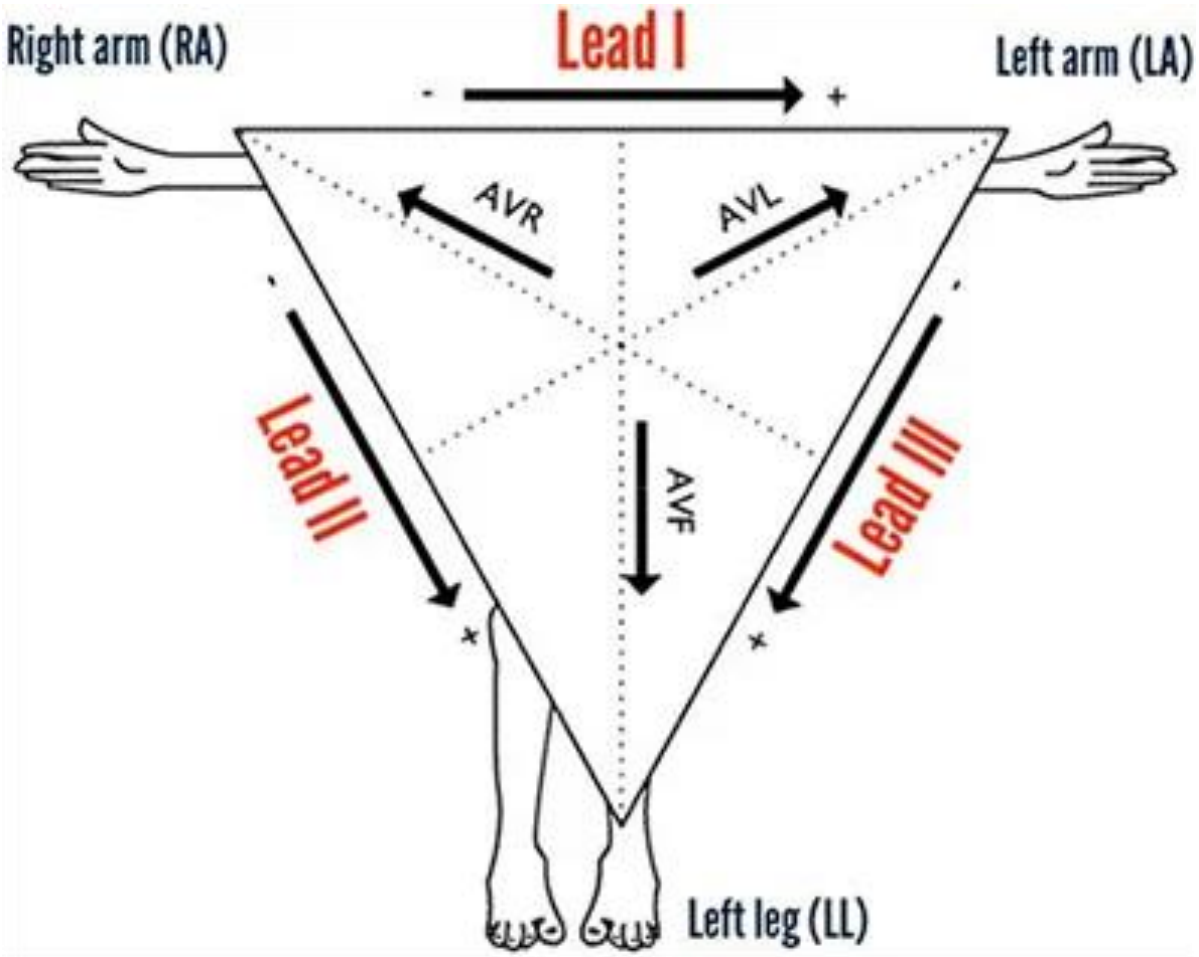


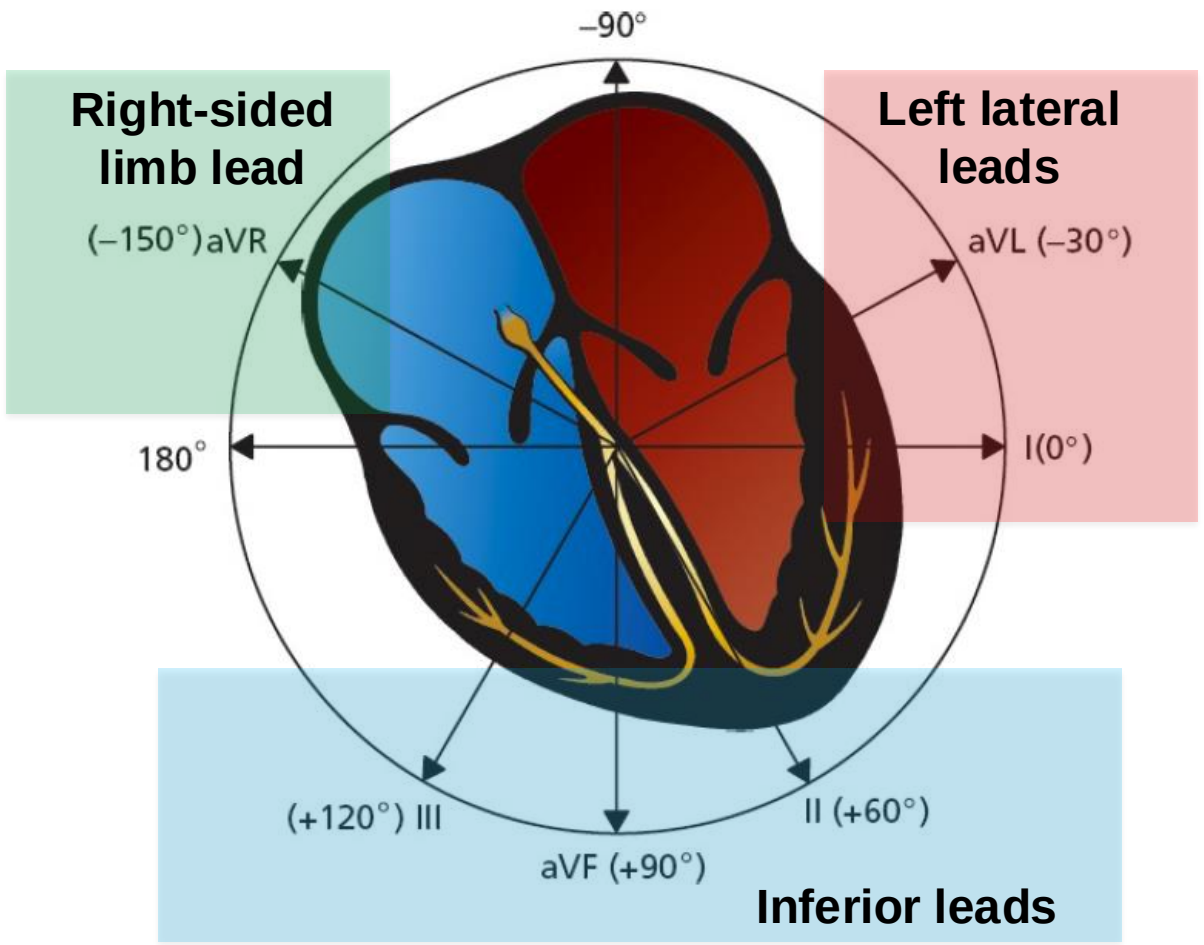


V1: 4th intercostal space, right of the sternum
V2: 4th intercostal space, left of the sternum
V3: between V2 and V4
V5: between V4 and V6
V6: 5th intercostal space in the mid axillary line

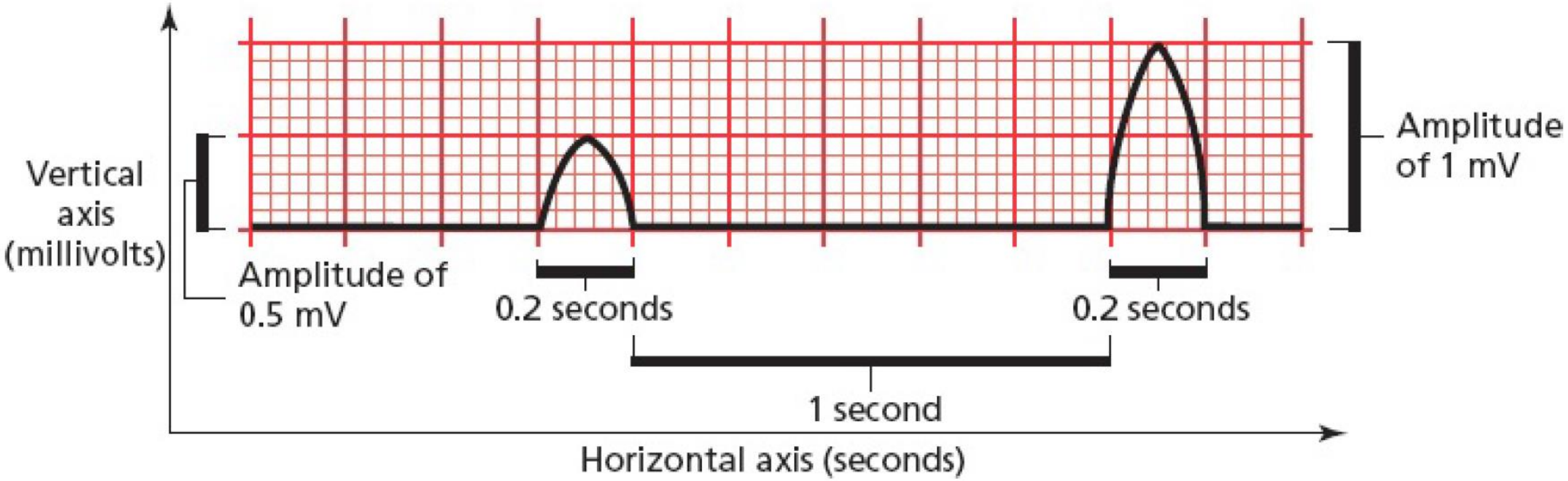
Thaler. *The Only EKG Book You'll Ever Need.* 2019.

