PennState Health
St. Joseph

Cardiology/EKG Board Review

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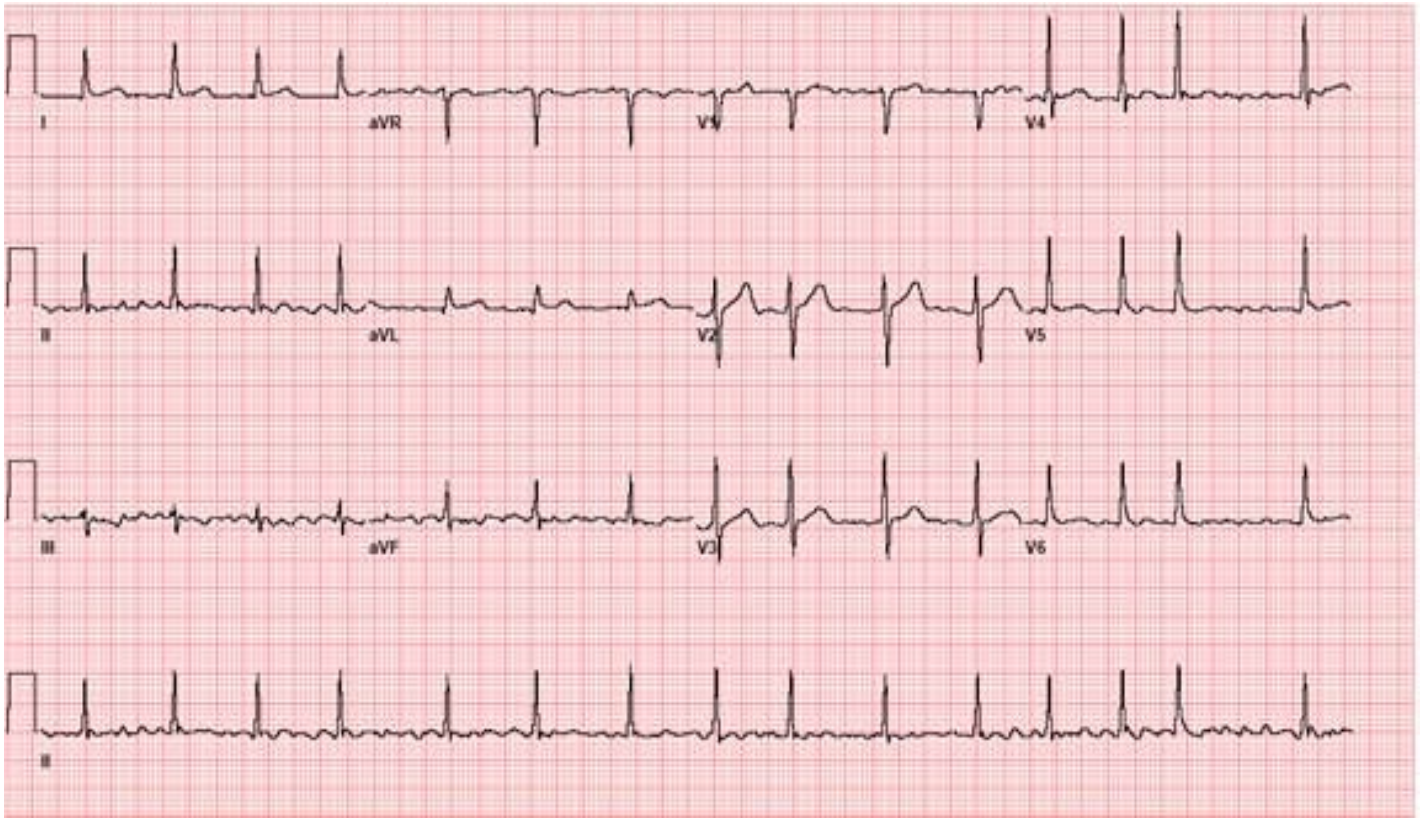
Objectives

- Review general method for EKG interpretation
- Review specific points of “data gathering” and “diagnoses” on EKG
- Review treatment considerations
- Review clinical cases/EKG’s
- Board exam considerations

EKG



EKG – 12 Leads

- Anterior Leads - V1, V2, V3, V4
- Inferior Leads – II, III, aVF
- Left Lateral Leads – I, aVL, V5, V6
- Right Leads – aVR, V1

11 Step Method for Reading EKG's

- "Data Gathering" – steps 1-4
  - 1. Standardization – make sure paper and paper speed is standardized
  - 2. Heart Rate
  - 3. Intervals – PR, QT, QRS width
  - 4. Axis – normal vs. deviation

11 Step Method for Reading EKG's

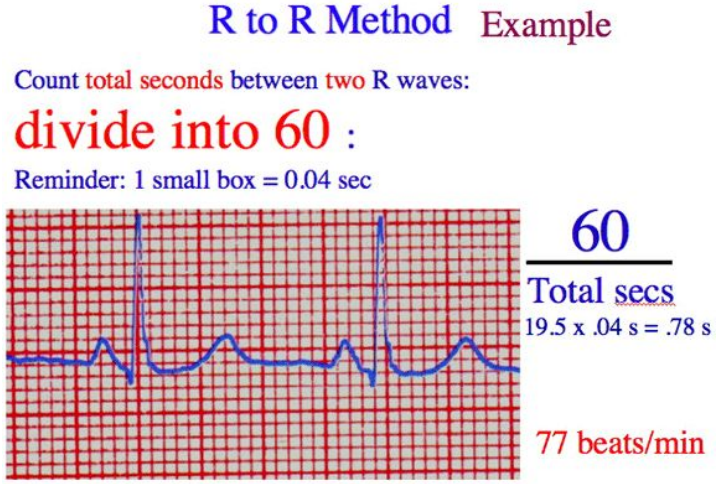
- "Diagnoses"
  - 5. Rhythm
  - 6. Atrioventricular (AV) Block
  - 7. Bundle Branch Block or Hemiblock
  - 8. Preexcitation
  - 9. Enlargement and Hypertrophy
  - 10. Coronary Artery Disease
  - 11. Utter Confusion

Conduction  Disturbances

- The Only EKG Book You'll Ever Need
  Malcolm S. Thaler, MD

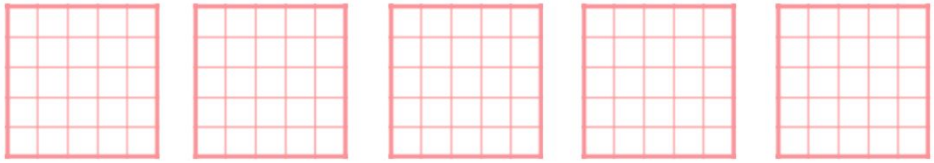
Heart Rate

- Regular Rhythms



Heart Rate

- Irregular Rhythms

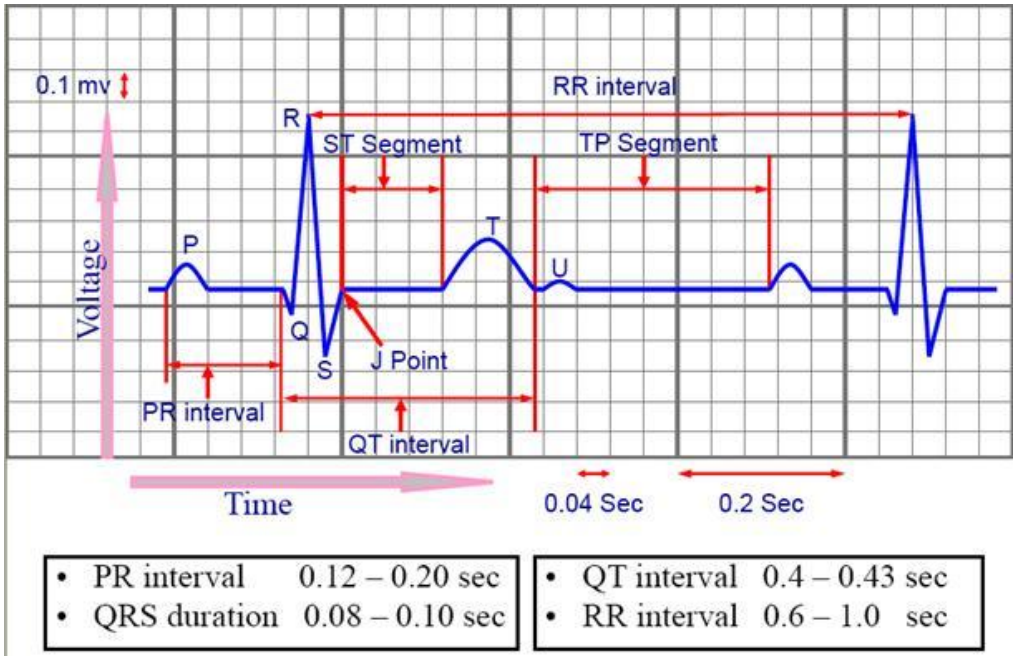


- 5 big boxes = 1 sec
- 1 ECG = 10 sets of 5 big boxes
- Therefore one ECG = 10 secs

- Rate = BPM or R Waves/60secs
- 1 ECG x 6 = 1 min
- Count up R waves in one ECG x 6 = BPM

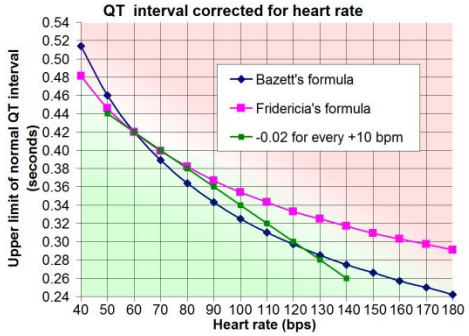
Intervals

- Measure length of PR interval, QT interval, width of P wave, QRS complex



QTc

- QTc = QT interval corrected for heart rate
  - Uses Bazett's Formula or Fridericia's Formula

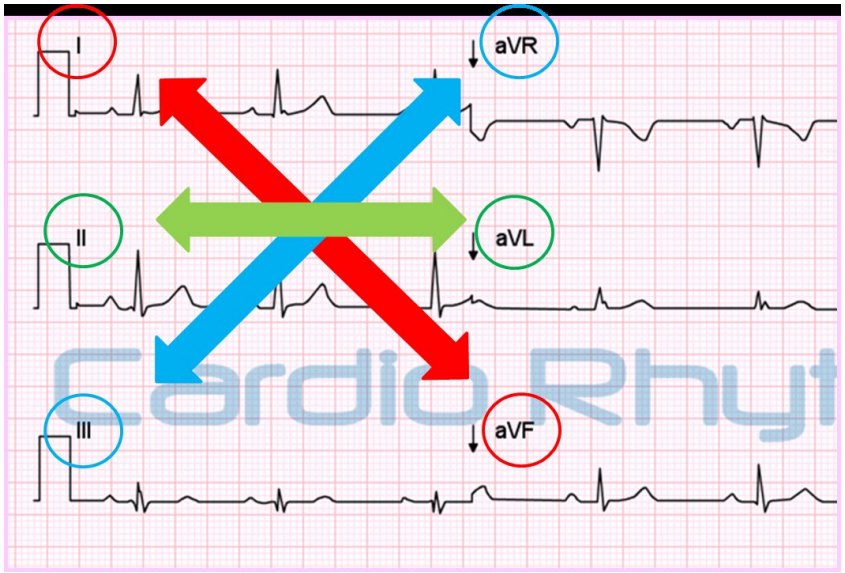


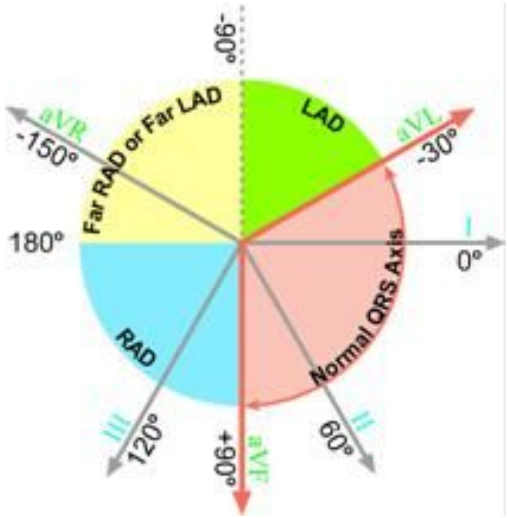
$$\text{QTc (Bazett)} = \frac{\text{QT}}{\sqrt{\text{RR}}}$$

$$QTcF = \frac{QT}{\sqrt[3]{RR}}$$

- Long QT syndrome – inherited or acquired (>75 meds); torsades de ponites/VF; syncope, seizures, sudden death

