

# **Cardiovascular system I**

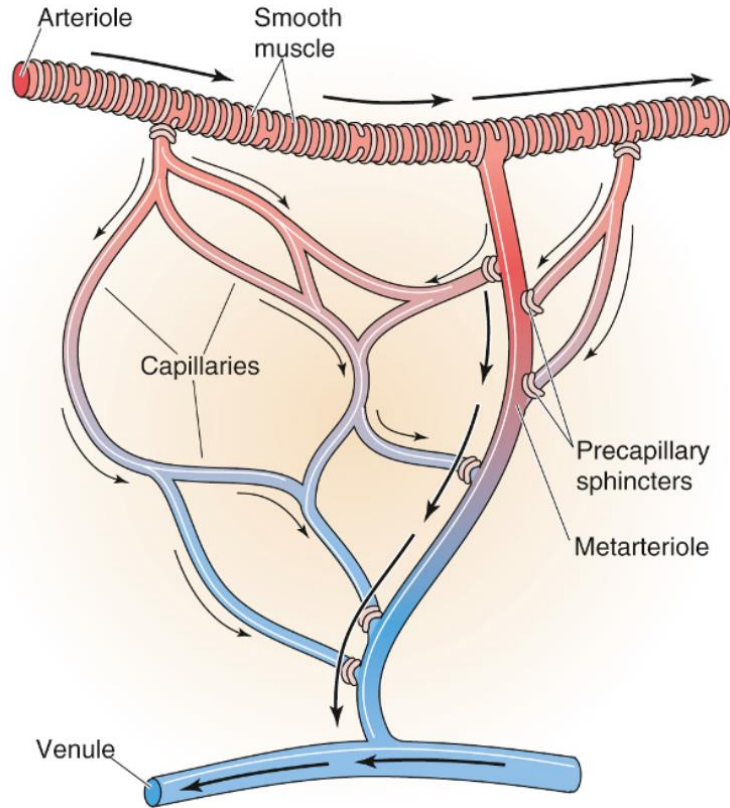
**Organization of cardiovascular system. Blood. Arteries and veins. Microcirculation. Cardiac electrophysiology and ECG. Heart rate.**

