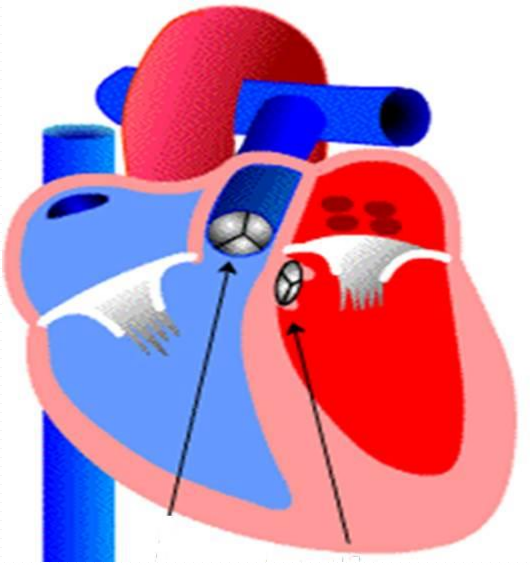
Cardiovascular System Block
Cardiac Cycle- 2
(Physiology)



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Learning Objectives

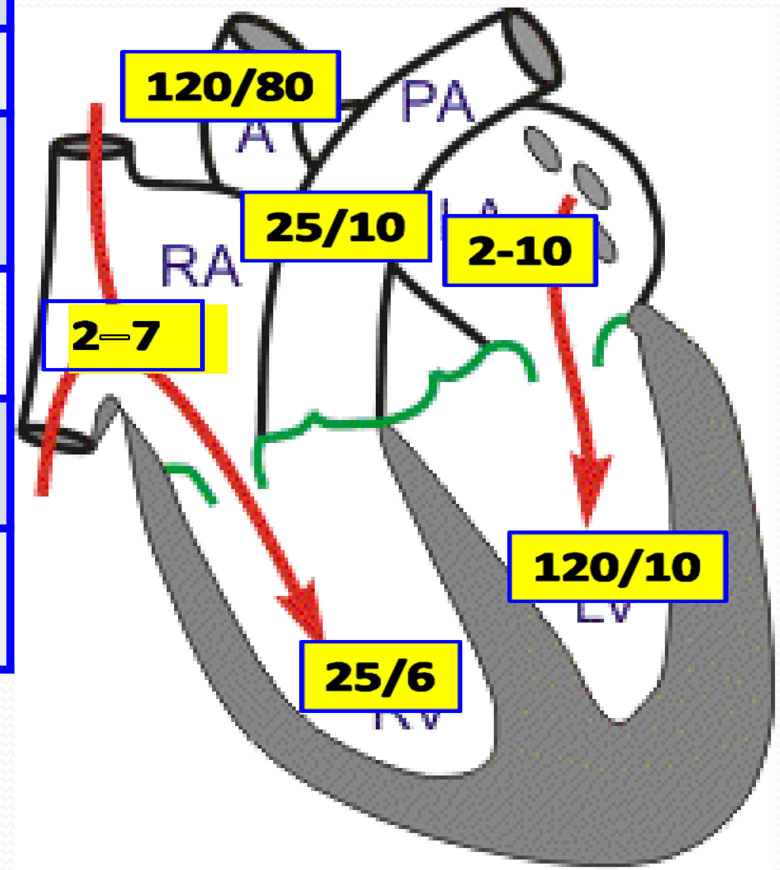
1. Pressure Changes During Cardiac Cycle
2. Heart Sounds During Cardiac Cycle
3. Electrical Changes During Cardiac Cycle
4. Ventricular Volume-Pressure Diagram

Recorded Pressure Changes During Cardiac Cycle

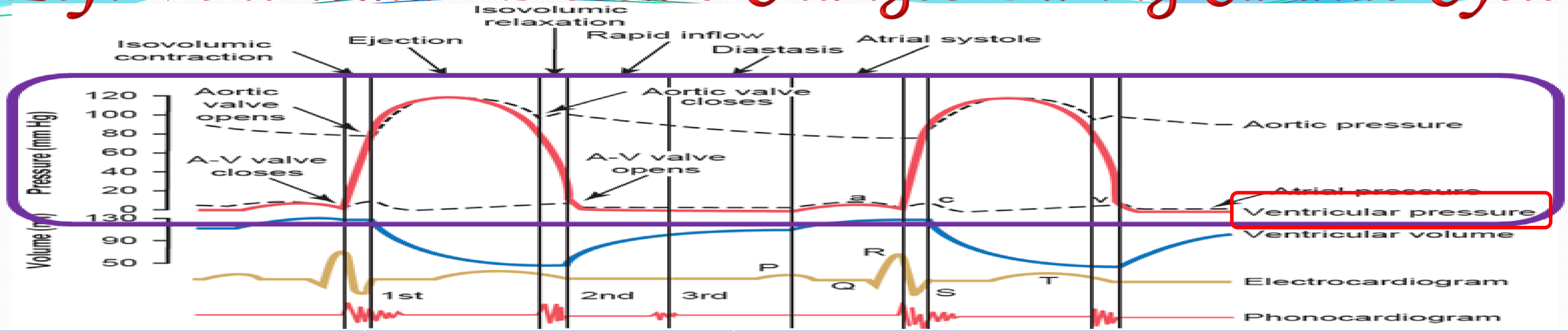
- Ventricular pressure
- Aortic pressure
    - Arterial pressure waves
- Atrial pressure
    - Jugular venous pressure

Pressure Changes In Cardiac Cycle

CHAMBERS	NORMAL RANGE (mm of Hg)
Right Atrium	**2 – 7**
Left Atrium	**2-10**
Right Ventricle (systolic) (diastolic)	**15 – 25 2 -8**
Left Ventricle (systolic) (diastolic)	**100 – 120 2 – 10**
Pulmonary Artery (systolic) (diastolic)	**25 10**
Aorta (systolic) (diastolic)	**120 80**



Left Ventricular Pressure Changes During Cardiac Cycle



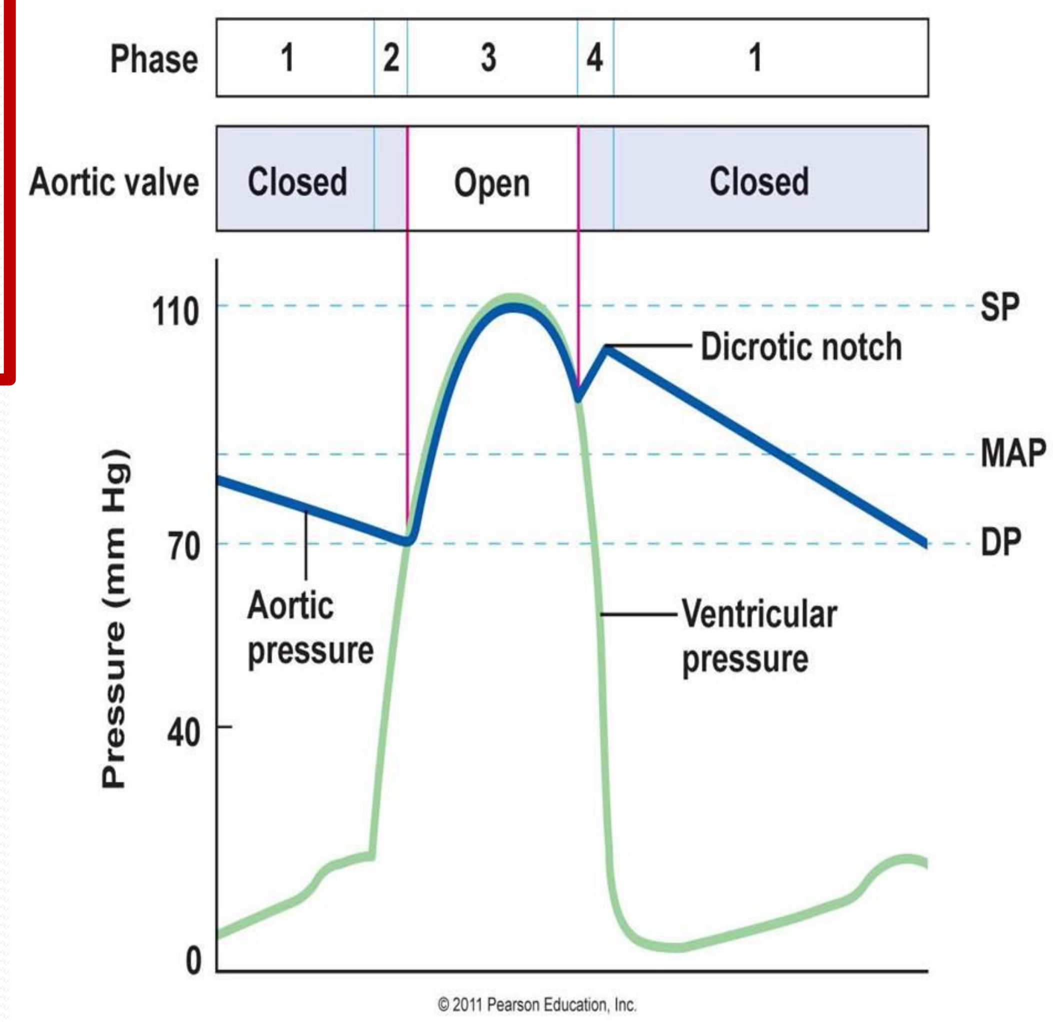
Phases	Ventricular Pressure	Cause
1- Atrial systole	First slightly ↑ Then ↓	Entry of blood from atria Dilatation of ventricles
2- Isovolumetric contraction	↑ suddenly (80 mmHg)	All the valves are closed & the contraction is isovolumetric
3- Rapid Ejection	↑ sharply (120 mmHg)	Shortening of ventricular wall and ejection of blood
4- Reduced Ejection	↓ gradually	Volume of blood leaving ventricles > the decrease in ventricular volume.
5- Isovolumetric Relaxation	↓ rapidly	All the valves are closed & the relaxation is isovolumetric
6- Rapid Filling	Slightly ↑ but < atrial pressure	Entry of blood from atria
7- Reduced Filling	Slightly ↑ gradually	Entry of blood from atria