Axis


I
aVR
II
aVL
III
aVF


-90°
aVR
-150°
Far RAD or Far LAD
LAD
aVL
-30°
180°
I
0°
RAD
Normal QRS Axis
III
120°
+90°
aVF
II
60°

Rhythm

- 4 Questions
  - 1. Are normal P waves present?
  - 2. Are QRS complexes narrow or wide (≤ or ≥ 0.12)?
  - 3. What is relationship between P waves and QRS complexes?
  - 4. Is rhythm regular or irregular?
- Sinus rhythm = normal P waves, narrow QRS complexes, 1 P wave to every 1 QRS complex, and regular rhythm

Types of Arrhythmias

- Arrhythmias of sinus origin
- Ectopic rhythms
- Conduction Blocks
- Preexcitation syndromes

AV Block

- Diagnosed by examining relationship of P waves to QRS complexes
- First Degree – PR interval > 0.2 seconds; all beats conducted through to the ventricles
- Second Degree – only some beats are conducted through to the ventricles
  - Mobitz Type I (Wenckebach) – progressive prolongation of PR interval until a QRS is dropped
  - Mobitz Type II – All-or-nothing conduction in which QRS complexes are dropped without PR interval prolongation
- Third Degree – No beats are conducted through to the ventricles; complete heart block with AV dissociation; atria and ventricles are driven by individual pacemakers

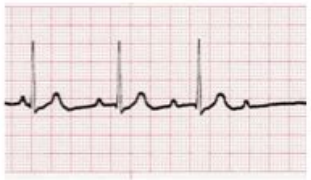
Heart Blocks

Constant P-R interval

Variable P-R Interval

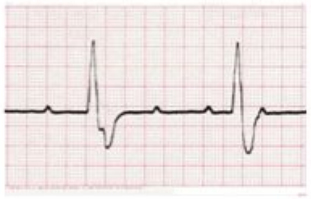
First Degree Heart Block

Second Degree Heart Block Type I



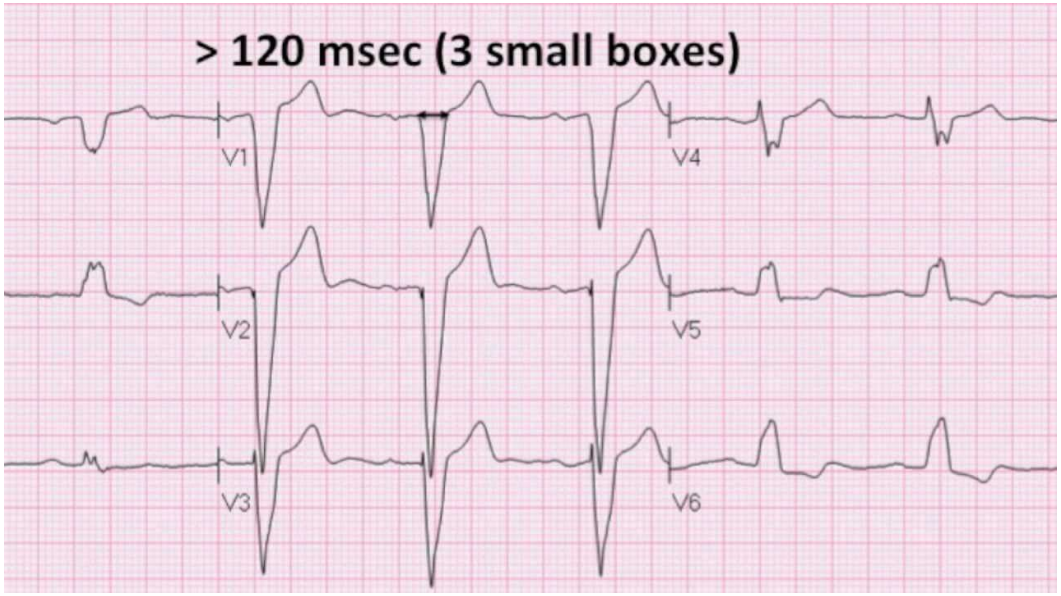
Second Degree Heart Block Type II

Third Degree Heart Block



Bundle Branch Blocks

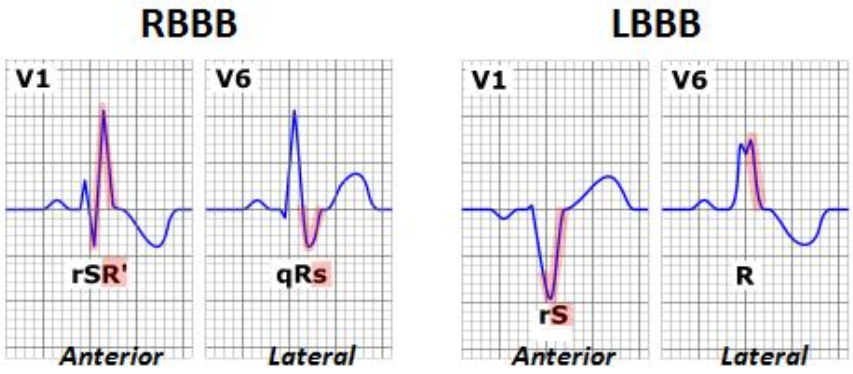
- Diagnosed by looking at width and configuration of QRS complexes

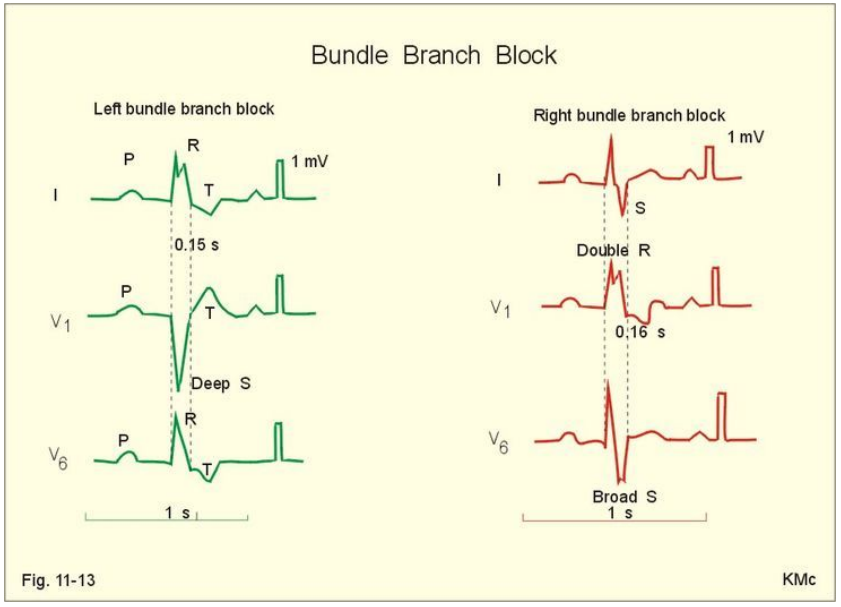


Bundle Branch Blocks

- RBBB criteria:
  - 1. QRS complex > 0.12 seconds
  - 2. RSR' in leads V1 and V2 (rabbit ears) with ST segment depression and T wave inversion
  - 3. Reciprocal changes in leads V5, V6, I, and aVL
- LBBB criteria:
  - 1. QRS complex > 0.12 seconds
  - 2. Broad or notched R wave with prolonged upstroke in leads V5, V6, I, and aVL with ST segment depression and T wave inversion.
  - 3. Reciprocal changes in leads V1 and V2.
  - 4. Left axis deviation may be present.

Bundle Branch Blocks





Hemiblocks

- Diagnosed by looking at right or left axis deviation
- Left Anterior Hemiblock
  - 1.Normal QRS duration and no ST segment or T wave changes
  - 2. Left axis deviation greater than -30°
  - 3. No other cause of left axis deviation is present
- Left Posterior Hemiblock
  - 1. Normal QRS duration and no ST segment or T wave changes
  - 2. Right axis deviation
  - 3. No other cause of right axis deviation is present

Bifascicular Block

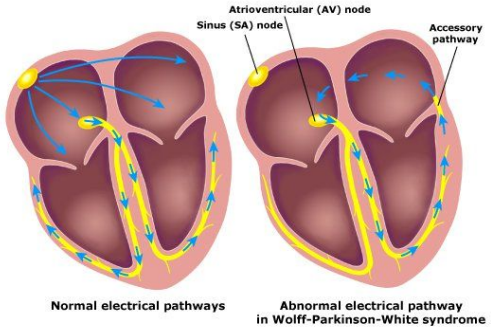
- RBBB with LAH
  - RBBB – QRS > 0.12 sec and RSR’ in V1 and V2 with LAH – left axis deviation
- RBBB with LPH
  - RBBB – RS > 0.12 sec and RSR’ in V1 and V2 with LPH – right axis deviation

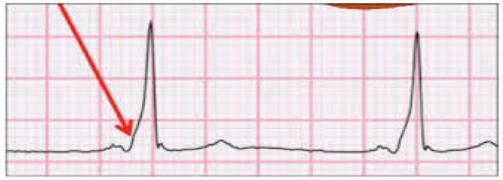
Preexcitation

- Wolff-Parkinson-White (WPW) Syndrome
  - 1. PR interval < 0.12 sec
  - 2. Wide QRS complexes
  - 3. Delta waves seen in some leads
- Lown-Ganong-Levine (LGL) Syndrome –
  - 1. PR interval < 0.12 sec
  - 2. Normal QRS width
  - 3. No delta wave
- Common Arrhythmias
  - Paroxysmal Supraventricular Tachycardia (PSVT) – narrow QRS's are more common than wide QRS's
  - Atrial Fibrillation – can be rapid and lead to ventricular fibrillation

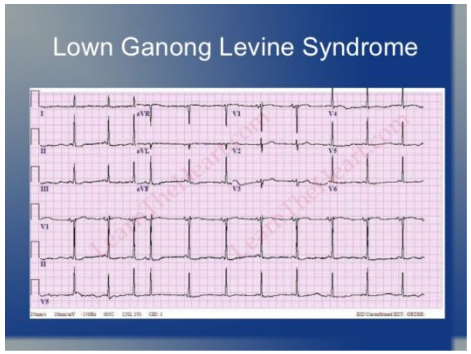
Preexcitation

WPW





LGL

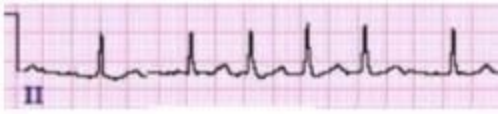


Supraventricular Arrhythmias

- PSVT- regular; P waves retrograde if visible; rate 150-250 bpm; carotid massage: slows or terminates
- Flutter – regular; saw-toothed pattern; 2:1, 3:1, 4:1, etc. block; atrial rate 250-350 bpm; ventricular rate ½, ⅓, ¼, etc. of atrial rate; carotid massage: increases block
- Fibrillation – irregular; undulating baseline; atrial rate 350 to 500 bpm; variable ventricular rate; carotid massage: may slow ventricular rate
- Multifocal atrial tachycardia (MAT) – irregular; at least 3 different P wave morphologies; rate –usually 100 to 200 bpm; sometimes < 100 bpm; carotid massage: no effect
- PAT – regular; 100 to 200 bpm; characteristic warm-up period in the automatic form; carotid massage: no effect, or mild slowing

