Introduction To
ECG Interpretation
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- I have no financial relationships with companies that make:
  - ECG or EKG equipment
  - ECG or EKG paper
  - ECG or EKG electrodes
  - ECG or EKG Calipers
  - ECG or EKG skin preps
  - Treadmills & bicycle ergometers
  - Single malt scotch
1905: “In the beginning...”

Photograph of a Complete Electrocardiograph, showing the manner in which the electrodes are attached to the patient, in this case the hands and one foot being immersed in jars of salt solution.
It began with only 3 leads........
...and evolved to 12 leads
Is this the future?
INTRODUCTION TO ECG INTERPRETATION
V10.0 (2017-2018)

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Dedicated To:

Dr. Alan Lindsay:
A Teacher of Substance and Style

INTRODUCTION
This document is dedicated to the memory of Alan E. Lindsay, MD (1923-1987) master teacher of electrocardiography, friend, mentor, and colleague. Many of the excellent ECG tracings illustrated in this learning program are from Dr. Lindsay's personal collection of ECG treasures. For many years these ECG's have been used in the training of medical students, nurses, house staff physicians, cardiology fellows, and practicing physicians in Salt Lake City, Utah as well as at many regional and national medical meetings.

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Objectives

• Understand the 3-dimensional aspects of the 12-lead ECG

• Approach to 12-lead ECG interpretation
  • The 5-Step Method

• Characteristics of “normal” ECG
  • Introduction to abnormalities

• Review technical problems
Critical Technical Issues

- Patient Position
- Electrode sites
  - Limbs (distal to shoulders and hips)
  - Chest positions
- Skin preparation (cleaning and gentle abrasion)
- Noise elimination
Correct lead placement is important!!
Recommendations

“Periodic retraining in proper lead positioning of the precordial leads should be routine for all personnel who are responsible for the recording of ECGs. Serial tracings in acute or subacute care settings should make use of some form of skin marking to promote reproducibility of lead placement when it is not possible to leave properly applied electrodes in place.”
Precordial lead placement problems

• Superior V1-2 (2\textsuperscript{nd} or 3\textsuperscript{rd} IS):
  - Poor R-progression (\textquestionmark Anterior MI)
  - rSr’ waves (\textquestionmark Incomplete RBBB)

• Inferior V5-6 (6\textsuperscript{th} IS or lower)
  - Miss the voltage criteria of LVH
  - Poor R-progression (\textquestionmark Anterior MI)

• Accounts for much of the voltage differences in serial (day-to-day) ECG recordings

• What to do about women with large-breasts ???
  - Under the breast ? (better voltage definitions)
    ◦ But may be in an incorrect intercostal space
    ◦ Current recommendation is \textbf{under} the breast
Each of the 12 ECG leads (more or less) indicates direction of electrical activity in 3-Dimensional space (i.e., 6 words)

Superior

Posterior

X: Right vs. Left

Y: Superior vs. Inferior

Z: Anterior vs. Posterior

Right

-180°

Left

(Lead I)

0°

X: axis of X from 0° to ± 180°;

right to left

Anterior

Vertical lead: superior (head) to inferior (foot)
All 12 Leads have a ‘+’ pole

Superior

Think:

6 Directions
In 3-D Space!

Right

Inferior

Superior

Left

Anterior

Posterior

Think:

6 Directions
In 3-D Space!

Remember:

↑: voltage towards ‘+’
↓: voltage away from ‘+’
THINK SPATIAL 3-D ORIENTATION !!
12-Leads ⇒ 3 Orthogonal Directions

- **Right ↔ Left direction (X)**
  - Lead I is the perfect lead
  - aVR, aVL, V5, V6 are imperfect

- **Superior ↔ Inferior direction (Y)**
  - aVF is the perfect lead
  - II, III are imperfect

- **Anterior ↔ Posterior direction (Z)**
  - V1, V2 are fairly perfect
  - V3, V4 are imperfect
Question

If lead II looks like this, what is the average direction of the QRS?

a. Mostly **inferior**
b. Mostly **superior**
c. Mostly **leftward**
d. Mostly **rightward**

And the answer is: _________
Question

If lead II looks like this, what is the average direction of the QRS?