Aortic Pressure Changes … 120/80 mmHg

Pulmonary artery pressure changes are similar to the aortic pressure changes [Magnitude 3-4 times less]. Normal pulmonary artery pressure during the cardiac cycle ≈ 25-30/4-12 mmHg

- ***Ascending or anacrotic limb:***
  - With 'rapid ejection phase'.
  - Aortic press.↑ up to 120 mmHg.

- ***Descending or catacrotic limb:***
  - Passes in 4 stages.



Stages of the Descending /Catacrotic Limb:

1. **↓ Aortic pressure:**
   With 'reduced ejection phase.'
   Amount of blood enters aorta < leaves.

2. **Dicrotic notch (incisura):**

   Sudden drop in aortic pressure.

   Due to closure of aortic valve.

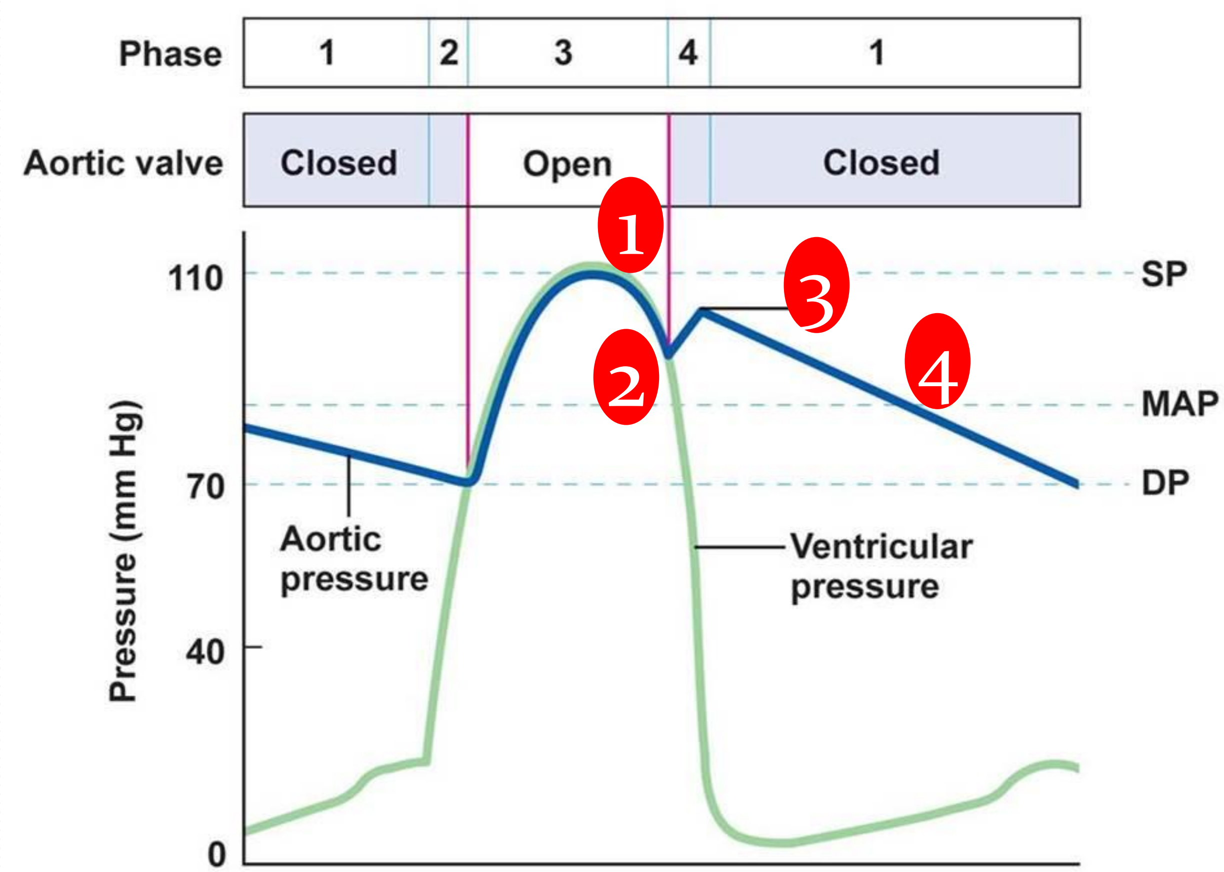
3. **Dicrotic wave:**

   Slight ↑ in aortic pressure.

   Due to elastic recoil of the aorta.

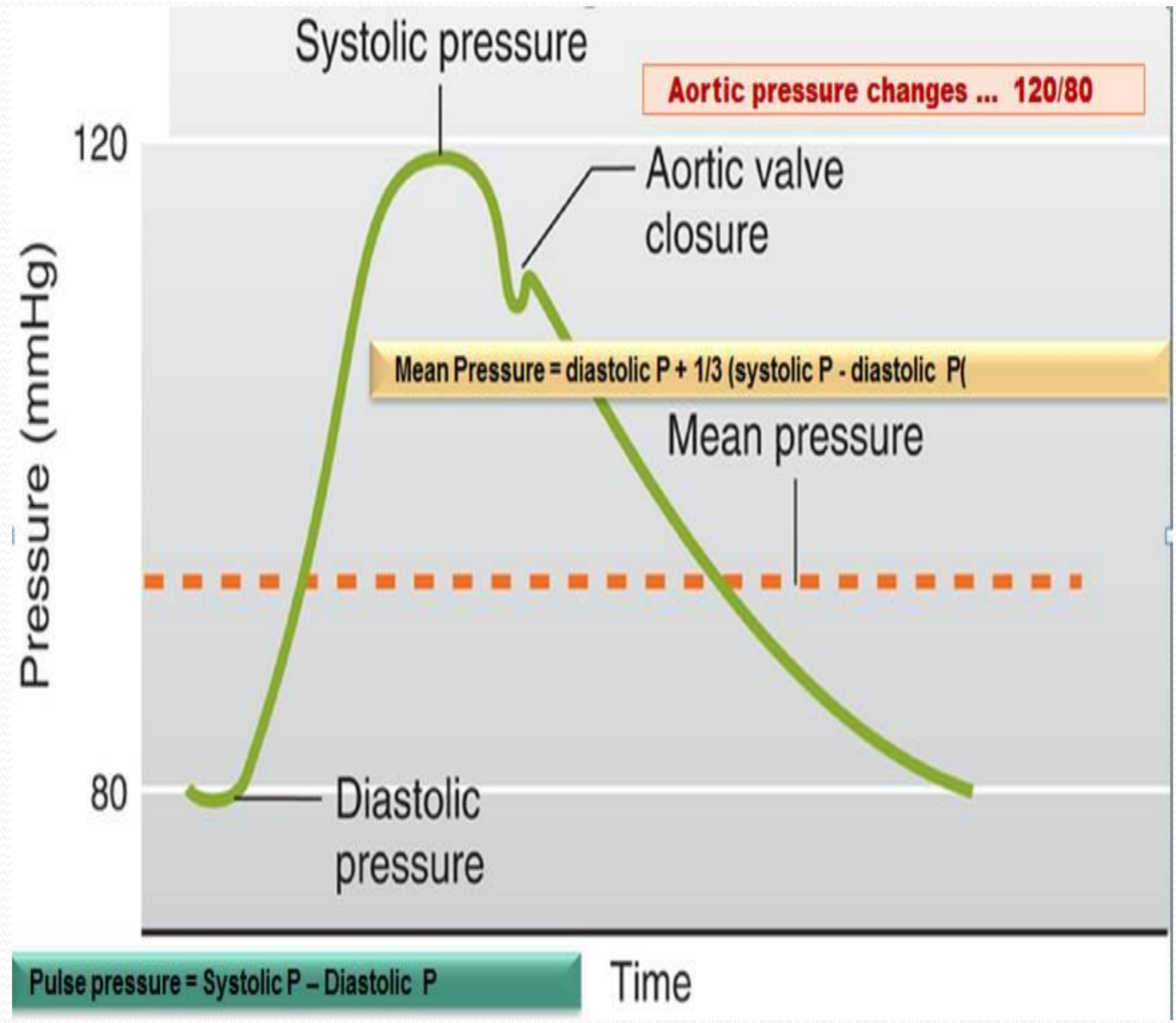
4. **Slow ↓ aortic press:** down to 80 mmHg.

