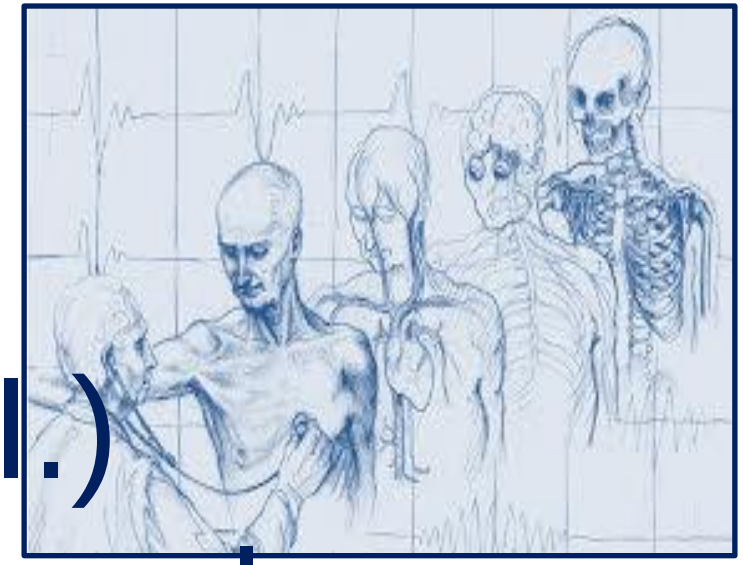


Apex beat. Heart sounds (VI.) Systolic time intervals (XIII.)

Department of Physiology

Faculty of Medicine

Masaryk University

Apex beat

- External manifestation of heart function
- Maximum in 4th or 5th intercostal space on the left (1-2 cm from medioclavicular line)
- Observation (inspection), palpation

Heart sounds

- **1st heart sound:** Closing of mitral and tricuspid valves
- **2nd heart sound:** Closing of aortic and pulmonary valves
- **systolic pause:** Time interval between 1st and 2nd heart sounds
- **diastolic pause:** Time interval between 2nd and 1st heart sounds
- **3rd heart sound:** In first part of diastole, physiological in young people; in elderly people sign of decreased compliance of LV (hypertrophy)

Heart sounds

1st heart sound - CHARACTERISATION

- **Vibration of mitral and tricuspid valves due to their rapid closure (because of increase of pressure in ventricles above the pressure in atria in the beginning of systole)**
- **Low-frequency sound takes 100 ms**
- **Circa 50 ms after beginning of QRS**
- **Maximum in region of apex beat (laying on left side)**
- **Clinically relevant: assessment of loudness of heart sound – intensification or attenuation, or splitting**

Heart sounds

2nd heart sound - CHARACTERISATION

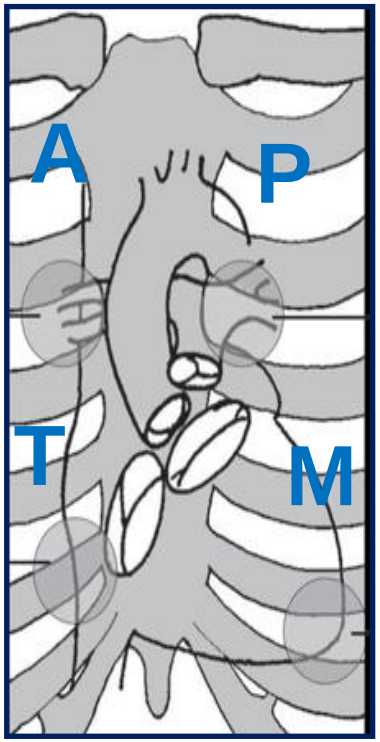
- **Vibration of aortic and pulmonary valves due to their rapid closure (because of decrease of pressure in ventricles under the pressure in aorta at the end of systole)**
- **High-frequency sound has two components – aortic and pulmonary; physiological splitting in inspiration (unsplit when the subject is holding his/her breath in expiration)**
- **Maximum in region of apex beat (laying on left side)**
- **Clinically relevant: assessment of loudness of heart sound – intensification or attenuation, or splitting**

