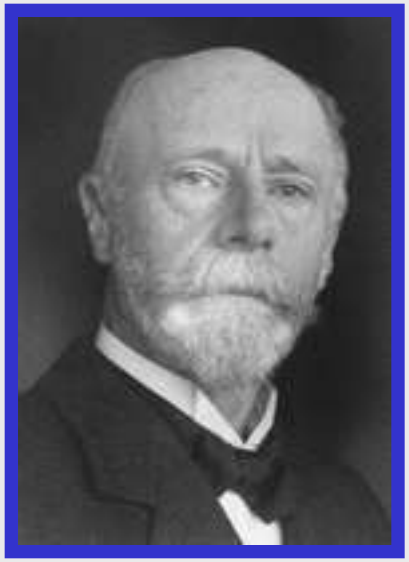
ELECTROCARDIOGRAPHY



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

Willem Einthoven

1860 - 1927

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

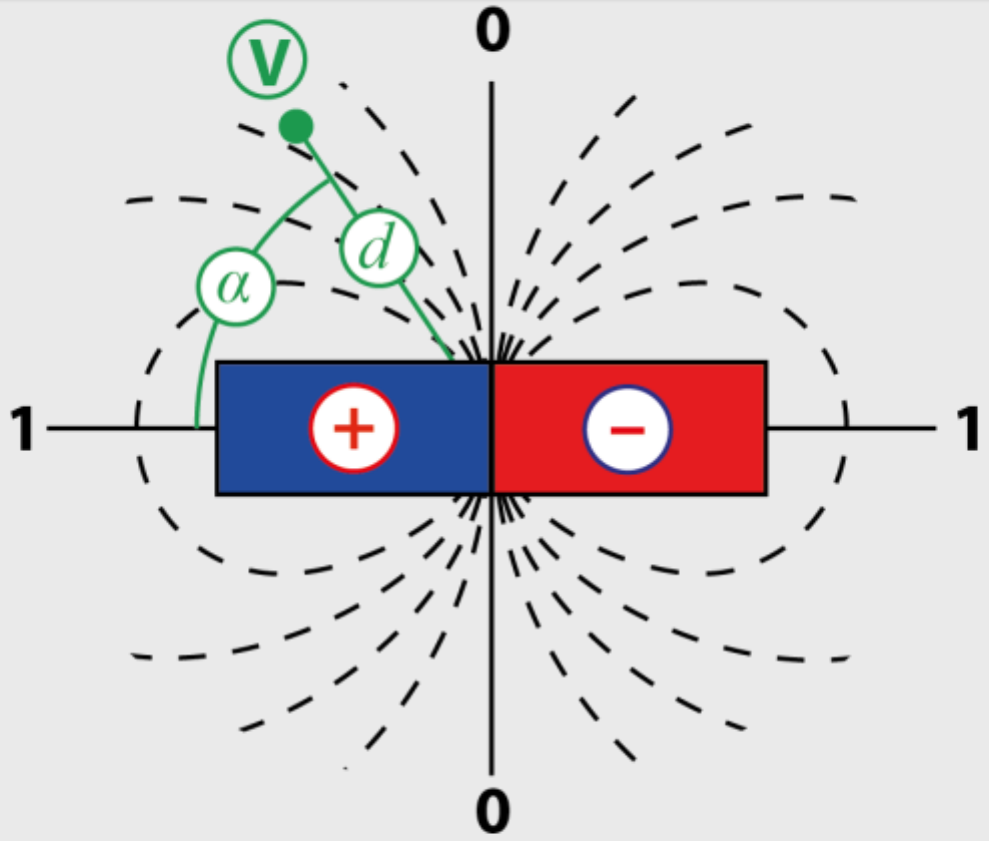
ECG – information about:

1. Frequency disorders (changes of HR in SA node or arrhythmias, sick sinus syndrome)
2. Conduction disorders (blocks – SA, AV)
3. Rhythm disorders (ES – supraventricular, ventricular)
4. Disorders of ventricular gradient (relationship between depolarisation and repolarisation:

origin – metabolic, haemodynamic, anatomic, physical…ischemia, hypertrophy, dilatation, cardiomyopathy, inflammations, changes in electrolytes, drugs…)

