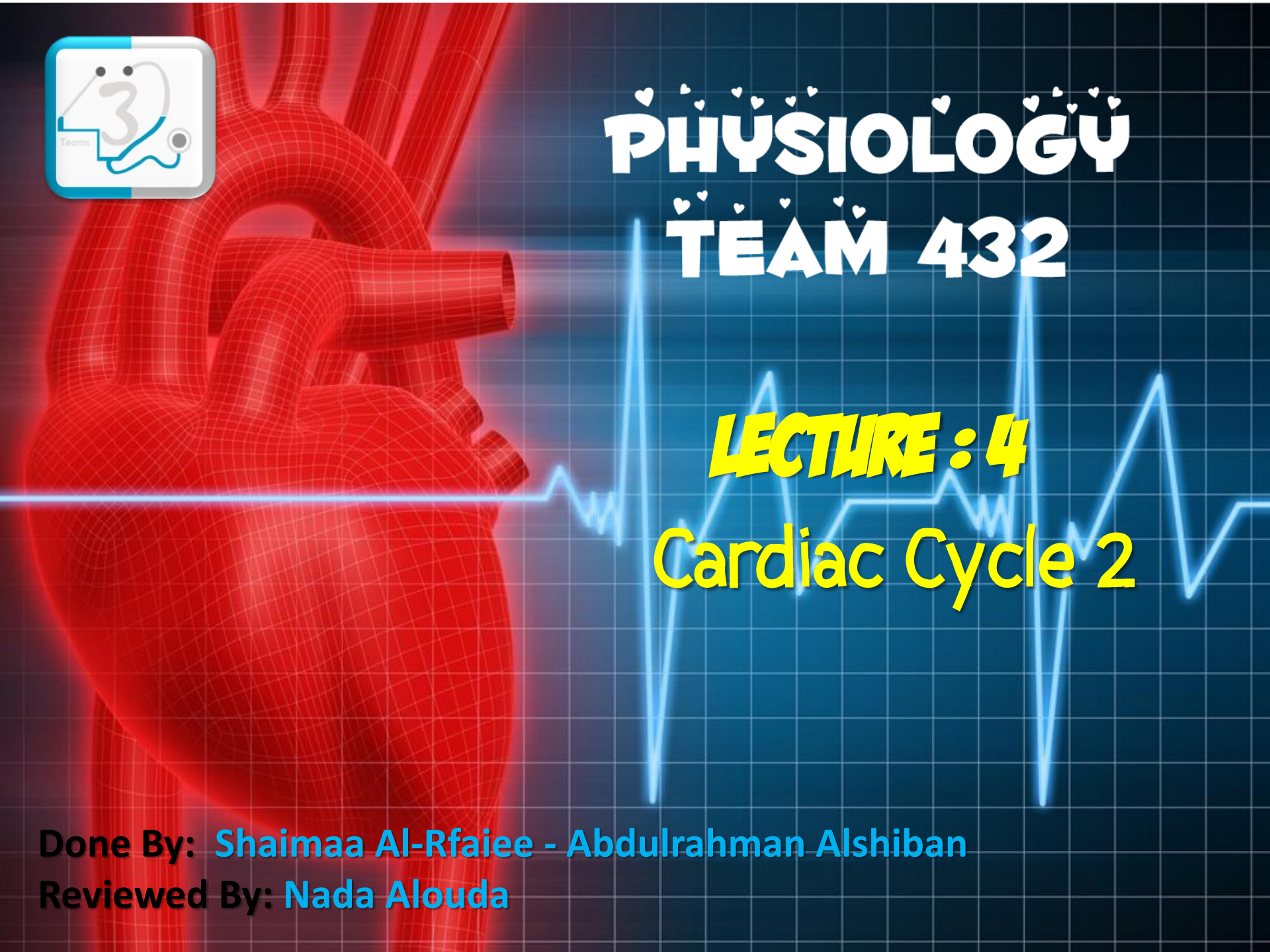


PHYSIOLOGY TEAM 432

LECTURE : 4

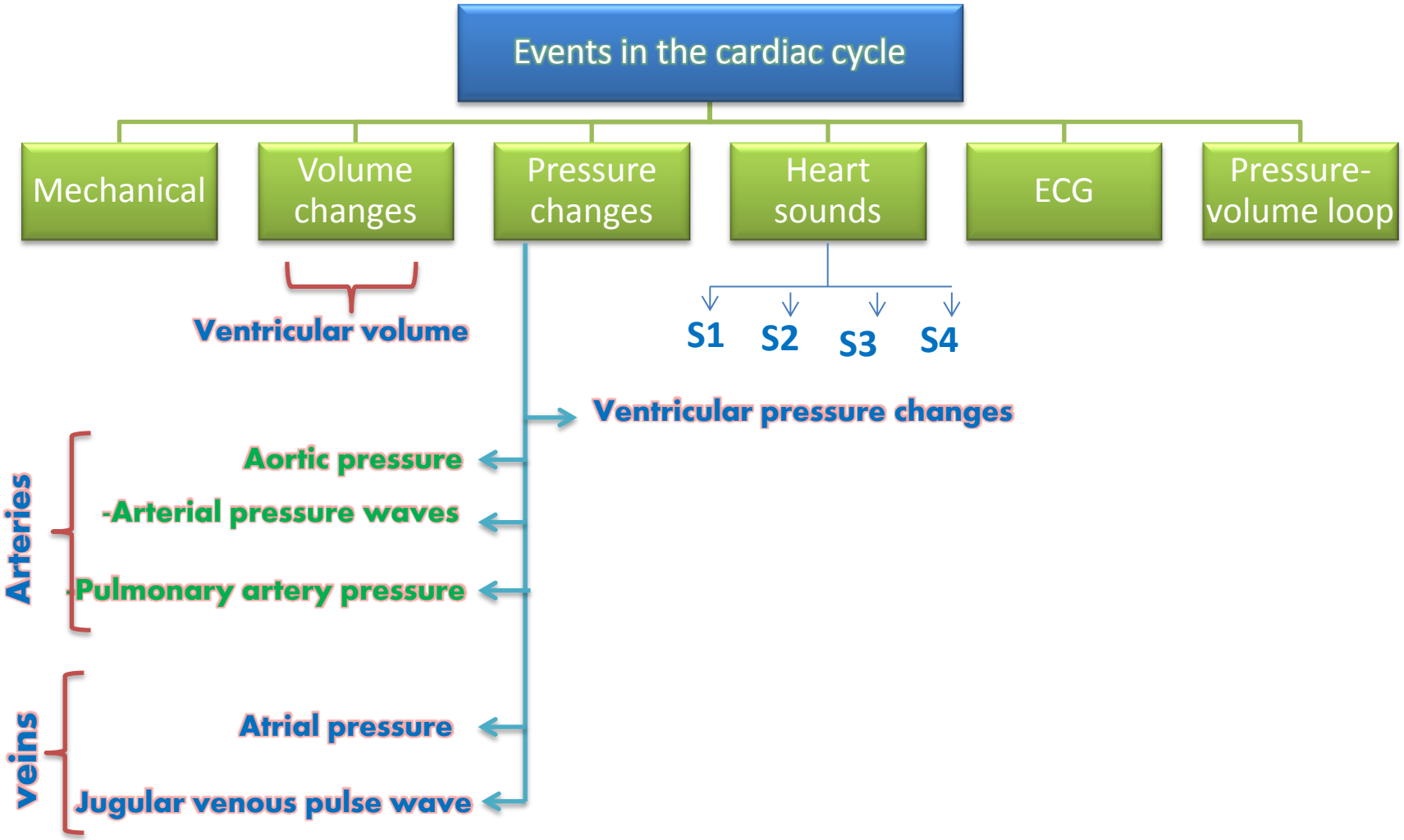
Cardiac Cycle 2

Done By: Shaimaa Al-Rfaiee - Abdulrahman Alshiban
Reviewed By: Nada Alouda

OBJECTIVES

- Volume changes that occur during cardiac cycle.
- Pressure changes that occur during cardiac cycle.
- Electrical changes that occur during cardiac cycle.
- Different heart sounds produced during cardiac cycle.
- Correlation of different events that occur during cardiac cycle.
- Volume-Pressure relationship in the left ventricle.

MIND MAP


Events in the cardiac cycle
Mechanical
Volume changes
Pressure changes
Heart sounds
ECG
Pressure-volume loop
Ventricular volume
S1
S2
S3
S4
Ventricular pressure changes
Arteries
Aortic pressure
-Arterial pressure waves
-Pulmonary artery pressure
veins
Atrial pressure
Jugular venous pulse wave

Events in the cardiac cycle..