**Heart sounds. Polygraphic record.**

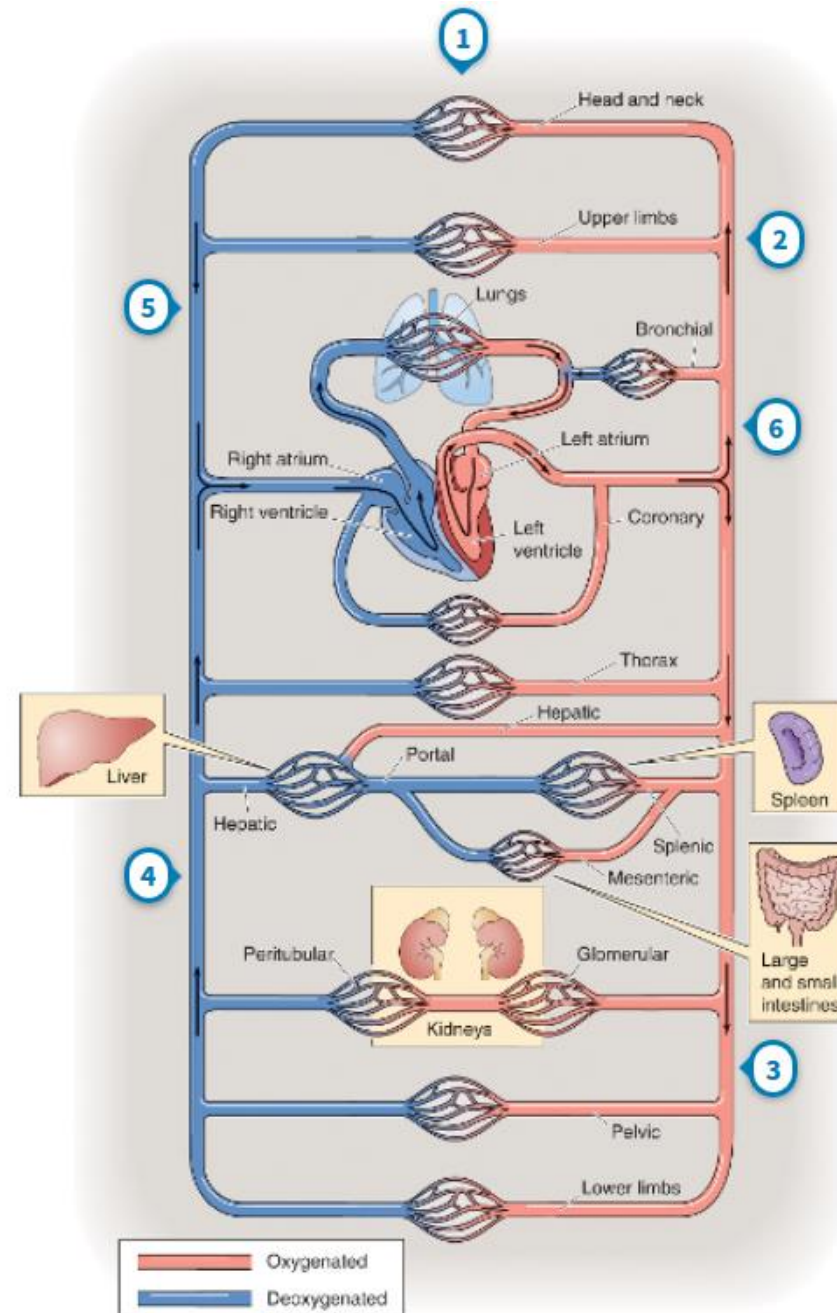
Compendium of Physiology – autumn 2022

Tibor Stračina

# Organization of CVS



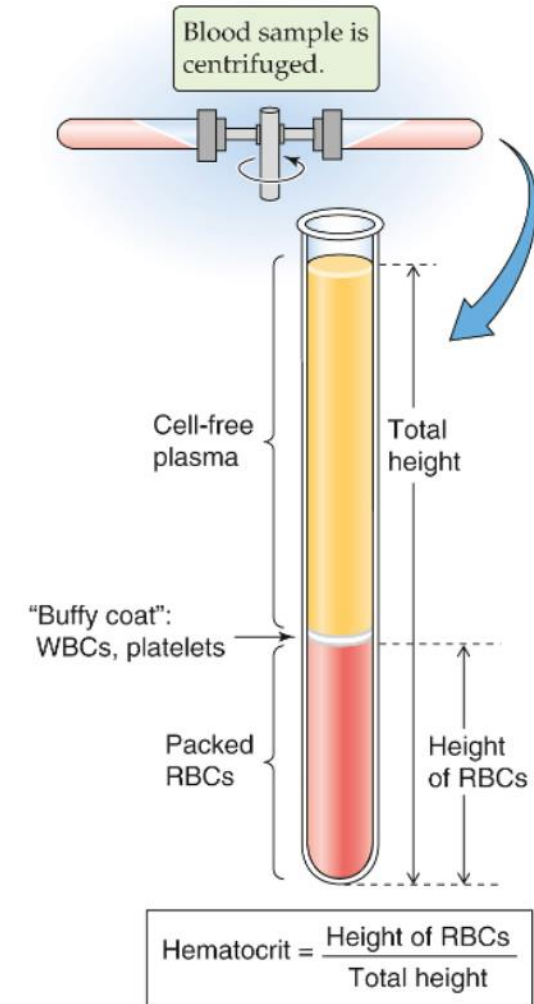
<https://studentconsult.inkling.com/read/boron-medical-physiology-3e/chapter-20/figure-20-1>



<https://studentconsult.inkling.com/read/boron-medical-physiology-3e/chapter-17/figure-17-3>

# Blood

- Blood plasma
  - Water
  - Ions
  - Proteins
  - Urea, glucose, etc.
- Erythrocytes
- Leukocytes
- Platelets



<https://studentconsult.inkling.com/read/boron-medical-physiology-3e/chapter-18/figure-18-1>

# Red blood cells. Haemolysis

- Erythropoiesis
- Life span
- Degradation
- Function
  - Transport (O<sub>2</sub>, CO<sub>2</sub>)
  - Buffer (hemoglobin)

## Haemolysis

- Physical
  - Mechanical
  - Osmotic
  - Thermic
- Chemical
- Biological
  - Immune response

# Blood groups. AB0 system

- Surface antigens on the RBCs
- AB0 system
  - The highest immunoactivity
  - 2 surface antigens (A, B), co-dominance
  - 4 blood groups: A, B, AB, 0
  - Antibodies constantly produced
- Other systems: Rh, MNS, P, Kell, Lewis, Duffy, Diego

# ABO system – slide method

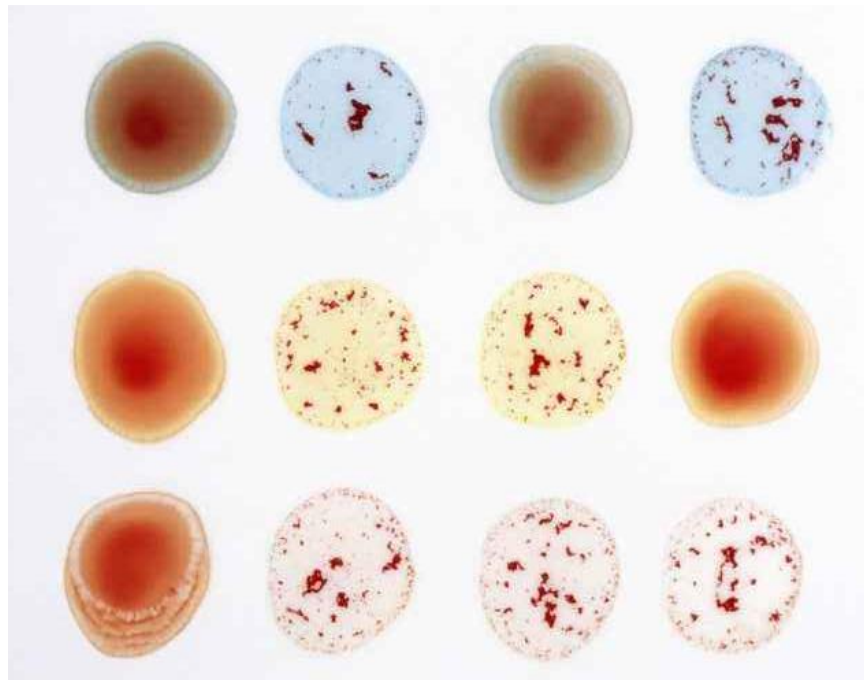
Serum (antibodies)