ELECTRICAL DIPOLE

stationary in homogenously conducting environment



Local currents

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

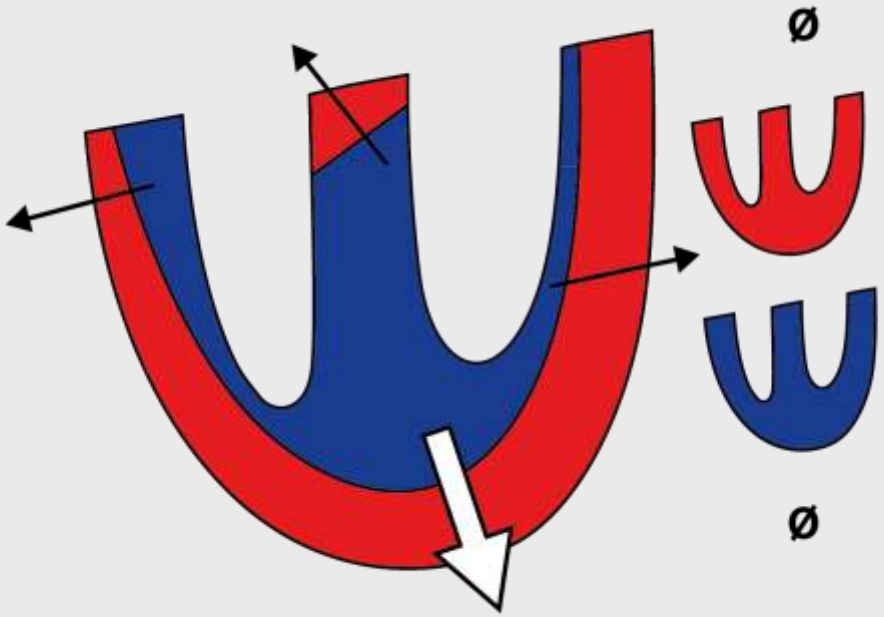
SPREADING OF DEPOLARIZATION FRONT

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

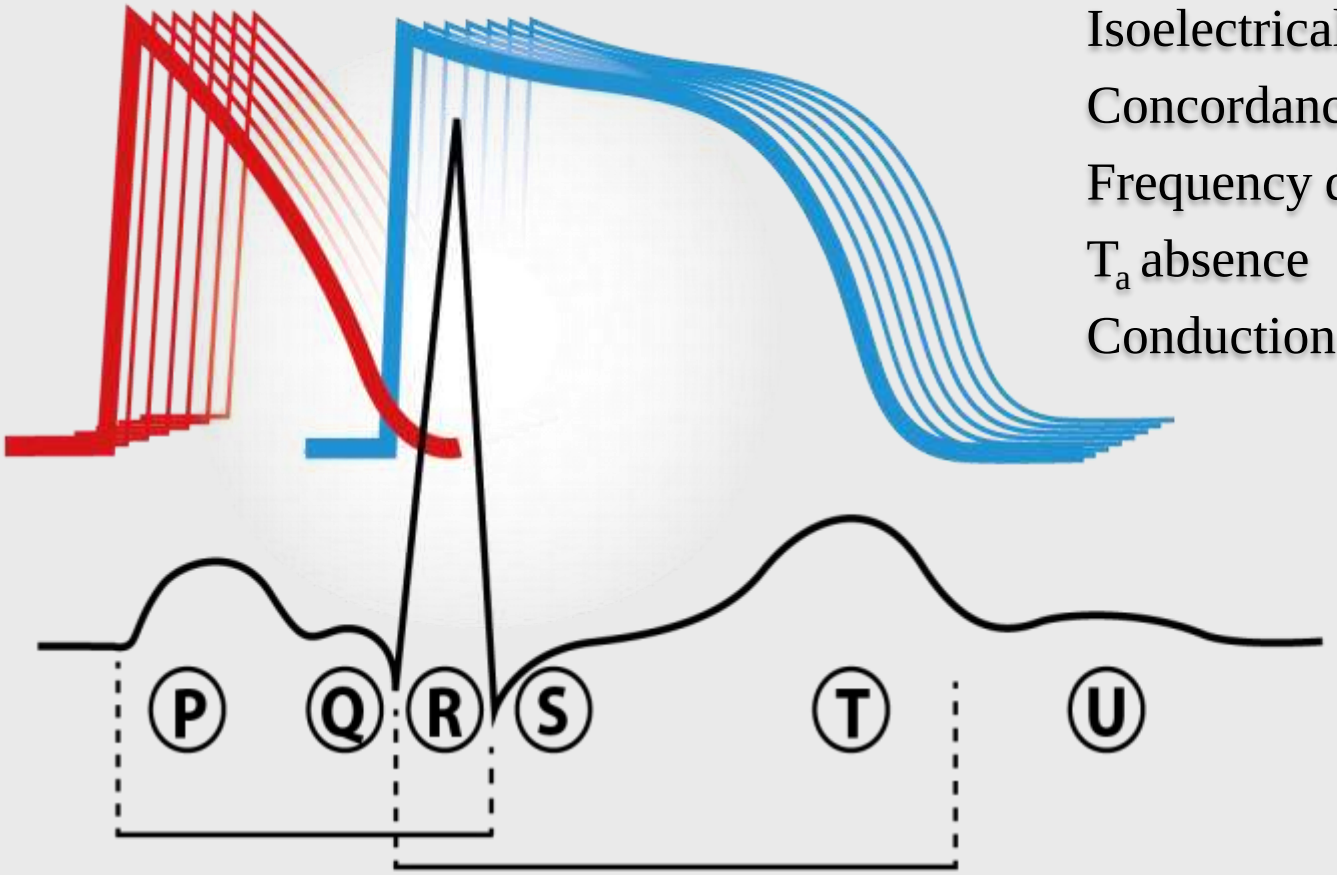


REGIONAL VECTORS
INTEGRAL VECTOR
during excitation is changing:

•Size of momentary dipoles

•Their direction

•They are spreading to body surface – ELECTROCARDIOGRAPHY



Isoelectrical segments

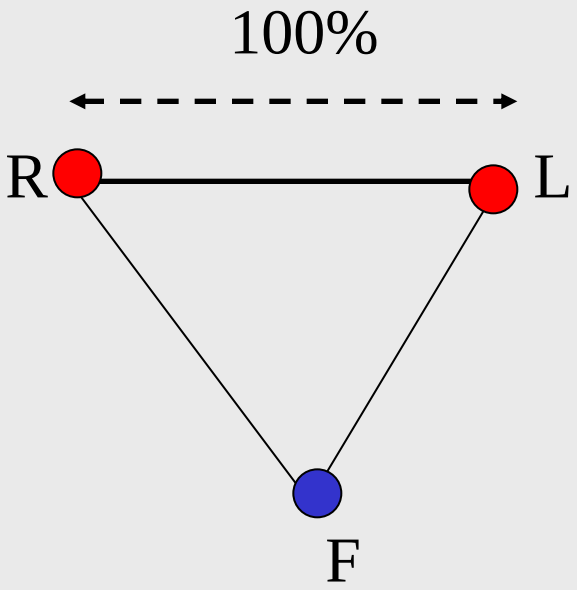
Concordance of T wave

Frequency dependence

T_a absence

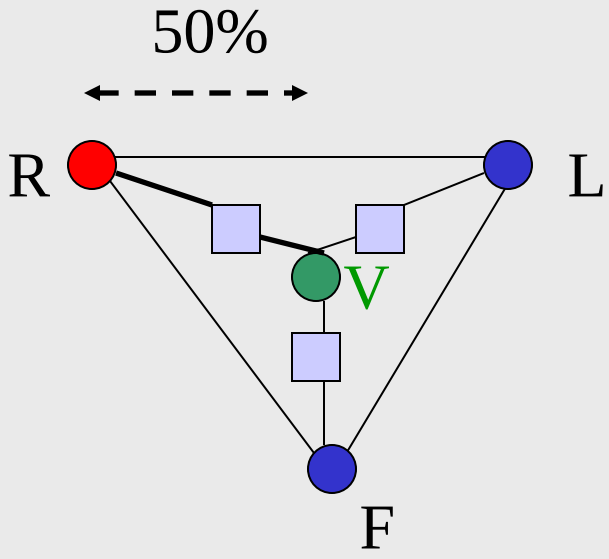
Conduction system

HR – dependent

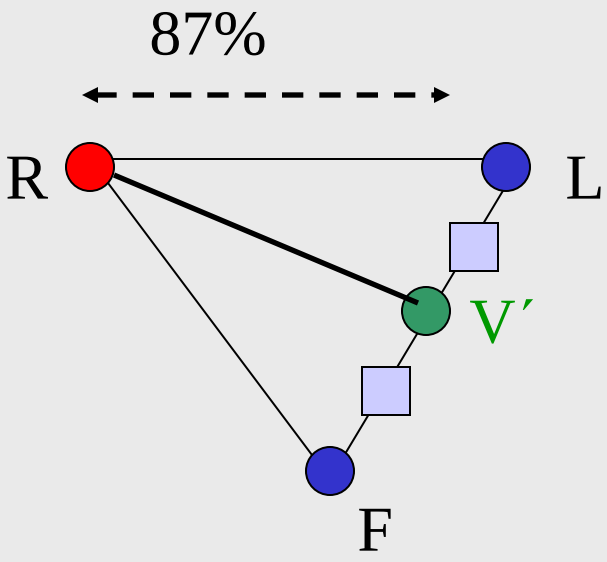


Einthoven, 1913

I, II, III

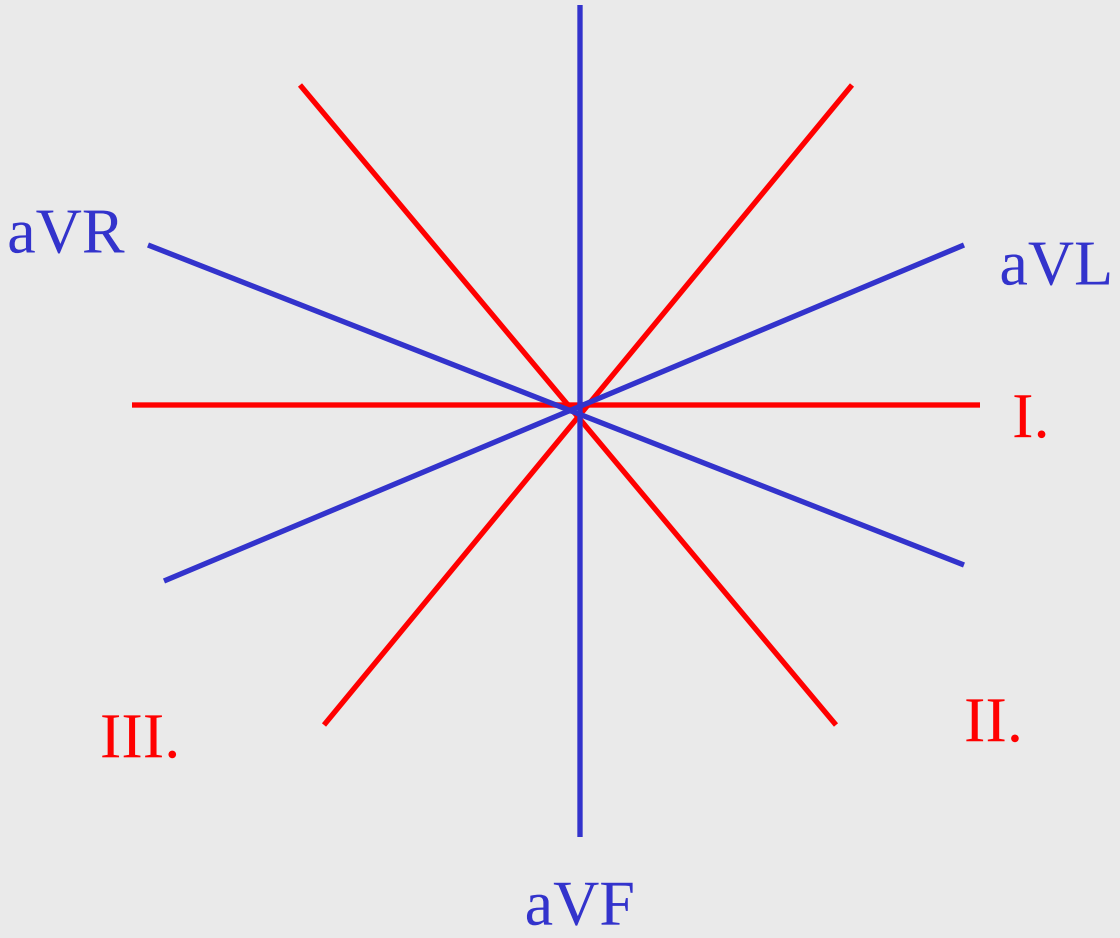


Wilson, 1934, VR, VL, VF

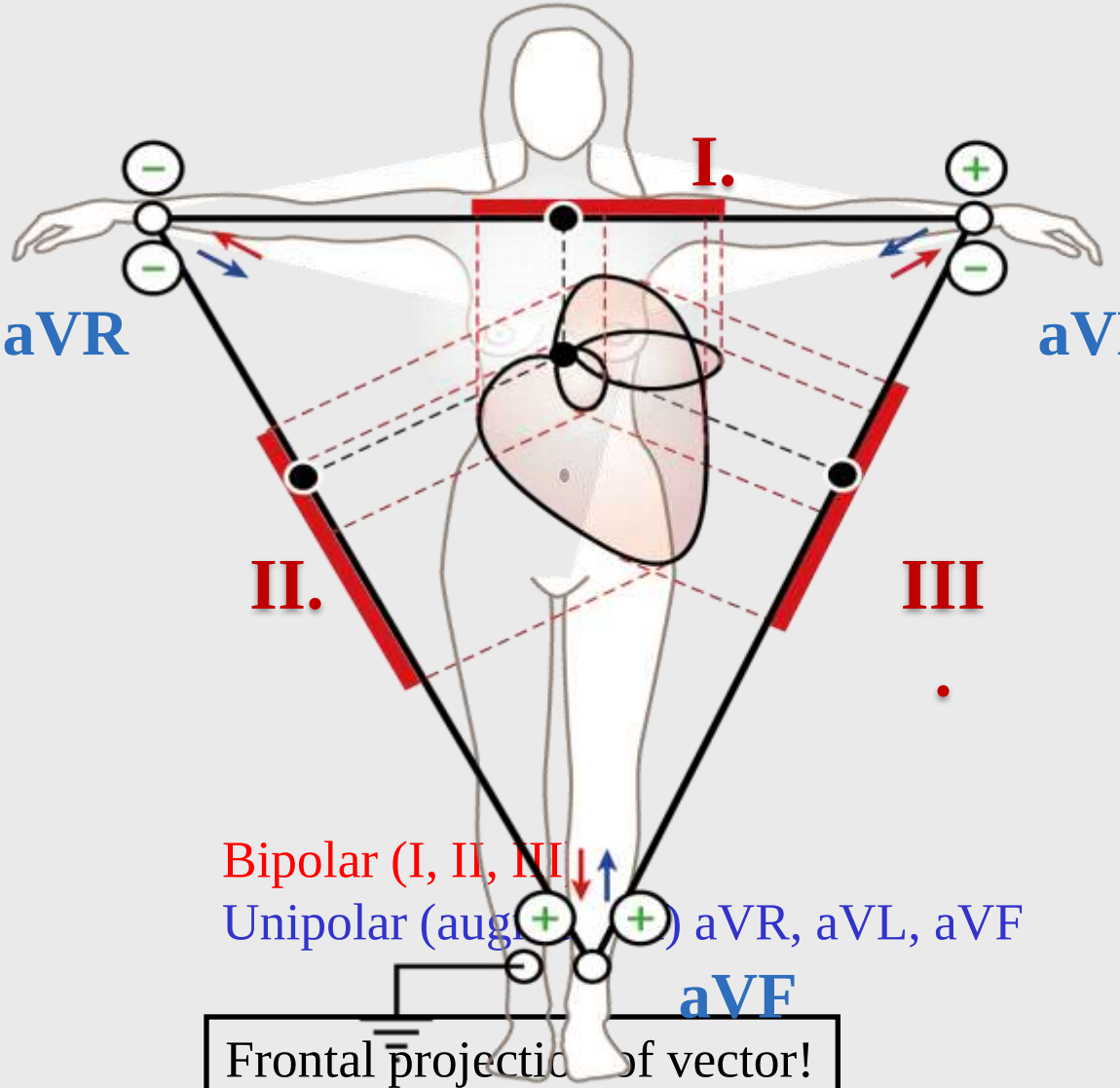


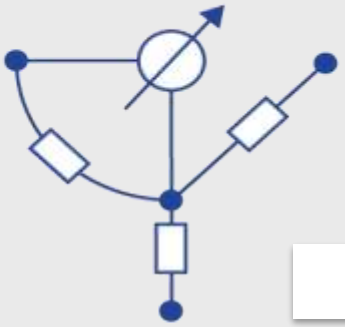
Goldberger, 1947, aVR, aVL, aVF

HEXAAXIAL SYSTEM