- Mechanical events.
- Volume changes.
- Pressure changes.
- Heart sounds.
- Electrical events (ECG).

Ventricular volume changes

-Ventricular pressure changes.

-Aortic pressure.
-Arterial pressure waves.
-Pulmonary artery pressure.

-Atrial pressure.
-Jugular venous pulse wave.

S_1
S_2
S_3
S_4

Ventricular Volume Changes

Constant, because the ventricle in this phase is a closed chamber; no blood come in or out

Phases	Ventricular volume
1. Atrial systole	↑
2. Isometric contraction phase	Constant
3. Rapid ejection phase	↓ rapidly
4. Reduced ejection phase	↓ slowly
5. Protodiastole	Constant
6. Isometric relaxation phase	Constant
7. Rapid filling phase	↑ rapidly
8. Reduced filling phase	↑ slowly

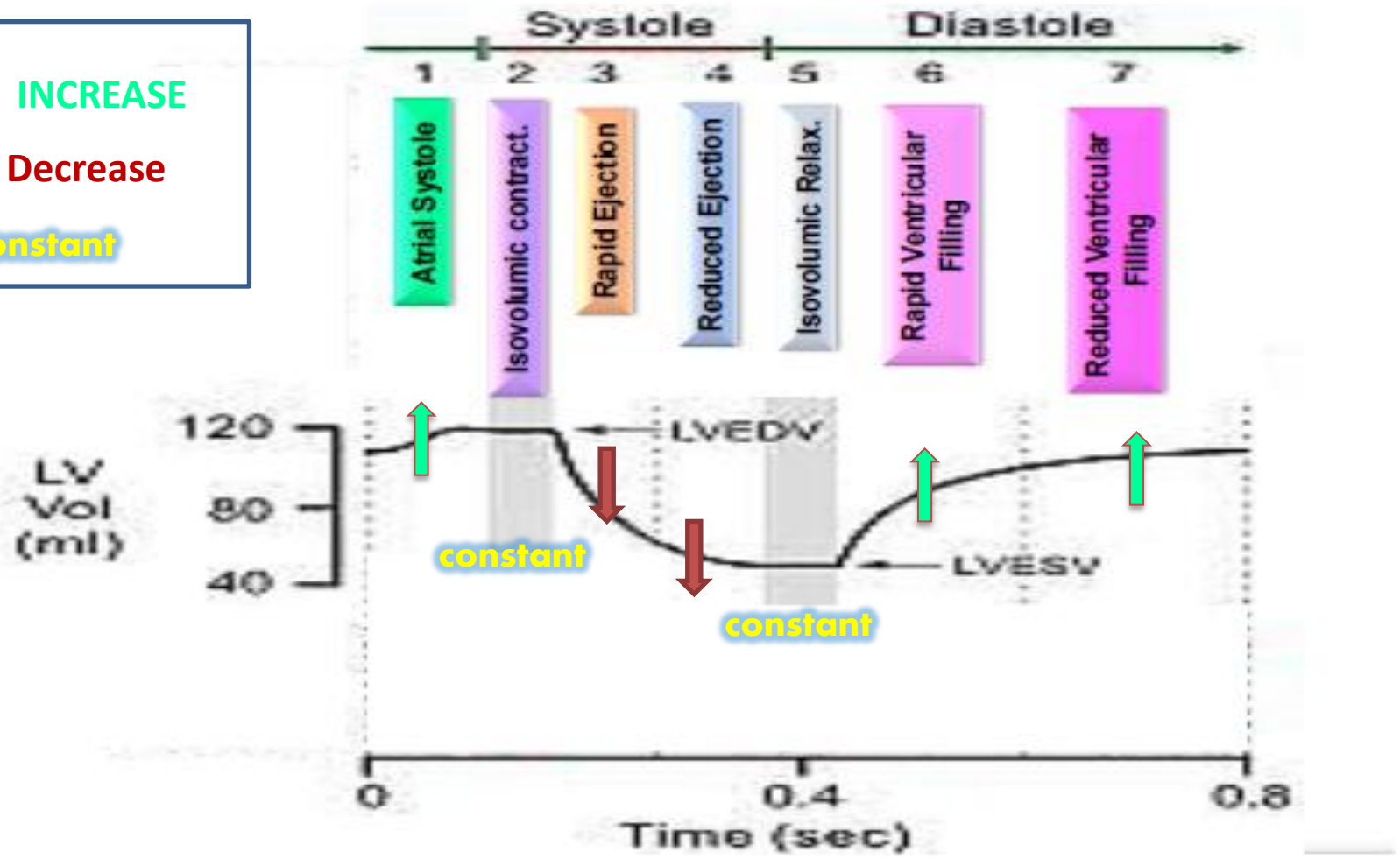
* You have to go back to mechanical events to understand the causes of these ventricular volumes in each phase.

Ventricular Volume Changes.. Cont.

INCREASE

Decrease

constant



Pressure Changes During the cardiac cycle..

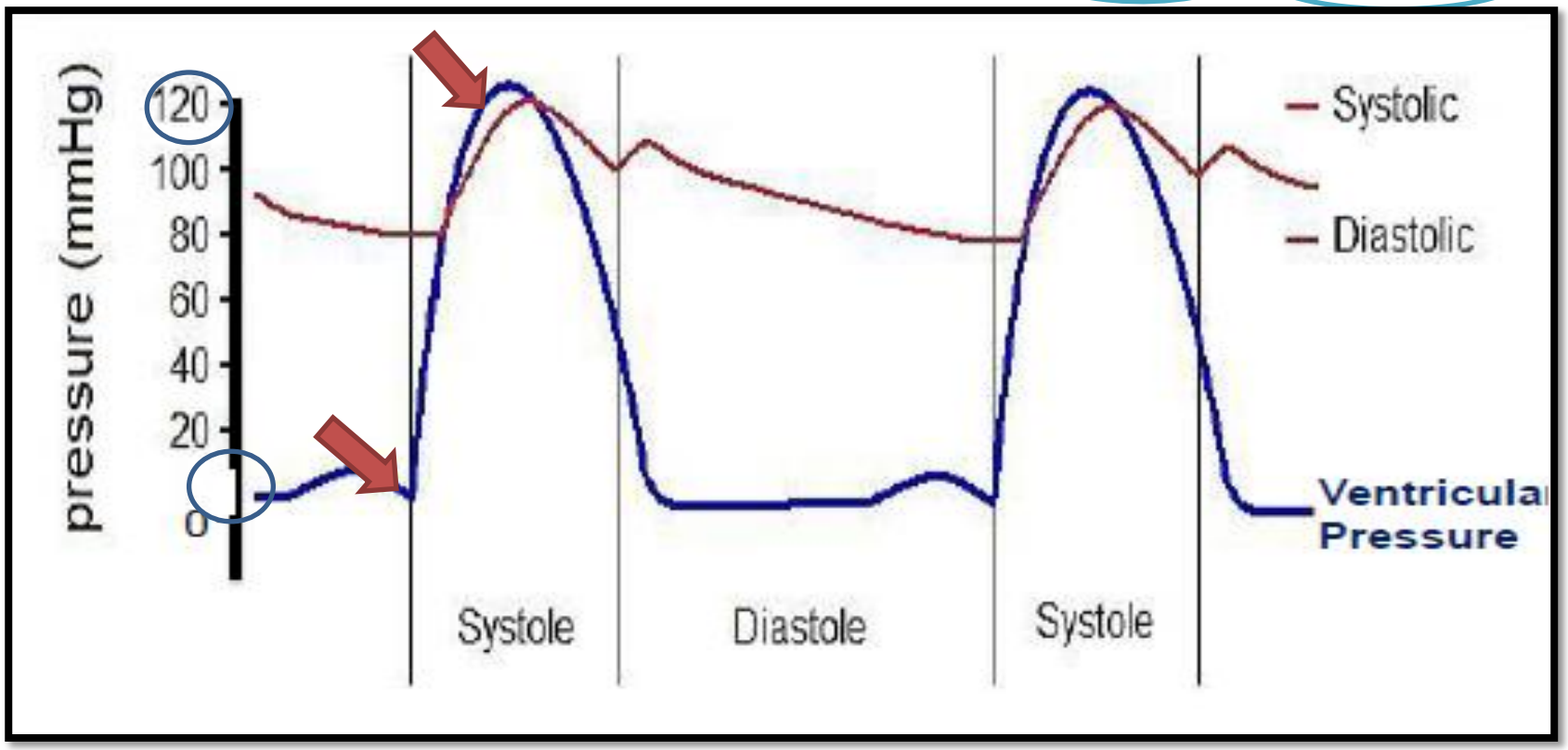
-Ventricular pressure changes — ventricular