Einthoven's Triangle





Scale


Vertical axis (millivolts)
Amplitude of 0.5 mV
0.2 seconds
0.2 seconds
Amplitude of 1 mV
1 second
Horizontal axis (seconds)

Stepwise Approach to EKGs

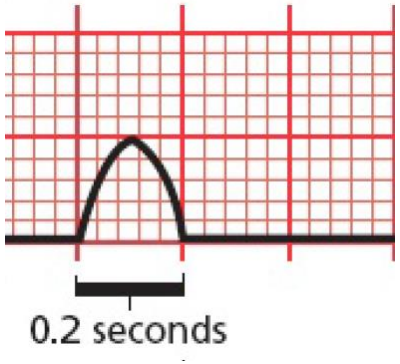
1. **Rate**
2. Rhythm
3. Axis
4. Intervals
5. Conduction Blocks
6. Ischemia
7. Voltage/Hypertrophy

Calculating the rate

1 large box = 200ms

1 small box = 40ms

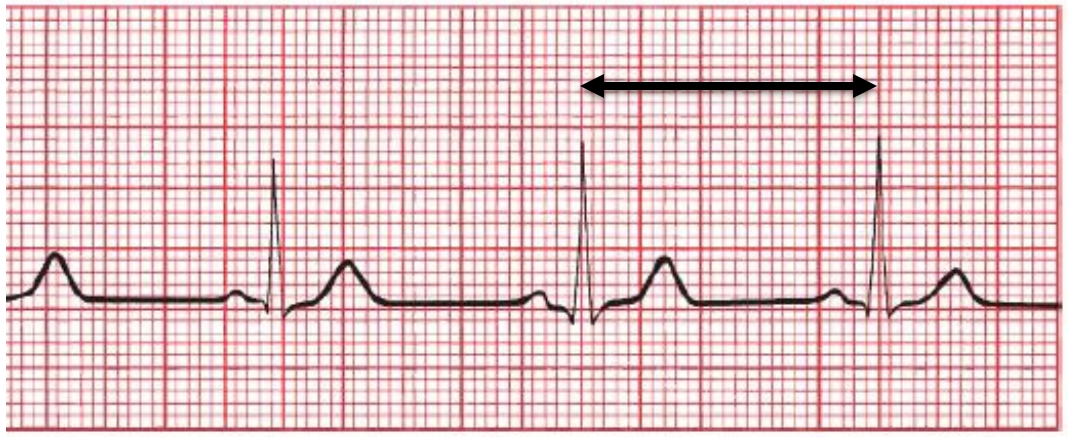
1 page = 50 boxes = 10,000ms



$$Rate = \frac{1\ beat}{1000ms} x \frac{1000ms}{1sec} x \frac{60sec}{1\ min} = \frac{60{,}000}{1000} = 60 \frac{beats}{minute}$$

$$Rate = \frac{1\ beat}{5\ boxes} x \frac{5\ boxes}{1sec} x \frac{60sec}{1\ min} = \frac{300}{5\ boxes} = 60 \frac{beats}{minute}$$

5 large boxes = 1000ms



Calculating the rate

$$\frac{60{,}000}{Cycle\ length\ (ms)}$$

$$\frac{300}{Cycle\ length\ (\#\ of\ boxes)}$$

# of beats per page (10 seconds) x 6 **Best for irregular rhythms

Calculating the rate

# of boxes between successive R-R

1 large square = 300beats/min

2 large squares = 150beats/min

3 large squares = 100beats/min

4 large squares = 75beats/min

5 large squares = 60beats/min

6 large squares = 50beats/min

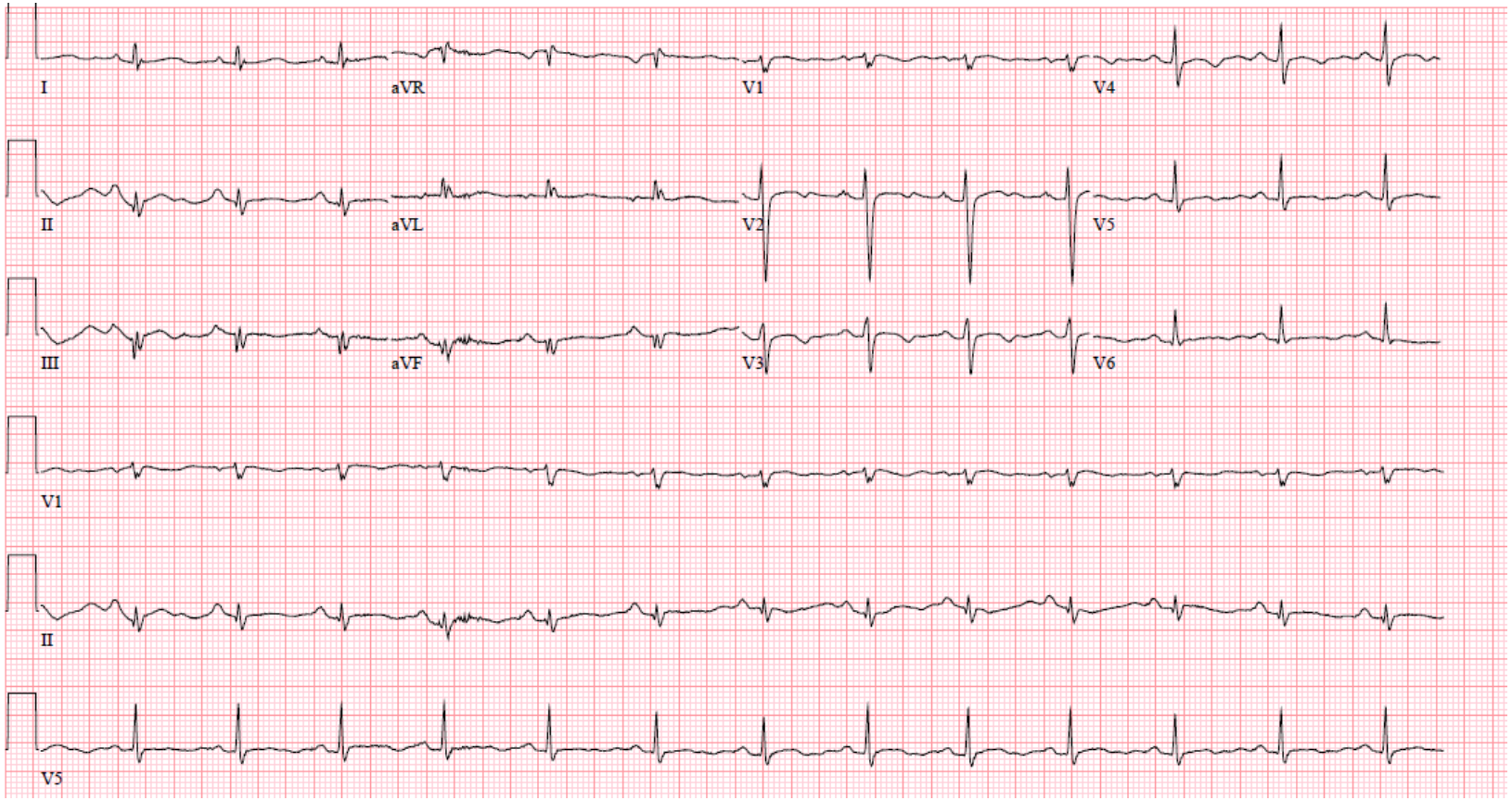
Rate

Bradycardia	**<60bpm**
Normal	**60-100bpm**
Tachycardia	**>100bpm**

Rate

Inherent Rates of Pacemaker Cells	
Sinus node	60-100bpm
Atrium	60-80bpm
AV junction	40-60bpm
Ventricle	20-40bpm

