Interpreting ECGs
David Winchester, MD MS
Assistant Professor of Medicine
Division of Cardiovascular Medicine

History of the ECG
- Invented by Einthoven in 1887
- Nobel Prize in 1924
- Einthoven’s triangle
I: RA(-) to LA(+)
II: RA(-) to LL(+)
III: LA(-) to LL(+)
aVR: [LA & LL(-)] to RA(+)
aVL: [RA & LL(-)] to LA (+)
aVF: [RA & LA(-)] to LL (+)

[Limb leads] (-) to Precordial leads (+)
Normal conduction

Normal Conduction
Why do we need to know this?
Steps in interpretations

- Right patient, right time, clinical setting
- Correct leads, gain, and speed
- Rate
- Rhythm
- Axis
- Heart Block, Waves & Intervals: PR, QRS, QT
- Ischemic changes: Q waves, ST-T Changes
- Other Patterns: LVH, delta waves, low voltage, pericarditis, R progression, etc.
Correct leads, gain, speed

Lead switch
Incorrect gain

Rate

• Multiply the # of QRS on the tracing by 6 to estimate the rate
What’s the rate?

Rhythm

- Sinus:
  - Normal P axis (upright in lead II)
  - P for each Q and Q for each P

- “Irregularly irregular”
  - Atrial fib, PVCs, PACs, 2° AVB Mobitz 2, Multifocal Atrial Tach

- “Regularly irregular”
  - Bigeminy, Trigeminy, 2° AVB Mobitz 1
**Rhythm**

- **Tachy at 150 bpm**
  - Atrial flutter
- **No or abnormal P waves**
  - AVnRT, Junctional rhythm, ectopic atrial rhythm
- **Ventricular rhythm**
  - VT, VF
- **Pacing: atrial, ventricular, both**

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**Sinus Arrhythmia**
Atrial fibrillation

Ventricular Tachycardia
Ventricular pacing

Axis

- Up in I, up in aVF = normal axis
  - Lead II is tie breaker
- Find most isoelectric lead
  - Lead at 90° with + deflection is axis

Normal Axis

Left Axis

Right Axis
Left axis deviation

Heart Block, Waves & Intervals

- **Heart Block**
  - 1st, 2nd, and 3rd degree
- **P waves**
  - Best seen in lead II (upright), may be inverted in V1/V2
  - If wide (0.12 sec) = LAE (P mitrale)
  - If tall (> 2.5 mm) = RAE (P pulmonale)
- **PR interval**
  - Duration < 0.2 seconds
Heart block, Waves & Intervals

- Q waves
  - > 1 box deep and wide, > 25% of QRS usually significant
- QRS complex
  - Duration < .120 sec
- QT (not 100% agreed upon)
  - < ½ RR interval
  - < 460 (men) or < 480 (women)
- U wave
  - Not usually seen: hypokalemia, hypothermia

1st degree AVB

- PR interval > 0.2 seconds
2nd degree AVB Mobitz 1

- Mobitz 1 progressive PR lengthening

2nd degree AVB, Mobitz 2

- Dropped beats
3rd degree AVB (complete)

- More P's than Q's, no relationship

RBBB

- QRS > 120 msec, rR' in V1, S in I and V6
LBBB

- QRS > 120 msec, Q in V1, S in V6

Ischemic changes

- ST segments
  - Should be flat and < 1 mm above/below baseline
- T waves
  - Often inverted in V1, may be inverted in V2
  - Always upright in leads I, II, V3-V6
  - Always inverted aVL
Localization of ischemia

ST elevation

- Concave usually benign
- Convex usually not
- J point is transition from QRS to ST
- Usually measured 0.08 sec after J point
Early repolarization

Inferior MI
Inferior MI

- J point: 0.08 sec
- 3 mm elevation

Other patterns and findings

- R wave progression
  - R > S by V4

- LVH, multiple criteria
  - R in aVL > 11 mm
  - R in aVL + S in V3
    - >24 mm men
    - >20 mm women
  - S in V1 + R in V5 or V6 > 35 mm
Other patterns

- Pumonary embolus
  - “S1, Q3,T3”
- Electrolyte abnormalities
  - HypoK: U waves, T flattening
  - HyperK: peaked T, QRS widening, “sine wave”
- Wolf Parkinson White
  - Delta wave and short PR interval
- PVCs and PACs

LVH with “strain”
Hyperkalemia

- Peaked T waves

Pulmonary embolus

- S1, Q3, T3 (most specific)
- Sinus tachycardia (most sensitive)