a. Mostly inferior
b. Mostly superior
c. Mostly leftward
d. Mostly rightward

And the answer is: _______ ‘b’
Question

• If lead V1 looks like this, what is the average direction of the QRS?
  
  a. Mostly inferior
  b. Mostly superior
  c. Mostly posterior
  d. Mostly anterior

And the answer is: ____________
Question

If lead V1 looks like this, what is the average direction of the QRS?

a. Mostly inferior
b. Mostly superior
c. Mostly posterior
d. Mostly anterior

And the answer is: _____‘C’_______
Anatomy of the 12-Lead ECG

32 y.o. healthy man (ECG #1)
32 y.o. healthy man (ECG #2)

- Vent. Rate: 53 bpm
- PR interval: 128 ms
- QRS duration: 96 ms
- QT/QTc: 408/382 ms
- P-R-T axes: 171/110/150
- P duration: 90 ms
- RR interval: 1184 ms

*** Suspect arm lead reversal, interpretation assumes no reversal
Unusual P axis, possible ectopic atrial bradycardia
Lateral infarct, age undetermined
Abnormal ECG
RA / LA Arm Reversal
(aVF stays the same)
32 y.o. healthy man  (ECG #3)

QRS Axis -10°
QRS Axis $+69^\circ$

LA / LL Reversal
(aVR stays the same)
(both ECG’s look normal)
Here’s a question about lead placement errors

A 12-lead ECG shows almost a flat line in lead II. What is the most likely cause

a. Right arm and left arm electrodes are reversed
b. Right arm and left leg electrodes are reversed
c. Right arm and right leg electrodes are reversed
d. Left arm and right leg electrodes are reversed

And you answer is: __________
Here’s a question about lead placement errors

A 12-lead ECG shows almost a flat line in lead II. What is the most likely cause

a. Right arm and left arm electrodes are reversed
b. Right arm and left leg electrodes are reversed
c. Right arm and right leg electrodes are reversed
d. Left arm and right leg electrodes are reversed

And you answer is: ‘c’
32 y.o. healthy man (ECG #4)

- Vent. Rate: 54 bpm
- PR interval: 122 ms
- QRS duration: 100 ms
- QT/QTc: 410/388 ms
- P-R-T axes: -21/144/18
- P duration: 82 ms
- RR interval: 1116 ms
Lead II: RA - LL

Lead II: RL – LL
(no voltage difference)

RA / RL Reversal
32 y.o. healthy man

(ECG #5)

Precordial Leads

(what’s wrong?)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vent. Rate</td>
<td>54 bpm</td>
<td>Sinus bradycardia</td>
</tr>
<tr>
<td>PR interval</td>
<td>132 ms</td>
<td>Cannot rule out Anterior infarct, age undetermined</td>
</tr>
<tr>
<td>QRS duration</td>
<td>100 ms</td>
<td>Abnormal ECG</td>
</tr>
<tr>
<td>QT/QTc</td>
<td>406/385 ms</td>
<td></td>
</tr>
<tr>
<td>P-R-T axes</td>
<td>18/71/28</td>
<td></td>
</tr>
<tr>
<td>P duration</td>
<td>94 ms</td>
<td></td>
</tr>
<tr>
<td>RR interval</td>
<td>1094 ms</td>
<td></td>
</tr>
</tbody>
</table>
V1 / V3 Reversal

ECG #1

ECG #5

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vent. Rate</td>
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<tr>
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<td>18/7/18</td>
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<tr>
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<td>94 ms</td>
<td></td>
</tr>
<tr>
<td>RR interval</td>
<td>1094 ms</td>
<td></td>
</tr>
</tbody>
</table>
And finally, what’s wrong with this ECG?

a. Wandering baseline
b. Electrical noise artifact
c. High placement of V1 and V2 electrodes
d. All of the above
And finally, what’s wrong with this ECG?

a. Wandering baseline
b. Electrical noise artifact
c. High placement of V1 and V2 electrodes
d. All of the above

Answer: ‘d’
A 5-Step Method of ECG Interpretation (12-lead ECG)

