ECG

Electrocardiography

By
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Overview

- Objectives for this lecture
- What is an ECG?
- Overview of performing electrocardiography on a patient
- Simple physiology
- Interpreting the ECG

Types of questions

By the end of this tutorial the student should be able to:

- State a definition of electrocardiogram
- Perform an ECG on a patient, including explaining to the patient what is involved
- Draw a diagram of the conduction pathway of the heart
- Draw a simple labelled diagram of an ECG tracing
- List the steps involved in interpreting an ECG tracing in an orderly way
- Recite the normal limits of the parameters of various parts of the ECG
- Interpret ECGs showing the following pathology:
  - MI, AF, 1st 2nd and 3rd degree heart block, p pulmonale, p mitrale, Wolff- Parkinson-White syndrome, LBBB, RBBB, Left and Right axis deviation, LVH, pericarditis, Hyper- and hypokalaemia, prolonged QT.

What is an ECG?

ECG = Electrocardiogram means,

Tracing or recording of electrical activities in the conducting system of the heart

Note = ECG does NOT record the contraction of the heart

Recording of ECG

Overview of procedure

- GRIP
  - Greet, rapport, introduce, identify, privacy, explain procedure, permission
- Lay patient down
- Expose chest, wrists, ankles
- Clean electrode sites
  - May need to shave
- Apply electrodes
- Attach wires **correctly**
- Turn on machine
  - Calibrate to 10mm/mV
  - Rate at 25mm/s
- Record and print
- **Label** the tracing
  - Name, DoB, hospital number, date and time, reason for recording
- Disconnect if adequate and remove electrodes

Electrode placement

- 10 electrodes in total are placed on the patient
- Firstly self-adhesive ‘dots’ are attached to the patient. These have single electrical contacts on them
- The 10 leads on the ECG machine are then clipped onto the contacts of the ‘dots’

Types of Leads

- Coronal plane (Limb Leads)
  1. Bipolar leads — I , II , III
  2. Unipolar leads — aVL , aVR , aVF

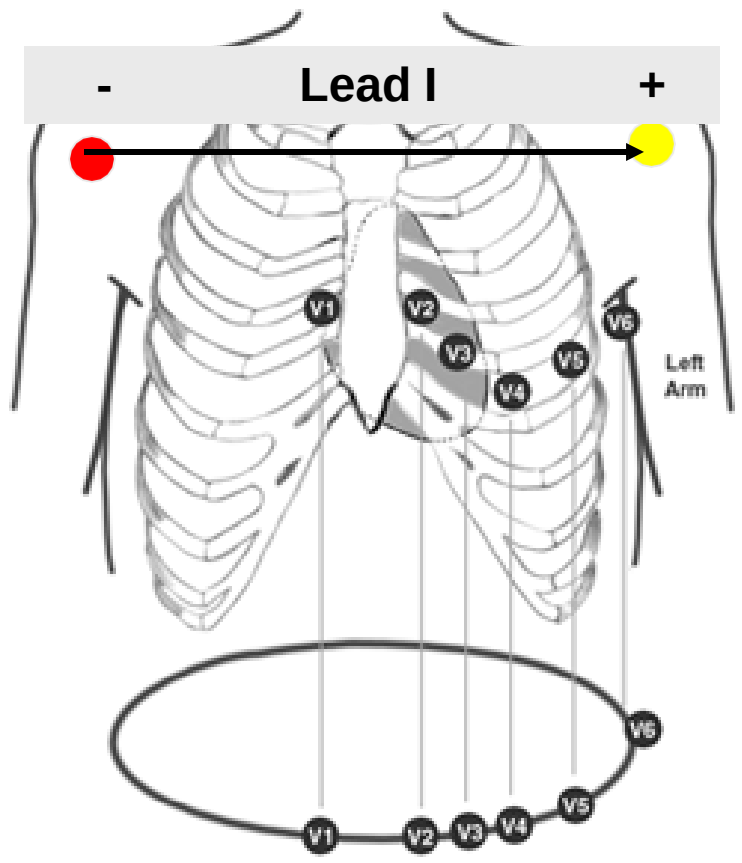
- Transverse plane

  V_1 — V_6 (Chest Leads)

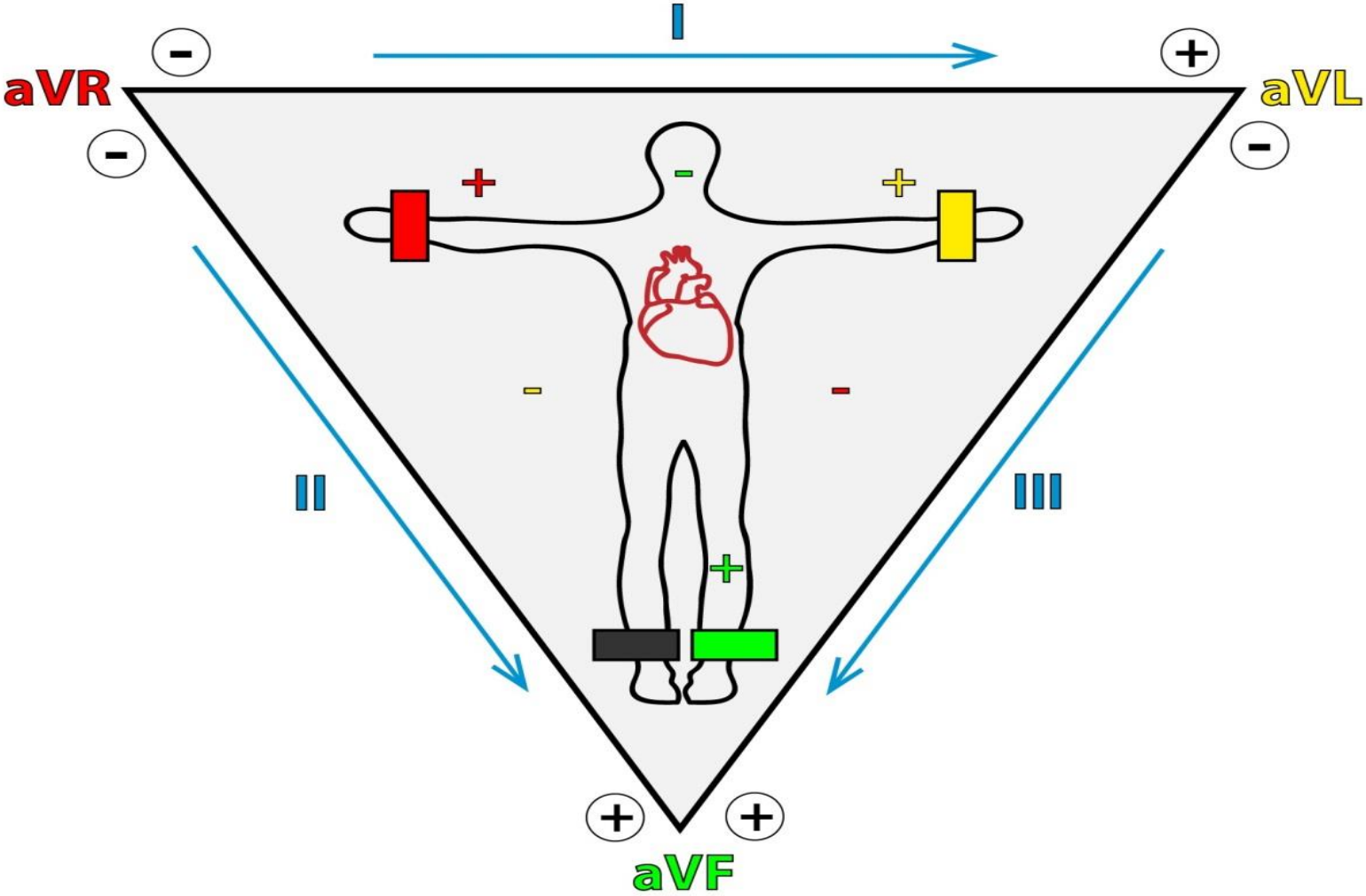
Leads

How are the 12 leads on the ECG (I, II, III, aVL, aVF, aVR, V1 – 6) formed using only 9 electrodes (and a neutral)?

- Lead I is formed using the right arm electrode (red) as the negative electrode and the **left arm (yellow)** electrode as the positive



