Intermediate ECG Interpretation Workshop

Darwin Brown, MPH, PA-C

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Objectives

- Describe the pathophysiology of left ventricular hypertrophy, myocardial infarctions, Wolff-Parkinson-White syndrome, and the AV Blocks.
- Develop the common diagnostic criteria to evaluate LVH, myocardial infarctions, WPW, and AV Blocks.
- Interpret MI, LVH, WPW and AV Blocks using specific diagnostic criteria.
- Analyze unknown 12-Lead ECGs and rhythm strips and accurately diagnose myocardial infarctions, LVH, WPW and AV Blocks.

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Disclosure Statement

- No association or financial arrangement with any vendor or pharmaceutical company.

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First Things First

- Coming from a Primary Care Perspective
- Evaluate an ECG the same way each time
- Develop a system to accomplish this process
- Force yourself to practice

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Plan for Workshop

- Case-based ECG interpretation
- Work through each case (in your handouts)
- Discuss and focus on key concept
- Move on to next case
- Ask questions along the way

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One Method

- Gestalt or general impression
- Determine the Heart Rate
- Determine the Rhythm
- Measure the Longest Interval in the Limb Leads
- Determine the Axis
- Assess the R-Wave Progression

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What Next

- For each ECG lead, note the following:
  - Location and morphology of P-waves
  - QRS pattern (presence of Q-waves)
  - ST Segment (elevation or depression)
  - T wave changes

  Review all leads except aVR.

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Case #1

Patient is a 57-year-old male who presented with chest pressure while at home and had his son drive him to the ER. Symptoms include shortness of breath, increasing chest pressure, and anxiety. Vitals are stable. He has not seen a health care provider in several years. However, he remembers being told years ago he had something wrong on his ECG.

Based on your assessment of his ECG, what is the most likely interpretation?

A. Left Ventricular Hypertrophy
B. Hyperkalemia
C. Left Bundle Branch Block
D. Acute Inferior MI
E. Wolff-Parkinson-White

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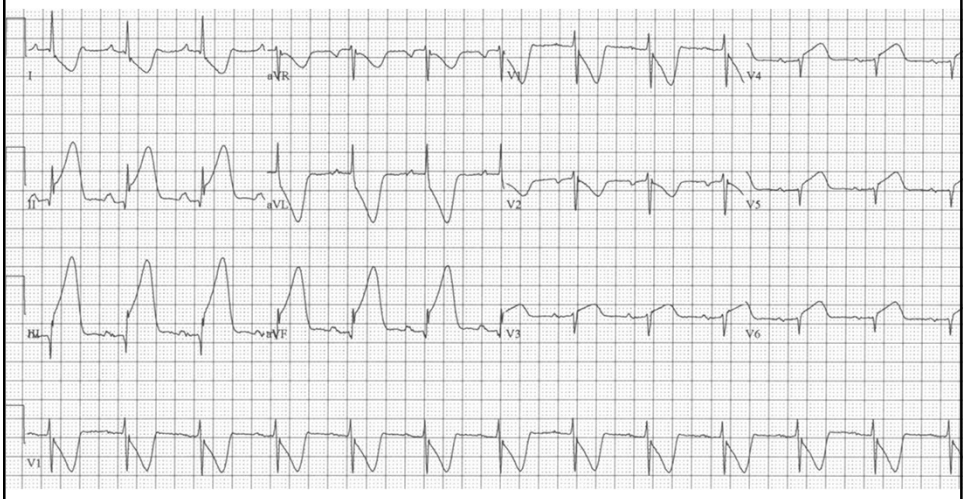
Case #1



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Myocardial Infarction

- Area fraught with interpretation issues
- Will focus only on STEMI (ST elevation MI)
- A normal ECG does NOT necessarily rule out an impending MI
- If available, review old ECGs
- Evaluate the entire 12-lead ECG

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Key Criteria for Diagnosis

- Ischemia
  - ST segment depression (2 mm or greater)
  - T-wave inversion (symmetrical)
- Differentiate from NSTEMI

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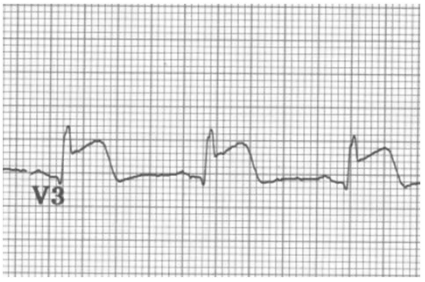
Key Criteria for Diagnosis

- Injury Pattern
  - ST segment elevation (1 mm or greater)
  - T-wave peaks initially then inverts later



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Key Criteria for Diagnosis

- Infarction Pattern
  - Presence of Significant Q-waves
    - Defined as:
    - 1) Q-wave that is 1/4 total height of QRS
    - 2) Wider than 40 ms

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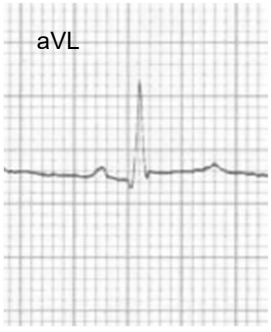
Insignificant Q-waves

- Do not meet the criteria for significance
- Typically found in following leads:
  - Leads I, aVL, $V_4 – V_6$ (Septal Q-waves)



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Other Important Information

- Timing of MI
  - Based on presence of ST elevation and/or Q waves
  - Current terminology: Acute, Age indeterminate
  - Assess only ST and T-wave changes
  - Q-waves can often mislead

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ST segment T wave Q wave

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Location of MI

Location	Direct Changes	Reciprocal Changes	Artery Affected
High Lateral	I, aVL	II, III, aVF	Circumflex
Inferior	II, III, aVF	All other leads	RCA, Post. desc.
Anteroseptal	V_1 , V_2 , V_3	II, III, aVF	LAD
Anterolateral	V_4 , V_5 , V_6	II, III, aVF	LAD, Circumflex
Posterior	----------	V_1 - V_2	Distal Circumflex or Post. Descending

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Case 1a (Use ECG #1)

What is the reason for the ST depressions seen in leads I, aVL, V1-V2?

A. Normal finding if present on a previous ECG
B. Reciprocal changes associated with an acute MI
C. Signs of ongoing ischemia suggesting more myocardium at risk
D. Strain pattern associated with left ventricular hypertrophy

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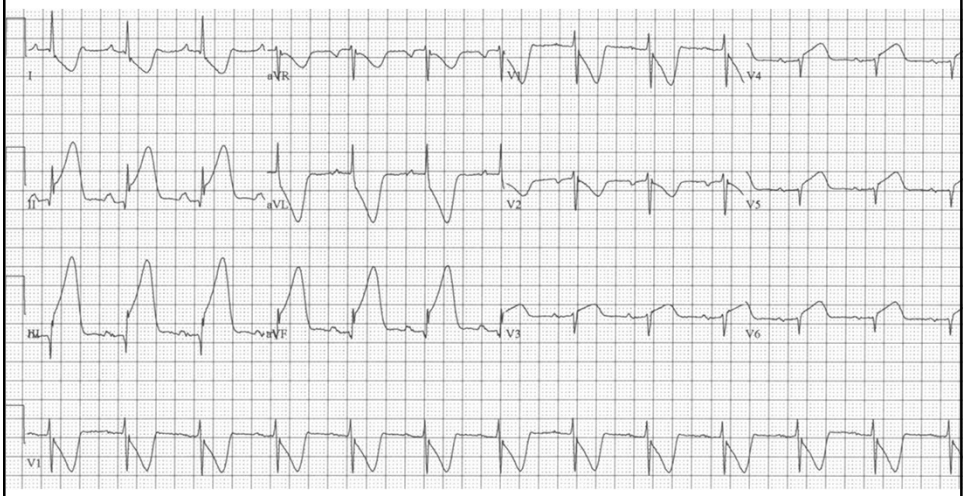
Case #1



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Reciprocal Changes

- Often associated with Acute MI, but not always
  - Usually occur very early in process
  - Do not last very long (hours)
  - Are represented by opposite ST-T changes

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Case 2

Patient is a 44-year-old ultra marathon runner. He was on a 50-mile run when he developed chest pain that caused him to quit the race. An unusual event. He continues to have chest pain, which is stable but present. He is on no medications, does not smoke or consume alcohol. He does state he had cold symptoms within the last two weeks that resolved without issue.