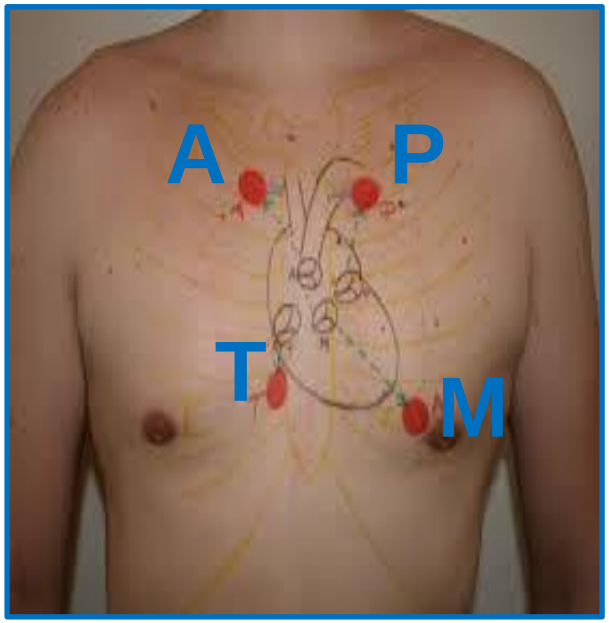
Heart sounds

- Auscultation
  - By ear
  - By stethoscope
  - By microphone - phonocardiography