Rate



300/3.8 boxes = 78 bpm

13 QRS complex x 6 = 78bpm

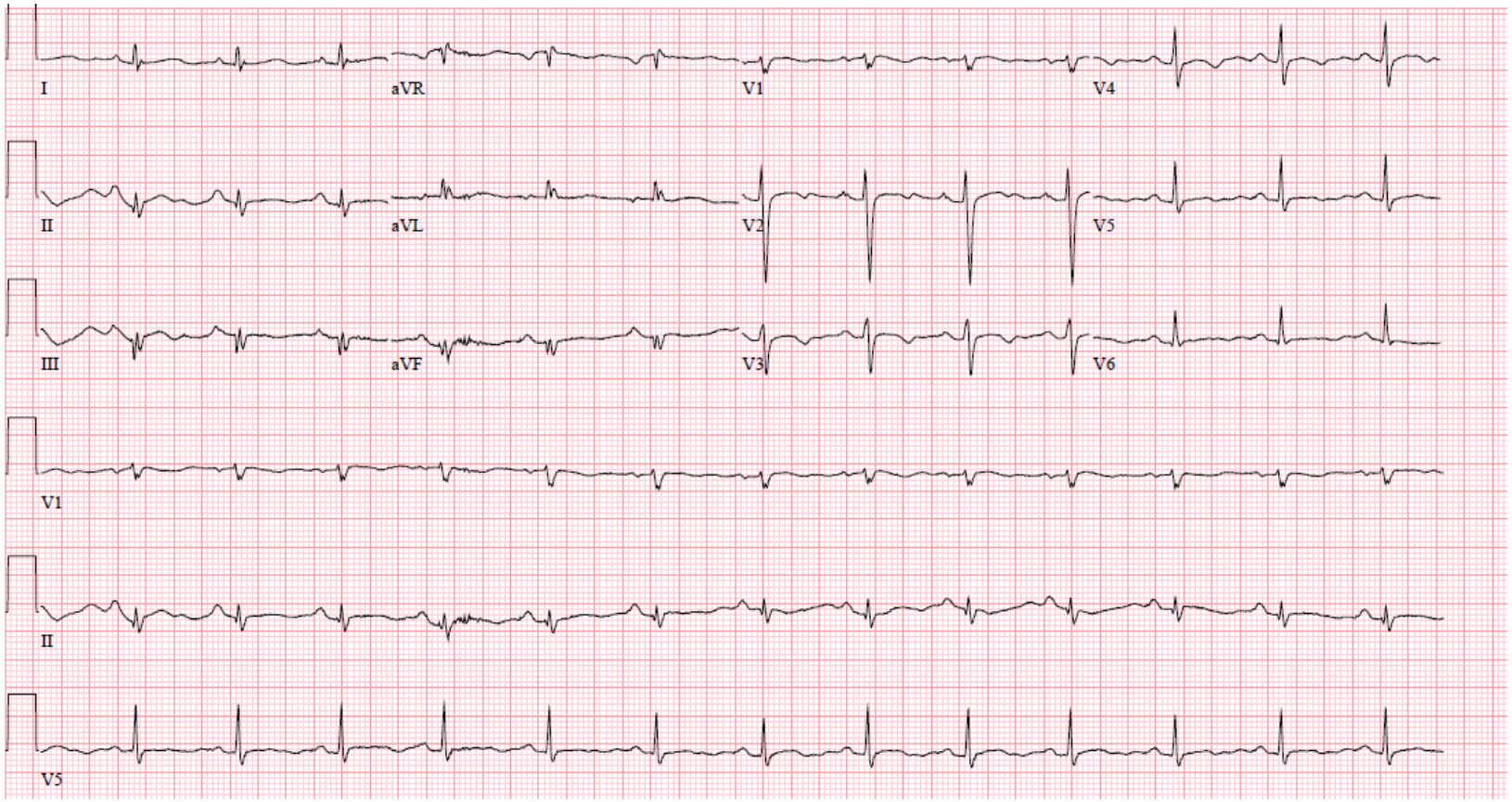
Stepwise Approach to EKGs

1. Rate
2. **Rhythm**
3. Axis
4. Intervals
5. Conduction Blocks
6. Ischemia
7. Voltage/Hypertrophy

Rhythm

1. Regular or irregular?
2. Wide or narrow
3. Are there P waves?
4. P wave to QRS ratio/relationship?
5. Paced rhythm?

Normal Sinus Rhythm

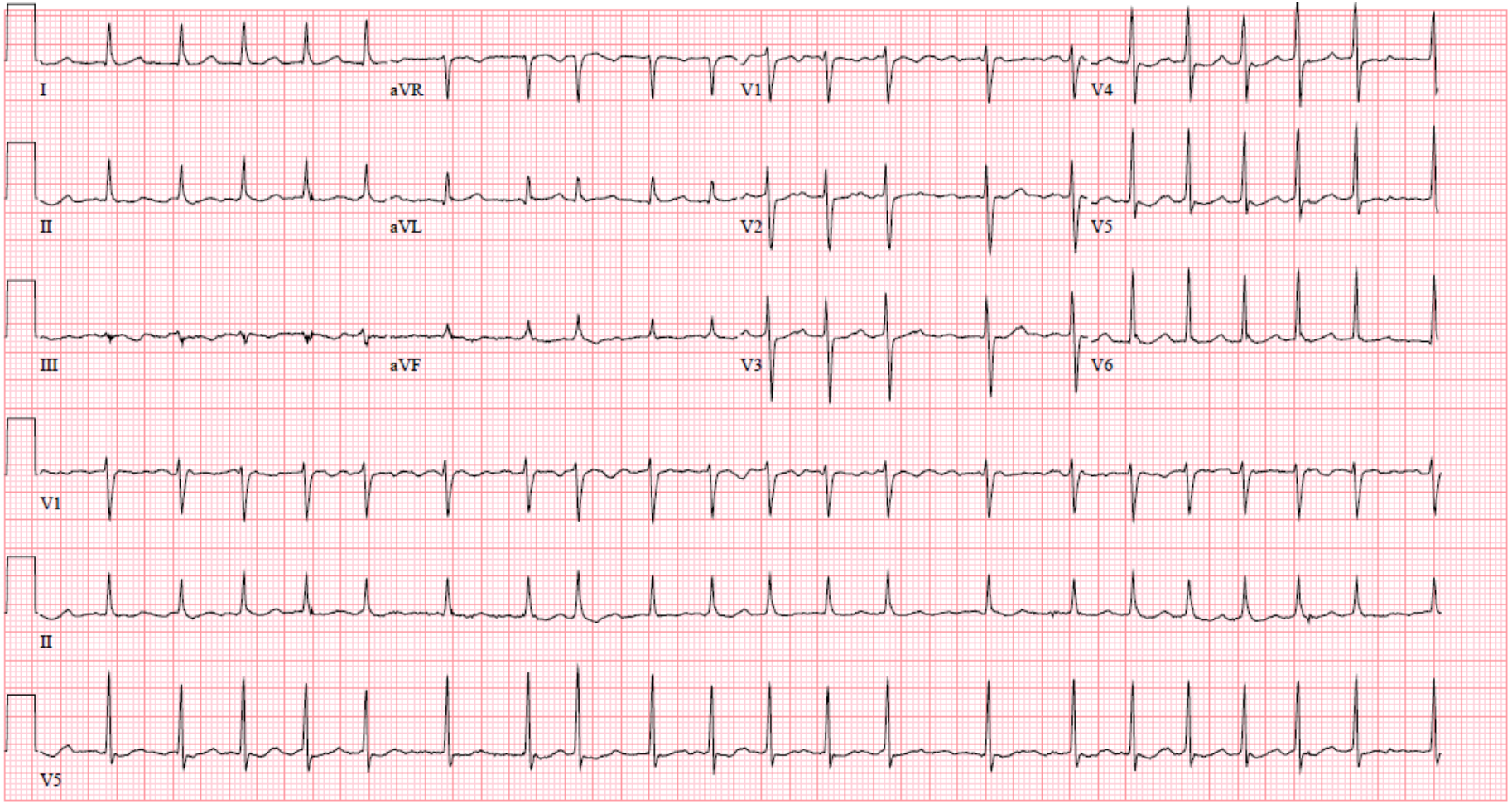


Rate:
300/3.8 boxes = 78 bpm
13 QRS complex x 6 = 78bpm

P waves upright in I, II, +/-aVF and biphasic in V1
Regular
P waves : QRS complex is 1:1

