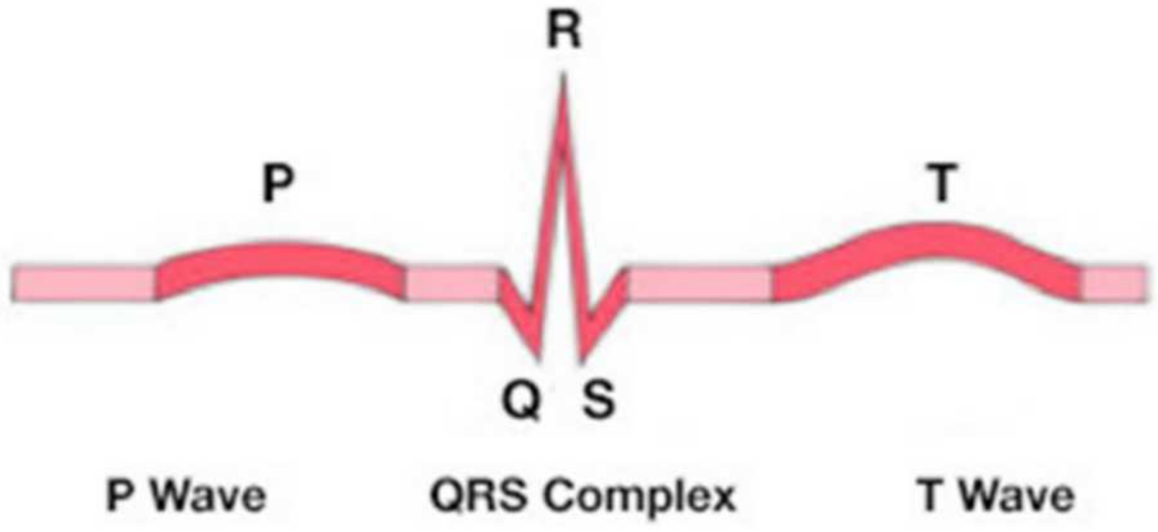
ECG Signals

- Cardiac action potentials
- Body-surface potentials
- Lead placement
- Waveforms
- QRS complex
- Normal and abnormal rhythms



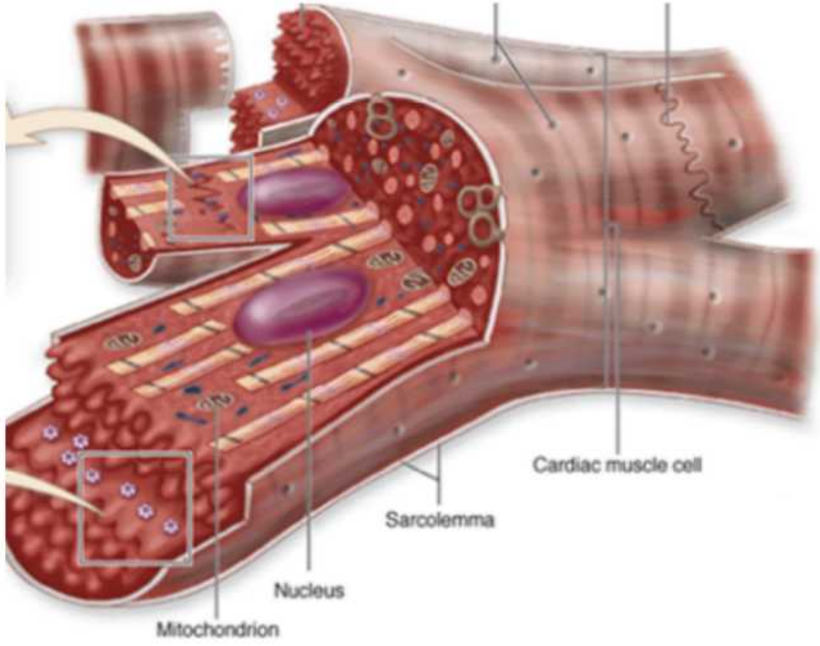
18.1.2 ECG signals

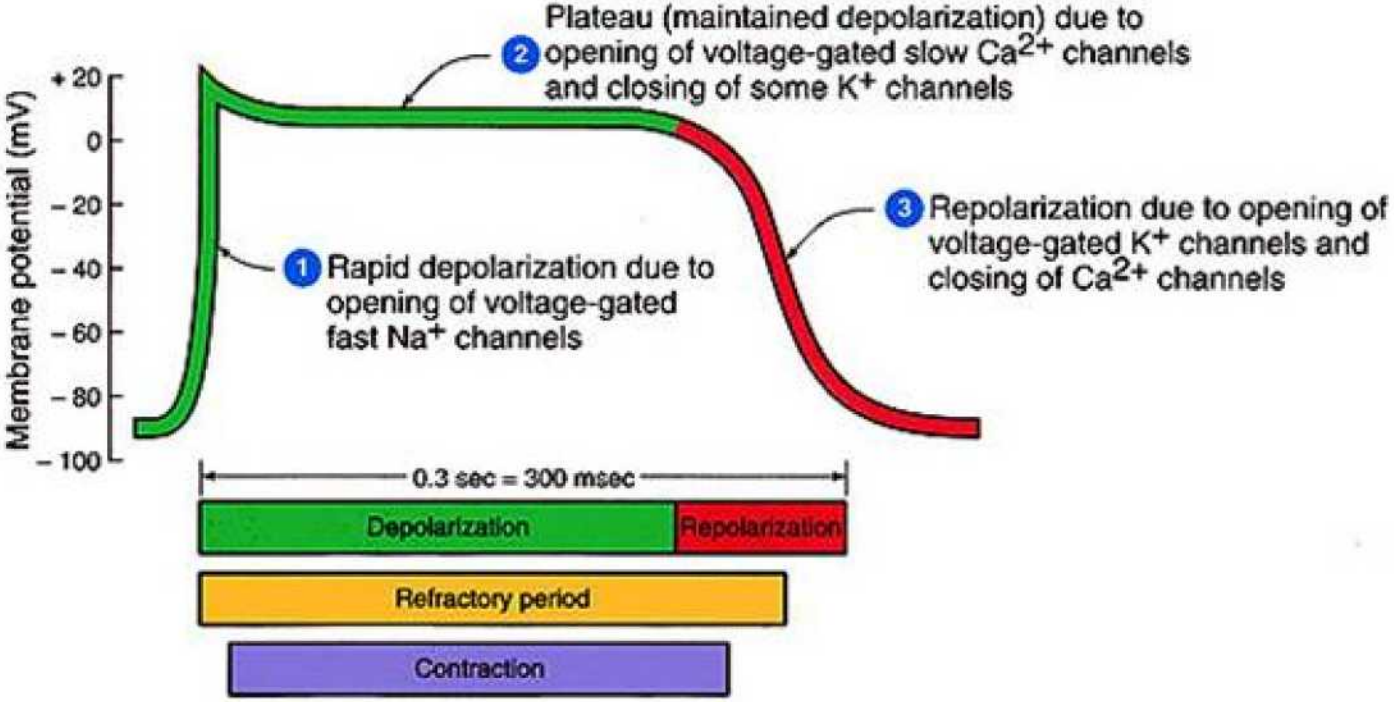
Unit C 18.1 Maintaining cardiovascular and monitoring equipment