Heart sounds

- Places of optimal audibility of particular valves





Aortic valve

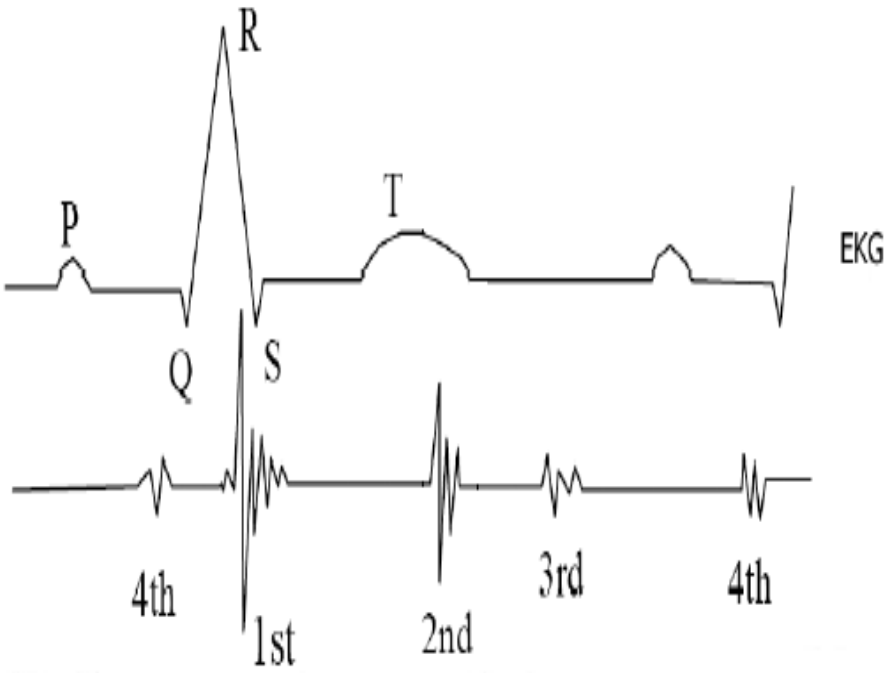
Pulmonary valve

Mitral valve

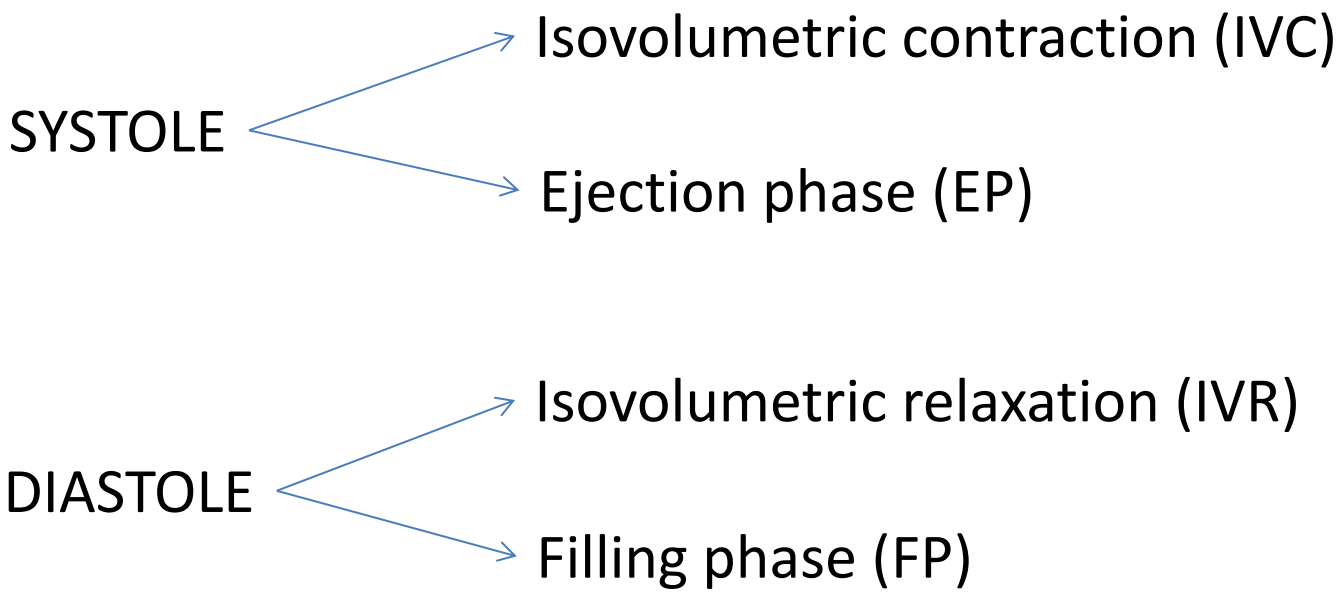
Tricuspid valve

Heart sounds

