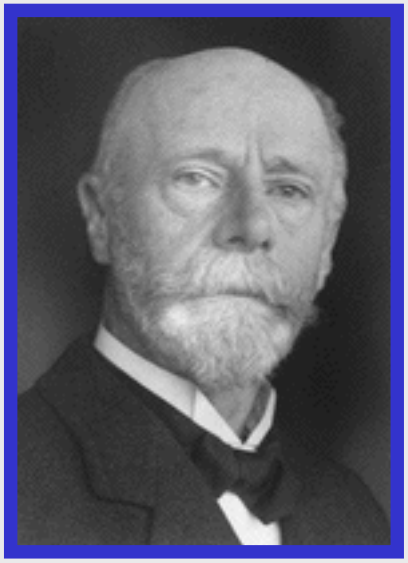
ELECTROCARDIOGRAPHY = methods enabling to register electrical changes caused by heart activity from body surface.



Willem Einthoven

1860 - 1927

1893 Einthoven introduces the term 'electrocardiogram'

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

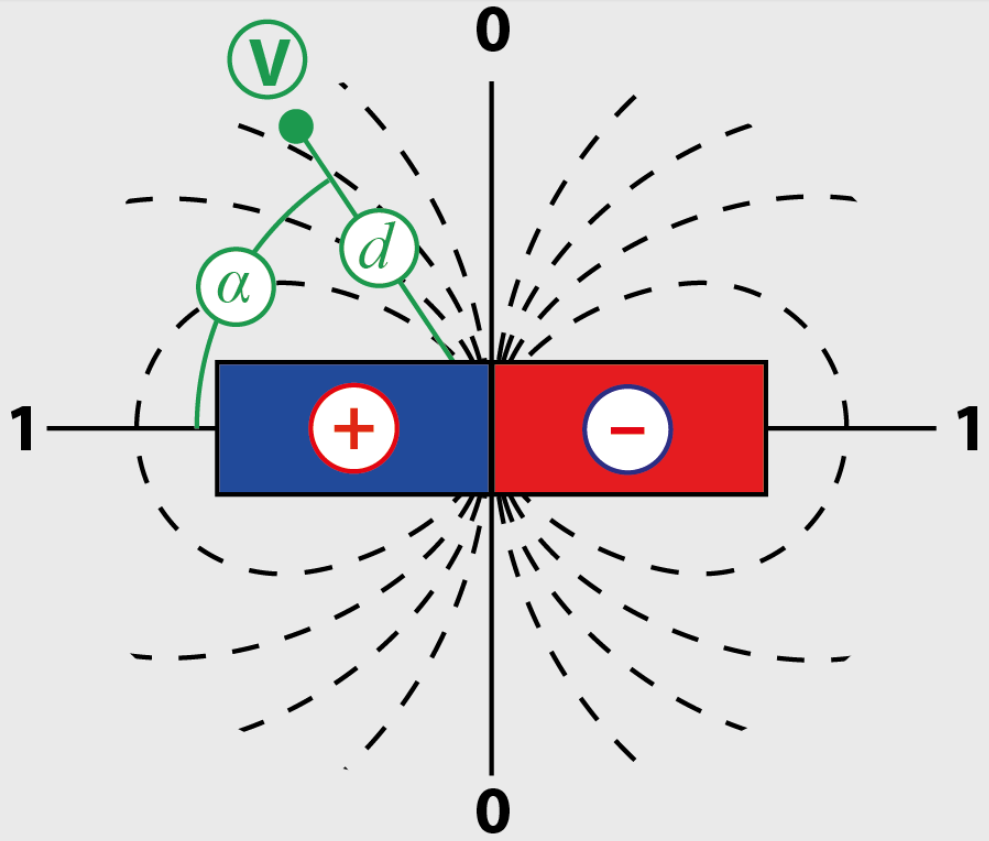
1902 Einthoven publishes the first electrocardiogram

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

1924 the Nobel prize

ELECTRICAL DIPOLE

stationary in homogenously conducting environment



Local currents

- Maximal in dipole axis (1)
- Zero in the place of the centre (0)

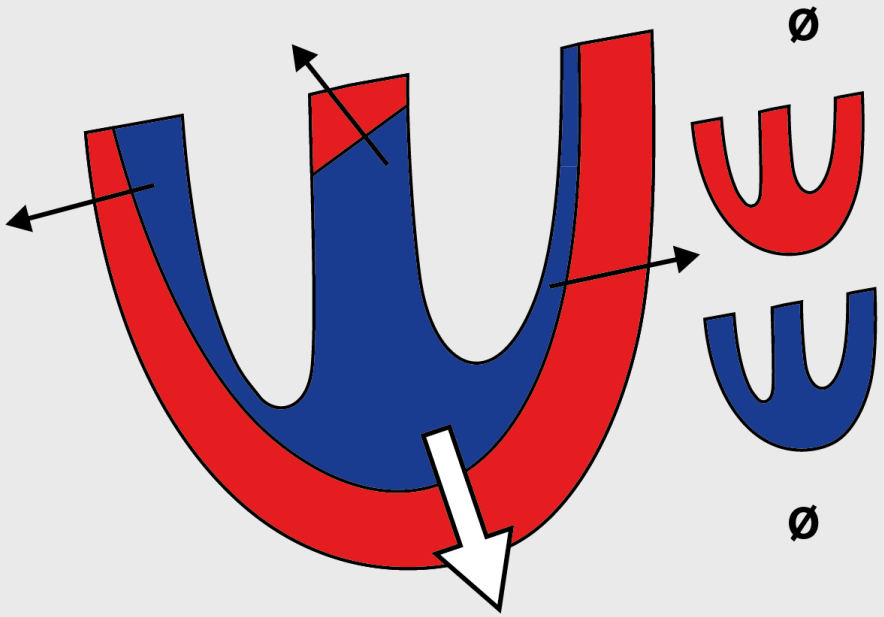
SPREADING OF DEPOLARIZATION FRONT

ELECTRICAL FIELD OF THE HEART (vector)