Module 279 19 C Medical Instrumentation II

Cardiac action potentials

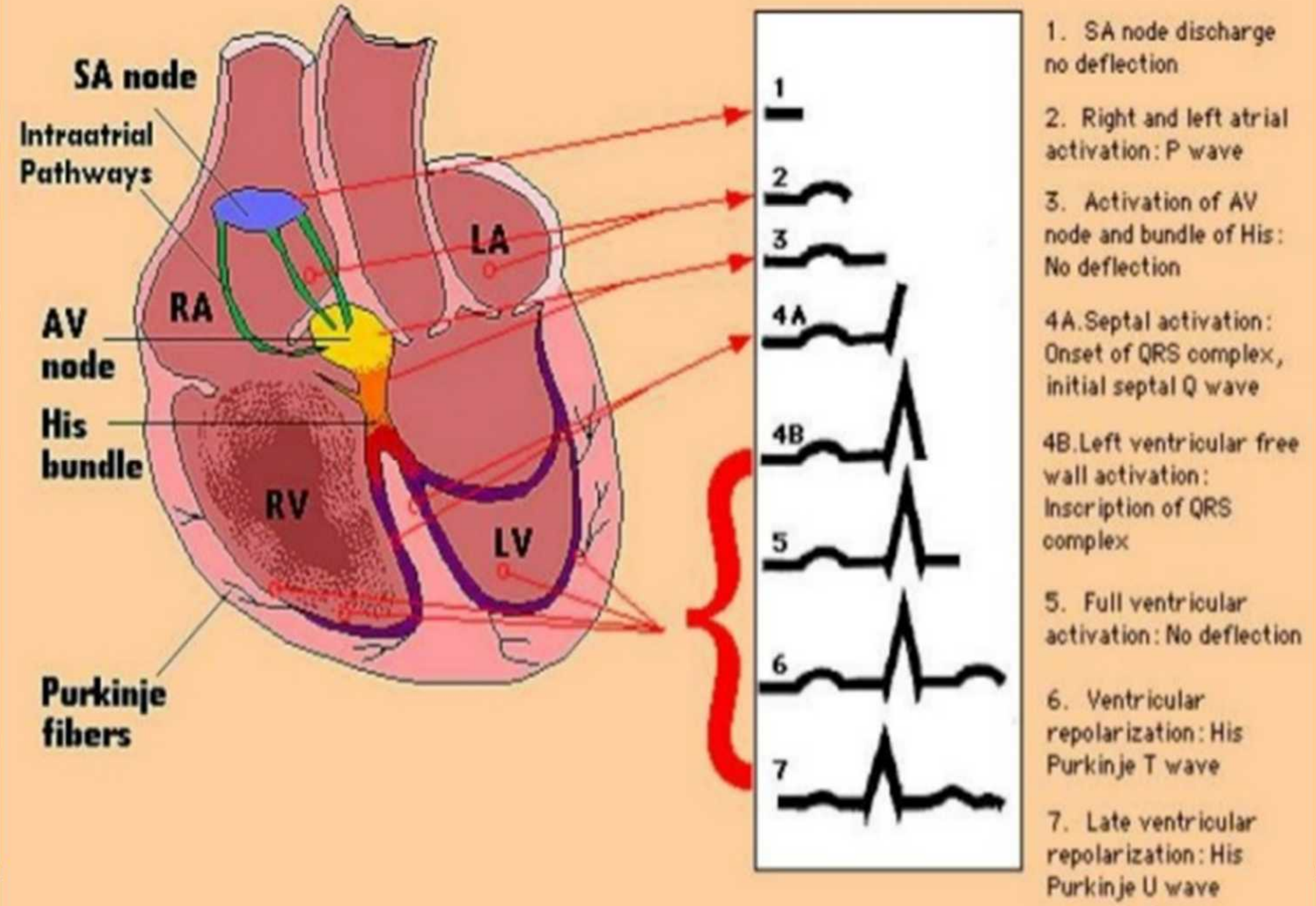
During a cardiac action potential the membrane potential (the difference of potential between the interior and the exterior) of a cardiac cell rises and falls.