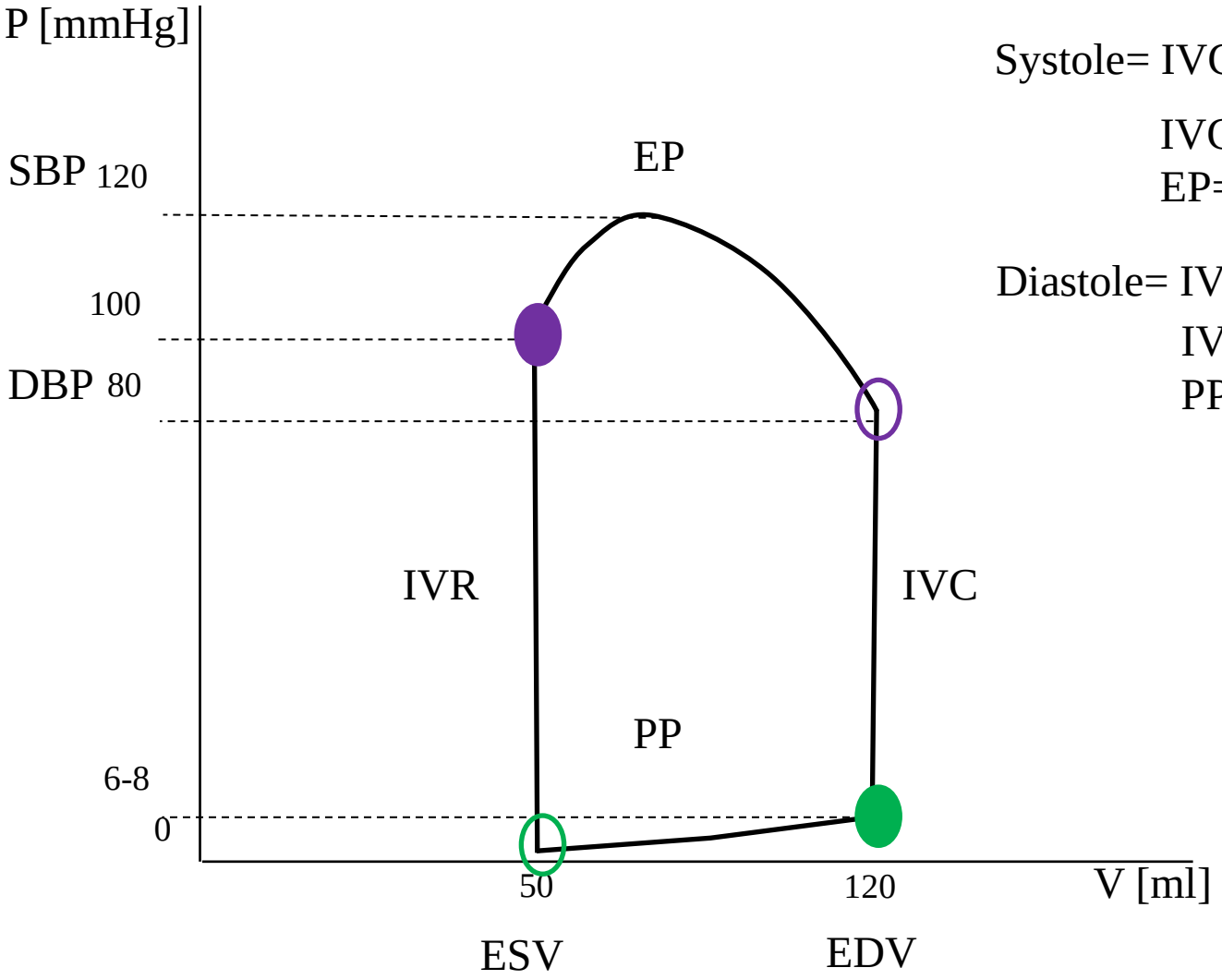
- Timing of heart sounds: ECG + phonocardiography



Heart cycle


SYSTOLE
Isovolumetric contraction (IVC)
Ejection phase (EP)
DIASTOLE
Isovolumetric relaxation (IVR)
Filling phase (FP)