Anti-A

Anti-B

Anti-A + Anti-B

Blood group



**O**

**AB**

**B**

**A**

Legend:

Negative reaction

Positive reaction



# Rh system and other systems

- Rh system
- Antigen D
- Anti-D antibodies
- Rh incompatibility (Rh- mother vs. Rh+ fetus)

# Arteries: blood pressure, R, blood flow

- Systemic arteries – high-pressure system
  - Elastic arteries (low resistance, high compliance)
  - Resistance arteries (high and regulable resistance)
- Pulmonary arteries – low-pressure system



# Veins: blood pressure, R, blood flow. Venous return. Venostasis.

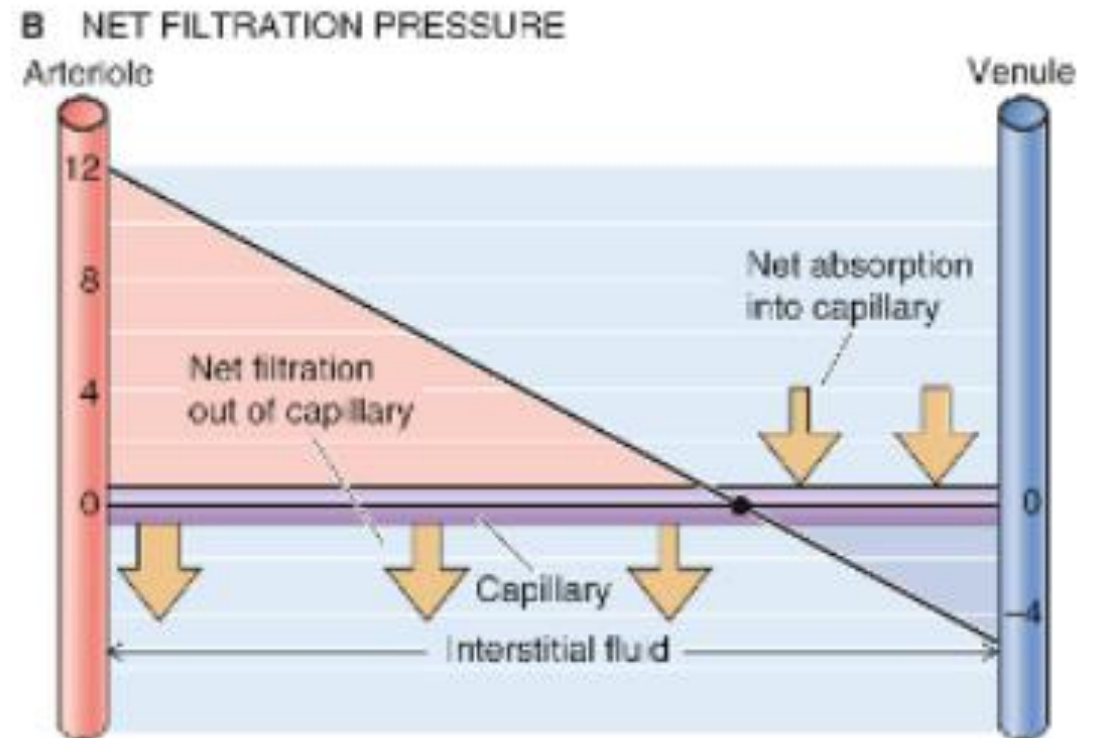
- High capacity - volume reserve
- Low pressure gradient
- Mechanisms of venous return
  - Muscle pump
  - Valves
  - Blood flow (pressure) through capillaries – *vis a tergo* = force from behind
  - Suction force of ventricular systole – *vis a fronte* = force from the front
  - Suction force of inspiration