the heart contains about 300 billion muscle cells

Electrical pathways in the heart



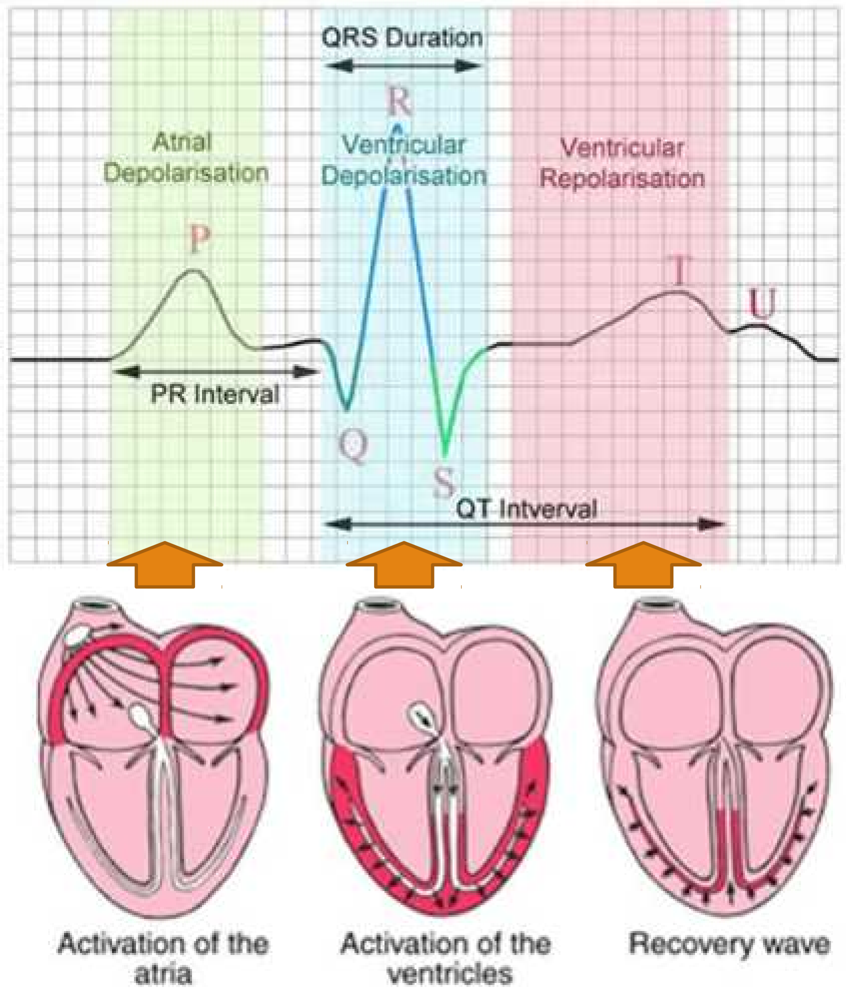
Body-surface potentials: ECG

Electrocardiography (ECG) is the process of recording the electrical activity of the heart over a period of time using electrodes placed on a patient's body. These electrodes detect the tiny electrical changes on the skin that arise from the heart muscle cells depolarizing during each heartbeat.

During each heartbeat, a healthy heart will have an orderly progression of depolarization that:

- starts with pacemaker cells in the **sino-atrial (SA) node**, with a rhythm influenced by the central nervous system (brain),
- spreads out through the **atrium**,
- passes with a delay through the **atrio-ventricular (AV) node**,
- spreads throughout the ventricles via specialized ‘**electrical path ways’.**

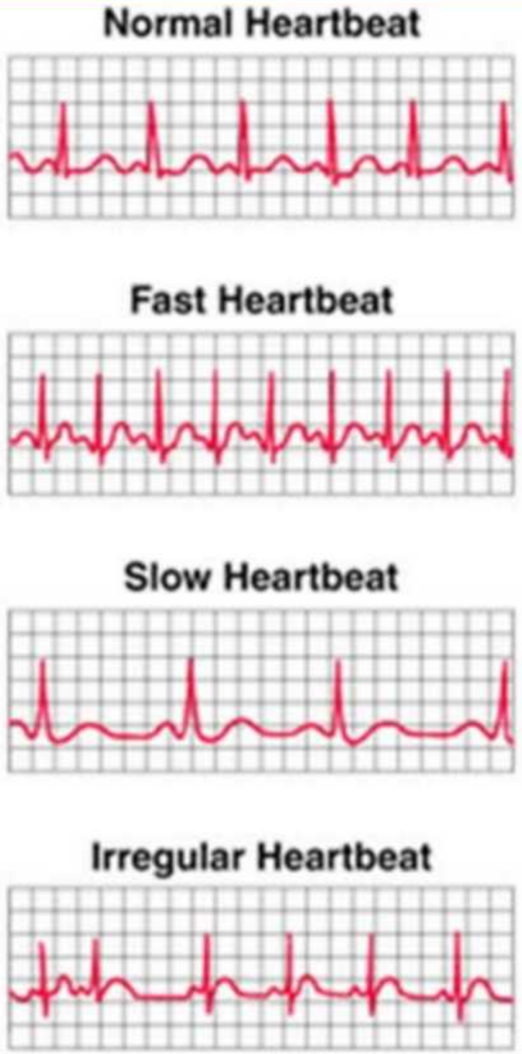
Note that the cardiac muscle cells also pass on the electrical signals to each other.
This orderly pattern of depolarization causes the specific ECG tracing.



