Cardiac Conduction and EKG’s

Ex 31

Conduction System

- The heart has its own intrinsic nervous system which travels in the myocardium just under the endocardium
- Cardiac action potential travels from atria to ventricles in these fibers
- Controls the heart rate
- Conducts impulses quickly through the myocardium so each area contracts essentially at once
- If the myocardium was responsible for propagating the impulse the conduction would be much slower and the heart would not contract uniformly
Conduction System

- Sinoatrial node
  - Located in right atrium inf. to opening of SVC
  - Action potential begins here
  - Initiates atrial contraction
- Atrioventricular node
  - Located in right atrium ant. to opening of coronary sinus
  - Main job is to delay the action potential to give atria time to contract
- Bundle of His (AV bundle)
  - Only site where atrial impulses can travel to the ventricles
- Bundle branches
- Purkinje fibers (not shown)
  - Small branches that travel from endocardium into myocardium

**Review**
- Cardiac action potential is initiated in the SA node
- Travels quickly through pathways to simultaneously contract the atria
  - The atria and ventricles are insulated from each other so atrial action potentials can only enter ventricles through one pathway
- Action potential enters AV node where the impulses are slowed down and held momentarily
  - This gives the atria time to contract
- The action potential then travels quickly to the rest of the ventricular myocardium through the AV bundle, bundle branches and Purkinje fibers
**Rhythmicity**

- The heart has built in pacemakers
  - SA node
    - main pacemaker of the heart
    - intrinsic rate of 60-100 bpm
    - if the SA node becomes diseased other areas pick up pacemaking responsibility
  - sometimes other areas of the atrium will begin pacing known as ectopic foci
  - AV node
    - secondary pacemaker of the heart
    - intrinsic rate of 40-60 bpm
  - Ventricular pacing
    - AV bundle, branches, purkinje fibers
    - 20-40 bpm

**Electrical Flow**

- resting myocardial cells have a net negative charge at rest
- when an AP reaches a cell it depolarizes causing the internal net charge to become positive
- electrically, the action potential traveling through the heart can be viewed as a wave of positive charge
- Vector
  - the average direction of all of the positive charges as they travel through the myocardium
  - the average vector in a normal heart travels to the left and downward
Electrical Flow

- **Vector Influences**
  - things that influence the overall amount of charge flowing through the myocardium will change the average direction the charge is flowing

- **Infarction**
  - essentially an area that no longer carries charge
  - what would happen to the vector if the posterior wall of the L. ventricle infarcted?

- **Hypertrophy**
  - essentially an area that carries extra charge
  - how would the vector change with L. ventricular hypertrophy?
  - vector points towards hypertrophy and away from infarction
Electrocardiogram

- You can measure the electric flow of the heart through skin sensors placed on the arms and legs.
- For simplicity we will look only at lead I for now.
- Lead I goes from left arm to right arm.
- Left lead is +.
- Right lead is –.
- Depolarization towards the positive lead causes upward deflection.
- Depolarization towards the negative lead causes negative deflection.

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Electrocardiogram

- EKG paper travels under the pen at 25mm/second.
- Horizontal squares every 1mm:
  - 1mm = 0.04 seconds
  - 5mm = 0.2 seconds
- 5 big boxes/sec.
- Vertical squares every 1mm:
  - 1mm = 0.1 mV
  - 5mm = 0.5 mV

- Keep in mind that the waves on the EKG only measure electrical activity in the heart and that contraction of myocardium delays the waves by a few milliseconds.
Electrocardiogram

The Waves

○ P wave
  - atrial depolarization
  - duration 0.11s
  - amplitude < 3mm
  - detects atrial function
  - SA node

○ QRS Complex
  - ventricular depolarization
  - duration 0.10s
  - detects ventricular function
  - Q wave
    - first downward stroke
  - R wave
    - first upward stroke
  - S wave
    - any downward stroke preceded by an upward stroke

○ T wave
  - ventricular repolarization
**Intervals and Segments**

- **PR segment**
  - End of P wave to start of QRS
  - Measures time of depolarization through AV node

- **PR interval**
  - Start of P wave to start of QRS
  - Measures time from start of SA conduction to end of AV node conduction
  - Normal 0.12-0.20s

