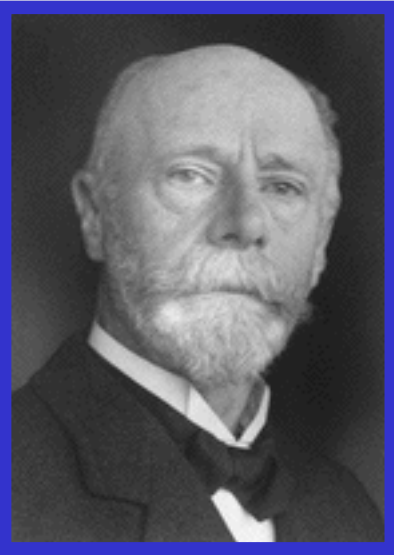


**ELECTROCARDIOGRAPHY** = methods enabling to register electrical changes caused by heart activity from body surface.



Willem Einthoven

1860 - 1927

1893 Einthoven introduces the term 'electrocardiogram'

1895 Einthoven distinguishes five deflections - P, Q, R, S and T

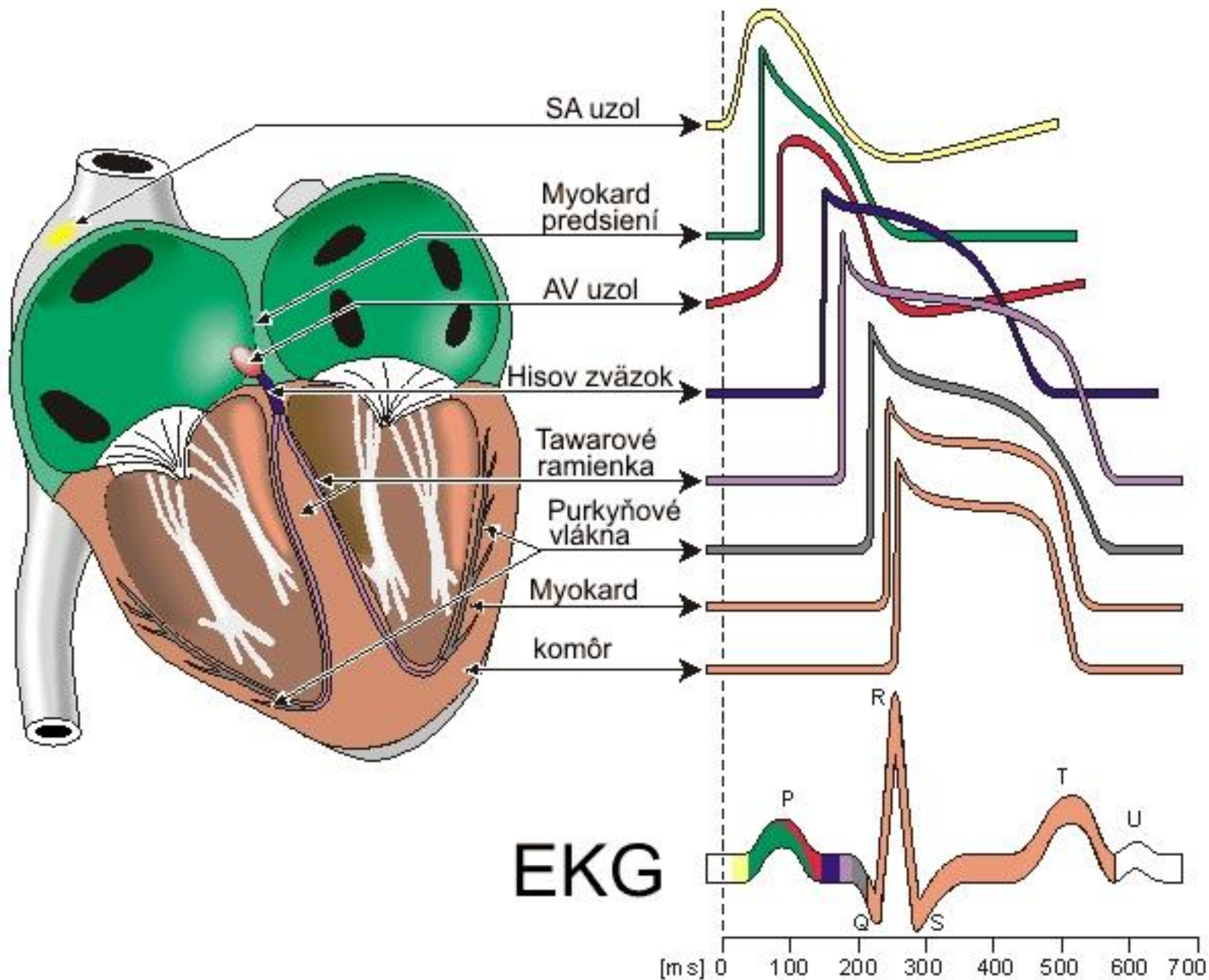
1902 Einthoven publishes the first electrocardiogram

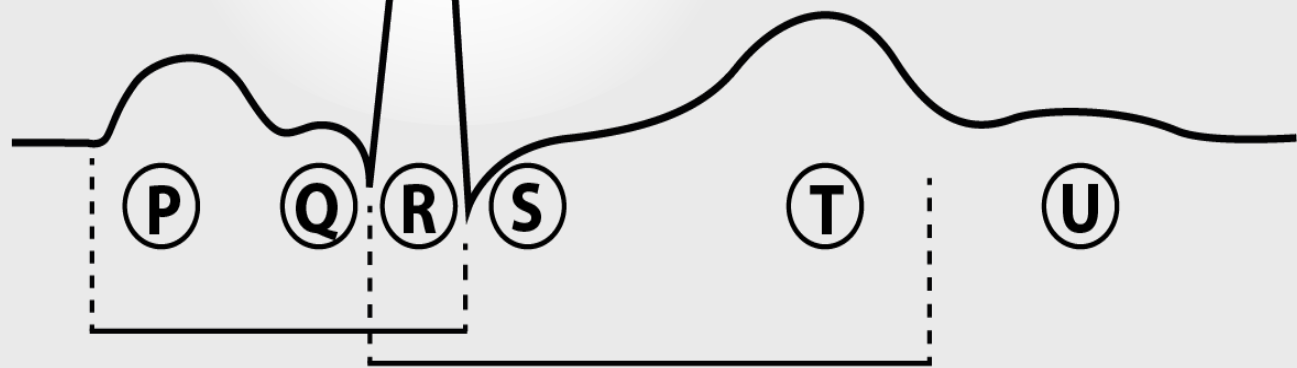
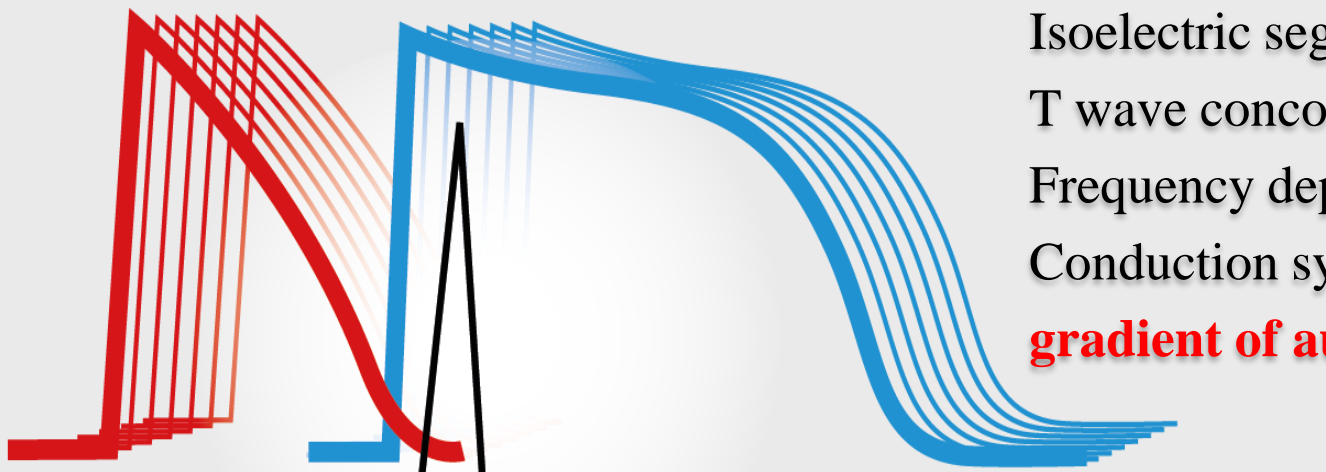
1905 Einthoven starts transmitting electrocardiograms from the hospital to his laboratory 1.5 km away via telephone cable

1924 the Nobel prize

## ECG gives information about:

1. **Frequency** (changes of HR in SA node or arrhythmias, sick sinus syndrome)
2. **Conduction** (blocks – SA, AV)
3. **Rhythm** (ES – supraventricular, ventricular)
4. **Ventricular gradient** (relationship between depolarization and repolarization: origin – metabolic, hemodynamic, anatomic, physical...ischemia, hypertrophy, dilatation, cardiomyopathy, inflammations, changes in electrolytes, drugs...)