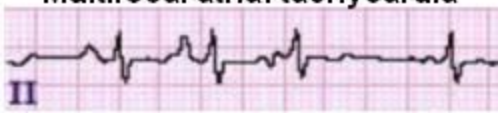
Supraventricular Arrhythmias

Atrial fibrillation



Atrial flutter

Multifocal atrial tachycardia



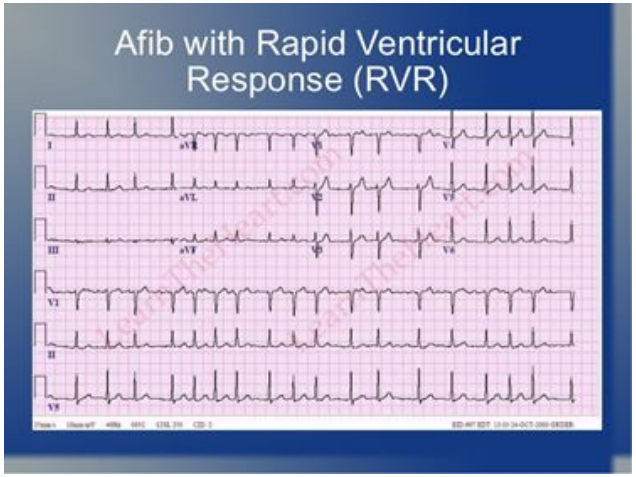
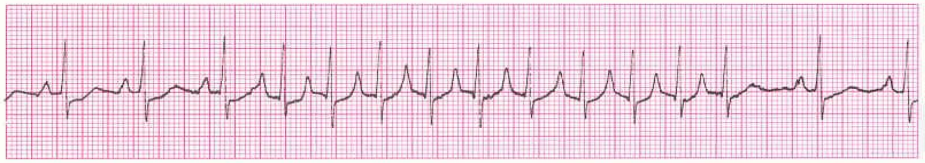


TABLE 4-3 CHARACTERISTICS OF SUPRAVENTRICULAR TACHYCARDIA (SVT)

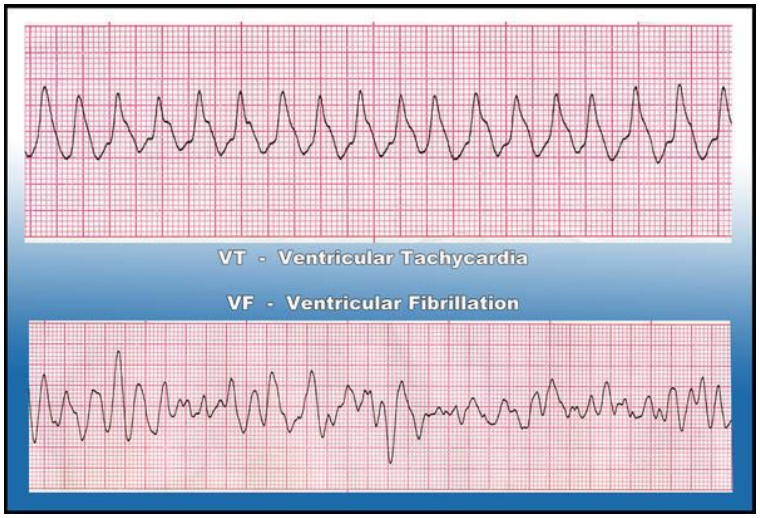
Rate	150-250 beats/min
Rhythm	Regular
P waves	Atrial P waves may be observed that differ from sinus P waves
PR interval	If P waves are seen, the PRI will usually measure 0.12-0.20 sec
QRS duration	Less than 0.10 sec unless an intraventricular conduction delay exists

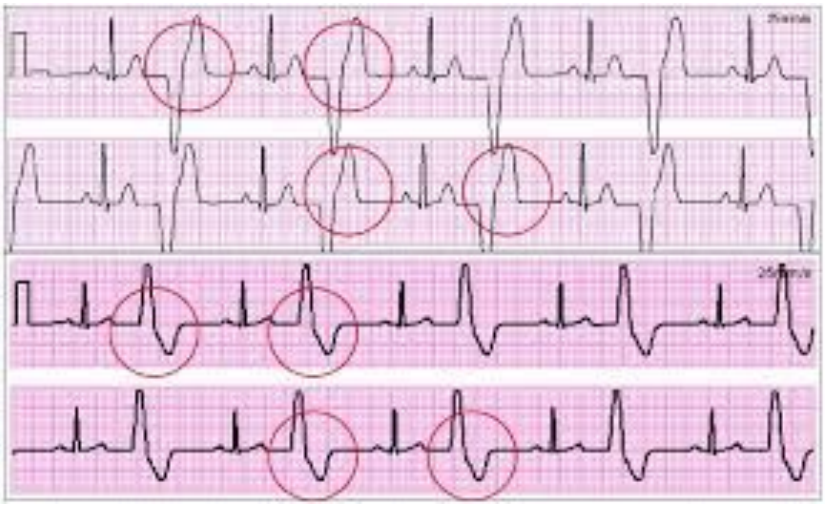


Rules of Aberrancy

	Ventricular Tachycardia	Paroxysmal supraventricular Tachycardia
Clinical Clues		
Clinical History	Diseased heart	Usually normal heart
Carotid Massage	No response	May terminate
Cannon A Waves	May be present	Not seen
EKG Clues		
AV Dissociation	May be seen	Not seen
Regularity	Slightly irregular	Very regular
Fusion Beats	May be seen	Not seen
Initial QRS deflection	May differ from normal QRS complex	Same as normal QRS complex

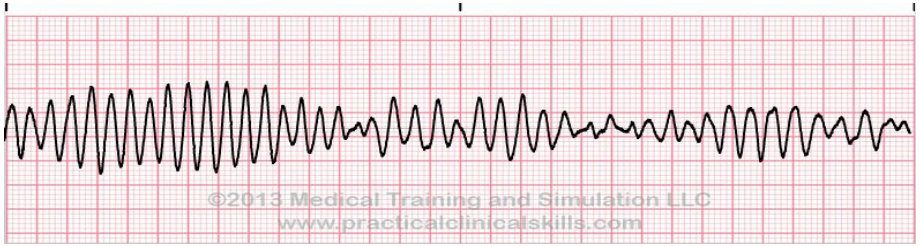
Ventricular Arrhythmias





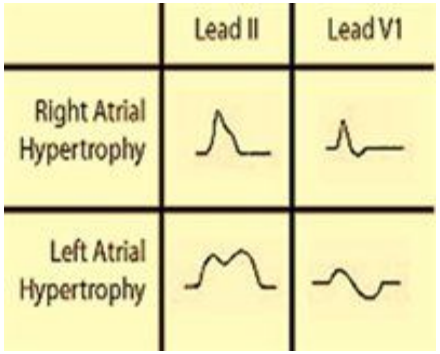
PVC’s

Torsades de Pointes



Atrial Enlargement

- Look at P waves in leads II and V1
- Right atrial enlargement (P pulmonale)
  - 1. Increased amplitude in first portion of P wave
  - 2. No change in duration of P wave
  - 3. Possible right axis deviation of P wave
- Left atrial enlargement (p mitrale)
  - 1. Occasionally, increased amplitude of terminal part of P wave
  - 2. More consistently, increased P wave duration
  - 3. No significant axis deviation



Ventricular Hypertrophy

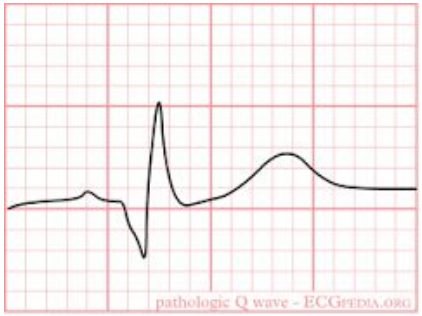
- Look at the QRS complexes in all leads
- Right ventricular hypertrophy (RVH)
  - 1. RAD > 100°
  - 2. Ratio of R wave amplitude to S wave amplitude > 1 in V1and < 1 in V6
- Left ventricular hypertrophy (LVH)

Precordial Criteria	Limb Lead Criteria
R wave in V5 or V6 + S wave in V1 or V2 > 35 mm	R wave in aVL >13 mm
R wave in V5 > 26 mm	R wave in aVF > 21 mm
R wave in V6 > 18 mm	R wave in I > 14 mm
R wave in V6 > R wave in V5	R wave in I + S wave in III > 25 mm

Myocardial Infarction

- Dx – Hx, PE, serial cardiac enzymes, serial EKG's
- 3 EKG stages of acute MI
  - 1. T wave peaks and then inverts
  - 2. ST segment elevates
  - 3. Q waves appear

Q Waves

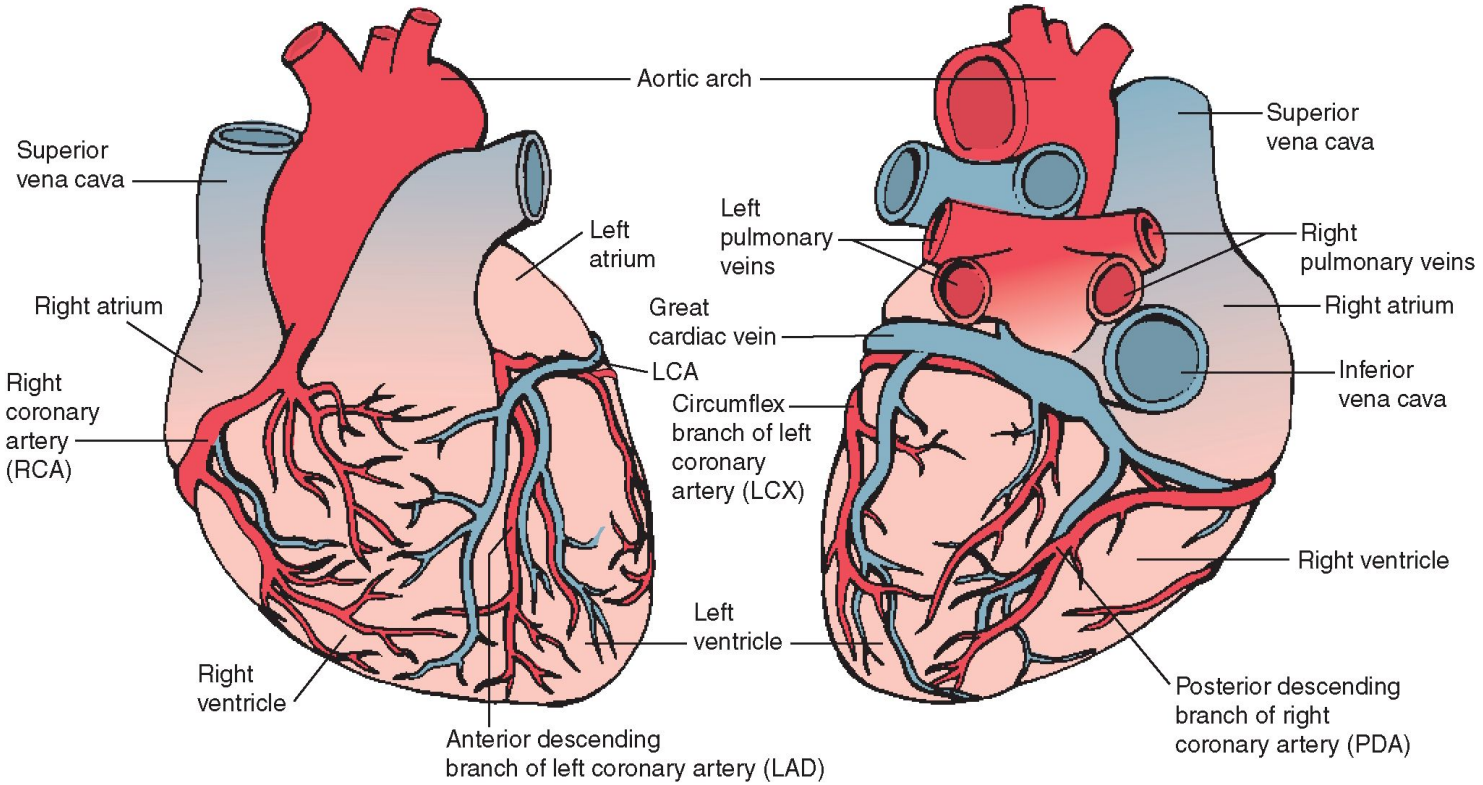


- Criteria for significant Q waves
  - Q wave > 0.04 seconds in duration
  - Q wave depth > ⅓ height of R wave in same QRS complex
- Criteria for Non-Q Wave MI
  - T wave inversion
  - ST segment depression persisting > 48 hours in appropriate clinical setting