Based on your assessment of his ECG, what is the most likely interpretation?

A. Acute Anterior MI
B. Acute Pericarditis
C. Age indeterminate Anterior MI
D. Printzmetal's Angina
E. Left Bundle Branch Block

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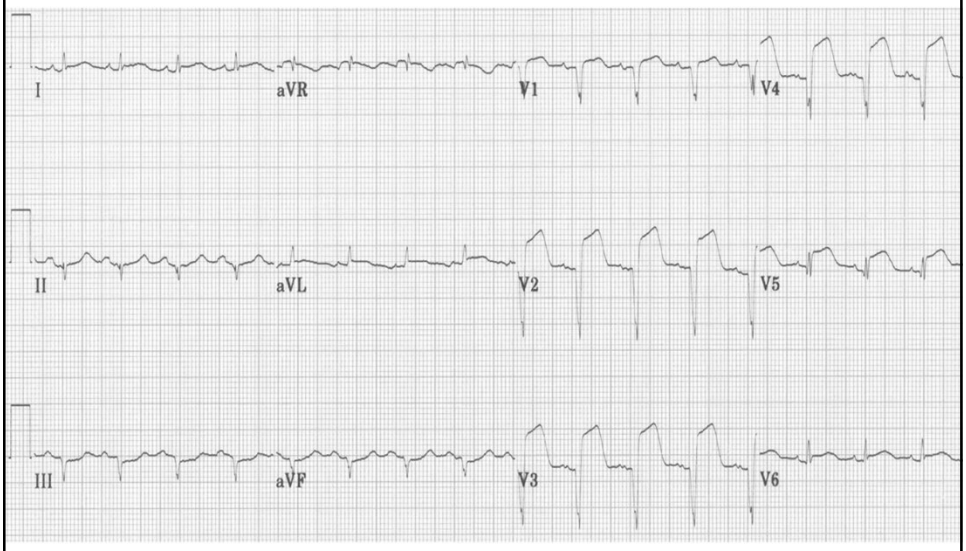
Case #2



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Case 2a

Upon further review, what do the findings in the inferior leads (II, III, and aVF) suggest?

A. Reciprocal changes associated with an acute MI
B. Evidence of age indeterminate Inferior MI
C. Nothing, these are expected normal findings
D. Evidence of an acute Inferior MI

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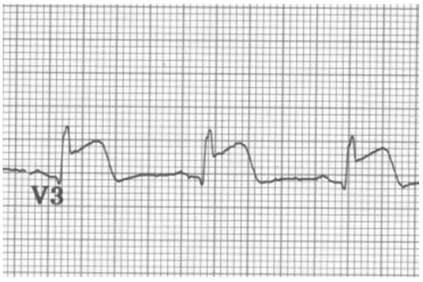
Differential Diagnosis of ST-Elevation

- Acute STEMI
- Printzmetal's Angina
- Ventricular Aneurysm
- Pericarditis
- Normal Variant
  - Early Repolarization



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Case #3

Patient is a 63-year-old female complaining of chest pressure, shortness of breath and neck pain. She was out with family when drama ensued, and her symptoms developed. She suffers from COPD and some ill-defined bowel condition. She denies previous cardiac issues.

Based on your assessment of her ECG, what is the most likely interpretation?

A. Acute Inferior MI
B. Left ventricular hypertrophy
C. Left anterior fascicular block
D. Within normal limits
E. Acute Anterolateral MI

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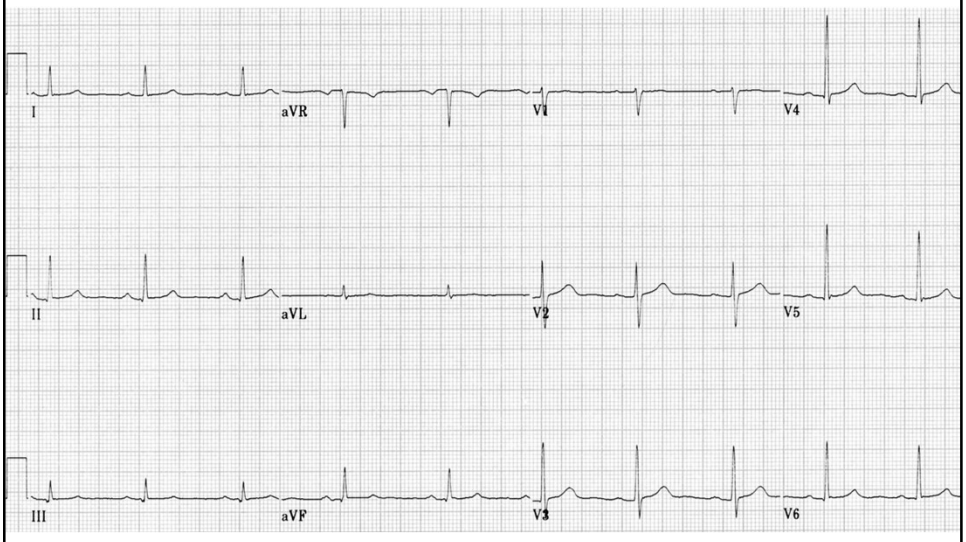
Case #3



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Case #4

A 71-year-old man arrives at the ER with his daughter, complaining of shortness of breath and feeling tired. This is atypical for the patient as he feels full of energy most days. His past medical history includes hypertension, type 2 diabetes, and sleep apnea, all of which have been well controlled. No previous history of any cardiac events.

Based on your assessment of his ECG, what is the most likely interpretation?

A. Right Bundle Branch Block
B. Left Ventricular Hypertrophy with strain
C. Acute Inferior-posterior MI
D. Acute Anterior ischemia
E. Acute High Lateral MI

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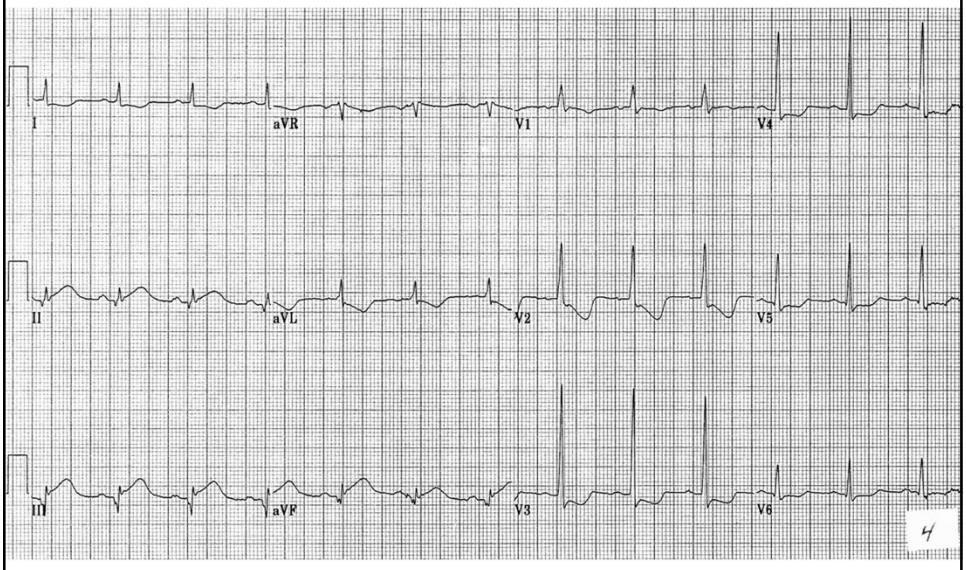
Case #4



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Case #5

Your patient is a 75-year-old woman who suffers from heart failure. She is in for routine follow up today. She is complaining of some edema in legs bilaterally, but no other symptoms. Her weight is stable from last visit. She mentions that she had a bout of acute diarrhea for a few days last month. She is currently taking medication for high blood pressure and heart failure without side effects.

Based on your assessment of her ECG, the most likely interpretation is?