PQ interv. 0,16  
 QRS 0,1  
 QT 0,3

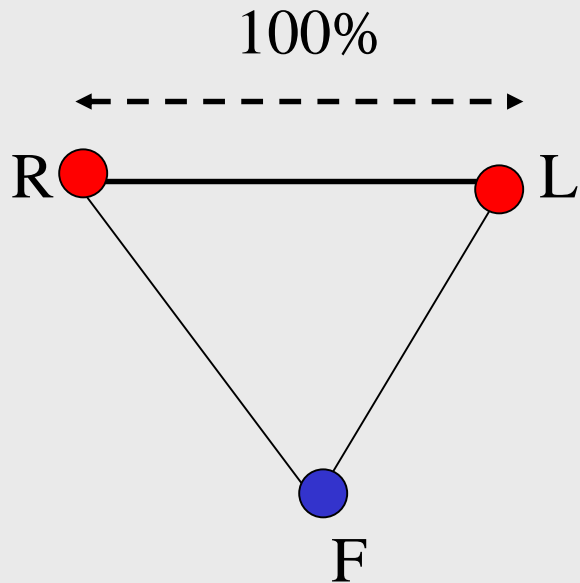
**HR – dependent**

**Atrial depol.**

**Ventricular complex**

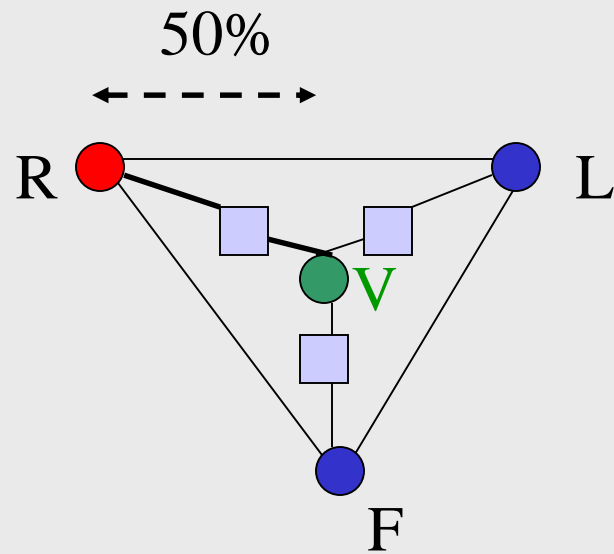
(depol.)

(repol.)