Diagnosis:
Normal Sinus Rhythm

Atrial Fibrillation

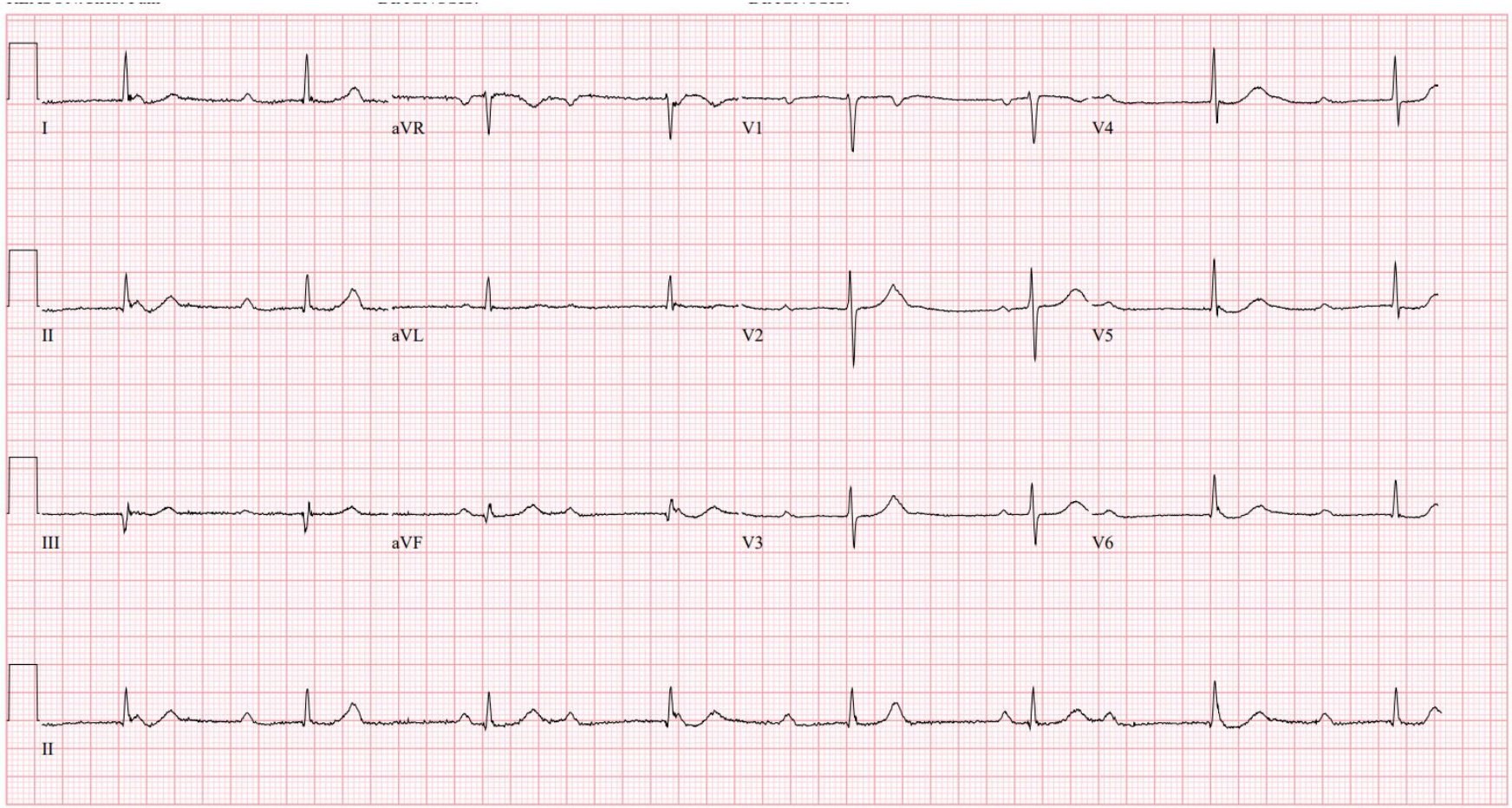


Rate:
21x6 = 126

No P waves
Irregularly irregular

Diagnosis:
Atrial fibrillation with rapid ventricular response

Complete Heart Block

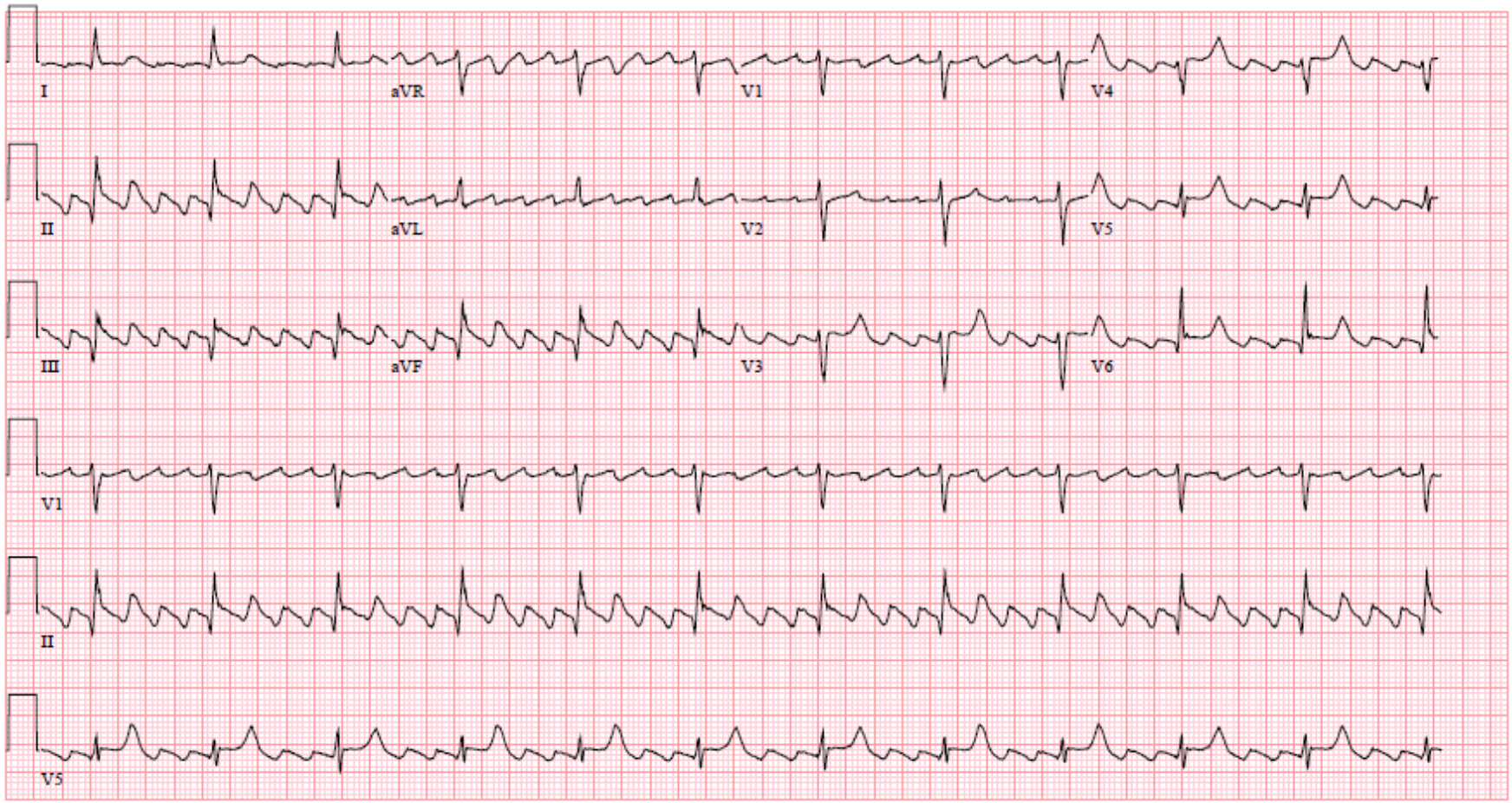


Rate:
Sinus rate: 300/3.5 = 85bpm
Ventricular rate: 300/6.5=46bpm

Sinus P waves
Regular
AV Dissociation

Diagnosis:
Normal sinus rhythm with complete heart block and a junctional escape

Atrial Flutter

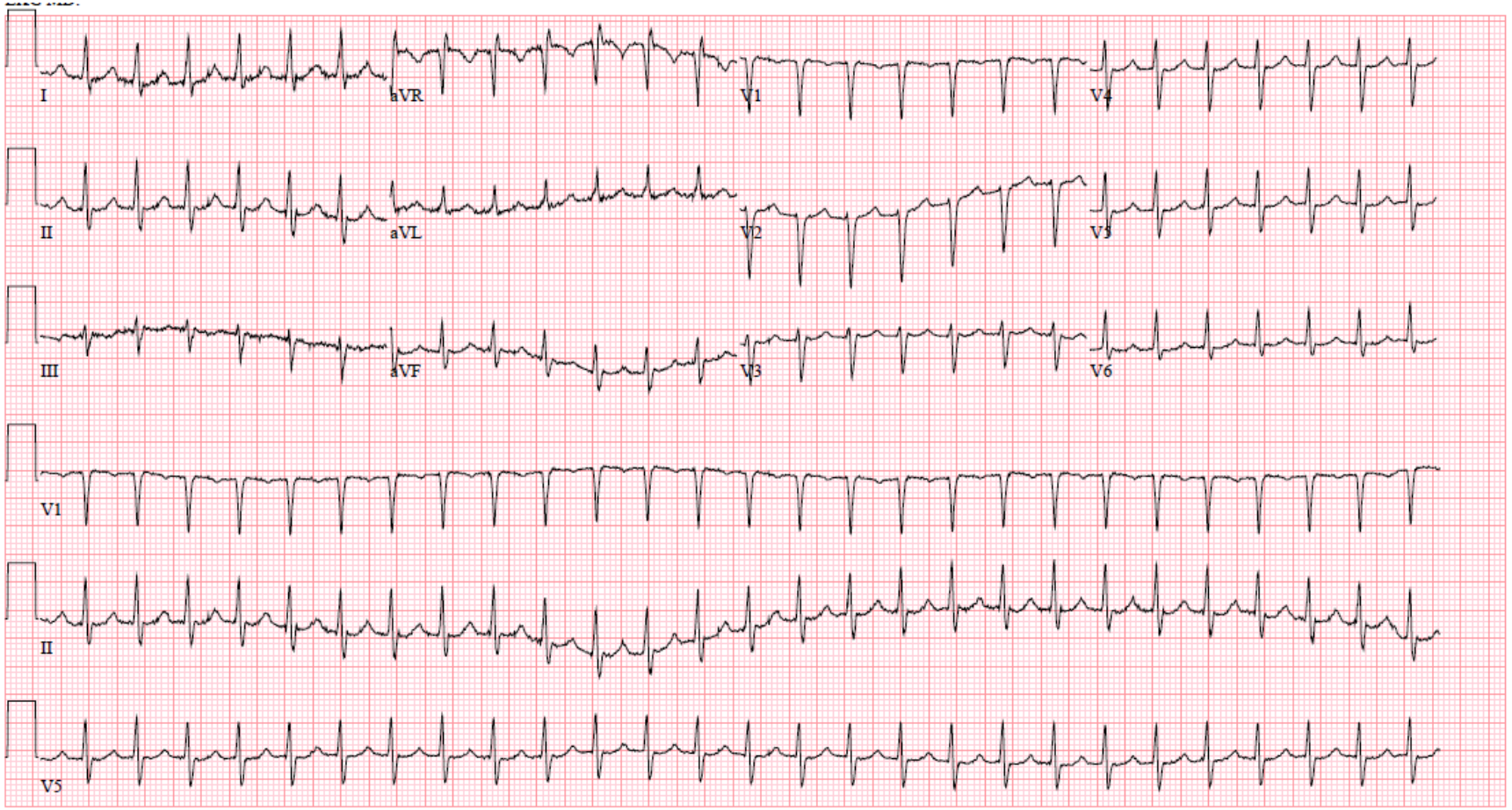


Rate:
12x6 = 72
300/4=75bpm

Sawtooth P waves
Regular
More P waves than QRS

Diagnosis:
Atrial flutter, 4:1 A-V conduction

Supraventricular tachycardia

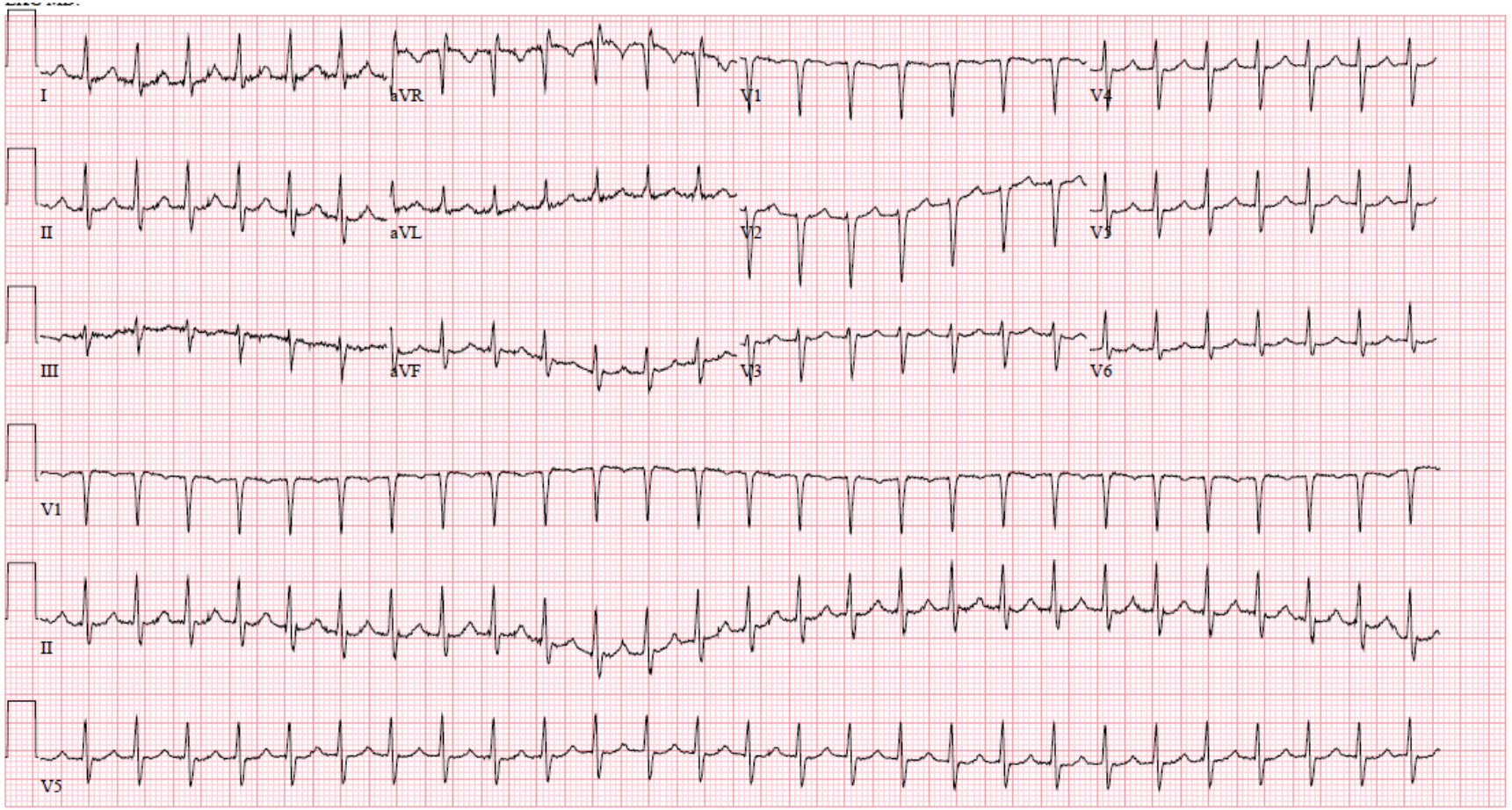


Rate:
300/1.8 = 167bpm

No P wave s
Regular, narrow, fast

Diagnosis:
Supraventricular tachycardia