Localizing MI on EKG

- Inferior infarction – leads II, III, aVF
  - Often caused by occlusion of right coronary artery or its descending branch
  - Reciprocal changes in anterior and left lateral leads
- Lateral infarction – leads I, aVL, V5, V6
  - Often caused by occlusion of left circumflex artery
  - Reciprocal changes in inferior leads
- Anterior infarction – any of the precordial leads (V1- V6)
  - Often caused by occlusion of left anterior descending artery
  - Reciprocal changes in inferior leads
- Posterior infarction – reciprocal changes in lead V1 (ST segment depression, tall R wave)
  - Often caused by occlusion of right coronary artery

Localizing MI on EKG



ST segment

- Elevation
  - Seen with evolving infarction, Prinzmetal's angina
  - Other causes – J point elevation, apical ballooning syndrome, acute pericarditis, acute myocarditis, hyperkalemia, pulmonary embolism, Brugada syndrome, hypothermia
- Depression
  - Seen with typical exertional angina, non-Q wave MI
  - Indicator of + stress test

Electrolyte Abnormalities on EKG

- Hyperkalemia – peaked T waves, prolonged PR, flattened P waves, widened QRS, merging QRS with T waves into sine wave, VF
- Hypokalemia – ST depression, flattened T waves, U waves
- Hypocalcemia – prolonged QT interval
- Hypercalcemia – shortened QT interval

Drugs

- Digitalis
  - Therapeutic levels – ST segment and T wave changes in leads with tall R waves
  - Toxic levels – tachyarrhythmias and conduction blocks; PAT with block is most characteristic.
- Multiple drugs associated with prolonged QT interval, U waves
  - Sotalol, quinidine, procainamide, disopyramide, amiodarone, dofetilide, dronedarone, TCA's, erythromycin, quinolones, phenothiazines, various antifungals, some antihistamines, citalopram (only prolonged QT interval – dose-dependent)

EKG Δ's in other Cardiac Conditions

- Pericarditis – Diffuse ST segment elevations and T wave inversions; large effusion may cause low voltage and electrical alternans (altering QRS amplitude or axis and wandering baseline)
- Myocarditis – conduction blocks
- Hypertrophic Cardiomyopathy – ventricular hypertrophy, left axis deviation, septal Q waves

EKG Δ's in Pulmonary Disorders

- COPD – low voltage, right axis deviation, and poor R wave progression.
- Chronic cor pulmonale – P pulmonale with right ventricular hypertrophy and repolarization abnormalities
- Acute pulmonary embolism – right ventricular hypertrophy with strain, RBBB, and S1Q3T3 (with T wave inversion). Sinus tachycardia and atrial fibrillation are common.

EKG Δ's in Other Conditions

- Hypothermia – Osborn waves, prolonged intervals, sinus bradycardia, slow atrial fibrillation, beware of muscle tremor artifact
- CNS Disease – diffuse T wave inversion with T waves wide and deep, U waves
- Athlete's Heart – sinus bradycardia, nonspecific ST segment and T wave changes, RVH, LVH, incomplete RBBB, first degree or Wenckebach AV block, possible supraventricular arrhythmia

Utter Confusion

- Verify lead placement
- Repeat EKG
- Repeat standardized process of EKG analysis- starting over from the beginning with basics – rate, intervals, axis, rhythm, etc. and proceed through entire stepwise analysis
- Consider Cardiology consultation

Arrhythmia Indications to Consult Cardiology

- Diagnostic or management uncertainty
- Medications not controlling symptoms
- Patient is in high-risk occupation or participates in high-risk activities (pilot, scuba driving)
- Patients prefers intervention over long-term meds
- Preexcitation
- Underlying structural heart disease
- Associated syncope or other significant symptoms
- Wide QRS

Care Considerations Prior to Cardiology Consult

- Thorough Hx and PE
- Basic labs
- EKG and repeat EKG
- Holter monitor
- Echocardiogram
- Acuity of care required – consider risks, hemodynamic stability

Pacemaker Considerations

- Third-degree (complete) AV block
- Symptomatic lesser degree AV block or bradycardia
- Sudden onset of various combinations of AV block and BBB during acute MI
- Recurrent tachycardias that can be overdriven and terminated by pacemakers

Osteopathic Considerations

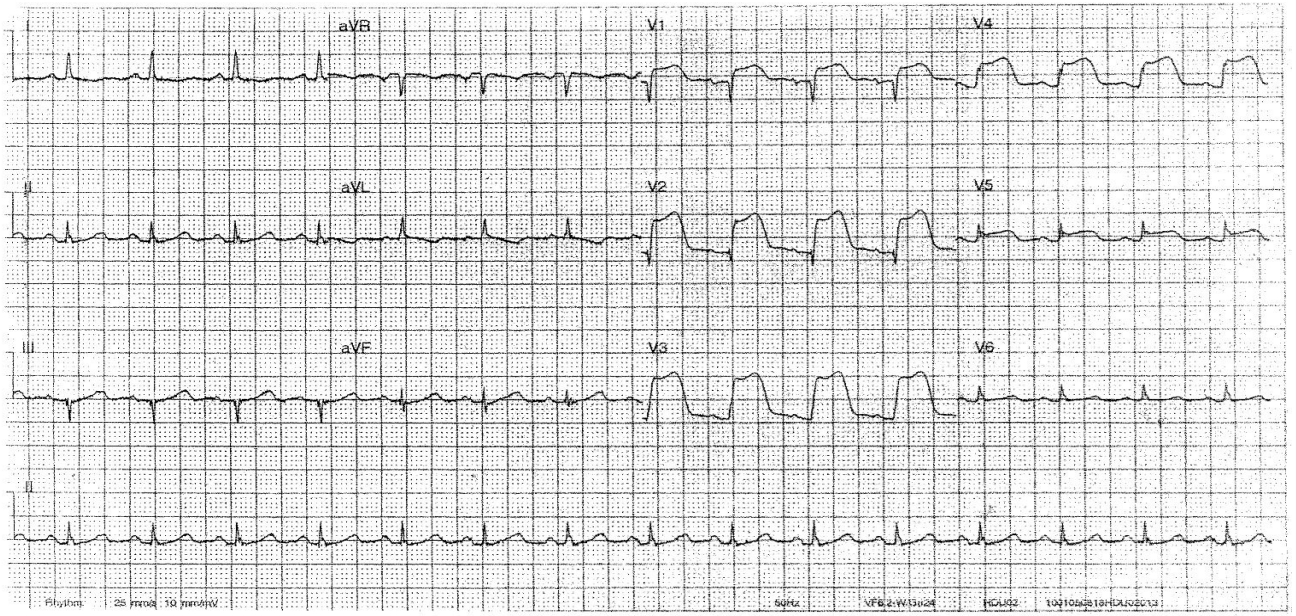
- Treatments –
  - Lymphatics – thoracic inlet, abdominal diaphragm, rib raising, lymphatic pumps
  - Sympathetics (**T1-T6**) – cervical ganglion, rib raising, T1-T6, Chapman's reflexes, T10-L2 for adrenal/kidney
  - Parasympathetics – OA/AA/cranial – vagus nerve

Clinical Cases/EKG's

Case 1

- 53 year old caucasian female with 4 day hx of severe central chest pain on exertion, previously alleviated with rest; now worsened over last 24 hours and sustained at rest
- PMHx – DM2, HTN, hyperlipidemia
- Appears unwell, in pain, sweaty, and grey

Case 1



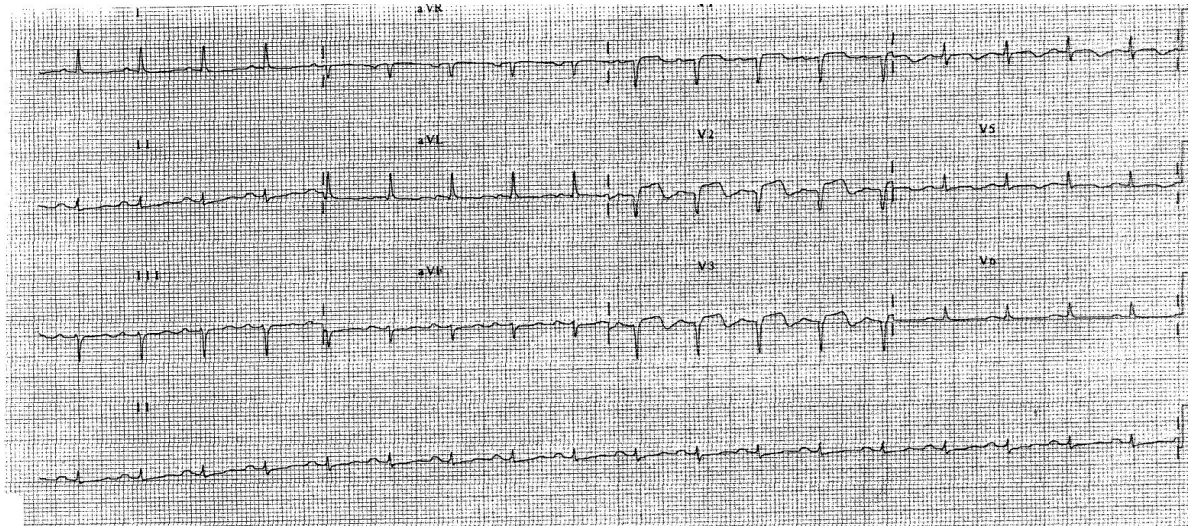
- Diagnosis? EKG findings?

Case 1

- Acute anterior ST-elevation MI with “tombstone” or “fireman’s hat” in V1-V4
- Tx? Localization?

Case 1

- PCI stenting of LAD

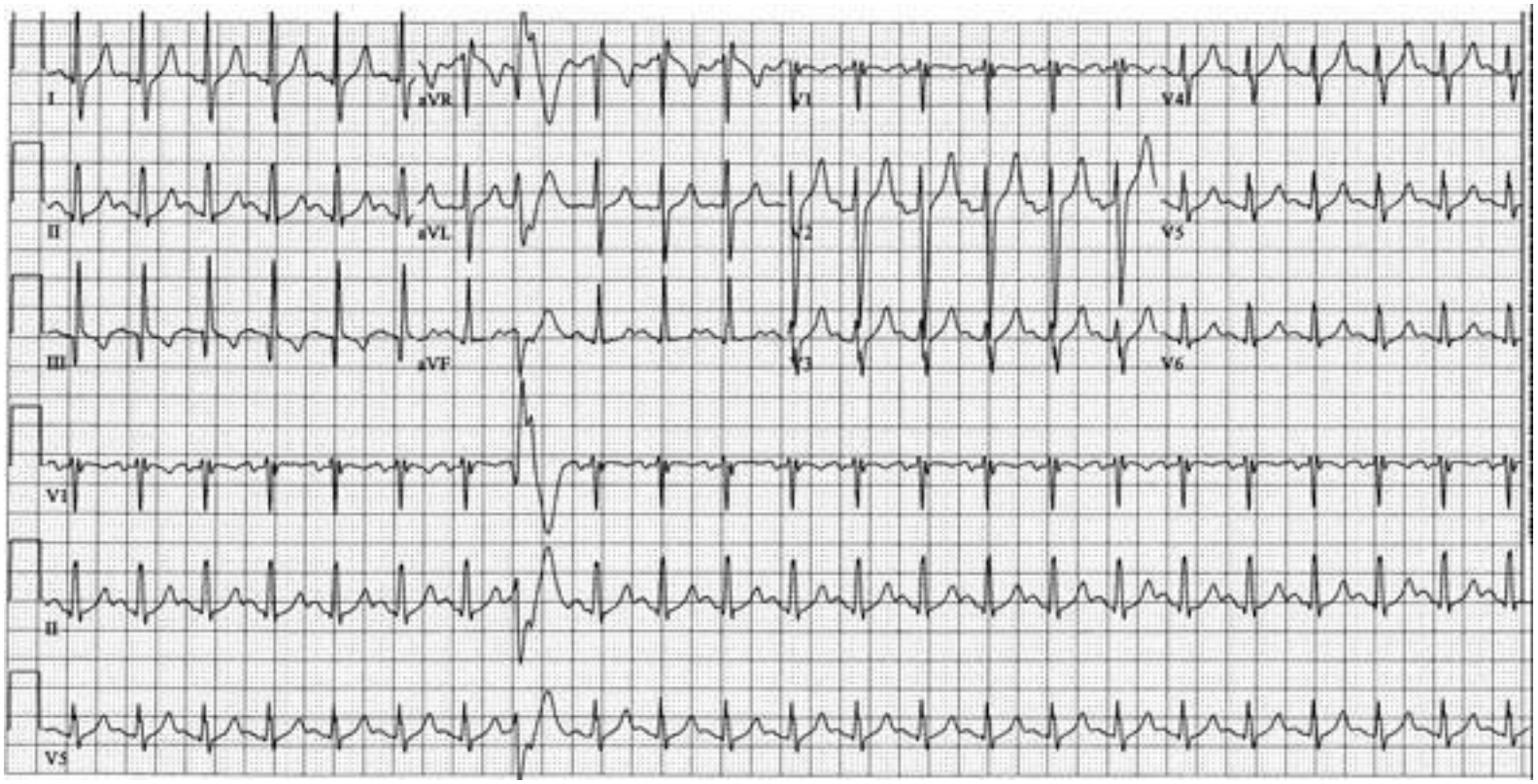


- Post-procedure = resolving ST elevation; loss of ominous tombstone effect; Q waves developing

Case 2

- 45 yo male presents with acute SOB s/p long vacation in Paris
- PMHx - asthma, Crohn's disease, anxiety, GERD, tobacco abuse
- VS 37, 148/92, 130, 26
- Patient appears uncomfortable but otherwise unremarkable exam

Case 2



- Diagnosis? EKG findings?