Einthoven's triangle

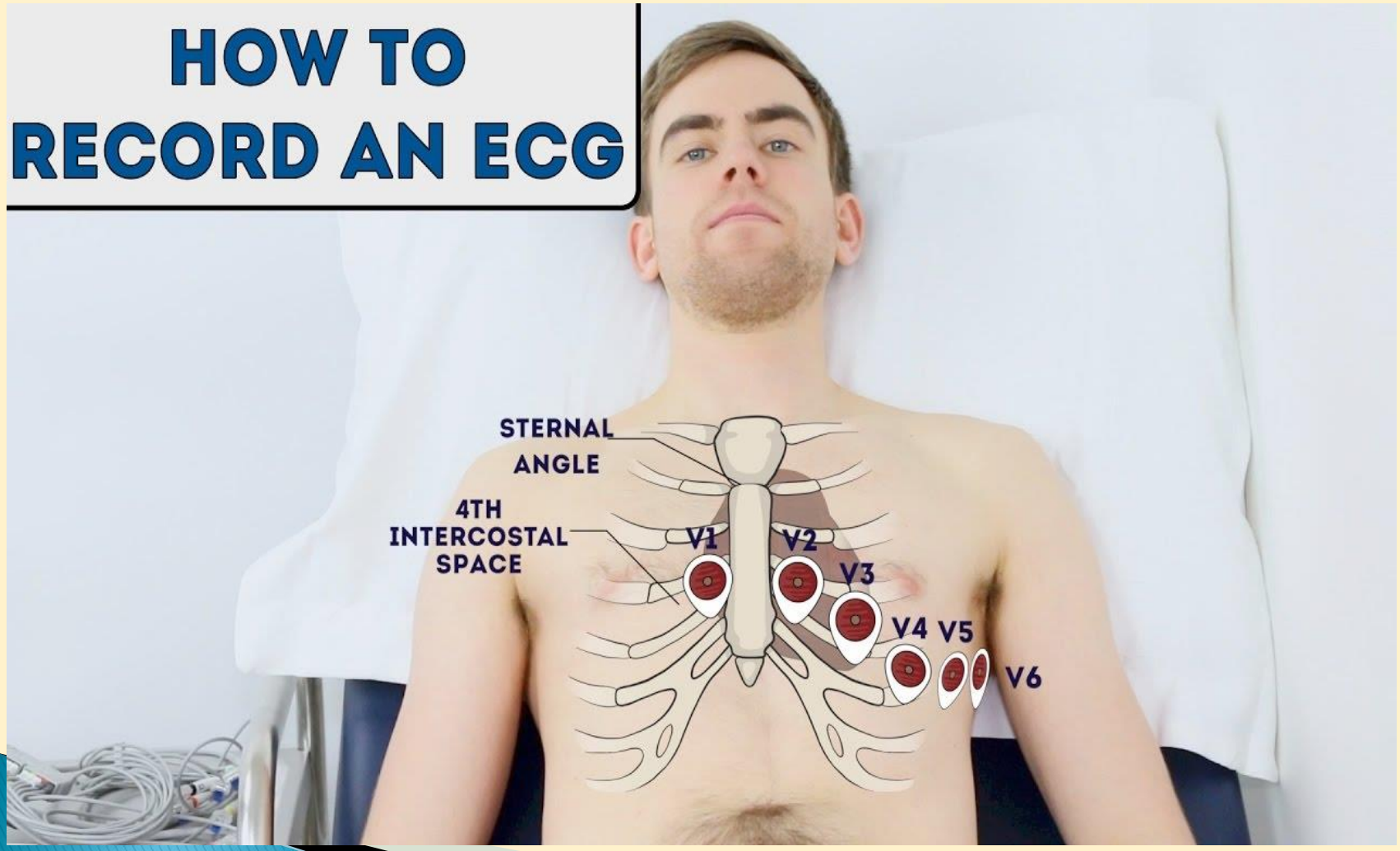


ECG terminal leads

EKG Cable with leadwires

ECG Electrodes

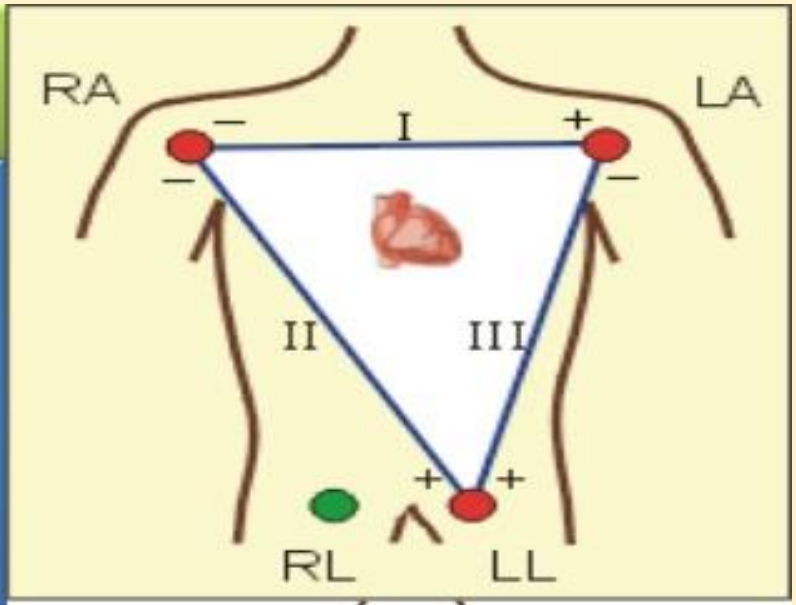
Chest Leads

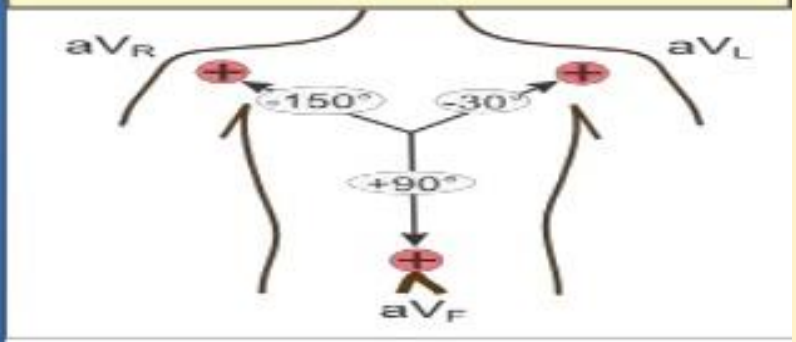

HOW TO
RECORD AN ECG
STERNAL
ANGLE
4TH
INTERCOSTAL
SPACE
V1
V2
V3
V4
V5
V6

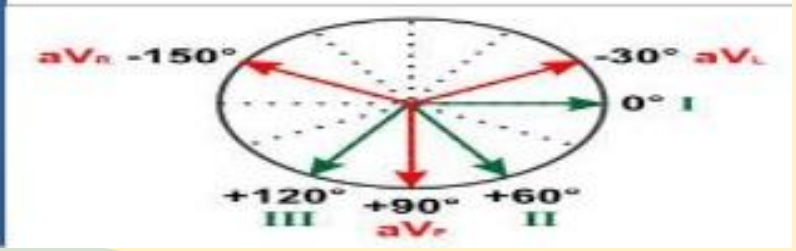
ECG

ECG Leads

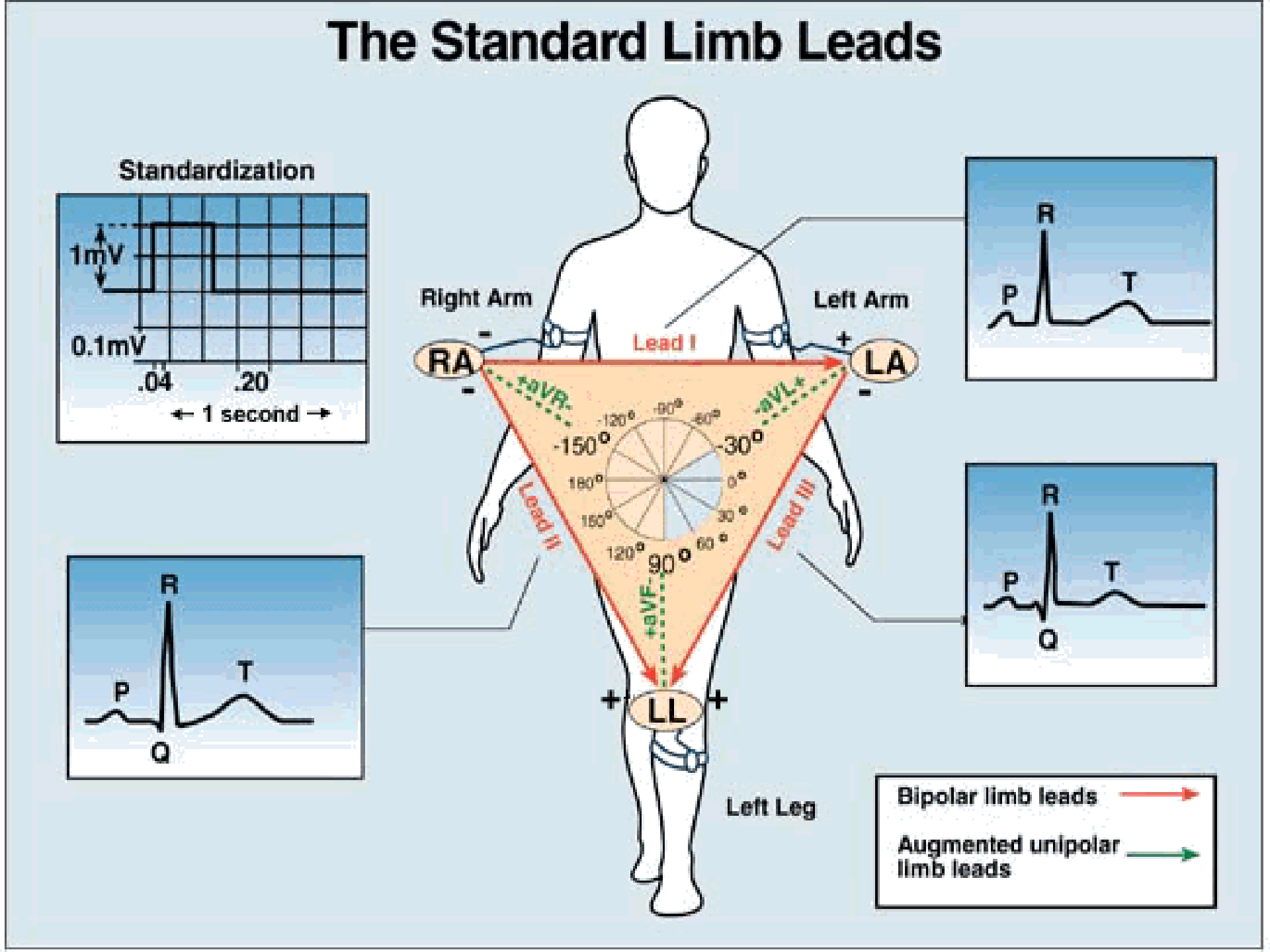
- The 12 lead consist of:
  - Three Standard limb or bipolar leads (I, II, III) utilize three electrodes; these leads form a triangle known as Einthoven's Triangle.
  - Three Augmented unipolar leads (aV_R, aV_L, aV_F).
  - Six Precordial unipolar leads (V_1, V_2, V_3, V_4, V_5, V_6).





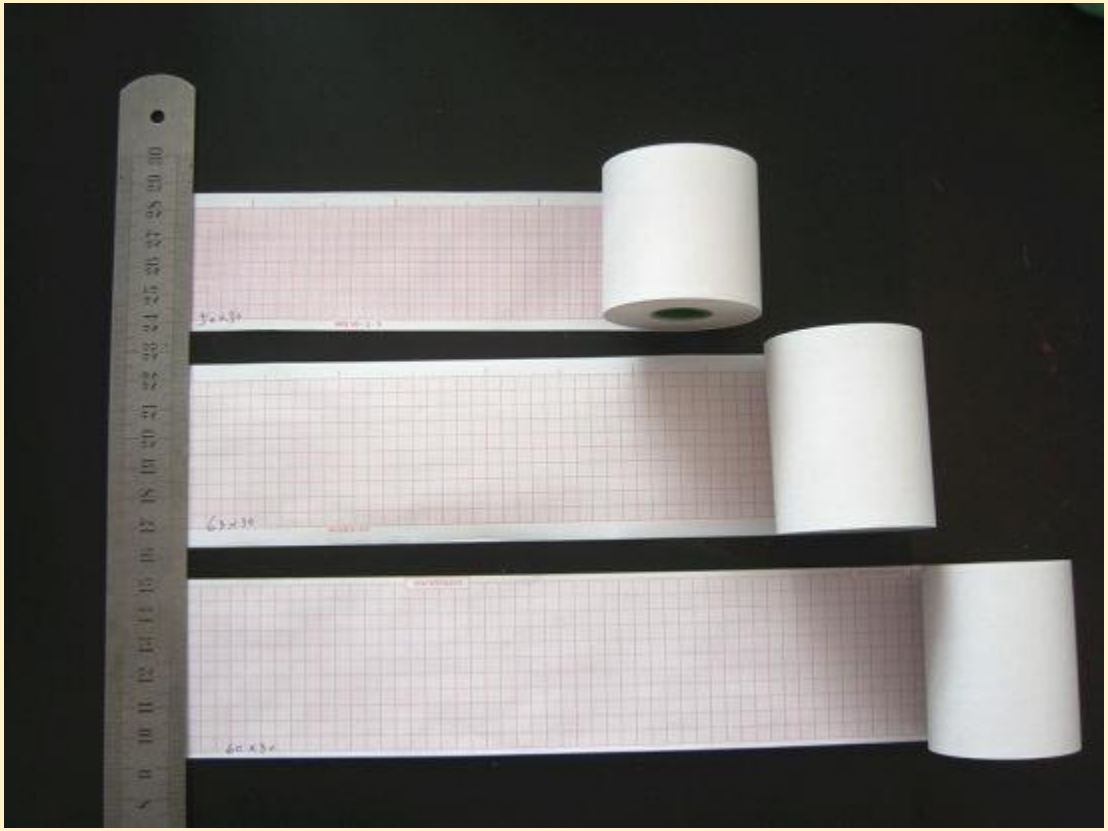


The Standard Limb Leads



ECG Paper

ECG graph paper



ECG

ECG

ECG

ECG

ECG

ECG

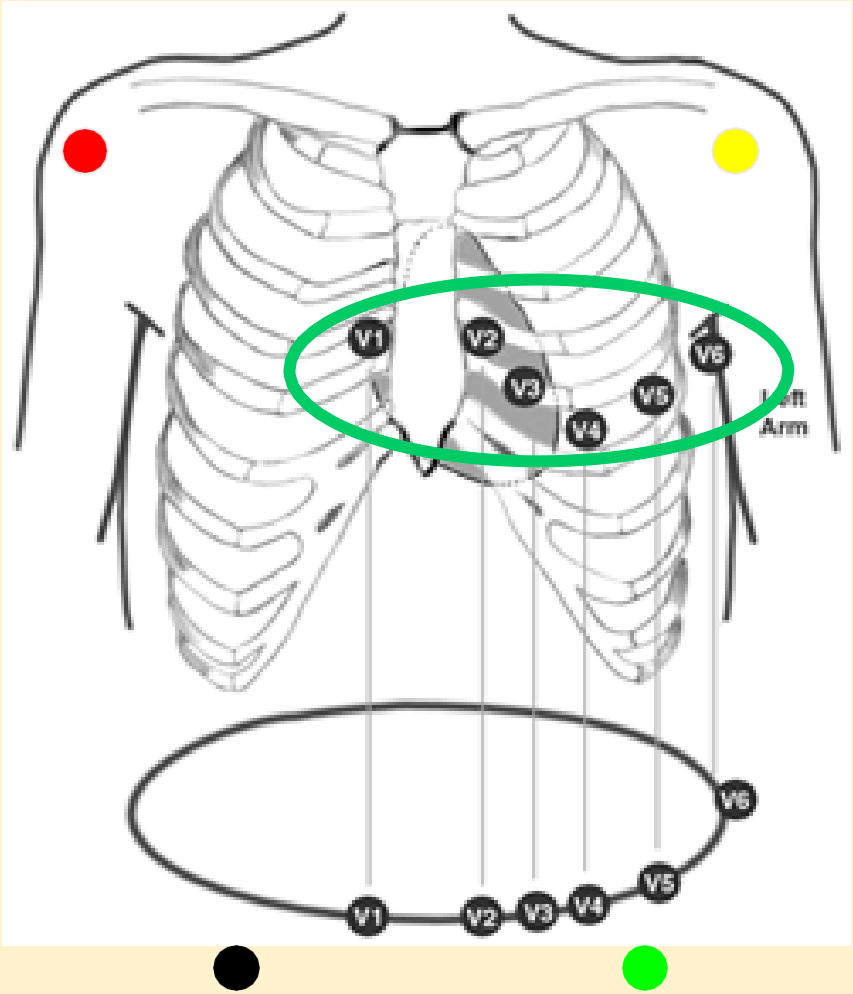
ECG

Electrode placement in 12 lead ECG

- 6 are chest electrodes
  - **Called V1-6 or C1-6**
- 4 are limb electrodes
  - **Right arm**
  - **Left arm**
  - **Left leg**
  - **Right leg**