   Due to continued flow of blood from aorta into systemic circulation.



Arterial Pressure Changes … 110-130/70-85 mmHg

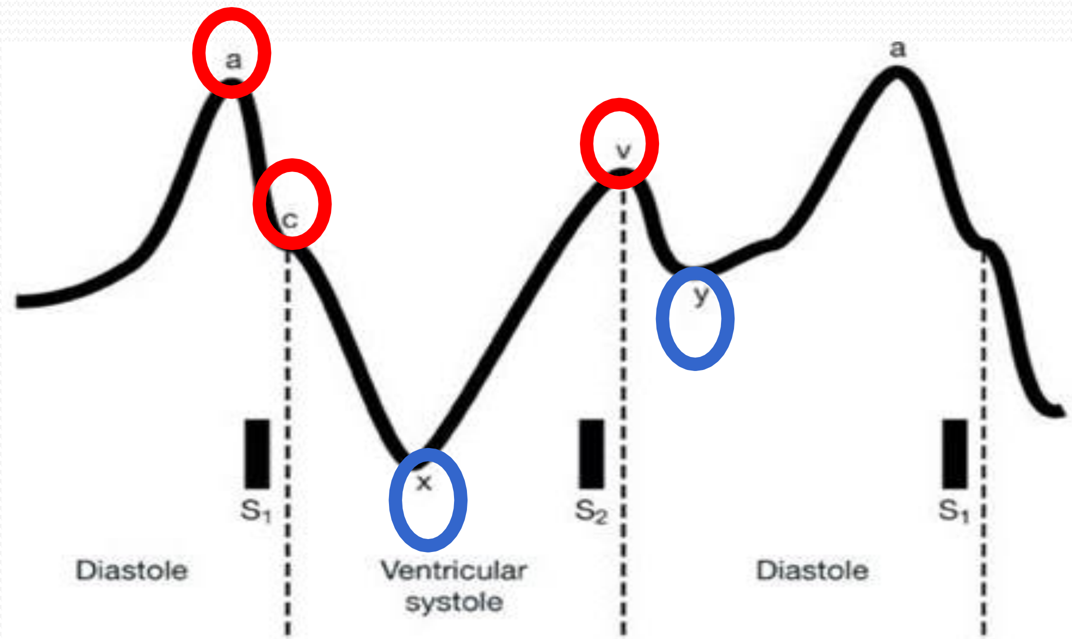
- Similar to aortic pressure waves, but **sharper.**
- Reflects a systolic peak pressure of 110-130 mmHg & a diastolic pressure of 70-85 mmHg.



Atrial Pressure Changes During Cardiac Cycle

Results in:

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



Causes of atrial pressure waves

- ***'a' wave: Atrial systole:***

  +ve due to atrial systole

  -ve due to blood passage into ventricles.

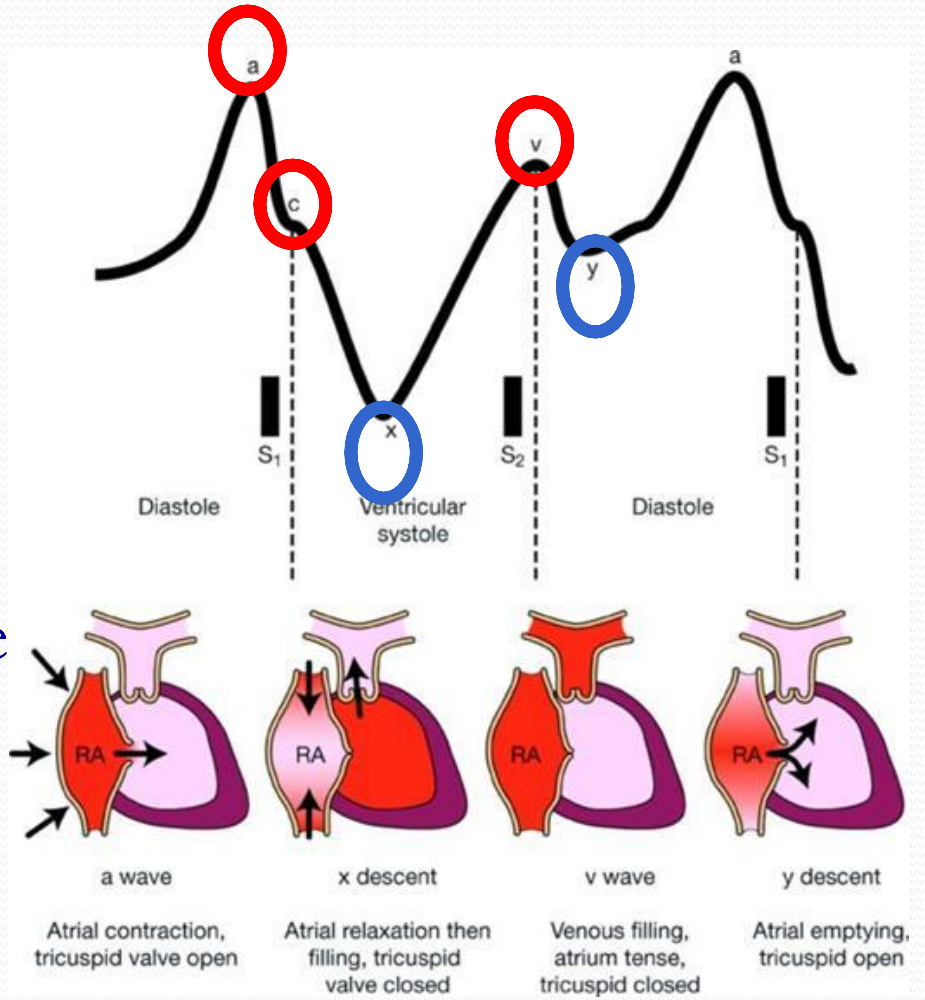
- ***'c' wave: Ventricular systole***

  +ve due to the bulging of A-V valves into the atria during 'isovolumetric contraction phase.'

  -ve due to the pulling down of the atrial muscle & A-V cusps during 'rapid ejection phase', resulting in ↓ atrial pressure.