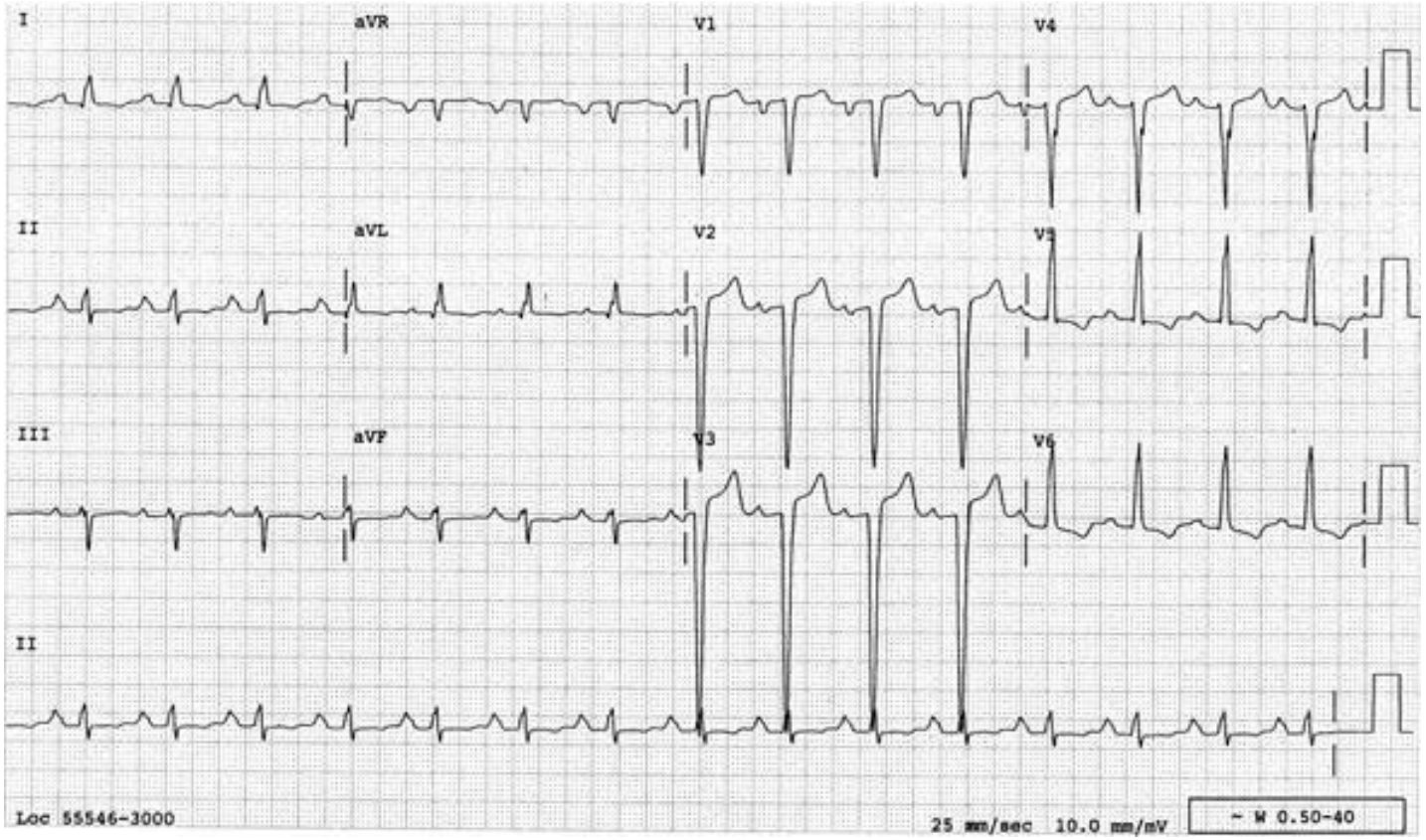
Case 2

- Acute PE with sinus tachycardia, a PVC, and S1Q3T3 pattern

Case 3

- 72 yo male presents to the office for evaluation prior to cataract surgery
- No complaints
- PMHx – B/L cataracts, OA, HTN, hyperlipidemia, and chronic low back pain
- VS 37.2, 152/86, 74, 14

Case 3



- Diagnosis? EKG findings?

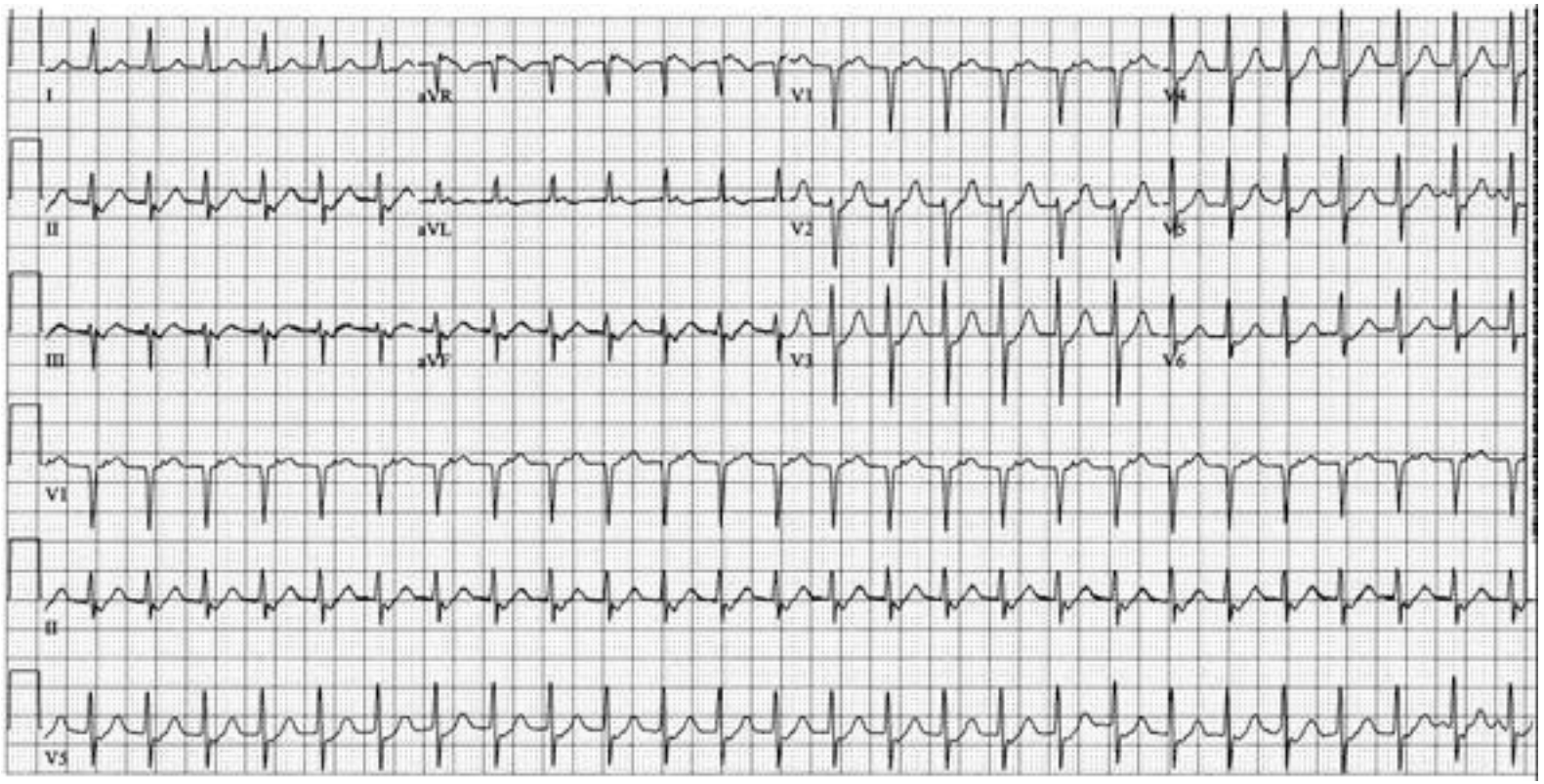
Case 3

- LVH – QRS voltage criteria in precordial leads and repolarization changes in V5, V6

Case 4

- 27 yo female presents to the ED with c/o chest discomfort and palpitations after studying all night for graduate school exams
- Appears nervous and “uneasy” with rapid pulse
- PMHx – unremarkable; no meds, admits to occasional alcohol, non-smoker, denies illicit drug use, used coffee to stay awake to study

Case 4



- Diagnosis? EKG findings?

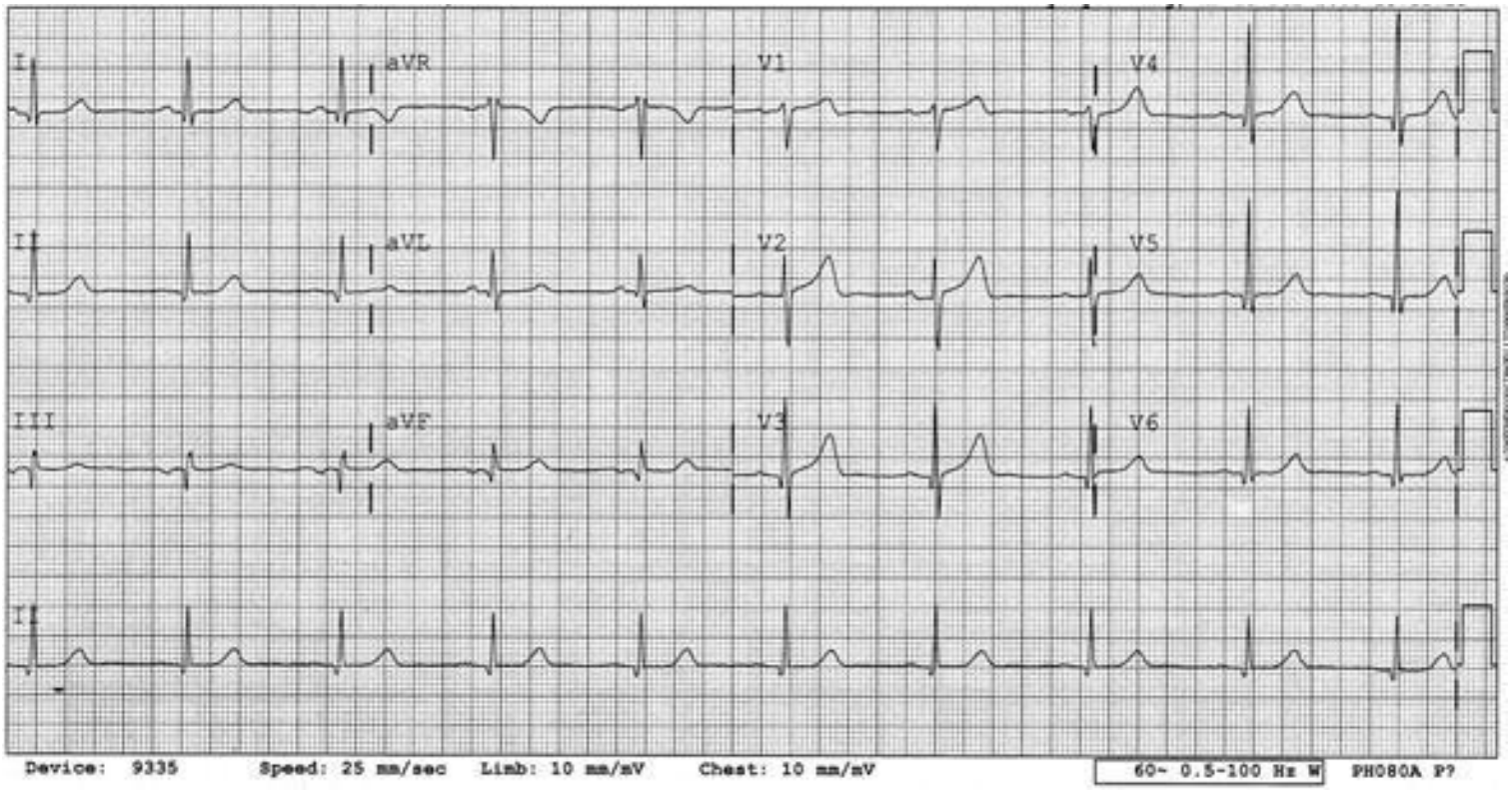
Case 4

- SVT – regular, narrow-QRS tachycardia, rate of 160 bpm

Case 5

- 46 yo male presents to ED with c/o severe HA persisting over 5 hours despite acetaminophen and NSAID attempts as abortive therapy
- PMHx – occasional left shoulder pain, non-smoker
- Construction worker
- VSS; unremarkable exam

