Matters of the Heart: Comprehensive Cardiology

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Who am I?
Class Outline

- Gross anatomy of the heart
- Trip around the heart
- Micro anatomy: cellular and tissue level
- Introduction to electrophysiology
- ECG interpretation
What is the heart?

- Organ and a muscle
  - Size of your fist
- Pump
- Circulates blood: oxygen, nutrients, metabolic waste products
Where is the heart?

- Chest - mediastinum
- Protected by the ribs and the spine
- Pleural Cavity - heart and lungs
  - Pleural sac - pleural fluid
Position of the heart

- Base of the heart = portion of the heart closest to your head
  - Wider, in the centre of your chest underneath your sternum/ “breast bone”
- Apex of the heart = portion of the heart closest to your toes
  - Between the 4th & 5th rib on the left side
- Pericardium - heart’s own fluid filled sac
A look inside the heart

- Atria (upper chambers)
- Ventricles (lower chambers)
- Divided by the septum
Systole and Diastole

- Different phases of the heart
- Systole = contraction
- Diastole = relaxation

**Figure 12-19**

**Systole:**
- Ventricles contracting

**Diastole:**
- Ventricles relaxed
Valves

Held in place by chordae tendinae aka “heart strings”
Heart Sounds

- Video: https://www.youtube.com/watch?v=FtXNnmifbhE

Heart sound: “Lub-dub, lub-dub”

- Heart sounds are caused by the closing of valves

<table>
<thead>
<tr>
<th>“Lub”</th>
<th>“Dub”</th>
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<tbody>
<tr>
<td>recoil of blood against closed AV valves</td>
<td>recoil of blood against closed semilunar valves</td>
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Heart murmur:
defective valves causing hissing sound when blood squirts backward through valves

Lub-dub with Bill Nye: https://www.youtube.com/watch?v=riDPxasfz_I
Trip around the heart

- RA receives de-oxygenated blood from the vena cava
- Through tricuspid to LV
- From LV, through pulmonic to Pulmonary artery
- From pulmonary artery to lungs
Gas exchange

- Occurs in the lungs and in the tissues
- Cells pick up oxygen in the lungs and deposit it in the tissues
- Gas exchange done at the level of the capillaries
Trip around the heart

- From lungs back to LA
- From LA, through the mitral valve and into the LV
- From the LV, through the aortic valve, into the aorta and through to the rest of the body
The trip around the heart

- Video: https://www.youtube.com/watch?v=oHMmtqKgs50
- Stop @ 1:50
Coronary Arteries

- The heart’s blood supply
- Coronary = “Crown”
- Blood is diffused during diastole
Coronary Arteries

- Branch from the Aorta into left and Right
- Right: Right coronary Artery (RCA)
- Left: Left Main (LM), splits into Left Circumflex (LCX) and the Left Anterior Descending (LAD)
Summary: Parts of the heart/ trip around the heart.
Microanatomy of the heart
**Muscle cells:**

- **Smooth**
- **Skeletal**
- **Cardiac**

<table>
<thead>
<tr>
<th></th>
<th>Smooth</th>
<th>Cardiac</th>
<th>Skeletal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location</strong></td>
<td>Wall of hollow organs, vessels, respiratory passageways</td>
<td>Wall of heart</td>
<td>Attached to bones</td>
</tr>
<tr>
<td><strong>Cell characteristics</strong></td>
<td>Tapered at each end, branching networks, nonstriated</td>
<td>Branching networks; special membranes (intercalated disks) between cells; single nucleus; lightly striated</td>
<td>Long and cylindrical; multinucleated; heavily striated</td>
</tr>
<tr>
<td><strong>Control Action</strong></td>
<td>Involuntary Produces peristalsis; contracts and relaxes slowly; may sustain contraction</td>
<td>Involuntary Pumps blood out of heart; self-excitative but influenced by nervous system and hormones</td>
<td>Voluntary Produces movement at joints; stimulated by nervous system; contracts and relaxes rapidly</td>
</tr>
</tbody>
</table>
Differences in muscle cells