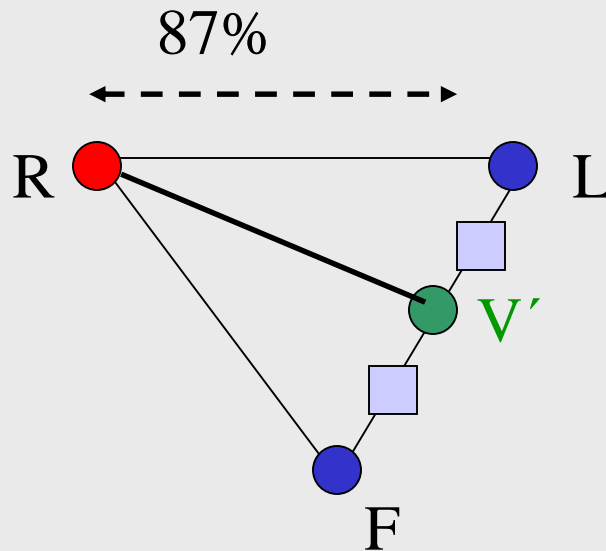


Einthoven, 1913

I, II, III

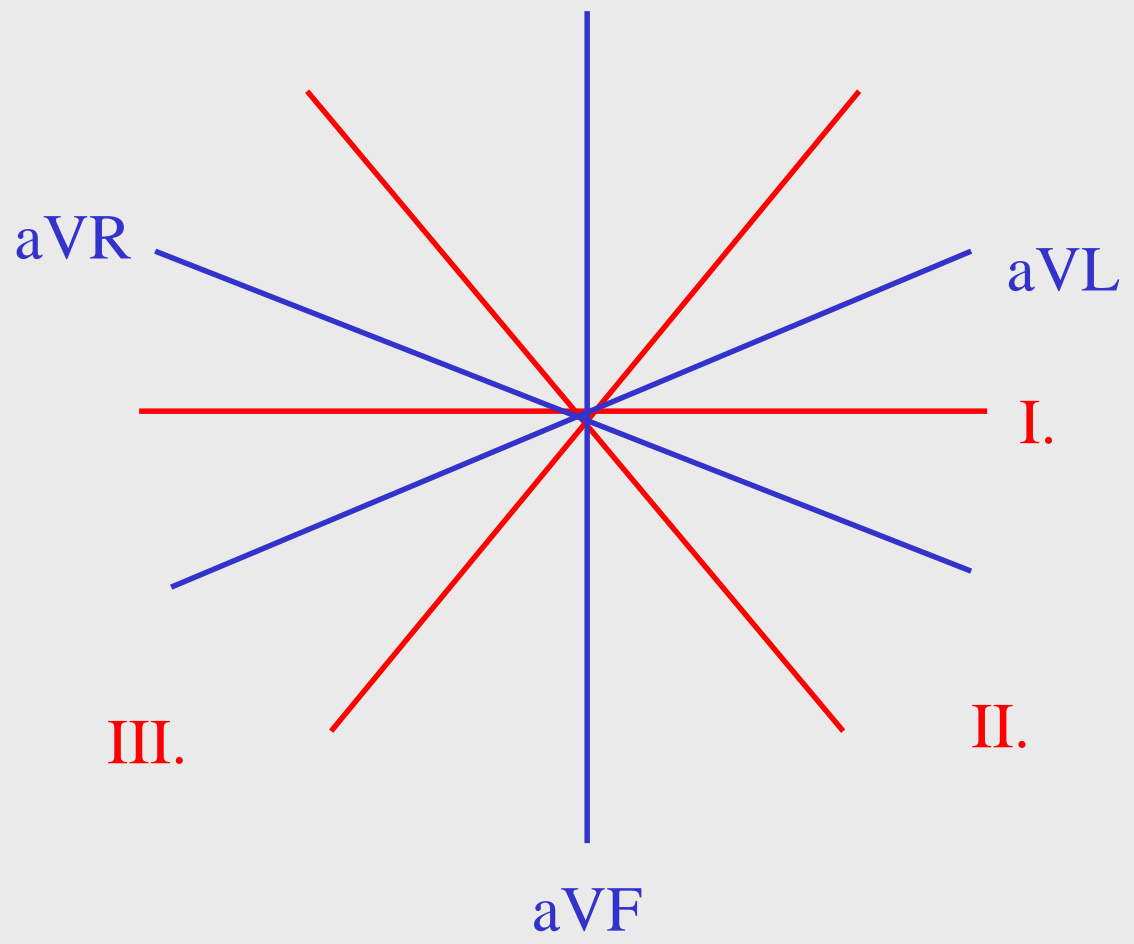


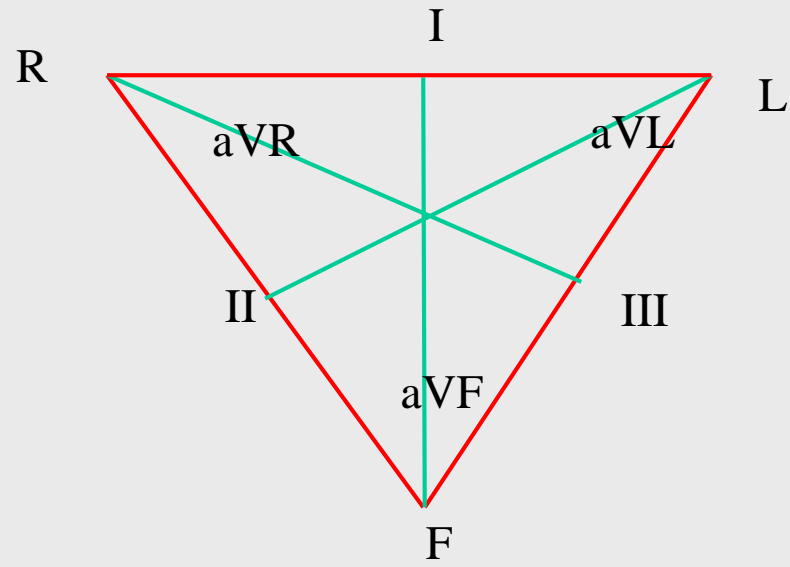
Wilson, 1934, VR, VL, VF



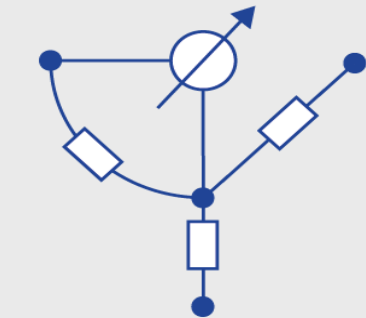
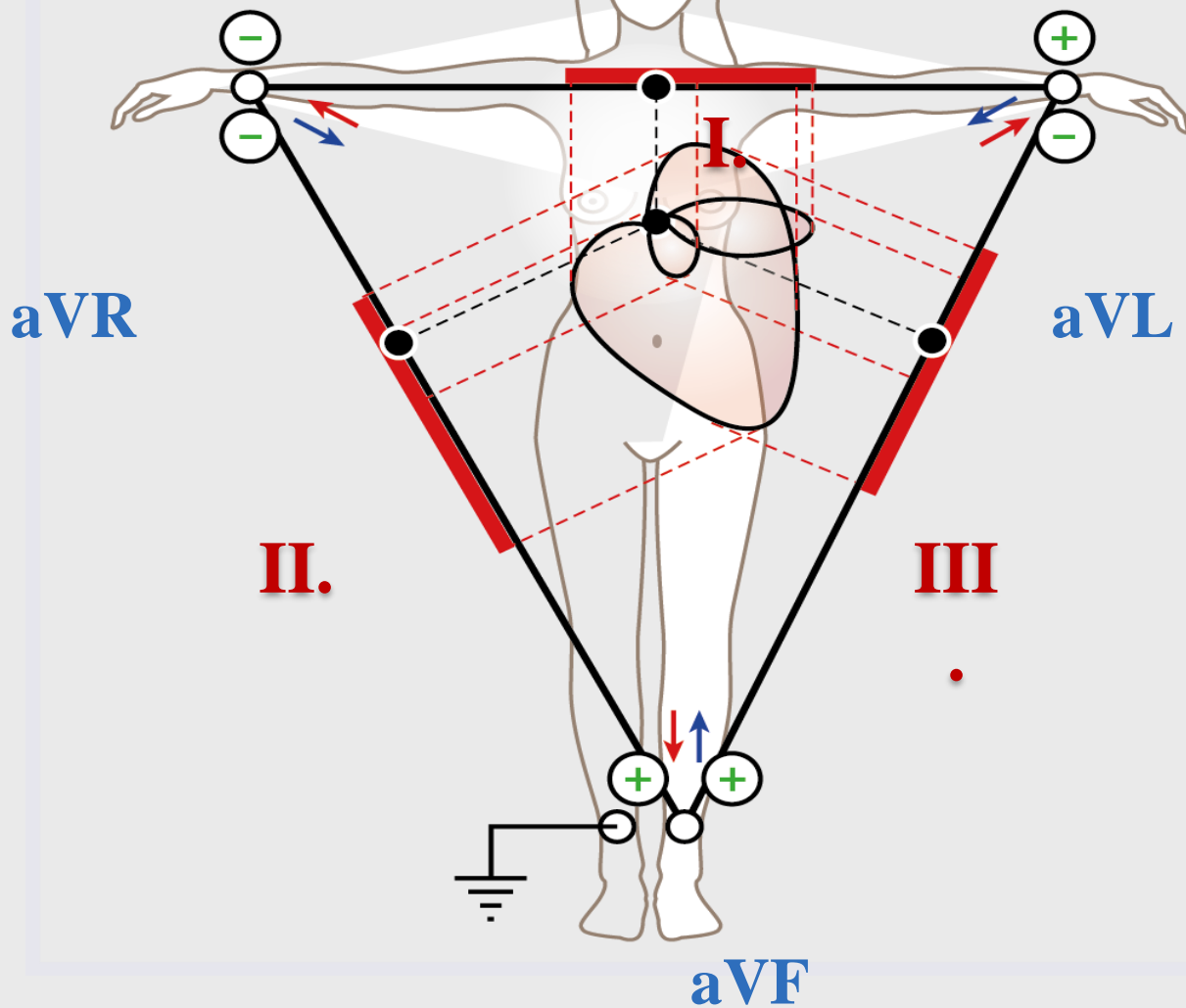
Goldberger, 1947, aVR, aVL, aVF