Case 5



- Diagnosis? EKG findings?

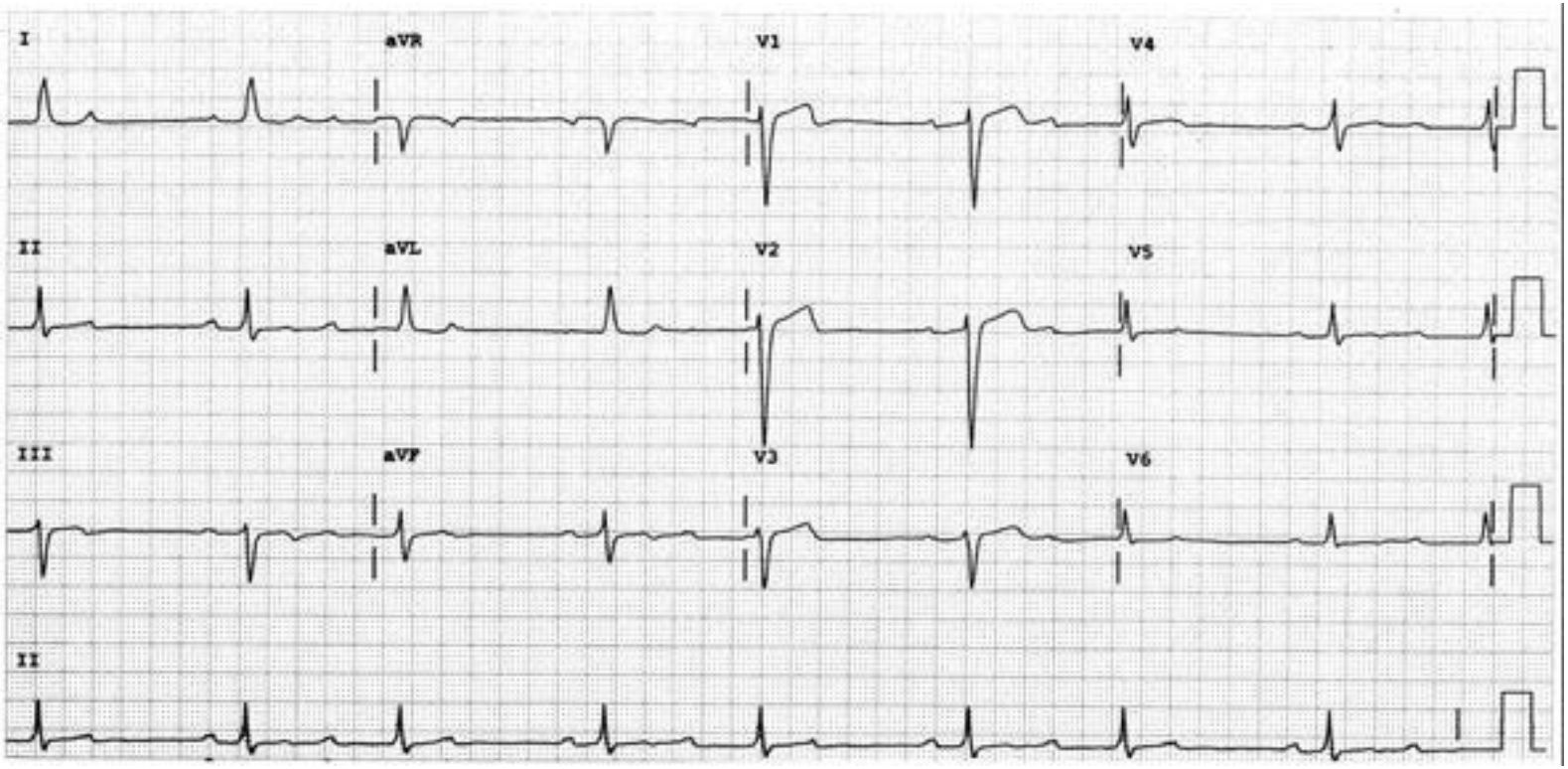
Case 5

- Normal EKG

Case 6

- 56 yo female presents to family physician with c/o light-headedness and occasional flutter in her chest
- PMHx – anxiety, depression, obesity, smoker
- Works as retail store manager
- VSS; course breath sounds, otherwise unremarkable exam

Case 6



- Diagnosis? EKG findings?

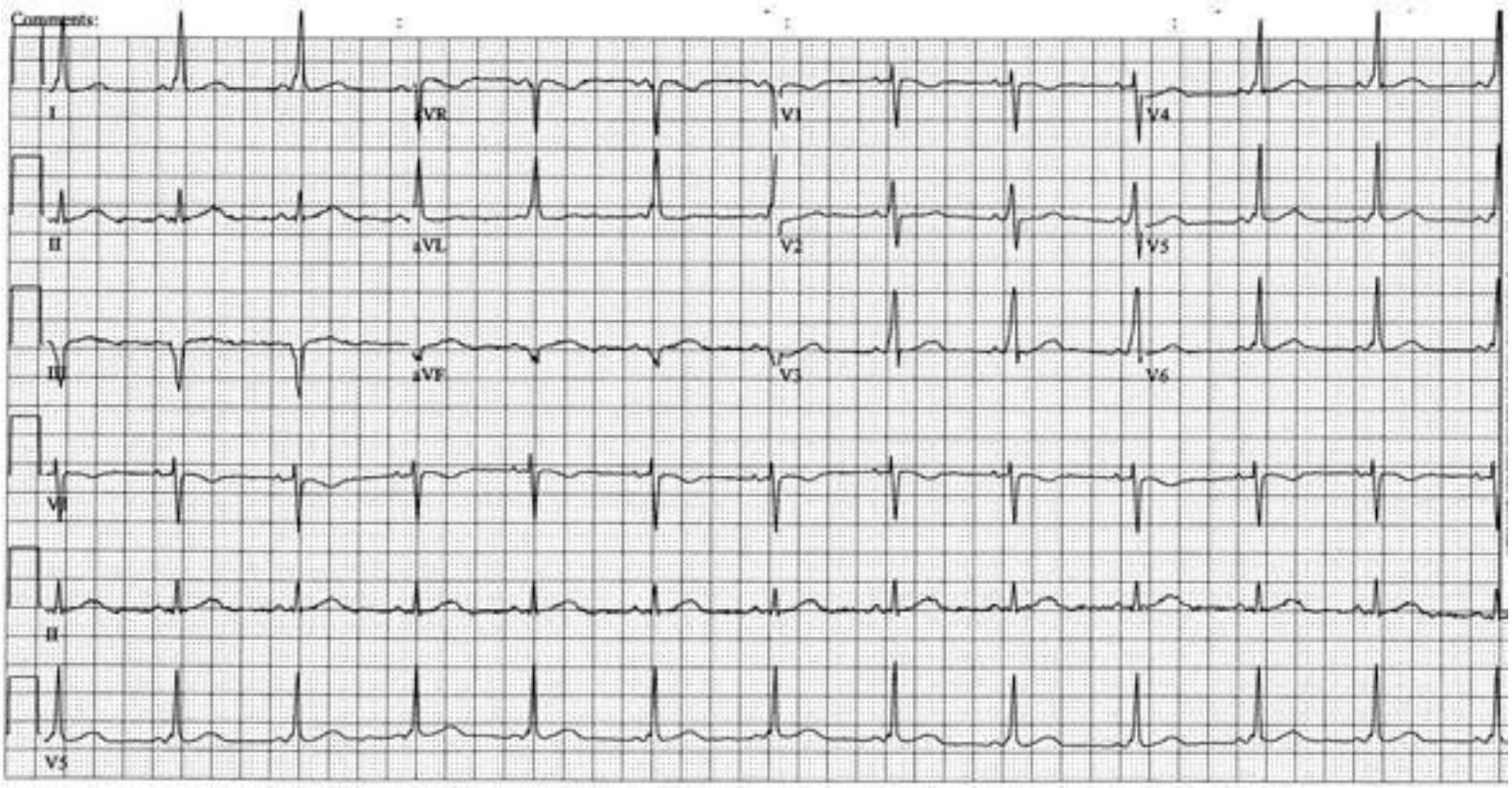
Case 6

- Second degree AV block – Mobitz Type I – Wenckebach (specifically 3:2 AV Wenckebach phenomenon where every 3rd P wave is blocked)

Case 7

- 28 yo male presents for commercial driver's license (CDL) evaluation
- No complaints
- VSS; asymptomatic; exam without significant findings

Case 7



- Diagnosis? EKG findings?