•Consists of sum of momentary dipoles on the depolarization front

•**Its size** is a function of number of dipoles and steepness of boundary line

•**Direction from** depolarized (-) to (re)polarized (+) area

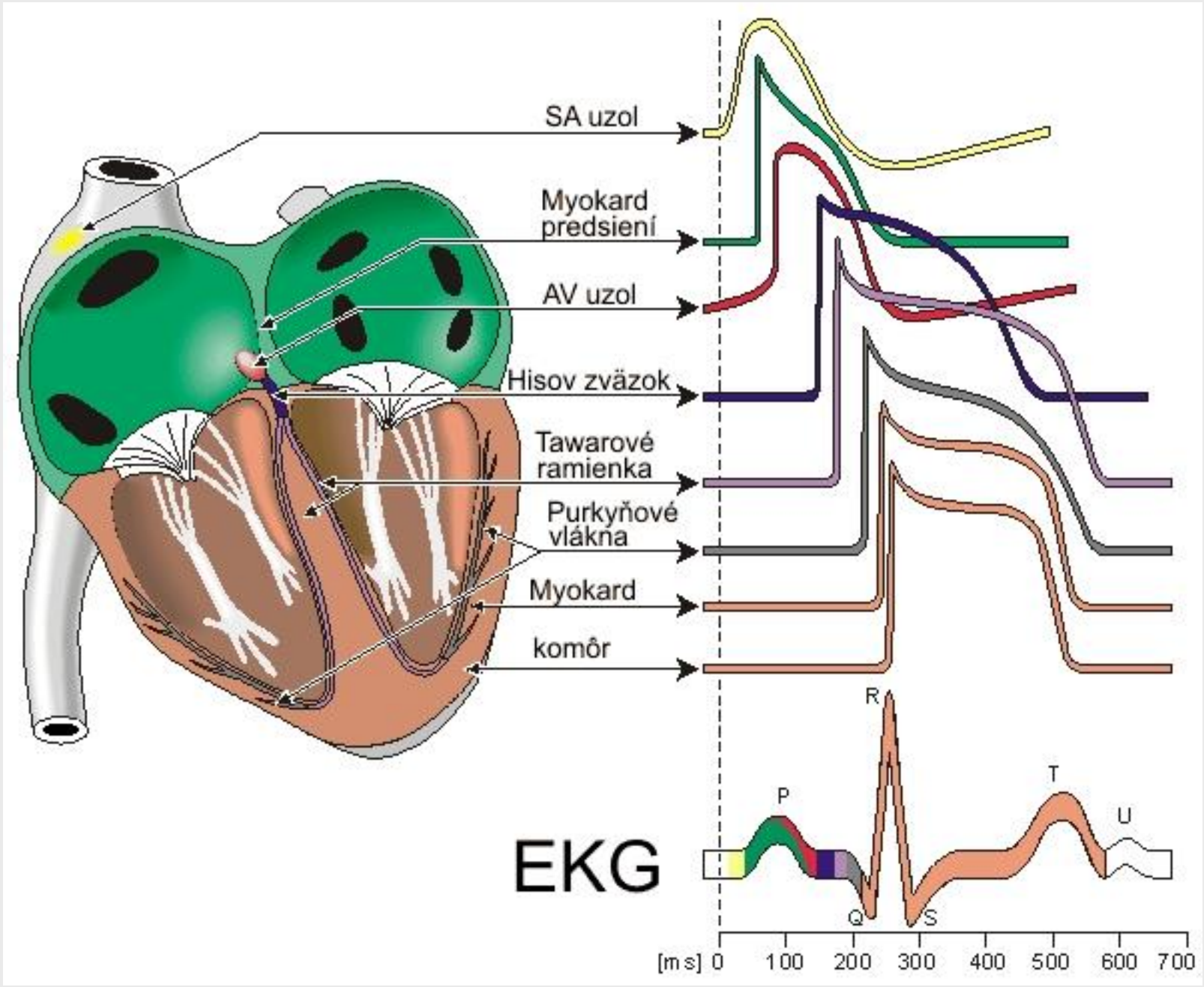


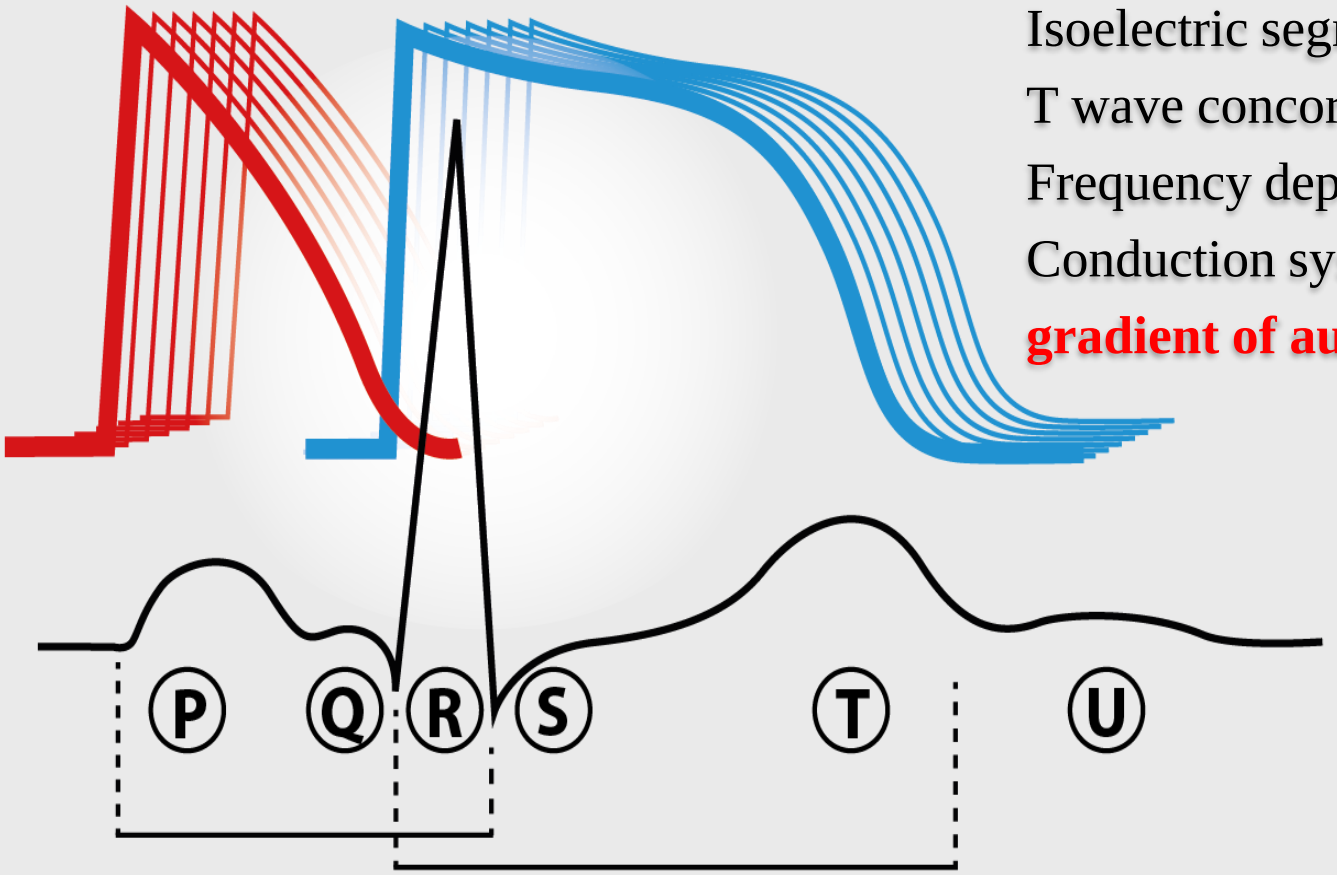
REGIONAL VECTORS
INTEGRAL VECTOR
during excitation is changing:

•Size of momentary dipoles

•Their direction

•They are spreading to body surface – ELECTROCARDIOGRAPHY


SA uzol
Myokard predsiení
AV uzol
Hisov zväzok
Tawarové ramienka
Purkyňové vlákna
Myokard komôr
EKG
R
P
T
U
Q
S
[ms] 0 100 200 300 400 500 600 700



Isoelectric segments

T wave concordance

Frequency dependence

Conduction system –

gradient of automaticity

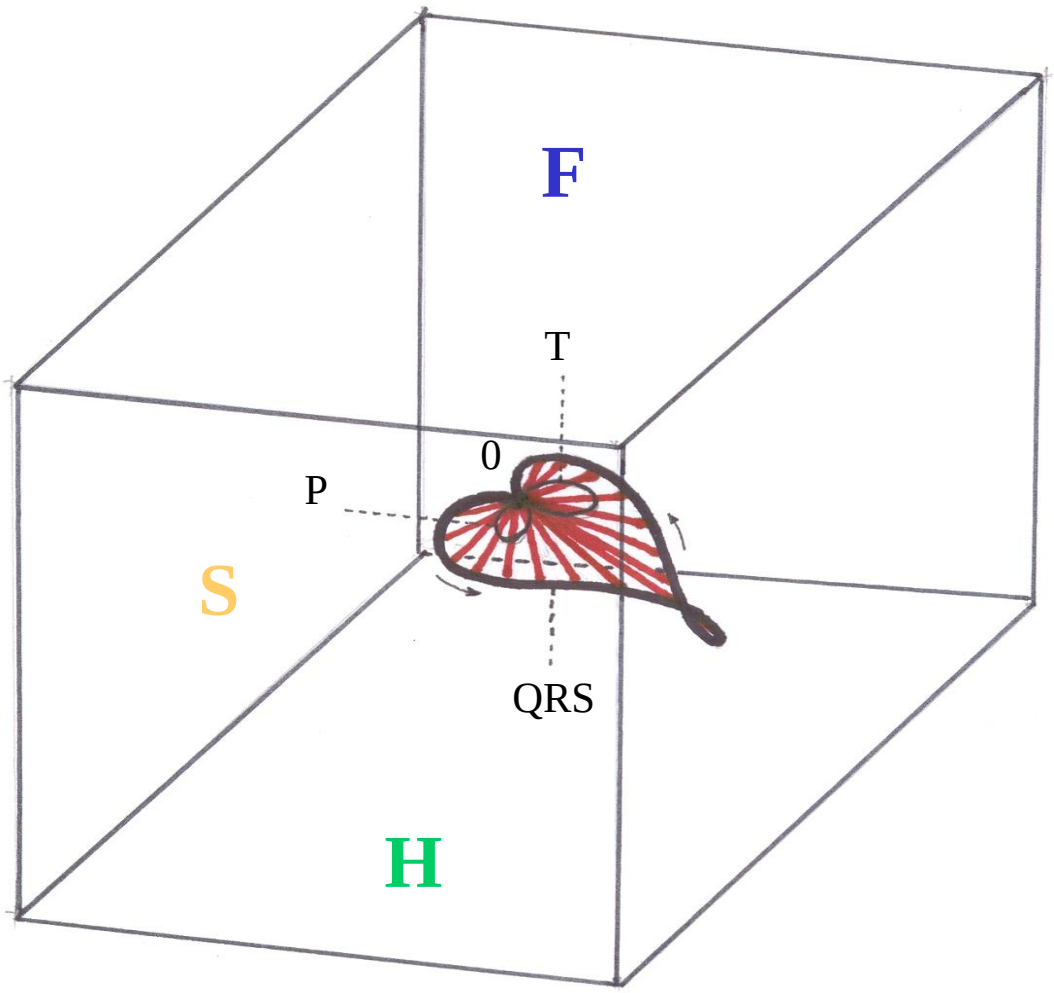
HR – dependent

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…)

3D LOOPS OF ELECTRICAL AXIS

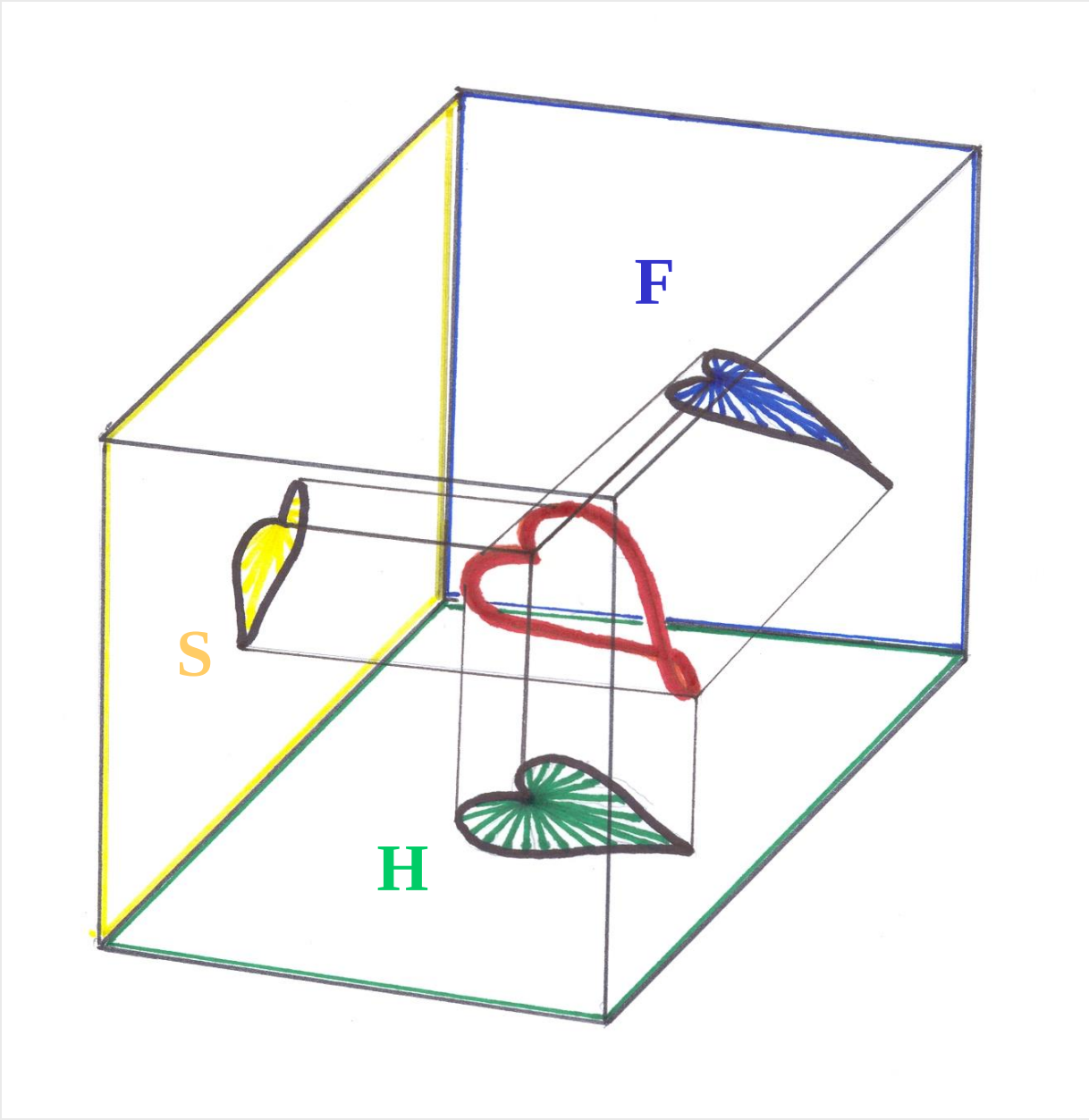
F – frontal plane
S – sagittal plane
H – horizontal plane