# HEXAAXIAL SYSTEM

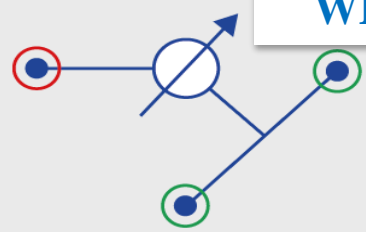




# LIMB LEADS



WILSON



GOLDBERG augmented

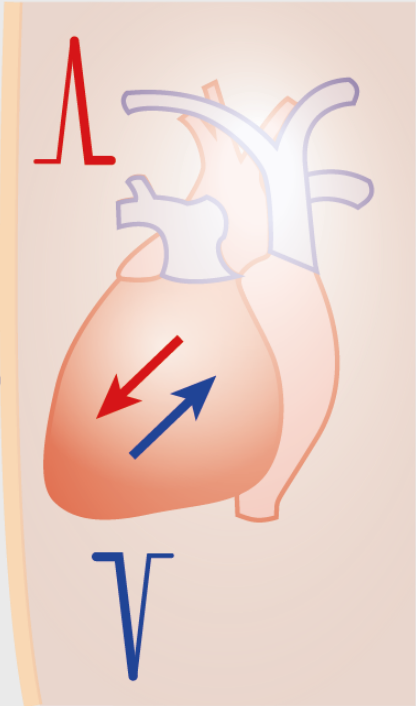
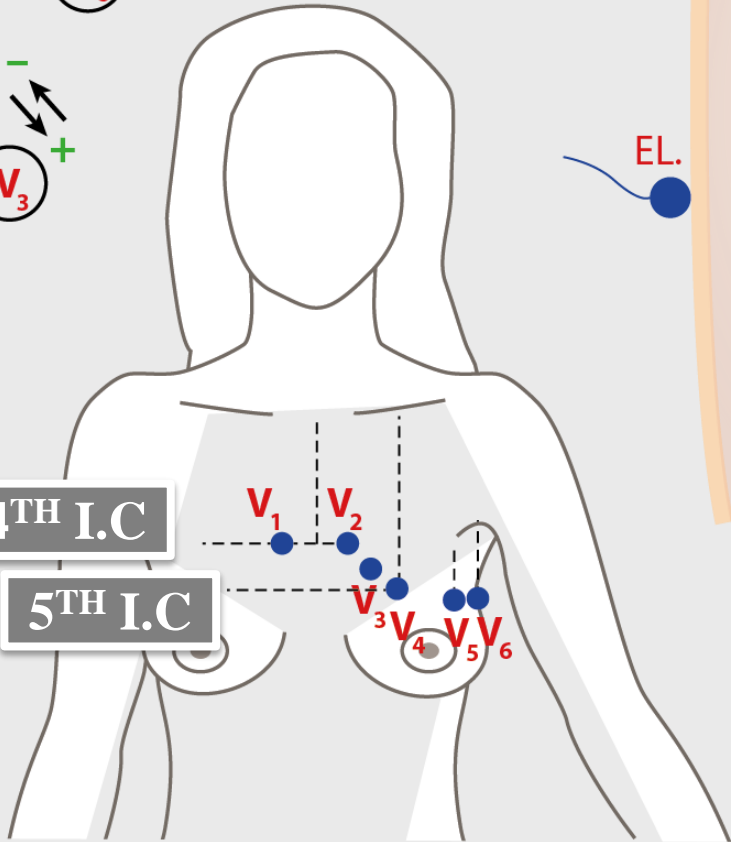
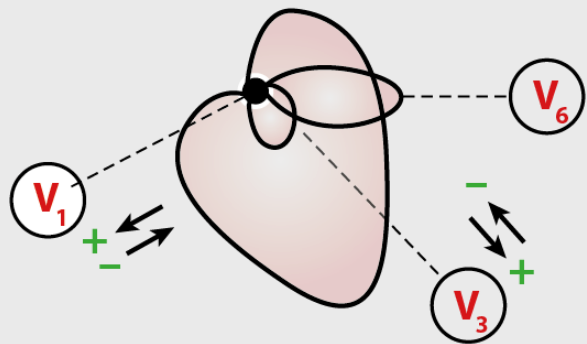
Frontal projection of vector!

Bipolar (I, II, III)

Unipolar (augmented) aVR, aVL, aVF



# CHEST LEADS



Horizontal projection of vector!

# PROJECTION PLANES OF CARDIAC VECTOR AND ECG LEADS

## Frontal plane

limb leads

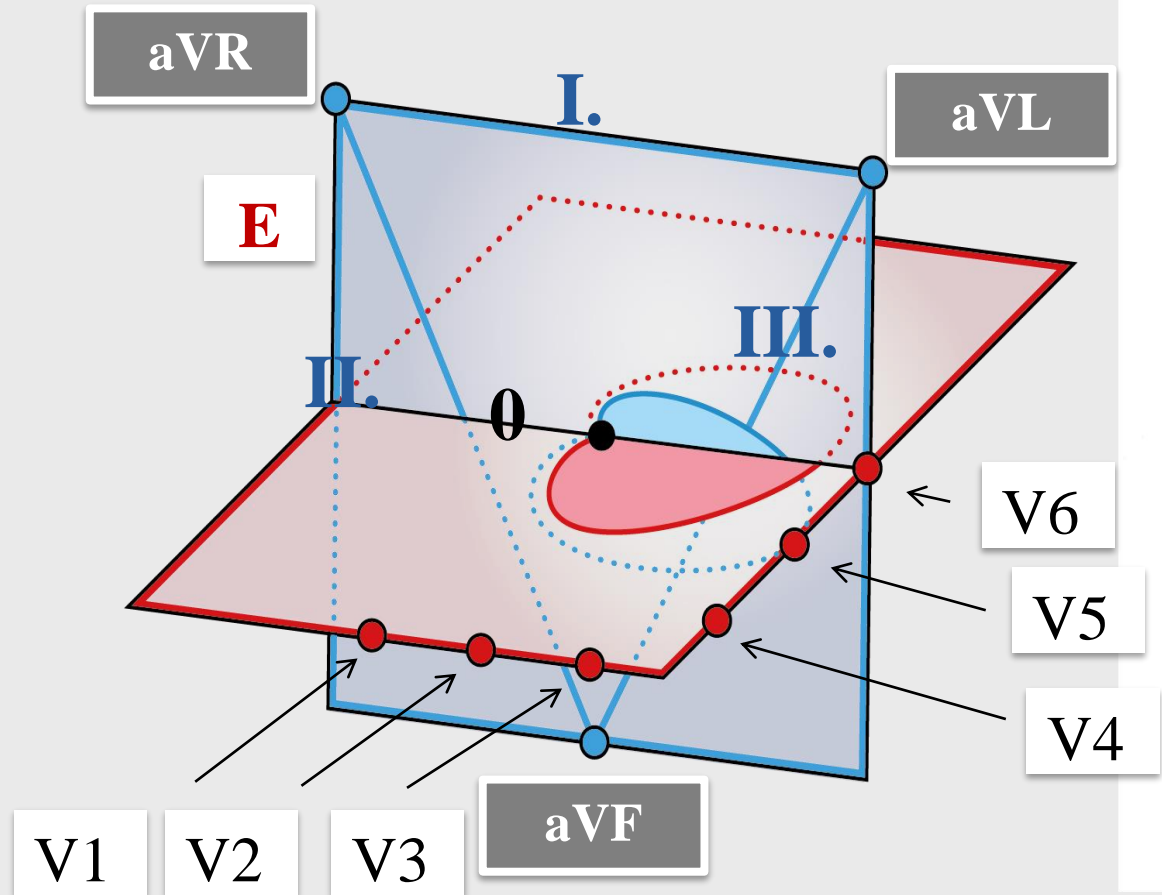
I., II., III., aVR, aVL, aVF

## Horizontal plane

V1 – V6

Both planes are shifted into the level of electrical centre of the heart (0)

E – Einthoven triangle

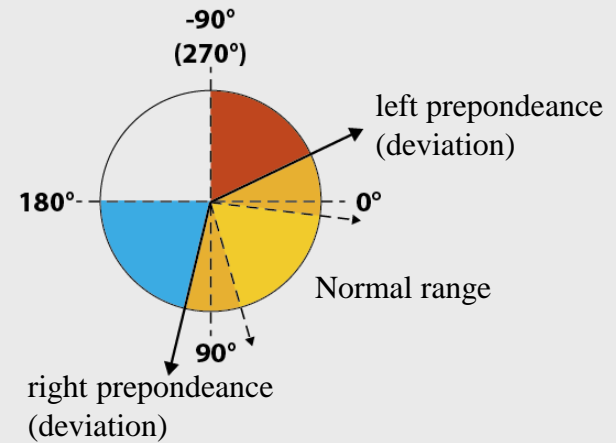
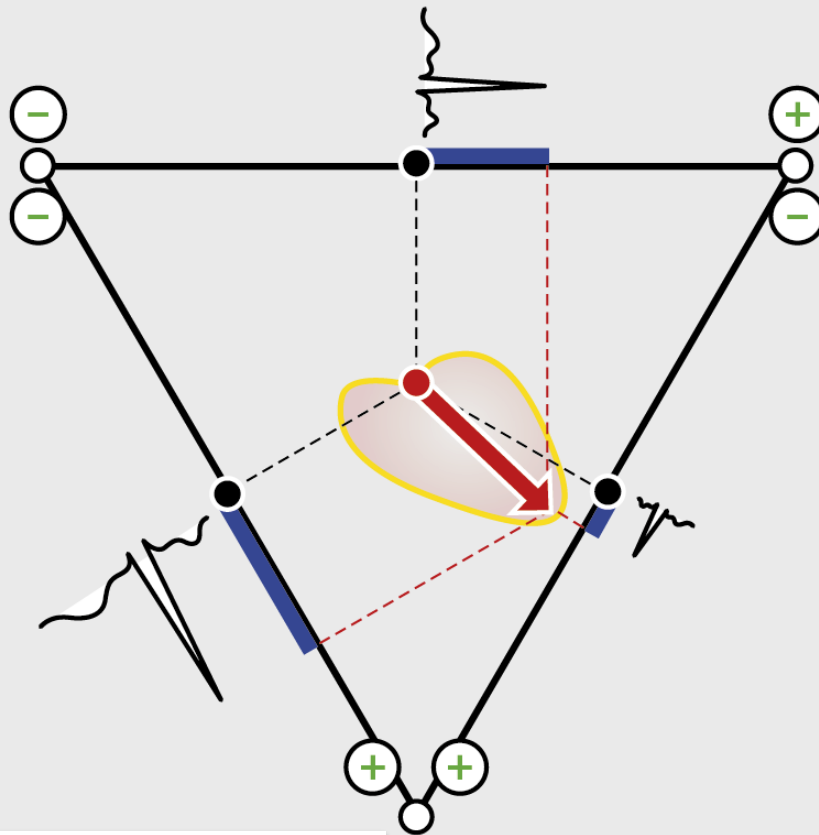