# Microcirculation

## – Net filtration pressure

### (Starling forces)

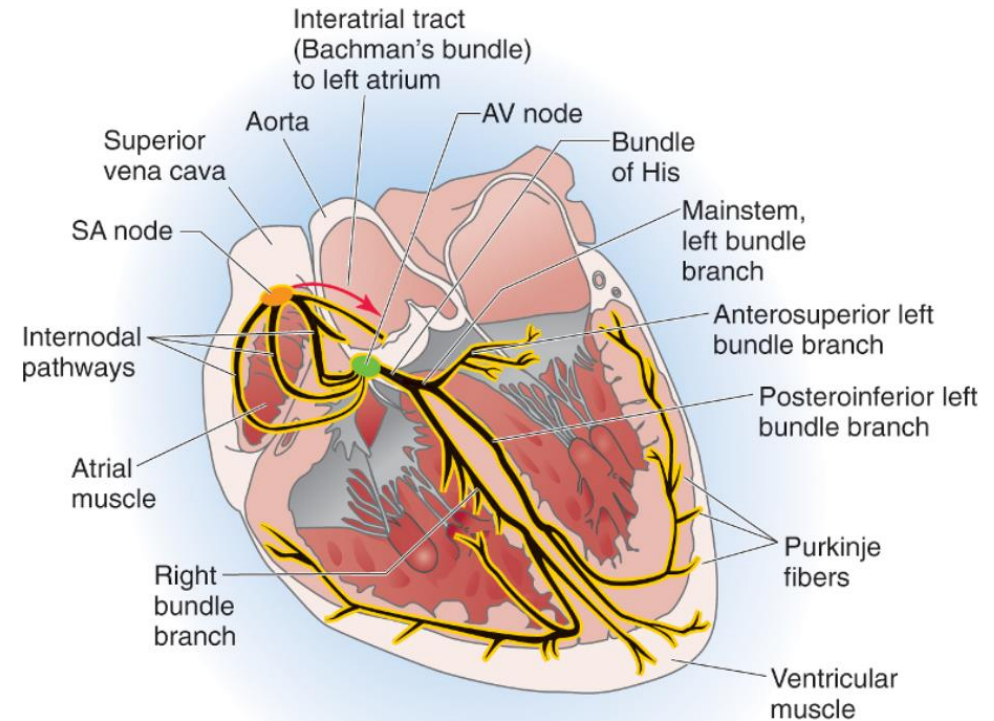
- Hydrostatic (blood) pressure in capillary
- Hydrostatic pressure in interstitium
- Osmotic pressure in capillary
- Osmotic pressure in interstitium



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# Heart. Cardiac muscle as an excitable tissue

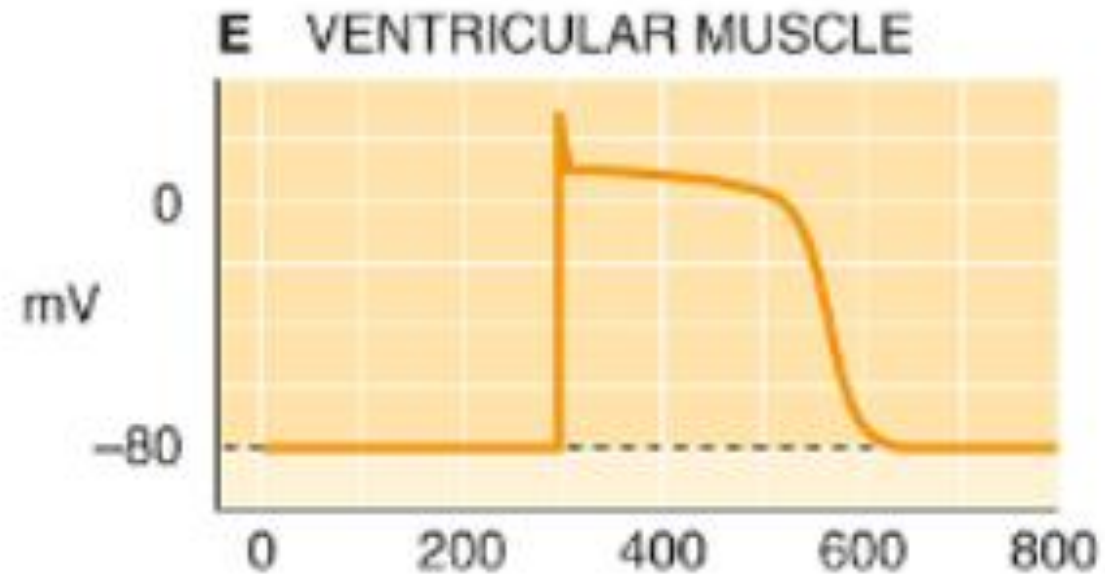
## – Excitability



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## – *Task: Draw AP of working ventricular cardiomyocyte.*