A. Left ventricular hypertrophy
B. Sinus bradycardia secondary to second degree AV block
C. Acute Anterior MI
D. Within normal limits
E. Acute pericarditis

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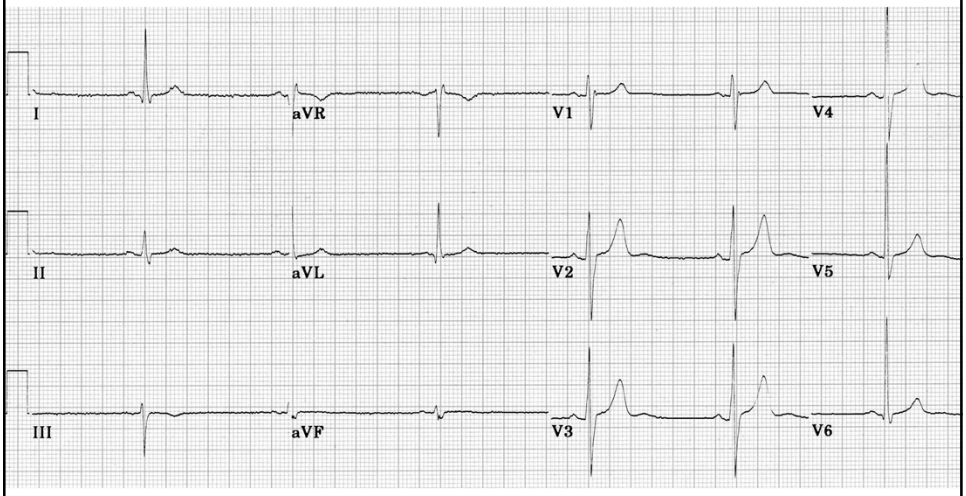
Case #5



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Left Ventricular Hypertrophy

- Area that causes confusion
- Multiple criteria exists for diagnosis
- Limited sensitivity using ECG (60%) at best
- Diagnosis is enhanced by clinical correlation
- 30% of ED patients with CP
- Variable ECG criteria
- Age cut off

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Simple LVH Rule

Rule of 35

The amplitude of the S wave in V1 or V2 plus the amplitude of the R wave in V5 or V6 > 35 mm, in a patient of age > 35

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LVH Simplified Criteria

- 1. Deepest S wave in Lead V1 or V2 plus Tallest R wave in lead V5 or V6 ≥ 35
- 2. R wave in lead aVL ≥ 12
- 3. Patient ≥ 35 years old
- 4.

Adapted from Sokolow-Lyon criteria. 33

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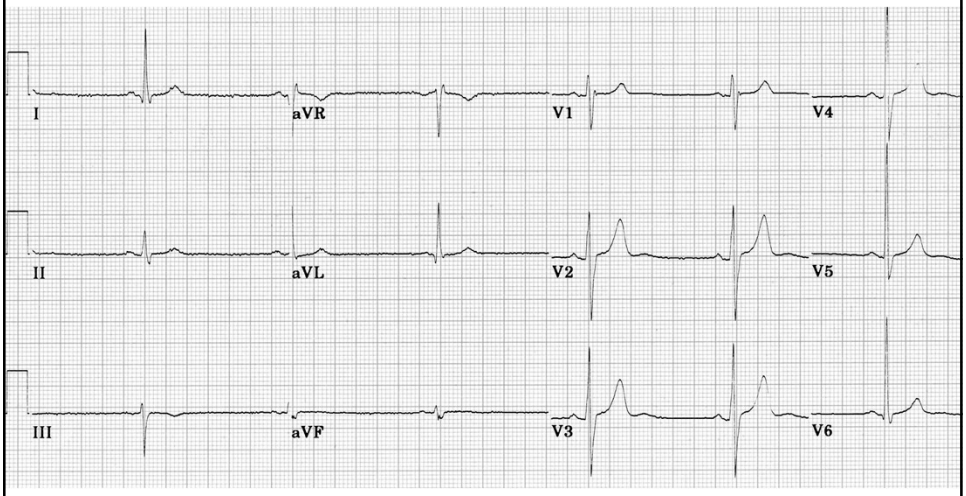
Case #5



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Case #6

You are seeing a 57-year-old woman with a long history of hypertension. She is complaining of shortness of breath, although this is no different than her COPD baseline. She is relatively non-compliant with her medications for hypertension and only takes her inhalers when her shortness of breath worsens.

Based on your assessment of her ECG, what is the most likely explanation for the T-wave inversions?

A. Nonspecific T-wave changes due to a bundle branch block
B. Symmetrical T-wave inversion secondary to ischemia
C. Nonspecific T-wave inversion that is within normal limits
D. Strain pattern associated with ventricular hypertrophy
E. T-wave inversion as a result of her medication

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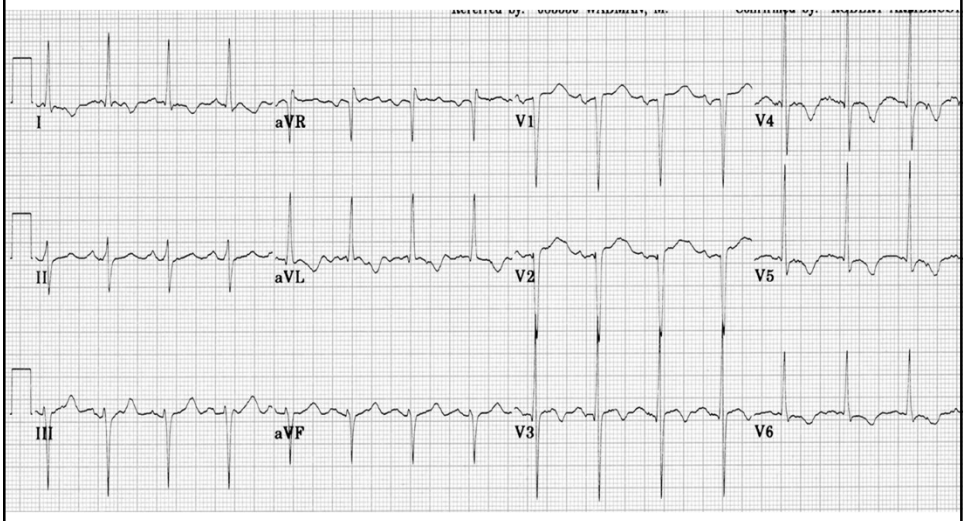
Case #6



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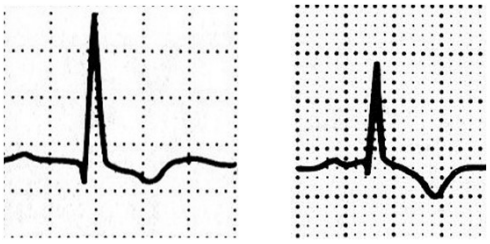
Strain Pattern

- Strain pattern shows asymmetric ST segment depression and T wave inversion
- ST segment manifests a slow downward decline with a much more rapid return to baseline.



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LVH Simplified Criteria

- 1. Deepest S wave in Lead V1 or V2 plus Tallest R wave in lead V5 or V6 ≥ 35
- 2. R wave in lead aVL ≥ 12
- 3. Patient ≥ 35 years old
- 4. "Strain" pattern present

Adapted from Sokolow-Lyon criteria. 38

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Case #7

Patient is an 87-year-old female who presented from an assisted living facility complaining of acute onset fatigue and a near syncopal episode. She has been treated for HTN for years on low dose HCTZ. Otherwise in good overall health.

Based on your assessment of her ECG, what is the most likely interpretation?