## ELECTRICAL AXIS OF THE HEART

Summary of all momentary vectors, which form ventricular depolarisation loop. Expresses the direction of ventricular activation. Reflects asymmetry in ventricular wall thickness and the position of the heart in the chest.

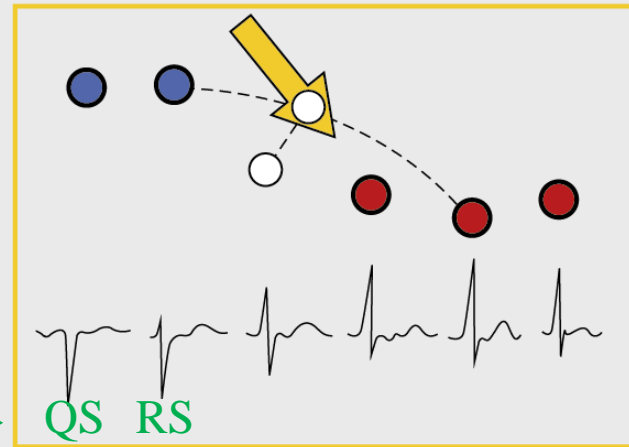
# ELECTRICAL AXIS – in the frontal plane

(R–Q–S) in lead I, II, III.

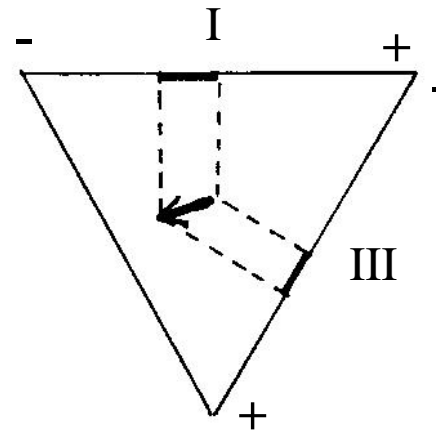
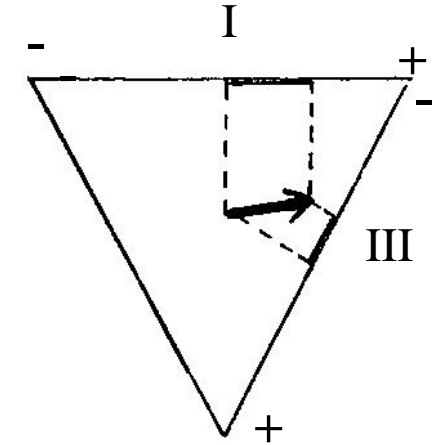
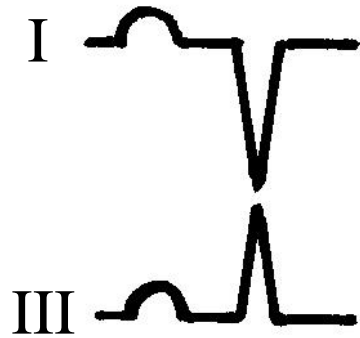
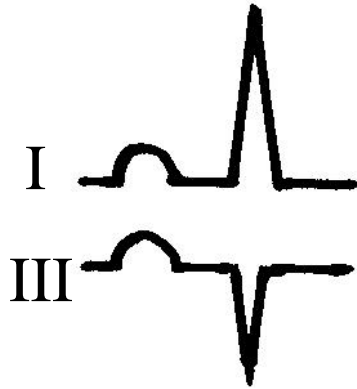


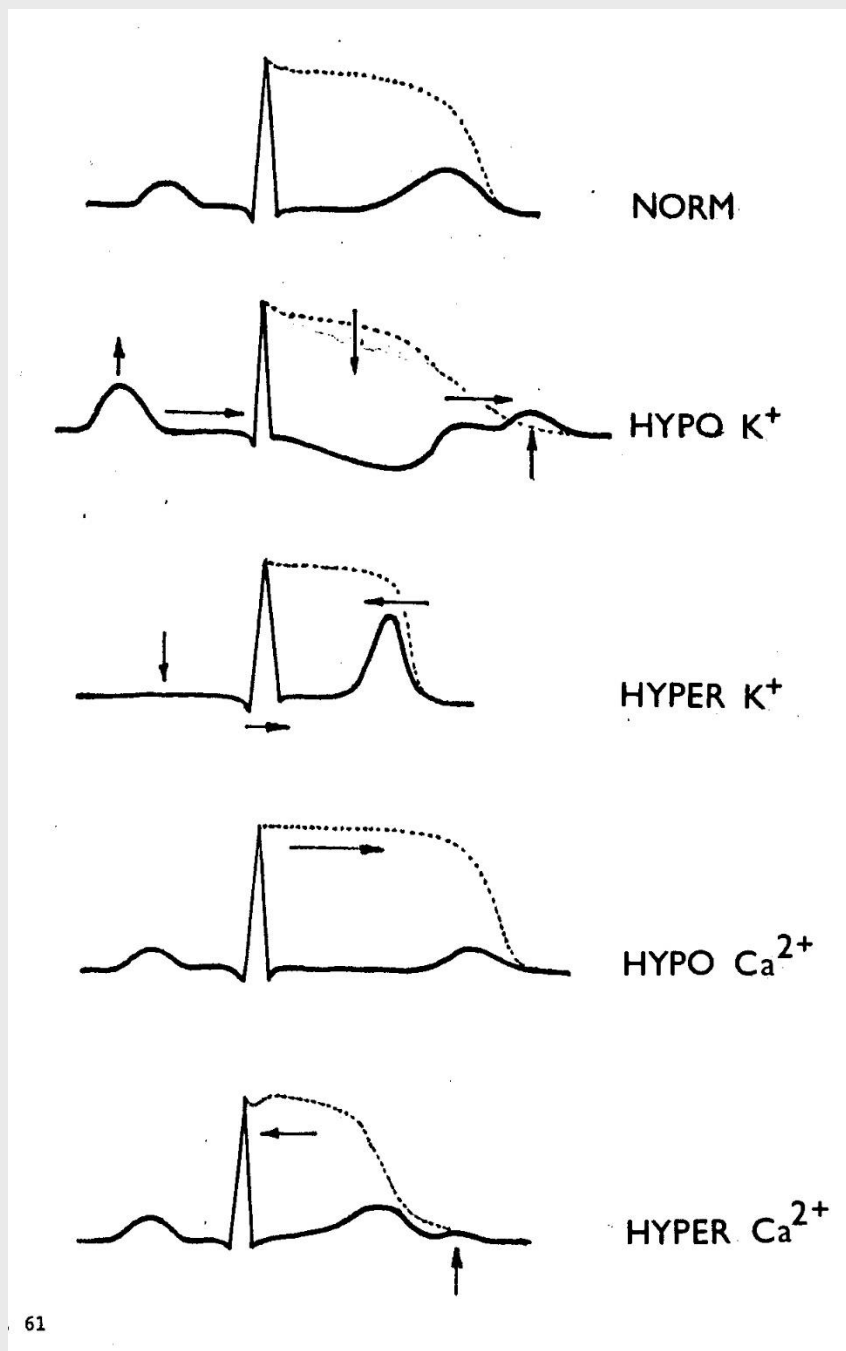
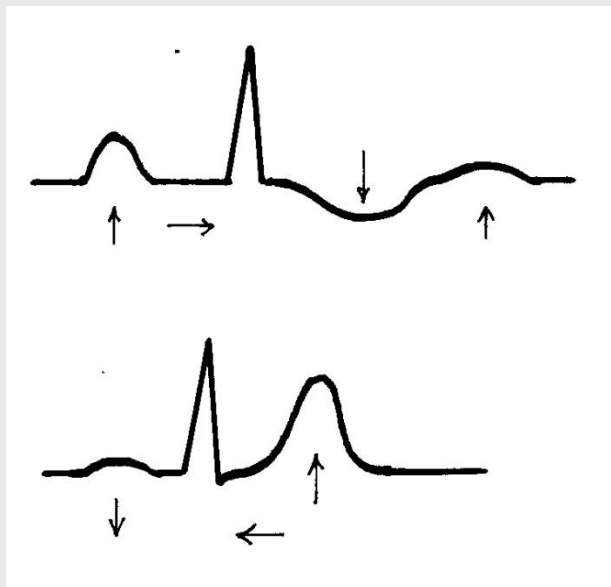
• **Eqilateral**  
Einthoven  
triangle