-Aortic pressure
-Arterial pressure waves
-Pulmonary artery pressure — arteries

-Atrial pressure
-Jugular venous pulse wave — veins

*we will talk about each of them in the next 6 slides .. ☺

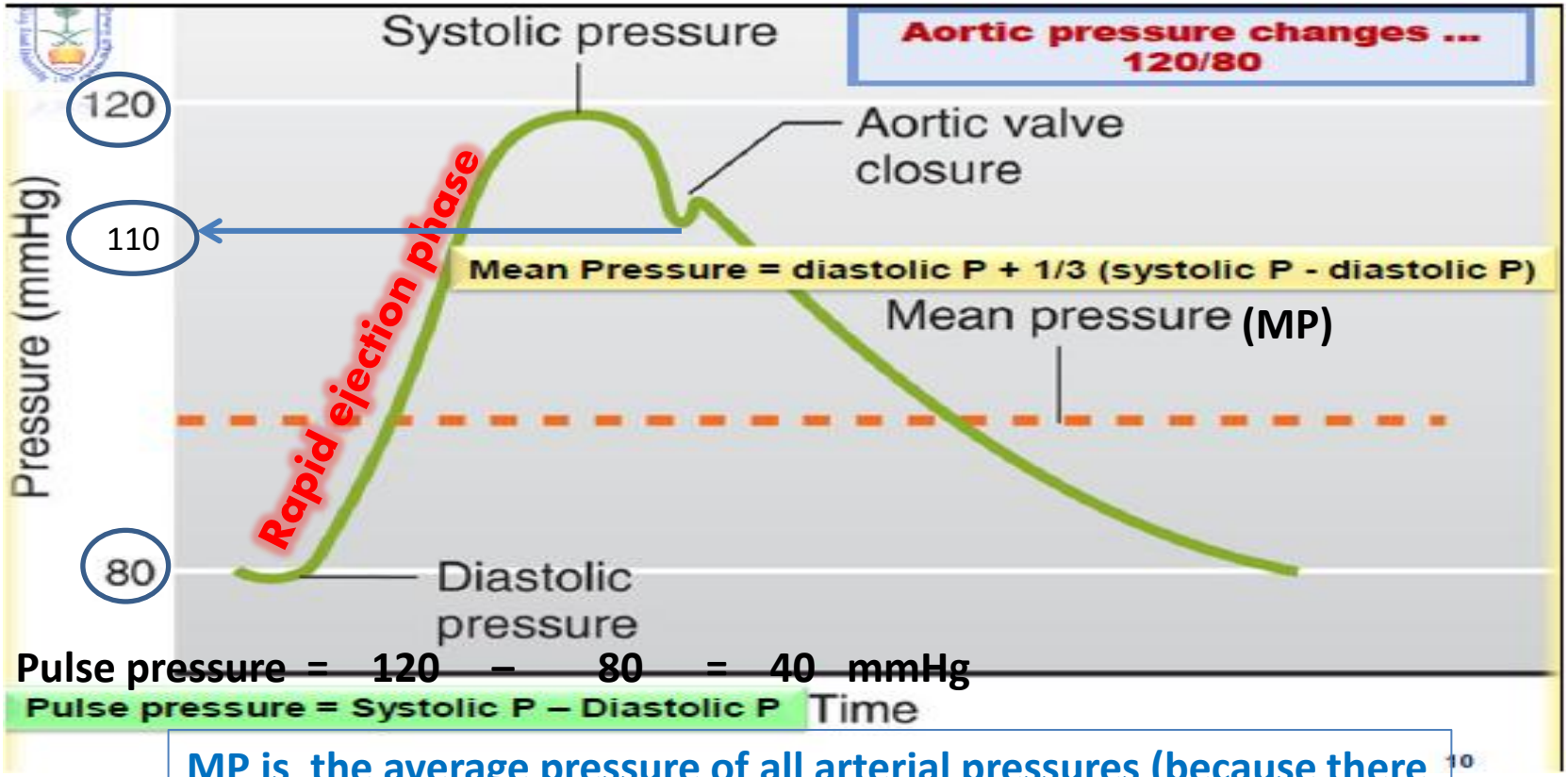
1-Ventricular pressure changes...120/3-12



*blue line represents the **ventricular pressure** & the RED one represent the **aortic pressure**.

*it starts ascending from 3-12 till reach 120, then it descends again to 3-12.

2-Aortic pressure changes...120/80



MP is the average pressure of all arterial pressures (because there is range) & it's (MP) critical in ICU patients.

*80 represents >> Diastolic pressure>> aortic valve is open>>bl. Ejected rapidly>>pressure reach 120>> reduce ejected till reach 110 (aortic valve closes)

*120 represents >> Systolic pressure

2-Aortic pressure changes...120/80...cont.

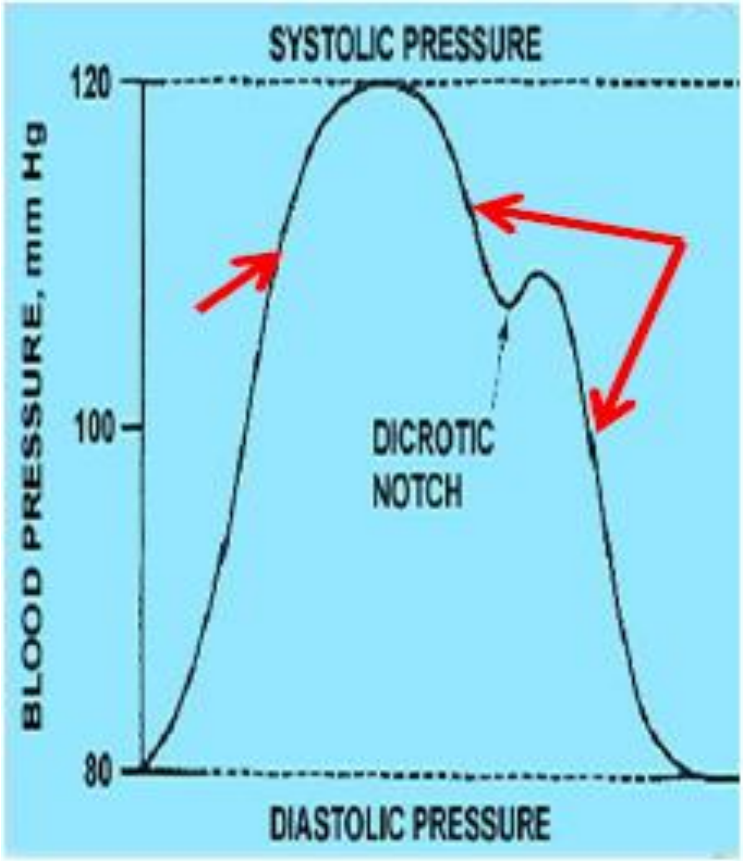
A- ascending or anacrotic limb:

- with **rapid ejection phase**
- pressure ↑ up to 120 mmHg.

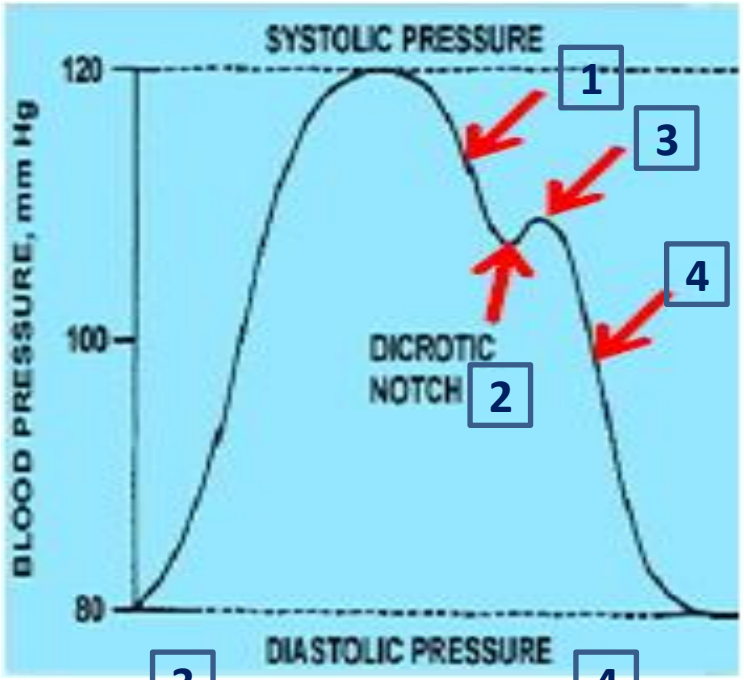
B- Descending or catacrotic limb:

passes in 4 stages:

- ↓ Aortic pressure
- Dicrotic notch(incisura)
- Dicrotic wave
- Slow ↓ aortic press -



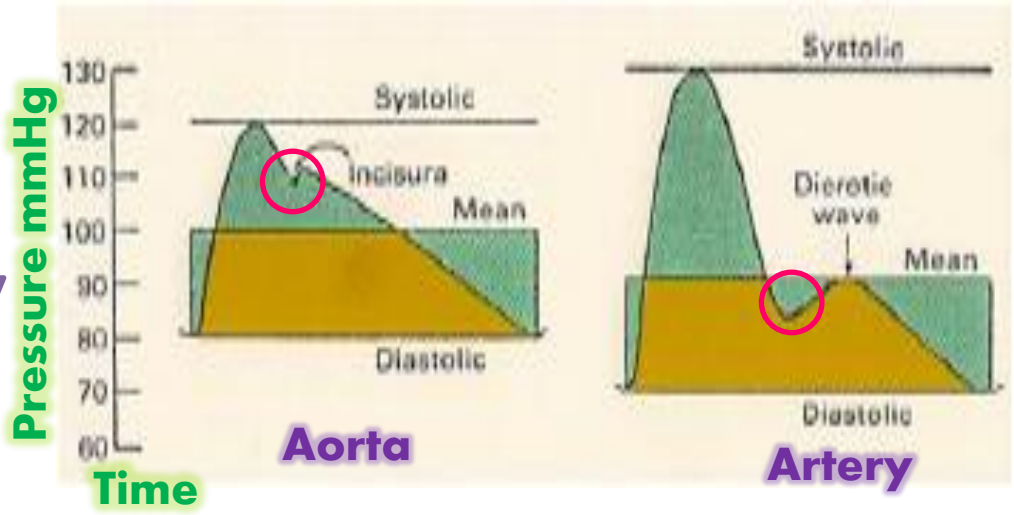
2-Aortic pressure changes...120/80...cont.



1	2	3	4
⬇ Aortic press	Dicrotic notch(incisura)	Dicrotic wave	Slow ⬇ aortic press
With reduced ejection phase. Amount of bl. Enters aorta < leaves.	-Due to closure of aortic-v -Sudden drop in aortic pressure -At end of ventricular systole	Due to elastic recoil of aorta. Slight ⬆ in aortic pressure	Up to 80 mmHg due to continued flow of bl. From aorta to systemic circulation

3-Arterial pressure changes...110-130/70-90

Arterial pressure similar to aortic pressure, but it has longer time to turn back to the valve to make the incisura wave because it's further than aorta from the heart.



-Similar to aortic pressure waves but <u>sharper</u>.
-Reflects a systolic peak pressure of 110-130 mmHg & a diastolic pressure of 70-90 mmHg.

4-Pulmonary artery pressure changes...25-30/4-12

Similar to aortic pressure but with <u>difference in magnitude</u>.(smaller)

*Normal range of arterial (systolic pressure) >> 110-130 mmHg
*Normal range of arterial (diastolic pressure)>> 70-90 mmHg

*If a person came with 130/85 >> we consider the pressure is normal
*If the systolic pressure from 130-140 >> pre- hypertensive with normal diastolic pressure (No medications; only control diet, exercise…)

*if the systolic pressure >=140 accompanied with diastolic pressure >= 85 the person is hypertensive needs medication.

Why do we consider the person with diastolic pressure equal to 85 or more (even when the pressure is in the normal range) that he may subject to have hypertension ?

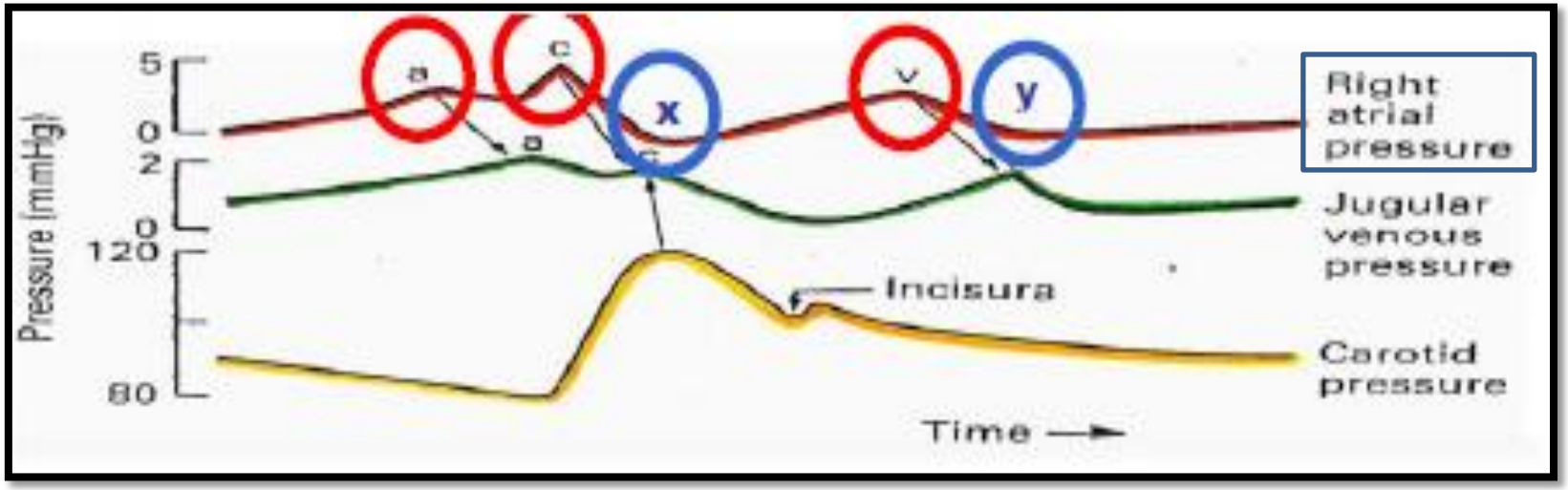
Because diastole has longer time than systole, so, the heart will be affected if it is under high pressure for a long time that may lead to HF.

5-Atrial pressure changes...

Results in:

- **3 upward deflection (a, c &v)**
  - **2 components in each wave: +ve (↑ press.), -ve (↓ press.)**
- **2 downward deflection (x & y)**

The 3 waves (a, c &v) are equal to one cardiac cycle =0.8 sec.



Causes of atrial pressure waves..

Very imp.

' a ' wave	' c ' wave	' x ' wave	' v ' wave	' y ' wave
Atrial systole Increase atrial pressure during atrial contraction	**Ventricle systole** **+ve** : bulging of AV-valves into the atria during '**iso-volumetric contraction phase**' **-ve :** pulling of the atrial muscles & AV cusps down during '**rapid ejection phase**', resulting in decrease atrial pressure	Downward displacement of AV valves during '**reduced ejection phase**'	**Atrial Diastole** Or **increase venous return (VR)** ••• Atrial press. increases gradually due to continuous VR	Decrease atrial pressure during **'rapid filling phase'** as a result of rapid emptying of blood from atria to ventricles

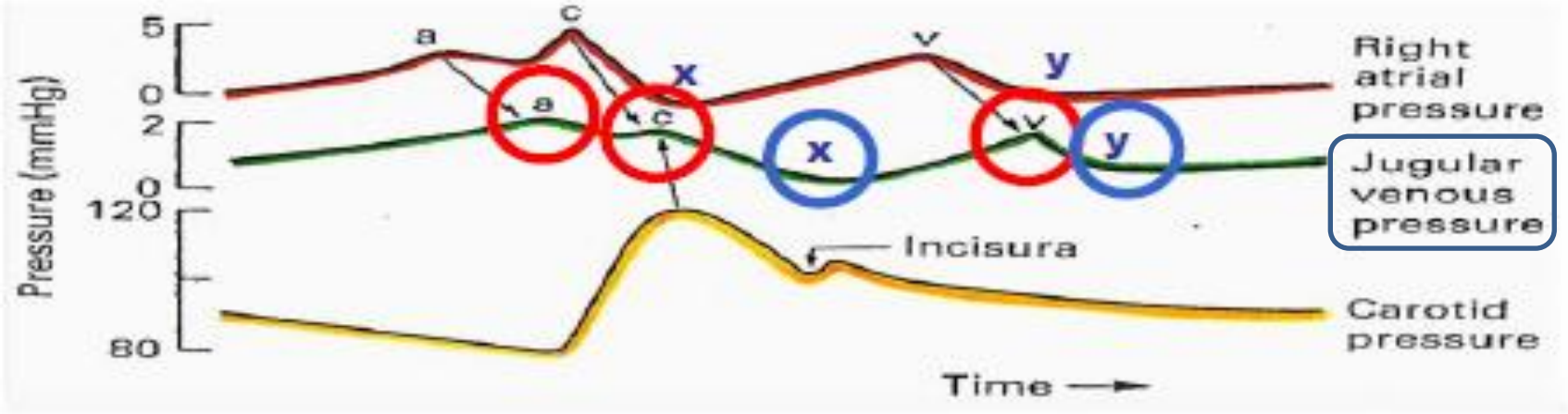
6 – Jugular venous pulse changes..