Heart cycle: PV diagram



Systole= IVC+EP

IVC=0.06s

EP=0.21s

Diastole= IVR+PP

IVR=0.07s

PP=0.49s

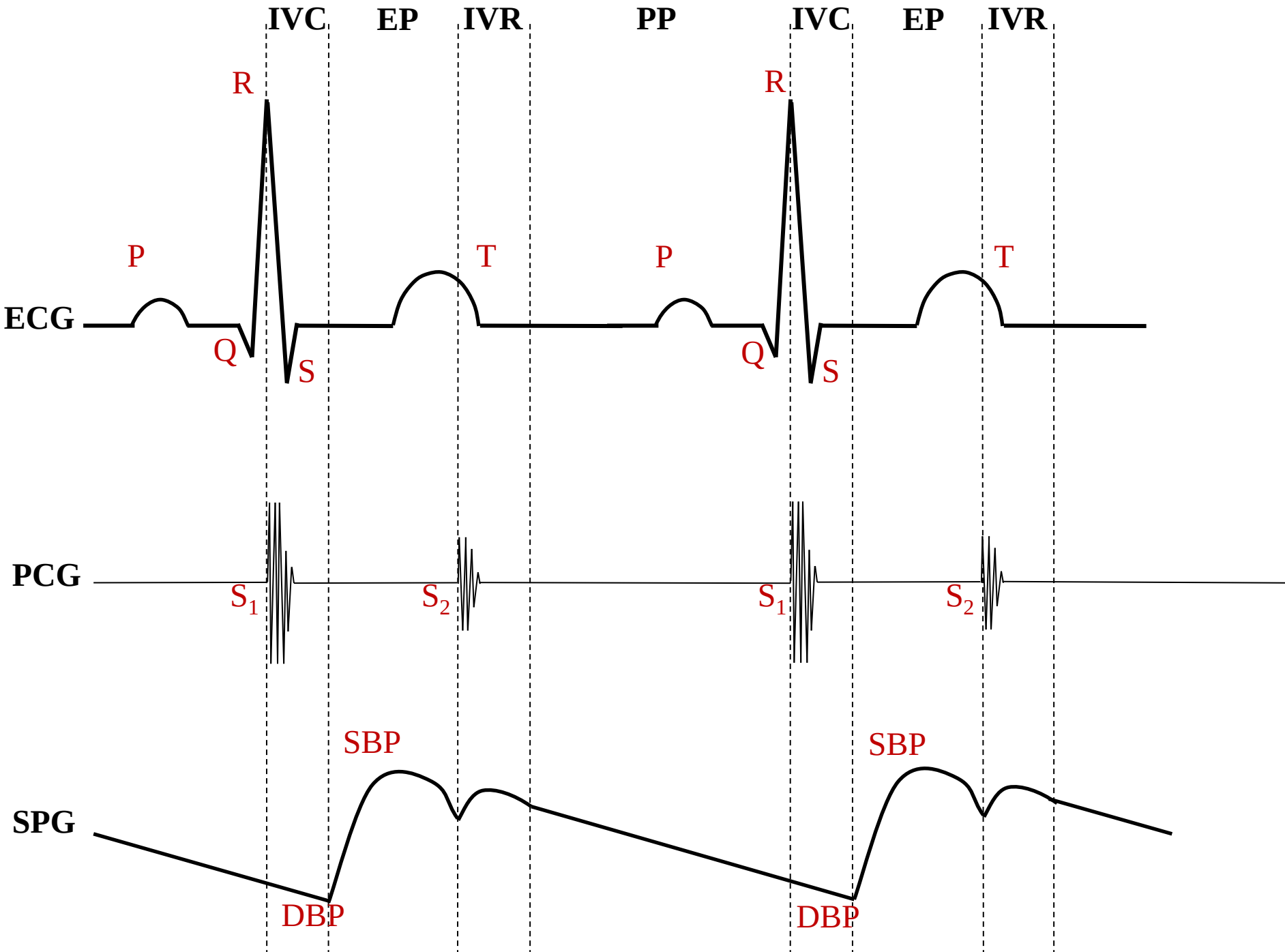