A. Acute anterior MI
B. Left bundle branch block
C. Left ventricular hypertrophy
D. Hyperkalemia
E. Acute pericarditis

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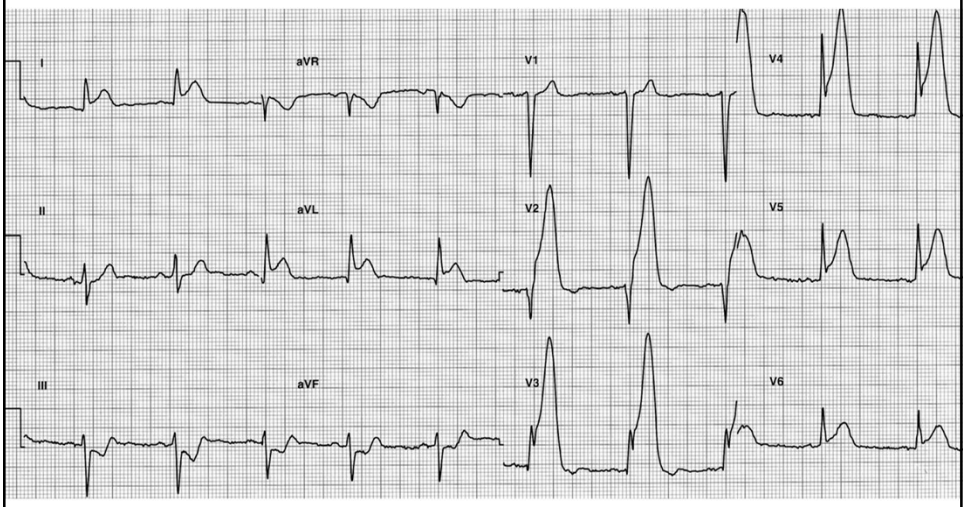
Case #7



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Case #8

Patient is a 41-year-old obese male who is complaining of tightness in his chest. He notes he has a sedentary lifestyle until 10 days ago when he started walking 30 minutes a day. It was during his walk that he developed the chest tightness. He is currently on no medications. He denies a family history of cardiac conditions but does note he had a head cold recently.

Based on your assessment of his ECG, what is the best interpretation?

A. Acute pericarditis
B. Acute inferior MI with lateral extension
C. Acute anterior wall ischemia
D. Inferior wall ventricular aneurysm
E. Acute anterior subendocardial MI

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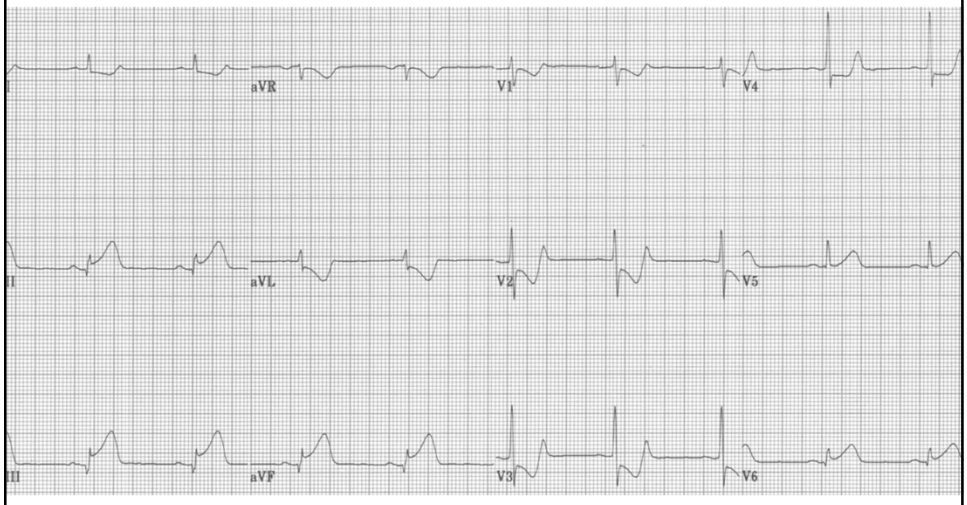
Case #8



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Case #9

Your 29-year-old male patient was brought to the ER via ambulance after being involved in a motorcycle accident. He is alert and complaining of right leg pain primarily. He did suffer a contusion on his chest, resulting in an ECG being obtained.

Based on your assessment of his ECG, what is the best interpretation?

A. Within normal limits
B. Left ventricular hypertrophy
C. Age indeterminate inferior MI
D. Wolff-Parkinson-White syndrome
E. Acute inferior wall MI

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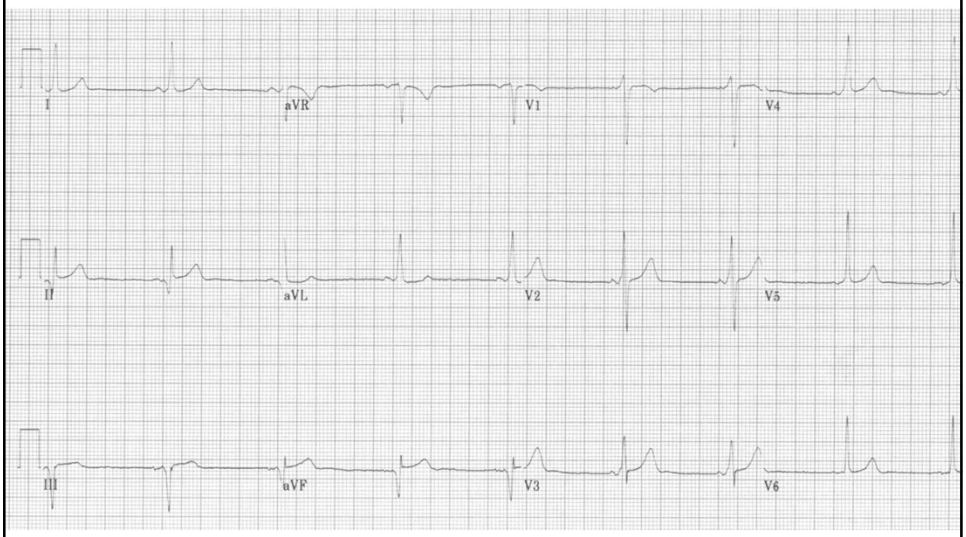
Case #9



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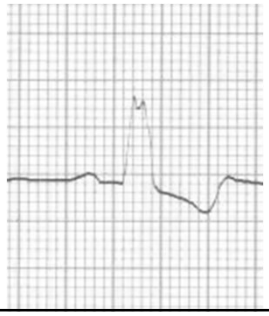
WPW Exception

- Diagnostic criteria for WPW
  - PR interval < 120 ms with a normal looking P-wave
  - Wide QRS complex: 110 ms or greater
  - Presence of "delta-wave" (initial slurring or QRS)
  - Secondary ST-T changes



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Case #10

This 27-year-old woman presents to the clinic with complaints of chest pain, worse when she reaches into higher cupboards and if she is pulling something towards herself. She is otherwise healthy and has recently joined a gym and has begun to workout with weights. She is only taking oral contraceptives. Drinks moderately but does not smoke. Denies any other symptoms or complaints.

Based on your assessment of her ECG, what is the best interpretation?

A. Hyperkalemia
B. Left ventricular hypertrophy with strain pattern
C. Sinus bradycardia otherwise within normal limits
D. Wolff-Parkinson-White associated ST elevation
E. Acute anterior wall MI

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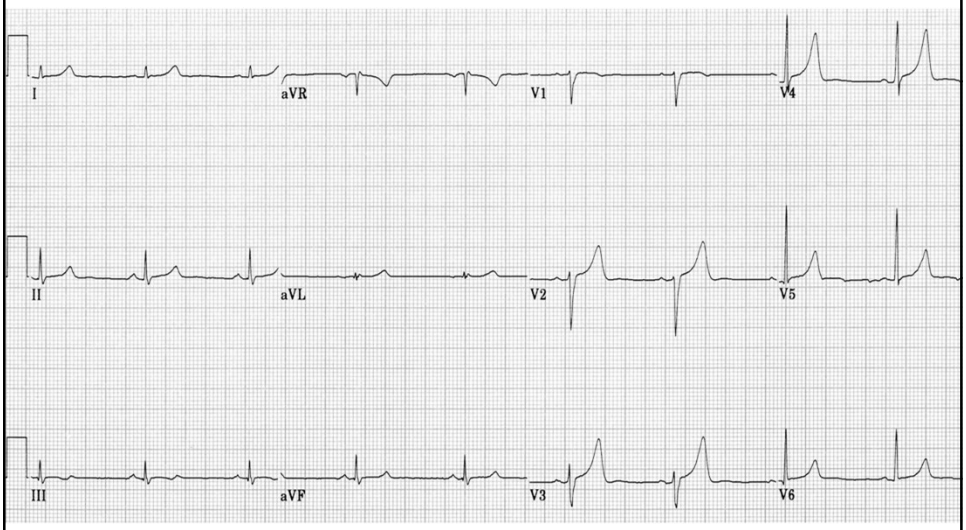
Case #10



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Case #11

This 51-year-old male presents to your office with complaints of pain in his chest that worsens with cough. He had the stomach flu a few weeks ago. He is otherwise healthy, taking no medications, does not smoke and consumes little alcohol. Current symptoms have been present for three days.