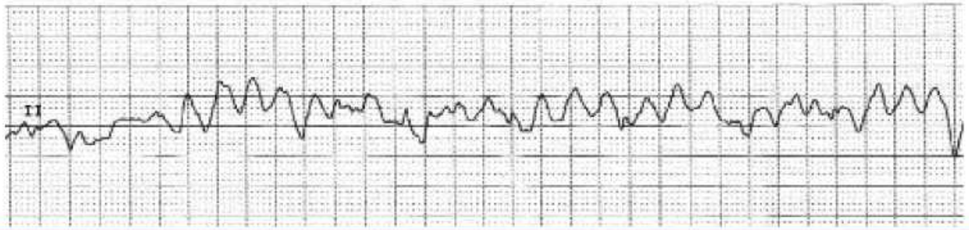
Normal and abnormal rhythms

An ECG can be used to:

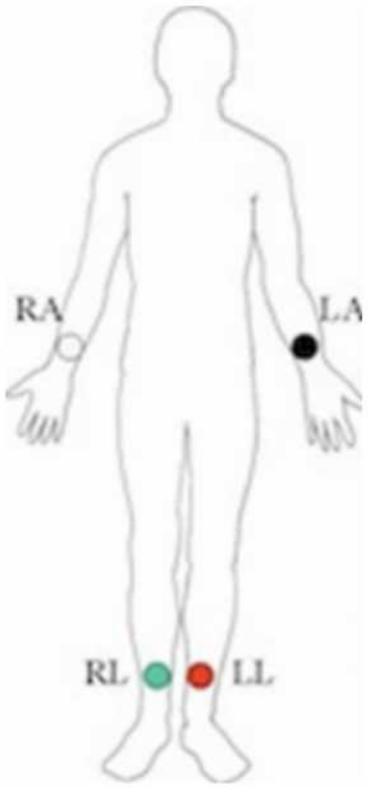
- measure the **rate** of heartbeats,
- measure the **rhythm** (regular, irregular) of the heart beats,
- measure the **size and position** of the heart chambers,
- detect the presence of any **damage** to the heart's muscle cells or conduction system,
- measure the effects of cardiac **drugs**,
- measure the function of implanted **pacemakers**.



ECG during Ventricular Fibrillation

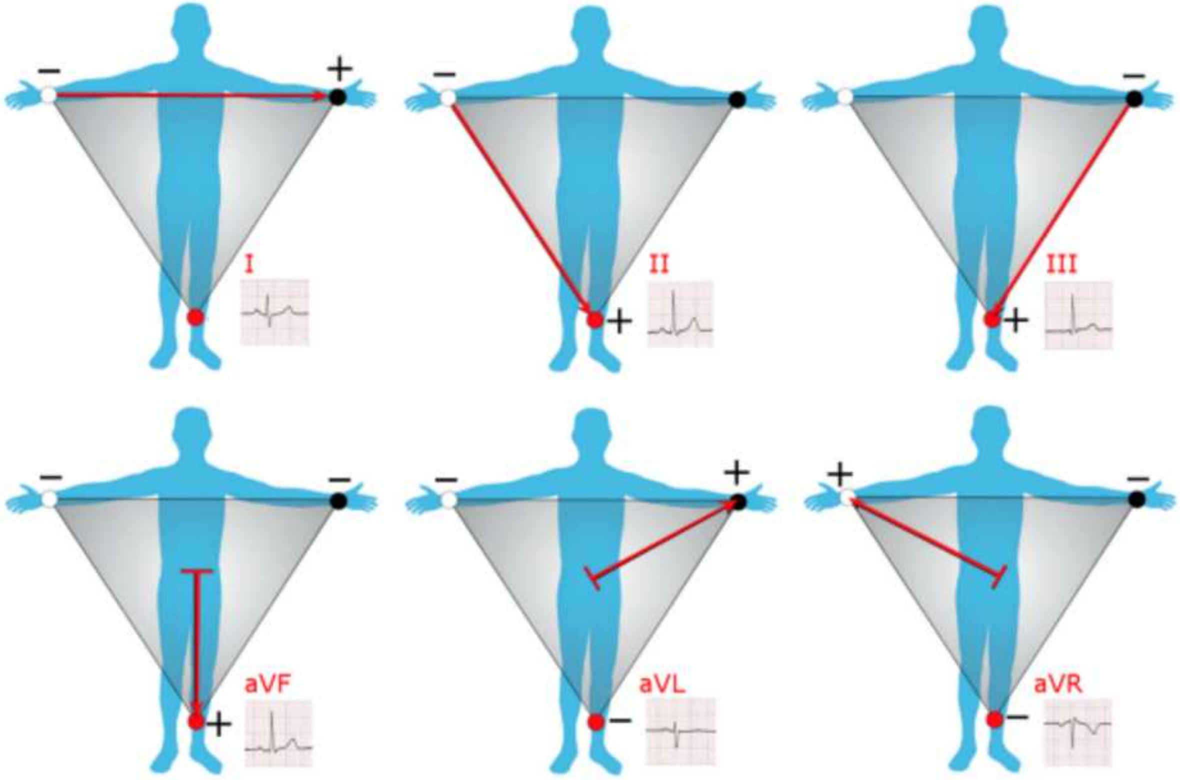


Lead Placement: 3 electrodes, 6 leads



ECG with 3 electrodes
on 3 limbs;
RL serves as ground

The 3-lead ECG has been in use for over 100 years. Currently, it is mainly used on transport monitors (e.g. in ambulances). The reason for this is that configurations with more leads provide more information.