Terminology →



# LEFT DEVIATION, RIGHT DEVIATION





# **ARRHYTHMIA(S)**

disturbance of impulse generation

or

disturbance of impulse conduction

# RESPIRATORY (SINUS) ARRHYTHMIA

1847, Ludwig, ECG and breathing of dog – respiratory sinus arrhythmia

Detectable already during prenatal life.

Present in numerous species in animal kingdom – in all vertebrates.

Physiological meaning ???? STABILISATION OF MEAN BP (protection against mechanical effect of intrathoracic pressure on arterial BP)

Key effect of parasympathetic NS (decrease of its tonus), sympathetic NS only modulates!!!

## MECHANISMS:

- 1) CENTRAL
- 2) REFLEXES FROM LUNGS
- 3) REFLEXES FROM BARORECEPTORS
- 4) REFLEXES FROM RECEPTORS IN THE RIGHT ATRIUM
- 5) LOCAL EFFECTS ON SA NODE
- 6) EFFECT OF OSCILLATIONS OF pH,  $paO_2$ ,  $paCO_2$



**ARRHYTHMIAS** = disturbance of impulse generation or conduction

## RHYTHM and FREQUENCY:

### Regular

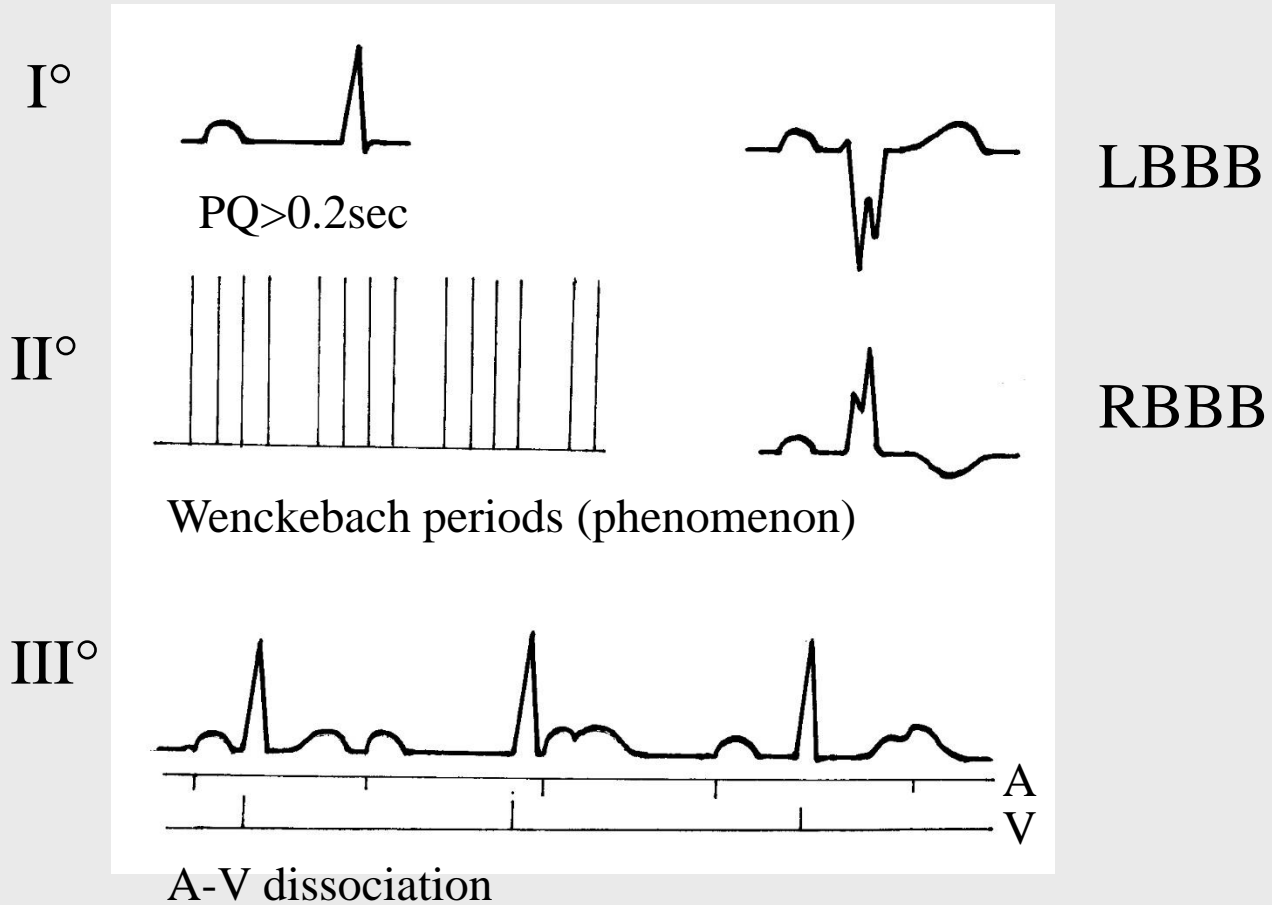
- 1) Normal HR range: 70 – 220 bpm; effect of age)
- 2) Sinus tachycardia (60 - 100 bpm; exercise; aging)
- 3) Sinus bradycardia (below 60 bpm; athletes' heart)
- 4) Nodal rhythm - below 40 bpm, ventricular rhythm - below 20 bpm)

### Irregular

1. sinus respiratory arrhythmia (**physiological**)
2. Sick sinus syndrome
3. Extrasystoles (ES) single or coupled (bigeminy, trigeminy), according to site or origin - sinus, atrial, junction, ventricular

# BLOCKS

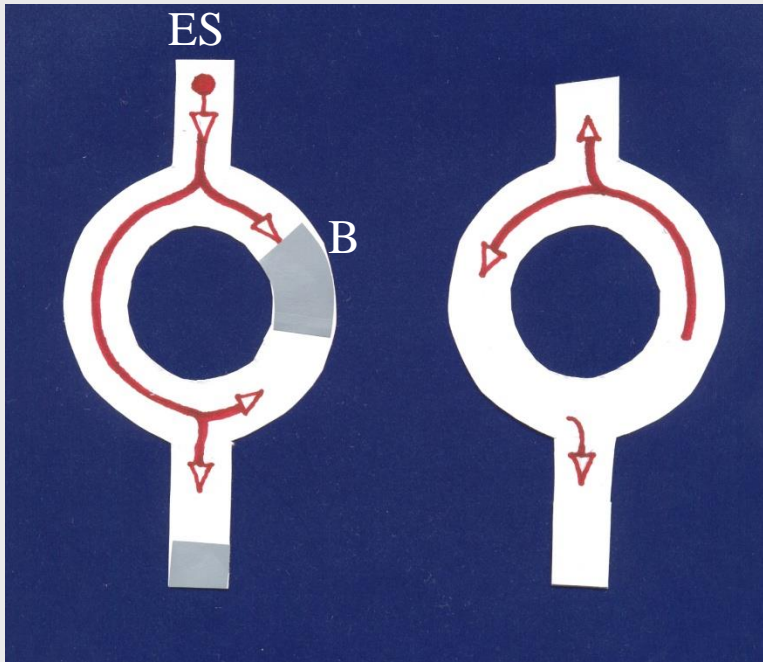
- SICK SINUS SYNDROM
- AV BLOCKS



- BUNDLE BRANCH BLOCK (BBB) – LEFT, RIGHT

# REENTRY

Common mechanism of (paroxysmal) tachycardias, extrasystoles, bigeminy, etc.



