A SYSTEMATIC APPROACH TO ECG INTERPRETATION

1. RATE

- Calculate the heart rate in beats / minute.
  - Number of small boxes between beets divided into 1500 or " 300, 150, 100 75, 60, 50, 43 " method
  - Rate > 100 and of sinus origin ➞ sinus tachycardia
  - Rate < 60 and of sinus origin ➞ sinus bradycardia

2. AXIS

- Quadrant location of axis by analysis of leads I and AVF.
  - I-Λ, AVF-Λ ➞ normal I-Λ, AVF-V ➞ LAD I-V, AVF-Λ ➞ RAD I-V, AVF-V ➞ Indeterminant
  - Axis is 90 degrees away from most **equiphasic lead (EL)** EL more + ➞ axis closer EL more – ➞ axis farther away
  - Normal axis limits = -30 to +110 degrees

- Steps for the degree estimate of axis
  - Find the most equiphasic limb lead or, in the case of no equiphasic limb lead, the smallest QRS deflection
  - The axis lies perpendicular to this lead within the quadrant noted above.
  - R-wave > than S-wave in most equiphasic lead ➞ axis lies proportionately closer (< 90° away) from that lead
  - S-wave > than R-wave in most equiphasic lead ➞ axis lies proportionately further (> 90° away) from that lead

3. RHYTHM

- Determine if rhythm is regular and of sinus origin or if rhythm disturbances are present
  - Regular rhythm with negative P-waves in AVR, positive P-waves in II, and no ectopic beats ➞ NSR
  - If ectopics are present, determine origin, frequency, and nature: escape beats, PAC, PJC, PVC
  - If rate is variable without ectopic complexes consider atrial fibrillation (noisy baseline) or sinus arrhythmia
  - 1st AV:PRI>.20, 2nd AV Mob I:pri⬆ until QRS dropped, 2nd AV Mob II:>1 P for each QRS, 3rd AV: no P-QRS relationship

4. CONDUCTION.

- Determine if atrioventricular and interventricular conduction is normal
  - Atrioventricular conduction: measure PRI: Normal .12 to .20 seconds
    - If < than .12 consider pre-excitation: WPW in presence of delta wave, LGL in its absence.
    - If > than .20 consider 1st, 2nd (Mobitz I or II), or 3rd degree AV block.
  - Interventricular conduction: Measure QRS width. Normally, the QRS complex is less than 0.10 seconds.
    - If > 0.12 with an RR' in leads V1, V2, or V3 ➞ RBBB
    - If > 0.12 with deep S-waves in V1, V2, or V3 and tall possibly notched R-waves in V5 & V6 ➞ LBBB
    - If between 0.10 and 0.12 with an RR' in leads V1, V2, or V3 ➞ incomplete RBBB

5. HYPERTROPHY / ENLARGEMENT.

- Determine if right or left atria are enlarged by evaluating the P-wave in leaad II
  - P-wave in lead II > .25 mV (P Pulmonale) consider RAH.
  - P-wave in lead II > .12 seconds and notched (P Mitrale) consider LAH.

- Determine if right or left ventricles are enlarged by evaluating QRS complexes in precordial leads
  - If R:S ratio > 1.0 in V1 plus persistent S waves in lateral precordial leads, consider RVH.
  - If S-wave depth inv1 or V2 + R-wave height in V5 or V6 > 35mm, consider LVH.
    - Note: LVH precordial voltage criteria void in presence of left bundle branch block

6. ISCHEMIA.

- Determine if ischemia exists at rest
  - Look for "nonspecific T-wave or ST-segment changes
    - Flat or inverted T-waves, "scooped", horizontal, or depressed ST-segments

- Determine if ischemia exists during exercise
  - ST-segment depression:
    - Upsloping with shallow depth (1-1.5mm) may be caused by ischemia - hard to be sure
    - Horizontal with moderate depth (1.6 - 2 mm) most likely caused by ischemia
    - Downsloping with significant depth (> 2 mm) almost always caused by ischemia
  - Things that strengthen the diagnosis of ischemia during an exercise test:
    - Chest pain - most powerful diagnostic tool
    - ST segments becoming progressively depressed or more downsloping with increasing workloads

7. INFARCTION.

- Resolved or Old MI: Look for significant Q waves in leads in which they don't belong (Q>0.04 sec + Q:R ratio ≥ 1:3).
- Acute or Ongoing MI: ST segment elevation in leads overlying the infarction region

Note: Old MI and other voltage criteria related abnormalities (ischemia, hypertrophy, etc.) are indeterminable (not able to be diagnosed) in the presence of LBBB