• 1. Measurements (Heart Rates, PR, QRS, QT, Axis)
• 2. Rhythm Analysis
  - Basic Rhythm
  - Additional Rhythms
• 3. Conduction Analysis
  - SA, AV, IV Conduction
• 4. Waveform Analysis
  - P, QRS, ST-T, U
• 5. Interpretation
  - Normal
  - Borderline
  - Abnormal

Step ‘5B’: Any change from previous ECG?
Why a “Method”

• Provides an organized, consistent approach to every ECG

• Make sense of complicated patterns

• Ensure getting everything right

• Prevent missing “minor” abnormalities
  - In the presence of “major” findings

• Builds confidence and competence
Welcome to the “5-Step Method”

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Rhythm (s):</th>
<th>Conduction:</th>
<th>Waveform:</th>
<th>Interpretation:</th>
</tr>
</thead>
<tbody>
<tr>
<td>A=</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>V=</td>
<td></td>
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<tr>
<td>PR=</td>
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<tr>
<td>QRS=</td>
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<tr>
<td>QT=</td>
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<tr>
<td>Axis=</td>
<td></td>
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</tbody>
</table>

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)
Standard Grid and Paper Speed

The paper runs at a constant velocity of 25 mm/second.
Heart Rates: Count the boxes (between P waves and QRS’s)

Atrial Rate: 3 boxes = 100 bpm
Ventricular Rate: ~ 6 boxes = ~50 bpm

3rd degree AV Block
• The atrial rate is approximately?
  a. 80 bpm
  b. 60 bpm
  c. 110 bpm
  d. Too variable to tell

• The ventricular rate is approximately?
  a. 80 bpm
  b. 30 bpm
  c. 50 bpm
  d. Too variable to tell
- The atrial rate is approximately?
  a. 80 bpm
  b. 60 bpm
  c. 110 bpm
  d. Too variable to tell

- The ventricular rate is approximately?
  a. 80 bpm
  b. 30 bpm
  c. 50 bpm
  d. Too variable to tell
• Which of the following is a **true** statement?
  a. The ECG shows 2:1 AV block
  b. The ECG shows normal sinus rhythm
  c. The ECG shows right bundle branch block
  d. The ECG shows type I 2\textsuperscript{nd} degree AV Block (Wenckebach)

And the answer is: ______________
• Which of the following is a true statement?
  a. The ECG shows 2:1 AV block
  b. The ECG shows normal sinus rhythm
  c. The ECG shows right bundle branch block
  d. The ECG shows type I 2nd degree AV Block (Wenckebach)

And the answer is: ____________

Complete interpretation:
1. Normal sinus rhythm
2. Complete (3rd degree AV block)
3. Junctional escape rhythm with complete AV dissociation
Anything > ~200 ms is 1st degree AV Block

Dr. ANDRÉS RICARDO PÉREZ RIERA
1st Degree AV Block
(PR Interval too long)

PR = 360 ms (9 x 40 ms)
WPW-Preexcitation
(PR Interval too short)

PR = 90 ms

Delta-wave
WPW

ACCESSORY CONNECTION (shortcut)

SINUS NODE
LEFT ATRIUM
ATRIOVENTRICULAR NODE
RIGHT ATRIUM
LEFT VENTRICLE
RIGHT VENTRICLE

P WAVE
DELTA WAVE
FUSION
QRS DURATION OR INTERVAL
FACTORS THAT INFLUENCE ON QRS DURATION

A) Age
- From 0 to 5 years: up to 80 ms (as maximal value);
- From 5 to 14 years: 40 to 90ms;
- Teenagers after 14 years old and adults: 60 to 100 ms (2% present QRS >100 ms).

B) Gender
- Men have 5 to 8 ms longer than QRS.

C) Heart rate
- Inversely proportional.