0 – electric center of the heart
P – atrial depolarization
QRS – ventricular depolarization
T – ventricular repolarization

2D PROJECTION OF HEART AXIS

F – frontal plane
S – sagittal plane
H – horizontal plane



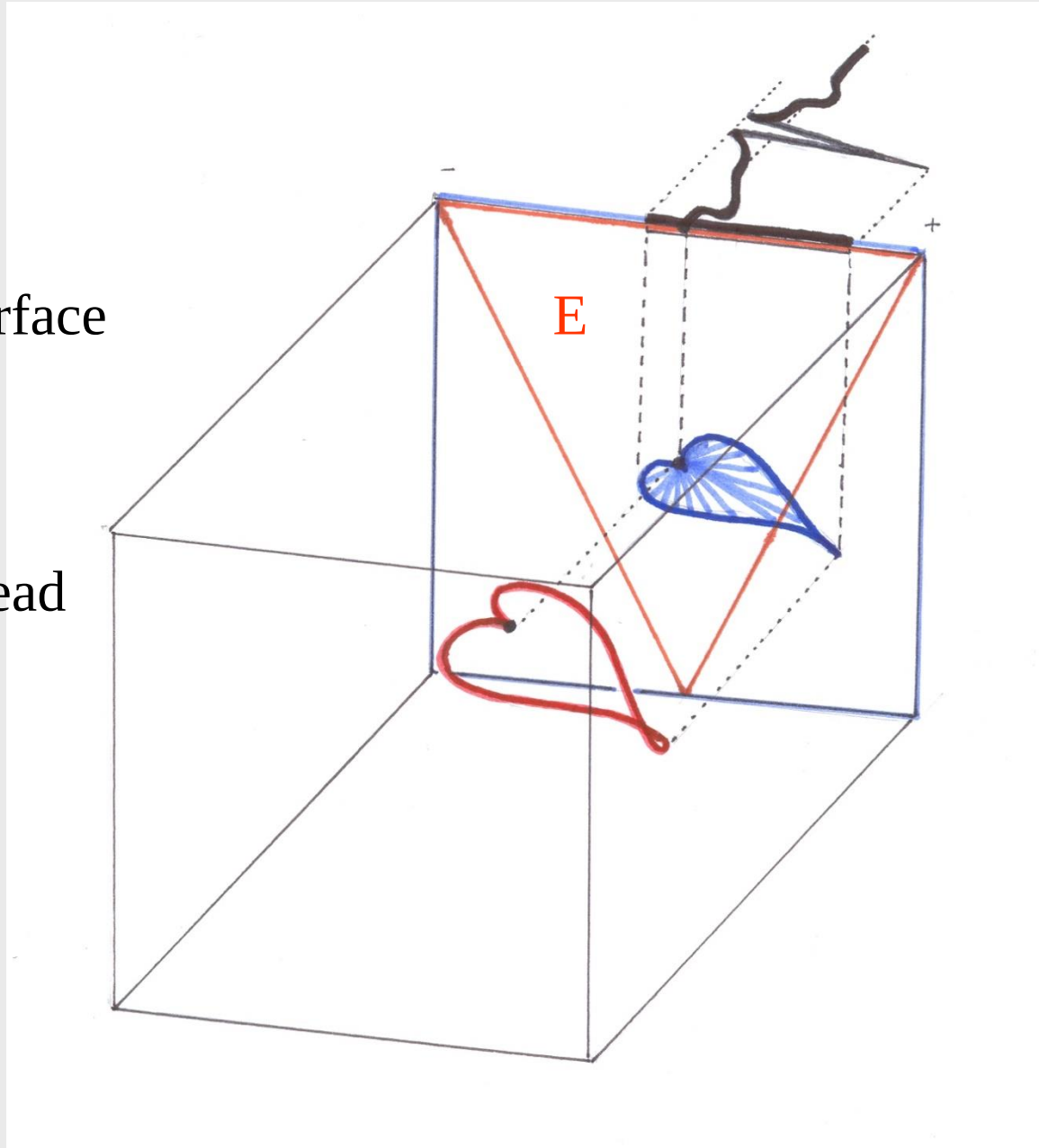
1D PROJECTION OF HEART AXIS

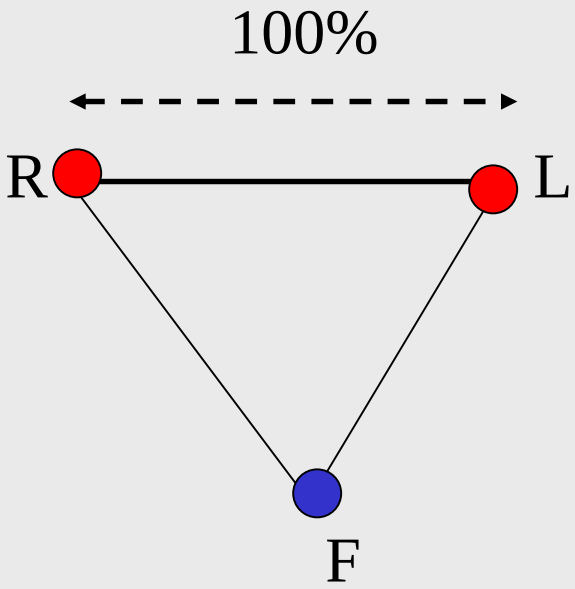
Projection on the chest surface into frontal plane (2D)