- Single vs Multinucleic
- Striations
- Speed
- Automaticity
The layers of the heart: Pericardium

- Peri= outside
- From the outside in-
- Fibrous pericardium
  - Attached to the diaphragm and the sternum
  - Densely woven connective tissue
- Serous pericardium
  - 2 layers: visceral and parietal
  - Parietal layer makes pericardial fluid
  - Visceral layer aka epicardium
The layers of the heart: epi to endo

- Epicardium: also known as the visceral pericardium
- Myocardium: muscular tissue of the heart
- Endocardium: inner most layer of the heart - inside of the chambers
Assessing the heart
Visual exam

- Cyanosis
- Respiratory condition
- Heaves/ thrills
Assessing by touch

- Temperature
- Pulse
- Capillary Refill
Blood pressure

- Systolic (top number) over Diastolic (bottom number)
- Normal- around 120/80
- Measures the pressure exerted by the heart against the arterial system
- Can be measured non-invasively (sphygmomanometer) or invasively (arterial catheterization)
Auscultation

- Moving the stethoscope to hear different valve locations
- S1: Tricuspid and Mitral Valves
- S2: Aortic and Pulmonic Valves
- Splitting of heart sounds may occur related to stethoscope placement
X-Ray

Normal Sized Heart

Abnormally Large Heart (Cardiomegaly)
Echocardiograph

- Ultrtrasound of the heart
- More descriptive than an Xray
- Better view of heart chambers/ movement
Cardiac MRI

- Most descriptive
- Several “slices” of the heart can be seen
- Good for visualizing more discreet structures
Introduction to electrophysiology
The heart’s electrical route

- **Sinoatrial (SA) Node**: The heart’s pacemaker
  - Intrinsic rate: 60-100 bpm

- **Internodal Pathways**

- **Atrioventricular (AV) Node**: Gate keeper/ back up pacemaker
  - Intrinsic rate: 40-60 bpm

- **Bundle of His**
- **Left and Right Bundle Branches**
- **Purkinje Fibres**
  - Intrinsic rate: 20-40 bpm
How do we measure the heart’s conduction system?

- Non invasive test- ECG
- Gives practitioners important information about several aspects of a patient’s heart-rate, force of conduction, regularity of beats/ arrythmias
- Used to diagnose serious medical conditions such as myocardial infarctions (heart attacks)
The ECG

- Single unit represents a heart beat
- Recorded on grid paper
- Height = amplitude
  - Measured in mVolts
- Length = time
  - Large square represents 0.20 seconds
  - Small square represents 0.04 seconds
Depolarization and Repolarization

- Depolarization = contraction
- Repolarization = relaxation

- Movement captured on the ECG as changes in the waveform from the isoelectric (flat) line
What do the different waves represent?

- **P wave**: atrial depolarization
- **QRS complex**: ventricular depolarization
- **T wave**: ventricular repolarization
Look at a 6 second strip and identify/ determine the following:
1. Are P waves present, upright, and identical?
2. Is there a QRS complex following every P wave?
3. What is the PR interval?
4. How long does the QRS complex last?
5. What is the distance between R’s/ is the rhythm regular?
6. What is the heart rate?
7. INTERPRET THE RHYTHM!
1. P waves

- Represent atrial depolarization
- Normally 0.06 to 0.12 seconds long
- Are p waves present?
- Are they all facing the same direction (upright vs downward)?
- Are they all the same shape?
2. Is there a QRS complex following every P wave?

- SA node as pacemaker vs AV node as pacemaker
- Cannot calculate the PR interval if there’s no QRS
3. PR interval

- Distance from the beginning of the P wave to the beginning of the QRS complex

- Normally, 0.12-0.20 seconds long
4. QRS Complex

- Normal length is 0.06-0.10 seconds
- Same shape/length throughout?
- Too long or too short can lead to problems
5. Regular vs. Irregular

- How far apart are the beats?
- Same distance every time?
- R-R intervals
6. Heart Rate

- 6 second strip: multiply # of beats by 10 for approximate rate
- Normal heart rate = 60-100 bpm
7. Interpret!