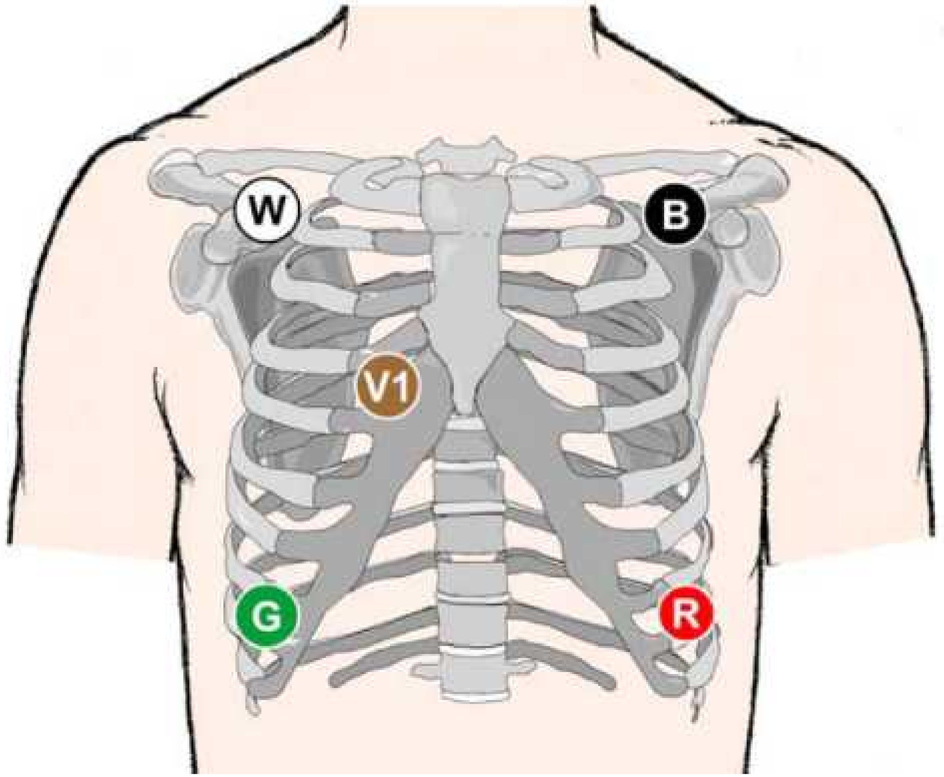
Recordings are made between two electrodes:
Lead I, II, III

or

between one electrode and the average of the other two:
Lead aVR, aVL, aVF

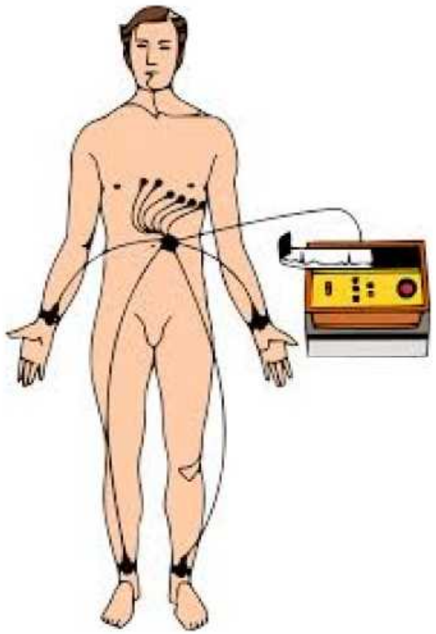
Lead Placement: 5 electrodes

The 5-lead ECG is often preferred in an
ICU (Intensive Care Unit).
It gives more information than the 3 Lead ECG.

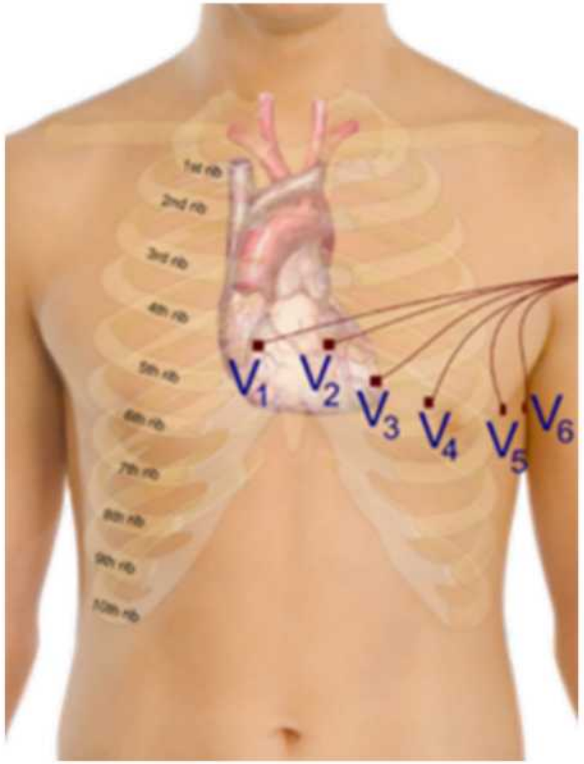


position of electrodes in **5 Lead ECG** system

Lead Placement: 10 electrodes for standard 12 lead ECG



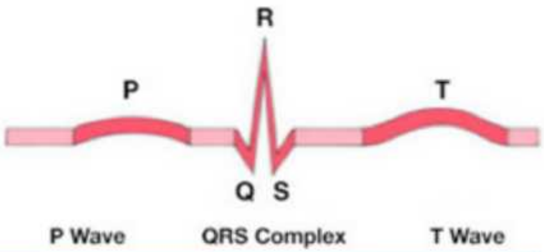
ECG with 10 electrodes for best detail

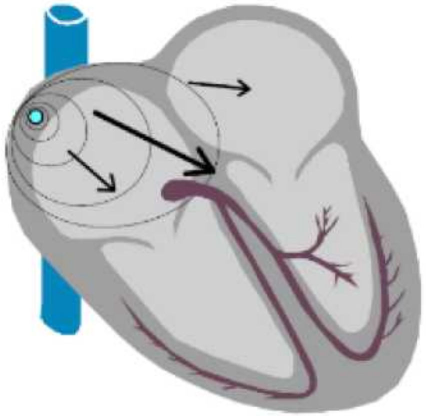


Electrode name	Electrode placement
RA	On the right arm, avoiding thick muscle.
LA	In the same location where RA was placed, but on the left arm.
RL	On the right leg, lateral calf muscle.
LL	In the same location where RL was placed, but on the left leg.
V_1	In the fourth intercostal space (between ribs 4 and 5) just to the right of the sternum (breastbone).
V_2	In the fourth intercostal space (between ribs 4 and 5) just to the left of the sternum.
V_3	Between leads V_2 and V_4.
V_4	In the fifth intercostal space (between ribs 5 and 6) in the mid-clavicular line.
V_5	Horizontally even with V_4, in the left anterior axillary line.
V_6	Horizontally even with V_4 and V_5 in the midaxillary line.