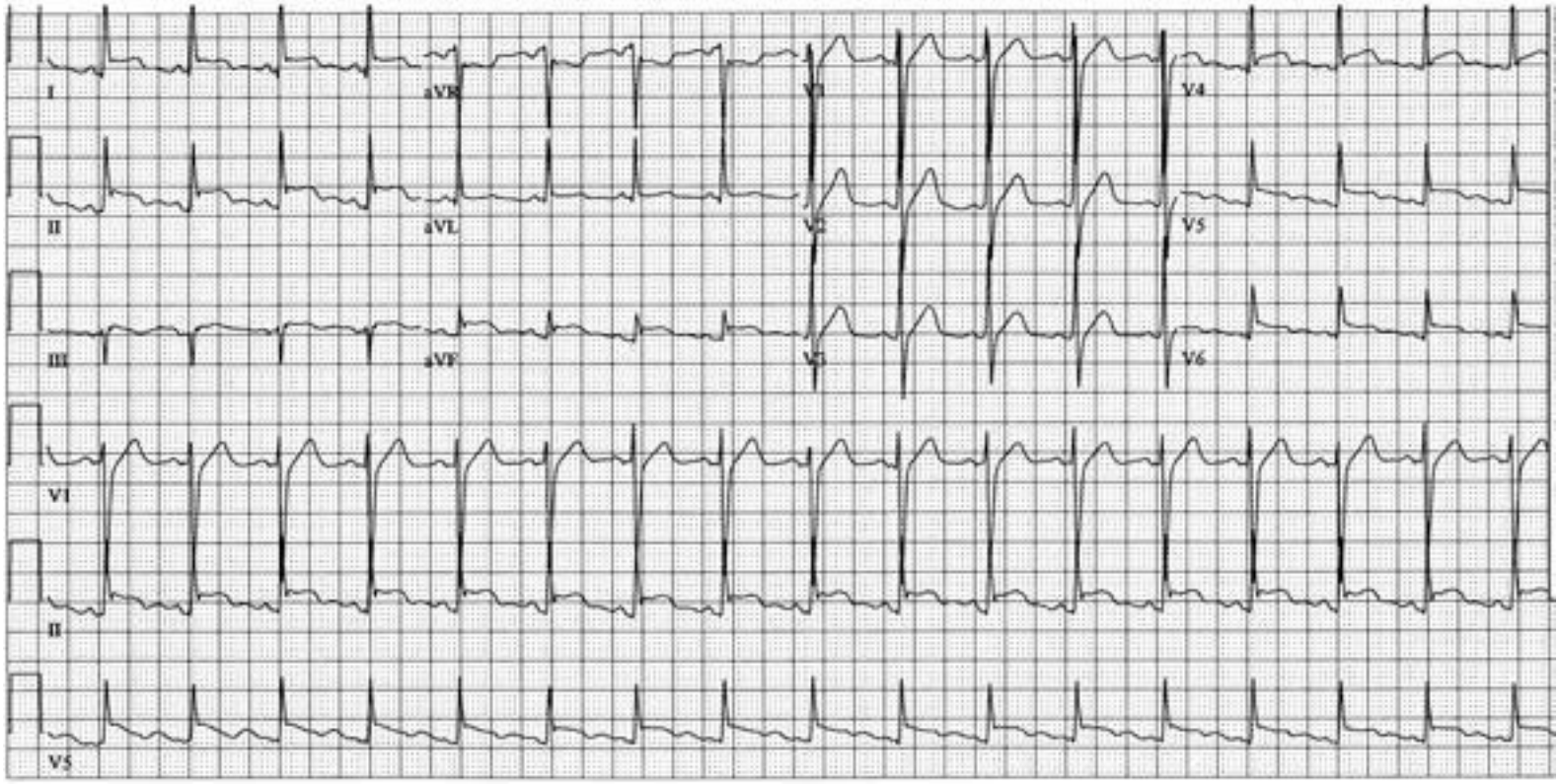
Case 7

- Typical preexcitation (WPW) pattern
- Short PR interval and delta waves in many leads
- Tx is close observation unless patient has had SVT or atrial fibrillation which indicates tx with ablation of accessory pathway

Case 8

- 32 yo male presents to ED with c/o feeling sick for the last 6 days
- Symptoms include fevers, cough, and difficulty catching his breath
- PMHx – hyperlipidemia, obesity, metabolic syndrome
- VS 38.1, 105, 128/84, 22

Case 8



- Diagnosis? EKG findings?

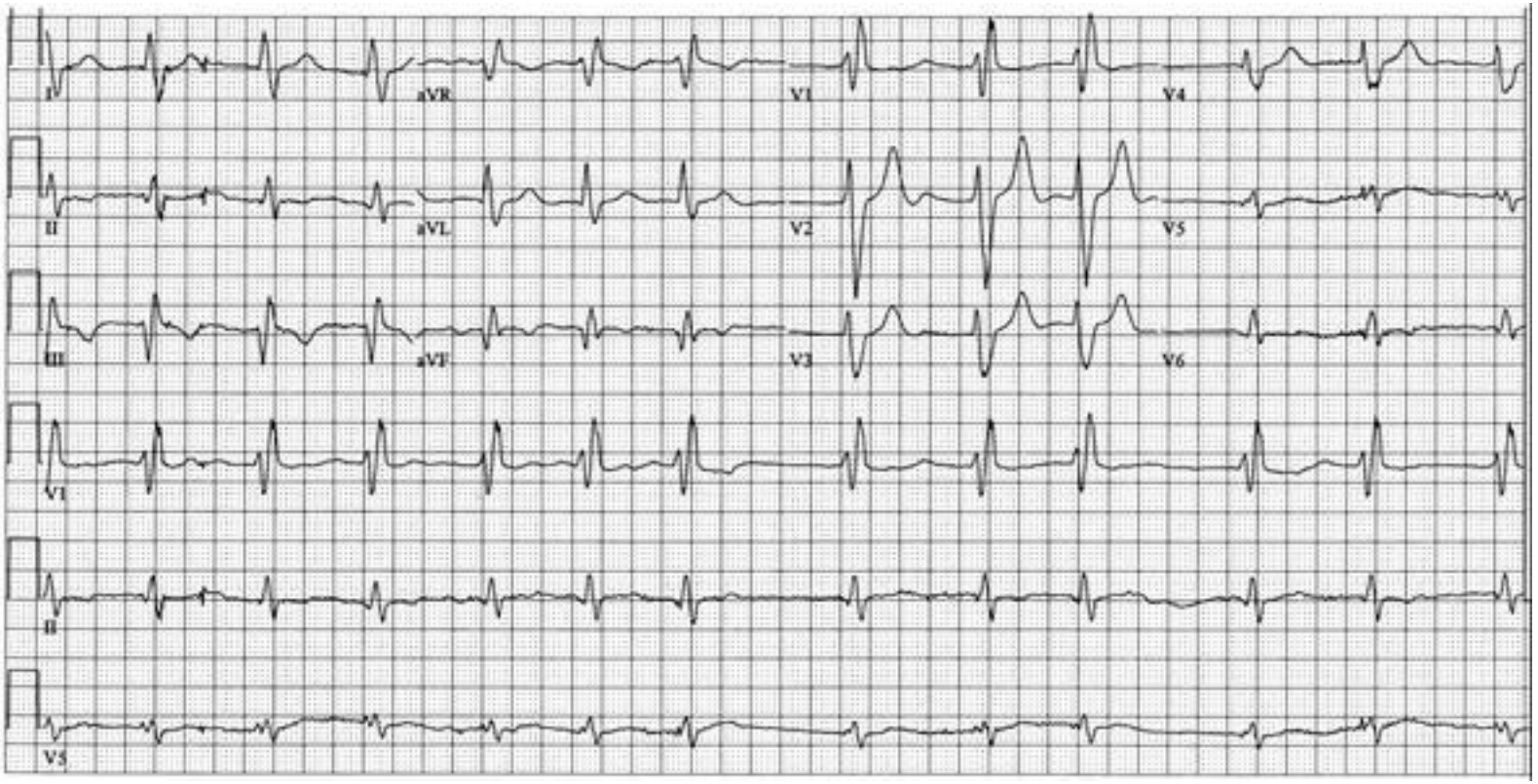
Case 8

- Acute pericarditis – diffuse ST elevation with PR segment depression is diagnostic

Case 9

- 67 yo male presents to his cardiologist for out-patient 6 week post-hospital visit
- Previous hospitalization for non-cardiac chest pain
- Post-hospital cardiac meds – ACE inhibitor, beta blocker, aspirin, nitrate
- No current complaints

Case 9



- Diagnosis? EKG findings?

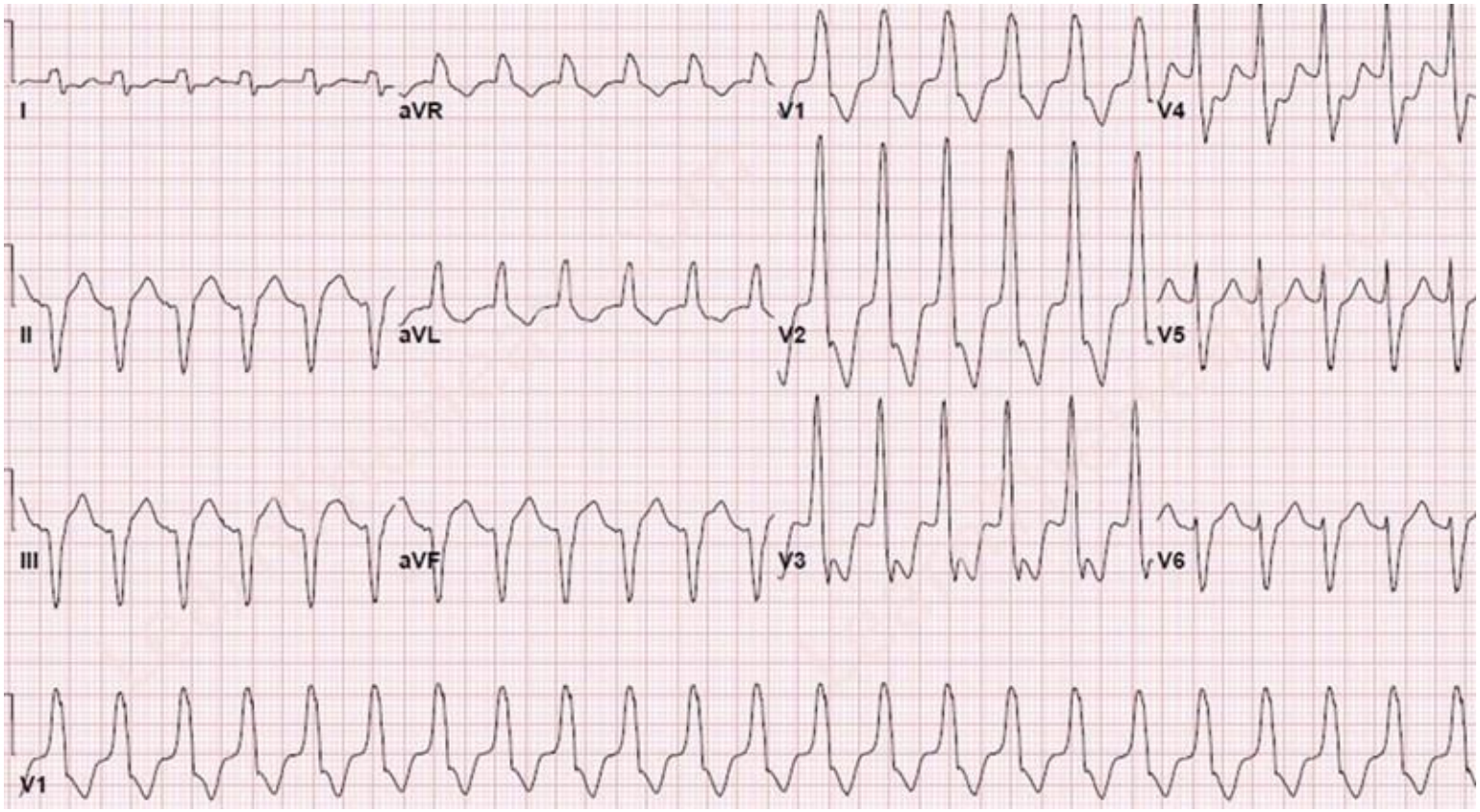
Case 9

- Atrial fibrillation – irregularly irregular without P waves
- RBBB – wide QRS with rsR’ pattern in V1, broad S waves in leads I and aVL
- Inferior infarct – non-acute (> 1 week) pathologic Q waves in inferior leads (II, III, and aVF)

Case 10

- 79 yo male brought to ED via EMS with chest pain, SOB, and near-syncope
- PMHx – unobtainable secondary to patient distress
- VS – 36.9, 140's, 82/40, 28

Case 10



- Diagnosis? EKG findings?