POLYGRAPHY

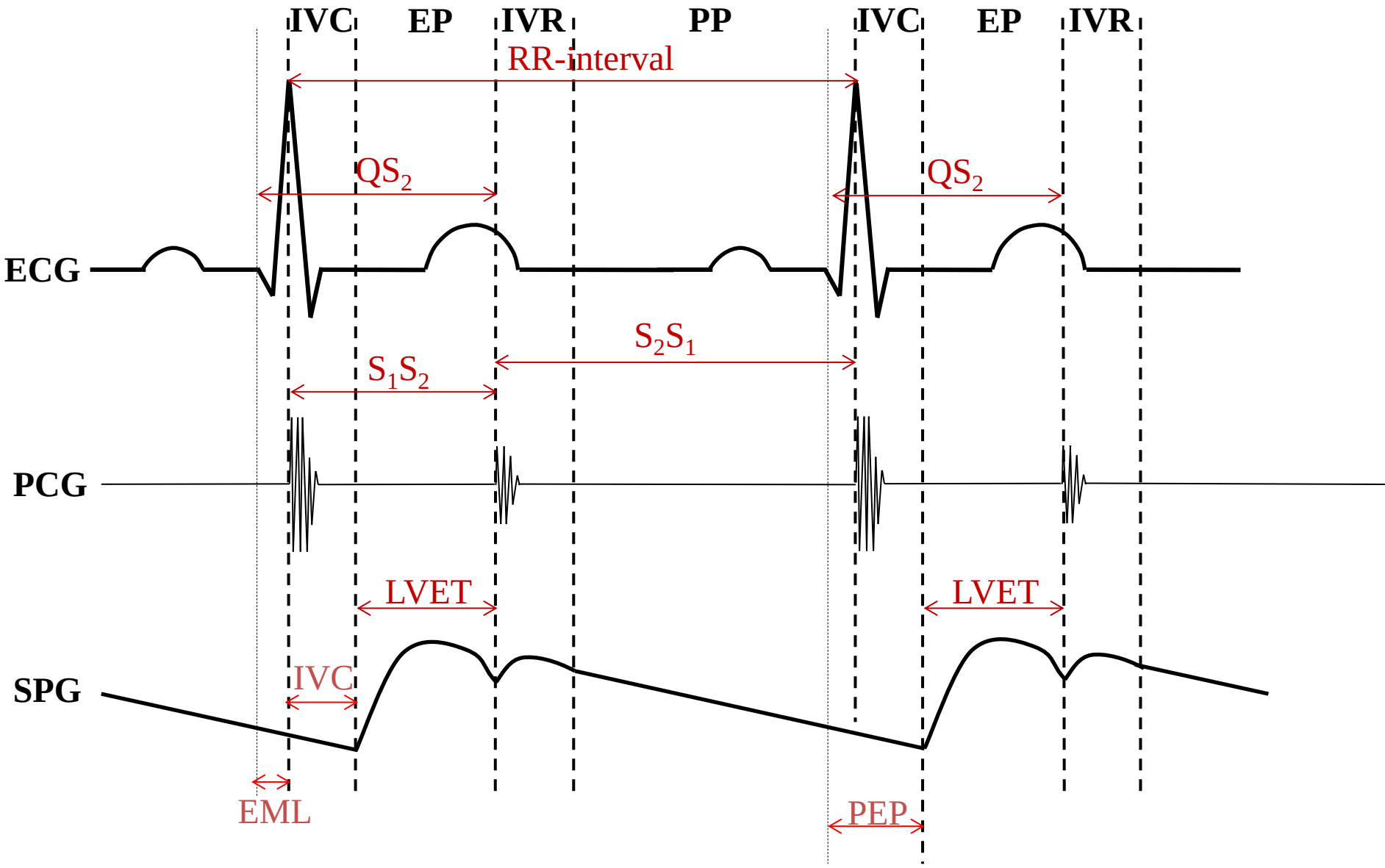
– recording of several physiological quantities (signals) in the same time