Supraventricular tachycardia



Rate:
300/1.8 = 167bpm

No P wave s
Regular, narrow, fast

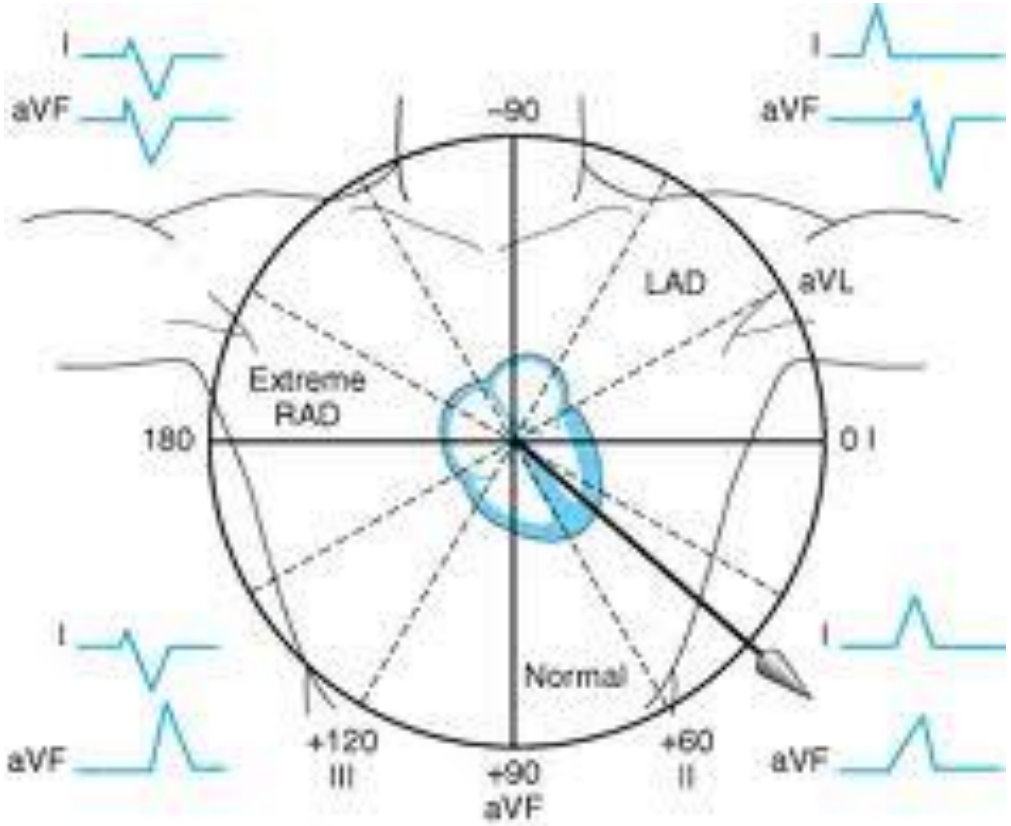
Diagnosis:
Supraventricular tachycardia

Stepwise Approach to EKGs

1. Rate
2. Rhythm
3. **Axis**
4. Intervals
5. Conduction Blocks
6. Ischemia
7. Voltage/Hypertrophy

Axis Deviation

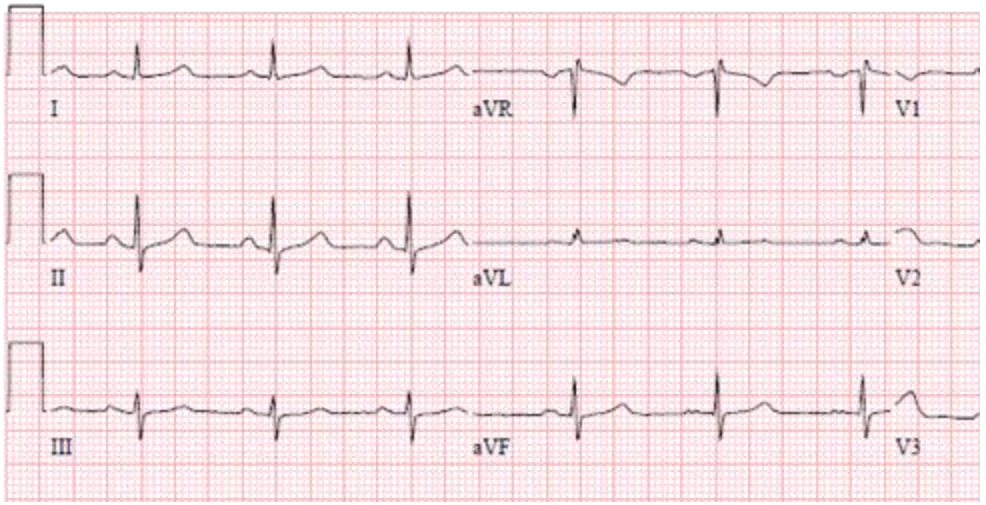
Look at I and aVF



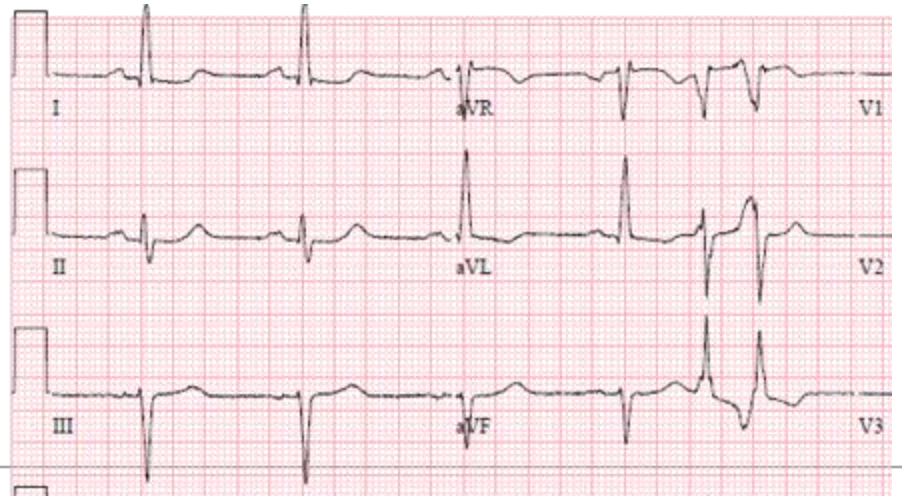
Left axis deviation

Right axis deviation

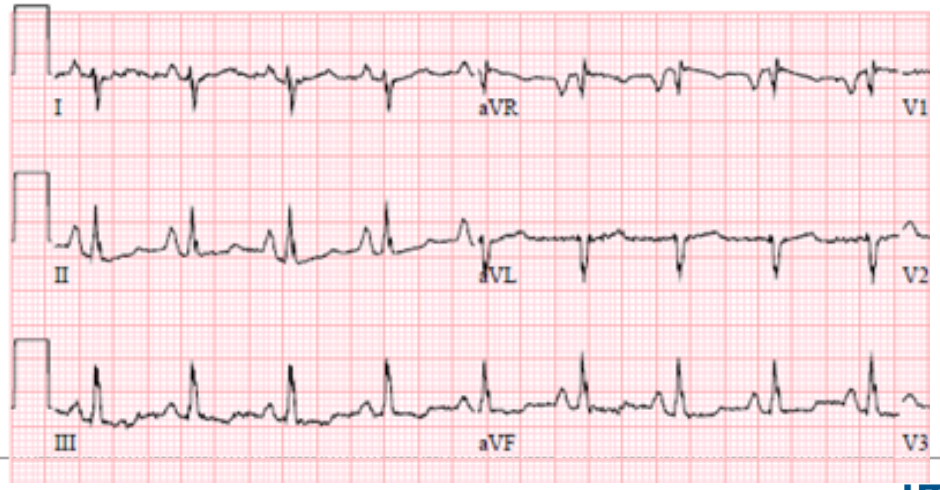
Axis Deviation



Normal axis



Left Axis

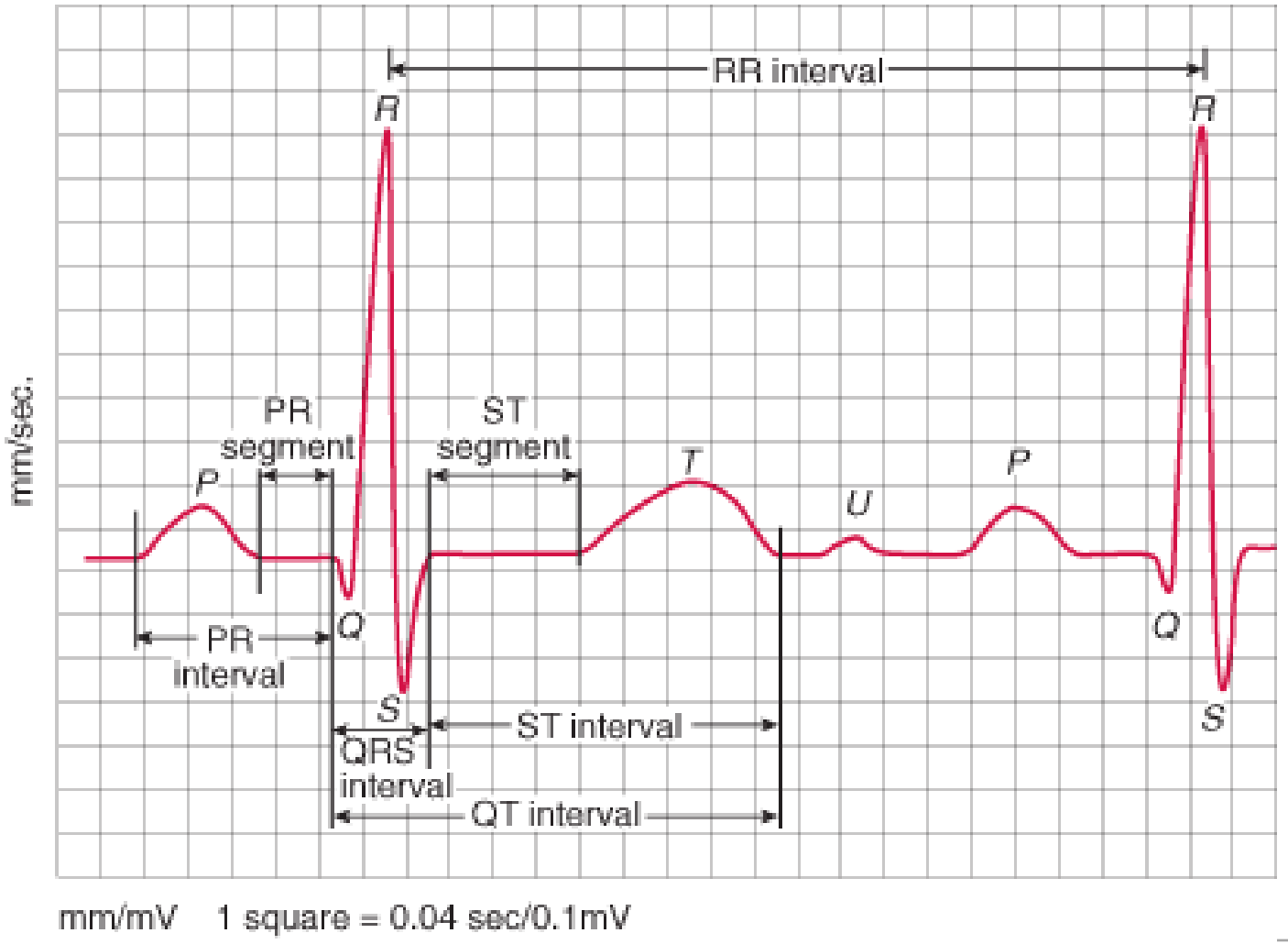


Right Axis

Stepwise Approach to EKGs

1. Rate
2. Rhythm
3. Axis
4. **Intervals**
5. Conduction Blocks
6. Ischemia
7. Voltage/Hypertrophy

Intervals



PR	**200ms** ***Long → AV block*** ***Short → WPW/pre-excitation***
QRS	**<120ms** ***Long → bundle branch block***