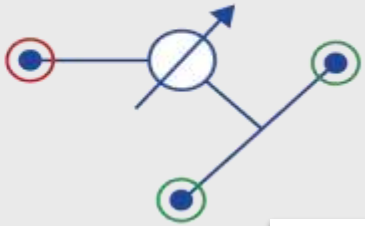


LIMB LEADS



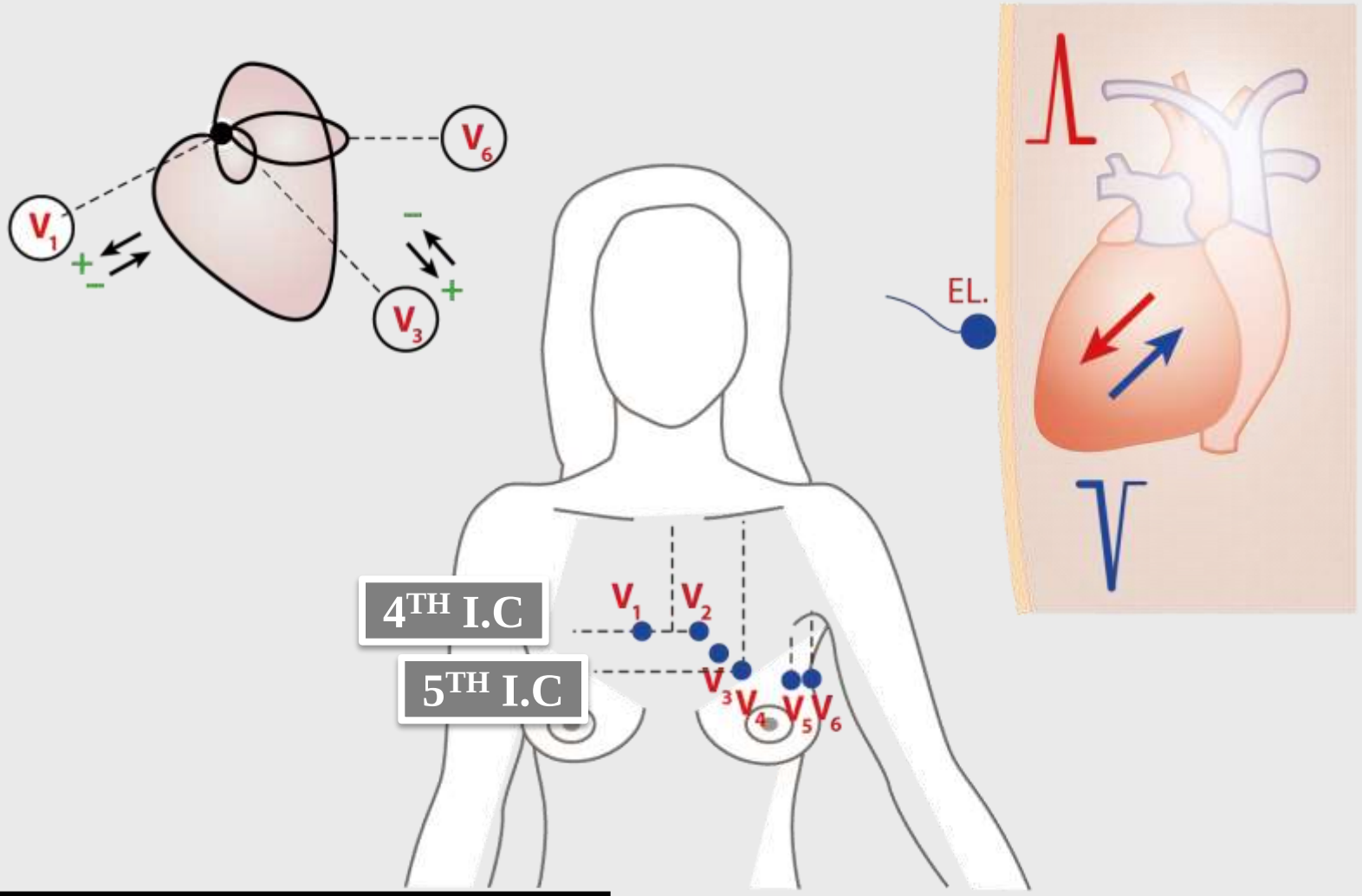


WILSON



GOLDBERG
augmented

CHEST LEADS



Horizontal projection of vector!

PROJECTION PLANES OF CARDIAC VECTOR AND ECG LEADS

Frontal plane

limb leads

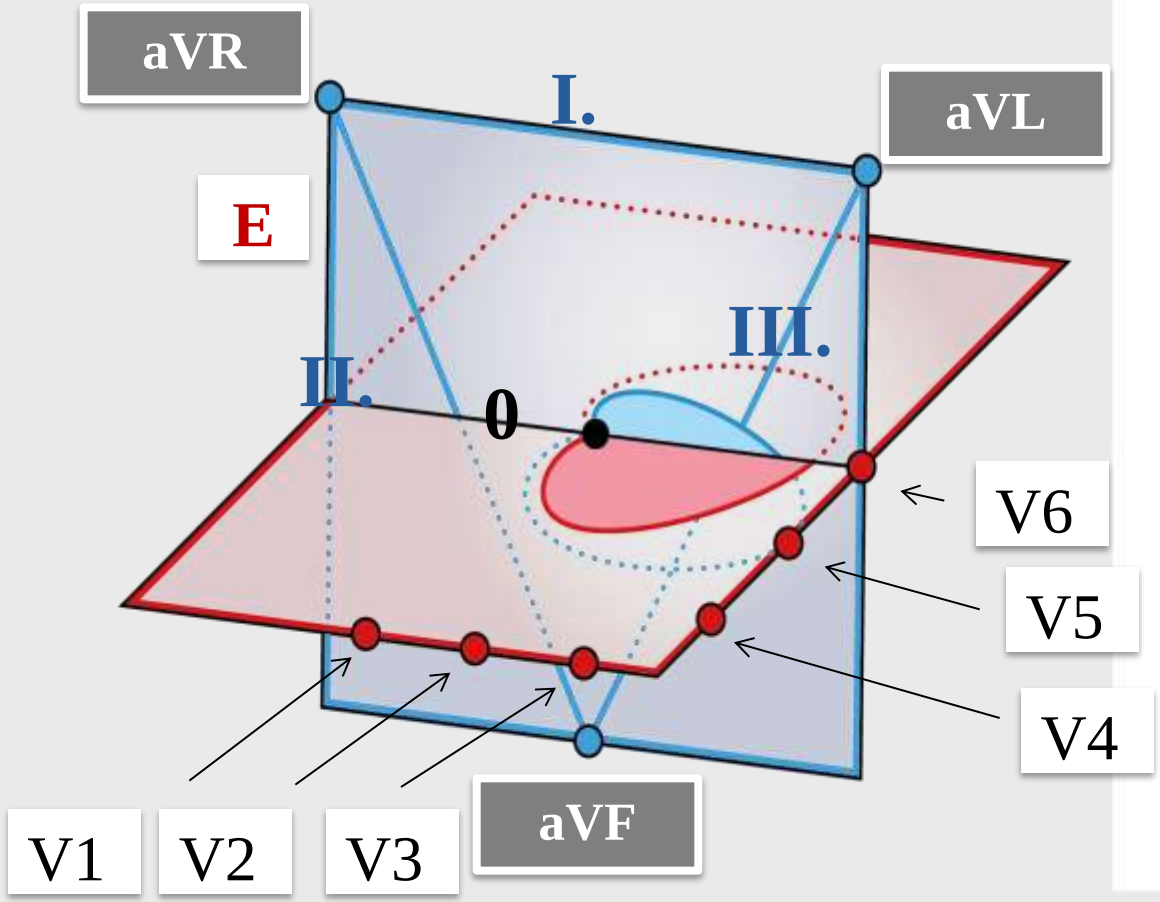
I., II., III., aVR, aVL, aVF

Horizontal plane

V1 – V6

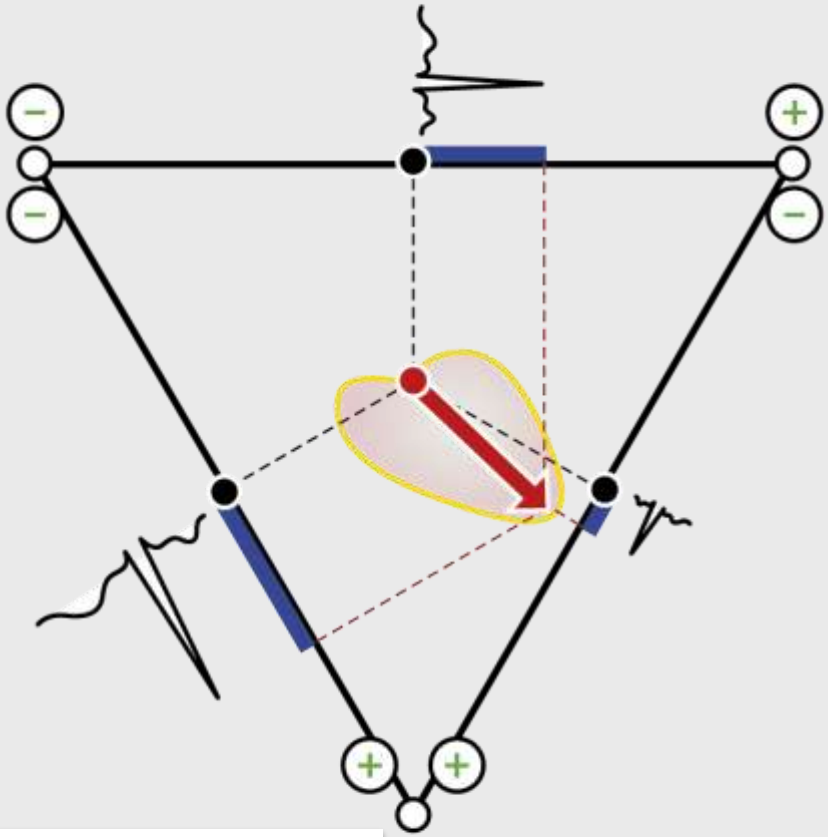
Both planes are shifted into the level
of electrical centre of the heart (0)

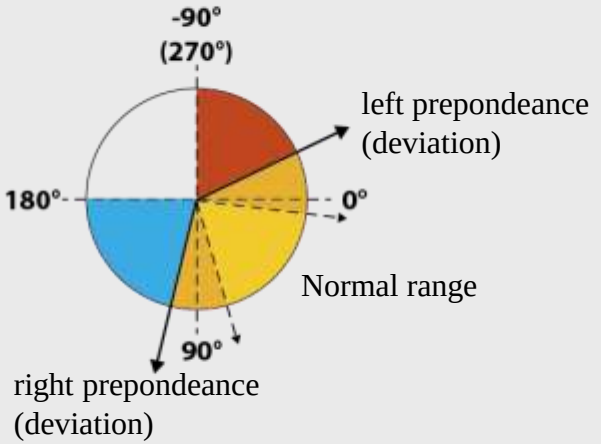
E – Einthoven triangle



ELECTRICAL AXIS – in frontal plane

(R–Q–S) in lead I., II., III.