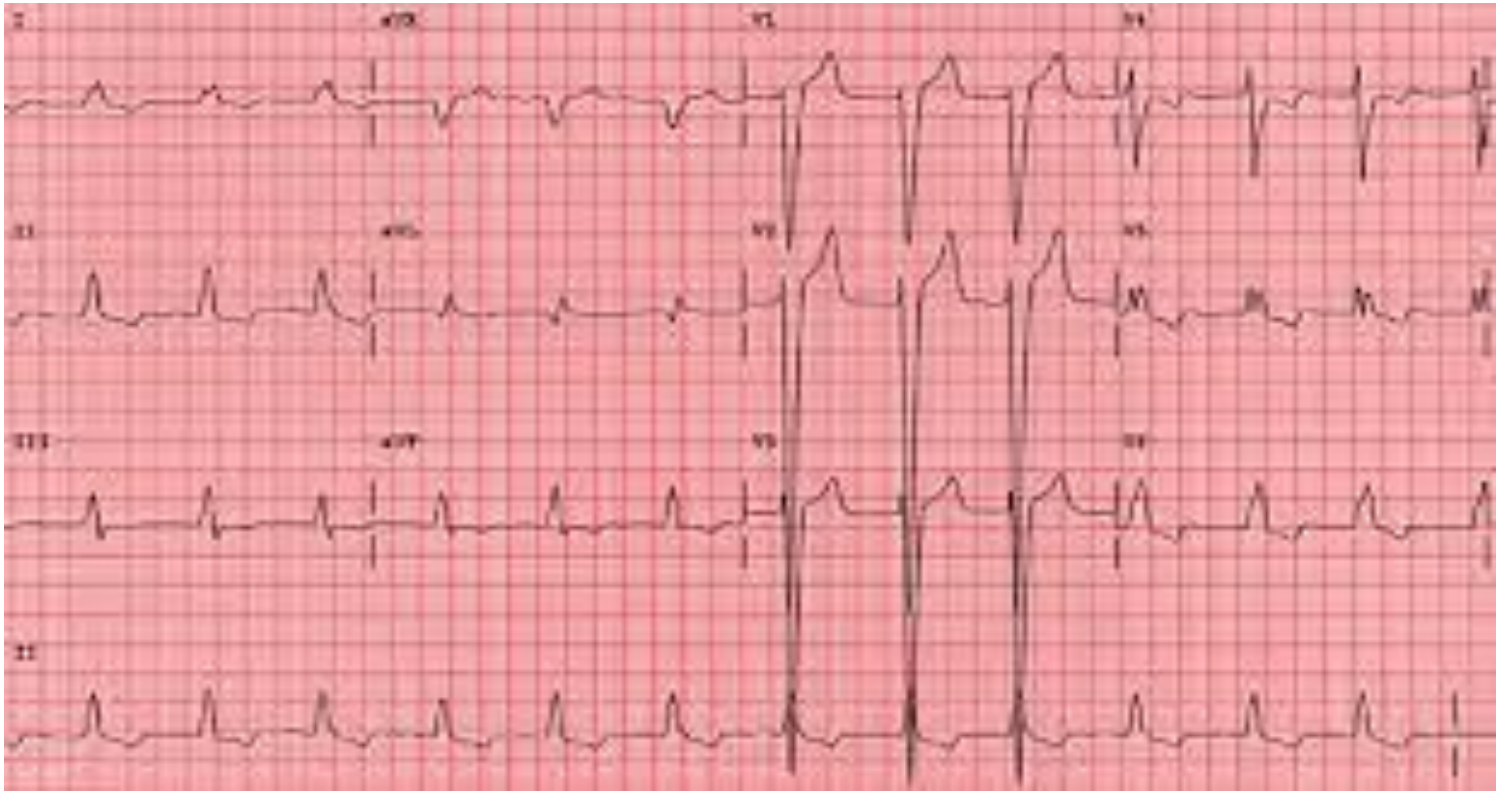
Case 10

- Monomorphic sustained ventricular tachycardia (VT) – could rapidly deteriorate into VF, torsades de pointes, asystole, or sudden death

Case 11

- 82 yo female admitted to acute care hospital secondary to chest pain
- PMHx – HTN, DM2, CHF, obesity, depression
- Cardiology planning cardiac catheterization secondary to new finding during initial consultation

Case 11



- Diagnosis? EKG findings?

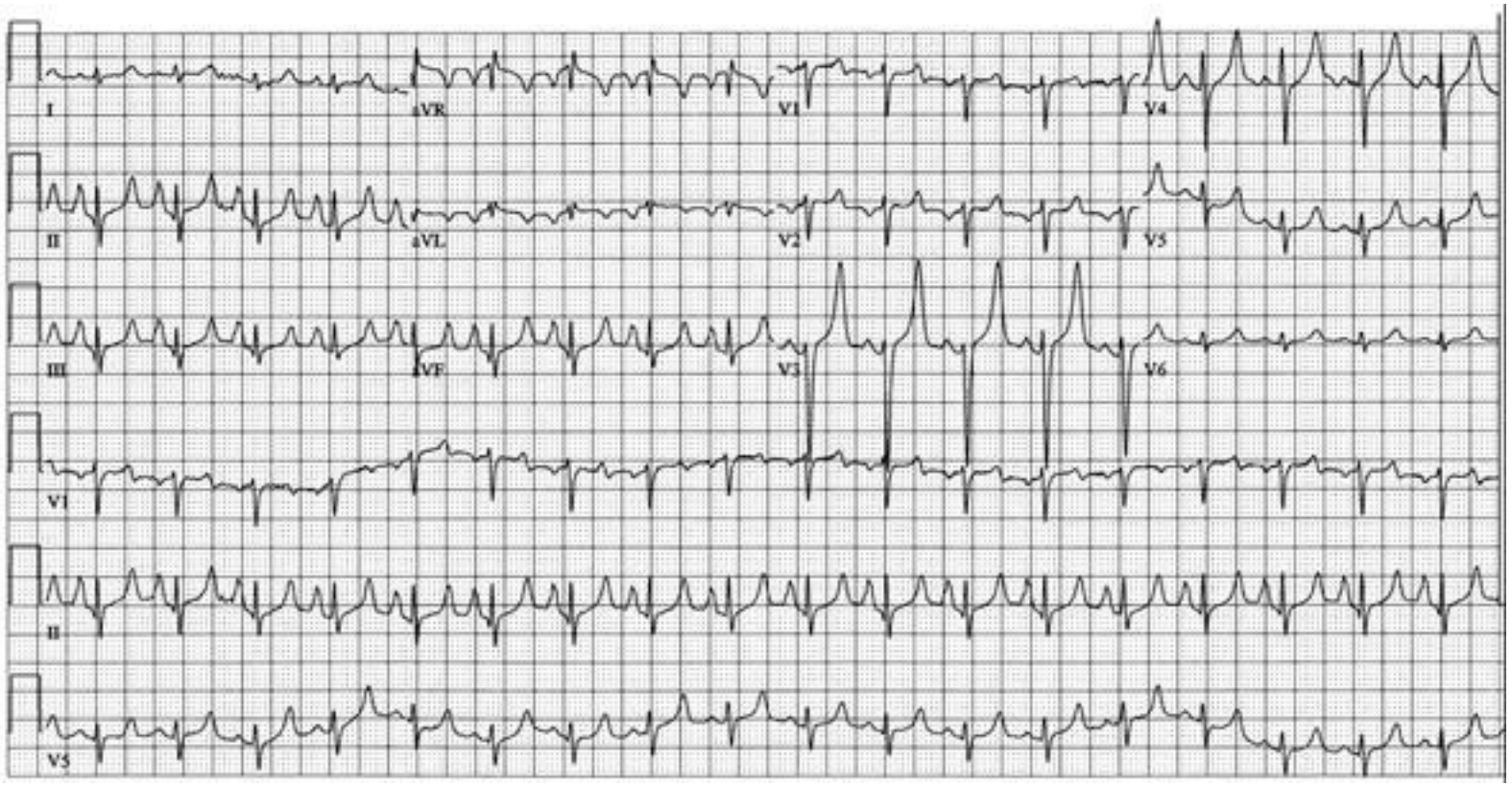
Case 11

- LBBB – wide QRS; broad, notched R wave in V5, V6 and I with ST depression and T wave inversion

Case 12

- 59 yo male presents to ED diaphoretic and in distress
- PMHx – HTN, ESRD, DM2, Left BKA
- VS – 37.5, 108, 96/58, 24

Case 12



- Diagnosis? EKG findings?

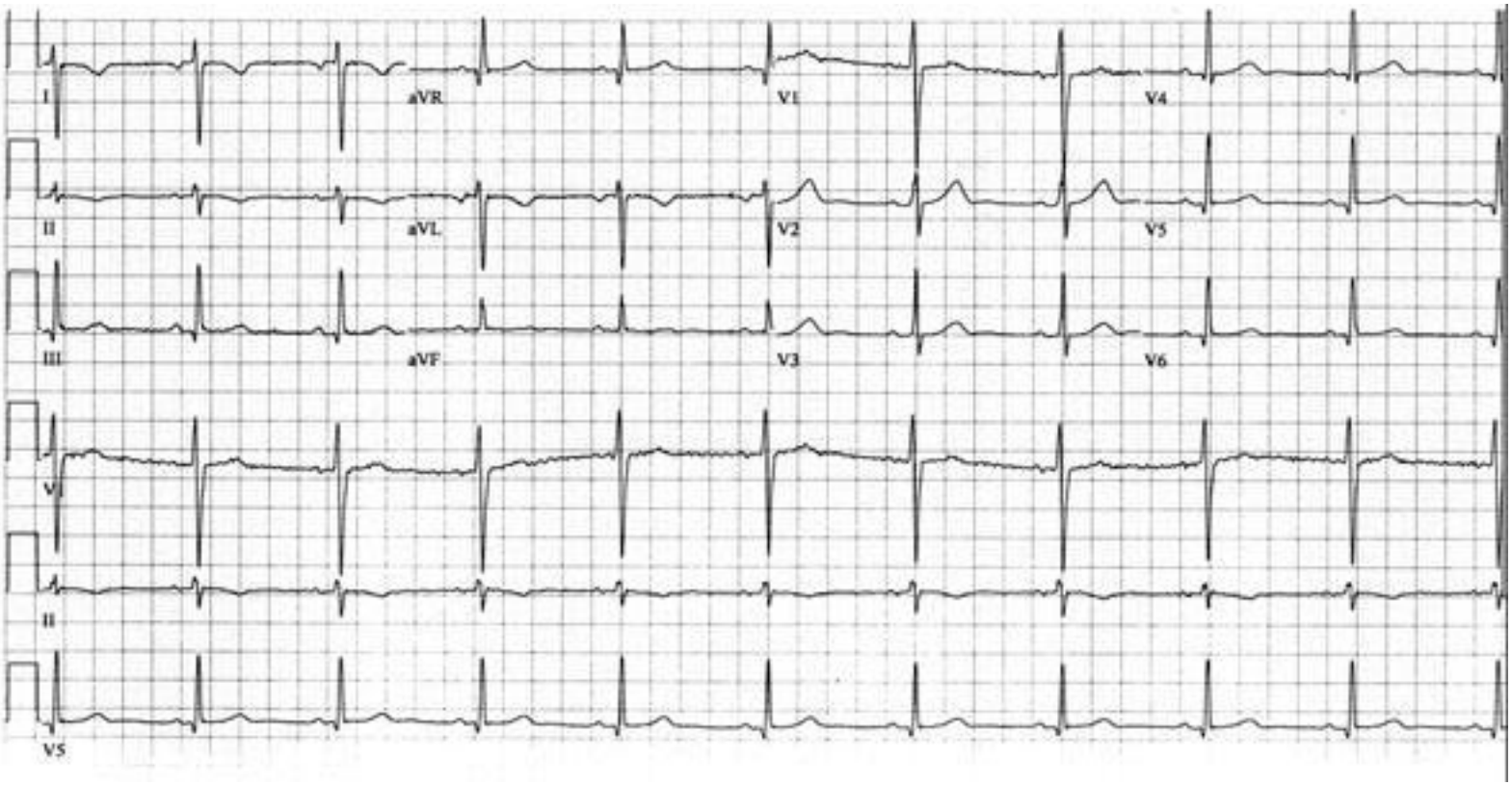
Case 12

- Hyperkalemia – tall peaked T waves present throughout; other progressive EKG changes may follow with increasing potassium levels – prolonged PR interval, flattened P waves, widening QRS, sine waves
- Sinus tachycardia also present

Bonus Case

- 18 yo male undergoing military physical exam and evaluation prior to boot camp
- No complaints
- PMHx – denies
- VSS; exam unremarkable

Bonus Case



- Diagnosis? EKG findings?

Bonus Case

- Reversed arm leads – inverted P waves in lead I with normal R wave progression in precordial leads

Board Exam Points

- EKG's likely to have 1 main finding
- Clinical case likely included with each EKG
- Question likely to focus on clinical case as well as EKG
- Straight forward without tricks or obscure findings (not likely to see "zebras")
- Focus on common arrhythmias, common cardiac diagnoses, common non-cardiac EKG abnormalities, or emergent "can't miss" diagnoses

Questions?

Resources

- Sources and Suggested References
  - The Only EKG Book You'll Ever Need - Malcolm S. Thaler
  - Rapid Interpretation of EKG's – Dale Dubin, M.D.
  - "…Except for OMT!" – Dale Pratt-Harrington
  - American Family Physician – November 1, 2015
  - Up to Date
  - blog at wordpress.com
  - cme.umn.edu
  - ekgcasestudies.com
  - healio.com
  - lifeinthefastlane.com
  - learntheheart.com