Ride on
Your
Green
Bike

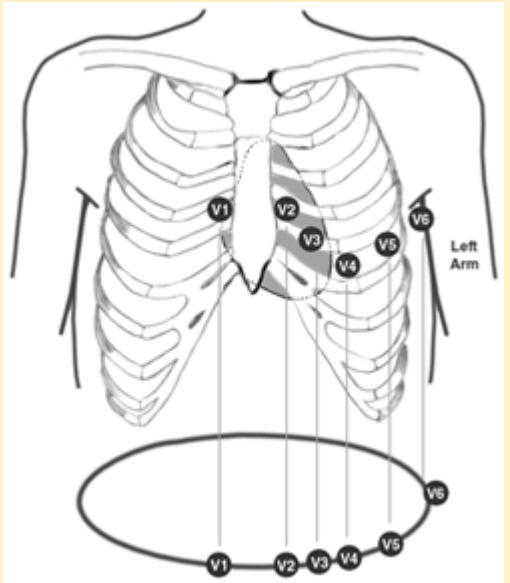
- Remember
  - The right leg electrode is a neutral or “earth”!



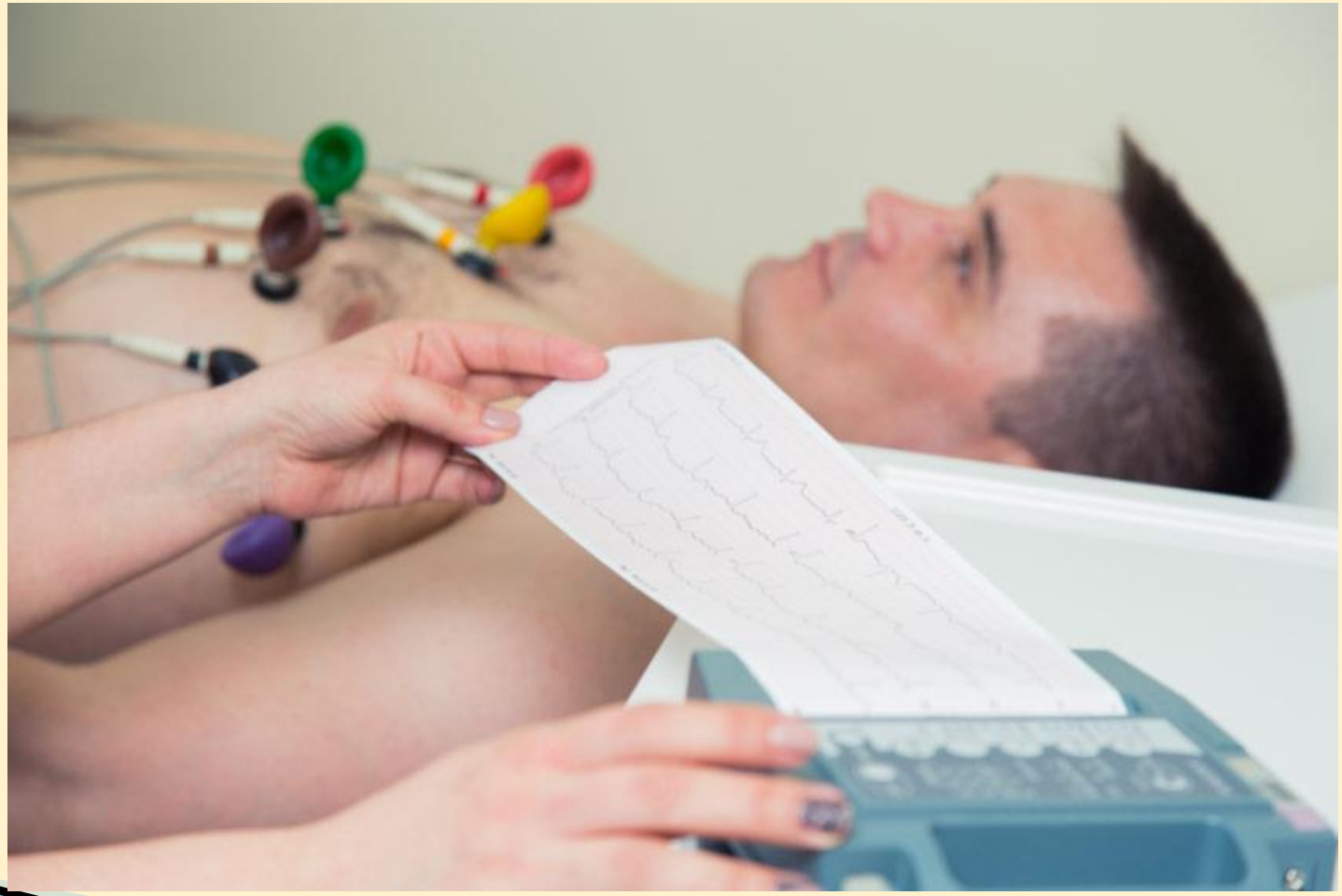
Electrode placement

For the chest electrodes

- V1 4th intercostal space right sternal edge
- V2 4th intercostal space left sternal edge
  - (to find the 4th space, palpate the manubriosternal angle (of Louis)
  - Directly adjacent is the 2nd rib, with the 2nd intercostal space directly below. Palpate inferiorly to find the 3rd and then 4th space
- V4 over the apex (5th ICS mid-clavicular line)
- V3 halfway between V2 and V4
- V5 at the same level as V4 but on the anterior axillary line
- V6 at the same level as V4 and V5 but on the mid-axillary line



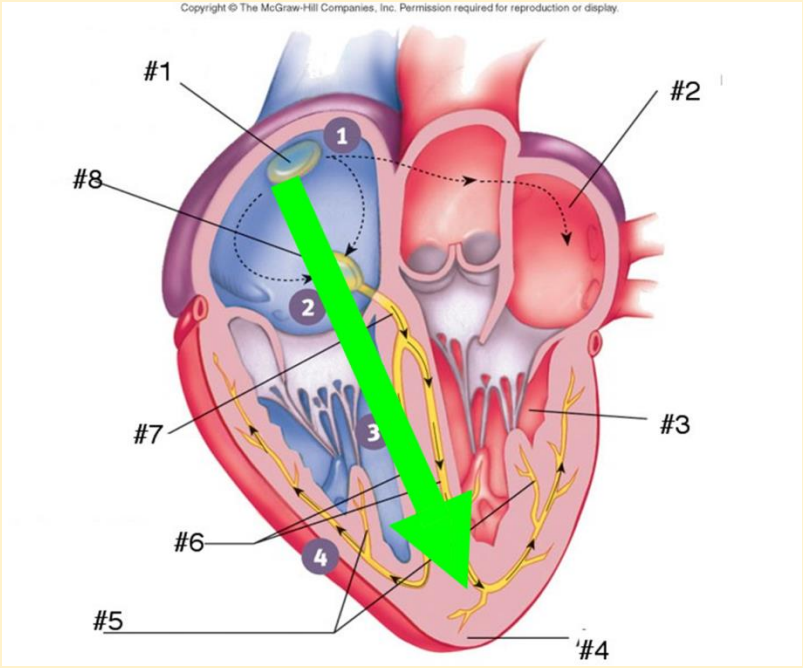
ECG



Recording the trace

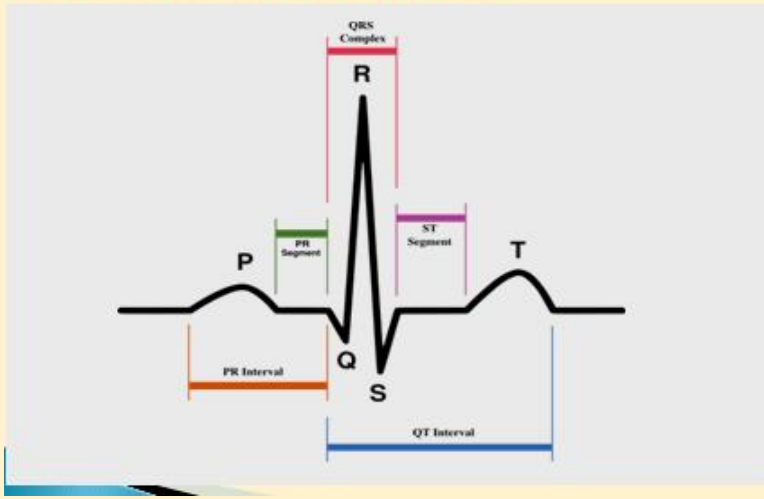
- Different ECG machines have different buttons that you have to press.
- Ask one of the staff on the ward if it is a machine that you are unfamiliar with.
- Ask the patient to relax completely. Any skeletal muscle activity will be picked up as interference.
- If the trace obtained is no good, check that all the dots are stuck down properly – they have a tendency to fall off.