QT	**<440msec in men** **<460msec in women** **<1/2 RR**
QTC	$\frac{QT}{\sqrt{RR}}$

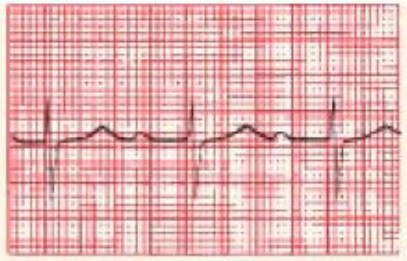
Stepwise Approach to EKGs

1. Rate
2. Rhythm
3. Axis
4. Intervals
5. **Conduction Blocks**
6. Ischemia
7. Voltage/Hypertrophy

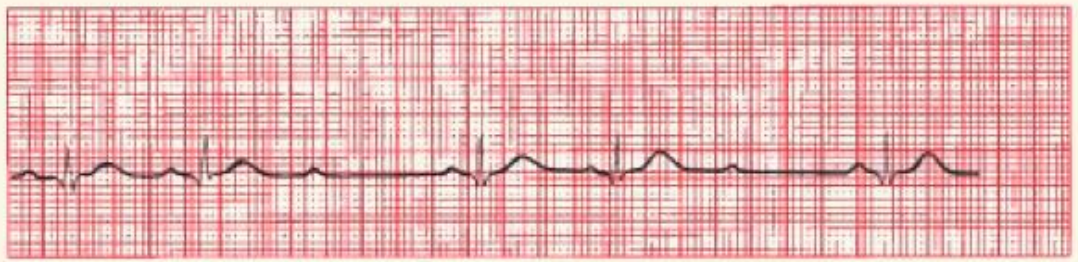
Conduction Blocks

AV Blocks	
First Degree	PR >120ms
Second Degree	
Mobitz I	Progressive prolongation of PR until drop of QRS
Mobitz II	Dropped QRS without PR prolongation
Third degree	Complete AV dissociation

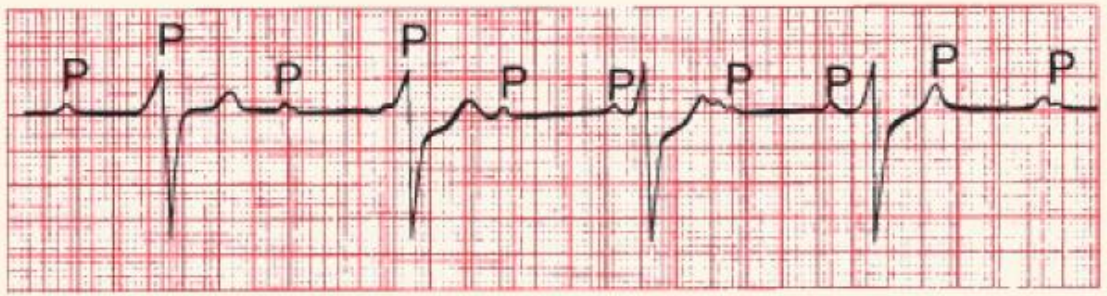
Conduction Blocks



(A) First-degree AV block. (B) Mobitz type I second-degree AV block (Wenckebach block).



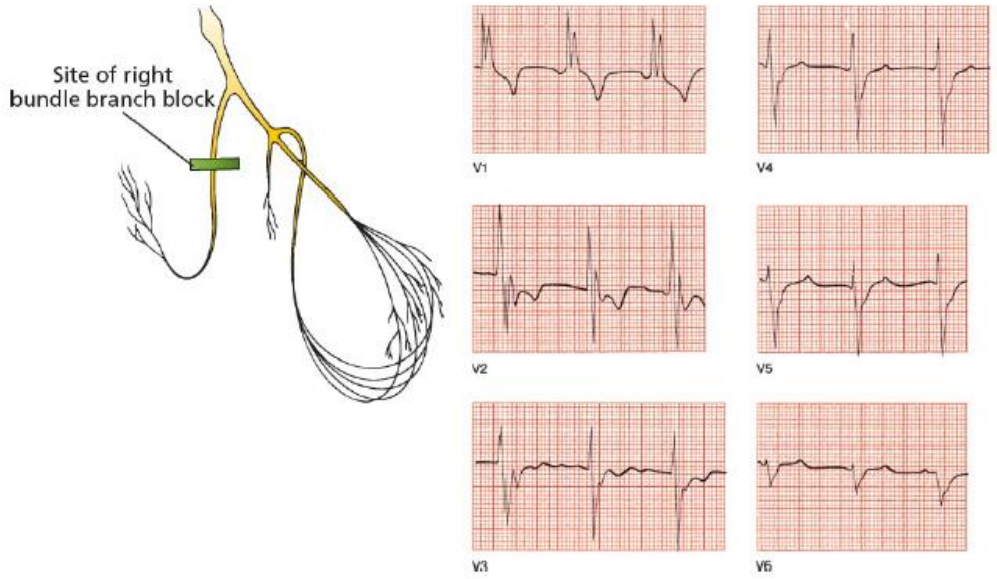
(C) Mobitz type II second-degree AV block.

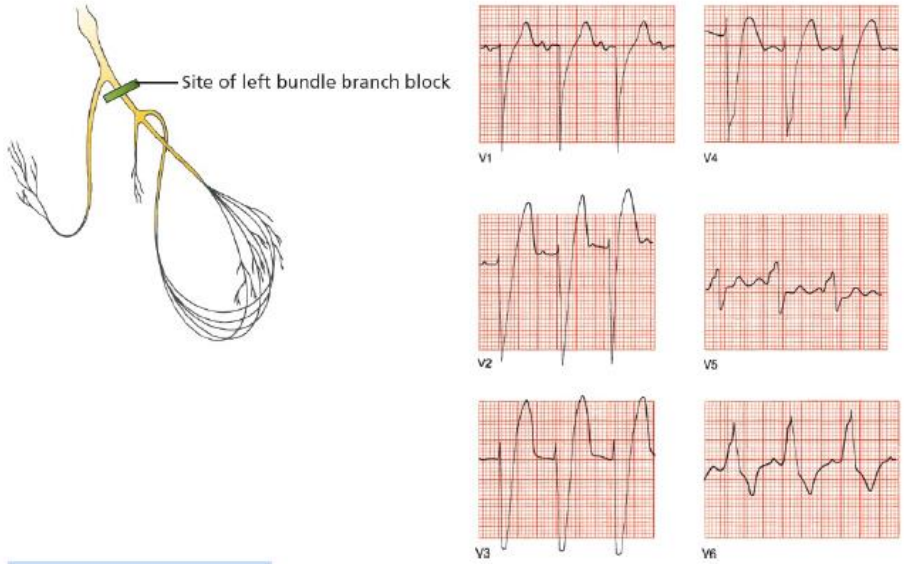


(D) Third-degree AV block.