Also results in recording of transmitted atrial waves:

- 3 **upward waves: a, c, & v**
- 2 **downward waves: x & y**

•There is a delay in jugular venous pulse compared with atrial P. because jugular vein is in contact with right atrium.

•Jugular curve resembles the atrial curve because jugular vein is in contact with right atrium.



Heart sounds

4 heart sounds can be detected:

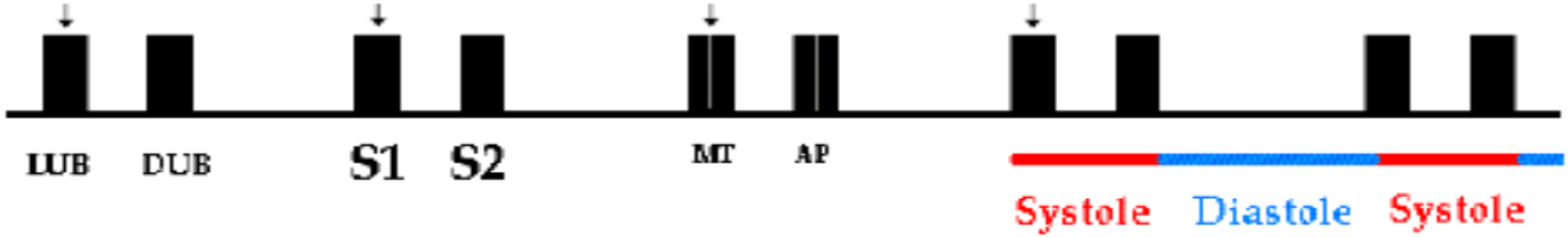
1^{st} & 2^{nd} heart sounds... usually audible (in systole)

3^{rd} & 4^{th} heart sounds... sometimes detected (in diastole)

Important for diagnosis of valvular heart diseases (murmurs)

S1 (LUB)

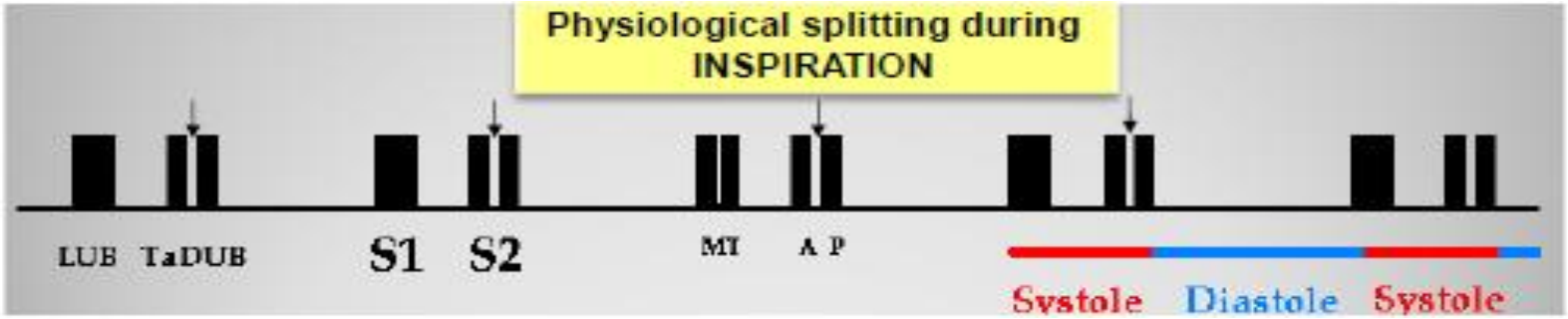
- **Due to closure of AV-valves**
- Recorded at the beginning of the **'iso-volumetric contraction phase'**
- It marks **beginning of ventricular systole**



S2 (DUB)

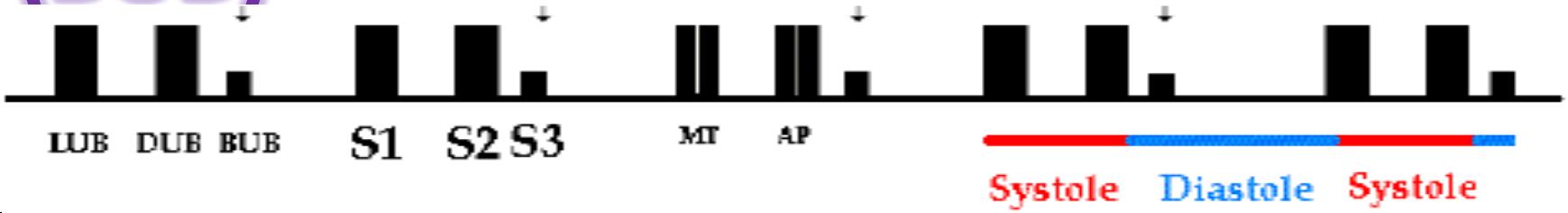
-**Due to closure of semilunar- vs**
-Recorded at the <u>beginning</u> of the **'iso-volumetric relaxation phase'**
-Marks the <u>beginning</u> of **ventricular diastole**
-S2 splits physiologically during inspiration:
- •aortic v closes slightly earlier than pulmonary v

It's called **physiological splitting during inspiration.** **You will hear (TaDUB) when you take deep inhalation because you'll take more blood to the lungs so the pulmonary valve will take a slight time to close.**



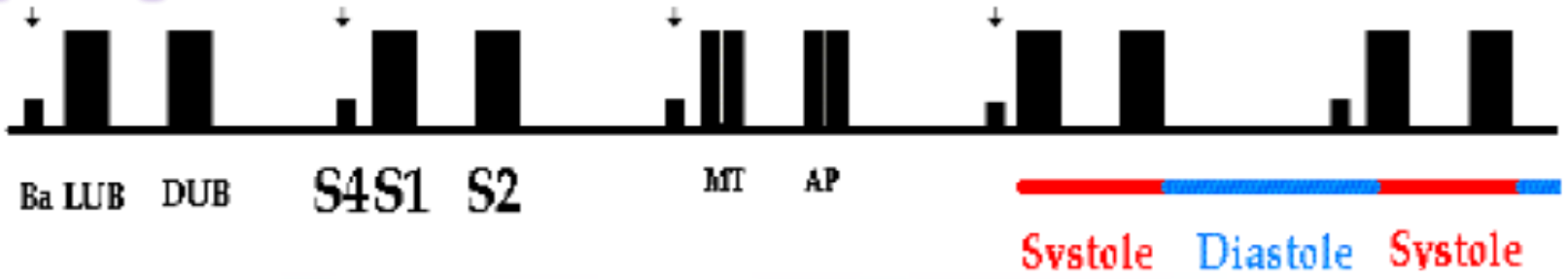
S3 (BUB)

