Normal Impulse Conduction

Sinoatrial node
↓
AV node
↓
Bundle of His
↓
Bundle Branches
↓
Purkinje fibers
The “PQRST”

- **P wave** - Atrial depolarization
- **QRS** - Ventricular depolarization
- **T wave** - Ventricular repolarization
The PR Interval

Atrial depolarization + delay in AV junction (AV node/Bundle of His)

(design allows time for the atria to contract before the ventricles contract)
Pacemakers of the Heart

- **SA Node** - Dominant pacemaker with an intrinsic rate of 60 - 100 beats/minute.

- **AV Node** - Back-up pacemaker with an intrinsic rate of 40 - 60 beats/minute.

- **Ventricular cells** - Back-up pacemaker with an intrinsic rate of 20 - 45 bpm.
The ECG Paper

• Horizontally
  – One small box - 0.04 s
  – One large box - 0.20 s

• Vertically
  – One large box - 0.5 mV
• Every 3 seconds (15 large boxes) is marked by a vertical line.
• This helps when calculating the heart rate.

**NOTE:** the following strips are not marked but all are 6 seconds long.
Rhythm Analysis

- Step 1: Calculate rate.
- Step 2: Determine regularity.
- Step 3: Assess the P waves.
- Step 4: Determine PR interval.
- Step 5: Determine QRS duration.
Step 1: Calculate Rate

• Option 2
  – Find a R wave that lands on a bold line.
  – Count the # of large boxes to the next R wave. If the second R wave is 1 large box away the rate is 300, 2 boxes - 150, 3 boxes - 100, 4 boxes - 75, etc. (cont)
Step 2: Determine regularity

Look at the R-R distances (using a caliper or markings on a pen or paper).

Regular (are they equidistant apart)? Occasionally irregular? Regularly irregular? Irregularly irregular?

Interpretation? Regular
Step 3: Assess the P waves

- Are there P waves?
- Do the P waves all look alike?
- Do the P waves occur at a regular rate?
- Is there one P wave before each QRS?

Interpretation? *Normal P waves with 1 P wave for every QRS*
Step 4: Determine PR interval

• Normal: 0.12 - 0.20 seconds.
   (3 - 5 boxes)

Interpretation? 0.12 seconds
Step 5: QRS duration

- **Normal:** 0.04 - 0.12 seconds. 
  (1 - 3 boxes)

**Interpretation?** 0.08 seconds
Rhythm Summary

- Rate: 90-95 bpm
- Regularity: regular
- P waves: normal
- PR interval: 0.12 s
- QRS duration: 0.08 s

Interpretation? *Normal Sinus Rhythm*
Arrhythmias

- Sinus Rhythms
- Premature Beats
- Supraventricular Arrhythmias
- Ventricular Arrhythmias
- AV Junctional Blocks
NSR Parameters

- Rate: 60 - 100 bpm
- Regularity: regular
- P waves: normal
- PR interval: 0.12 - 0.20 s
- QRS duration: 0.04 - 0.12 s

Any deviation from above is sinus tachycardia, sinus bradycardia or an arrhythmia.

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Sinus Rhythms

- **Sinus Bradycardia**
- **Sinus Tachycardia**
Rhythm #2

- Rate? 130 bpm
- Regularity? regular
- P waves? normal
- PR interval? 0.16 s
- QRS duration? 0.08 s

Interpretation? Sinus Tachycardia
Rhythm #1

- Rate? 30 bpm
- Regularity? regular
- P waves? normal
- PR interval? 0.12 s
- QRS duration? 0.10 s

Interpretation? *Sinus Bradycardia*
Premature Beats

• *Premature Atrial Contractions* (PACs)

• *Premature Ventricular Contractions* (PVCs)
Rhythm #3

- Rate? 70 bpm
- Regularity? occasionally irreg.
- P waves? 2/7 different contour
- PR interval? 0.14 s (except 2/7)
- QRS duration? 0.08 s

Interpretation? NSR with Premature Atrial Contractions
Rhythm #4

- Rate? 60 bpm
- Regularity? occasionally irreg.
- P waves? none for 7th QRS
- PR interval? 0.14 s
- QRS duration? 0.08 s (7th wide)