From the 10 electrodes, **12 leads** are recorded, each lead being a combination of two or three electrodes

Wave forms





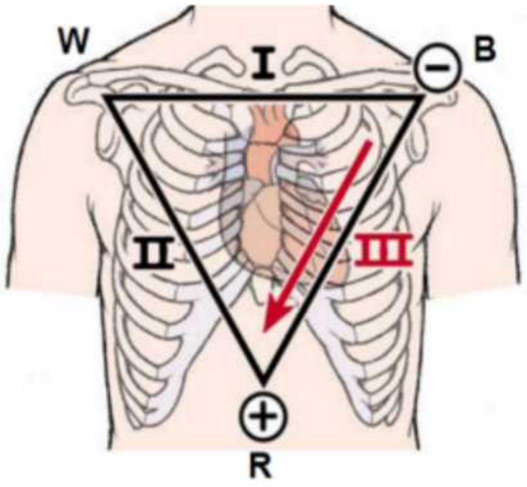
A depolarizing wave moving through the myocardium can be thought of as a **vector.** A vector is a force moving in a direction symbolized by an arrow. The larger the force, the larger the arrow.

For example, the impulse initiated by the SA node moves towards the AV node and the left atrium. On average, the depolarizing wave travels **down** and **to the left** side of the body. Atrial depolarization then has a vector that points down and towards the left.

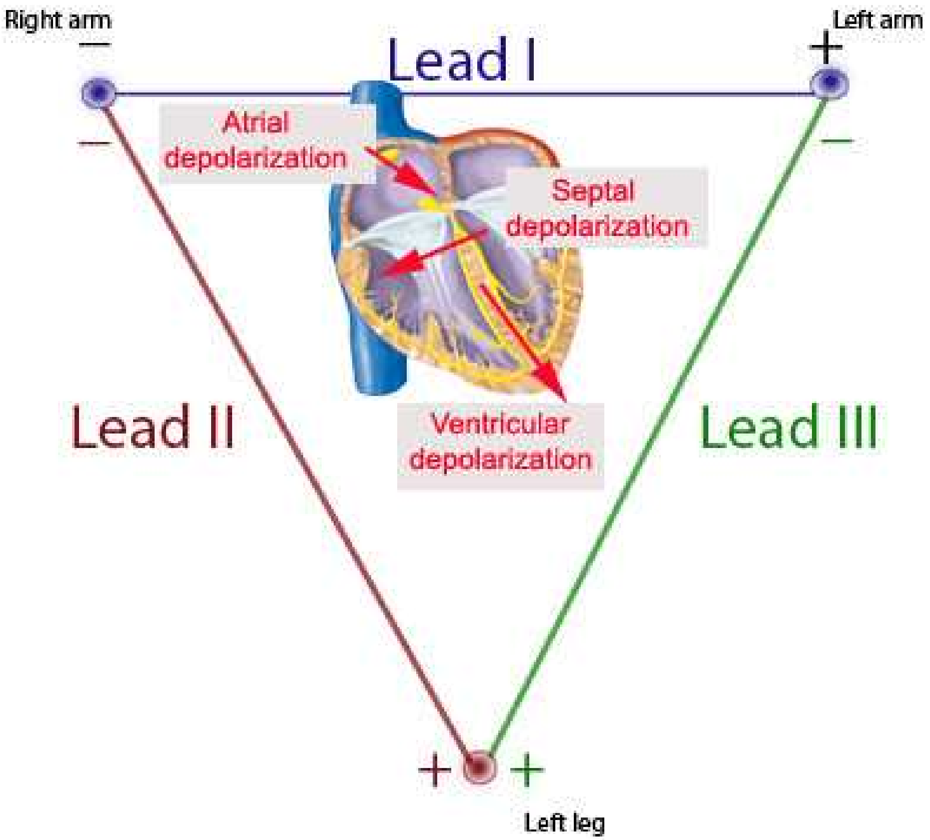
A depolarizing electrical wave that is directed towards a positive lead produces an upright waveform on an ECG. Conversely, an inverted waveform results when a depolarizing wave moves away from a positive lead.

As an example: in lead I,II and III, the normal **P-wave** is always positive:

- in lead I (B = positive) because the wave goes to the left side of the body
- in Lead II and III (R = positive) because the wave goes to the down side of the body.

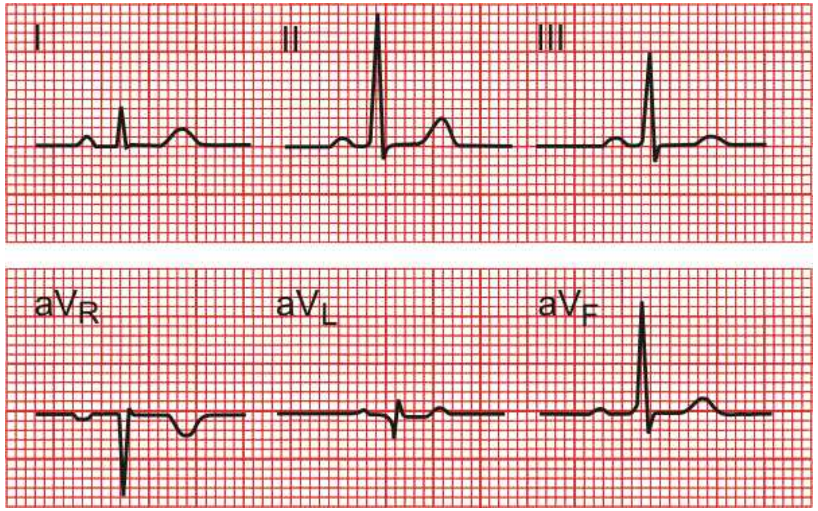


Wave forms



The heart vector changes direction in the different phases of **ventricular depolarization**.