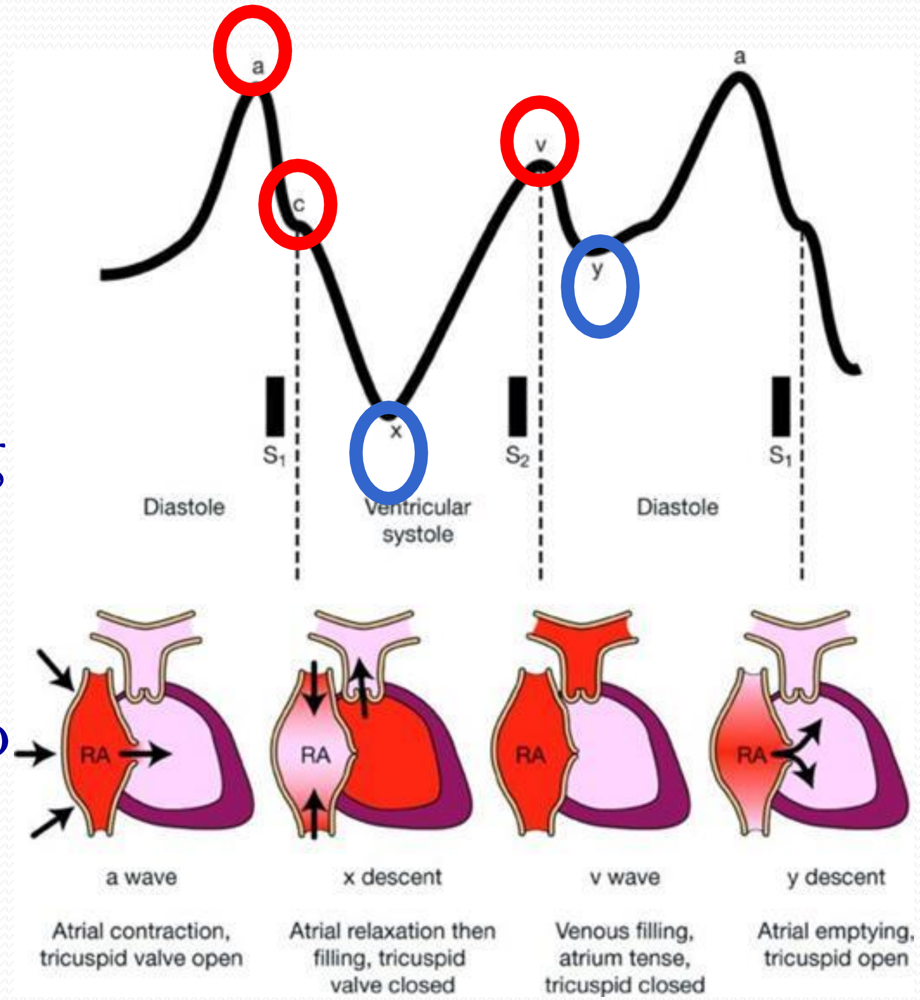
- ***'x' descent:***

  Downward displacement of A-V valves during 'reduced ejection phase.'

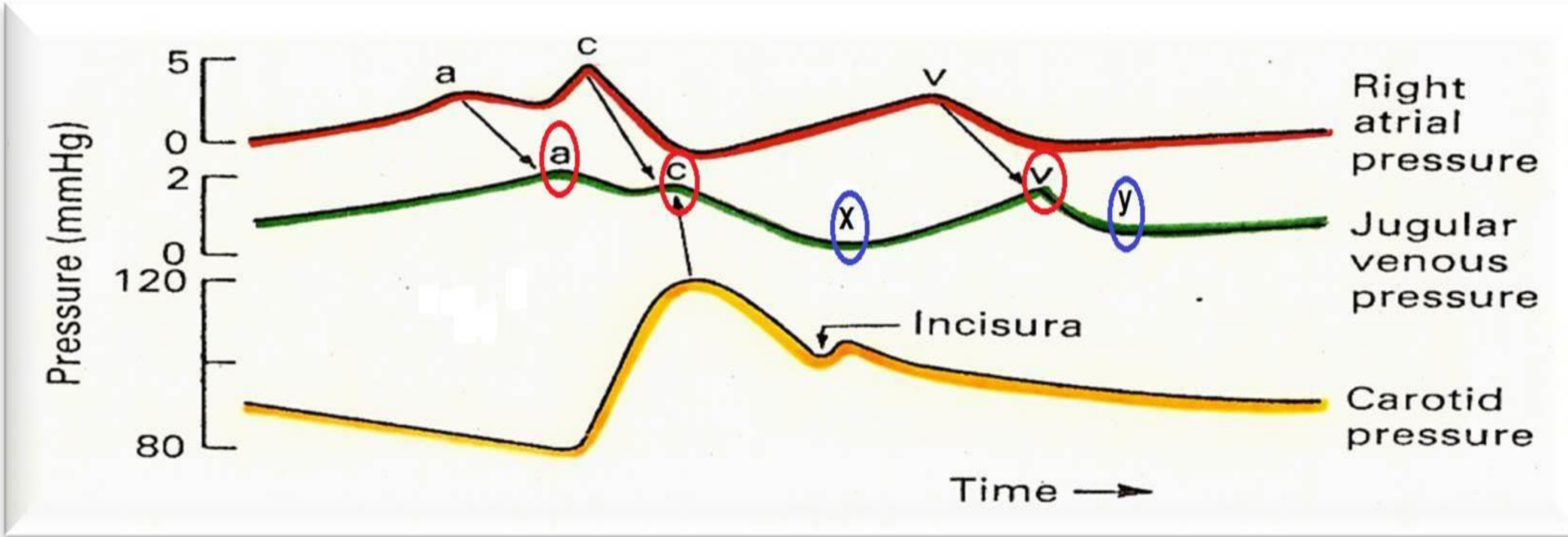


Causes of atrial pressure waves…..Cont.

- ***<u>'v' wave:</u>***
  +ve due to ↑ venous return during atrial diastole.
  -ve due to entry of blood into ventricles during 'rapid filling phase.'
- ***<u>'y' descent:</u>***
  ↓↓ atrial pressure due to entry of blood into ventricles during 'reduced filling phase.'



Jugular venous pulse changes:



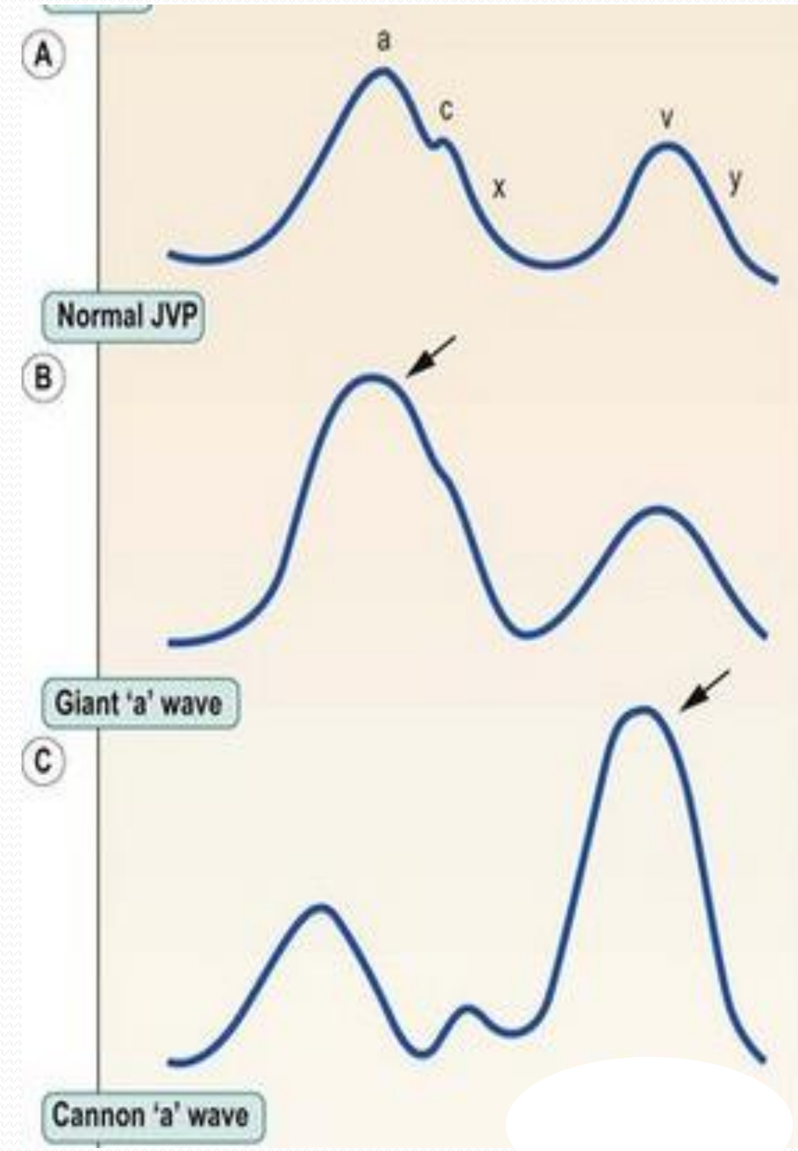
Similar recordings of transmitted delayed atrial waves:

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

Abnormalities Of "a" Wave

- **Elevated '*a*' wave**
  - Tricuspid stenosis
  - Decreased ventricular compliance (ventricular failure, pulmonic valve stenosis, or pulmonary hypertension)
- **Cannon 'a' wave**
  - Atrial-ventricular asynchrony (atria contract against a closed tricuspid valve):-