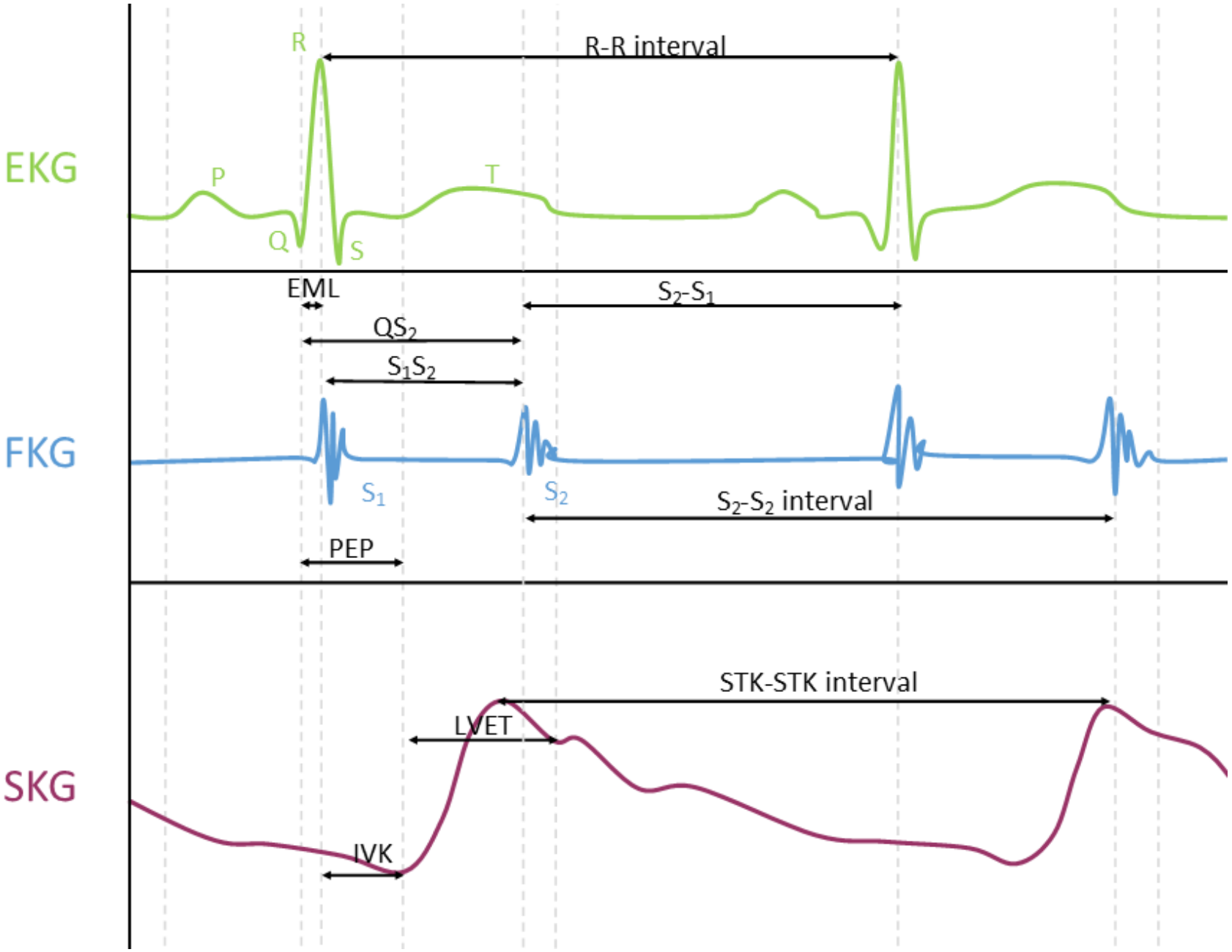
PHONOCARDIOGRAPHY - recording of heart sounds (by microphone)

ELECTROCARDIOGRAPHY (ECG)

SPHYGMOGRAPHY - recording of arterial pulse wave


IVC
EP
IVR
PP
IVC
EP
IVR
R
R
P
T
P
T
ECG
Q
S
Q
S
PCG
S_1
S_2
S_1
S_2
SBP
SBP
SPG
DBP
DBP


IVC
EP
IVR
PP
IVC
EP
IVR
RR-interval
QS2
QS2
ECG
S2S1
S1S2
PCG
LVET
LVET
SPG
IVC
EML
PEP


EKG
R
R-R interval
P
T
Q
S
FKG
EML
S_2-S_1
QS_2
S_1S_2
S_1
S_2
S_2-S_2 interval
PEP
SKG
STK-STK interval
LVET
IVK

The cardiac contractility indexes

I. Ejection fraction:

$$EF = \frac{stroke\ volume}{enddiastolic\ volume} \text{ x } 100 \text{ in \%}$$