D) Race
- Tendency to be shorter in black race.
QRS = 80 ms

QRS = 160 ms

QRS = 150 ms

QRS = 140 ms
Wide QRS Complex Duration (≥110 ms)

- Supraventricular rhythms
  - Bundle branch blocks (≥120 ms)
  - Some fascicular blocks (LAFB, LPFB)
  - WPW preexcitation
  - Nonspecific IVCD’s (generalized conduction slowing)
    - Electrolyte disorders (e.g., hyperkalemia)
    - Drugs that slow conduction (e.g., flecainide)

- Ventricular rhythms (QRS ≥120 ms)
  - Ventricular tachycardia
  - Ventricular pacemaker rhythm
  - Idioventricular escape and accelerated ventricular rhythms
  - PVC’s
Bazett’s formula

\[ QTc = \frac{\text{measured QT}}{\sqrt{RR}} \]

**QT upper limits:**
- HR 90: 360ms
- HR 80: 380ms
- **HR 70:** 400ms
- HR 60: 420ms
- HR 50: 440ms
- etc…

(poor man’s guide)

\[ QTc: 350 – 460 \text{ ms} \]
The QT Interval is the distance between the QRS onset and T wave end

- What is the significance of a prolonged QTc interval?
  a. Increased incidence of atrial fibrillation
  b. Increased incidence of ventricular tachycardia and sudden cardiac death
  c. Increased incidence of 3rd degree AV block
  d. Increased incidence of AV nodal supraventricular tachycardia

And you answer is: __________
The QT Interval is the distance between the QRS onset and T wave end.

What is the significance of a prolonged QTc interval?

a. Increased incidence of atrial fibrillation
b. Increased incidence of ventricular tachycardia and sudden cardiac death
c. Increased incidence of 3rd degree AV block
d. Increased incidence of AV nodal supraventricular tachycardia

And you answer is: ‘b’
..tell you something on the ‘QT’
(What prolongs the QT…and how ?)

- **Acquired QT prolongation**
  - Many drugs (e.g., erythromycin, flecainide, sotolol)
  - Electrolyte abnormalities
    - $\downarrow K^+$, $\downarrow Mg^{++}$, $\downarrow Ca^{++}$
  - Autonomic nervous system imbalance (CNS)
    - E.g. subarachnoid hemorrhage, head trauma
  - Myocardial diseases (e.g., ischemic, cardiomyopathy)

- **Hereditary Long QT Syndrome (LQTS)**
  - At least 7 genotypes have been described
    - Important cause of sudden cardiac death in children and young adults
Hereditary Long QT Syndrome

F, age 15

~600 ms
FEM, 6 Y.O., CONGENITAL LONG QT - QT: 670 ms

- TdP
- ALTERNATING T WAVE
- VF

Dr. ANDRÉS RICARDO PÉREZ RIERA
The “QRS Axis” is the average direction of ventricular depolarization (QRS) in the frontal plane.

Normal: -30° to +90°
Sequential vectors of ventricular depolarization: Average vector = QRS axis
Frontal Plane QRS Axis
(it’s all about the average direction of the QRS)

• Normal axis (adult): -30° to +90°
  - Lead I and II are both positive (up-going)
• Left axis deviation (LAD): >-30° to -90°
  - Lead I (positive), Lead II (negative)
    ◦ Left anterior fascicular block (LAFB)
    ◦ Some cases of left ventricular hypertrophy (LVH)
    ◦ Some cases of inferior MI (extra deep Q-waves in II, III, aVF)
    ◦ Chronic pulmonary disease
• Right axis deviation (RAD): >+90° to +180°
  - Lead I (negative), Lead II (positive)
    ◦ Right heart disease (e.g., pulmonary hypertension)
    ◦ Left posterior fascicular block (LPFB)
• Bizarre axis (-90° to ±180°)
  - Lead I (negative), Lead II (negative)
    ◦ Lead placement error (most common cause)
    ◦ Rare cases of myocardial infarction, etc…
a) look for an isoelectric lead (not always found)
b) find the 2 perpendiculars (choose one)
a) look for an isoelectric lead (not always found)
b) find the 2 perpendicularly (choose one)
Left Anterior Fascicular Block (LAFB)
(a very common cause of LAD)

Note: the anterior division is more ‘superior’ in the LV
If lead I is (+) and lead II is (-):
Must have **left axis deviation**

**LAFB in the frontal plane**

“rS” complex II, III, aVF (superior)

**AXIS = -60°**

Note: -60° is directed **superior**!
If lead I is (-) and lead II is (+): Must have **right axis deviation**

**AXIS ~ +130°**
Right Axis Deviation (RAD):

Isoelectric
The normal range for the QRS Axis is -30° to +90°

Which of the following reflects a QRS axis in the normal range?