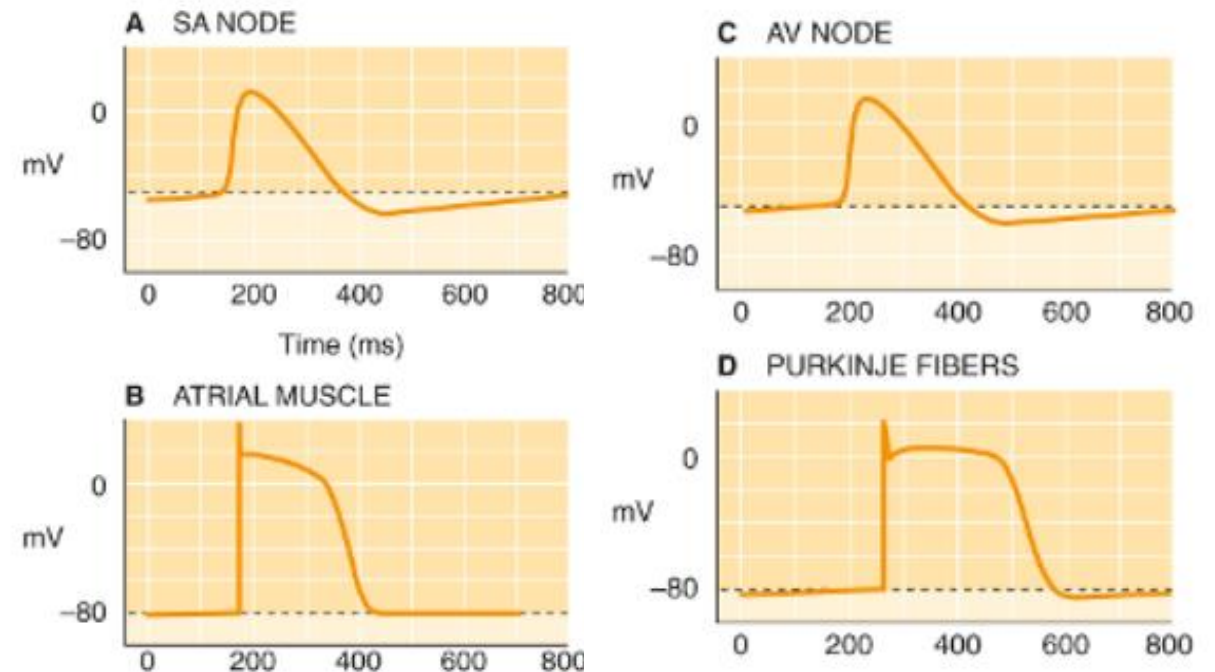
# Action potential: Ventricular muscle cells



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# Cardiac automaticity. Conductive system

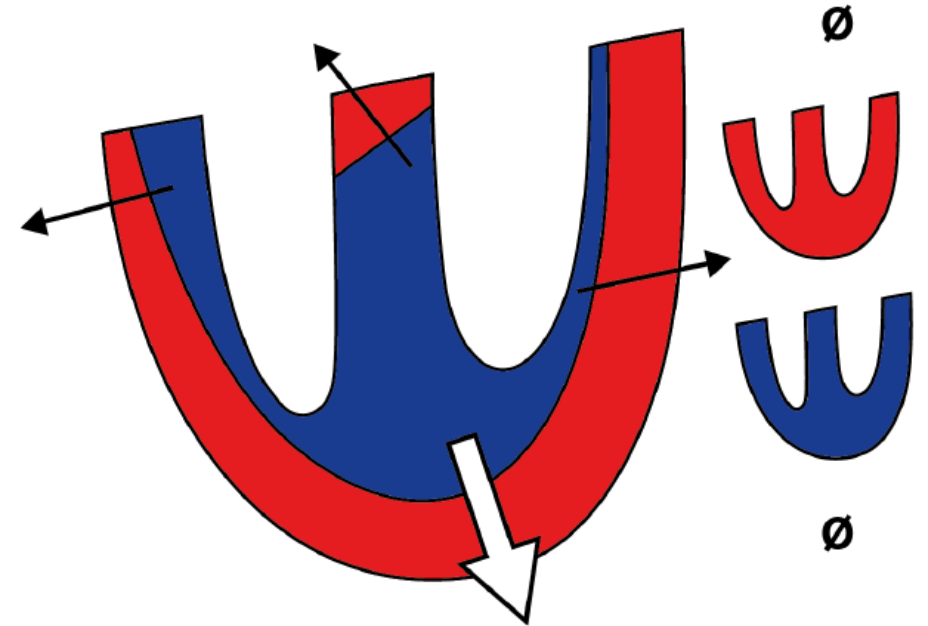
- Pacemaker activity
  - SA node >> AV node >> Purkinje fibres
- Conductive system
  - Fast conduction
  - Delay (AV-His)



<https://studentconsult.inkling.com/read/boron-medical-physiology-3e/chapter-21/figure-21-2>