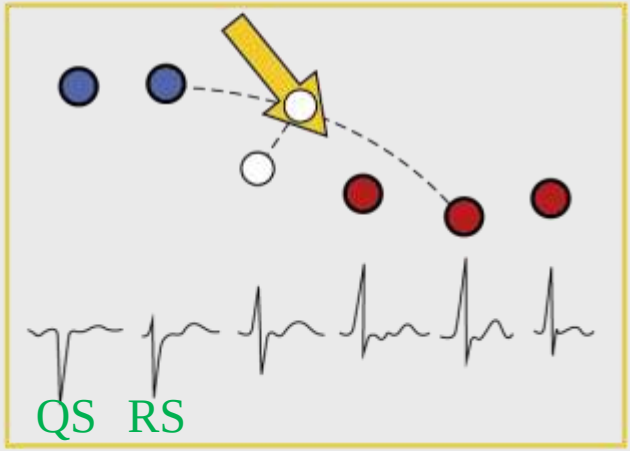




- **Eqilateral**

Einthoven triangle

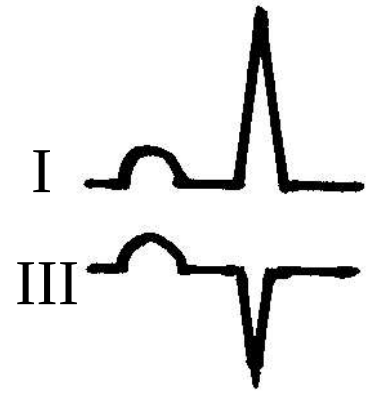
Terminology →

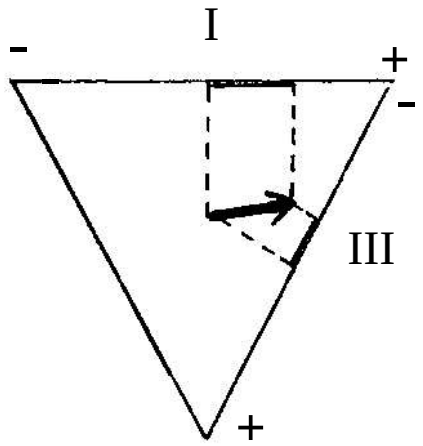


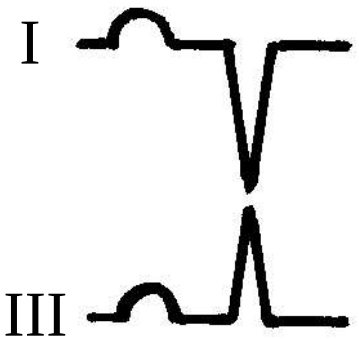
ELECTRICAL AXIS OF THE HEART

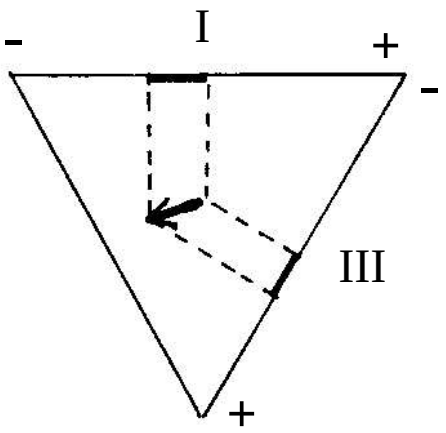
Summary of all momentary vectors, which form ventricular depolarisation loop. Expresses the direction of ventricular activation. Reflects asymmetry in ventricular wall thickness and the position of the heart in the chest.