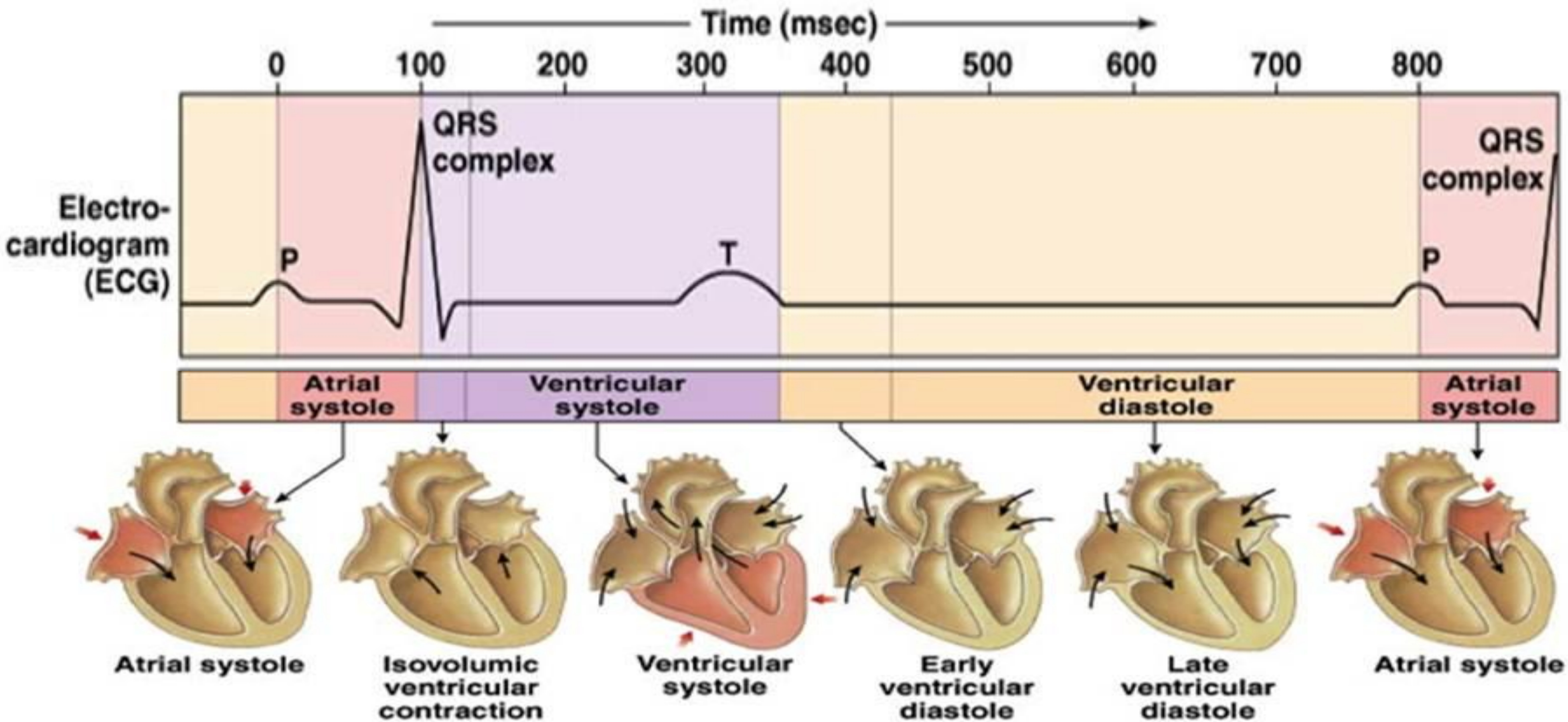
    Complete heart block, following premature ventricular contraction, during ventricular tachycardia, with ventricular pacemaker
- **Absent '*a*' wave**
  - Atrial fibrillation
  - Atria flutter



Heart Sounds during Cardiac cycle

Phase	Heart Sound	Causes of the Sound
1- Atrial systole	4th heart sound	1- Contraction of atria 2- Blood rush from atria to ventricles.
2-Isovolumetric contraction	1st heart sound	1- Sudden closure of A-V valves 2- Vibration of chordae tendinae of papillary muscles.
3-Maximum Ejection	1st heart sound continues	1- Contraction of ventricles. 2- Vibration of walls of aorta & pulmonary artery.
4-Reduced ejection	No sound	
5-Isovolumetric relaxation	2nd heart sound	Sudden closure of semilunar valves
6-Rapid filling	3rd heart sound	Rush of blood into ventricles and vibration in ventricular wall
7-Reduced filling	No sound	

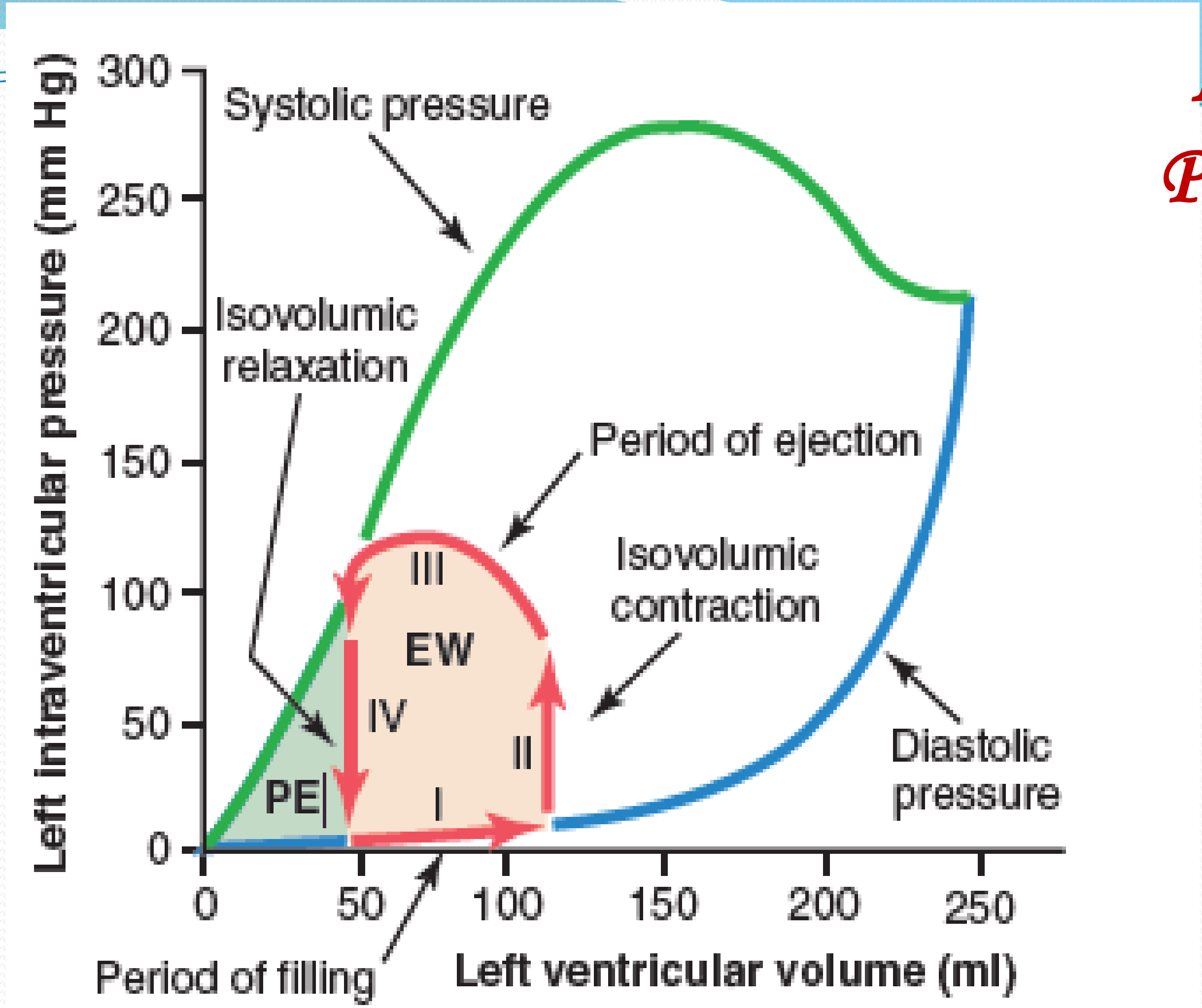
ECG changes during the Cardiac cycle



ECG changes during the Cardiac cycle

Phase	ECG Changes
1- Atrial systole	P- wave starts 0.02 sec. before atrial systole & continues. Q- wave occurs at the end of this phase.
2-Isovolumetric contraction	Q- wave starts 0.02 sec. before this phase. R & S- waves occur during it.
3-Maximum Ejection	T- wave starts at the last part of it.
4-Reduced ejection	T- wave continues
5-Isovolumic relaxation	T- wave ends
6-Rapid filling	T-P segment.
7-Reduced filling	P- wave of the next cycle starts at the end of this phase.