# Electric vector of the heart. ECG

- Potential differences
- Summary of all partial vectors
- Changes in time



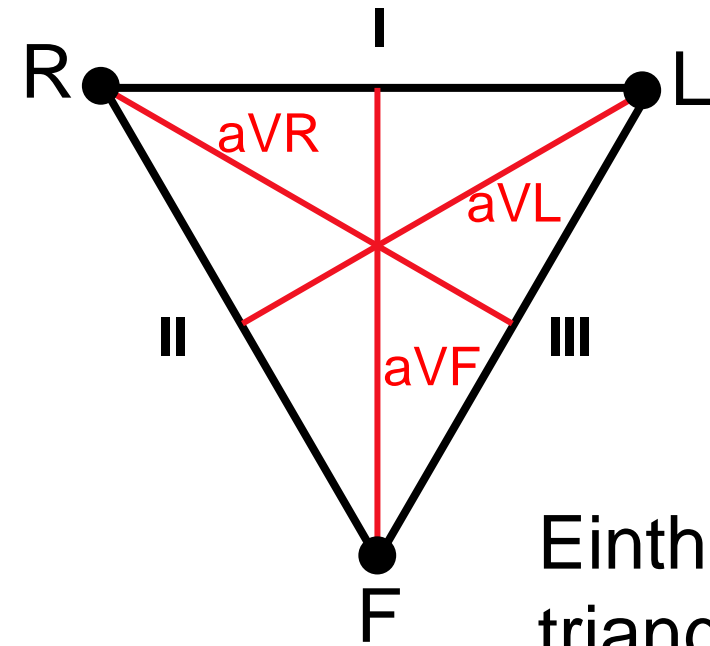
Author: MN; <https://is.muni.cz/auth/el/med/jaro2020/aVLFY0422p/um/ECG-2020-GM.pdf>

# ECG electrodes. ECG leads

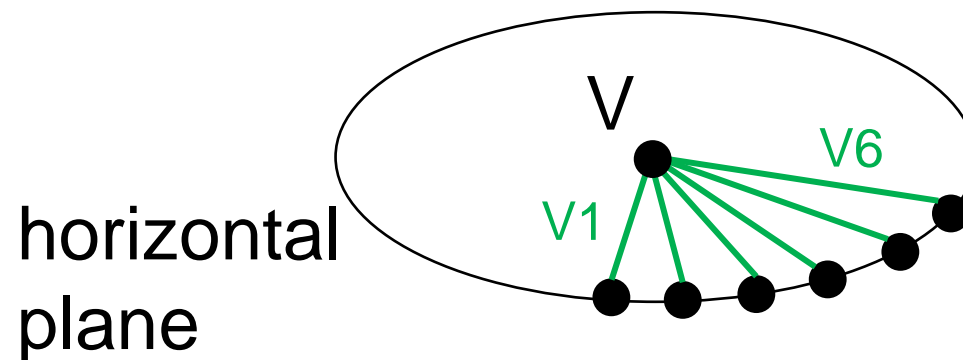
- ECG electrode
- ECG lead – connection of two active exploring electrodes (bipolar lead) or one exploring electrode and one reference electrode/clamp (unipolar lead)

# Standard 12-lead ECG

- 3x bipolar limb leads
  - I, II, III
- 3x unipolar augmented limb leads
  - aVR, aVL, aVF
- 6x unipolar chest leads
  - V1, V2, V3, V4, V5, V6



Einthoven triangle – frontal plane





# Standard 12-lead ECG record

Patient's name; date and time of measurement

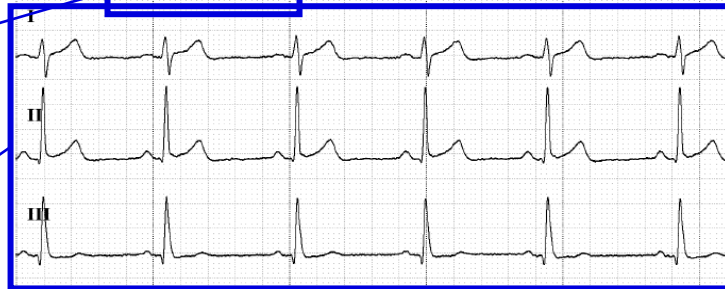
7.11.2017 8:27:58

EKG Praktik SEIVA  
8s1 - 2007/11/27 [SEIVA A01.002]

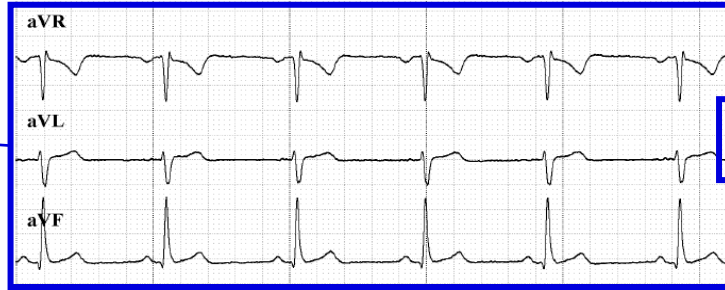
25 mm/s 10 mm/mV [35 Hz][AC 50 Hz][ad 0.3 Hz]

