General Introduction to ECG

Reading Assignment (p2-16 in PDF ‘Outline’)

Objectives
1. Practice the 5-step ‘Method’
2. Differential Diagnosis: R & L axis deviation
3. Differential Diagnosis: Poor R-wave progression
4. Differential Diagnosis: Prominent Anterior Forces
Welcome to the “5-Step Method”

ECG #:  

<table>
<thead>
<tr>
<th>Measurements:</th>
<th>Rhythm (s):</th>
<th>Conduction:</th>
<th>Waveform:</th>
<th>Interpretation:</th>
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<tbody>
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<td>A=</td>
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<td>V=</td>
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<td>PR=</td>
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<td>QRS=</td>
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<td>QT=</td>
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<td>Axis=</td>
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1. Compute the 5 basic measurements: HR, PR interval, QRS duration, QT interval, Axis
2. What’s the basic rhythm and other rhythm statements (e.g., PACs and PVC’s)
3. Any conduction abnormalities (SA blocks, AV blocks (Types I or II), and IV blocks)
4. Waveform abnormalities beginning with P waves, QRS complexes, ST-T, and U waves
5. Final interpretations: Normal ECG or Borderline or Abnormal ECG (list final conclusions)
30 year old woman (explain the sequence of activation from sinus node to ventricular muscle)

What are ‘septal’ q-waves?
### Measurements:
- **Rhythm:** Normal Sinus rhythm
- **Conduction:** Normal SA, AV, IV conduction
- **Waveform:** Normal P, QRS, ST, T; note normal U waves in precordial leads (*).
- **Interpretation:** Normal ECG (septal q-waves normally seen in II, III, aVF in ECG’s when the QRS axis is > +60°; see arrows)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>A</td>
<td>55</td>
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<td>V</td>
<td>55</td>
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<tr>
<td>PR</td>
<td>140</td>
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<td>QRS</td>
<td>100</td>
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<td>QT</td>
<td>430</td>
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<tr>
<td>Axis</td>
<td>+80</td>
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### Sequence of conduction:
- **SA node** → (RA→LA) → AV node → His Bundle → RBB & LBB → LAF & LPF & LSF → Purkinje network → left septal surface (onset of QRS)
- **Septal q’s in II, III, aVF**

(onset of ventricular activation begins on the left ventricular septal surface resulting in small *septal q*-waves)
65 Year old woman

Where are the ‘septal’ q-waves?
Measurements: | Rhythm(s): | Conduction: | Waveform: | Interpretation: |
---|---|---|---|---|
A=65 | V=65 | Sinus Rhythm | Normal SA, AV, IV | Normal ECG (septal q-waves are normally seen in leads I, and aVL when the QRS axis is < +60°) |
PR=169 | | Normal SA, AV, IV | Normal P, QRS, ST-T, Septal q-waves I, aVL (arrows) (onset of ventricular activation begins in the left ventricular septal surface) | |
22 year old man; just waking up.
Junctional escape rhythm (Escape rhythms serve as backup pacemakers when the primary pacemaker gets too slow or when heart block prevents primary pacemaker from reaching the ventricles)

• Normal IV
  • Normal QRS, ST, T, U (*)
  • Retrograde P waves after the QRS in the ST segment, best seen in II, III, aVF (arrows); it’s like someone took a bite out of the T wave!

Note: normal U waves are best seen in leads V2-5 (*); these are the best leads to see U waves especially at slow heart rates.

Abnormal ECG (likely a normal variant in an athlete)
1. Slight right axis deviation (can be normal in 22 year old man)
2. Junctional escape rhythm (probably due to vagal slowing of the sinus rate in a healthy athlete; sinus rhythm would reappear after light exercise)
27 year old woman; feeling anxious.
### Measurements:
- **A** = 110
- **V** = 110
- **PR** = 120
- **QRS** = 80
- **QT** = 300
- **Axis** = +10

### Rhythm (s):
- Ectopic atrial tachycardia

### Conduction:
- Normal AV, IV

### Waveform:
- Inverted P waves II, III, aVF; upright P waves in lead aVR; (low atrial ectopic pacemaker)
- Normal QRS, ST, T waves

**Note:** In the horizontal plane (V1-6) ectopic atrial P waves may look normal in morphology; i.e., upright in direction.