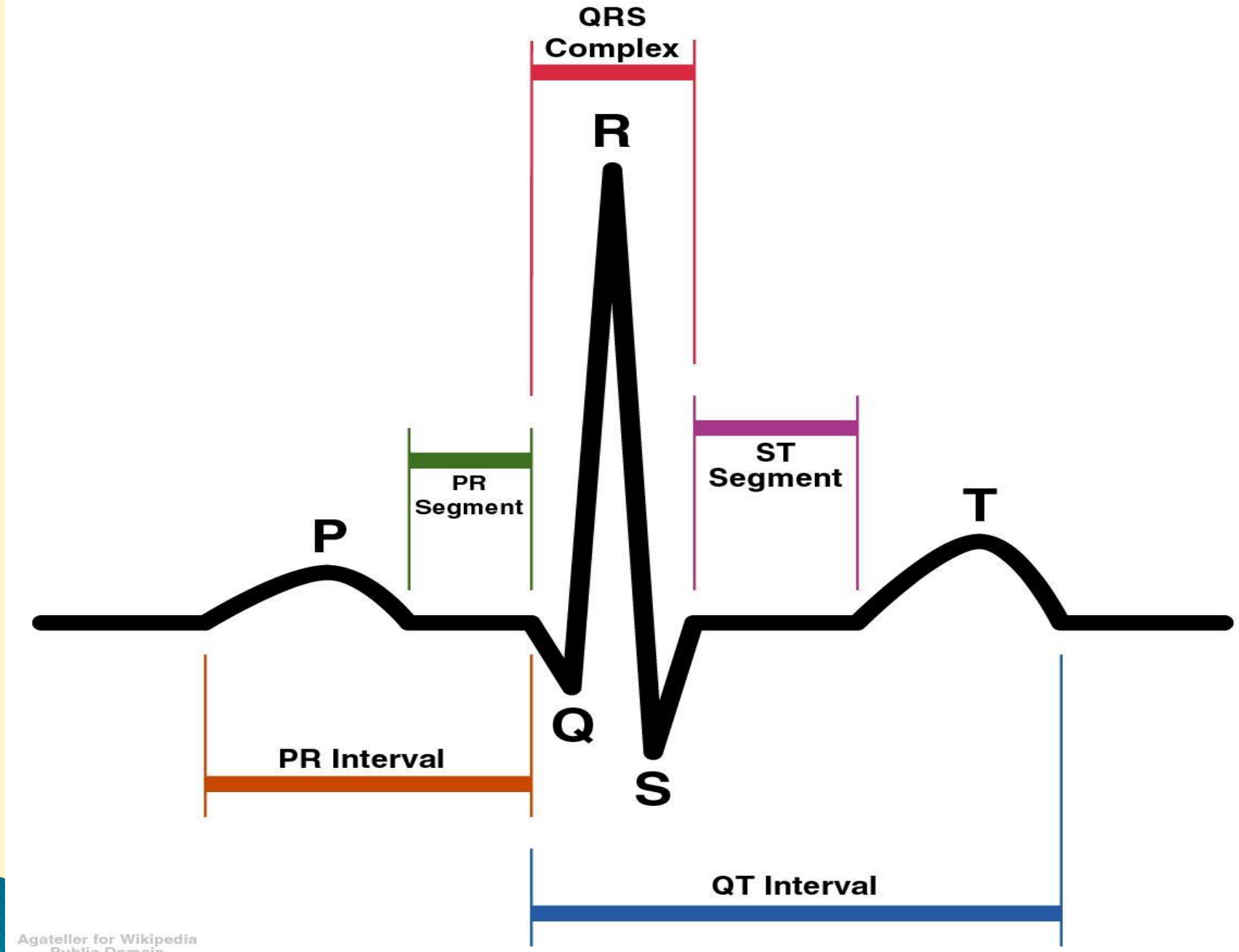
Electrophysiology



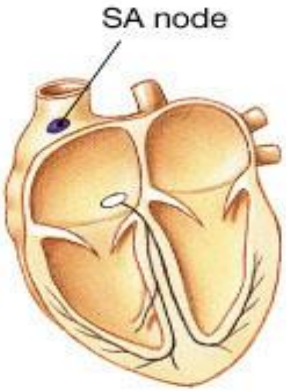
- Pacemaker = sinoatrial node
- Impulse travels across atria
- Reaches AV node
- Transmitted along interventricular septum in Bundle of His
- Bundle splits in two (right and left branches)
- Purkinje fibres

Elements of the trace



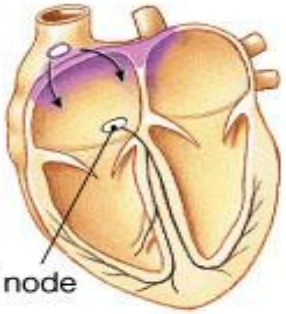


Conduction of Impulses through the Heart



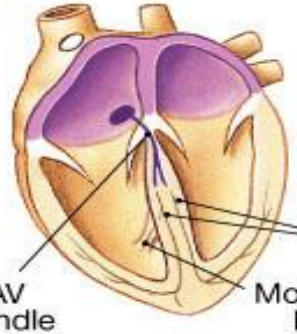
STEP 1:
SA node activity and atrial activation begin.

Time = 0



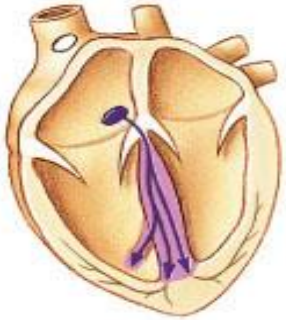
STEP 2:
Stimulus spreads across the atrial surfaces and reaches the AV node.

Elapsed time = 50 msec



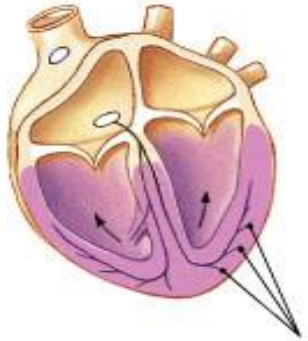
STEP 3:
There is a 100-msec delay at the AV node. Atrial contraction begins.

Elapsed time = 150 msec



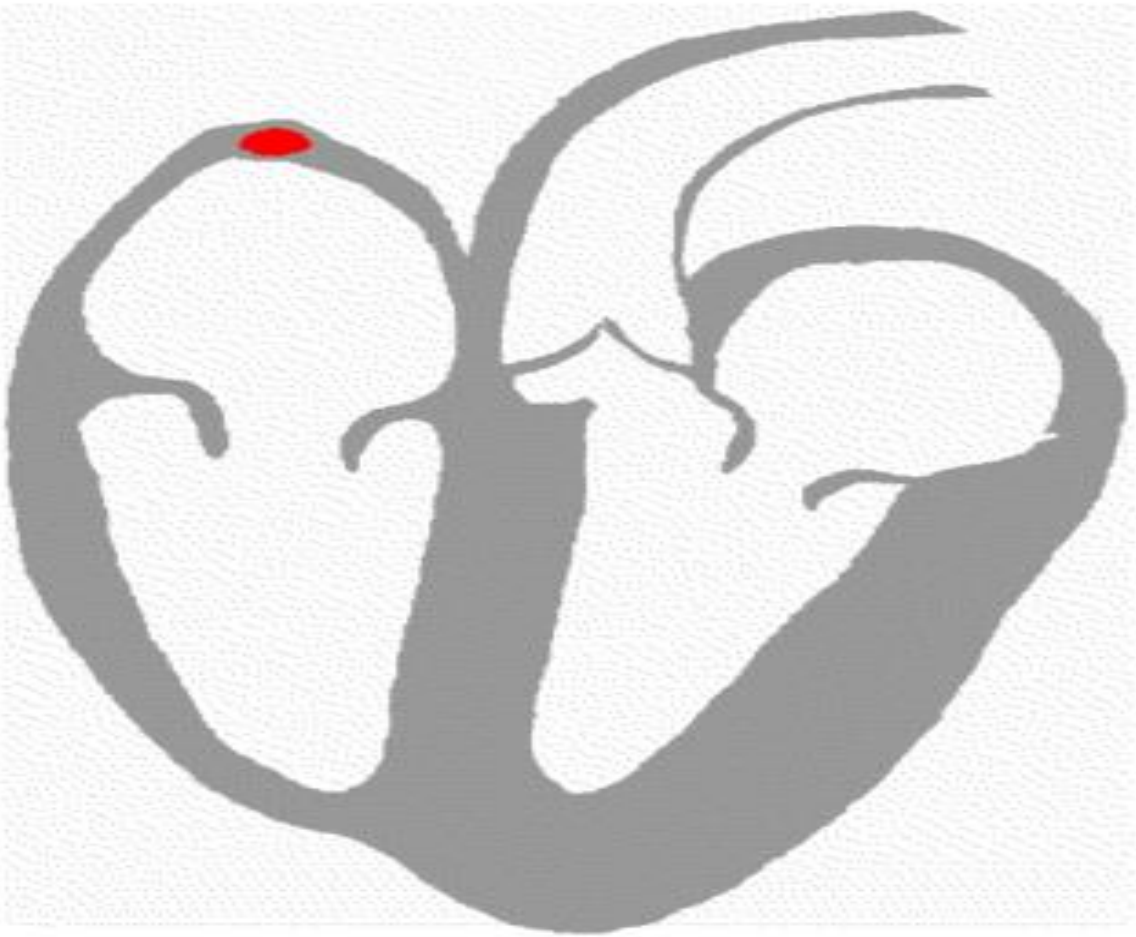
STEP 4:
The impulse travels along the interventricular septum within the AV bundle and the bundle branches to the Purkinje fibers and, via the moderator band, to the papillary muscles of the right ventricle.

Elapsed time = 175 msec



STEP 5:
The impulse is distributed by Purkinje fibers and relayed throughout the ventricular myocardium. Atrial contraction is completed, and ventricular contraction begins.

Elapsed time = 225 msec

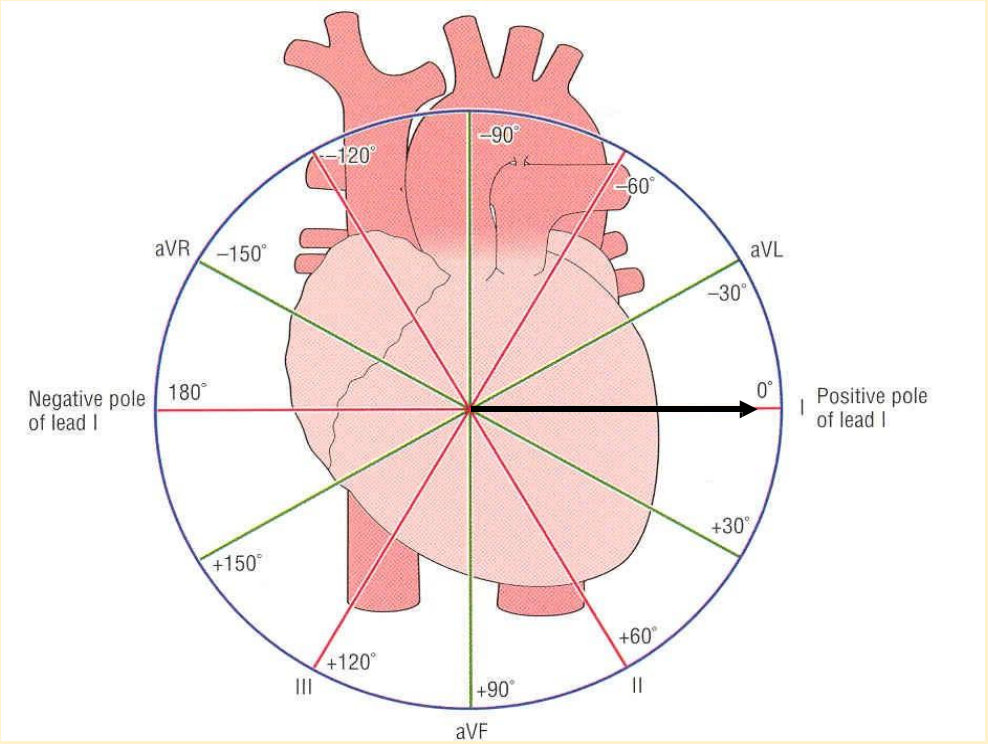


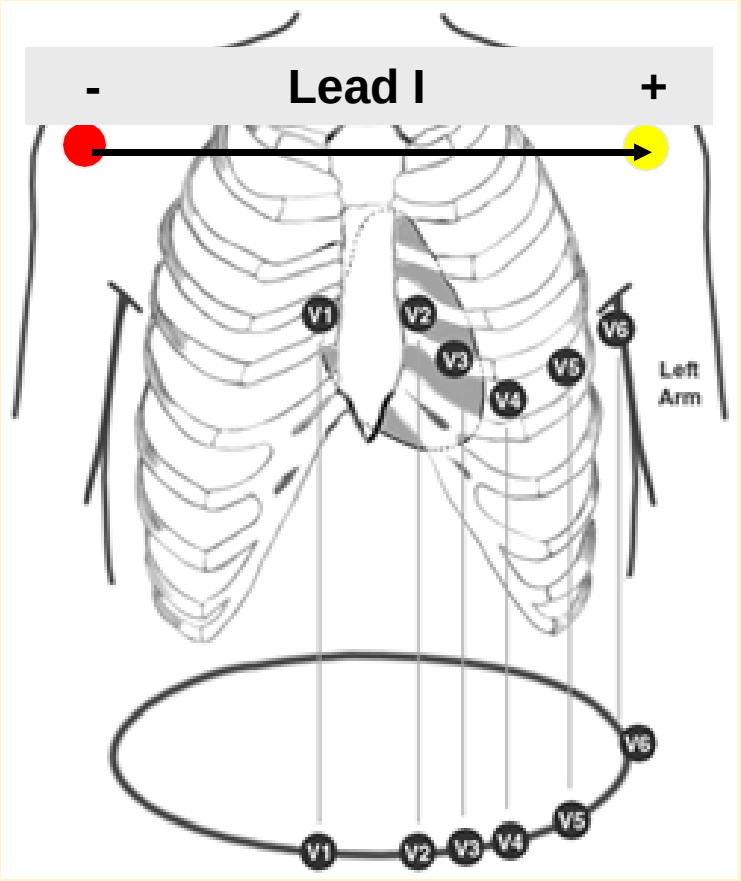
Electrophysiology

How does the ECG work?

