Cardiovascular system I.
Terminology, ECG basics, heart sounds
Components of cardiovascular system

• Blood
  – Liquid medium that is responsible for transport

• Heart
  – Pump that creates pressure

• Blood vessels
  – Distribution cannals/pipes of various lumen
Heart characteristics

- **Inotropy**
  - Ability of heart to contract

- **Batmotropy**
  - Ability of heart to get excited

- **Dromotropy**
  - Ability of heart to conduct impulse

- **Chronotropy**
  - Ability of heart to create impulses

- **Luzitropy**
  - Ability of heart to relax
Neurohormonal components that affect CVS

- **Autonomous nervous system**
  - sympatheticus
    - $\forall \uparrow$ heart frequency
    - $\forall \uparrow$ heart contraction
    - sympathetic neurons
    - noradrenaline
  - parasympathicus
    - Slows down heart frequency
    - nervus vagus
    - acetylcholine

- **Renin-angiotensin-aldosteron (RAAS)**

- **Endotelin**

- **Natriuretic peptides**

- **Nitric oxide (NO)**
**Phases of ventricular action potential**

**Phase 4:** The sodium-potassium (Na⁺/K⁺-ATPase) pump maintains the resting membrane potential.

**Phase 0:** Fast sodium channels open to allow an influx; depolarization of the cell membrane occurs and is represented by the QRS complex on ECG.

**Phase 1:** Sodium channels close and potassium efflux channels open, polarizing the cell and allowing voltage-gated calcium channels to open.

**Phase 2:** Calcium-channel activation permits calcium influx and a sustained myocardial contraction.

**Phase 3:** With persistent potassium efflux, calcium channels close to facilitate the repolarization of myocardial cells, which restores their resting potential, an action that corresponds with the QT interval on ECG.
Heart cycle

1/3 systole
2/3 diastole

80% ventricle filling is passive
20% is active by atrium contraction

3. Ventricular systole.
   - Both ventricles contract simultaneously.
   - The AV valves close.
   - The semilunar valves open and blood enters the pulmonary trunk and aorta.

4. Atrial and ventricular diastole.
   - Atria and ventricles are relaxed.
   - Atria and ventricles fill passively.
   - AV valves are open, semilunar valves are closed.

2. Atrial systole.
   - The semilunar valves are closed and the AV valves are open.
   - Both atria contract, forcing blood into the ventricles.
Heart sounds

- Contraction = systole
- Relaxation = diastole

- Heart sounds
  - systole – lub
  - diastole – dub
  - above aorta d t d t d t
Heart sounds

• 1.sound
  – Beginning of the systole
  – Systolic sound
  – Closing of the mitral and tricuspidal valve, when the pressure is increased in left ventricle after atrium relaxiation
  – Speed of pressure rise in left ventricle togehter with anatomical composition of valves is responsible for loudness of the sound
  – Louder sound
    • Mitral stenosis
  – Weaker sound
    • Fibrosis,calcifications
  – Split of 1st sound
    • Asynchronne contraction of ventricles when left or right Tawar branch is blocked.
Heart sounds

• 2. sound
  – Closing of semilunar aortal and pulmonar valve
  – Two components
    • Pulmonar
    • Aortal
  – Split of 2nd sound
    • enhanced in inspirium
Heart sounds

- **S1** – beginning of ventricle contraction
- **S2** – closing of semilunar valves
- **S3** – 3. sound – rapid ending of ventricle expansion during the diastole beginning
- **S4** – 4. sound – atrium systole and subsequent beginning of ventricle expansion
- **Gallop**
  - three phase rhythm, that sounds like horse gallop
  - combination of tachycardia and 3rd and 4 sound
Heart murmurs

- Heart murmur is abnormal extra sound during heart cycle; this sound is created by turbulent blood flow through the heart, and its valves.
Examples

- normal
- Split S2
- Systolic click
  - dr t  dr t
- Mitral stenosis
  - d tr  d tr
- Aortal insufficiency
- Aortal stenosis
Electrocardiogram

- PR interval: 0.12 – 0.20 sec
- QRS duration: 0.08 – 0.10 sec
- QT interval: 0.4 – 0.43 sec
- RR interval: 0.6 – 1.0 sec
ECG

- **P wave/PQ interval**
  - Depolarization of atria/including AV and His bundle

- **PQ segment**
  - Depolarization of AV node and His bundle

- **QRS**
  - Depolarization of ventricles

- **ST segment**
  - Repolarization of ventricles

- **Repolarization of atria?**
  - Hidden in QRS complex
Conduit times

- PQ/PR interval – atrium depolarisation
  - 0.12 – 0.20 s

- QRS complex – depolarization of ventricles
  - ≤ 0.12 sec

- QT interval - ≤ 0.36 sec
  - $QT_c = (QT/\sqrt{RR}) = <0.44$ sec
Leads of a 12-lead ECG

- **Bipolar**
  - I, II, III

- **Unipolar**
  - Augmented limb leads
    - aVR, aVL, aVF
  - Chest/precordial leads
    - V1, V2, V3, V4, V5, V6
    - V can be also C

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*a = augmented, V = voltage, R = right hand, L = left hand, F = foot
Electrical axis

- **Lead Axis** is the imaginary straight line connecting the two electrodes is called AXIS of the lead.

- Given by the sum of vectors of electrical potentials at the given time.
Limb Lead Diagram

Std I

Std II

Std III
Electrical axis

- Lead I & aVF are +ve = normotype
- Lead I & aVF are -ve = os v NW zone
- Lead I -ve & aVF are +ve = rightward axis
- Lead I +ve & aVF are -ve
  - Lead II is important

- Lead II +ve = normotype
- Lead II -ve = leftward axis
ECG amplitudes and electrodes

- The reference point is electrode
- If the depolarization wave is moving towards electrode, the amplitude is positive
- If the depolarization wave is moving away from electrode, the amplitude is negative
ECG amplitudes and electrodes

- If the electrode is in the middle of the electrical axis, the amplitude is biphasic (positive and negative)
Electrocardiogram - description

1. Rhythm
   - sinus, non-sinus – atrial fibrillation?, AV junction?, malign rhythm?
2. Action
   - regular, irregular
3. Frequency
4. Electrical axis
   - rightward, leftward, normal
5. Conduction times PQ, QRS, QT
6. Deformities of P, QRS
   - mitral P, biphasic P, QRS deformities – rSR config., delta wave
7. Transition zones in precordial leads
8. ST segment
   - isoelectric, depression and elevation
9. T wave
   - positive, negative, flattened, peak
**ECG description**

1. Heart rate  
   (slow-normal-fast)
2. Rhythm  
   (regular-irregular)
3. QRS width  
   (narrow-broad)
4. ST segment  
   (elevation, depression)

**ECG description for surgeons**

- **Upward peaks**  
  - Everything OK
- **Downward peaks**  
  - Call intern
- **No peaks**  
  - Call anaesthesiologist
- **Now?**  
  - Is it longer?
  - Call morgue
25mm/s, so Rate = $\frac{300}{4} = 75$ bpm
Practical tasks

• Auscultation of heart sounds (p. 127)

• Examination of arterial pulse (p. 141)

• Experiments on the isolated heart muscle (p. 136)