### Interpretation:
- Abnormal ECG:
  1. Rhythm: (this rhythm abnormality can be the result of various internal or external stress perturbations; e.g., hypoxia, stimulants, sepsis, et al.)
  2. Brief ectopic atrial rhythms (usually 3-6 beat runs) are common in otherwise healthy people (may also occur in sick individuals).
Just an ordinary guy getting an insurance physical.
Measurements: | Rhythm(s): | Conduction: | Waveform: | Interpretation: |
---|---|---|---|---|
A=80 V=80 | Sinus rhythm | Normal SA, AV, slight IV conduction delay | - Normal P  
- rS in II, III, aVF ($S_m > S_n$)  
- Small q in I, aVL  
- Delayed QRS transition in horizontal plane (V5); note persistent S waves in V5-6. | |}

Abnormal ECG:
1) Left anterior fascicular block (LAFB is the most common IV conduction disorder)

The left bundle branches into two (sometimes three) fascicles: anterior, (septal), and posterior. (see pp 55-58 in the *Outline*)
F, Age 87 (sick and dehydrated)
### Interpretation:

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</table>
| A=80 V=80    | Sinus rhythm with 2 PACs (*) | Normal SA, AV, IV | • Normal P, QRS  
• Slight ST depression V5-6  
• T inversion in III, V2-4 | Abnormal ECG:  
1) Prolonged QT (upper limit @ 80 bpm is ~380 ms); many etiologies to consider!  
2) Nonspecific ST-T abnormalities (consider abnormal electrolytes, drugs, various heart diseases, etc)  
3) Rhythm: 2 PACs |
| PR=160       | Note: The PAC’s are early beats with different P wave morphology; the first PAC is followed by a pause (longer RR cycle) | Normal SA, AV, IV | | |
| QRS=80       | | Normal SA, AV, IV | | |
| QT=480       | | Normal SA, AV, IV | | |
| Axis= -20    | | Normal SA, AV, IV | | |
V₁-₆: Differential Diagnoses

- **Poor R-wave progression** (small or no r-waves \(V_{1-3} + R:S_{V4} < 1\))
  - Normal variant (esp. in women)
  - Misplaced precordial leads
  - Left ventricular hypertrophy
  - Anterior and anteroseptal MI
  - LBBB and incomplete LBBB
  - Left anterior fascicular block
  - Emphysema and COPD
  - Some cases of WPW
  - Diffuse infiltrative diseases
  - Dextrocardia

- **Prominent anterior forces** (PAF: \(R:S_{V1-2} \geq 1\))
  - Normal variant
  - Misplaced precordial leads
  - Right ventricular hypertrophy
  - RBBB and incomplete RBBB
  - ‘True Posterior’ (now called Lateral) MI
  - Some cases of WPW
  - Left septal fascicular block
  - Muscular dystrophy
68 y.o. woman (History of hypertension on Rx)
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<tbody>
<tr>
<td>A=85 V=85</td>
<td>Sinus rhythm</td>
<td>Normal SA, AV, IV</td>
<td>• Increase P terminal force V1 (arrow) • Multiple voltage criteria for LVH • Poor R wave progression V1-4 • ST depression, T inversion in I, aVL, V5-6</td>
<td>Abnormal ECG 1. LAE 2. LVH with strain pattern (seen in LV pressure overload conditions like aortic stenosis, hypertensive heart disease, IHSS) (See p61 in the 2018 pdf Outline for various LVH criteria; ECG criteria for LVH has very poor sensitivity but high specificity)</td>
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18 year old woman who is pretty sick!
## ECG Analysis

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</table>
| P=100 V=100  | Sinus tachycardia | Normal SA, AV, IV | • P_{II, V2} ≥ 2.5 mm (arrows)  
• Prominent anterior forces (PAF) with QR pattern in V1  
• ST depression, T wave inversion multiple leads | Abnormal ECG:  
1. Right atrial enlargement (RAE)  
2. RVH with strain pattern  
3. Heart rate (tachycardia)  
(This is a patient with primary pulmonary hypertension; severe right heart disease)  
(See p64 in the 2018 pdf Outline for various RVH criteria) |
| PR=180       |             |             |           |                 |
| QRS=80       |             |             |           |                 |
| QT=330       |             |             |           |                 |
| Axis= +130   |             |             |           |                 |
35 year old woman admitted for acute alcohol intoxication

What else went wrong?
Measurements: | Rhythm (s): | Conduction: | Waveform: | Interpretation:
--- | --- | --- | --- | ---
A=105 V=105 | Sinus tachycardia | Normal SA, AV, IV | - P, QRS, T in lead I are all inverted (this is a clue!)
- Minimal signal in lead II (this is clue!)
- Poor R wave progression (can be a normal variant in women) | Abnormal ECG:
1. Lead reversal error (RA and LA)
2. Lead error (RA and right foot)
3. Heart rate (tachycardia)

Note: lead errors are common (the most common is RA / LA reversal; RA / right leg reversal gives no signal in lead II; why is that?...answer: lead II becomes right leg vs. left leg (i.e., no potential difference).
Oh, oh..... What to do?
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<tbody>
<tr>
<td>A=110</td>
<td>V=110</td>
<td>Normal SA, AV, IV</td>
<td>Much artifact (but you can still recognize aspects of the ECG waveform (see lead III))</td>
<td>Artifact precludes accurate ECG interpretation; sinus tachycardia is present. Artifact in this case is from a patient with Parkinson's disease (skeletal muscle).</td>
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<td>PR=140</td>
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<td>QRS=70</td>
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<td>QT=300</td>
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<td>Axis=?</td>
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