- *Electrical impulse (wave of depolarisation) picked up by placing electrodes on patient*
- *The voltage change is sensed by measuring the current change across 2 electrodes – a positive electrode and a negative electrode*
- If the electrical impulse travels **towards** the positive electrode this results in a **positive** deflection
- If the impulse travels **away** from the positive electrode this results in a **negative** deflection

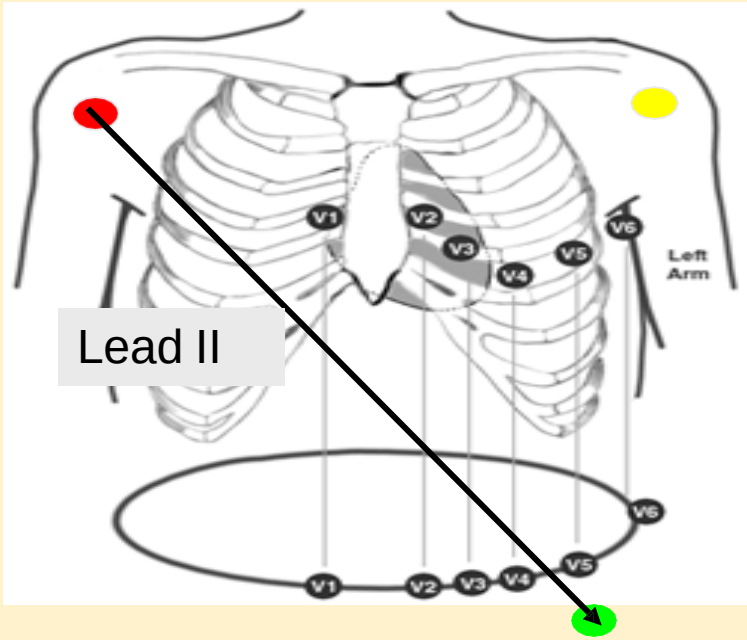
Leads

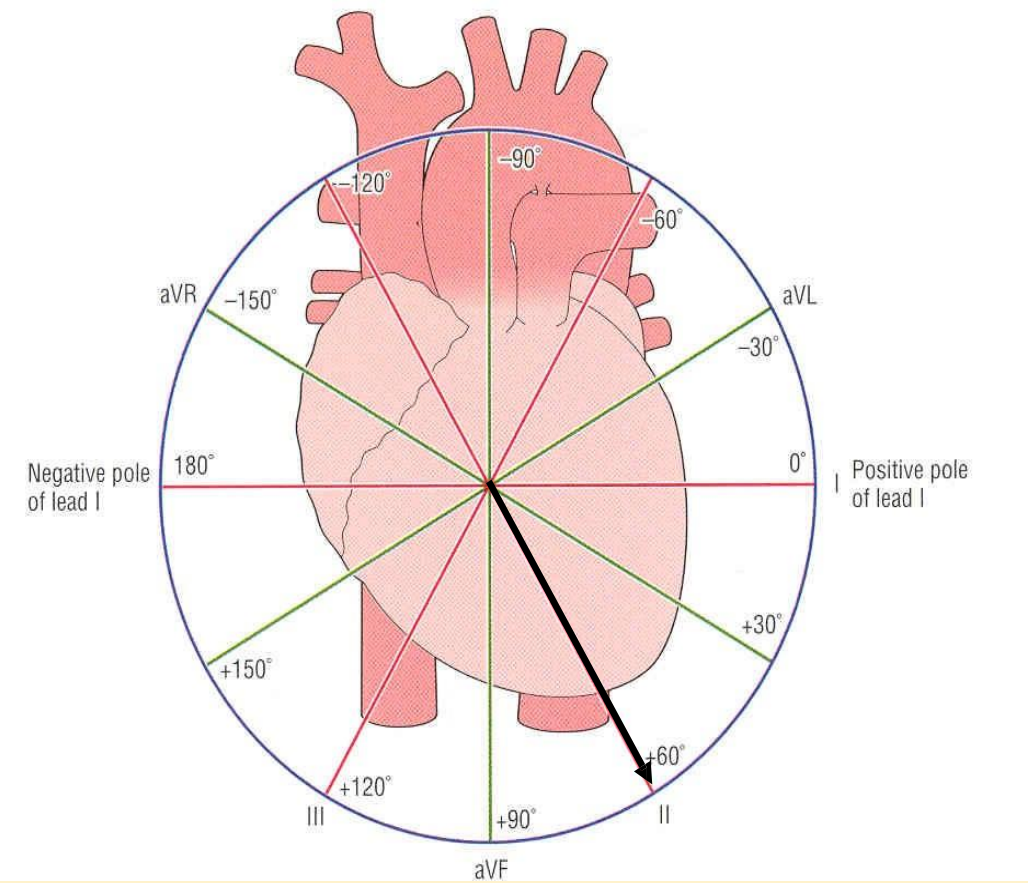

–120°
–90°
–60°
aVR
–150°
aVL
–30°
Negative pole
of lead I
180°
0°
I
Positive pole
of lead I
+30°
+150°
+60°
+120°
III
+90°
II
aVF

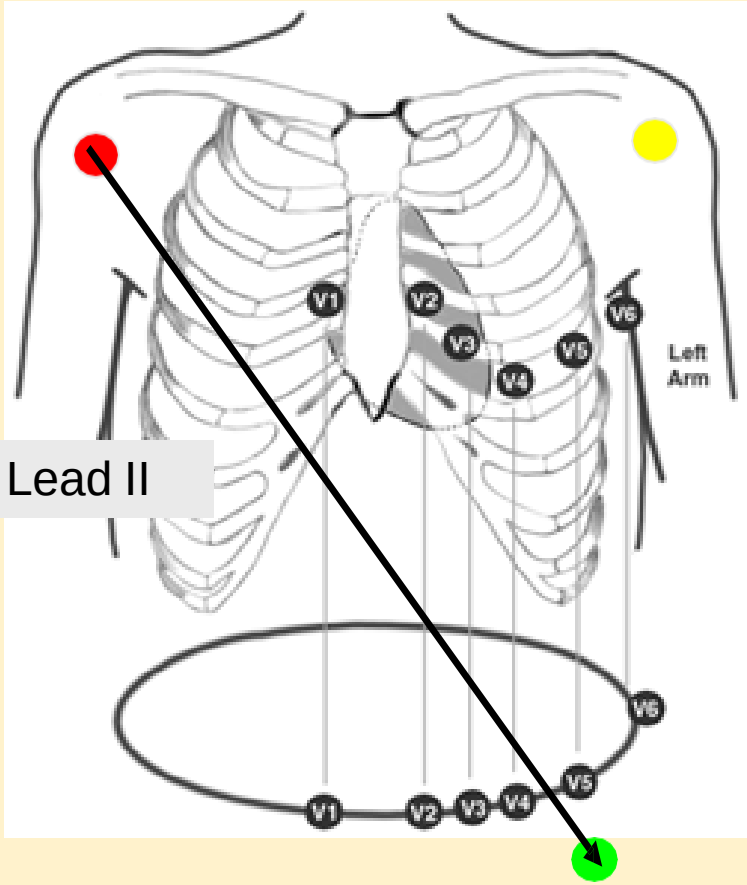

-
Lead I
+
V1
V2
V3
V4
V5
V6
Left
Arm

Leads

- Lead II is formed using the right arm electrode (red) as the negative electrode and the left leg electrode as the positive




–90°
–120°
–60°
aVR
–150°
aVL
–30°
Negative pole
of lead I
180°
0°
I
Positive pole
of lead I
+30°
+150°
+60°
+120°
III
+90°
II
aVF


V1
V2
V3
V4
V5
V6
Left
Arm
Lead II

Leads

- Lead III is formed using the left arm electrode as the negative electrode and the left leg electrode as the positive

- aVL, aVF, and aVR are *composite leads*, computed using the information from the other leads

Leads and what they tell you

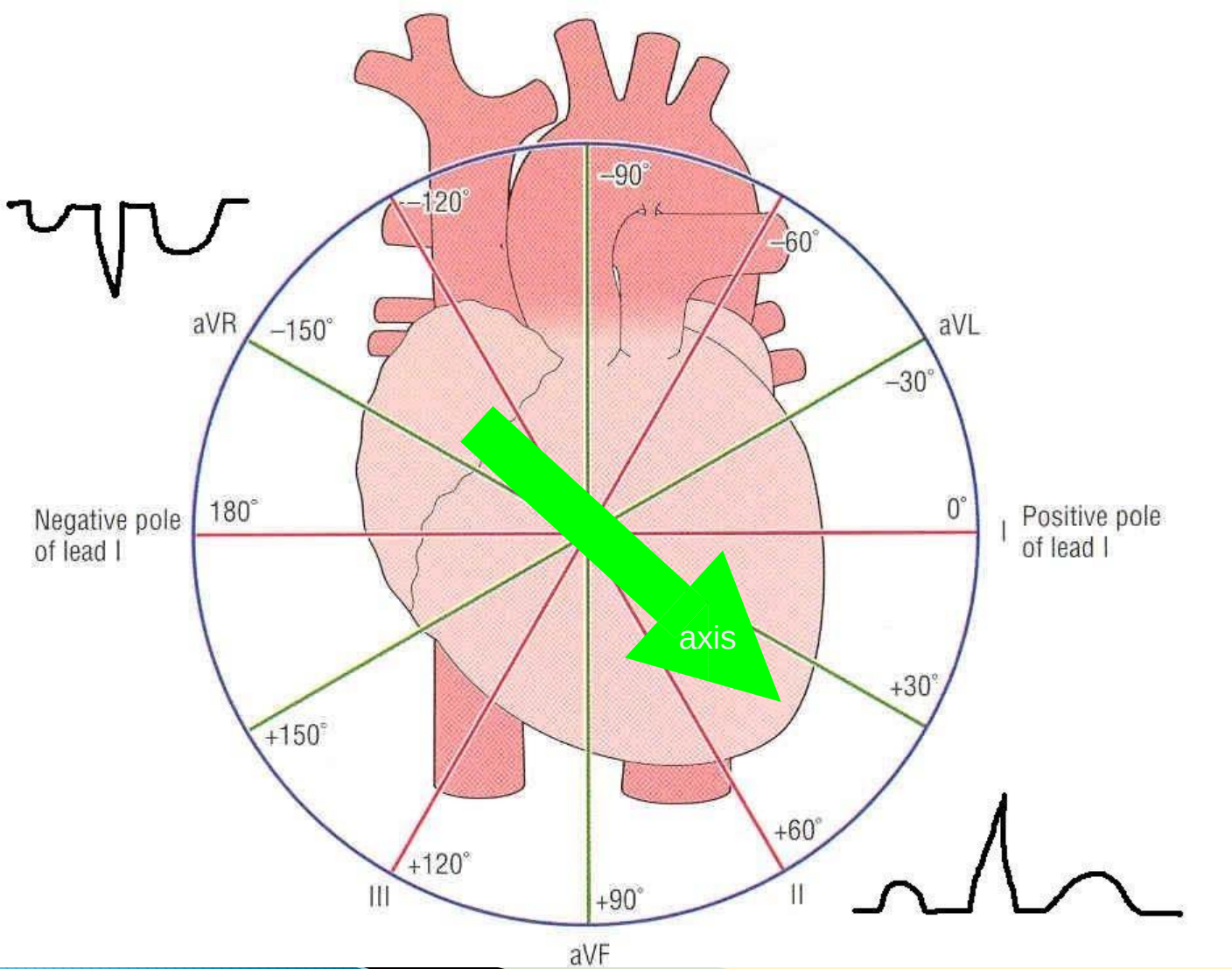
Limb leads

Limb leads look at the heart in the coronal plane

- aVL, I and II = lateral
- II, III and aVF = inferior
- aVR = right side of the heart

Leads look at the heart from different directions

− ve



+ve

Leads and what they tell you

Each lead can be thought of as ‘looking at’ an area of myocardium

Chest leads

V_1 to V_6 ‘look’ at the heart on the transverse plain

- V_1 and V_2 look at the anterior of the heart and R ventricle
- V_3 and V_4 = anterior and septal
- V_5 and V_6 = lateral and left ventricle

What do the components represent ?

