P waves only in V3-6
ST elevation in R-sided leads
ST segment elevation greater in lead III than II
Inferior wall MI
P waves only in V3-6
Biphasic T waves
Right Ventricular MI
Right Ventricular MI Criteria

- Inferior wall MI
- ST segment elevation greater in lead III than II
- ST segment elevation in V₁ (possibly extending to V₆)
- ST depression in V₂ (unless elevation extends, as in #3 above)
- ST depression in V₂ cannot be > half the ST elevation in aVF
- More than 1 mm of ST elevation in the right-sided leads (V₄R to V₆R)
Simple Cellular Electrophysiology

- Cardiac cells, in their resting state, are electrically polarized (negatively charged)
  - Maintained by membrane pumps to ensure appropriate ion distribution (K+, Na+, Cl, Ca+) to keep the inside cell electronegative.
- Cells lose their internal “-” during deplolarization
- Cells restore their resting polarity during repolarization
Electricity and the Heart

- Pacemaker cells
- Electrical conducting cells
- Myocardial cells
- Depolarization
- Repolarization
Pacemaker Cells

- Electrical power source of the heart
- Dominant cells located in “Sinoatrial” (SA) node area of heart
- Able to depolarize over and over
- Fires at rate of 60-100 times per minute
  - Depends on activity of autonomic nervous system
- Each depolarization initiates one complete cardiac cycle (contraction and relaxation)
Electrical Conducting Cells

- Carry current throughout the heart similar to that of an electrical wiring.
Myocardial Cells

- Constitute major part of heart muscle
- Responsible for repeatedly contracting/relaxing forcing blood to rest of body.
- After depolarization, these cells contract $2^0$ to Ca$^{++}$ release
Depolarization

- Considered an advancing wave of + charges within heart myocytes. In turn causes..
- Progressive contraction of myocardium
SA Node

- Heart’s dominant pacemaker
- Ability of SA node to generate pacemaking stimuli is known as automaticity
- Depolarization of atria detected by electrodes
- Noted as “P” wave on EKG
  - should not be more than 1 box wide or 1 box tall
- Understood as “atrial depolarization”
Variations of the P-wave

- Tall, symmetrical, peaked waves seen in increased right atrial pressure (P pulmonale)
- Notched/wide waves seen increased left atrial pressure (P mitrale)
- Biphasic P waves can occur in both R & L atrial dilation. Typically appear in leads $V_1$ & $V_2$
Sinus Rhythm

SA Node
"Sinus Node"
Atrial Contraction

- Depolarization slows within AV node…
- Brief pause occurs
  - Allows blood from atria to pass through AV valves into ventricles
PR Interval

- Measures the time from the start of atrial depolarization to the start of ventricular depolarization.
- Normal interval lasts from 0.12 – 0.2 seconds
Ventricular Depolarization

- Depolarization starts slowly but picks up speed in the Bundle of His…
- Down the bundle branches…
- Depolarization quickly distributed to the myocytes of the ventricles via terminal filaments of Purkinje fibers
- Produces a “QRS” complex on EKG
  - Normal QRS complex is 0.06 – 0.1 seconds
Ventricular Contraction
QRS Complex

• Q-wave: first NEGATIVE (downward) deflection of the QRS complex.
  – Sometimes absent
• R wave: first POSITIVE (UPWARD) wave of the QRS complex
• S wave: any downward wave preceded by an upward wave.
Variations of the QRS Complex
Repolarization

- Occurs after contraction of the myocytes.
- Myocyte interior regain their resting negative charge.
- Recovery phase.
Ventricular Repolarization

- Following QRS complex, segment of horizontal baseline known as the ST Segment
  - Represents initial phase of ventricular repolarization.
  - Usually lasts 0.08 - 0.12 seconds
- T wave: represents final “rapid” phase of repolarization
  - Accomplished by K+ ions leaving myocytes
QT Interval

• Represents the duration of ventricular systole and is measured from the beginning of the QRS until the end of the T-wave.
• Normal QT interval is affected by many factors.
Heart Rate Determined QT

- 115 - 84 bpm: QT 0.30 to 0.37 seconds
- 83 - 72 bpm: QT 0.32 to 0.40 seconds
- 71 - 63 bpm: QT 0.34 to 0.42 seconds
- 62 - 56 bpm: QT 0.36 to 0.43 seconds
- 55 - 45 bpm: QT 0.39 to 0.46 second
Prolonged QT Etiologies

- Familial long QT Syndrome
- Congestive Heart Failure
- Myocardial Infarction
- Hypocalcemia
- Hypomagnesemia
- Type I Antiarrhythmic drugs
- Rheumatic Fever
- Myocarditis
- Congenital Heart Disease

Indicates prolonged ventricular repolarization which means a longer relative refractory period

Watching for this entity is important b/c it can lead to life threatening dysrhythmias such as Torsades de Pointes
Shortened QT Etiologies

- Digoxin (Digitalis)
- Hypercalcemia
- Hyperkalemia
- Phenothiazines
Plateau & Rapid Phases of Repolarization
Complete Cardiac Cycle
U Wave

- The U wave is a medical curiosity.
- It is not clear what relationship it has with cardiac activity but it is thought to represent the repolarization of the His-Purkinje complex.
- Becomes taller in hypokalemia and pts taking Quinidine
- Can flip in CAD.
- Usually follows the direction of the T wave and is best seen in lead V3.
- Due to the weakness of the signal, the U-wave is often not seen on the ECG.
U-Wave
J-Point

• The point at which the QRS meets the ST segment
• The J point is at the end of Ventricular depolarization
• An essential landmark for measuring QRS duration
J-Point
Recording the EKG

- Recorded on ruled (graph) paper
- Smallest divisions are 1 millimeter (mm) long and 1 mm high
- Time
  - Horizontal axis represents time
  - Each small block is .04 seconds
  - Every 5 blocks (between heavy lines) is .2 seconds
EKG Paper
Timing
Isoelectric Line

3 mm high

baseline

2 mm deep
Each ECG lead provides a different view of the heart.
Limb and Chest Leads
Limb Leads
Chest Leads

Diagram showing chest leads V1, V2, V3, V4, V5, V6.
Rhythm Counting

Using the triplets:
Name the lines following the "Start" line.
Finer Rhythm Counting
Finer Rhythm Counting

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