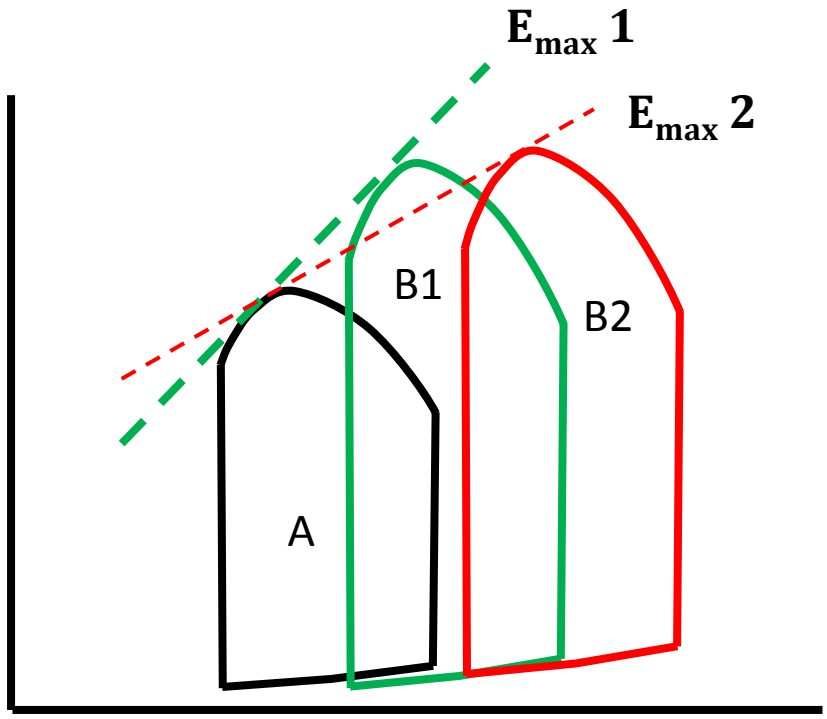
Physiological range of EF is about 60-70%. EF less than 40% could mean systolic dysfunction (contraction disorder).

II. End-diastolic pressure (EDBP) and end-diastolic volume (EDV) ratio at rest and after work load

Systolic dysfunction - EDV and EDBP are increased during exercise in comparison with rest
Diastolic dysfunction - EDBP increases during exercise, but EDV does not change

The cardiac contractility indexes

III. Cardiac contractility index derived from the systolic ejection phase



$$\mathbf{Emax} = \frac{\mathbf{dP}}{\mathbf{dV}}$$

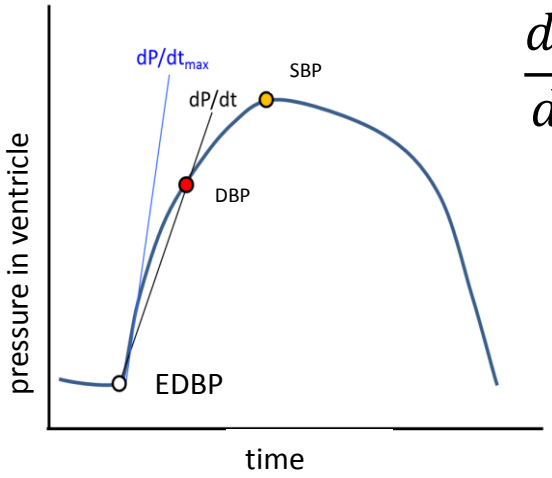
Sagawa-Suga index

A: normal P-V diagram
B: P-V diagram with increased afterload
1: healthy heart
2: failing heart

The cardiac contractility indexes

IV. The cardiac contractility index derived from the isovolumic phase of the systole

$$\frac{dP}{dt} = \frac{DBP - EDBP}{IVC}$$



$$\frac{dP}{dt} max$$

- in practical we determine the average speed of pressure development during IVC:

$$\frac{\text{DTK - 8}}{\text{IVK}}$$