This is the reason that the QRS complex changes from positive to negative, depending on the Leads from which the ECG is taken.

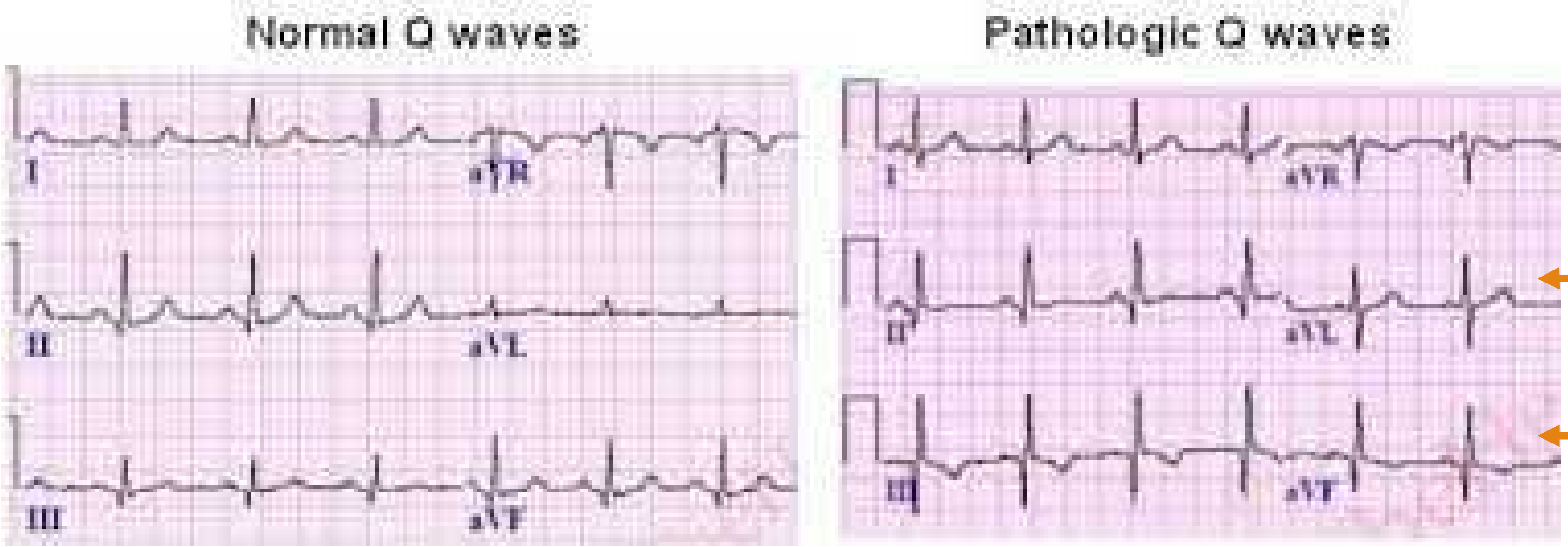


The following slides will give examples of common abnormalities in the ECG and their interpretation. It shows you what sort of things the Medical Doctors are interested in, in an ECG.

Wave forms: Abnormalities

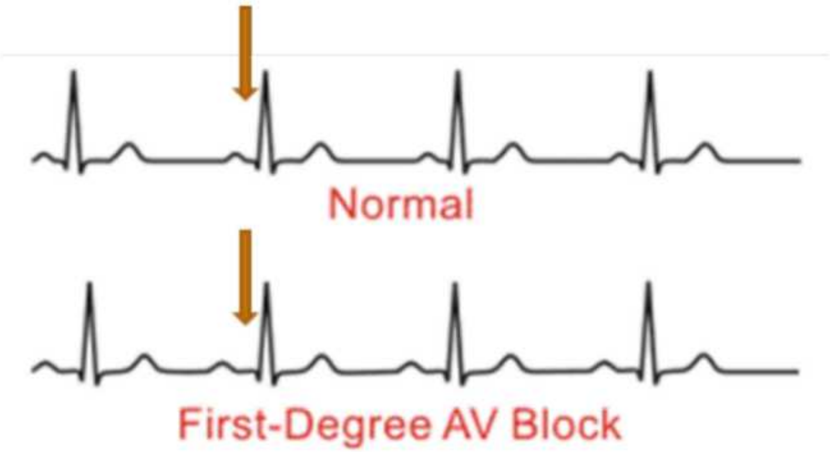
If a part of the patient's heart muscle is non-functional ('**old infarction**'), then this will cause a change in the direction of the depolarization wave. Also the **size of the heart and the orientation of the heart** will have an impact on the depolarization wave.

Such variations show up in the ECG as differences in the amplitude and direction (positive, negative) compared with the normal ECG wave forms.



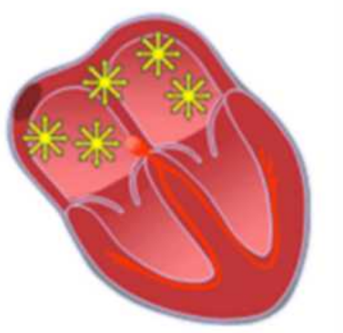
aVL and aVF are clearly 'not normal'

Wave forms: abnormalities in the conduction system

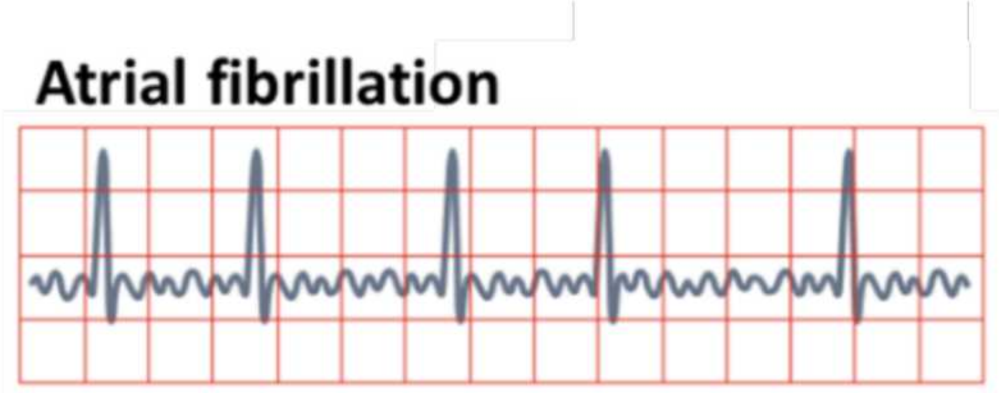


If a patient has a disturbance in the **conduction of the electricals signals** through the heart, this will show up as a change in timing within the ECG signals.