Based on your assessment of his ECG, what is the best interpretation?

A. Within normal limits with benign early repolarization changes
B. Acute anterior wall MI with reciprocal changes
C. Printzmetal's angina
D. Left ventricular hypertrophy with strain
E. Acute pericarditis

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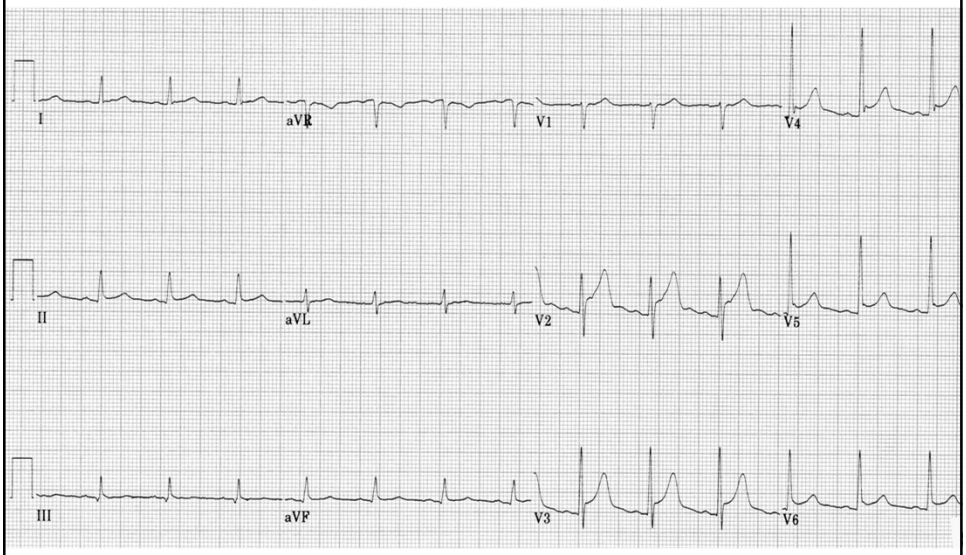
Case #11



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Pericarditis/Myocarditis

- Commonly presents with signs/symptoms of acute MI
- Results from diffuse inflammation of pericardial surface
- Common manifestation is ST elevation

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ECG Stages of Pericarditis

- Stage 1
  - Diffuse ST elevation and PR depression
- Stage 2
  - ST segment normalization
- Stage 3
  - T wave inversion
- Stage 4
  - Complete normalization

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Case #12

This 60-year-old woman presents to the ED with her husband after she fainted while working in the garden. She had been working in the garden most of the day, planting her spring flowers. She is a long-time smoker (57 pack years) but denies other health issues. Taking no medications currently.

Based on your assessment of the ECG, what is the best interpretation?

A. Acute Inferior wall MI
B. Acute Posterior wall MI
C. Acute Anteroseptal ischemia
D. Acute Anterolateral ischemia
E. Benign early repolarization variant

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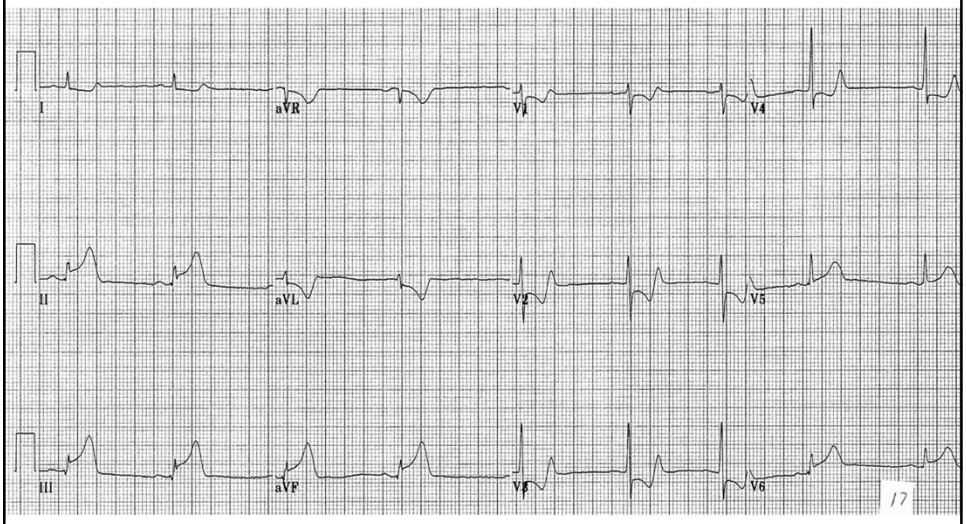
Case #12



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Case #13

This 87-year-old woman is brought to the ED by her daughter after she complained of unrelenting indigestion after Easter dinner. The daughter notes the symptoms have lasted 5 hours and were unresponsive to Zantac. She has a known history of atherosclerosis, hypertension, and stroke. She takes ASA daily along with her blood pressure and cholesterol meds.

Based on your assessment of her ECG, what is the best interpretation?

A. Acute Pericarditis
B. Left bundle branch block
C. Acute inferior wall MI
D. Acute anterior wall MI
E. Age indeterminate lateral wall MI

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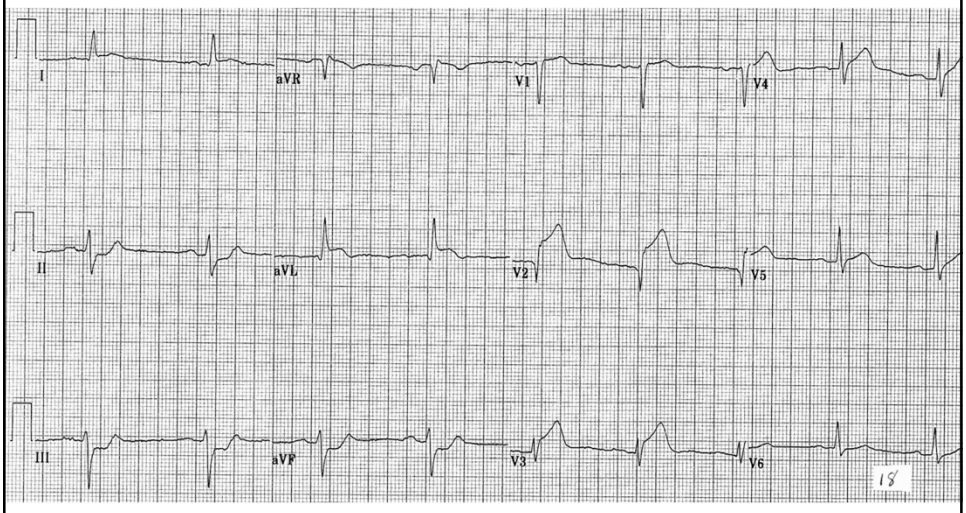
Case #13



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ATRIOVENTRICULAR BLOCKS

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AV Heart Blocks

- Helpful hints to assist with diagnosing
  - Look for the P wave. Is there one P wave before each QRS or more than one?
  - Measure the regularity of the atrial rhythm (P-P) and ventricular rhythm (R-R).
  - Measure the PR interval. Is it fixed, consistent or does it vary? This is the key!!
  - Is the QRS narrow (normal) or wide?
  - Slower Ventricular rates

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First-Degree AV Block

Rate: 60 -100 bpm
Rhy: Regular
P-wave: Sinus, one P wave to each QRS complex
PR: > 200 ms, fixed and prolonged
QRS: <120 ms

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First-Degree AV Block

- Causes
  - Ischemia, injury of AV node, drug effects (beta blockers, CCBs, digitalis, amiodarone), hyperK, increased parasympathetic tone, …….
- Asymptomatic
- No treatment necessary
- Can progress, monitor until stabilized
- Review drugs that might induce