Bundle Branch Blocks

Left Bundle Branch Block	**QRS >120ms** **Broad R wave in V5, V6, I, and aVL**
Right Bundle Branch Block	**QRS>120ms** **RSR in V1 and V2 (Rabbit ears) or tall broad R wave**





Stepwise Approach to EKGs

1. Rate
2. Rhythm
3. Axis
4. Intervals
5. Conduction Blocks
6. **Ischemia**
7. Voltage/Hypertrophy

Ischemia

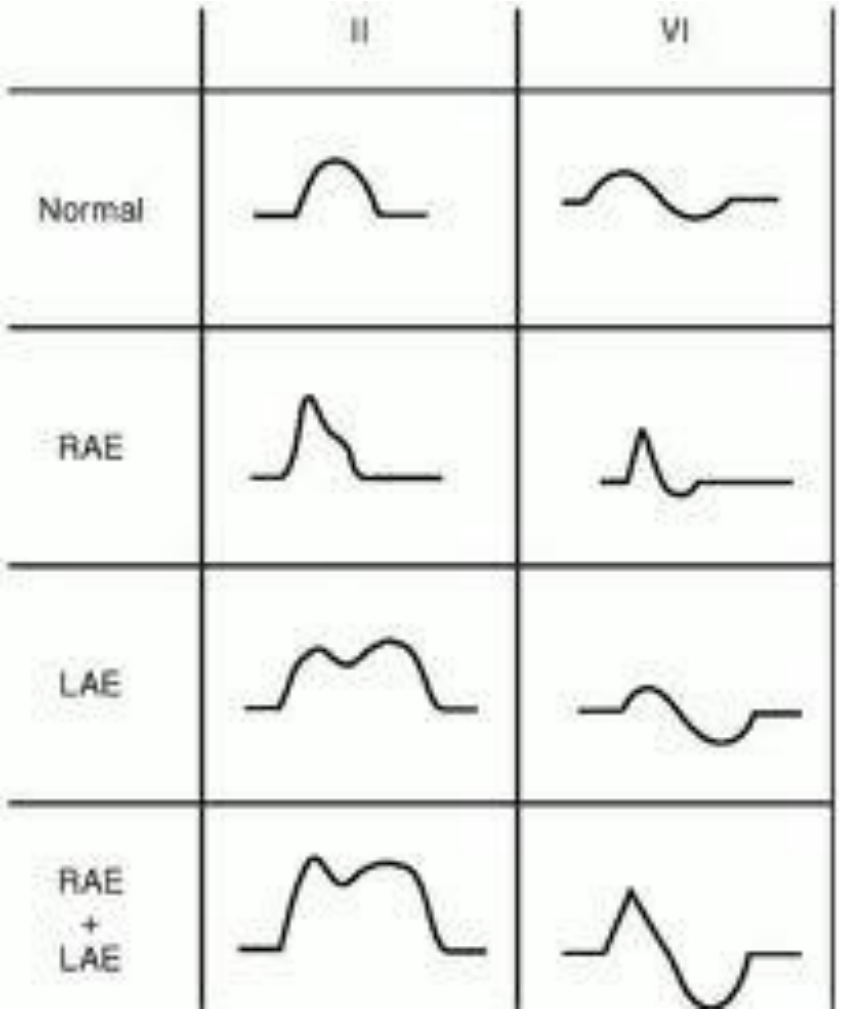
STEMI	Ischemia
≥2.5mm in men <40 and ≥ 2.0 in men ≥ 40 1.5mm in women in V2-V3	Q waves ≥ 40msec Depth must be 1/3 of R wave hight
≥1mm in other continuous chest leads	T wave inversion, ST depression
2 contiguous leads	

Stepwise Approach to EKGs

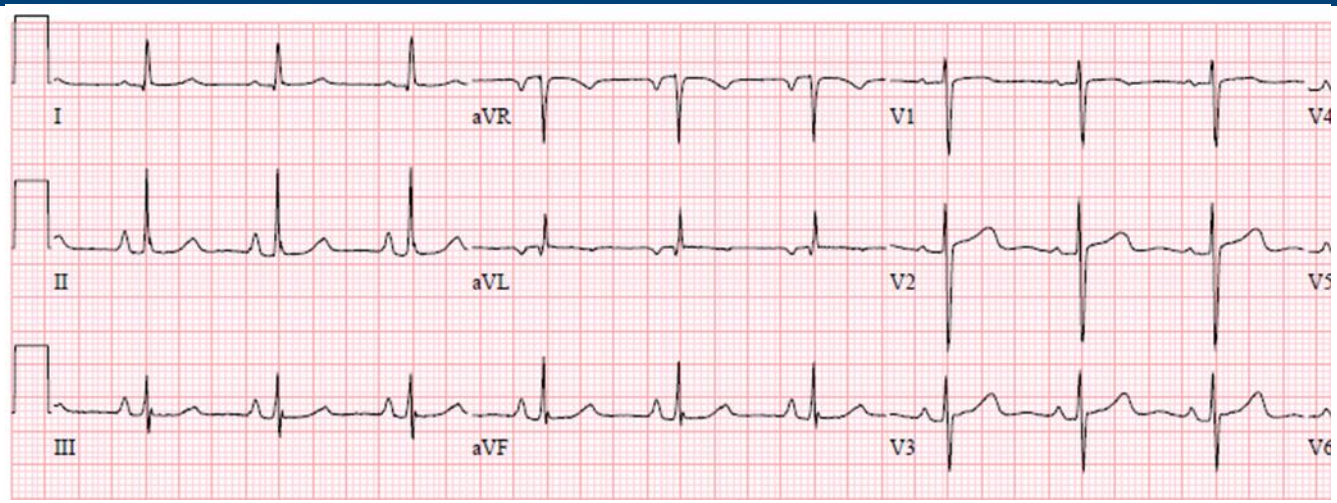
1. Rate
2. Rhythm
3. Axis
4. Intervals
5. Conduction Blocks
6. Ischemia
7. **Voltage/Hypertrophy**

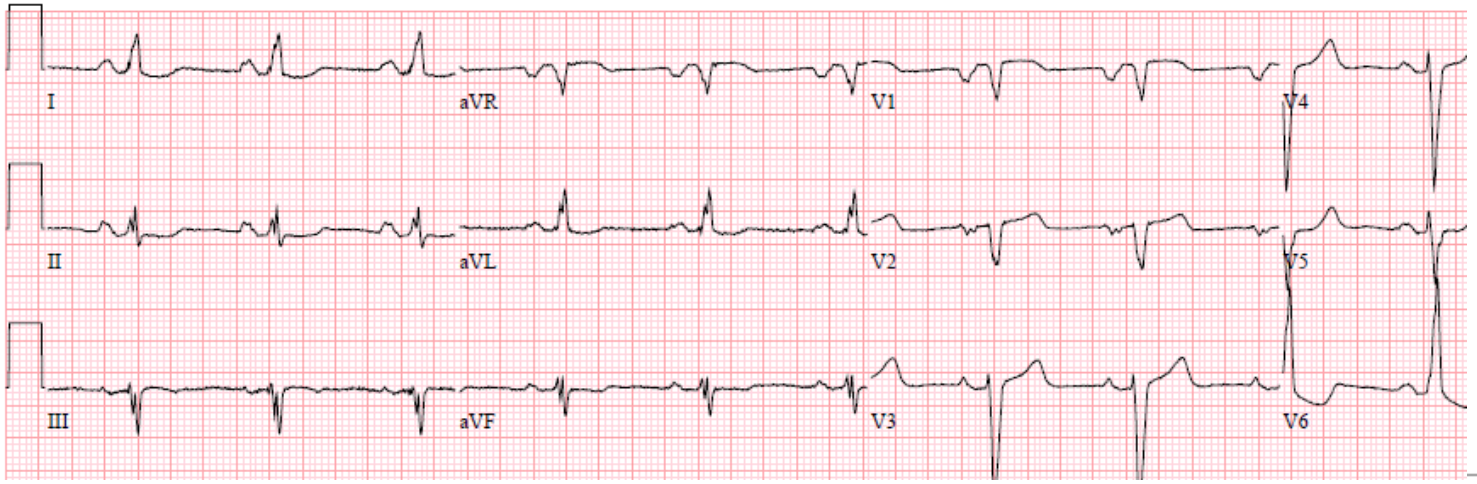
Hypertrophy

Right atrial enlargement	**≥ 2.5mm of height in the inferior leads**
Left atrial enlargement	**>1 little box wide and deep in V1 >120ms in II – humped**