Time and voltage scale

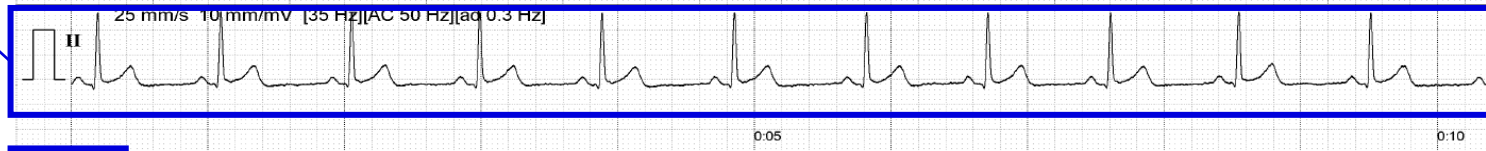
Bipolar limb leads (I, II, III)



Unipolar augmented limb leads (aVR, aVL, aVF)

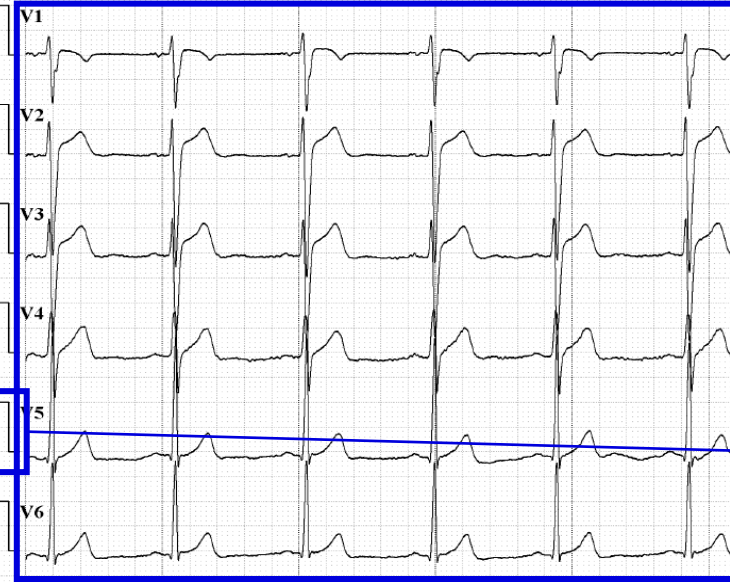


Lead II in long time scale



Values from automatic analysis (TF – heart rate)

TF [1/min]  
66



Unipolar chest leads (V1 – V6)