And its projection to line (1D), axis of the I. ECG lead

in time

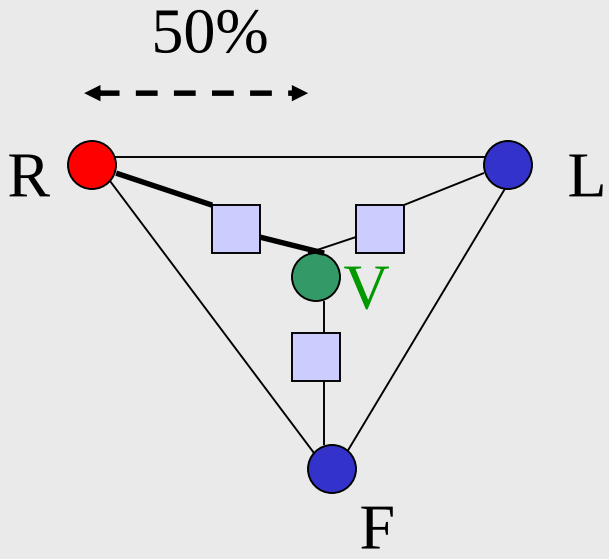
E – Einthoven triangle



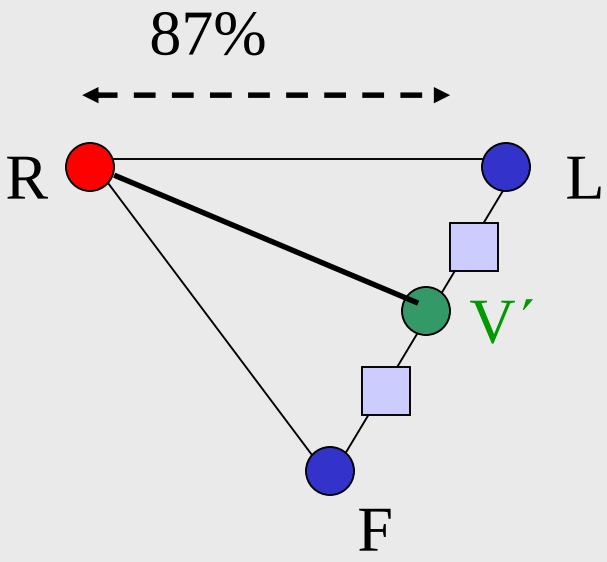


Einthoven, 1913

I, II, III

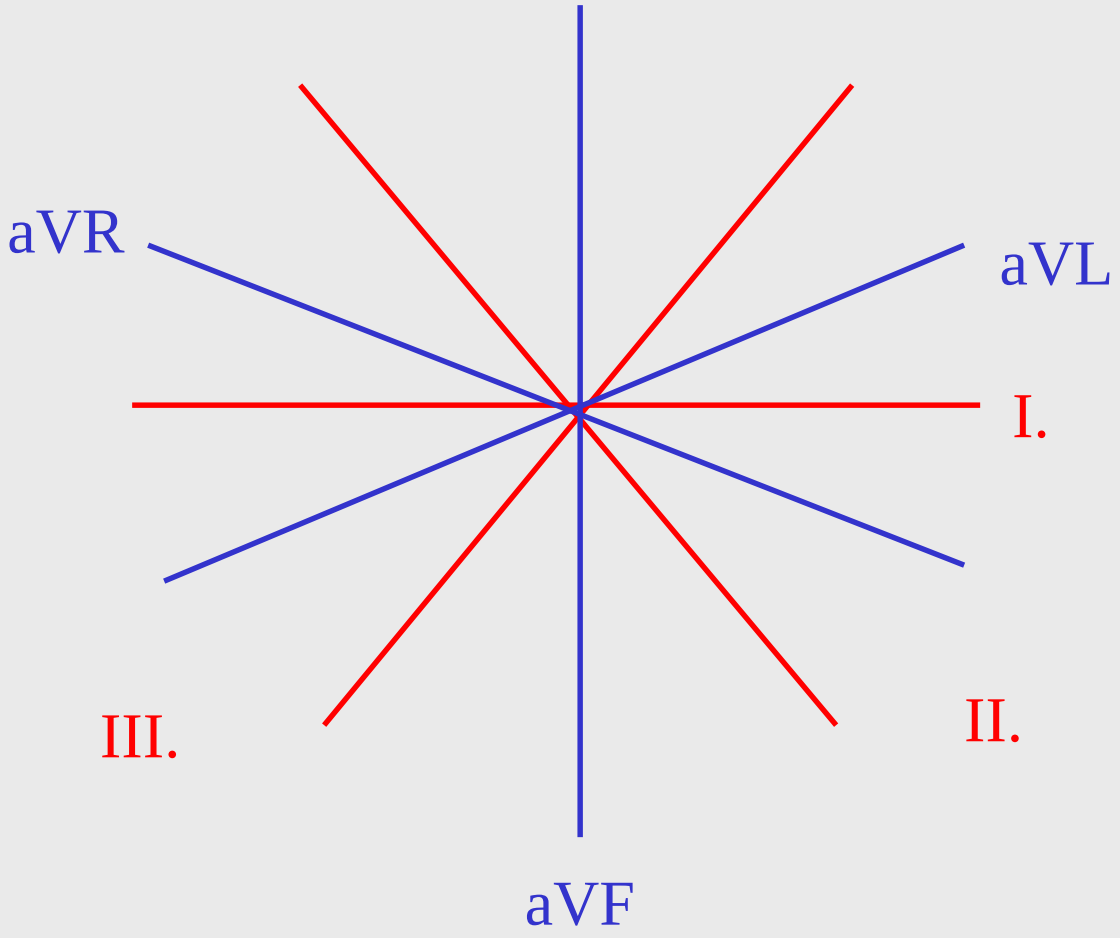


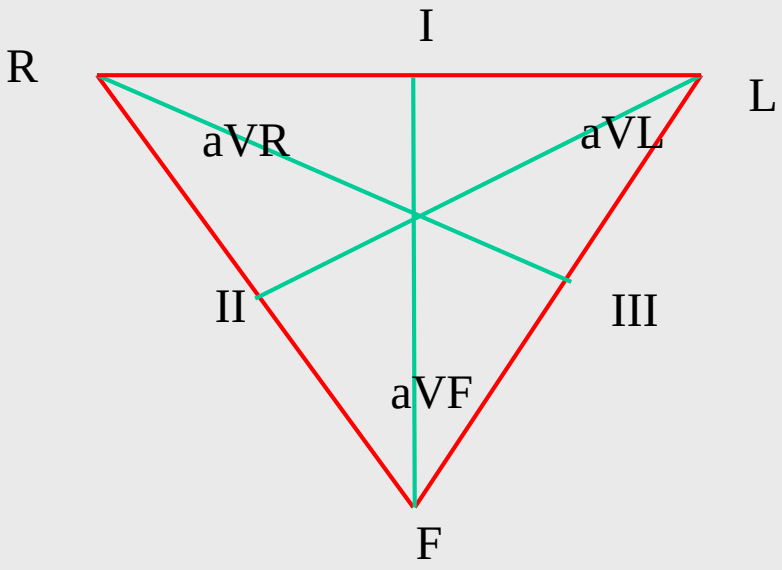
Wilson, 1934, VR, VL, VF



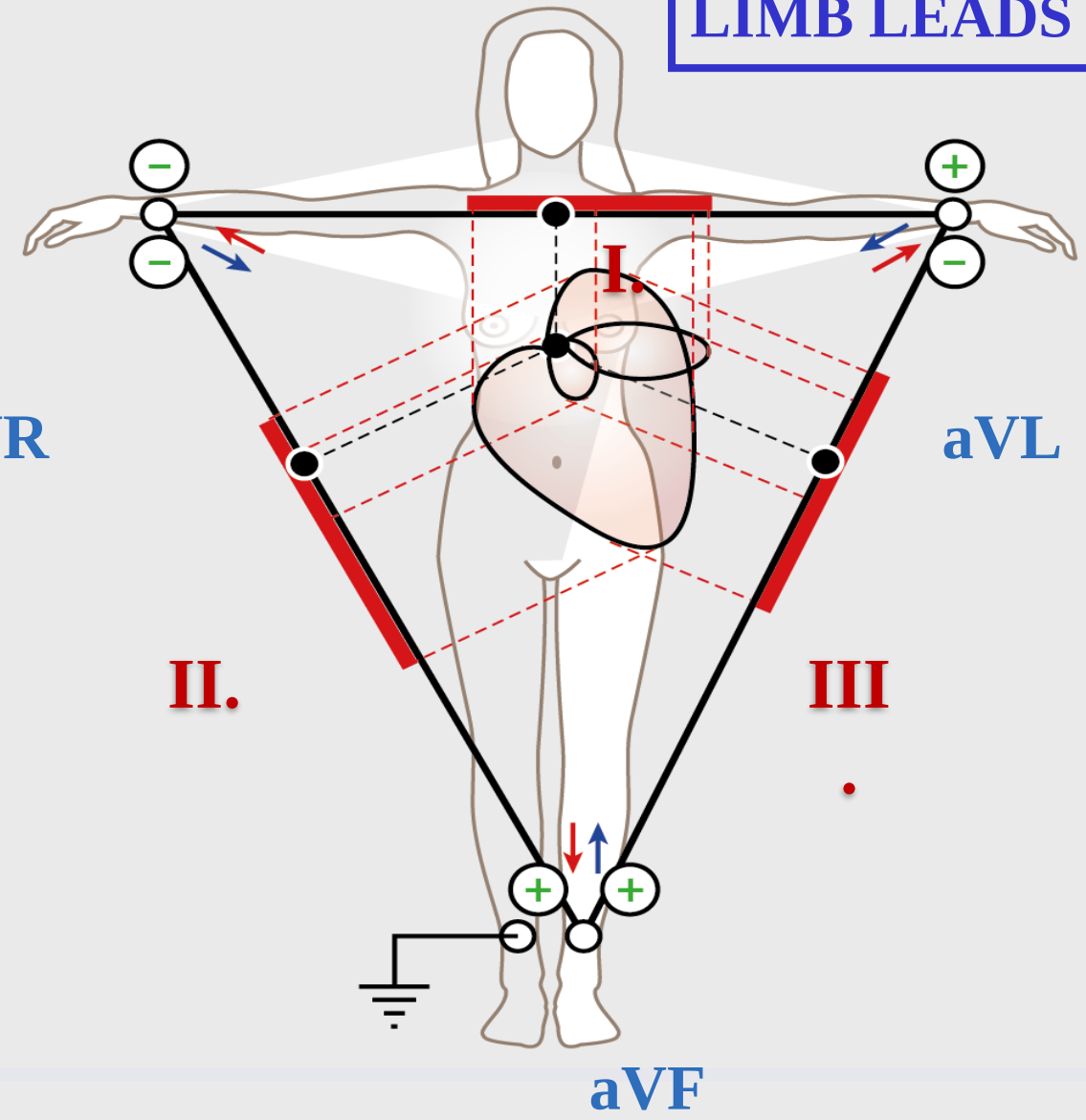
Goldberger, 1947, aVR, aVL, aVF

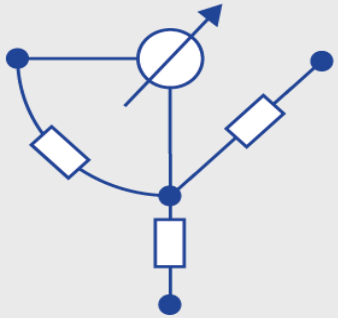
HEXAAXIAL SYSTEM



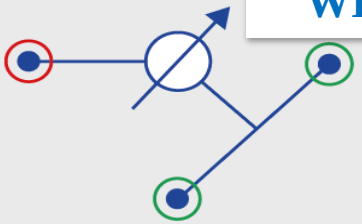

I
R
L
aVR