- P wave = atrial depolarisation
- QRS = ventricular depolarisation
- T = repolarisation of the ventricles

Electrocardiogram

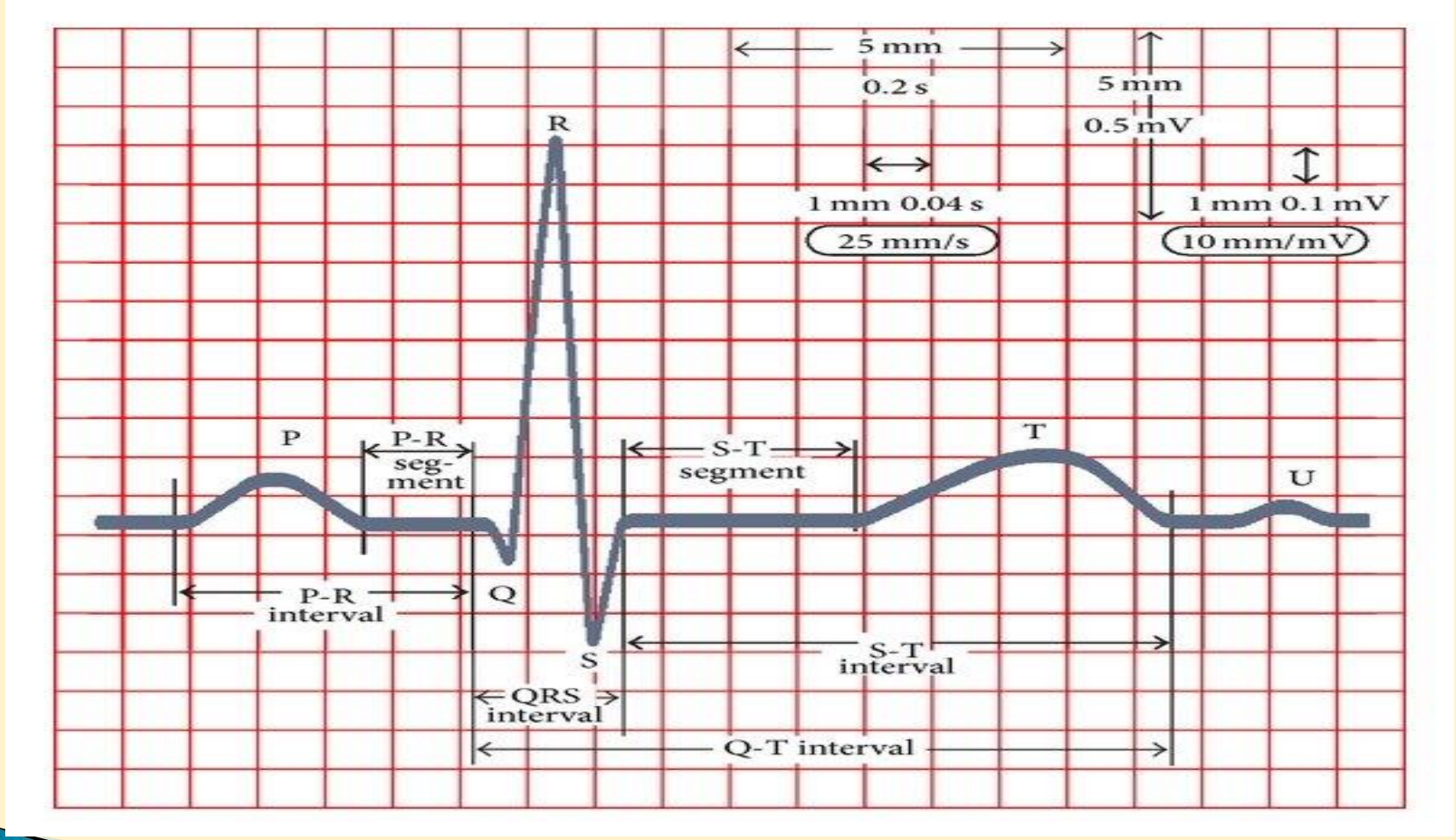
- Record of electrical events in the myocardium that can be correlated with mechanical events
- **P wave**: depolarization of atrial myocardium.
  - Signals onset of atrial contraction
- **QRS complex**: ventricular depolarization
  - Signals onset of ventricular contraction..
- **T wave**: repolarization of ventricles
- **PR interval** or PQ interval: 0.16 sec
  - Extends from start of atrial depolarization to start of ventricular depolarization (QRS complex) contract and begin to relax
  - Can indicate damage to conducting pathway or AV node if greater than 0.20 sec (200 msec)
- **Q-T interval**: time required for ventricles to undergo a single cycle of depolarization and repolarization
  - Can be lengthened by electrolyte disturbances, conduction problems, coronary ischemia, myocardial damage

Interpreting the ECG

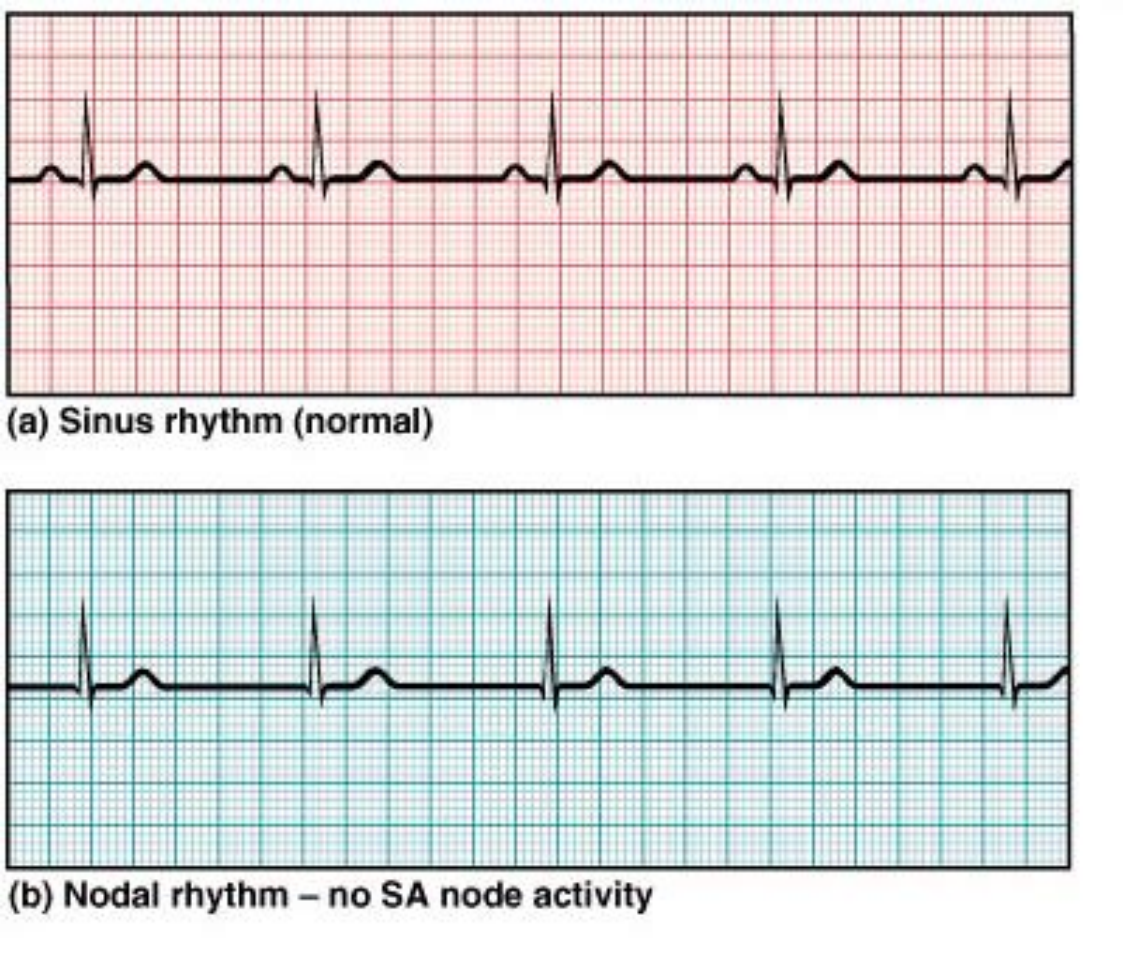
Interpreting the ECG

- Check
  - Name
  - DoB
  - Time and date
  - Indication e.g. “chest pain” or “routine pre-op”
  - Any previous or subsequent ECGs
  - Is it part of a serial ECG sequence? In which case it may be numbered
- Calibration
- Rate
- Rhythm
- Axis
- Elements of the tracing in each lead

ECG


5 mm
0.2 s
5 mm
0.5 mV
R
1 mm 0.04 s
25 mm/s
1 mm 0.1 mV
10 mm/mV
P
P-R
seg-
ment
S-T
segment
T
U
P-R
interval
Q
S
S-T
interval
QRS
interval
Q-T interval