Left Ventricular Pressure – Volume Diagram (Loop)



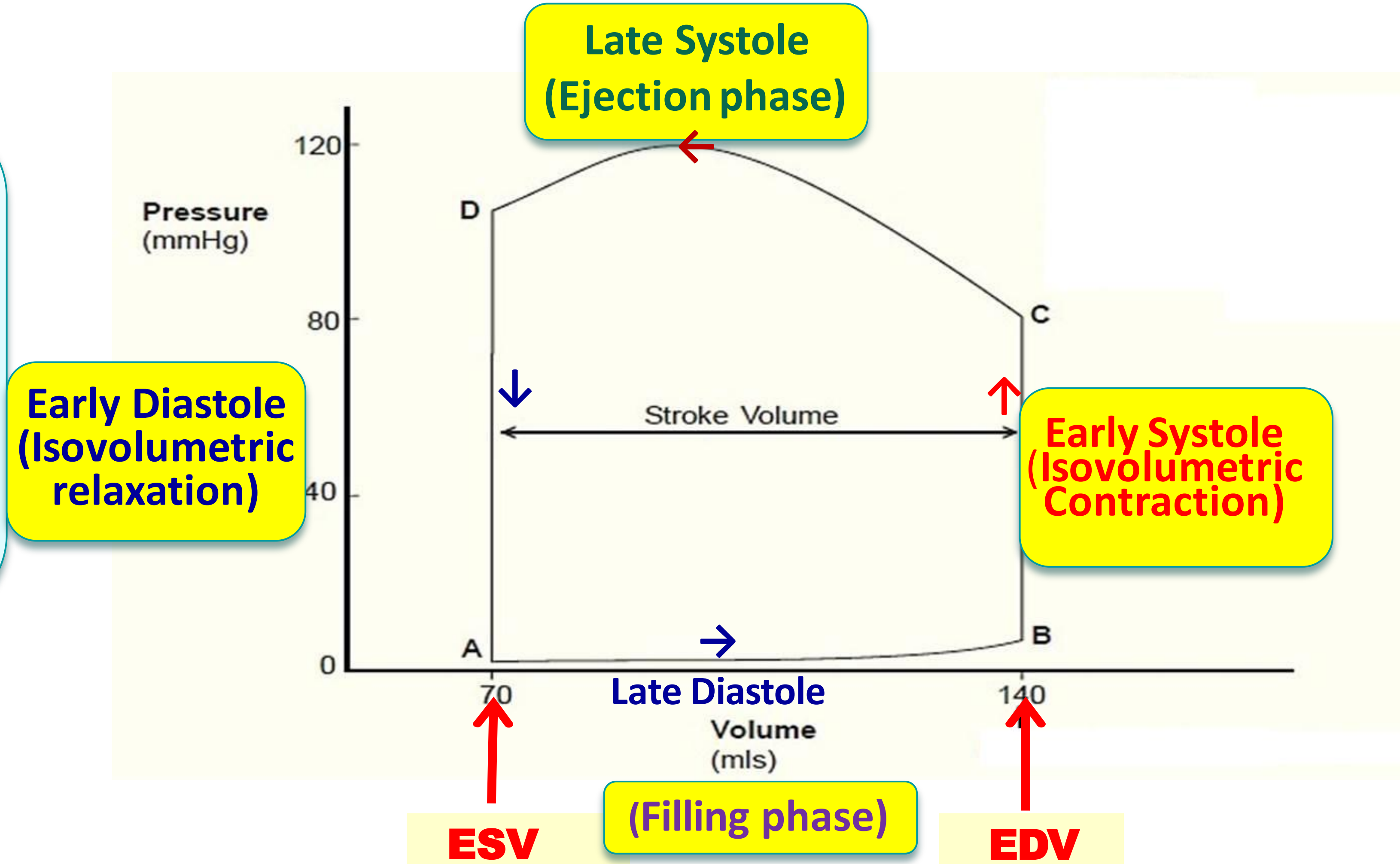
The "volume-pressure diagram," demonstrate the relationship between changes in intraventricular volume and pressure during the normal cardiac cycle (diastole and systole). EW, net external work; PE, potential energy.

Basic Myocardial Muscle Mechanics:

- Both ventricular systole & diastole can be divided into early & late phases.
- Systole:
  - Early systole = 'Isovolumetric Contraction.'
  - Late systole = Isotonic Contraction 'Ejection Phases.'
- Diastole:
  - Early diastole = 'Isovolumetric Relaxation.'
  - Late diastole = Isotonic Relaxation 'Filling Phases.'

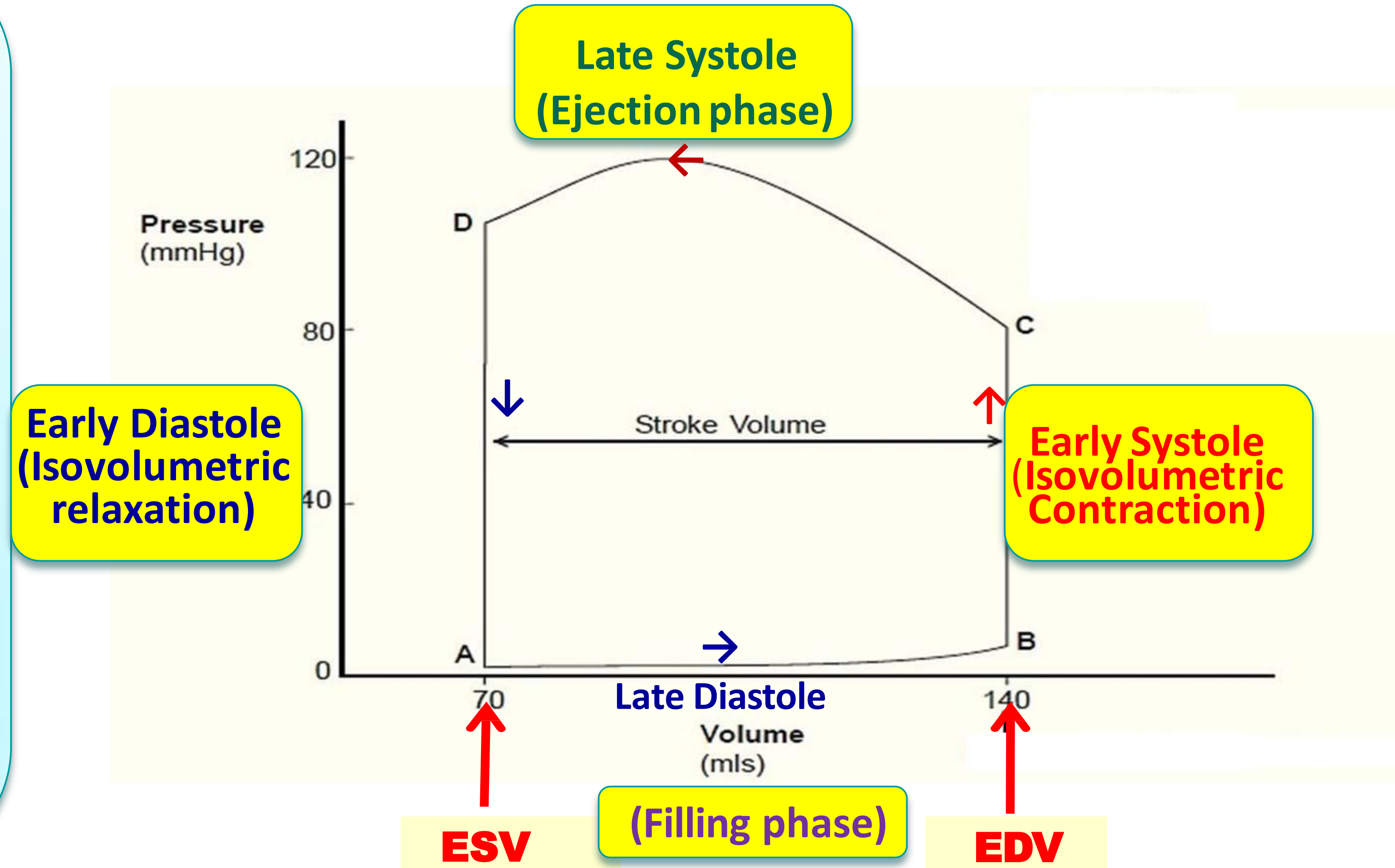
Left Ventricular Pressure - Volume Loop

- Plots LV pressure against LV volume during one complete cardiac cycle
- It is divided into four phases.