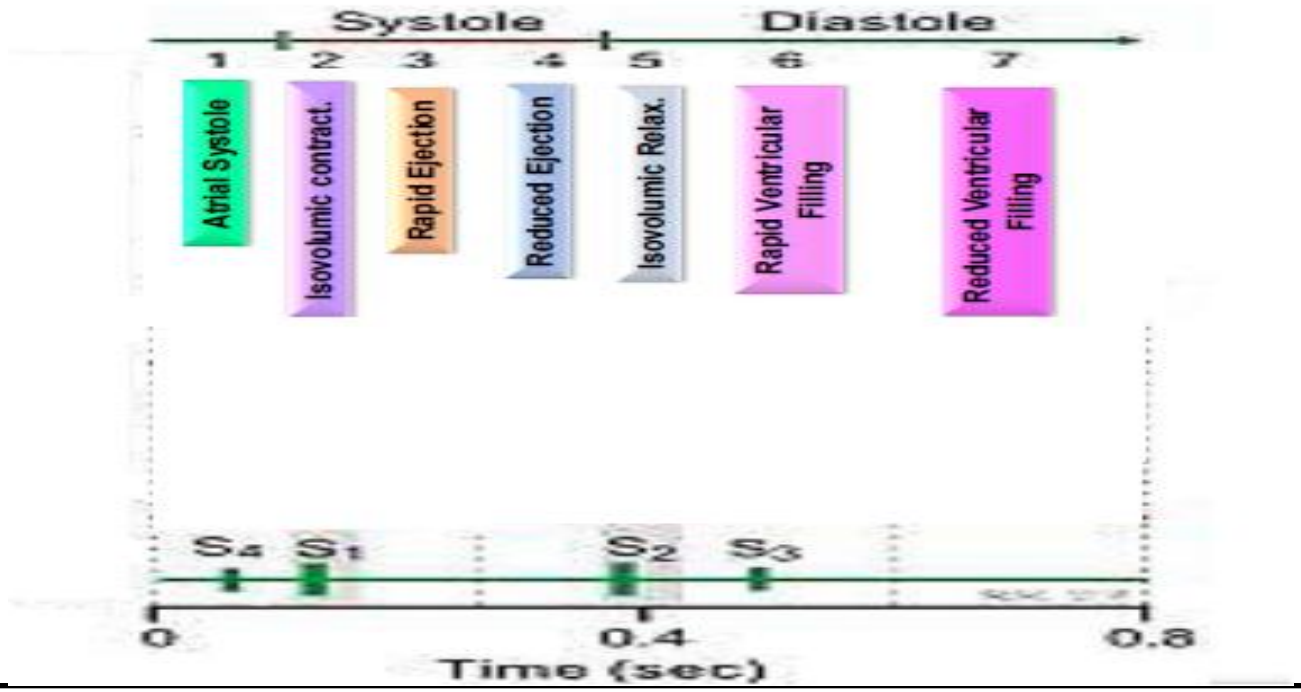
Recorded during the '**rapid filling phase**' due to blood rush.
S3 is usually not audible
? heard in **children**



S4 (Ba)

-Recorded **during atrial systole**
-S4 is usually not audible
-? heard in **elderly**





IF YOU INTERESTED TO HEAR THE FOUR HEART SOUNDS & TO GET MORE INFORMATION OBOUT them.. THERE YOU ARE ☺

NORMAL 1^{ST} & 2^{ND} HEART SOUNDS:

http://www.youtube.com/watch?v=hFFepTYcYdQ

NORMAL 3^{RD} HEART SOUNDS:

http://www.youtube.com/watch?v=hMrfSm8VD-4

NORMAL 4^{TH} HEART SOUND:

http://www.youtube.com/watch?v=n_mIZeLjnrQ

Fixed Splitting of the Second Sound:

http://www.youtube.com/watch?v=lohvovZ68aI

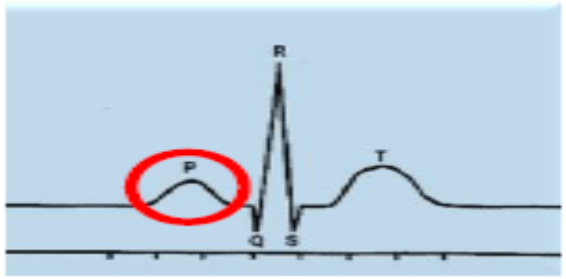
Electrical Events..(ECG)

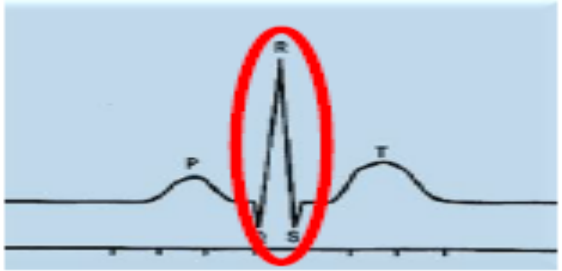
WHAT IS ECG ?!

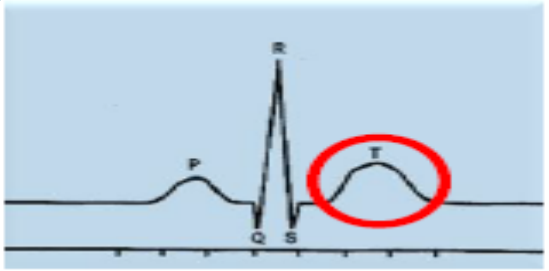
Record of the electrical activity (action potentials) generated by the heart from chest surface, per unit time.

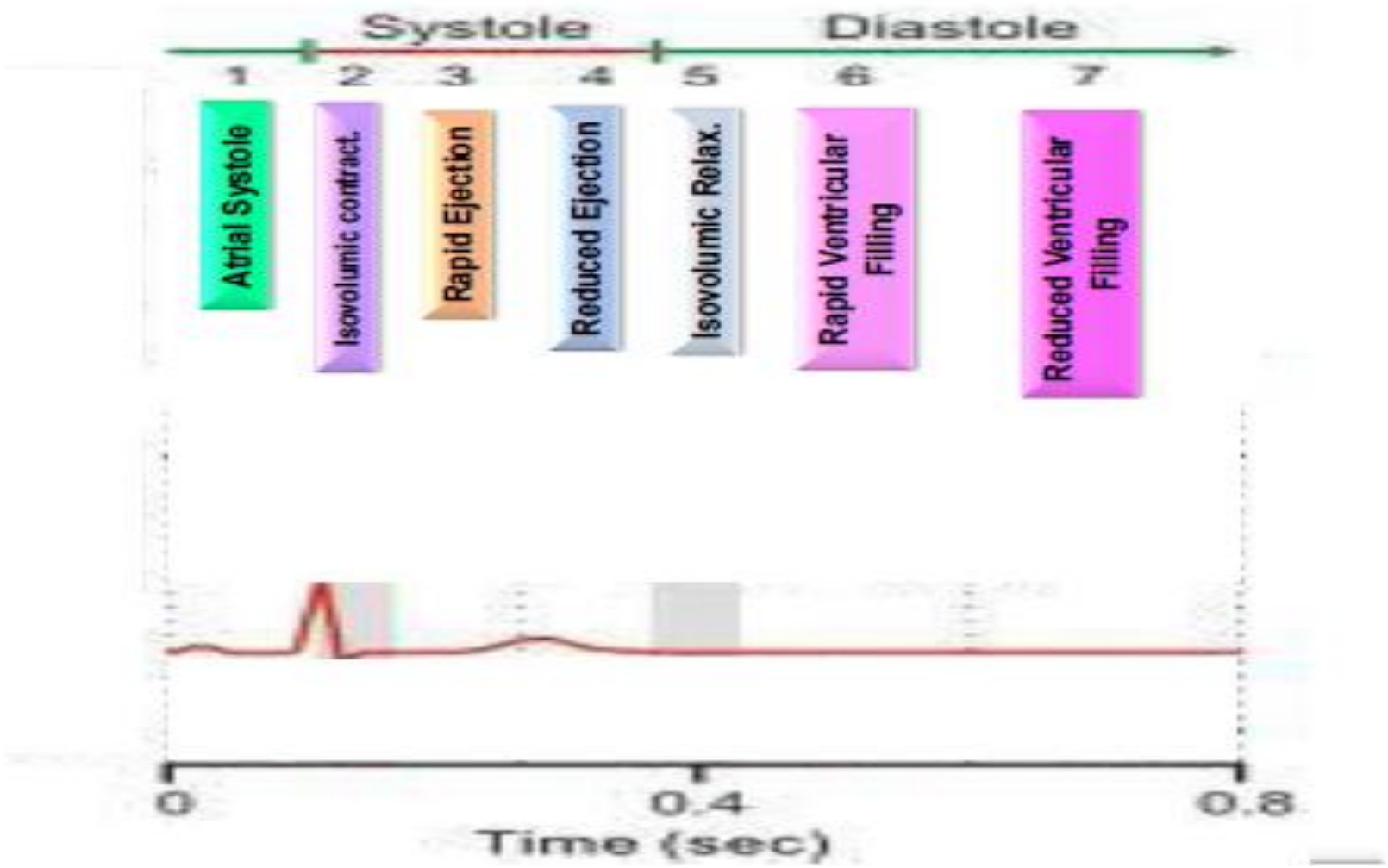
NOTICE.. These are ELECTICAL waves NOT pressure or mechanical waves

P- wave	QRS-complex	T- wave
-Due to **atrial depolarization** -P- wave is recorded before the onset of the atrial systole	-Due to **ventricular depolarization** -QRS complex is recorded before the onset of ventricular systole (iso-volumetric contraction phase)	-Due to **ventricular repolarization** -T- wave is recorded before the onset of ventricular diastole (reduced ejection phase)