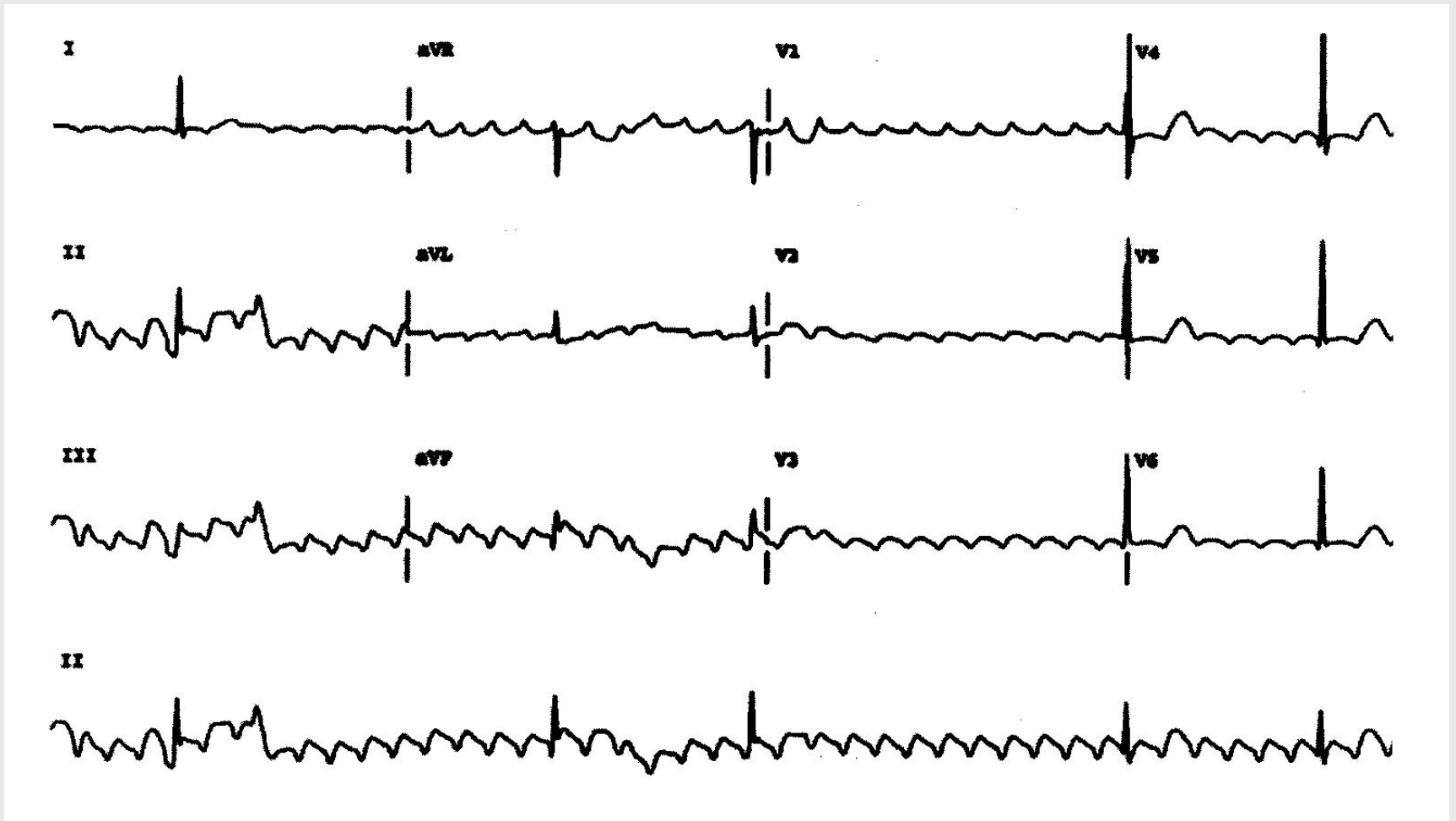
- **Loops most often at the level of AV junction**
- **Determinants of re-entry:**
  1. Proper dimension of the loop
  2. Proper timing of the trigger ES

- **Double pathway**  
Diverging and converging of excitation pathways
- **Unidirectional block**
  1. Long refractory period
  2. Slowed conduction
  3. **Reentry**

# TACHYARYTHMIA

- **SINUS TACHYCARDIA**
- **PAROXYSMAL TACHYCARDIA** (supraventricular, ventricular)
- **FLUTTER** (>250/min; atrial)
- **FIBRILLATION** (>600/bpm; **atrial, ventricular; breakdown of electrical homogeneity**)