a. Lead I (positive) and Lead II (negative)
b. Lead I (positive) and Lead II (positive)
c. Lead II (negative) and Lead aVR (positive)
d. Lead I (negative) and Lead II (positive)

And your answer is: ___________
The normal range for the QRS Axis is -30° to +90°

Which of the following reflects a QRS axis in the normal range?

a. Lead I (positive) and Lead II (negative)
b. Lead I (positive) and Lead II (positive)
c. Lead II (negative) and Lead aVR (positive)
d. Lead I (negative) and Lead II (positive)

And your answer is: ‘b’
The normal range for the QRS Axis is -30° to +90°

If the patient’s frontal plane QRS Axis is -60° (LAD), which of the following is seen?

a. Lead aVL (positive) and Lead I (negative)
b. Lead I (positive) and Lead II (positive)
c. Lead I (positive) and Lead aVR (isoelectric)
d. Lead I (negative) and Lead aVR (isoelectric)

And your answer is: __________
The normal range for the QRS Axis is \(-30^\circ\) to \(+90^\circ\)

If the patient’s frontal plane QRS Axis is \(-60^\circ\) (LAD), which of the following is seen?

a. Lead aVL (positive) and Lead I (negative)
b. Lead I (positive) and Lead II (positive)
c. Lead I (positive) and Lead aVR (isoelectric)
d. Lead I (negative) and Lead aVR (isoelectric)

And your answer is: ___‘C’____
A 5-Step Method of ECG Interpretation (12-lead ECG)

- Measurements (Heart Rates, PR, QRS, QT, Axis)
- Rhythm Analysis
  - Basic Rhythm
  - Additional Rhythms
- Conduction Analysis
  - SA, AV, IV Conduction
- Waveform Analysis
  - P, QRS, ST-T, U
- Interpretation
  - Normal
  - Borderline
  - Abnormal
How To Think About Rhythms And Conduction Disturbances

Rhythms
- Site of origin: (Sinus, Atria, AV Junction, Ventricles)
- Rate: (Normal, Fast, Slow)
- Regularity: (Regular, Irregular)
- Onset: (Passive escape, active)

Sinus node
Atria
AV Junction: (A-V, V-A)
Ventricular:

Conduction
- Antegrade
- Retrograde

Electrical Activity

1° Mobitz I
2° Mobitz II
3°

RBBB
LBBB

Anterior fascicular block
Posterior fascicular block
Septal fascicular block
<table>
<thead>
<tr>
<th>Site of Origin</th>
<th>Single Events</th>
<th>Slow Rates (&lt;50 bpm)</th>
<th>Intermediate Rates (50-99 bpm)</th>
<th>Fast Rates (≥100 bpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sinus</td>
<td></td>
<td>Sinus bradycardia</td>
<td>Normal sinus rhythm</td>
<td>Sinus tachycardia</td>
</tr>
<tr>
<td>Atria</td>
<td>PAC’s</td>
<td>Ectopic atrial bradycardia (unusual)</td>
<td>Ectopic atrial rhythm, Atrial fibrillation, Atrial flutter (e.g., 4:1 block)</td>
<td>Paroxysmal SVT, Atrial fibrillation, Atrial flutter (2:1 block), Ectopic atrial tachycardia, Multifocal atrial tachycardia (MAT)</td>
</tr>
<tr>
<td>Ventricles (Wide QRS)</td>
<td>PVC’s V-escape beats</td>
<td>V- escape rhythm (~35-50 bpm) aka: ‘Idioventricular Rhythm’</td>
<td>Accelerated V- rhythm (~50-99 bpm)</td>
<td>Ventricular tachycardia, Torsade de points, Ventricular fibrillation</td>
</tr>
</tbody>
</table>

Now let's continue with some real rhythms.............
Step 2: What’s the rhythm(s)?

- **Sinus rhythms**
  - Normal Sinus (60-99 bpm)
  - Sinus bradycardia (<60 bpm)
  - Sinus tachycardia (≥100 bpm)

- **Supraventricular rhythms** (atrial & junctional)
  - PAC’s, PJC’s
  - A-fib, A-flutter, PSVT, MAT, atrial tachycardia, etc.