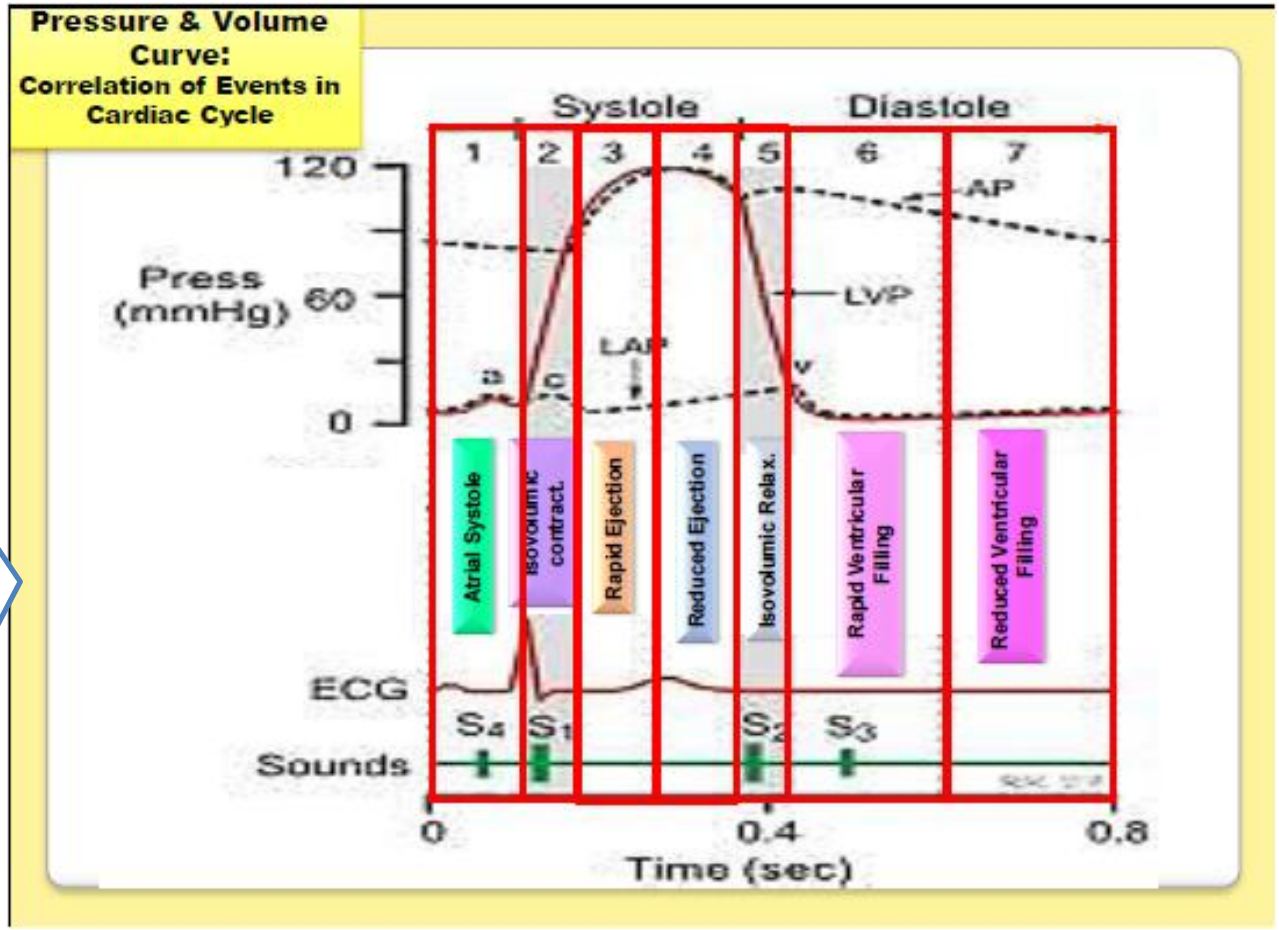



Systole
Diastole
1
2
3
4
5
6
7
Atrial Systole
Isovolumic contract.
Rapid Ejection
Reduced Ejection
Isovolumic Relax.
Rapid Ventricular Filling
Reduced Ventricular Filling
0
0.4
0.8
Time (sec)

Pressure – Volume curve
" THE COMPLETE PICTURE "

FOCUS ON:

- Pressures.
- Mechanical events.
- ECG.
- the 4 heart sounds.

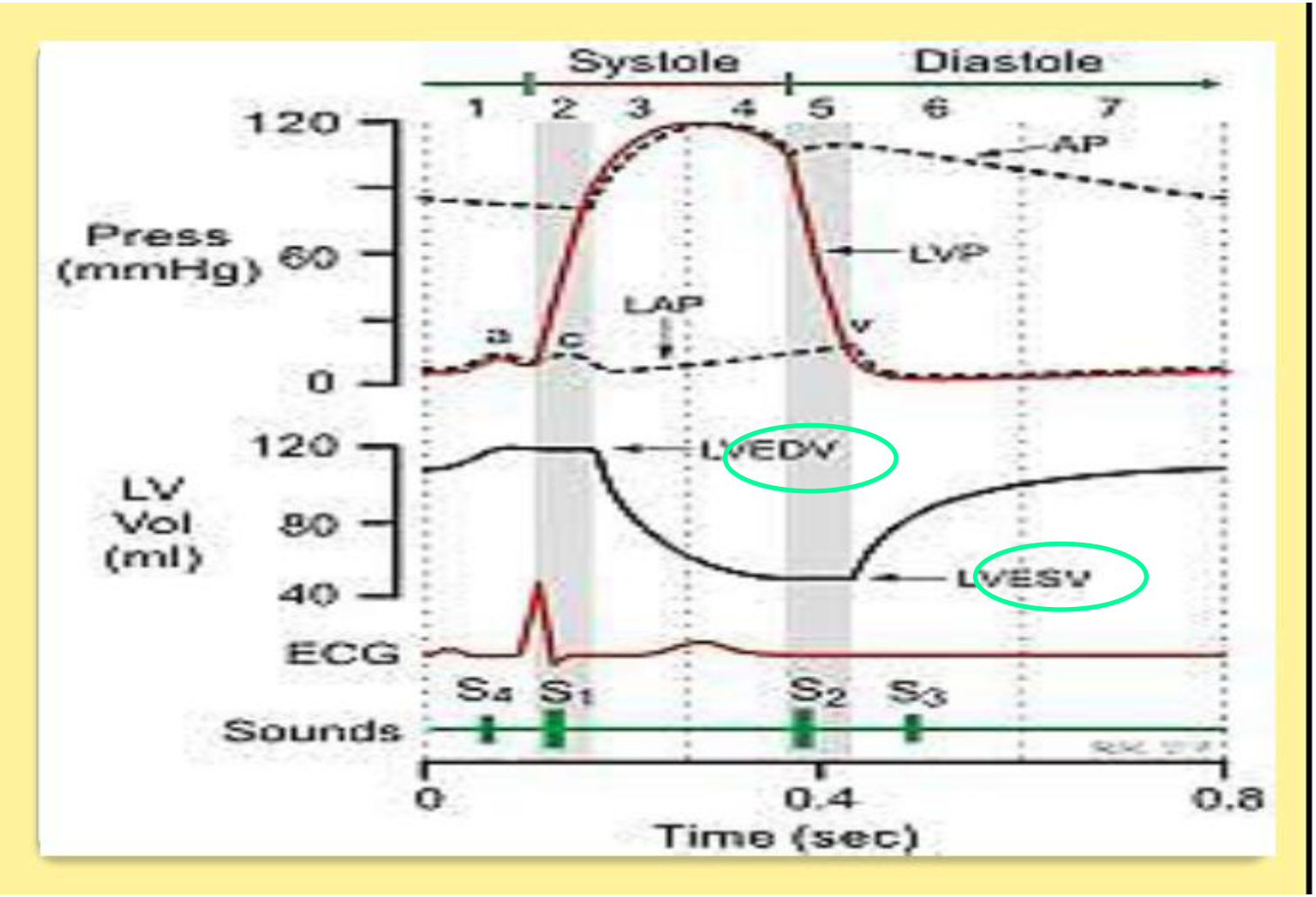


Remember (volume changes)