- If everything is normal (P, PR, QRS, R-R, rate)= Normal Sinus rhythm
- If any of the above is not true, we must classify the rhythm as something else
Let’s practice
• P's present/ upright/ identical:
• QRS for every P:
• PR interval:
• QRS width
• R-R distance/ regularity
• Rate:
• Interpretation:
- P's present/ upright/ identical:
- QRS for every P:
- PR interval:
- QRS width
- R-R distance/ regularity
- Rate:
- Interpretation:
P's present/ upright/ identical:

QRS for every P:

PR interval:

QRS width

R-R distance/ regularity

Rate:

Interpretation:
All strips Normal Sinus!

- They look different, but are all considered normal, as long as they:
  - Have P waves that are present, identical, and upright
  - Have a QRS complex for every P wave
  - Have a consistent PR interval
  - Have consistent QRS widths
  - Have regular r-R intervals
  - Are 60-100 beats/ minute
Let’s practice some more!
P's present/ upright/ identical:
QRS for every P:
PR interval:
QRS width
R-R distance/ regularity
Rate:
Interpretation:
P's present/ upright/ identical:

QRS for every P:

PR interval:

QRS width

R-R distance/ regularity

Rate:

Interpretation:
P's present/ upright/ identical:

QRS for every P:

PR interval:

QRS width

R-R distance/ regularity

Rate:

Interpretation:
Variations on Normal Sinus Rhythm

- Sinus Bradycardia: < 60bpm
- Sinus Tachycardia: >100bpm
- Sinus Arrhythmia: “regularly irregular”
Sinus Block vs Sinus Arrest

- Block = one missed beat
- Arrest = pause is not ‘regular’
  - Generally longer than a block
Atrial arrhythmias

- Atrial flutter: regularly irregular
- Atrial fibrillation
- Symptoms: shortness of breath, palpitations, feeling faint/tired
- Increased risk of stroke
Heart Blocks

**ECG Basics - Heart Blocks**

**First Degree AV Block**
- Rhythm: Regular
- PR interval: Prolonged >0.20 sec
- P Wave: Normal
- QRS: <0.11 sec

**Second Degree AV Block - Type 1 (aka Mobitz I, Wenkebach):**
- P-R intervals become progressively longer until one P wave is blocked, and a QRS is dropped.
- Rhythm: Increasingly prolonged
- PR interval: Irregular
- P Wave: Normal
- QRS: <0.11

**Second Degree AV Block - Mobitz Type 2**
- Common ratio 2:1, 3:1, or 4:1
- P waves are not related to the QRS complexes
- Rhythm: Irregular
- PR interval: Normal (more P waves then QRS)
- P Wave: Normal
- QRS: Usually wide >0.10

**3rd Degree AV Block**
- Rhythm: Regular
- PR interval: None
- P Wave: Normal does not relate to QRS
- QRS: Normal or wide

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**The Heart Block Poem**

by the Princeton Surgical Group & nurseslabs

If the R is far from P, then you have a **FIRST DEGREE**.

Longer, longer, longer, drop! Then you have a **WENKEBACH**.

If some P's don't get through, then you have a **MOBITZ II**.

If P's and Q's don't agree, then you have a **THIRD DEGREE**.
Deadly arrhythmias: VT and VF

- Ventricular tachycardia: wide complex QRS
  - Fast but regular
  - Person may still have a pulse
- Ventricular fibrillation
  - Fast and irregular
  - No pulse
  - Lethal
Pulseless Electrical Activity and Asystole

- Person is considered to be clinically dead
- No pulse for either rhythm
Next week:

- Cardiac conditions and pharmacology Part 1