aVL
II
III
aVF
F

LIMB LEADS





WILSON

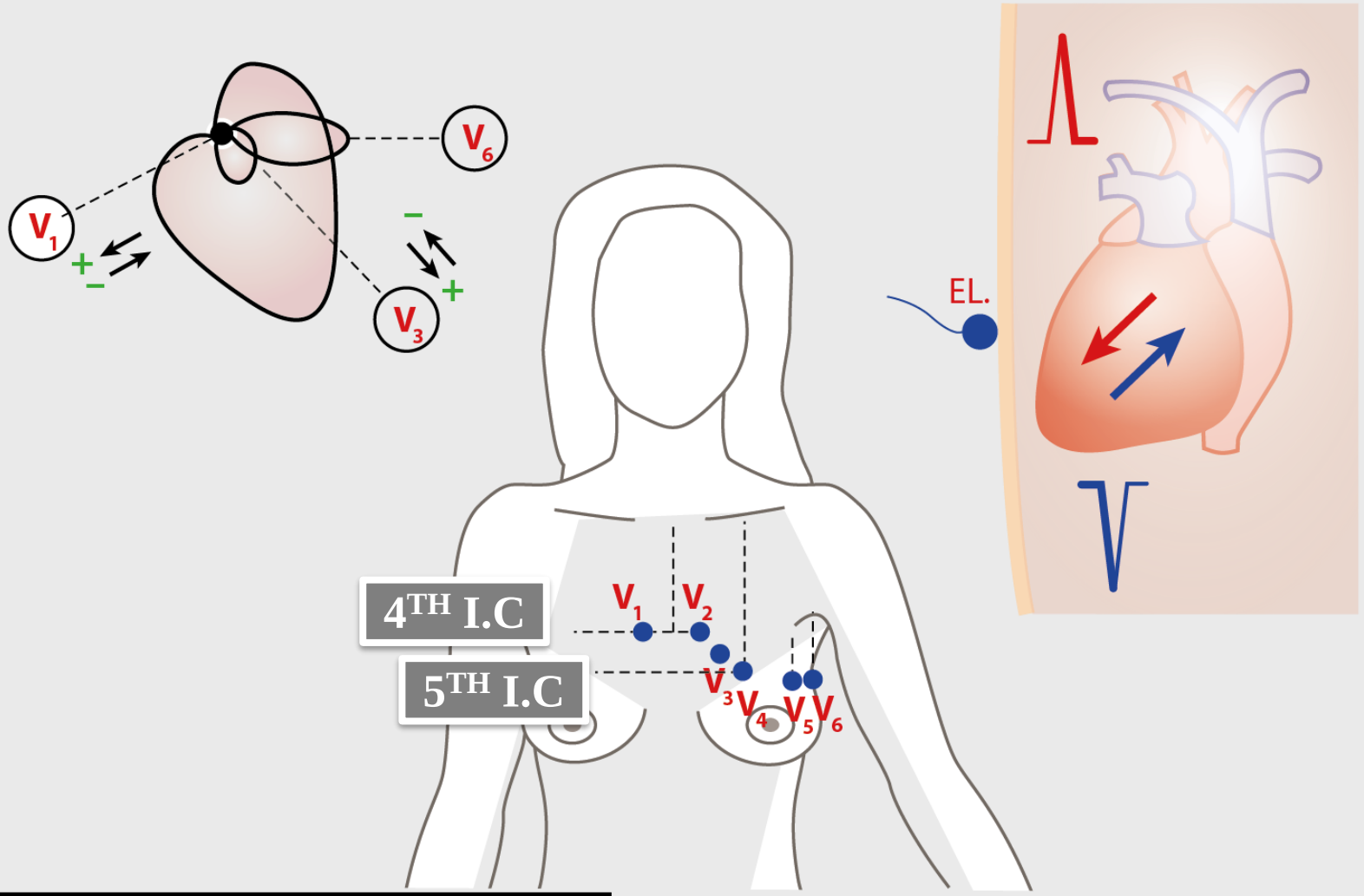


GOLDBERG
augmented

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

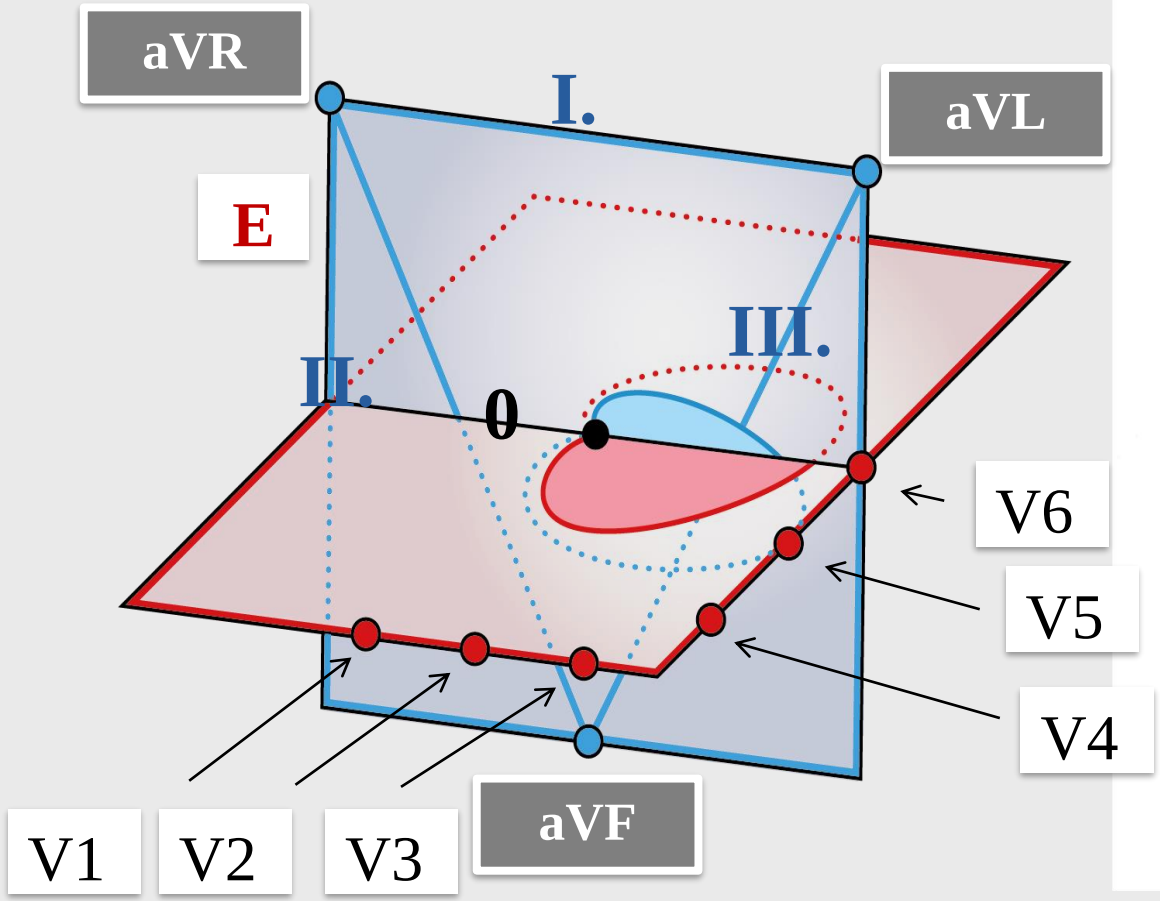
I., II., III., aVR, aVL, aVF

Horizontal plane

V1 – V6

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

E – Einthoven triangle

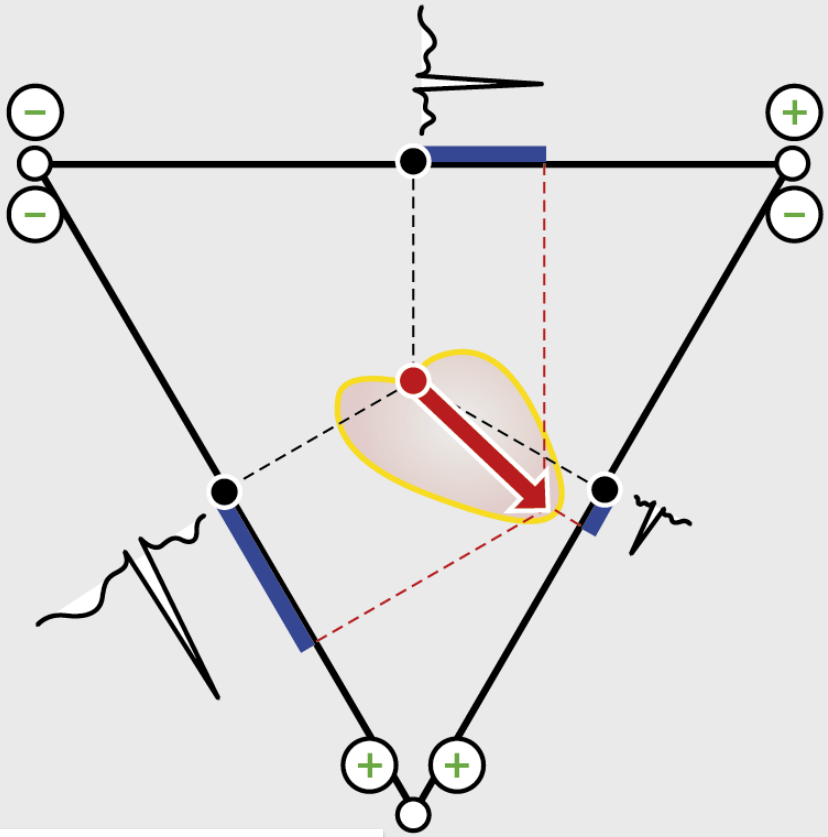


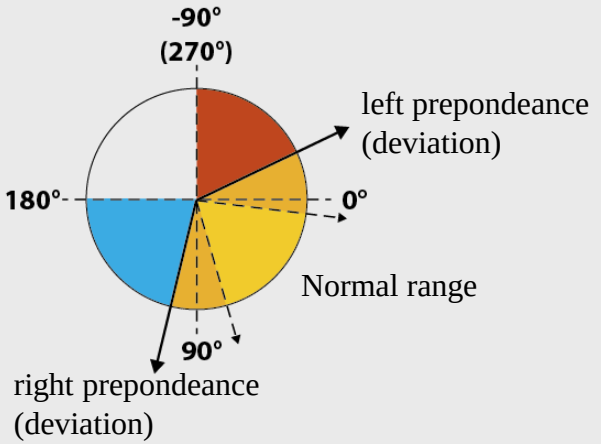
ELECTRICAL AXIS OF THE HEART

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.