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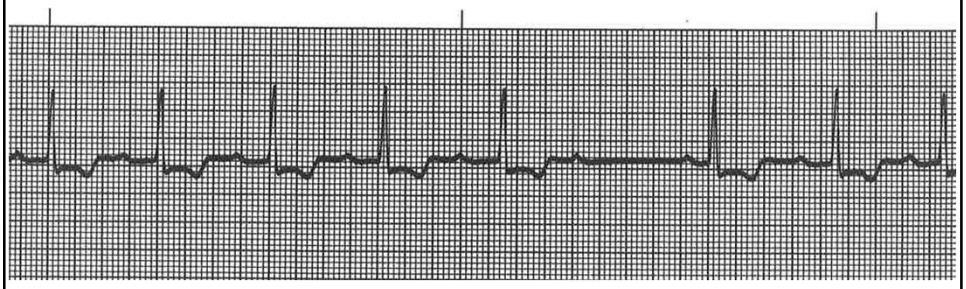
Second-Degree AV Block, Type I



Rate: Atrial – sinus rate. Vent depends on conduction
Rhy: Regular atrial rhythm, irregular ventricular rhy
P-wave: Sinus
PR: Progressively lengthens until P wave dropped
QRS: <120 ms

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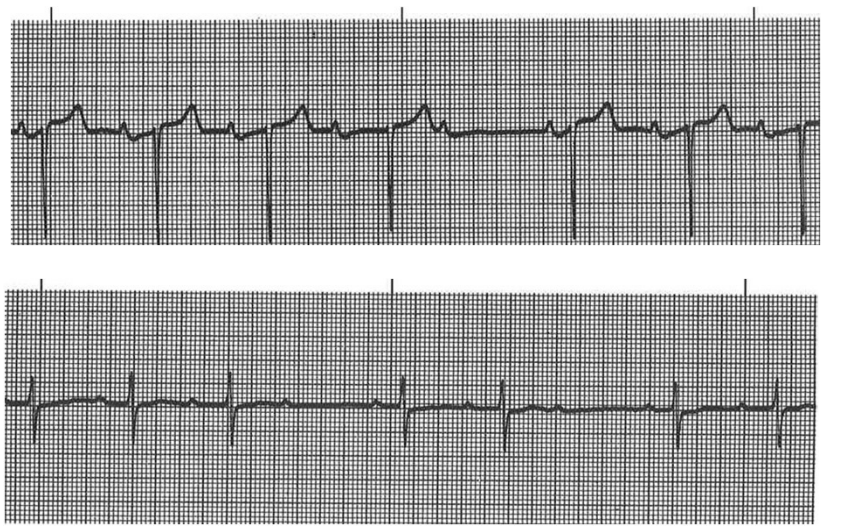
2nd AV Block Type I



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2nd AV Block Type I

- Cause
  - Inferior MI, increased vagal tone, meds (BB, CCBs, digitalis), hyperK, …
- Temporary and resolves spontaneously
- Asymptomatic usually, may become bradycardic
- Monitor for advancing AV block

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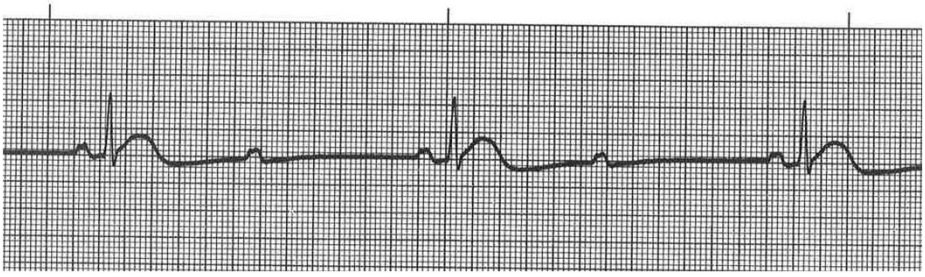
Second-Degree AV Block, Type II



Rate: Atrial – sinus rate. Vent depends on conduction, slow
Rhy: Regular atrial rhy. Vent usually reg, may be irregular
P-wave: Sinus, 2+ P waves per QRS. Map out to each other
PR: Fixed, may be normal or prolonged
QRS: <120 ms usually but may be prolonged if at BB level

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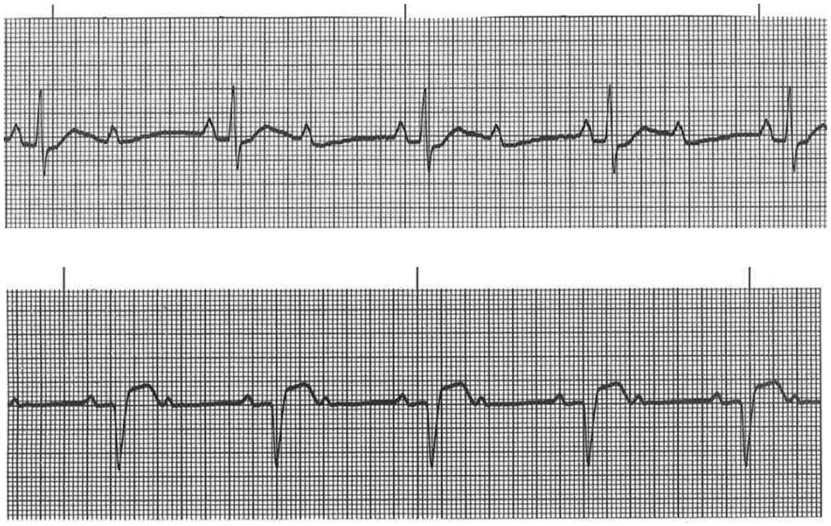
2nd AV Block Type II



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2nd AV Block Type II

- Causes
  - Anterior MI, acute myocarditis, degeneration of conduction system in elderly (not induced by drugs or increasing parasympathetic tone)
- Usually presents with significant bradycardia
- Less common, more serious, monitor for 3rd AV block
- Treat: pacemaker, avoid atropine if wide QRS

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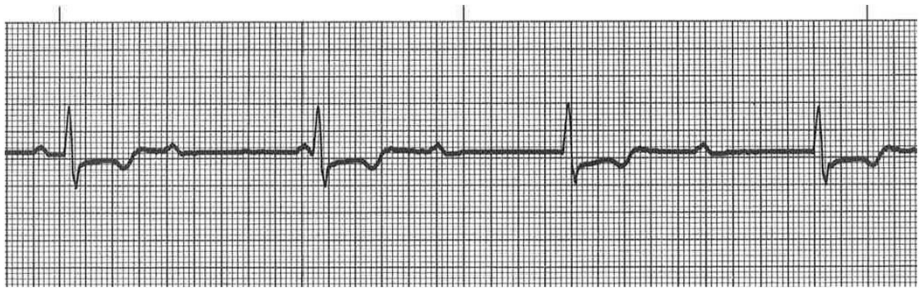
Third-Degree AV Block



Rate: Atrial at sinus rate. Vent: 40-60 if AV node, 20-40 if Vent
Rhy: Regular atrial rhy. Ventricular is regular usually
P-wave: Sinus but no consistent relationship with QRS. Can be hidden in QRS, ST or T waves.
PR: Not consistent
QRS: <120 ms if at AV node, prolonged if at BB level

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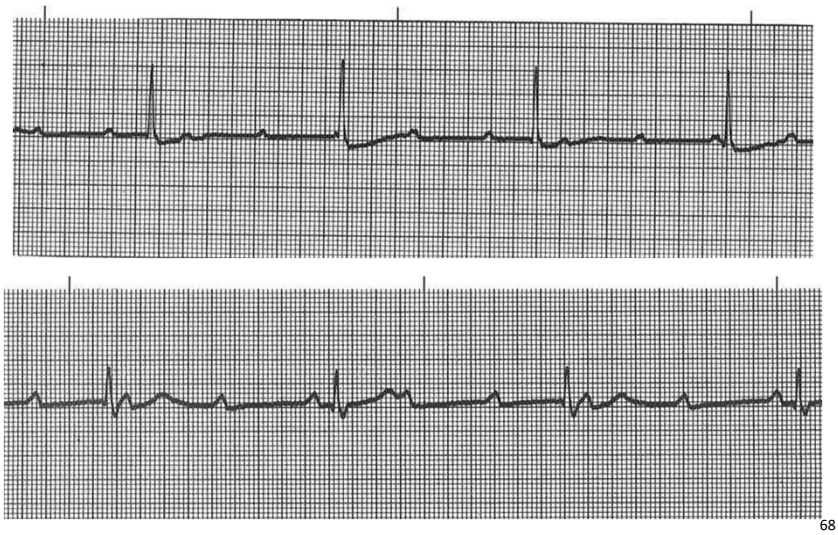
3rd Degree AV Block



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3rd AV Block

- Causes
  - CAD, MI, congenital HD, cardiac surgery, dig toxicity
- Presents usually as significant ventricular brady
- Symptoms of hypotension, dyspnea, CP, syncope, HF
- Serious, life threatening,
- Treat: pacemaker. Avoid atropine.