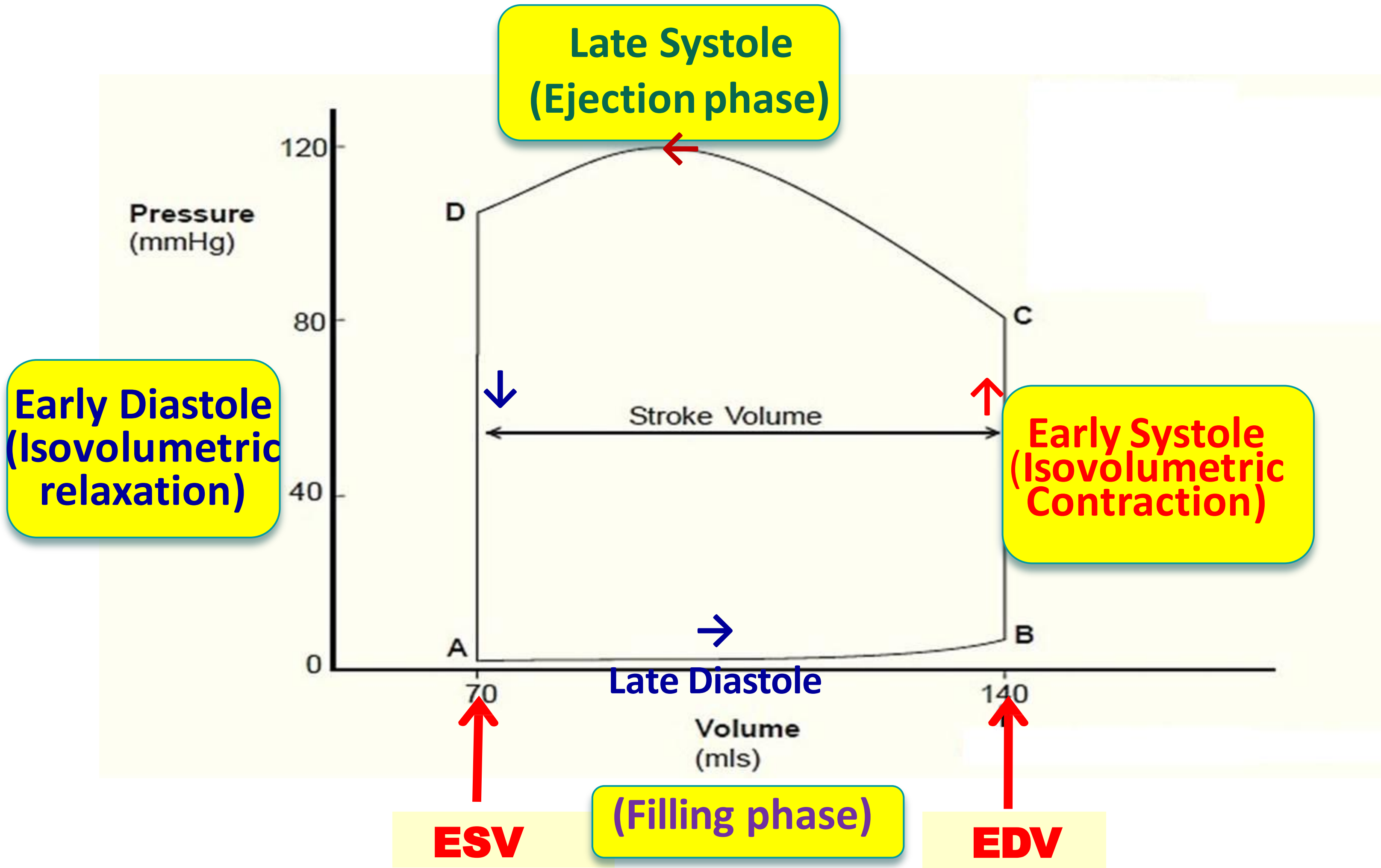
Ventricular Pressure - Volume Loop…..Cont

- ***Phase I (Filling phase):***
- Begins at a ventricular volume of about 70 milliliters and a diastolic pressure of 2 to 3 mm Hg (point A).
- The amount of blood that remains in the ventricle is the ESV.
- The ventricular volume normally increases to 140 milliliters EDV (point B).



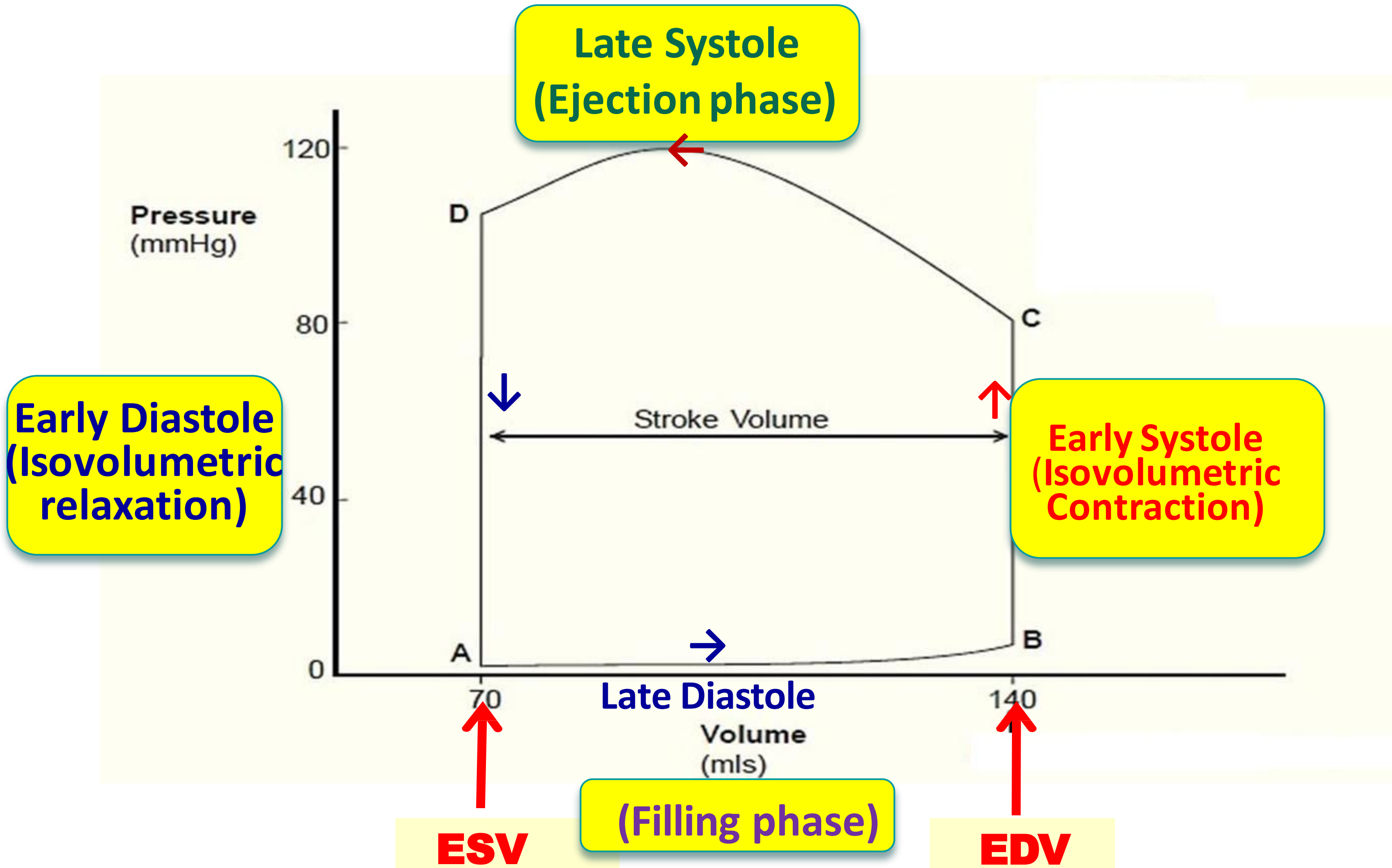
Ventricular Pressure - Volume Loop….Cont

- ***Phase II (Isovolumic contraction phase):***
- The volume of the ventricle does not change.
- Ventricular pressure rises to about 80 mm Hg (point C).



