Systematic EKG Interpretation
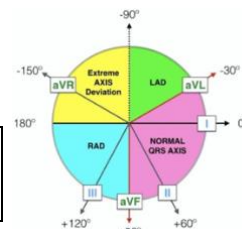### Written by Adam Russak

Group 1: Lead Placement and **Rate/Rhythm/Axis**
- Ensure general findings of proper lead placement are present (p wave up in I, QRS negative in V1, QRS positive in V6)
- Calculate Rate (Either use the 300/150/100/75/60/50 square counting method if the rhythm is regular, or if your strip is 10 seconds long count the total QRS complexes and multiply by 6)
- Determine Rhythm
  - 1: Look for signs of depolarization originating from SA node (Sinus Rhythm): Generally, p wave should be up in II & down in aVR
  - 2: Assess for regular rhythm (Consistent R-R intervals, p waves coordinate with QRS)
  - 3: If the rhythm is not normal sinus or is irregular, determine the rhythm (AV Block, Afib, AFlutter, MAT, PVCs, APCs, etc.)
- Determine the Axis (Generally, if QRS is up in I and II, the axis is within normal limits. More specifically, you can find the lead in which the QRS is isoelectric and the axis should be roughly orthogonal to that direction)

Inverted P waves, large S waves, and inverted T waves in lead I as a result of incorrect lead placement

Group 2: Calculate **Intervals**:

Interval	Normal Length
P-R	0.12 - 0.20 sec
QRS	0.06 – 0.10 sec
QTc	< 0.45 sec

> For standard EKG paper, each small box is 1 mm and 0.04 seconds (40 ms); Each large box is 5 mm and 0.2 seconds (200 ms)

> **Bazett's Formula:**
> $$QTc = \frac{QT}{sqrt(RR)}$$
> Alternatively, use MDCalc QTc Calculator

Group 3: Examine for **Chamber** Enlargements:
- LAE: May be present if p wave in V1 is negative with length or amplitude > 1 small box or if p wave in II is at least 3 small boxes in length
- RAE: p waves with amplitude at least 2.5 boxes in II, may appear peaked in morphology
- LVH (A few main criteria exist. Note: EKG is generally less sensitive for detecting LVH but is highly specific):
  - Sokolow & Lyon: S in V1 + R in either V5 or V6 (whichever is tallest) at least 35 small boxes (7 big boxes)
  - Cornell: R in aVL + S in V3 > 20 small boxes (4 big boxes) in women or > 28 small boxes (5.6 big boxes) in men
  - Most Specific Criteria: R in aVL > 11 small boxes (> 18 mm if left axis deviation present)

Group 4: Voltage and **R Wave Progression**
- Criteria for Low Voltage: Amplitude of QRS complex is < 5 mm in all limb leads or < 10 mm in all precordial leads
- Typically R wave amplitude consistently increases from V1 to V6, with the isoelectric QRS occurring around V3

Group 5: Look for **Ischemic Changes**
- Q waves (Normal q waves representing septal depolarization are ~30-40 ms in length and generally occur in inferior limb leads and/or lateral precordial leads. Pathologic q waves are longer, deeper, and are almost always abnormal if present in V1-V3).
- ST elevations or depressions (>1 mm in at least 2 consecutive leads; if present, note distribution pattern)
- T wave inversions, hyperacute T waves, or T wave flattening (may be first signs of myocardial ischemia)

*Wellen T waves: Possible indicator of critical LAD stenosis
(Left) Type A: Biphasic, initially positive and terminally negative precordial T waves
(Right) Type B: Deeply inverted precordial T waves*

Group 6: Other
- Including but not limited to S1Q3T3, Osborne Waves, RBBB, LBBB, Brugada, WPW, Pericarditis, Peaked T's, etc.).
- Further information can be found in Rapid Interpretation of EKGs (ISBN 0912912065), and here.

**Supplemental: Selected EKG Examples:**

PR depression with concave ST elevation in most limb and precordial leads and reciprocal ST depression and PR elevation in aVR often seen in pericarditis
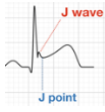
The above Osborne wave (or J wave) is sometimes seen with hypothermia, hypercalcemia, certain medications, neurologic insults, or as a normal variant

Classic dominant 'W'-shaped S wave in V₁ and broad, notched 'M'-shaped R wave in V₆ often seen in LBBB
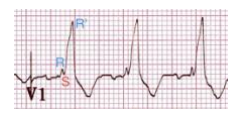
Classic RSR' pattern seen in a RBBB. Occasionally, RBBB will also present with a wide, slurred S wave in lead I

References:
1. https://en.ecgpedia.org/index.php?title=Main_Page
2. https://www.mdcalc.com/
3. https://litfl.com/