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Supplementary Basic ECG Info

Basic ECG Review Information

- Heart Rate determination
- Rhythm determination
- ECG Intervals
- Axis determination
- R-wave progression assessment

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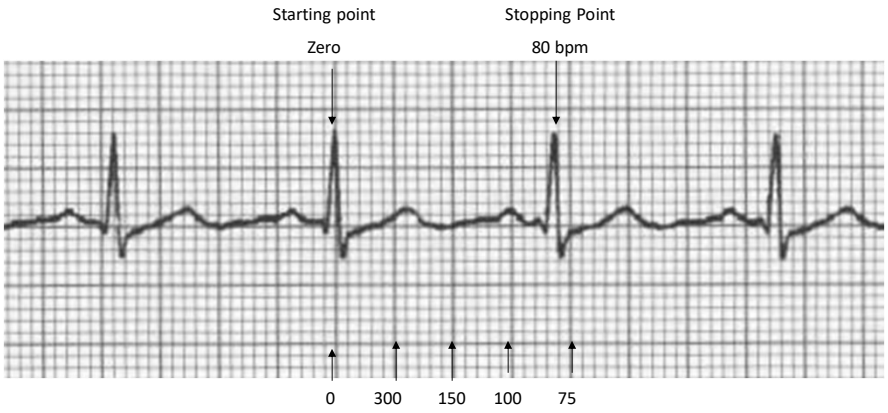
Heart Rate Determination



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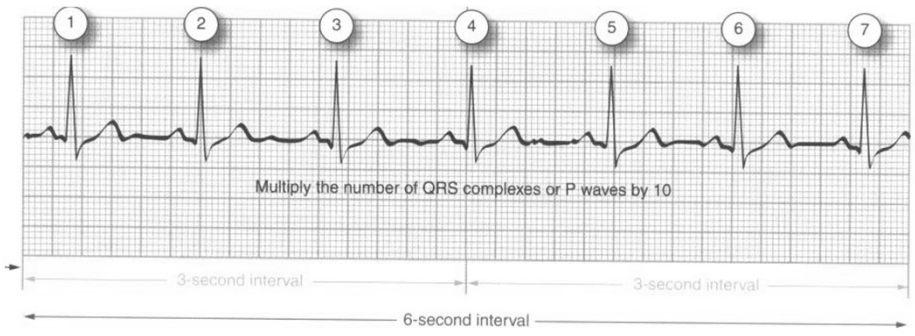
Heart Rate for Irregular Rhythms



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Rhythm Determination

Is the distance between one QRS complex the same as the others?

If yes, rhythm is considered Regular.

If no, rhythm is considered Irregular.

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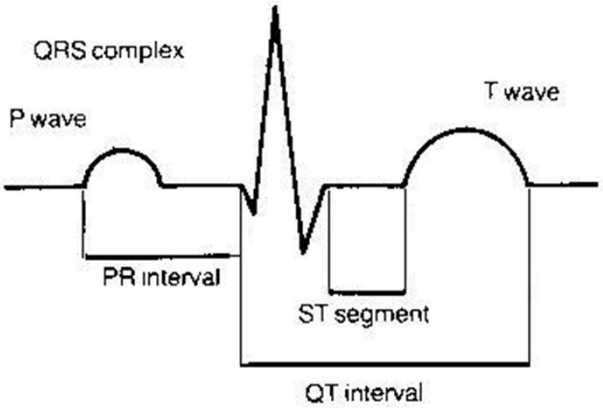
PR, QRS, QT Intervals



PR Normal: 120 – 200 ms

QRS Normal: < 120 ms

QT Normal: Heart rate dependent:

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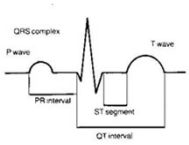
PR Interval

- Measure from start of P wave to start of QRS
- Best measured in limb lead II
- Conduction through the AV node
- Normal:
  - 120 ms to 200 ms
  - 3 to 5 boxes



- Short PR Interval
  - Preexcitation synd.
    - WPW, LGL
  - PACs
- Long PR Interval
- Lots of causes, don't really care about cause
- Refer to as: "First Degree AV Block"

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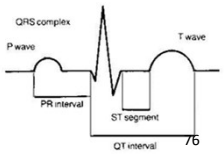
QRS Interval

- Beginning of QRS to the end (J-point)
- Normal: < 120 ms (less than 3 boxes)
- Use the Limb Lead with longest QRS to measure

- Causes of Prolonged QRS interval:
  - Bundle Branch Blocks, IVCD, WPW, LVH, RVH,
  - Rhythm: ventricular tach, PVCs, idoventricular rhythm



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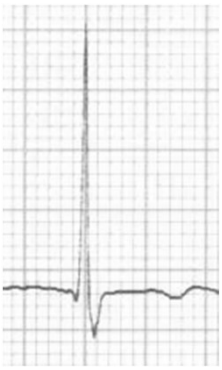
QT Interval

- Measures a complete ventricular cycle
  - From beginning of ventricular depolarization to ventricular repolarization
- Measure from start of QRS to end of T-wave
- Normal is defined based on heart rate
  - HR of 60 = 400 ms; HR of 100 = 320 ms
- Simple rule:
  - The QT is probably prolonged if it exceeds more than HALF of the R-R interval.
  - Rule works well as long as HR is not excessive



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Axis Determination

- Based on the frontal plane (limb leads)
- Ballpark estimates are usually fine, rarely necessary to have specific degrees noted
- Utilize the Quadrant Method
  - Based on two limb leads: I and aVF
  - Normal is based on quadrant

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Quadrant Method

- From the ECG, looking at Limb Lead I, determine the net deflection of the QRS complex (Positive, Negative, equal)
- Plot this on your axis diagram
- Next, from the ECG, looking at Limb Lead aVF, determine the net deflection of the QRS complex (Positive, Negative, equal)
- Plot this on your axis diagram

- Where the areas cross over, this is the quadrant in which the axis lies.

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Axis Pathology

- Left Axis Deviation
  - Left Bundle Branch Block
  - Left Ventricular Hypertrophy
  - Inferior Wall MI
  - Left Anterior Fascicular Block
- Right Axis Deviation
  - Right Bundle Branch Block
  - Right Ventricular Hypertrophy
  - High Lateral Wall MI
  - Left Posterior Fascicular Block

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R-wave Progression

- Precordial Chest leads V1 – V6
- R wave progresses from V1 through V6
- Descriptive term only, does not imply pathology
- Terminology:
  - Normal, early transition, late transition
- Causes:
  - LVH, RVH, MI, Conduction defects, normal variants, lead misplacement….

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R-wave Progression

Start small (V1) Get big (V6). Transition occurs at V3, V4, or between V3 & V4.