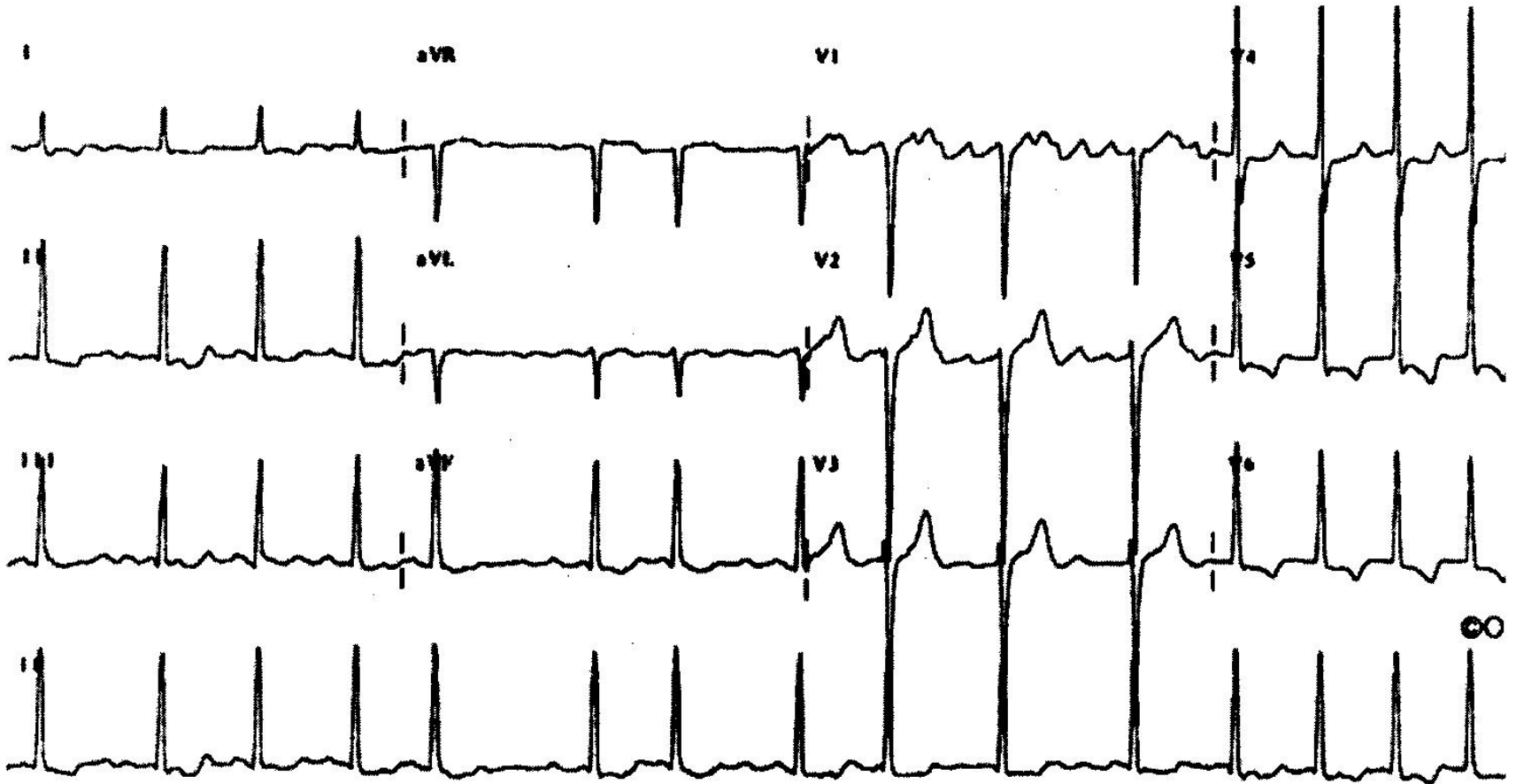
# ATRIAL FLUTTER



Frequency 250 – 600/bpm

Atrioventricular block n:1

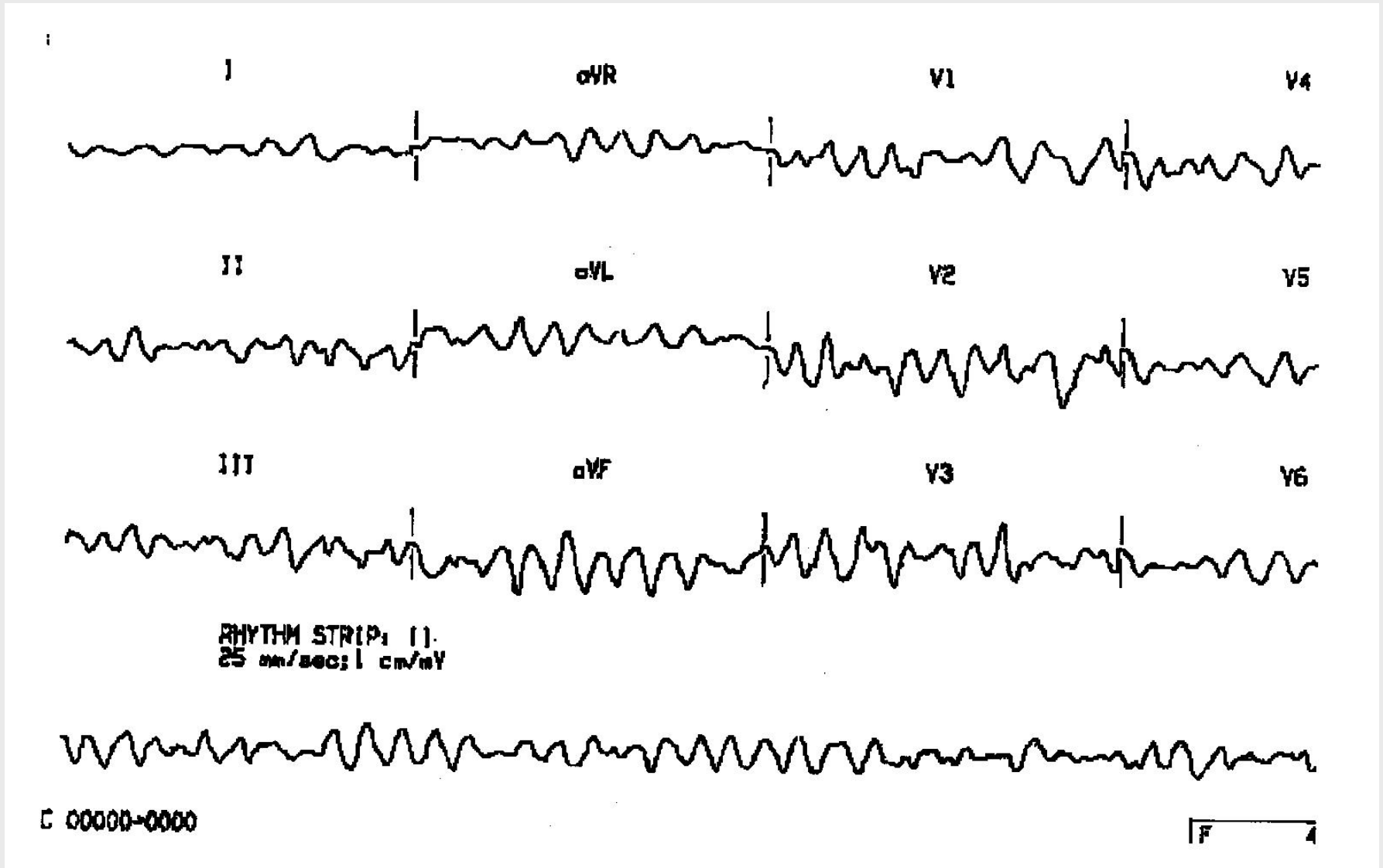
# ATRIAL FIBRILLATION



Irregular ventricular rhythm

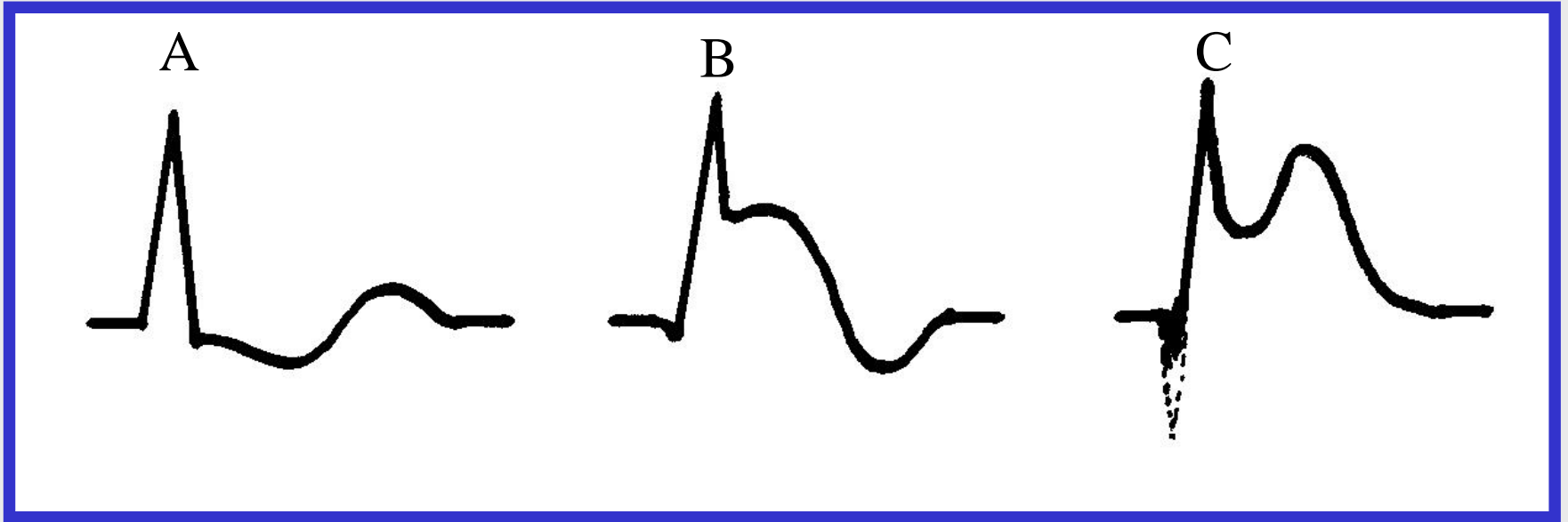
+ f-waves

# VENTRICULAR FIBRILLATION



Frequency above 600/bpm, **LETHAL**

## HEART ISCHEMIA



A: exercise angina pectoris

B: acute non-Q myocardial infarction

C: acute Q myocardial infarction