- **Ventricular rhythms**
  - PVC’s, V-tachy, V-fib, escape and accelerated ventricular rhythms, artificial pacemaker rhythms
Normal Sinus Rhythm
- ~60 to 99 bpm
- P wave before every QRS (although not necessary)
- P must be (+) upright in lead I, II, aVF
This is **Not** Normal Sinus Rhythm

- Negative P waves in II, III, aVF…consider:
  - Ectopic atrial pacemaker (P before QRS)
  - Junctional pacemaker (P usually after QRS)

F, Age 27
This is **Still** Sinus Rhythm

- Actually it’s **sinus tachycardia** (105 bpm)
- But there is also 2\(^{nd}\) degree AV block (some P waves conduct, some do not)

This is Sinus Rhythm **and** a Junctional Escape Rhythm

- Because it is 3\(^{rd}\) degree AV block (complete AV dissociation)
Step 3: How’s the conduction?

- 3 general *locations* of heart block
  - Between SA node and right atrium (SA ‘exit' block)
  - Between atria and ventricles (AV block)
    - includes the AV node and His bundle
  - Within the ventricles (bundles and fascicular blocks)

- 3 *degrees* of heart block (in each location)
  - 1st degree (always conducts, but takes longer)
  - 2nd degree (sometimes conduct, sometimes not)
  - 3rd degree (never conducts)
<table>
<thead>
<tr>
<th>Three Degrees</th>
<th>Sino-Atrial</th>
<th>AV Junction: (AV Node, His Bundle)</th>
<th>Intraventricular</th>
</tr>
</thead>
<tbody>
<tr>
<td>First (1°)</td>
<td>?</td>
<td>1° AV Block (PR &gt;200 ms)</td>
<td>Incomplete RBBB</td>
</tr>
<tr>
<td>Always conducts, but slower</td>
<td></td>
<td></td>
<td>Incomplete LBBB</td>
</tr>
<tr>
<td>Second (2°)</td>
<td>2° SA Block</td>
<td>2° AV Block Type I (Wenckebach) Type II (Mobitz)</td>
<td>Type II (Mobitz)</td>
</tr>
<tr>
<td>Sometimes conducts, sometimes doesn’t</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Third (3°)</td>
<td>?</td>
<td>3° AV Block</td>
<td></td>
</tr>
<tr>
<td>Never conducts</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- RBBB
- LBBB
- LAFB
- LPFB
- LSFB
- Bi- & Tri-fascicular Blocks
- Bilateral BBB
SA, ‘AV’, and IV Blocks
Three Locations and Three Degrees
Step 3: Conduction Analysis

• Sino-atrial (SA) ‘exit’ block
  - Can only recognize 2\textsuperscript{nd} degree SA block
    ◦ See intermittent failure of sinus ‘P’ to appear (unexpected pause)

• AV block
  - 1\textsuperscript{st} degree: PR > 200 ms (all P’s conduct)
  - 2\textsuperscript{nd} degree: some P’s conduct, some do not
    ◦ Type I (Wenckebach) – increasing PR, then no QRS (AV node)
    ◦ Type II (Mobitz) – fixed and normal PR; then no QRS (HIS)
  - 3\textsuperscript{rd} degree: must have an escape pacemaker

• IV block
  - Fascicular blocks (LAFB, LPFB, LSFB)
  - Bundle branch blocks (RBBB, LBBB)
  - Bi- and Tri-fascicular blocks
• The QRS complex (V1) illustrates which of the following?
  a. LBBB
  b. RBBB
  c. RVH
  d. LVH

• The AV conduction abnormality is:
  a. 2<sup>nd</sup> degree AV block (type I)
  b. 2<sup>nd</sup> degree AV block (type II)
  c. 3<sup>rd</sup> degree AV block
  d. Incomplete AV dissociation
• The QRS complex (V1) illustrates which of the following?
  a. LBBB  
  b. RBBB  
  c. RVH  
  d. LVH

• The AV conduction abnormality is:
  a. 2\textsuperscript{nd} degree AV block (type I)  
  b. 2\textsuperscript{nd} degree AV block (type II)  
  c. 3\textsuperscript{rd} degree AV block  
  d. Incomplete AV dissociation
2nd Degree SA Block