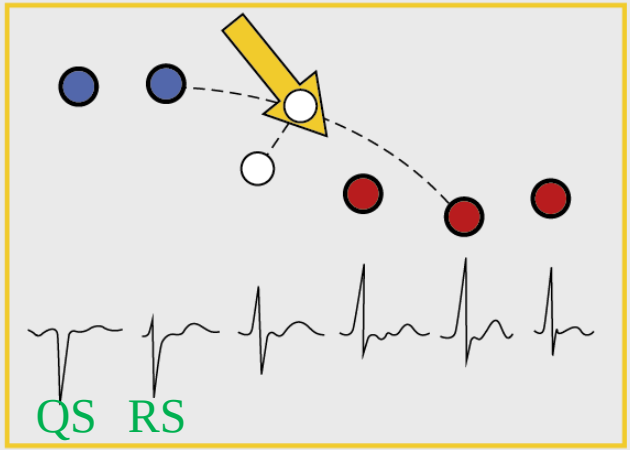




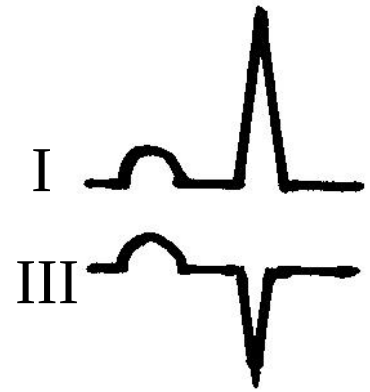
- **Eqilateral**

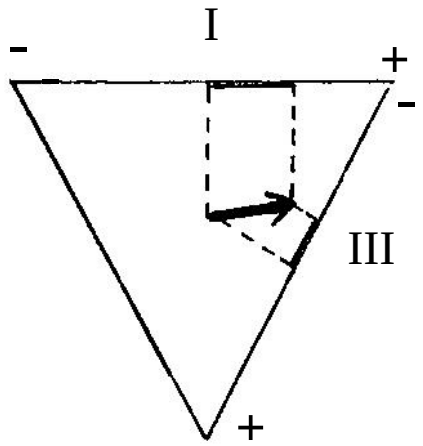
Einthoven triangle

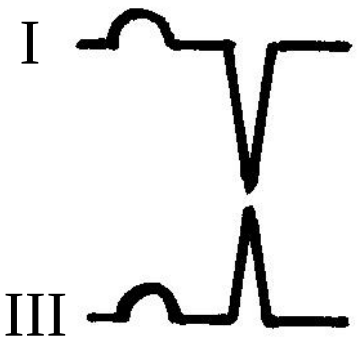
Terminology →

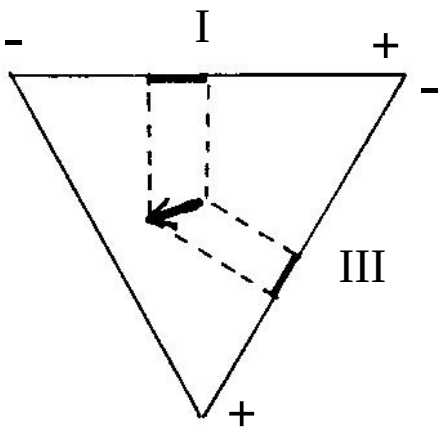


LEFT DEVIATION, RIGHT DEVIATION

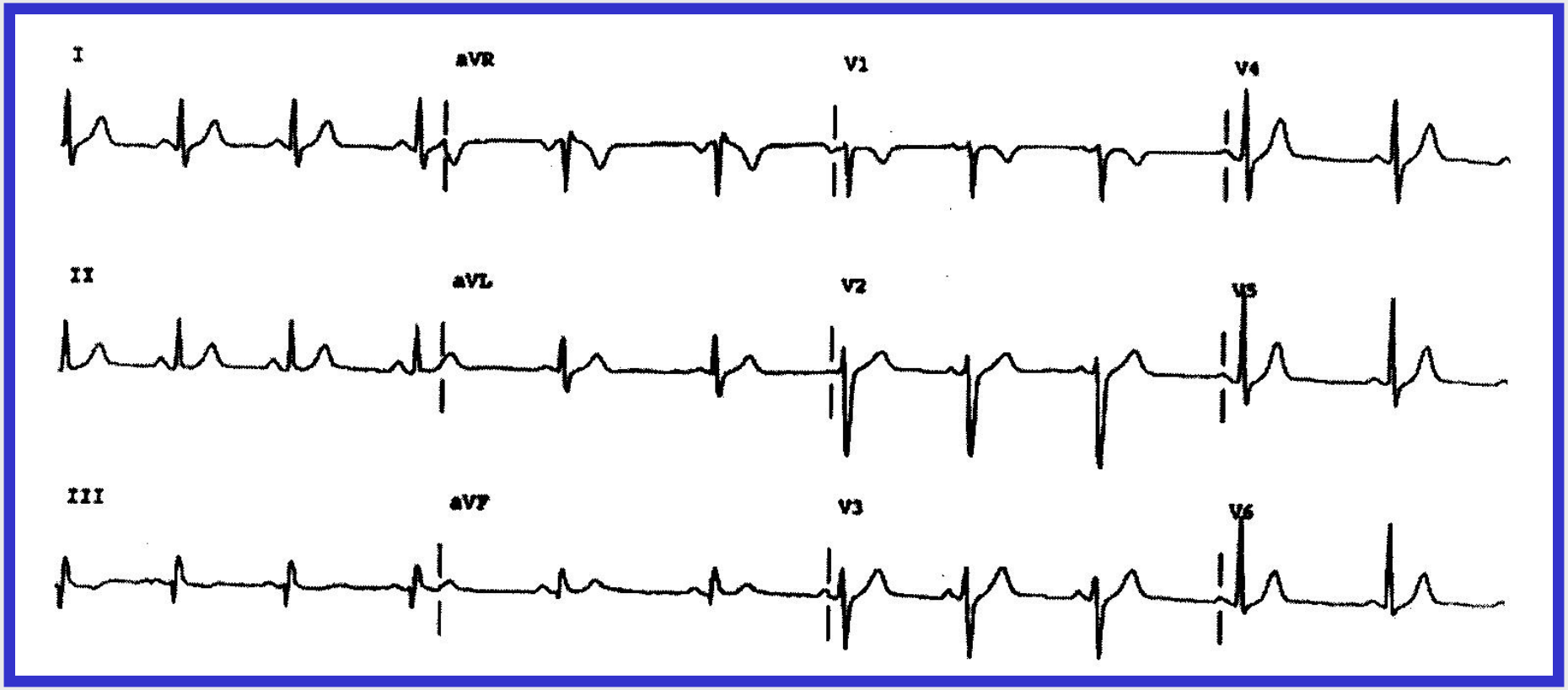






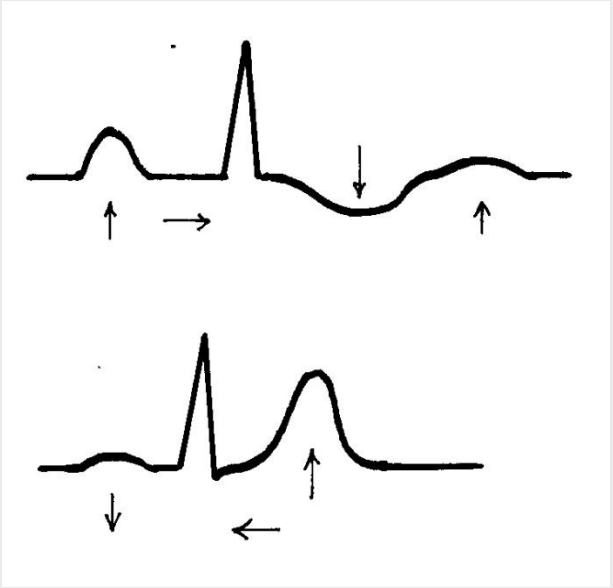


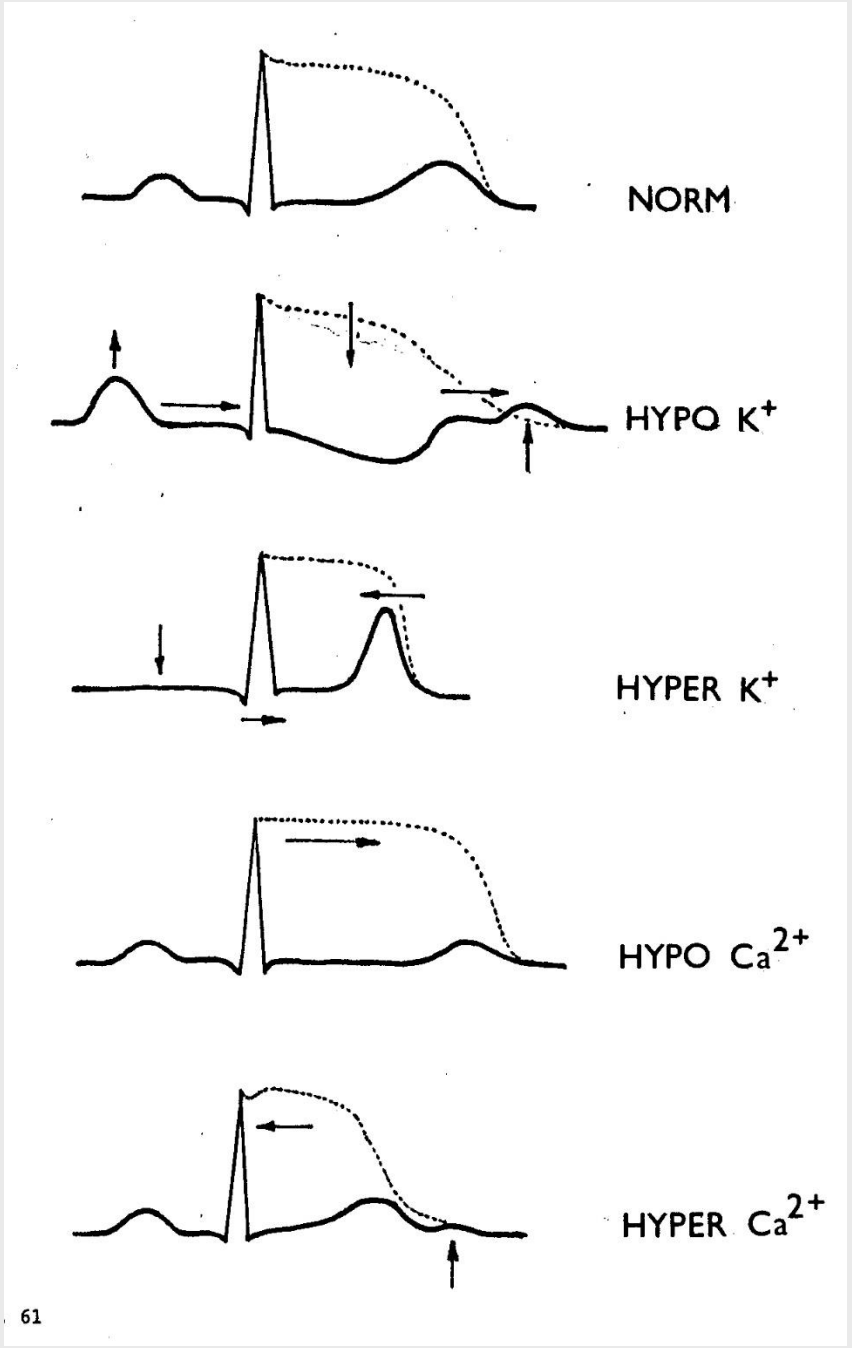
Physiological 12-lead electrocardiogram



ECG – information about:

1. Size and position of the heart (electrical axis)
2. Site of impulse origin (P, QRS)
3. Conduction path (P-Q, QRS)
4. Impulse regression – repolarization progress (T)
5. Rhythm (P-P, R-R)
6. Action potential alterations (ST, T)
7. Effect of drugs, remedies, ion composition changes,…





Štejfa et al.: Základy elektrokardiografie, 1991

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, $paCO_2$

Central mechanisms

- Central generator of RSA
- Respiratory neurons in medulla oblongata hyperpolarise preganglionic vagal neurons
- Vagal tonus decreases during inspiration – HR increases

Reflexes from lungs – inflation reflexes

- Stimulation of vagal stretch-receptors during inspiration

  supresses inspiratory centre and also cardio-inhibitory

  centre in medulla oblongata

Reflexes from baroreceptors

- Diverse opinions about the effect of arterial baroreceptors on RSA
- Fluctuation of sensitivity of baroreceptors during respiratory cycle

Reflexes from receptors in the right atrium

- Bainbridge, 1915
- Reflex increase of HR during atria stretching
- Applicable in explanted (denerved) heart

Local effects on SA node

- Stretching of SA node causes faster spontaneous depolarisation
- Effect of mechanosensitive chloride channels
- Changes of SA node perfusion (a. centralis) and possible compression of SA node by expanding lungs

Effect of pH, p_aO_2 and p_aCO_2 oscillations

- Oscillatory activity of peripheral chemoreceptors contributes to formation of RSA and increases its amplitude

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)

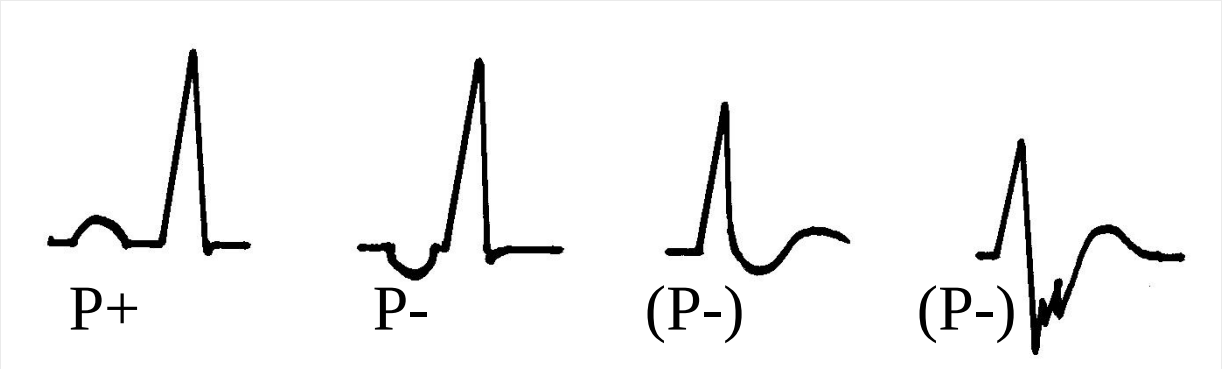
Irregular

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

ARHYTMIAS

SITE OF ORIGIN

SINUS ATRIA JUNCTION VENTRICLES



- Polarity of P wave
- PQ interval (QP)

(physiological PQ interval: 0.12 – 0.2 s)