Hypertrophy

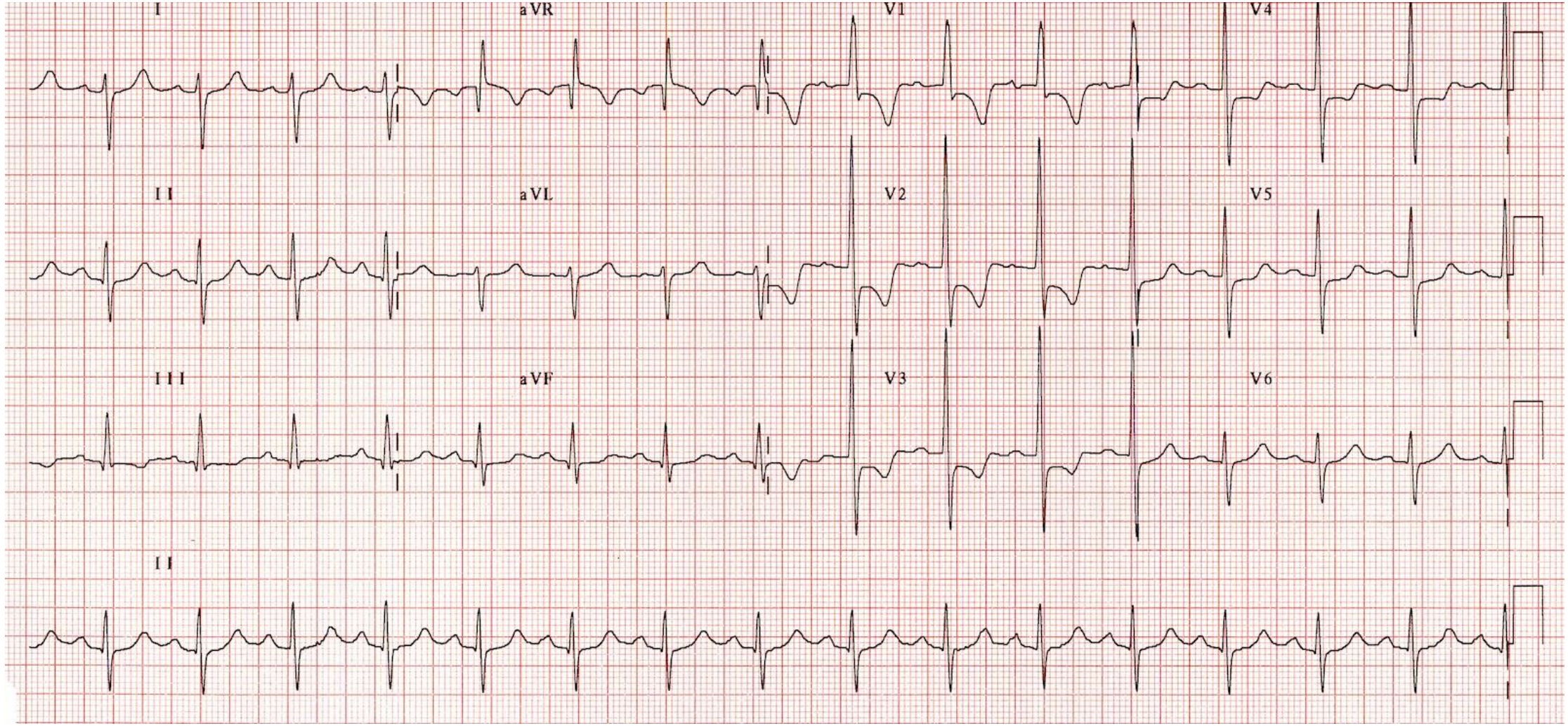




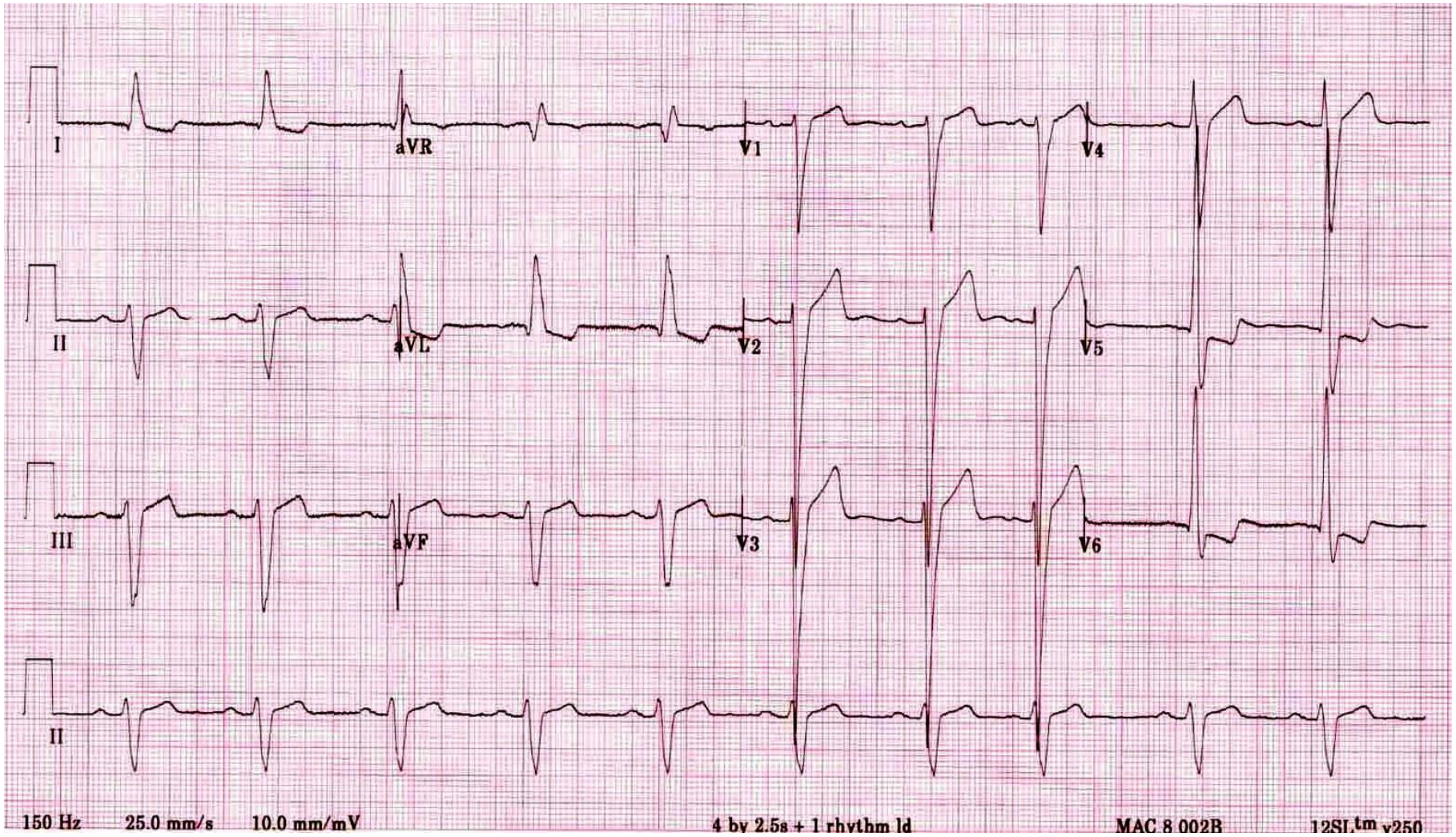
Hypertrophy

LVH	RVH
R wave in V5/V6 + S in V1 >35mm (Sokolow Lyon)	RAD
R wave in aVL >11mm	R wave in V1 (>7mm or R>S)
S V3 + R aVL >28mm in men SV3 + R aVL >20mm in women	

Hypertrophy



Hypertrophy

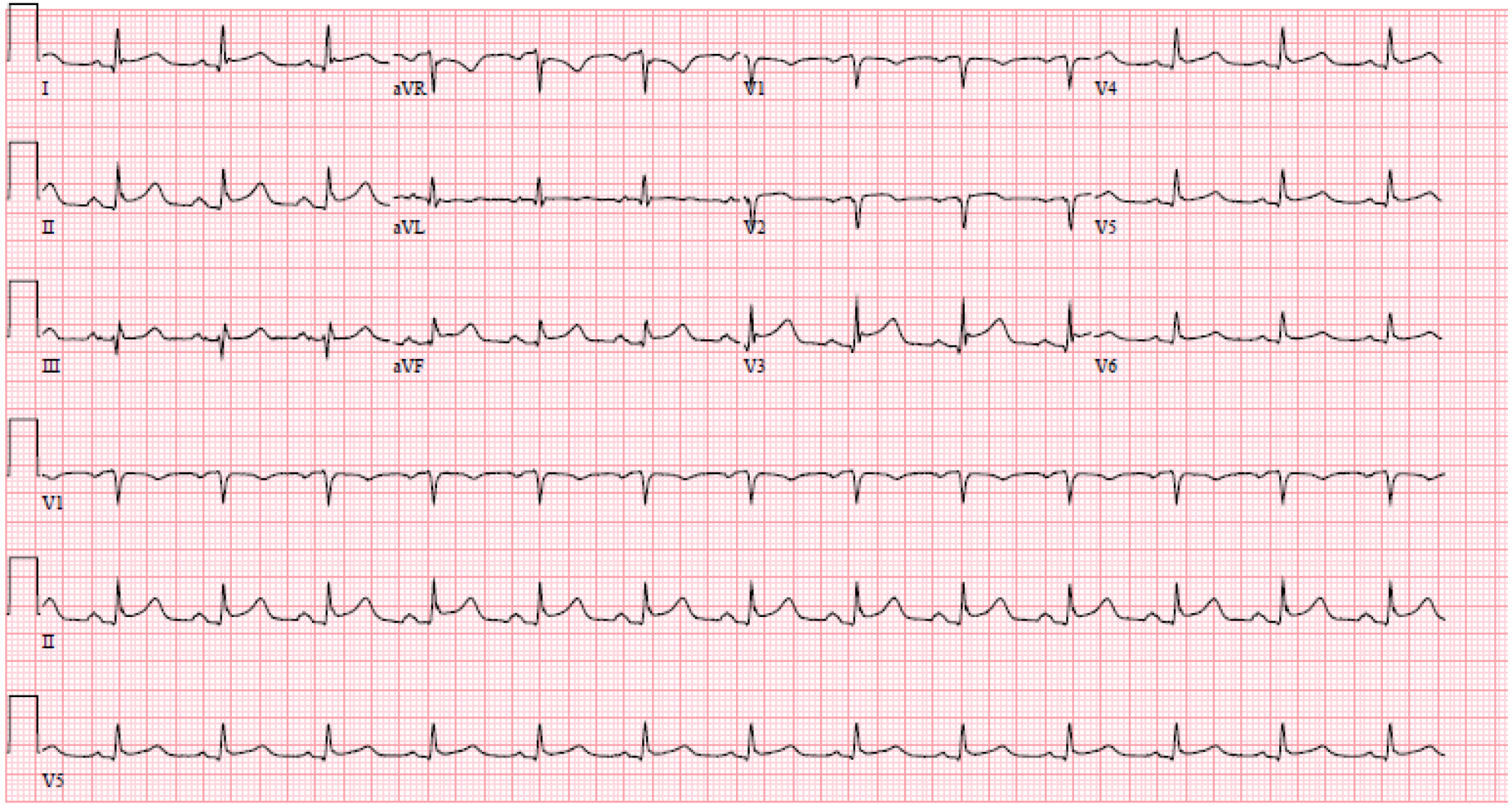


Voltage

Low Voltage
QRS<5mm in all limb leads
QRS<10mm in all precordial leads

Causes
Obesity
Pericardial Effusion
COPD
Infiltrative
Pleural effusion

Sample EKG



1. Rate
2. Rhythm
3. Axis
4. Intervals
5. Conduction Blocks
6. Ischemia
7. Hypertrophy

HR 90s

Normal sinus rhythm

Normal axis

Normal intervals

Narrow QRS, intact AV conduction

ST elevation in inferolateral leads

No hypertrophy/low voltage only in precordial leads

Normal sinus rhythm, inferolateral STEMI