- **End-diastolic volume (EDV):**
  - Volume of blood in ventricle at end of diastole: 110-130 ml
- **Stroke volume (SV):**
  - Amount of blood ejected from each ventricle during systole: 70 ml/beat
- **End-systolic volume (ESV):**
  - Amount of blood left in each ventricle at end of systole: 40-60 ml
- **Ejection fraction (EF):**
  - Fraction of end-diastolic volume that is ejected:

$$\frac{Blood\ ejected}{End\ diastole\ volume} = 60\text{-}65\%$$

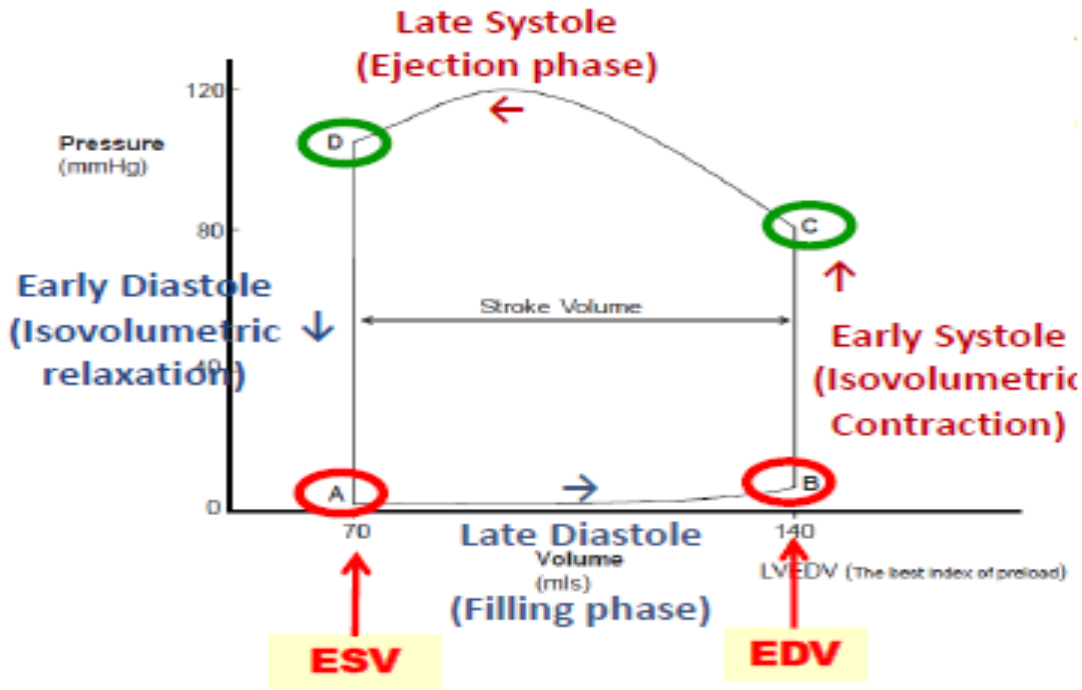
Pressure – Volume curve
" THE COMPLETE PICTURE " cont.



Pressure – Volume loop

Left ventricular pressure-volume loop:

Intra-ventricular changes in volume & pressure that occur during one cardiac cycle



-Plots left ventricular (LV pressure) against LV volume through one complete cardiac cycle

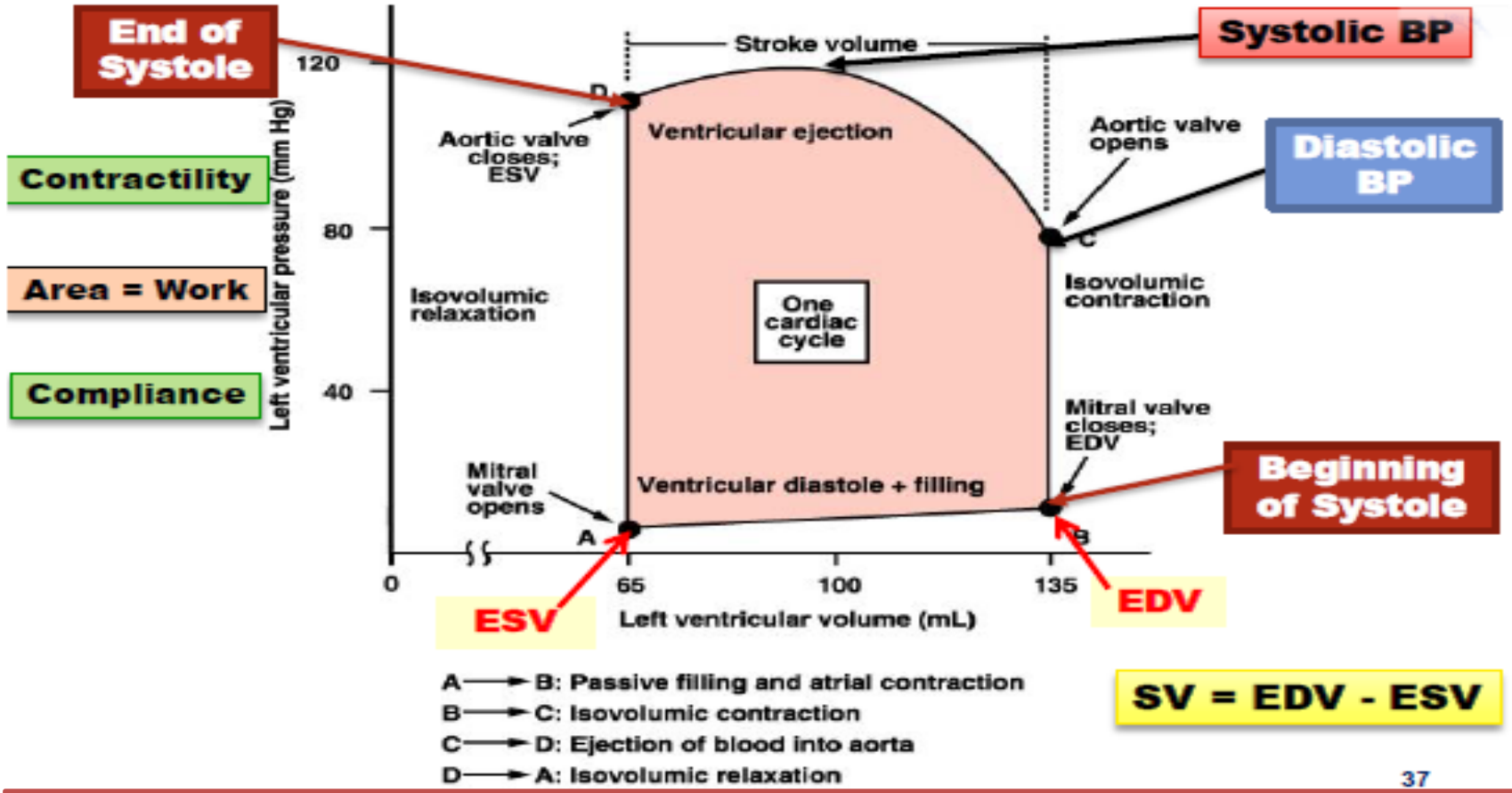
Systole: divided into,
- Early systole
- Late systole (includes both rapid & reduced)

Diastole: divided into,
- Early diastole
- Late diastole (includes both rapid & reduced)

What the doctor said you should know?

1) The beginning & ending of the 4 phases in the loop.
2) Functions of systole (contractility) & diastole (compliance=elasticity).
3) When the valves are opened & closed?

A – Mitral valve opens
B – Mitral valve closes
C – Aortic valve opens
D – Aortic valve closes



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Closer & opening of mitral & aortic- vs during each phase

Beginning of systole (B) & end (D)

Early & late systolic & diastolic periods

Beginning of diastole (D) & end (B)

Diastolic filling occurs between points A & B

Ejection occurs between points C & D

WHAT YOU SHOULD REMEMBER ABOUT P-V LOOP?

Summary of all cardiac cycle events

Atrial systole systole	Isometric contraction phase systole	Rapid ventricular ejection systole	Slow ventricular ejection systole	Isovolumetric relaxation phase diastole	Rapid filling Phase diastole	Slow filling Phase diastole
-4th heart sound heard -Aortic valve is Closed -Mitral valve is opened -pressure wave a produced in LA left atrium contract. P –wave is produced before this phase	-1st heart sound heard mitral valve is closed 'c' wave is produced in the atrium "v" wave is produced in the atrium- - QRS-wave is produce before this phase	-aortic valve (semilunar vs)is opened -ventricular volume decrease rapidly	-end of Systole -aortic-vs close at the end of this phase -ventricular volume decrease more slowly	-beginning of diastole -2nd heart sound heard -closure of semilunar vs -AV-vs open at the end of this Phase -LV is a closed chamber, no change in volume T- wave is recorded before the onset of ventricular diastole	--3rd heart sound heard -AV-vs is open --mitral valve will open -"v" wave start to decrease -ventricular volume increase rapidly -R.P.V.F	-AV-vs still open -LV volume increase slowly

THE END

If there are any problems or suggestions
Feel free to contact:

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THANK YOU

Actions speak louder than Words