- **ST segment**
  - End of QRS complex to start of T wave
  - Measures start of ventricular repolarization
  - Elevated in MI’s

- **ST interval**
  - End of QRS to end of T wave
  - Represents complete time of ventricular repolarization

- **QT interval**
  - Start of QRS to end of T wave
  - Duration of ventricular systole
  - Less than 1/2 of the RR interval
Intervals and Segments

- Intervals
  - The timing for depolarizations/repolarizations can be interpreted from the EKG
  - P-R 0.12-0.2 sec
    - Measures the time between the start of atrial depolarization and the start of ventricular depolarization
    - A long P-Q interval is a sign of AV node dysfunction
  - QT Interval, about 0.4 sec
    - Start of QRS to end of T wave
  - QRS 0.08-0.1 sec
    - Wider with ventricular dysfunction
  - ST segment (don’t worry about time)
    - Elevated with acute MI

Electrocardiogram

- The waves
  - More on the QRS
  - Note that the Q or the R or the S wave is not always present
  - Name according to direction of first deflection, second, etc
  - Q waves are often absent

- Lead V1
  - No Q
  - Small R
  - Large S

- Lead V2
  - No Q
  - Large R
  - Small S
Heart Rate

- Heart Rate
  - defined as beats per minute
  - easy way to estimate rate
  - find an R wave on a thick line
  - count off on the thick lines
    - 300, 150, 100, 75, 60, 50
    - until you reach another R wave

- in our example the middle R wave falls on the dark line
- the next R falls just before the 75, so estimate about 80 bpm

Normal Sinus Rhythm
- heart rate between 60-100 bpm
- pacing by SA node
- QRS after every P wave
- rhythm is regular

Sinus Tachycardia
- heart rate > 100 bpm
- p wave is there but hidden by the T wave
- regular QRS rhythm

Sinus Bradycardia
- heart rate < 60 bpm
- QRS after every P wave
- regular rhythm
ST segment elevation
- ischemia

Q wave
- in some leads may indicate ischemia and necrosis

T wave inversion
- late sign of necrosis and fibrosis

Wave Abnormalities

Atrial Fibrillation
- multifocal areas in atria firing
- no p waves and irregular heart rate

Rhythm Abnormalities
Rhythm Abnormalities

- Complete (3rd degree) AV Block
  - AV node cannot conduct impulse
  - P waves and QRS not connected
  - Irregular heart rate

- Premature Ventricular Contractions
  - Ventricles pace early
  - Early heart beat
  - Large QRS
Rhythm Abnormalities

- Ventricular Tachycardia
  - rapid ventricular pacing
    - rapid, regular rate
    - wide QRS

- Ventricular Fibrillation
  - multifocal ventricular beats
  - irregular
  - won’t last long
Axis

- QRS AXIS
- another name for the vector of depolarization
- an axis is measured in degrees
- the axis is measured by adding the positive deflection and subtracting the negative deflection
- overall + is left axis direction
- overall - is right axis direction
- for lead one most of the QRS is positive, therefore it has a leftward axis
- if an MI caused the QRS to be mostly negative the lead would have a rightward axis

For lead II:
- positive on left leg
- negative on right arm
- looking at the tracing we see that the QRS is mostly positive
- what does this mean?
QRS AXIS
lead III
- positive on left leg
- negative on left arm
looking at the tracing we see that the QRS is mostly positive
- what does this mean?

Axis
-90
- lead III
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- negative on left arm
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Blood Vessel Histology

- **Arteries**
  - Usually round and thick walled
  - Three layers
  - Tunica intima
    - Simple squamous epithelium
    - Internal elastic lamina
  - Tunica media
    - Smooth muscle cells
    - Elastic tissue
  - Tunica externa (adventitia)
    - Areolar or fibrous connective tissue

- **Veins**
  - Irregular, thin-walled
  - Three layers (but thinner!)
  - Tunica intima
    - Simple squamous epithelium
    - Internal elastic lamina
  - Tunica media
    - Smooth muscle cells
    - Elastic tissue
  - Tunica externa (adventitia)
    - Areolar or fibrous connective tissue
  - Valves seen in extremities
    - Shown at black arrows
Blood Vessel Histology

- capillaries
- simple squamous epithelium
- often can see single file RBC's