- Note: the red arrows are only in my imagination
  - we don’t see where the sinus fires on the ECG
  - we only see the result (i.e., the P wave)
- P-wave doesn’t appear when it is expected
  - see only an unexpected pause in rhythm
- Consider other causes of an unexpected pause
  - nonconducted PAC (most common cause)
  - marked sinus arrhythmia
- SA block occurs in ‘sick sinus syndrome’
  - Usually means patient needs artificial pacemaker
2° AVB: Two types and Two Locations

2nd Degree AV Block (Mobitz Type I, aka Wenckebach)

2nd Degree AV Block (Type II, aka Mobitz) with RBBB

2nd Degree AV Block (Type II, aka Mobitz) with LBBB
2nd Degree AV Block Type I (1899)

Karl Wenckebach 1864-1940
3rd degree AVB

- No atrial events (P waves) enter the ventricles

- Always see complete AV dissociation
  - Note: AV dissociation may occur for reasons other than complete AV block

- Location of block
  - AV node (usually see regular narrow and slow QRS rhythm: *J-escape rhythm*)
  - Bilateral BBB (always have regular wide and slow QRS rhythm: *V-escape rhythm*)

- Need to identify both rhythms:
  - Atrial rhythm; e.g., NSR, a-fib, a-flutter, etc.
  - Ventricular rhythm; e.g., **J-escape rhythm** (~45-55 bpm), **ventricular escape rhythm** (~35-50 bpm, AKA idioventricular rhythm)
  - Ventricular rate is *almost always* slower than the atrial rate!

- Ventricular rhythm (J-escapes or V-escapes) **must be regular**!
  - Early appearing QRS’s are usually “captures” from atria
    - Therefore it is not 3rd degree AVB
Note: Complete AV dissociation (3rd degree AV block)

Note: Complete AV dissociation (3rd degree AV block)

Note: incomplete AV dissociation with 2 sinus captures (not 3rd degree)
QRS starts in the LV and ends in the RV
QRS starts in the RV and ends in the LV
LBBB

Posterior

RBBB

Anterior

Right
Classic RBBB

- Note late rightward and anterior QRS forces
- Note normal frontal plane QRS axis
- Incidental finding: PVC (at end)
RBBB + LAFB

- Note late rightward and anterior QRS forces
- Left Axis Deviation (LAD): -75°
- $S_{III} > S_{II}$
- Small q-wave in I and aVL
RBBB + LPFB

- Note late rightward and anterior QRS forces
- Right Axis Deviation (RAD): + 135°
- Small q-waves in II, III, aVF
Classic LBBB

- Note late posterior and leftward QRS forces
- Note monophasic R in leads I, aVL, V6
Step 4: Let’s look at all the waves

- P wave morphology
  - RAE, LAE
  - Ectopic origin or retrograde P waves
- QRS morphology
  - RVH, LVH
  - Changes related to myocardial infarction
  - Bundle branch morphologies, WPW, etc.
- ST, T, and U wave morphology
  - Ischemic and injury changes
  - Drug, electrolyte, and other effects
Step 4: Let’s look at all the waves
.....beginning with P-waves
P Waves:

Normal: DI, V1
- > 120 ms
- > 1.5 mm

LAE: DI, V1
- > 2.5 mm

RAE: DI, V1
- > 2.5 mm

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.....next all the QRS’s

- Up (positive) in leads I and II (normal axis)?
- Any ‘pathologic’ Q-waves?
- Precordial R-wave progression?
- Voltage criteria for RVH or LVH?
- Miscellaneous stuff (e.g., delta waves) etc.
Q-waves of old inferior wall MI
…finally, look at ST, T, and U waves
..any leads with ST depression or elevation?
..any leads with T wave inversion?
..any abnormal prominent U waves?
Step 5: Final Interpretation

- Is it a normal ECG?
- Is it abnormal?
  - List final diagnoses
- Is it “borderline”?
  - Why.....

Abnormal ECG (e.g.)
1. Atrial fibrillation w rapid HR
2. Old inferior MI
3. Left ventricular hypertrophy

(Step 5B: Compare to previous ECG)

- Have there been any changes?
  - No change
  - Improved: how?
  - Worse: why?
Thank You!

Staying up to date

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