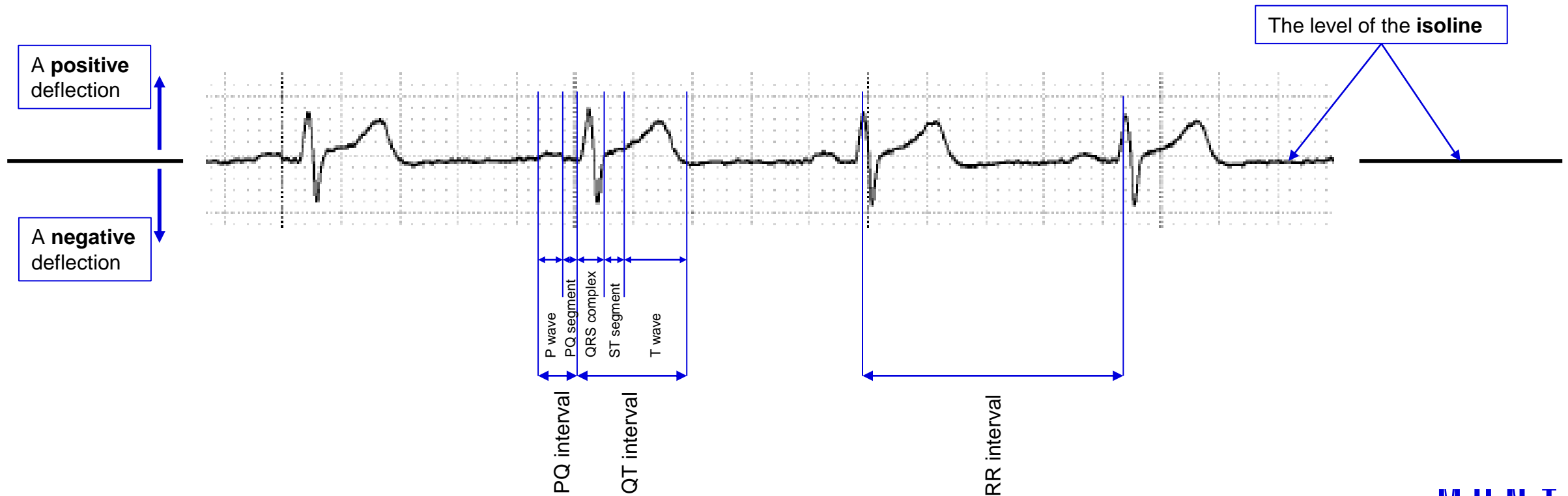
Calibration mark

Fysiologie  
LF-MU

MUNI  
MED

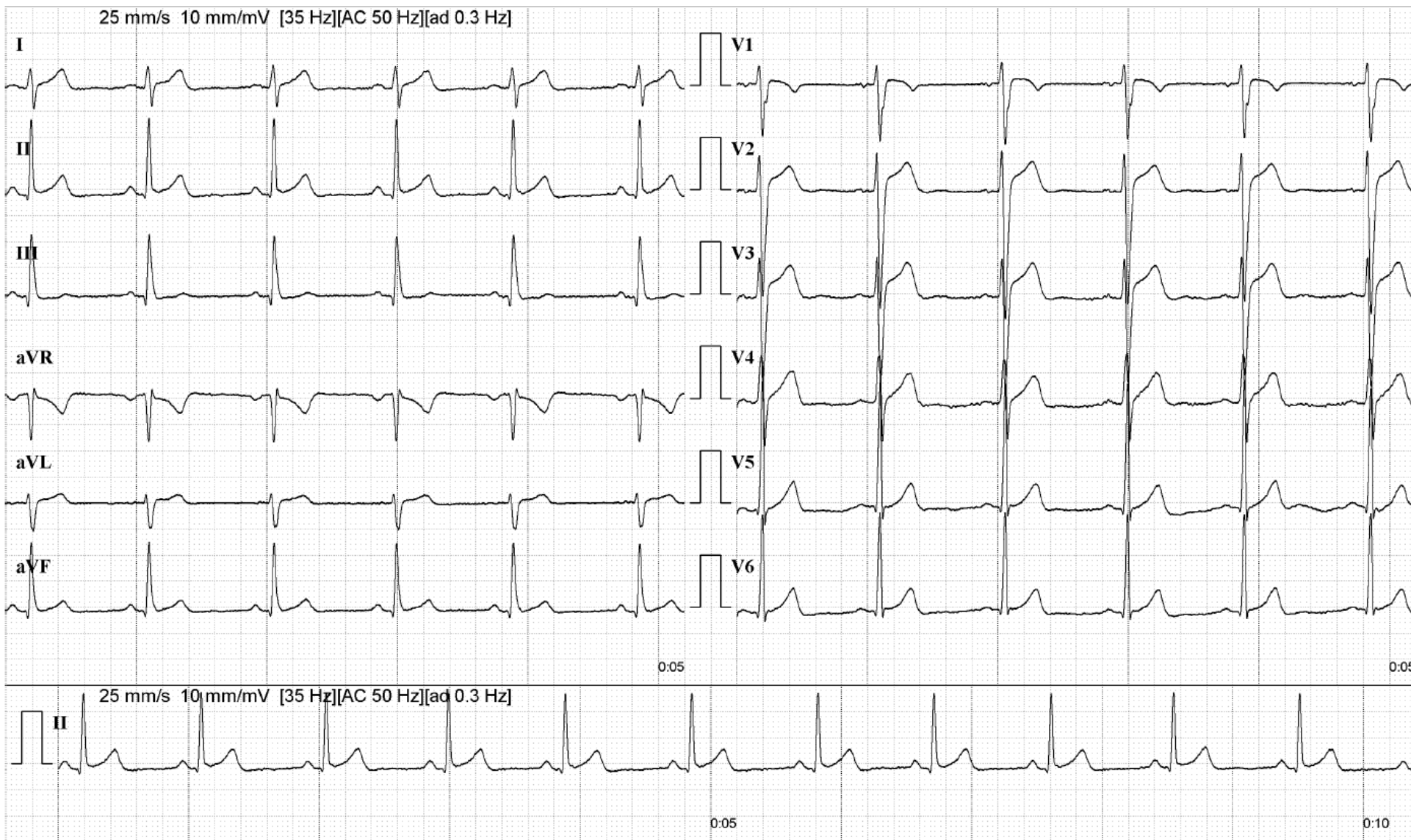
# Normal ECG curve - nomenclature

– Changes of voltage (mV) in time



# ECG evaluation – basic algorithm

1. Heart rhythm (regular/irregular; sinus/junctional/ventricular/other)
2. Heart rate (a value in bpm)
3. The duration of the P wave, the PQ interval, the QRS complex, and the QT interval (in ms)
4. Position of ST segment (in isoline/elevated/depressed)
5. Transitional zone (position; lead V1 – V6)
6. Electric axis of the heart (position in degrees)



TF [1/min]

66

# Heart rate and its regulation

- 60 – 90 bpm at rest (vagotonia; denervated heart: cca 100 bpm)
- Sympathetic stimulation: positive chronotropic effect
- Parasympathetic stimulation: negative chronotropic effect

# Heart sounds

- First sound – a-v valves
- Second sound – semilunar valves
  
- Third sound – rapid ventricular filling
- Fourth sound – atrial contraction

# Polygraphic record

- ECG, phonoCG, Ao BP, LV BP, LV V