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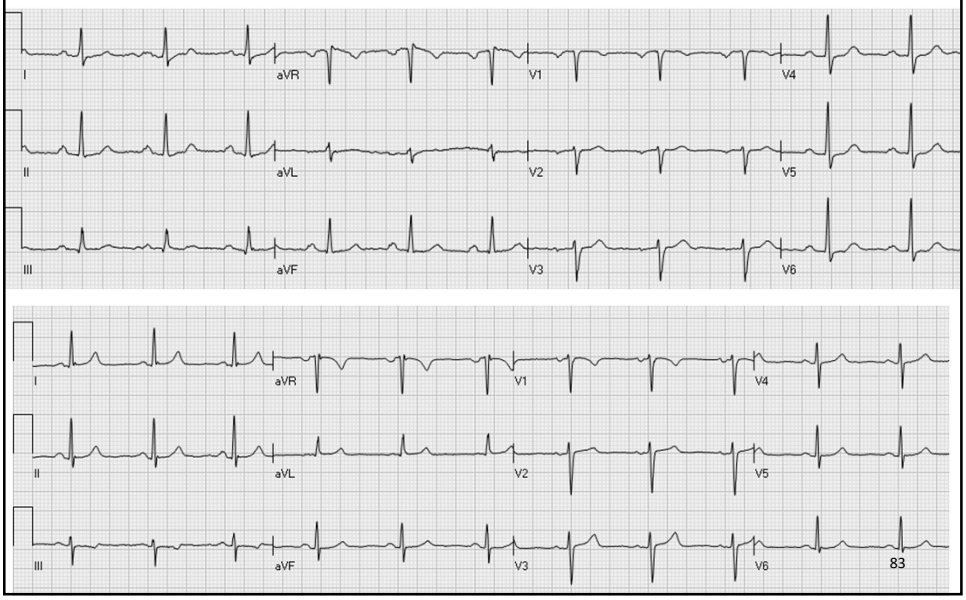
R-Wave Progression



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What Next

- For each ECG lead, note the following:
  - Location and morphology of P-waves
  - QRS pattern (presence of Q-waves)
  - ST Segment (elevation or depression)
  - T wave changes

Review all leads except aVR.

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Normal ECG:
The 12-lead ECG morphology for a normal individual is not always uniform. A number of constitutional variables can substantially alter a normal ECG, including sex, age, height, race and anatomic position of the heart within the chest. Lead placement, variations in technique and different machines can also distort a normal ECG.

Helpful Criteria:
* P-waves upright in I, II, V2-V6
* T-waves upright in I, II, V3-V6, Inverted in aVR
Variable in III, aVL, aVF, V4-V6

* Small Q-waves normal in I, aVL, V4-V6
* Deep Q-waves (QS) normal in aVR, and occasionally seen in leads III and V_1

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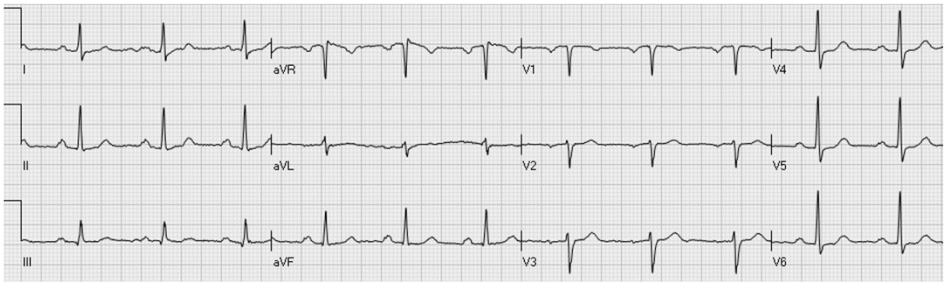

Helpful Criteria:
* P-waves upright in I, II, V2-V6
* T-waves upright in I, II, V3-V6, Inverted in aVR
Variable in III, aVL, aVF, V4-V6

- Small Q-waves normal in I, aVL, V4-V6
- Deep Q-waves (QS) normal in aVR and occasionally seen in leads III and V1

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Take Home Points

- Develop an organized process to evaluate ECGs
- Follow a process each time interpreting ECG
- Buy a decent ECG textbook as a resource
- Practice, Practice, Practice

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Unknown #1

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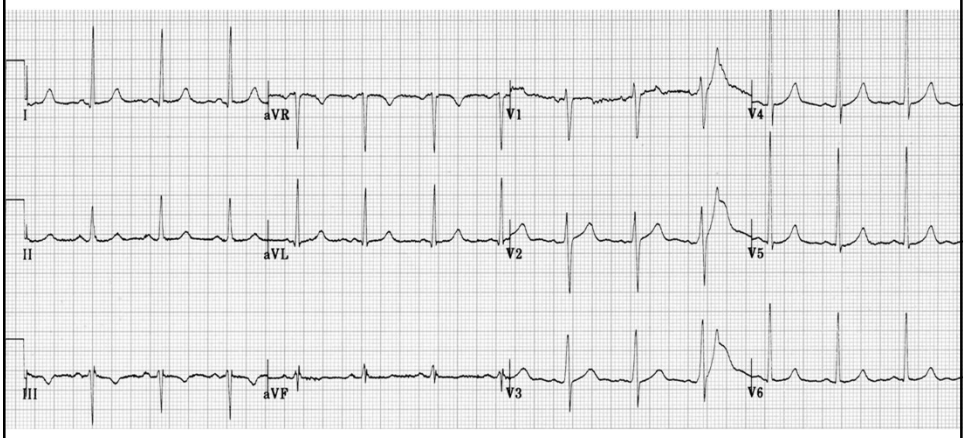
Unknown #2

89

Unknown #3



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Unknown #4

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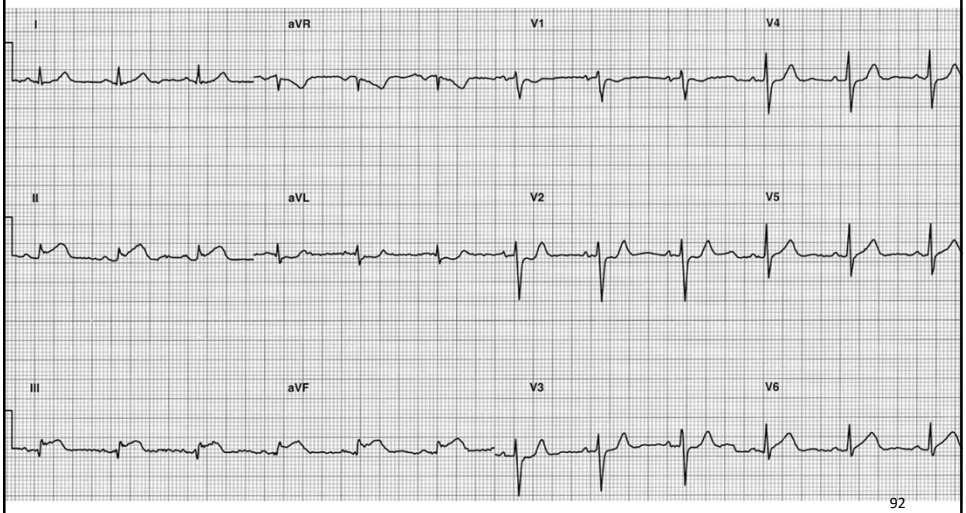
Unknown #5



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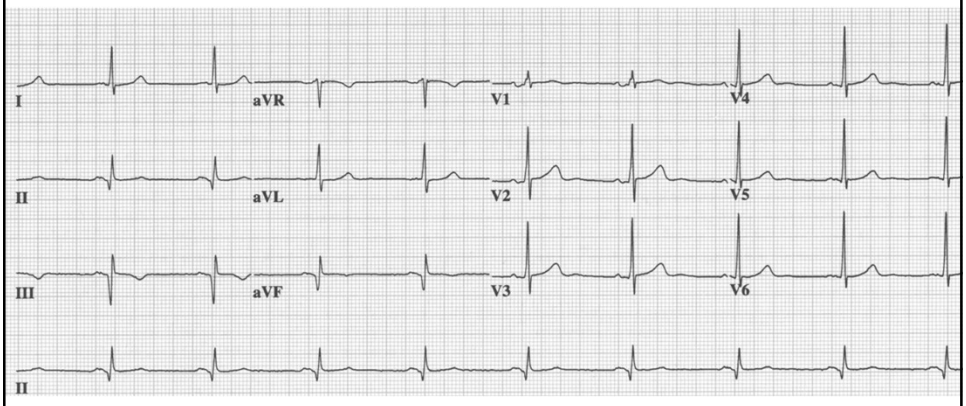
Unknown #6



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References

Sokolow M, Lyon TP: *The ventricular complex in left ventricular hypertrophy as obtained by unipolar precordial and limb leads.* Am Heart J 37: 161, 1949

Viskin S. The QT interval: too long, too short or just right. *Heart Rhythm;6(5):2009. 711-715.*

Up-to-Date

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