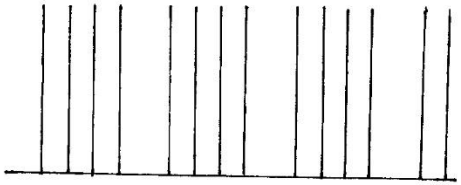
BLOCKS

- SICK SINUS SYNDROM
- **AV BLOCKS**

I°

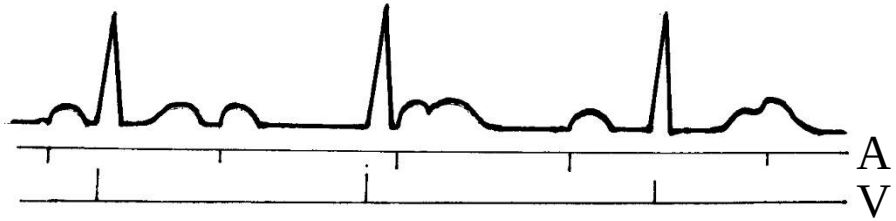
PQ>0.2sec

II°



Wenckebach periods (phenomenon)

III°



A-V dissociation

LBBB

RBBB

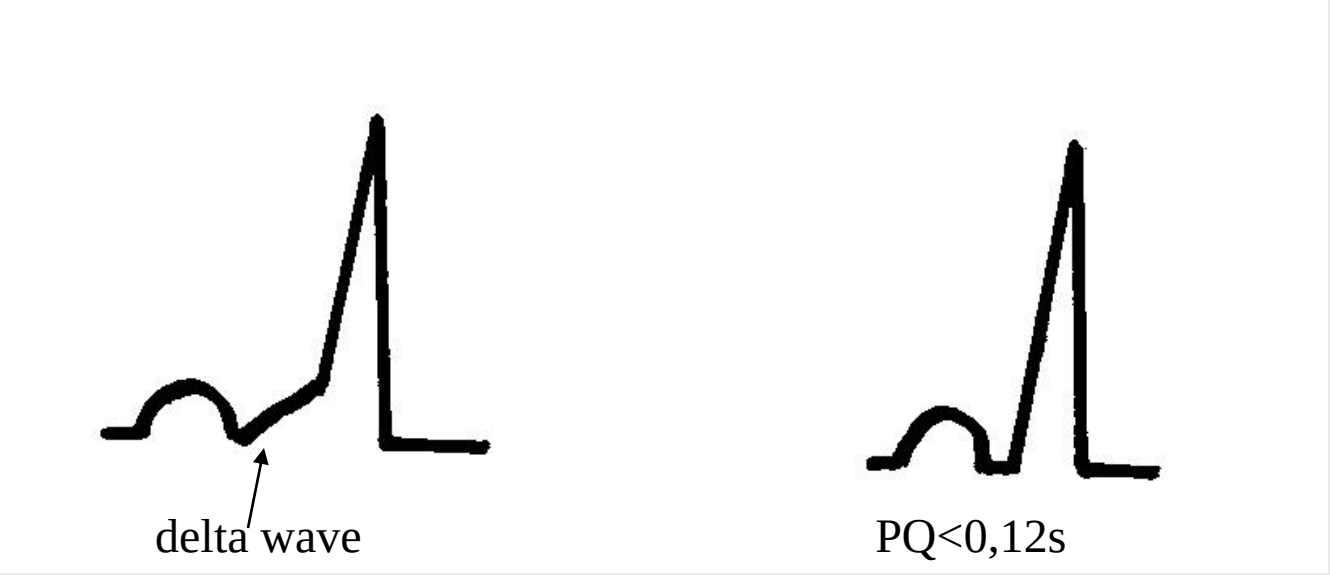
- **BUNDLE BRANCH BLOCK (BBB) – LEFT, RIGHT**

PREEXCITATION

AV node is „by-passed“, fast conduction

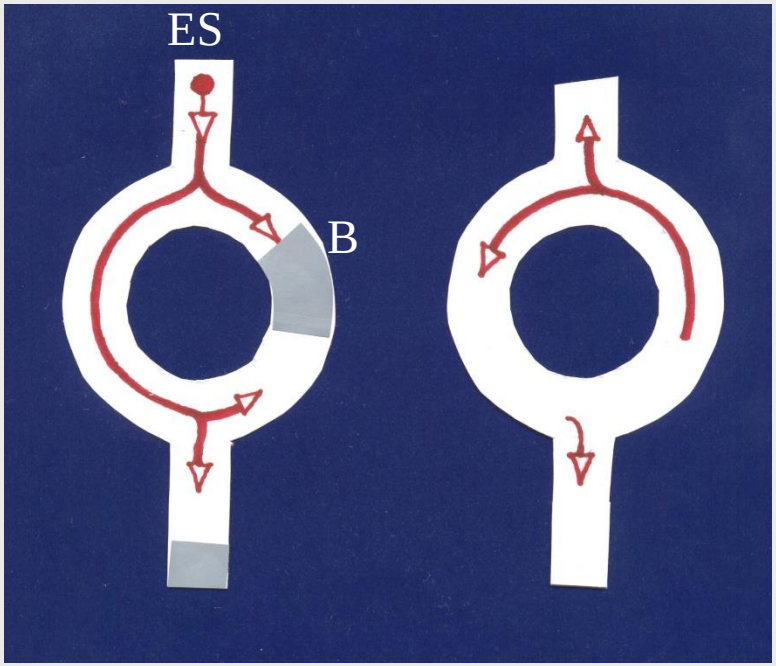
•„short nodus“

•Wolf-Parkinson-White syndrome (WPW) – sensitive to paroxysmal tachycardia – see re-entry



REENTRY

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



- Double pathway
  Diverging and converging of excitation pathways
- Unidirectional block

1. Long refractory period
2. Slowed conduction
3. Reentry

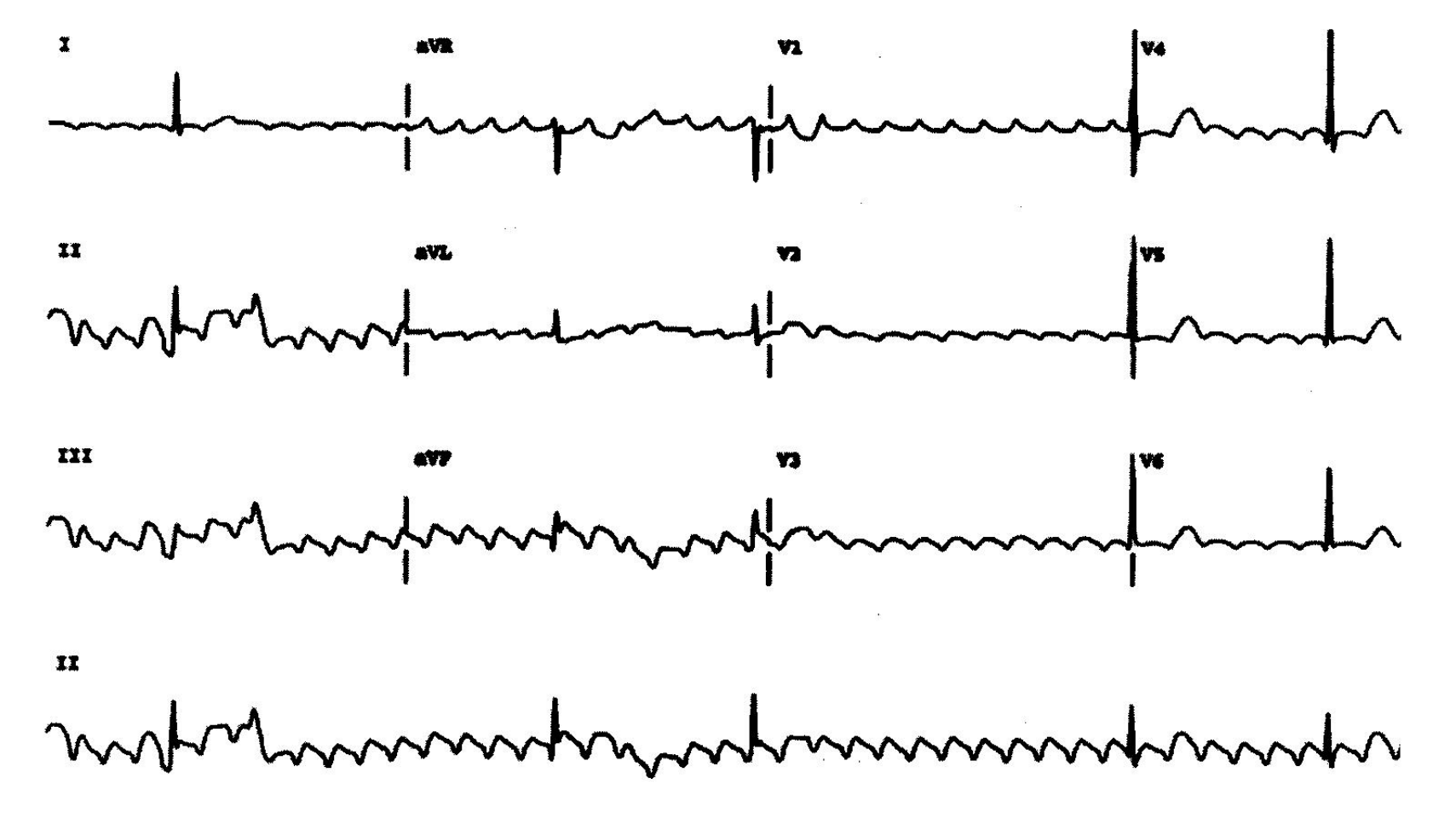
- **Loops most often at the level of AV junction**
- **Determinants of re-entry**:

1. Proper dimension of the loop
2. Proper timing of the trigger ES

TACHYARYTHMIA

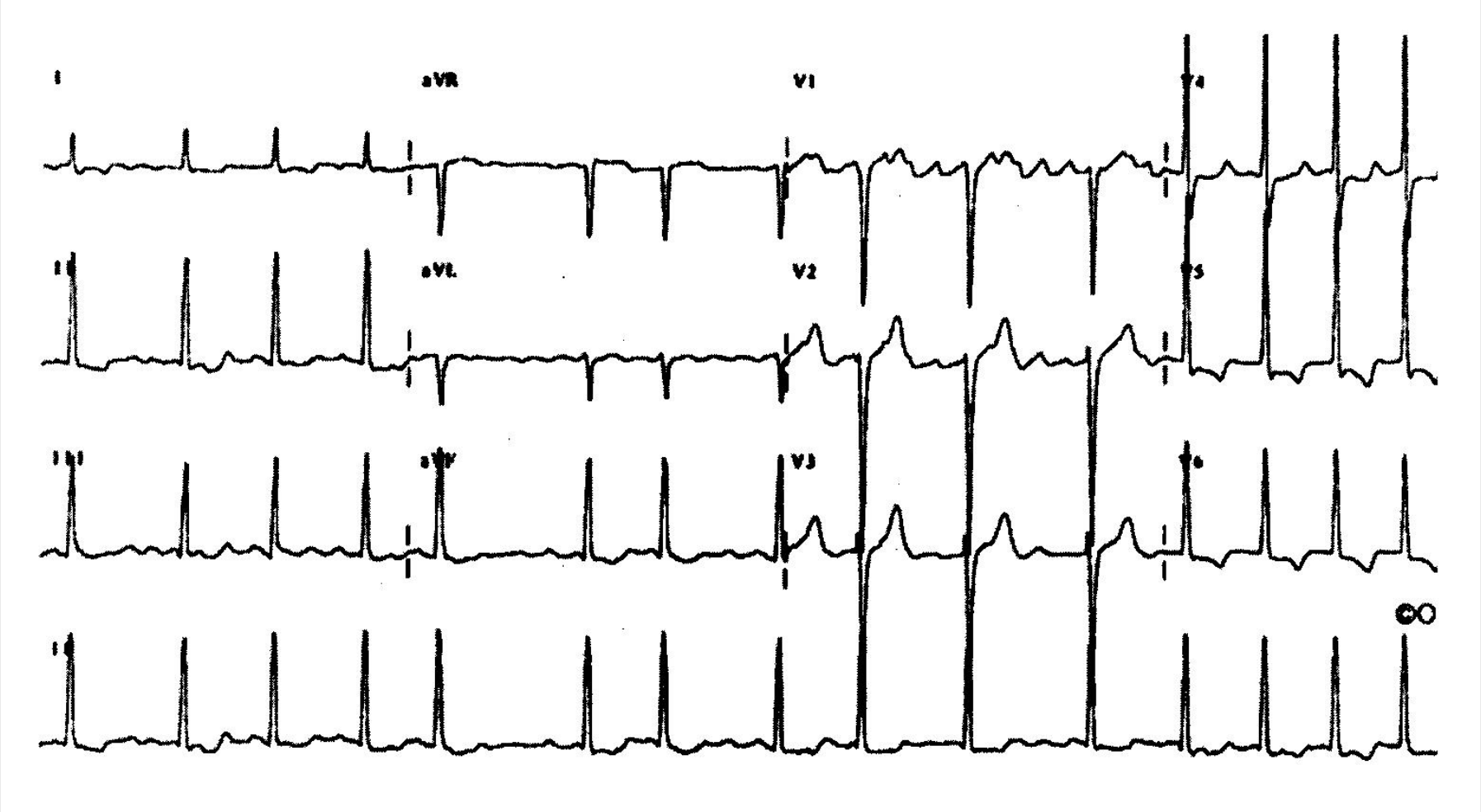
- **SINUS TACHYCARDIA**
- **PAROXYSMAL TACHYCARDIA** (supraventricular, ventricular)
- **FLUTTER** (>250/min; atrial)
- **FIBRILLATION** (>600/bpm; **atrial**, **ventricular**; breakdown of electrical homogeneity)

ATRIAL FLUTTER



Frequency 250 – 600/bpm
Atrioventricular block n:1

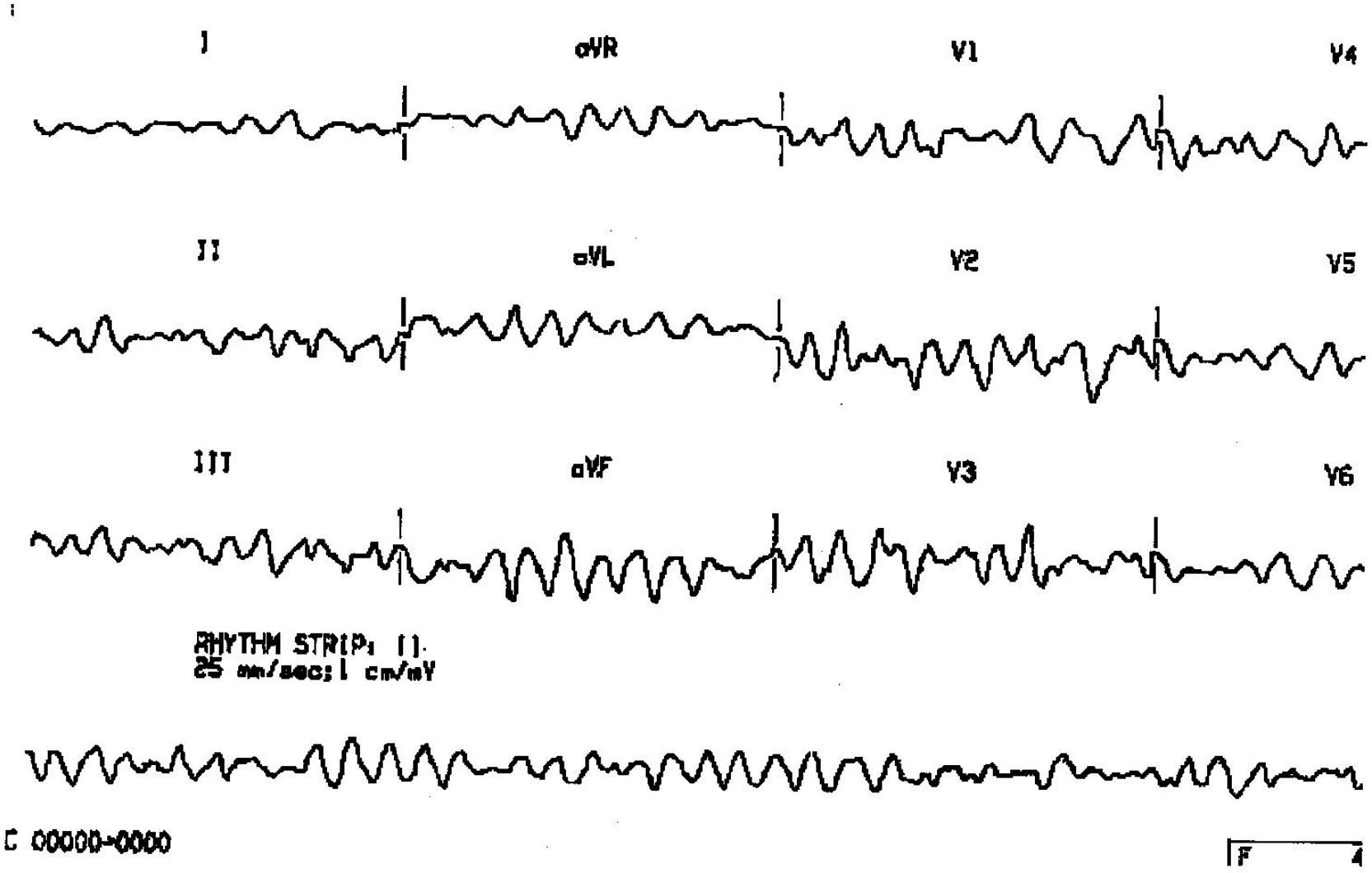
ATRIAL FIBRILLATION



Irregular ventricular rhythm

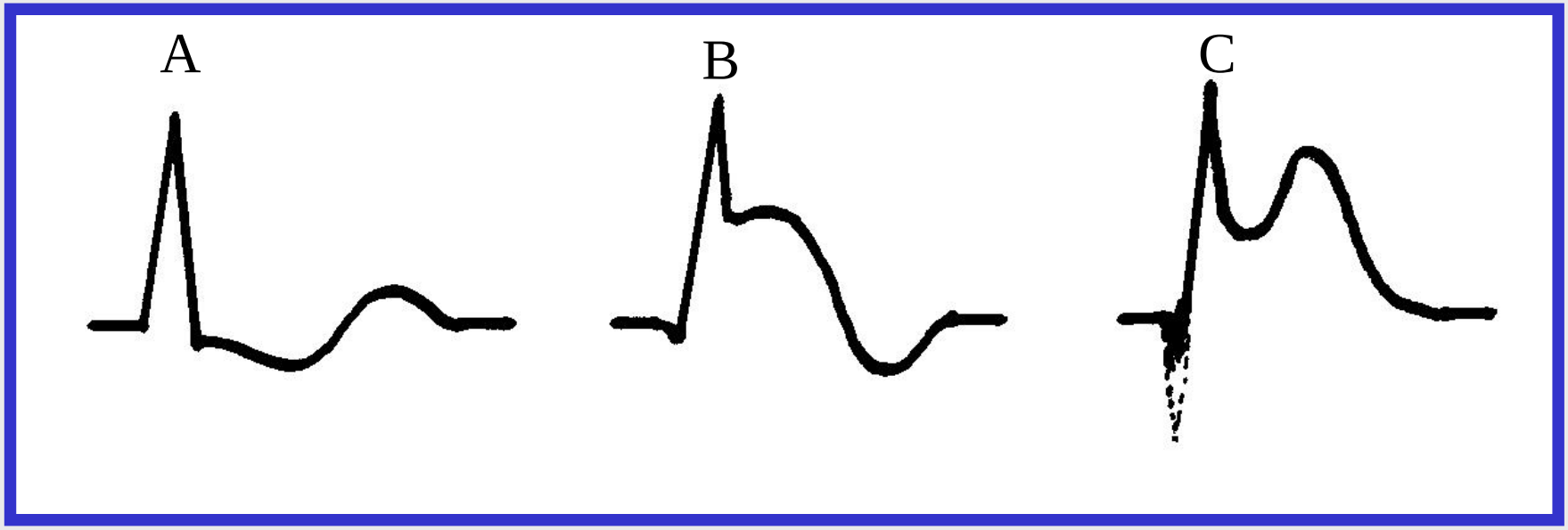
+ f-waves

VENTRICULAR FIBRILLATION



Frequency above 600/bpm, LETHAL

HEART ISCHEMIA



A: exercise angina pectoris
B: acute non-Q myocardial infarction
C: acute Q myocardial infarction

ANTIARRHYTHMICS

- BLOCKERS OF Na CHANNEL – prolong inactivation of I_{Na}, e.g. refracterity, „blocking“ fast ways
- BLOCKERS OF Ca CHANNELS – „blocking“ fast ways
- BLOCKERS OF K CHANNEL – prolonging refractory period
- β-SYMPATOLYTICS – slowing HR

Schémata a animace zpracovalo

Servisní středisko pro e-learning na MU

http://is.muni.cz/stech/

CZ.1.07/2.2.00/28.0041
Centrum interaktivních a multimediálních studijních opor pro inovaci výuky a efektivní učení

evropský sociální fond v ČR
EVROPSKÁ UNIE
MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY
OP Vzdělávání pro konkurenceschopnost
UNIVERSITAS MASARYKIANA BRUNENSIS

INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