ECG Definitions and Information

P-WAVE - represents atrial depolarization

1) Usually < .12 sec. and < 2-3 mm in height
2) P-wave > .12 sec. in Lead II indicates possible left atrial hypertrophy (p-mitrale)
3) P-wave > 2.5 mm in height in Lead II indicates possible right atrial hypertrophy (p-pulmonale)

PR INTERVAL (PRI) - time between activation of atria and activation of ventricles (atrial conduction + AV delay)

1) Normal PR interval is .12-.20 sec.
2) PR interval < .12 sec indicates pre-excitation syndrome (Wolf Park White or Lown-Ganong Levine)
3) PR interval > .20 sec indicates possible first degree AV block

QRS COMPLEX - represents ventricular depolarization

1) Normal QRS interval < .10 seconds with height or depth < 20 or 30 mm
2) Duration > .10 sec. But < .12 sec. Indicates possible incomplete BB block
3) Duration > .12 sec. Indicates possible complete BB block
4) Excessive height with normal duration in V5 or V6 indicates possible L ventricular hypertrophy

Q-WAVE - insignificant Q's represent depolarization of the ventricular septum

1) Significant Q's (1 mm wide - 2 mm deep or > 1/3 QRS height) indicates possible MI
2) Q's associated with MI represent lack of depolarization by dead myocardium - may affect axis

R & S WAVES - represent ventricular depolarization

ST SEGMENT - represents the slow phase of ventricular repolarization

T-WAVE - represents the fast terminal phase of ventricular repolarization.

1) Normally 5 mm tall in limb leads
2) Normally 10 mm tall in chest leads

U-WAVE - probably represents repolarization of Perkinge fibers. Inverted U's indicates possible ischemia.

QT INTERVAL - represents the time from initial septal depolarization until the ventricles are completely relaxed. It decrease when HR increases.

J-POINT - where QRS ends and ST segment begins (form stops being “spikey” and start becoming “curvey”).

NORMAL EKG RESPONSES TO EXERCISE

1) P-wave amplitude increases
2) PR interval decreases after 1 minute (< .15 at HR > 150)
3) R-wave amplitude decreases at HR > 150
4) S-wave amplitude becomes more negative as exercise progresses
5) J-point progressively decreases below baseline as exercise progresses
6) T-wave amplitude decreases then increases slightly as exercise progresses
7) U-wave (papillary repolarization) should not change during exercise
8) QRS-axis shifts to right - QRS duration unchanged
9) QT interval decreases as HR increases (inversely proportional)
10) P-waves may be superimposed on the preceding T-wave
11) Septal Q-wave amplitude increases

ST-SEGMENT DEPRESSION MAY REPRESENT:
1. Ischemia **(MOST COMMON)**
2. Subendocardial infarction
3. Reciprocal changes associated with acute infarction
4. Drug effects (digitalis, quinidine)

ST SEGMENT ELEVATION MAY REPRESENT
1. Acute infarction (when ST segment elevation is convex) **(MOST COMMON)**
2. Transmural ischemia – coronary artery spasm - unstable type angina
3. Ventricular aneurysm (non-subsiding ST elevation after infarction)
4. Pericarditis (convex with T wave also off the baseline)
5. When the ST elevation is above significant q-waves it may indicate wall motion ("squeezing" motion) abnormalities

ECG MANIFESTATIONS OF "ATHLETES HEART" SYNDROME (nodal suppression, ↑ vagal tone)
1. Bradycardia
2. Sinus arrhythmia
3. 1st & 2nd degree AV block
4. Junctional rhythm
5. ↑ p-wave amplitude
6. ↑ precordial voltage (LVH)
7. Interventricular conduction defects
8. RBBB
9. St-segment changes
10. ↑ amplitude and broadening of t-wave
11. Prominent U-waves

DETERMINING SIGNIFICANCE OF q-WAVES
1. Significant q's are: > 1/3 total QRS height and > 1 mm wide

2. q's are not significant:
    a. in AVR
    b. in III alone
    c. in AVF alone
    d. in V1 alone

CAUSES OF RIGHT VENTRICULAR HYPERTROPHY
1. COPD
2. Mitral valve stenosis
3. Pulmonic valve stenosis
4. Tricuspid valve insufficiency
5. Tetralogy of fallot

CAUSES OF A PROLONGED QT INTERVAL
1. Class I antiarrhythmic drugs
2. Electrolyte disturbances
3. Rheumatic fever
4. Heart disease
5. Myocarditis
6. Cerebrovascular disease
7. Hypothermia
8. Congestive heart failure
9. Stringent dieting
10. Mitral valve prolapse

DANGERS OF A PROLONGED QT INTERVAL
1. Increased predisposition to re-entry arrhythmias
2. Increased susceptibility to tachy-arrhythmias and sudden death

ECG MANIFESTATIONS OF LEFT VENTRICULAR STRAIN
1. Inverted T-waves in lateral precordial leads in association with LVH