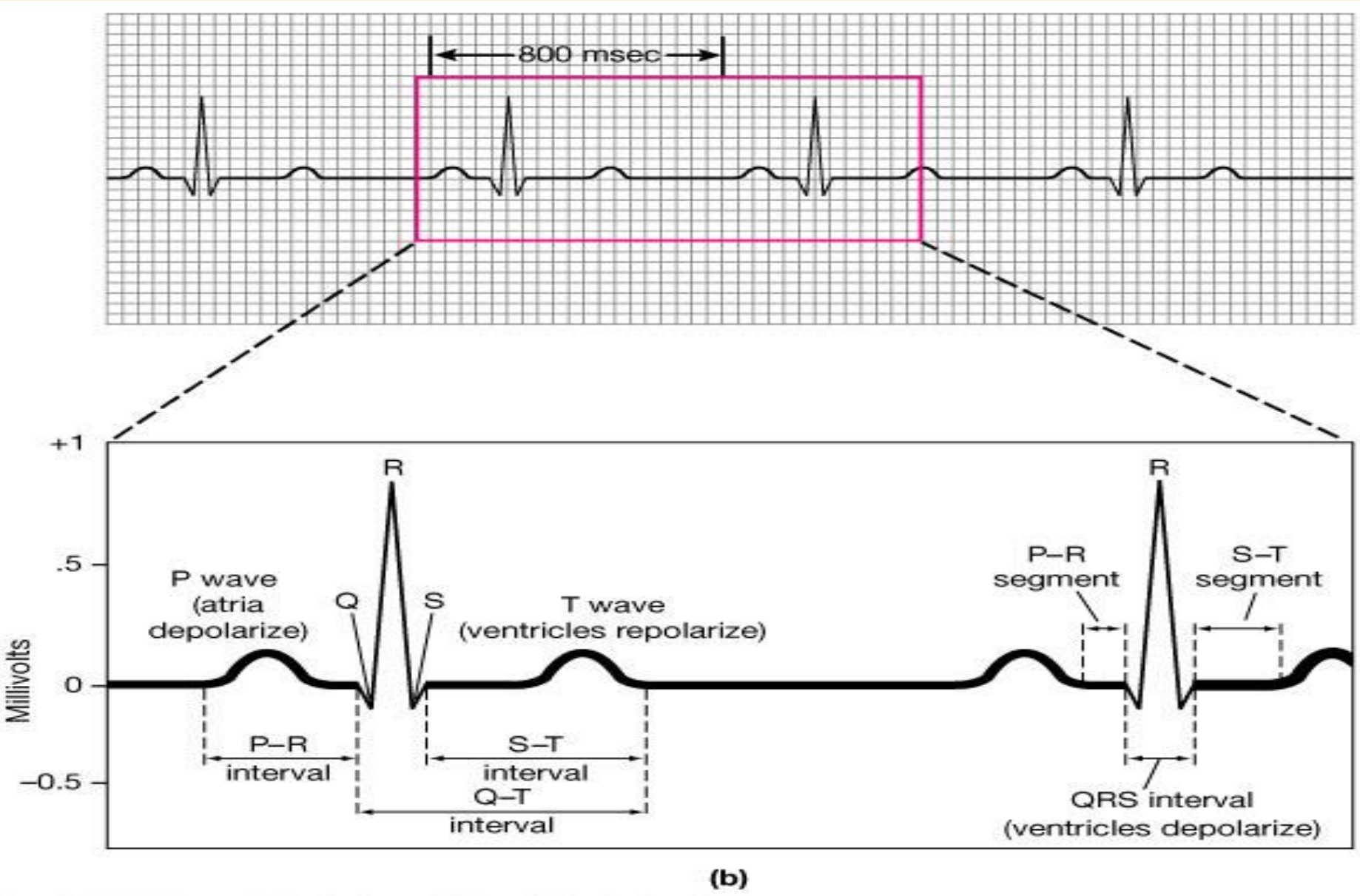
ECGs, Normal and Abnormal

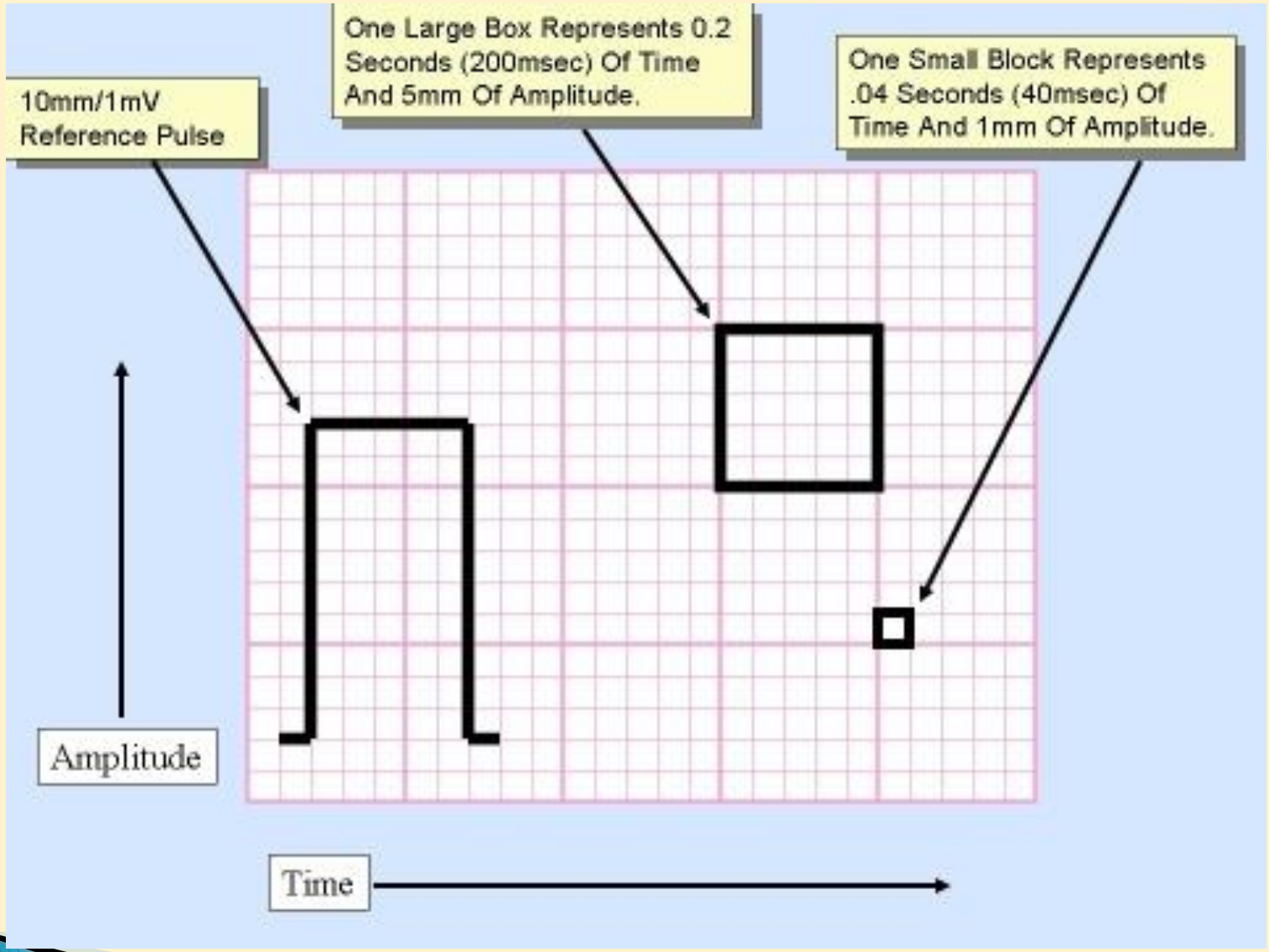


(a) Sinus rhythm (normal)

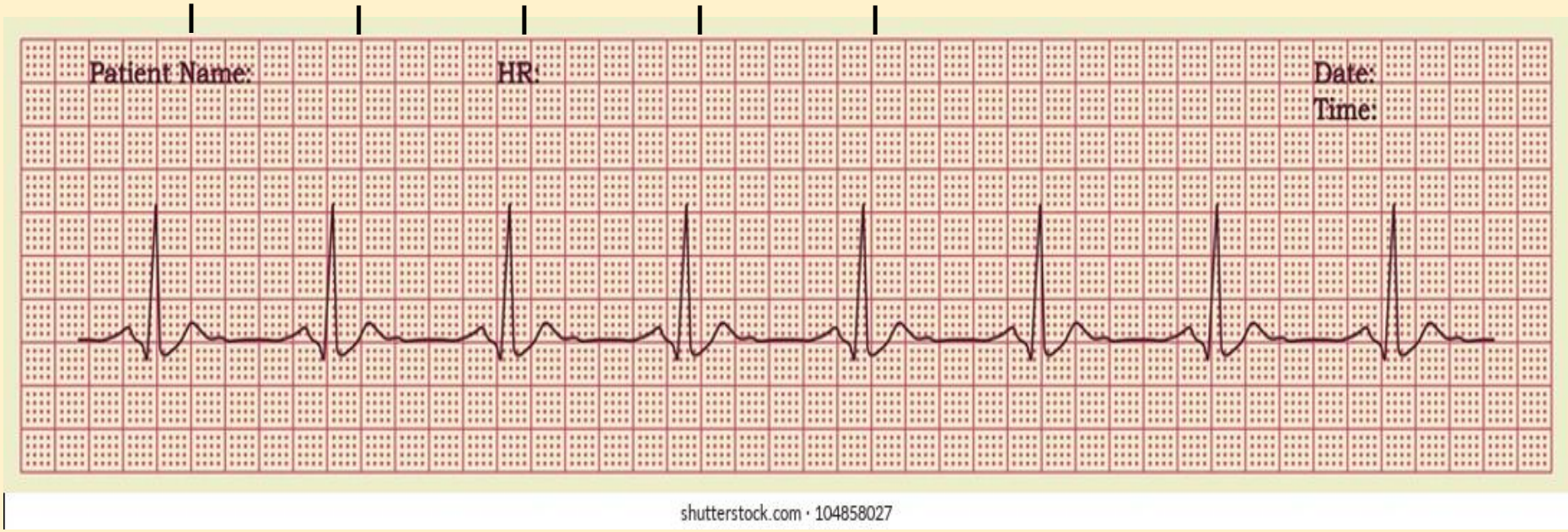
(b) Nodal rhythm – no SA node activity

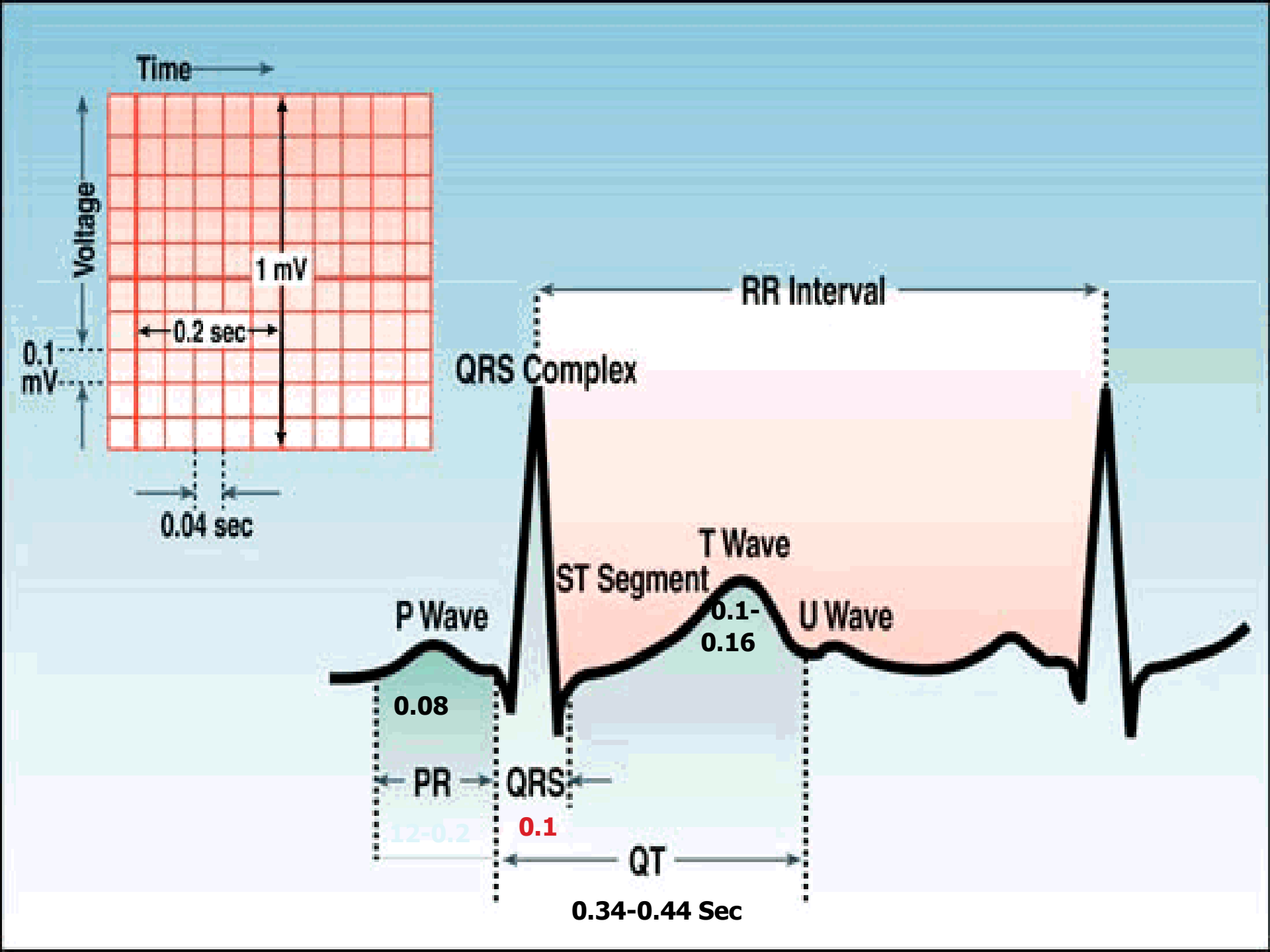
An Electrocardiogram



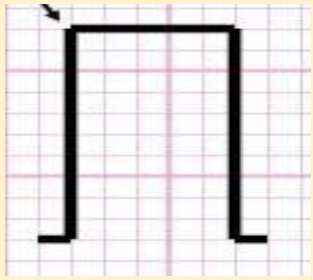

10mm/1mV
Reference Pulse
One Large Box Represents 0.2
Seconds (200msec) Of Time
And 5mm Of Amplitude.
One Small Block Represents
.04 Seconds (40msec) Of
Time And 1mm Of Amplitude.
Amplitude
Time

ECG




Time
Voltage
1 mV
0.2 sec
0.1 mV
0.04 sec
RR Interval
QRS Complex
T Wave
ST Segment
P Wave
0.1-0.16
U Wave
0.08
PR
QRS
0.1
QT
0.34-0.44 Sec