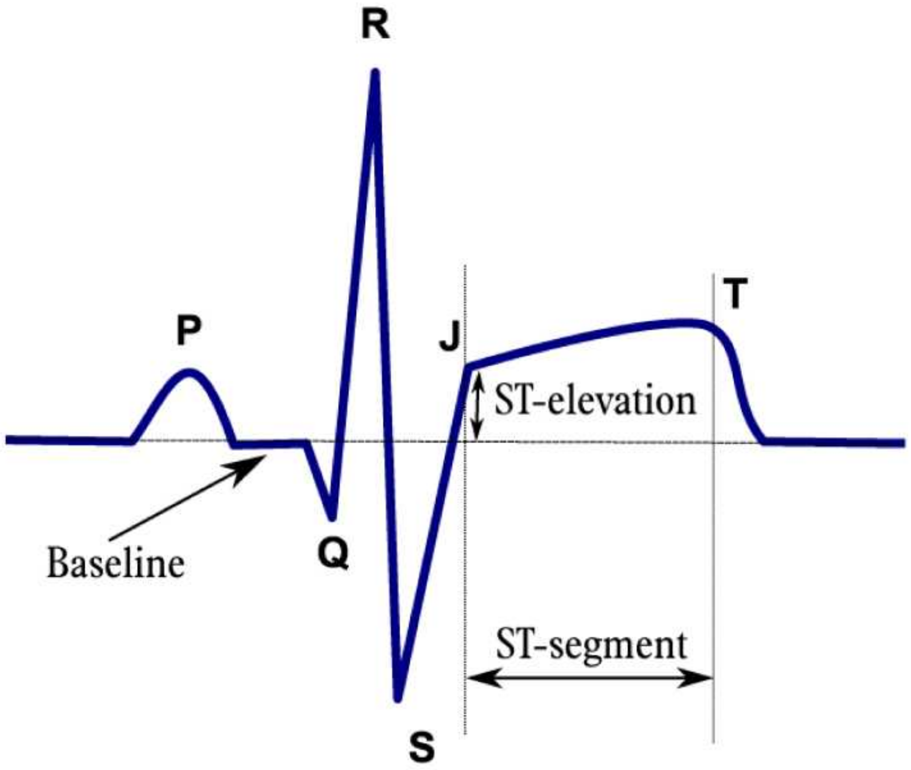
For example, an **AV block** (a time delay in signal conduction through the AV node) will result in a longer duration between the P wave and the QRS complex (see figure).



In **Atrial Fibrillation** (un-synchronized contraction of the atrial myocardium) the ECG will show up without a P-wave.



Wave forms: abnormalities through heart muscle infarction



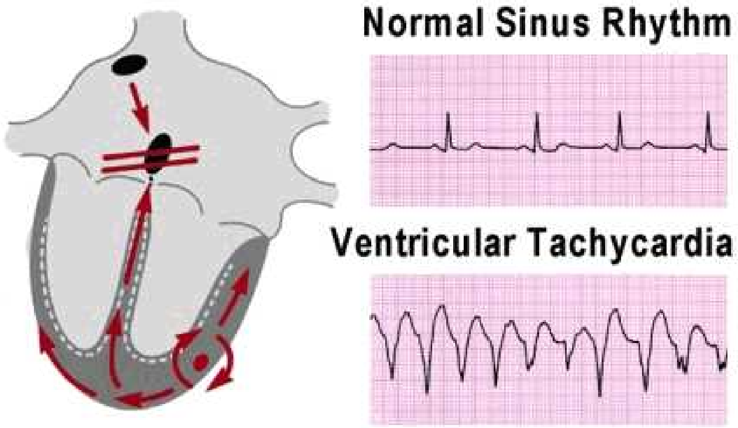
ST elevation is a positive (non-zero) value of the ECG between the QRS wave and the T-wave. **ST depression** is a negative value at this time.

Both phenomena usually point at a (recent) **infarction** from some of the heart muscle, related to the **closure/blockage of a coronary artery**.

From an analysis of the ECG wave forms in the different leads it can be derived which coronary artery is blocked. This is useful information to guide further therapy (drugs, bypass surgery, or angioplasty).

Heart Rhythm abnormalities

Tachycardia (‘tachy’ = fast, a fast heart rhythm) is defined as a heart rhythm of over 100 beats per minute for adults A tachycardia can simply be a high frequency heart beat with no other variations in the ECG.



However, tachycardia can also be associated with more serious phenomena. For example, tachycardia can be generated by abnormal ventricular heart muscle, creating its own electrical signal and triggering ventricular contractions unsynchronized with the atrium. It often runs between 120 and 260 beats/minute. This is called **Ventricular Tachycardia** (see figure).

Bradycardia (‘brady’ = slow, a slow heart rhythm) is the opposite phenomenon: a heart rhythm in rest of lower than 60 beats/minute. In young people this can indicate a very well trained heart. In older people it may be a sign of disease.

END

The creation of this presentation was supported by a grant from THET:
see https://www.thet.org/