LEFT DEVIATION, RIGHT DEVIATION

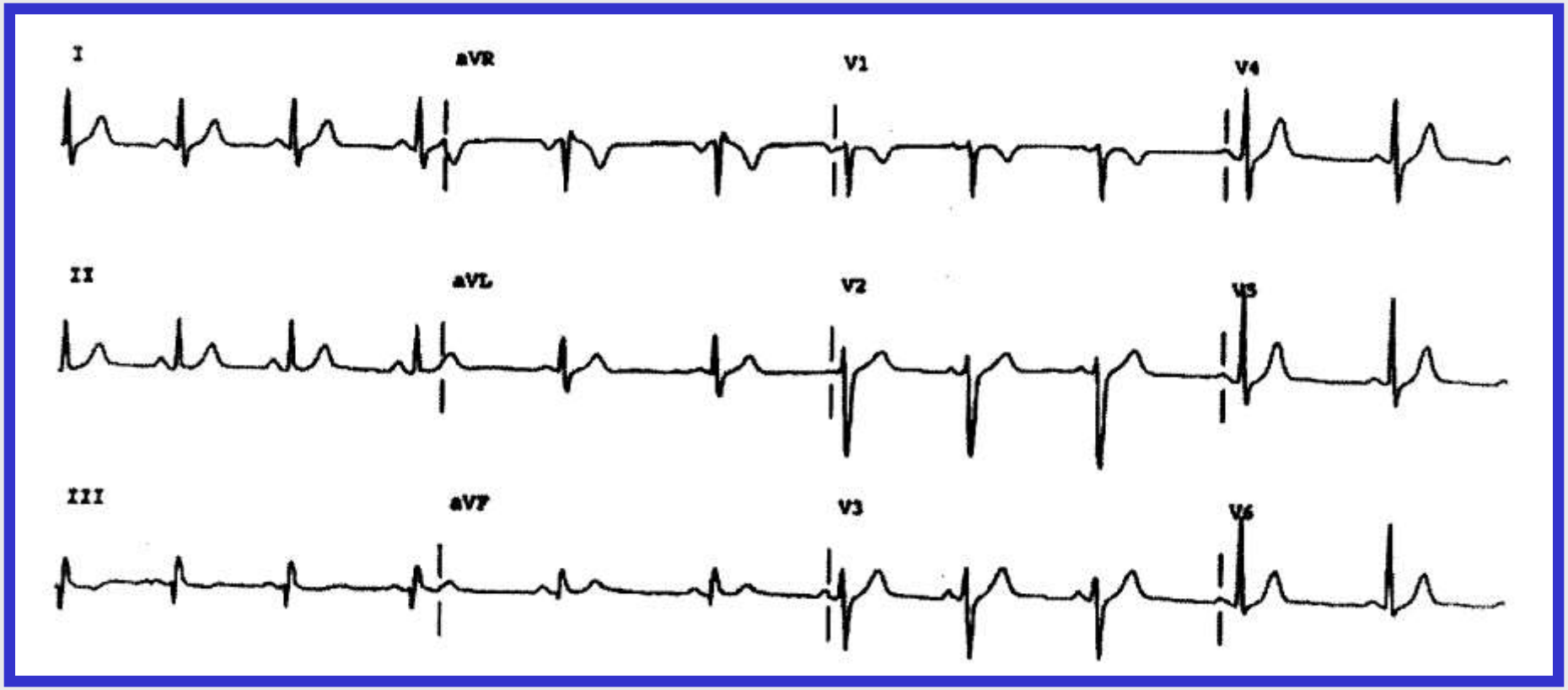






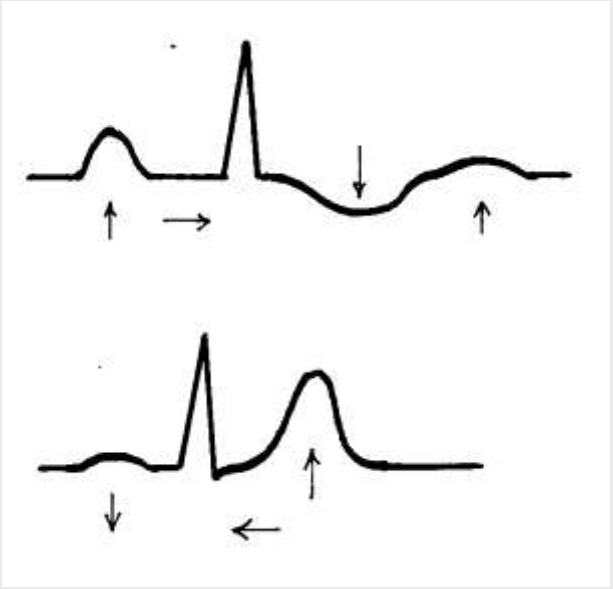


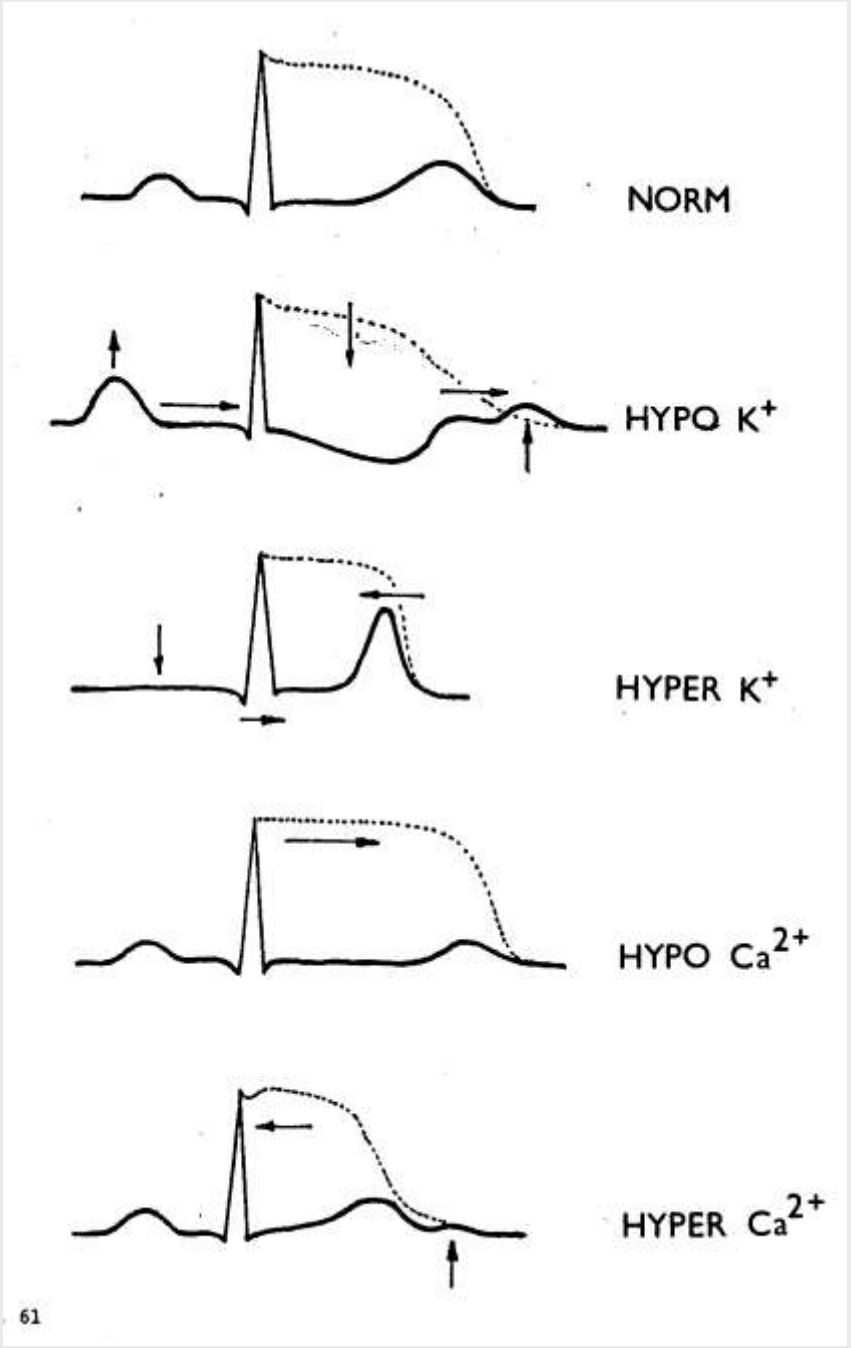
Normal 12-lead electrocardiogram



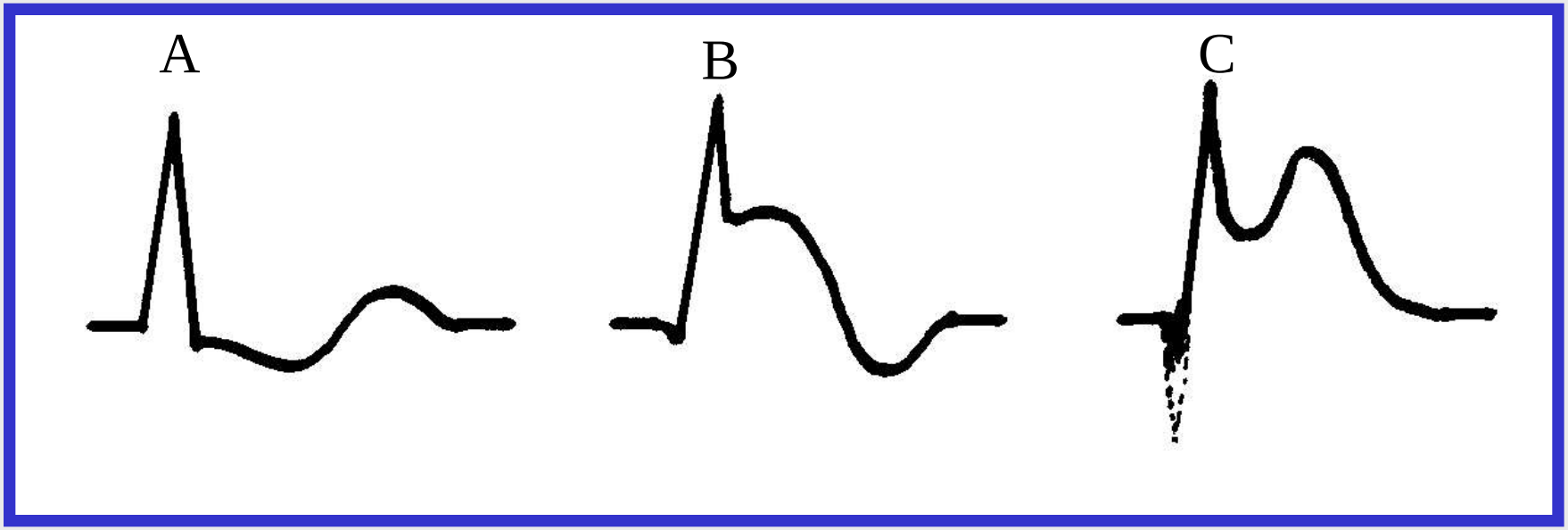
ECG – information about:

1. Magnitude and position of the heart (electrical axis)
2. Site of impulse origin (P, QRS)
3. Conduction path (P-Q, QRS)
4. Impulse regression (T)
5. Rhythm (P-P, R-R)
6. Action potential alterations (ST, T)




NORM
HYPO K+
HYPER K+
HYPO Ca2+
HYPER Ca2+

HEART ISCHEMIA



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

ARRHYTHMIAS

DISTURBANCES OF IMPULSE GENERATION OR CONDUCTION

RHYTHM: Regular
HEART RATE (normal range: 70 – 220 bpm; effect of age)

1. Sinus tachycardia (60 - 100 bpm; exercise)
2. Sinus bradycardia (below 60 bpm; athletes´ heart)

(nodal rhythm below 40 bpm, ventricular rhythm below 20 bpm)

RHYTHM: Irregular

sinus respiratory arrhythmia (physiological)

extrasystoles (ES) single, coupled (bigeminy, trigeminy)

sinus, atrial, junction, ventricular

- Sick sinus syndrome
- Syncope

BLOCKS

- SICK SINUS SYNDROM
- **AV BLOCKS**

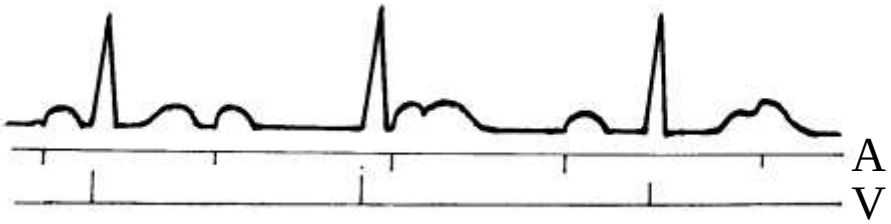
I°

PQ>0.2sec

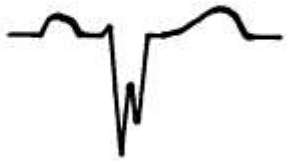
II°

Wenckebach periods (phenomenon)

III°



A-V dissociation



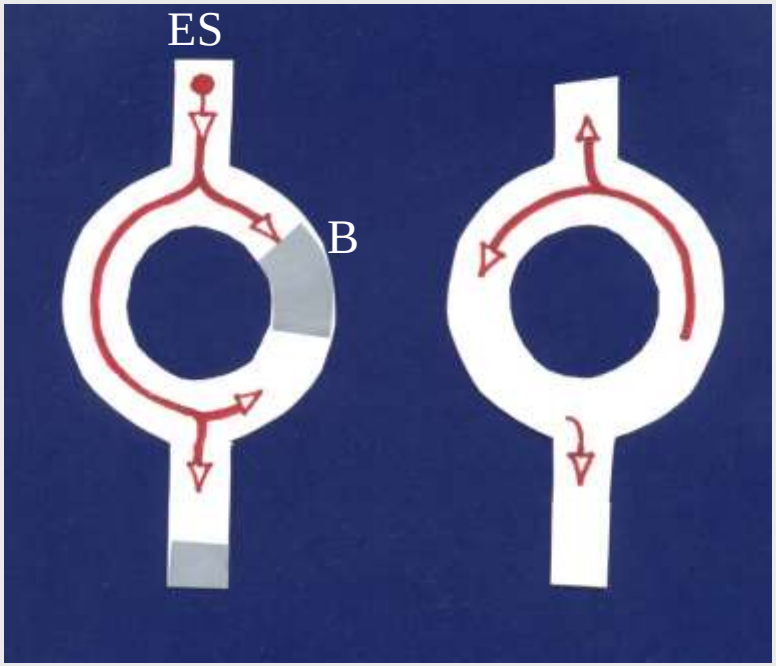
LBBB

RBBB

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

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

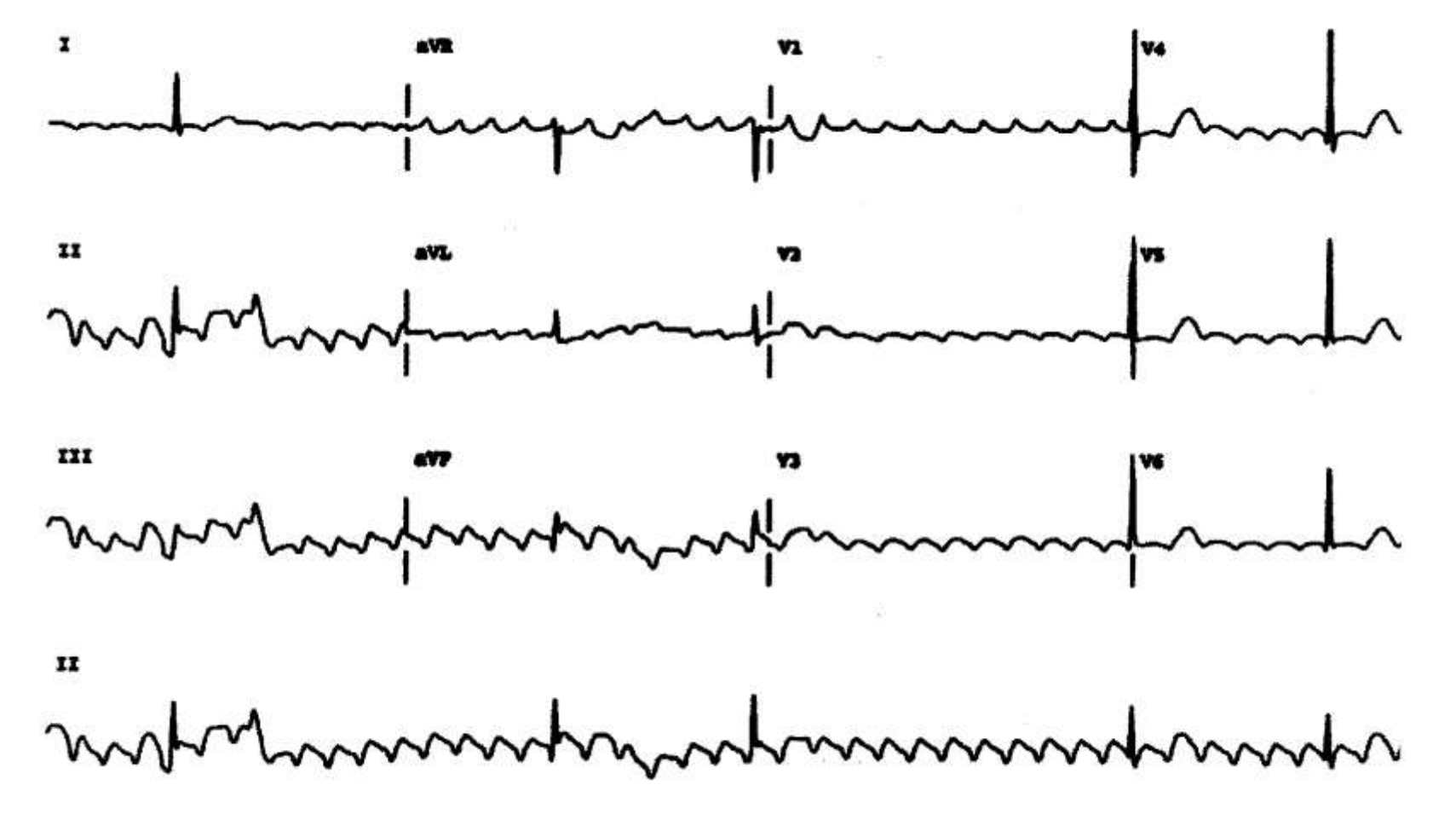
- **Loops most often at the level of AV junction**
- **Determinants of re-entry**:

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

TACHYARYTHMIA

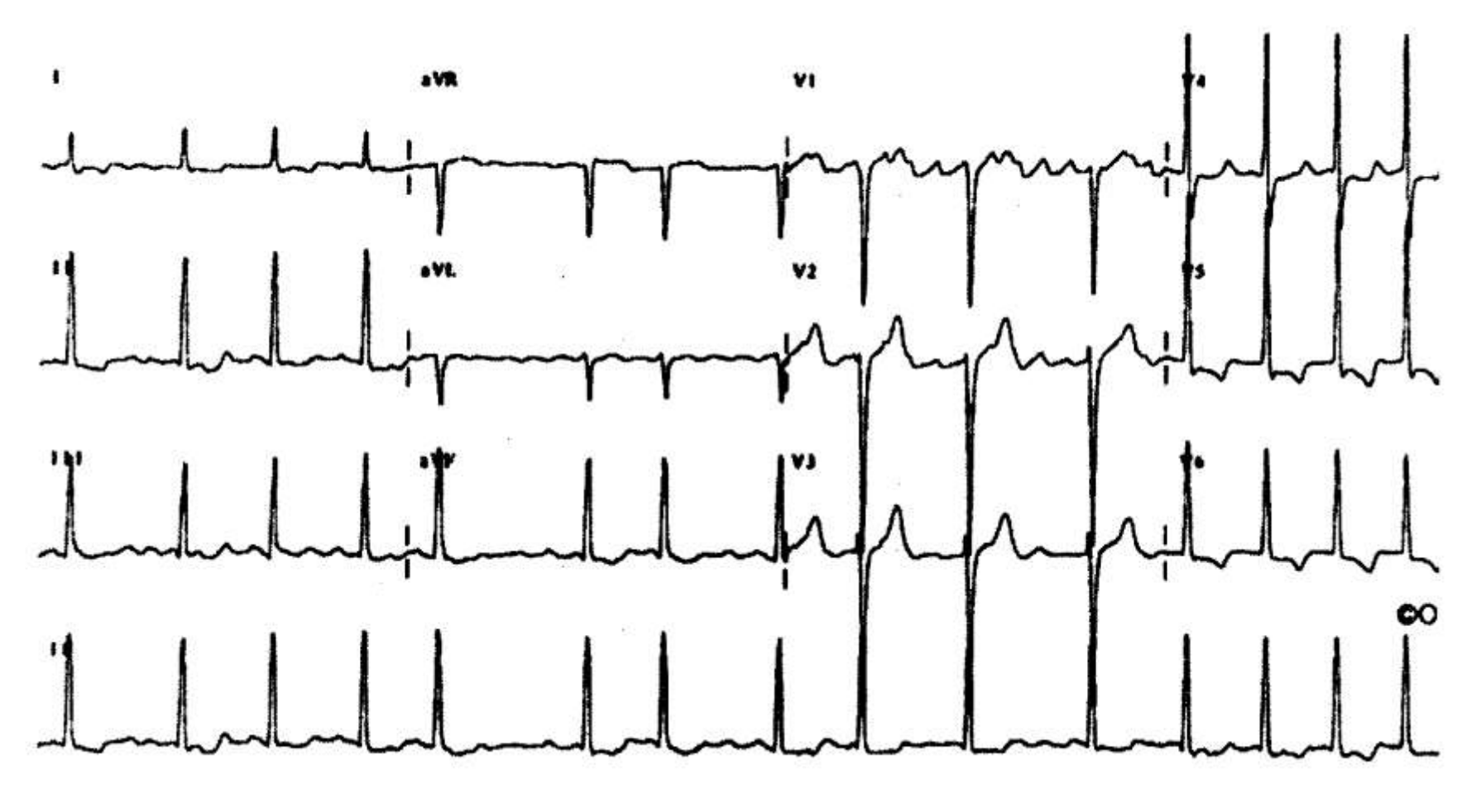
- **SINUS TACHYCARDIA**
- **PAROXYSMAL TACHYCARDIA** (supraventricular, ventricular)
- **FLUTTER** (>250/min; atrial)
- **FIBRILLATION** (>600/bpm; **atrial**, **ventricular**; breakdown of electrical homogeneity)

ATRIAL FLUTTER



Frequency 250 – 600/bpm
Atrioventricular block n:1

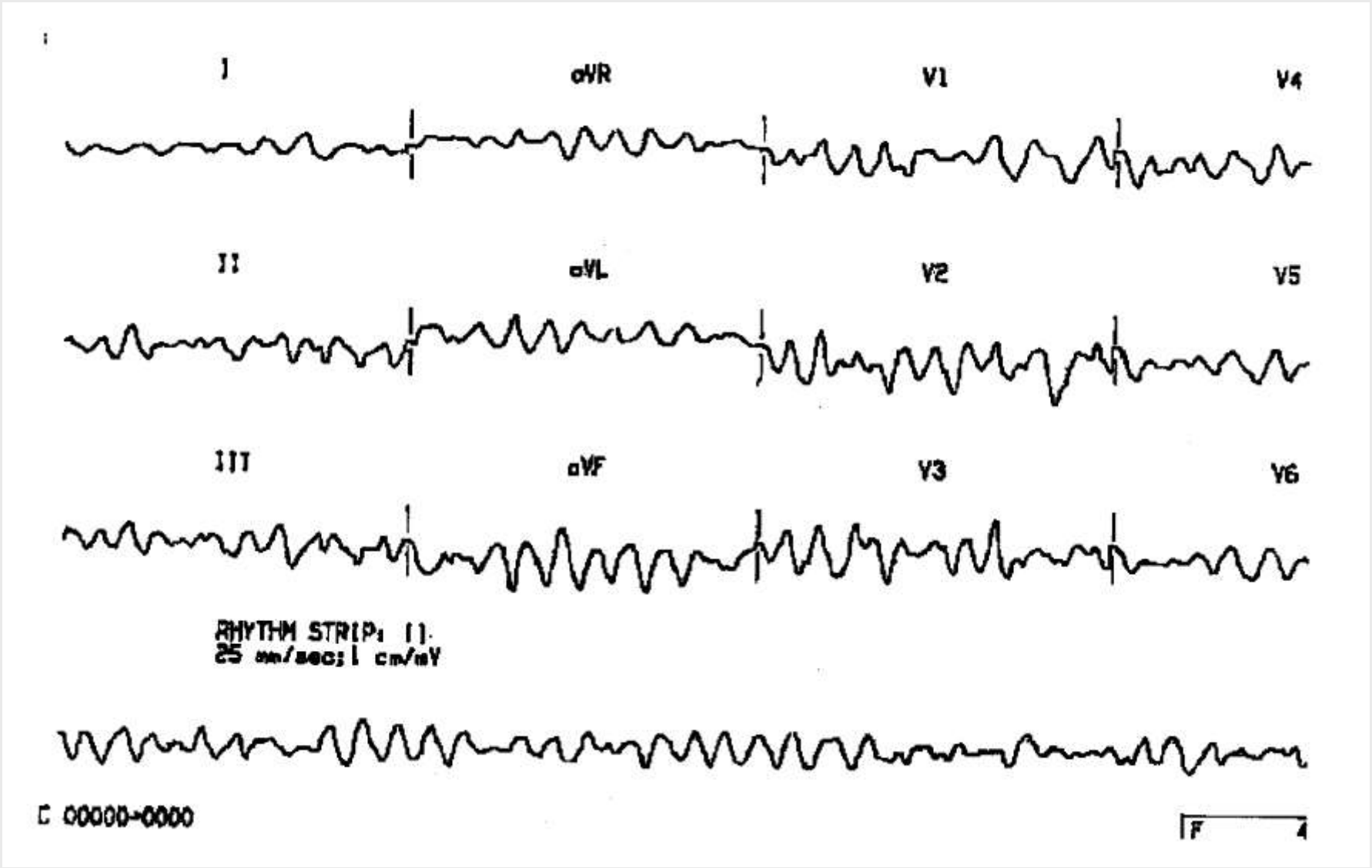
ATRIAL FIBRILLATION



Irregular ventricular rhythm

+ f-waves

VENTRICULAR FIBRILLATION



Frequency above 600/bpm