Calibration



Check that your ECG is calibrated correctly

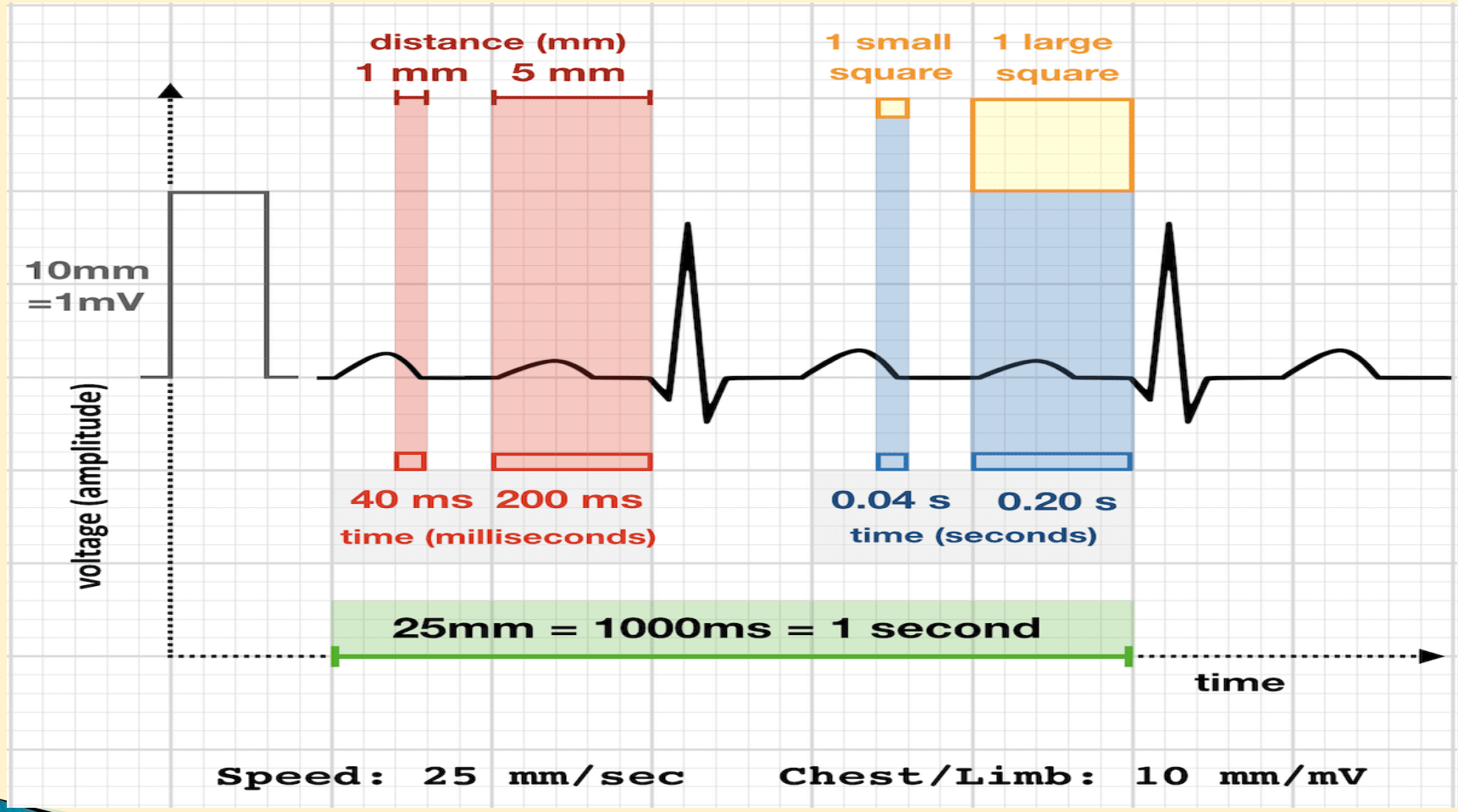
Height

- 10mm = 1mV
- Look for a reference pulse which should be the rectangular looking wave somewhere near the left of the paper. It should be 10mm (10 small squares) tall

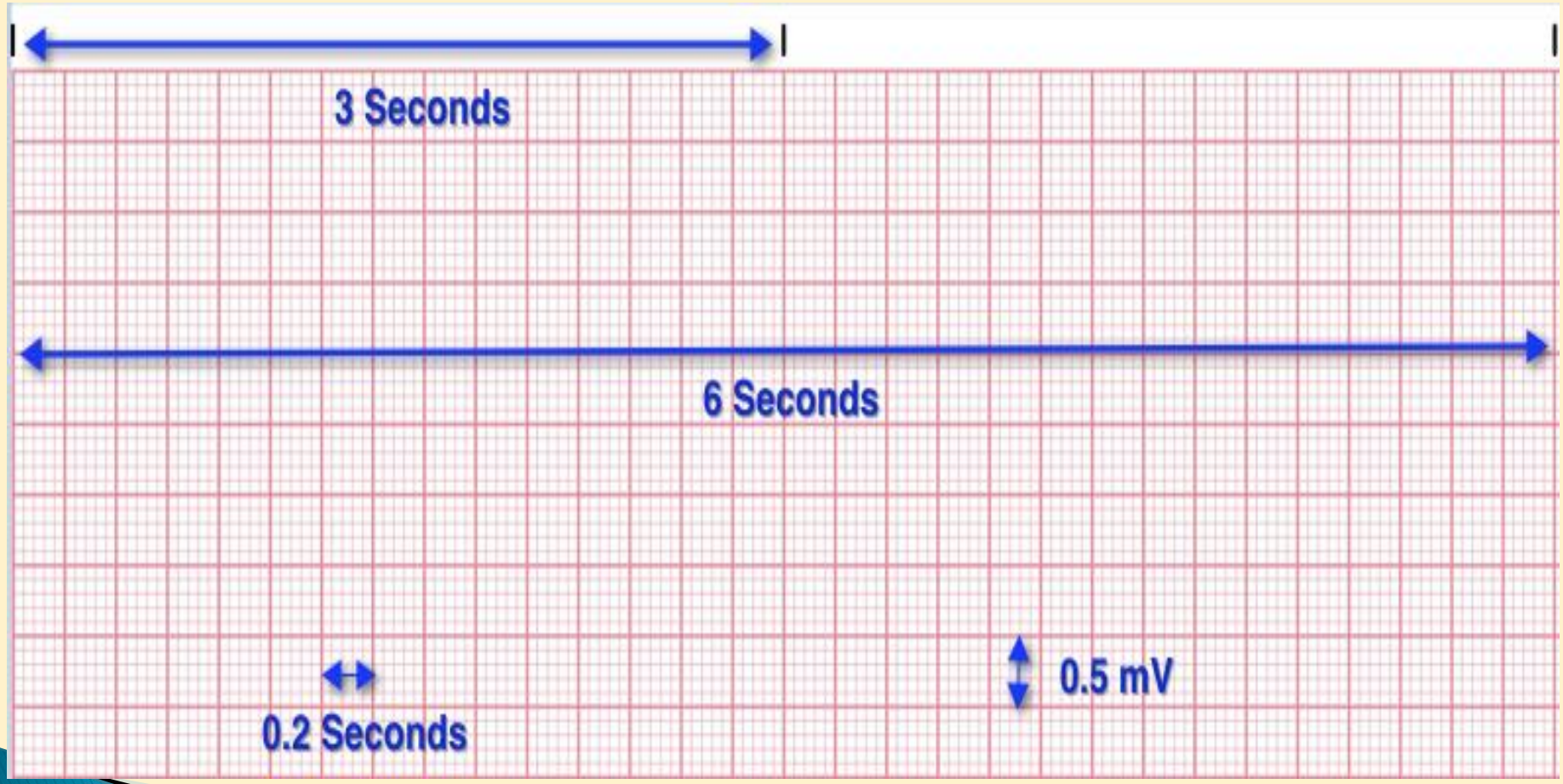
Paper speed

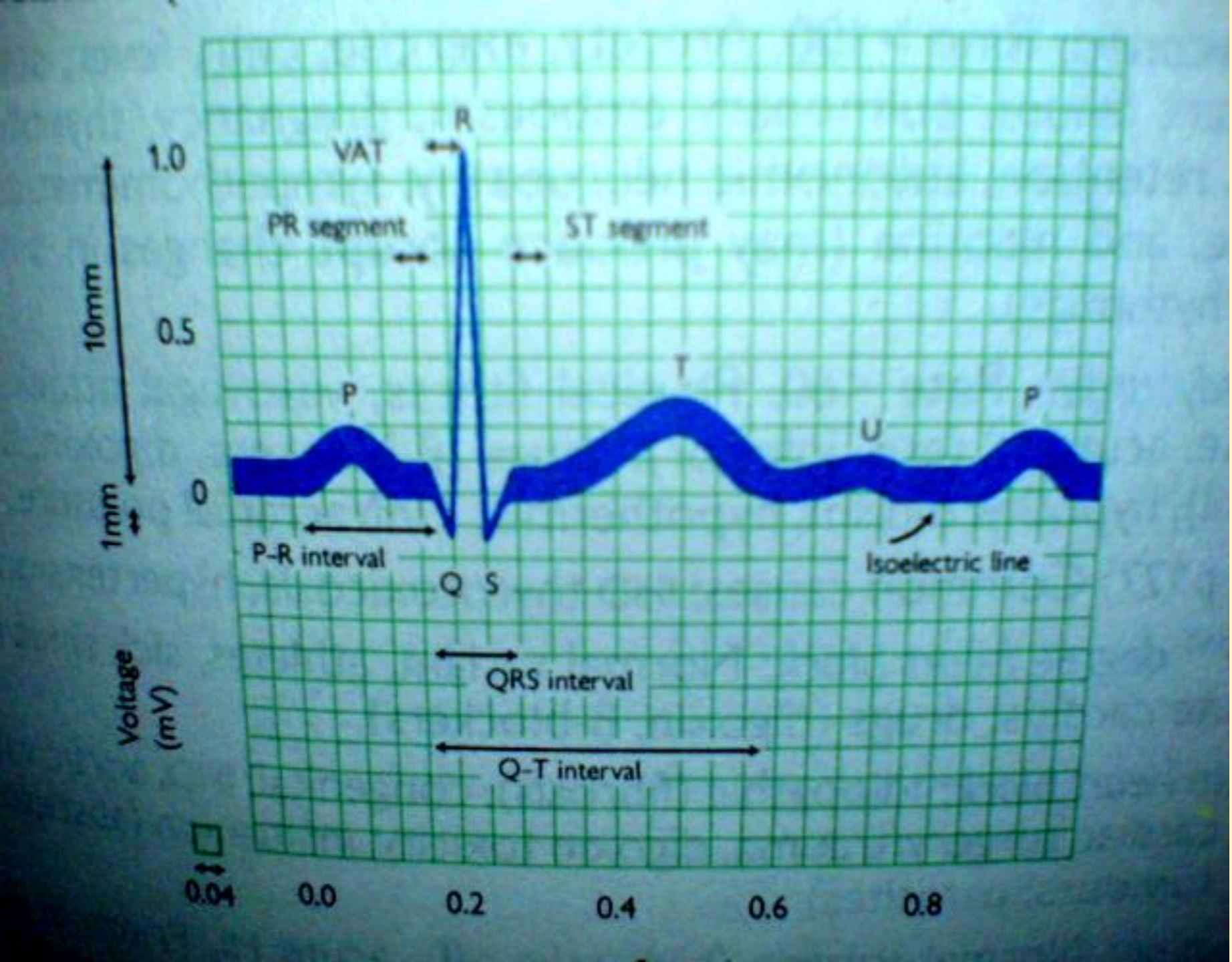
- 25mm/s
- 25 mm (25 small squares / 5 large squares) equals one second

ECG


distance (mm)
1 mm
5 mm
1 small square
1 large square
10mm =1mV
voltage (amplitude)
40 ms
200 ms
time (milliseconds)
0.04 s
0.20 s
time (seconds)
25mm = 1000ms = 1 second
time
Speed: 25 mm/sec
Chest/Limb: 10 mm/mV

ECG




R
VAT
1.0
PR segment
ST segment
10mm
0.5
T
P
P
U
0
1mm
P-R interval
Isoelectric line
Q S
QRS interval
Voltage (mV)
Q-T interval
0.04
0.0
0.2
0.4
0.6
0.8

Rate

- If the heart rate is regular
  - Count the number of large squares between R waves
    - i.e. the RR interval in large squares
    - Rate = $\frac{300}{RR}$

e.g. RR = 4 large squares

300/4 = 75 beats per minute

Rate

If the rhythm is irregular (see next slide on rhythm to check whether your rhythm is regular or not) it may be better to estimate the rate using the rhythm strip at the bottom of the ECG (usually lead II)

The rhythm strip is usually 25cm long (250mm i.e. 10 seconds)

If you count the number of R waves on that strip and multiple by 6 you will get the rate


Have
a sweet
day