Interpretation? Sinus Rhythm with 1 PVC
Supraventricular Arrhythmias

• *Atrial Fibrillation*

• *Atrial Flutter*

• *Paroxysmal Supraventricular Tachycardia*
Rhythm #5

- Rate?: 100 bpm
- Regularity?: irregularly irregular
- P waves?: none
- PR interval?: none
- QRS duration?: 0.06 s

Interpretation?: Atrial Fibrillation
Rhythm #6

- Rate?: 70 bpm
- Regularity?: regular
- P waves?: flutter waves
- PR interval?: none
- QRS duration?: 0.06 s

Interpretation?: Atrial Flutter
Rhythm #7

- Rate? 74 → 148 bpm
- Regularity? Regular → regular
- P waves? Normal → none
- PR interval? 0.16 s → none
- QRS duration? 0.08 s

Interpretation? *Paroxysmal Supraventricular Tachycardia (PSVT)*
Ventricular Arrhythmias

- Ventricular Tachycardia
- Ventricular Fibrillation
Rhythm #8

- Rate?: 160 bpm
- Regularity?: regular
- P waves?: none
- PR interval?: none
- QRS duration?: wide (> 0.12 sec)

Interpretation?: Ventricular Tachycardia
Rhythm #9

- Rate? none
- Regularity? irregularly irreg.
- P waves? none
- PR interval? none
- QRS duration? wide, if recognizable

Interpretation? Ventricular Fibrillation
AV Nodal Blocks

- 1st Degree AV Block
- 2nd Degree AV Block, Type I
- 2nd Degree AV Block, Type II
- 3rd Degree AV Block
Rhythm #10

- Rate? 60 bpm
- Regularity? regular
- P waves? normal
- PR interval? 0.36 s
- QRS duration? 0.08 s

Interpretation? 1st Degree AV Block
Rhythm #11

- Rate?: 50 bpm
- Regularity?: regularly irregular
- P waves?: nl, but 4th no QRS
- PR interval?: lengthens
- QRS duration?: 0.08 s

Interpretation?: 2nd Degree AV Block, Type I
Rhythm #12

- Rate? 40 bpm
- Regularity? regular
- P waves? nl, 2 of 3 no QRS
- PR interval? 0.14 s
- QRS duration? 0.08 s

Interpretation? 2nd Degree AV Block, Type II
Rhythm #13

- Rate? 40 bpm
- Regularity? regular
- P waves? no relation to QRS
- PR interval? none
- QRS duration? wide (> 0.12 s)

Interpretation? 3rd Degree AV Block
Diagnosing a MI

To diagnose a myocardial infarction you need to go beyond looking at a rhythm strip and obtain a 12-Lead ECG.
ST Elevation Infarction

The ECG changes seen with a ST elevation infarction are:

- **Before injury**: Normal ECG
- **Ischemia**: ST depression, peaked T-waves, then T-wave inversion
- **Infarction**: ST elevation & appearance of Q-waves
- **Fibrosis**: ST segments and T-waves return to normal, but Q-waves persist
ECG Changes

Ways the ECG can change include:

- Appearance of pathologic Q-waves
- T-waves
  - peaked
  - flattened
  - inverted
- ST elevation & depression

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One way to diagnose an acute MI is to look for elevation of the ST segment.
ST Elevation Infarction

Here’s an ECG of an **inferior MI**:

Look at the inferior leads (II, III, aVF).

**Question:** What ECG changes do you see?

ST elevation and Q-waves

**Extra credit:** What is the rhythm?

Atrial fibrillation (irregularly irregular with narrow QRS)!

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Non-ST Elevation Infarction

Here’s an ECG of an evolving non-ST elevation MI:

Note the ST depression and T-wave inversion in leads $V_2$-$V_6$.

**Question:**
What area of the heart is infarcting?

Anterolateral
Bundle Branch Blocks

With Bundle Branch Blocks you will see two changes on the ECG.

1. QRS complex widens (> 0.12 sec).
2. QRS morphology changes (varies depending on ECG lead, and if it is a right vs. left bundle branch block).
Left Ventricular Hypertrophy

Compare these two 12-lead ECGs. What stands out as different with the second one?

Answer: The QRS complexes are very tall (increased voltage)

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