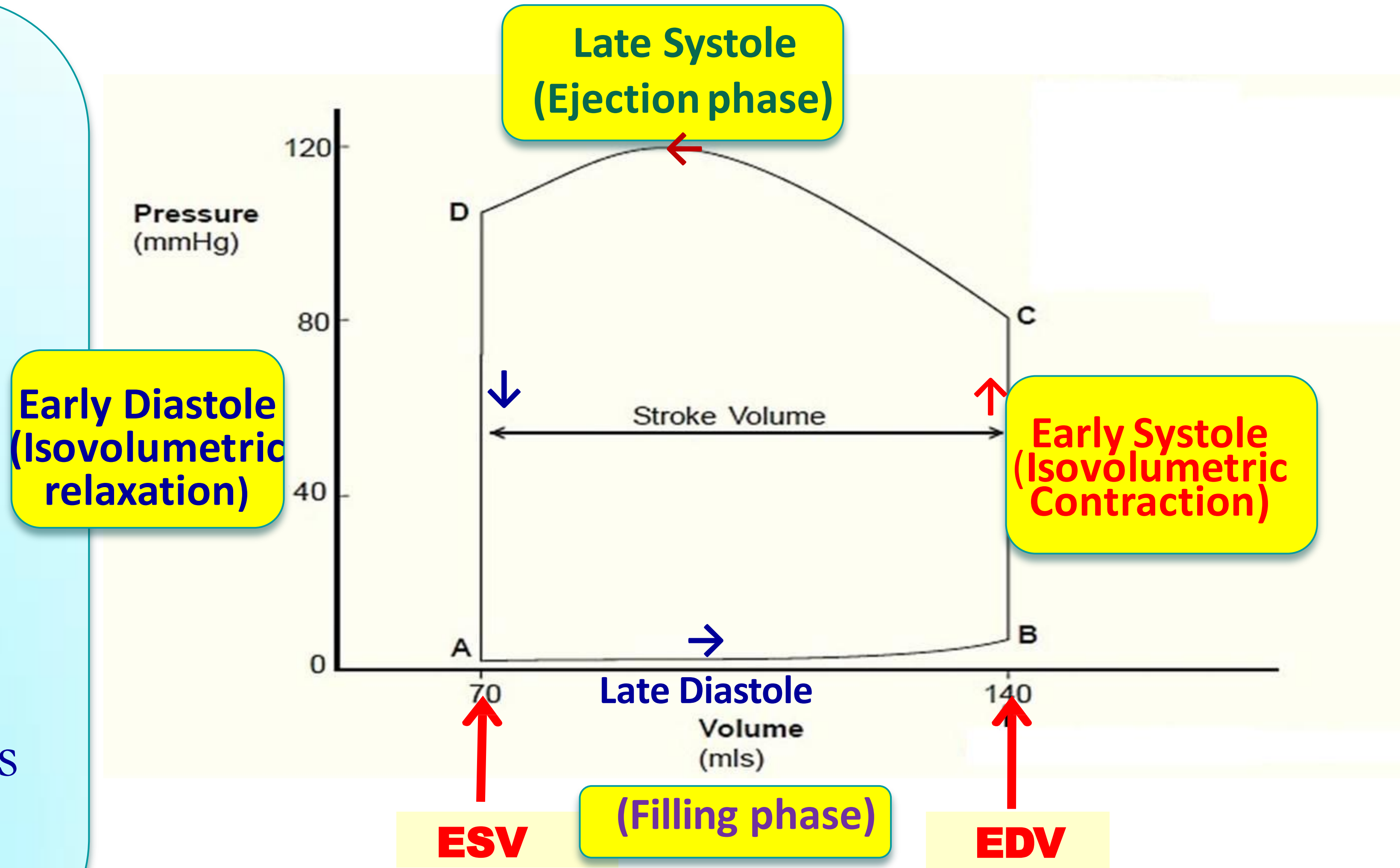
Ventricular Pressure - Volume Loop…..Cont

- ***Phase III (Ejection phase):***
- Systolic pressure rises (from 80 to 120 mmHg).
- The volume of the ventricle decreases because blood flows out of the ventricle into the aorta.

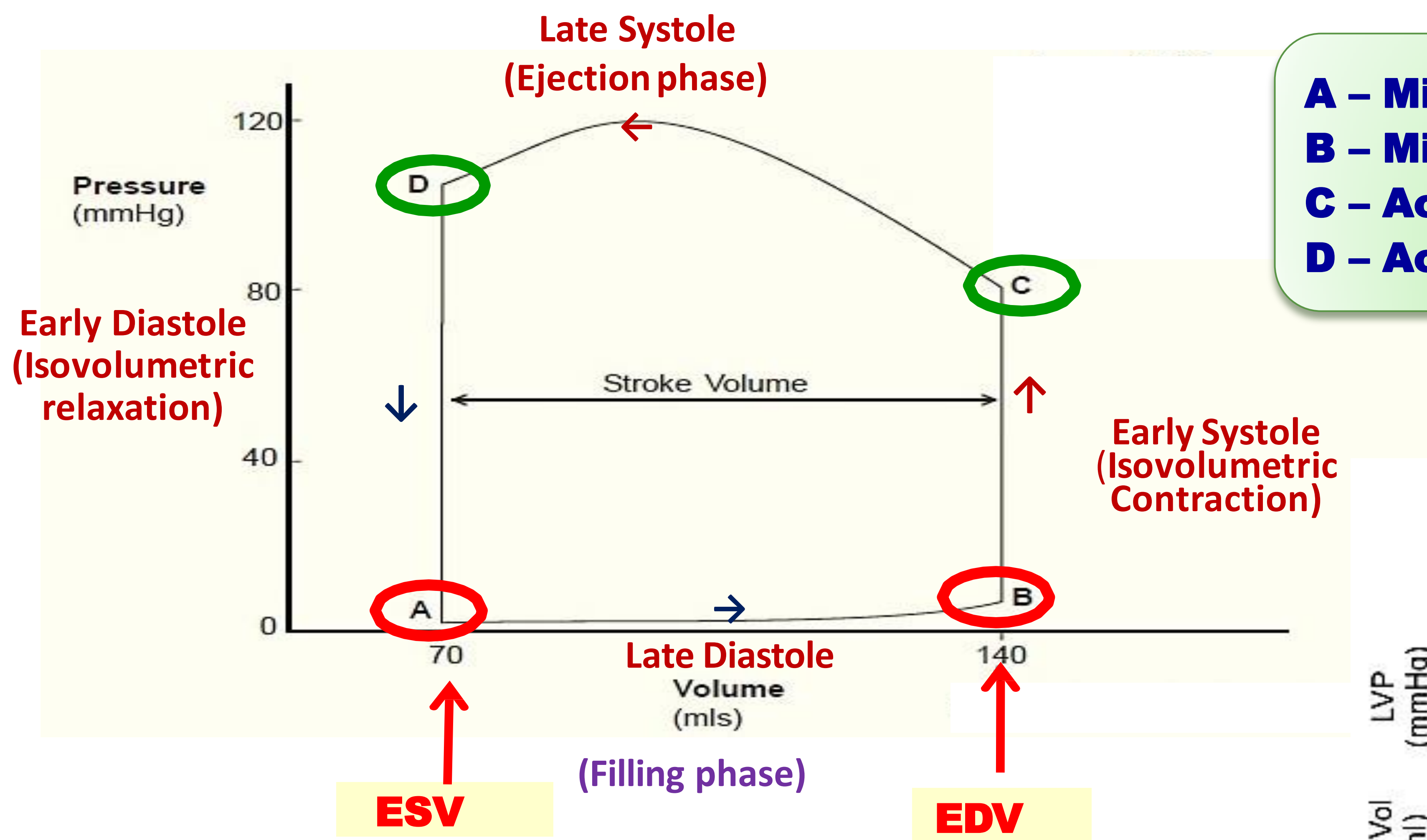


Ventricular Pressure - Volume Loop…..Cont

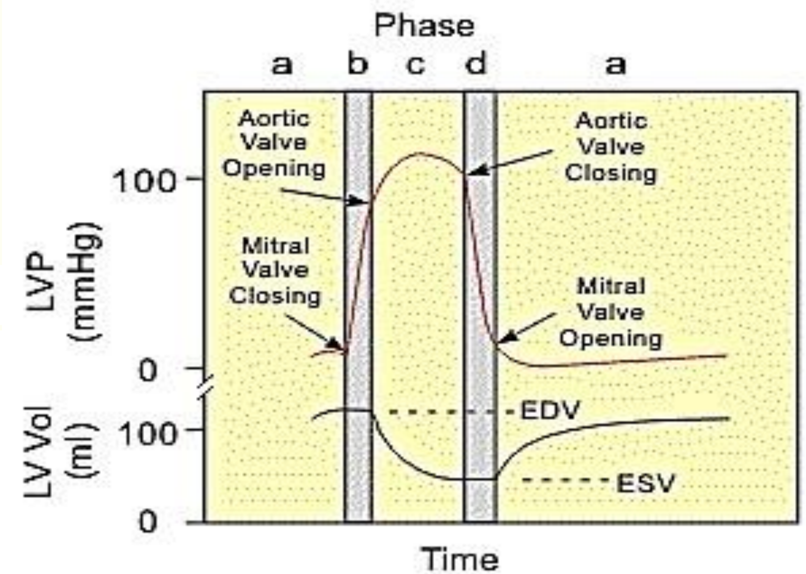
- ***Phase IV (Isovolumic relaxation phase):***
- At the end of ejection period (point D), the aortic valve closes
- Ventricular pressure falls back to the diastolic pressure level.
- The ventricle returns to its starting point (point A).



Ventricular Pressure - Volume Loop….Cont.

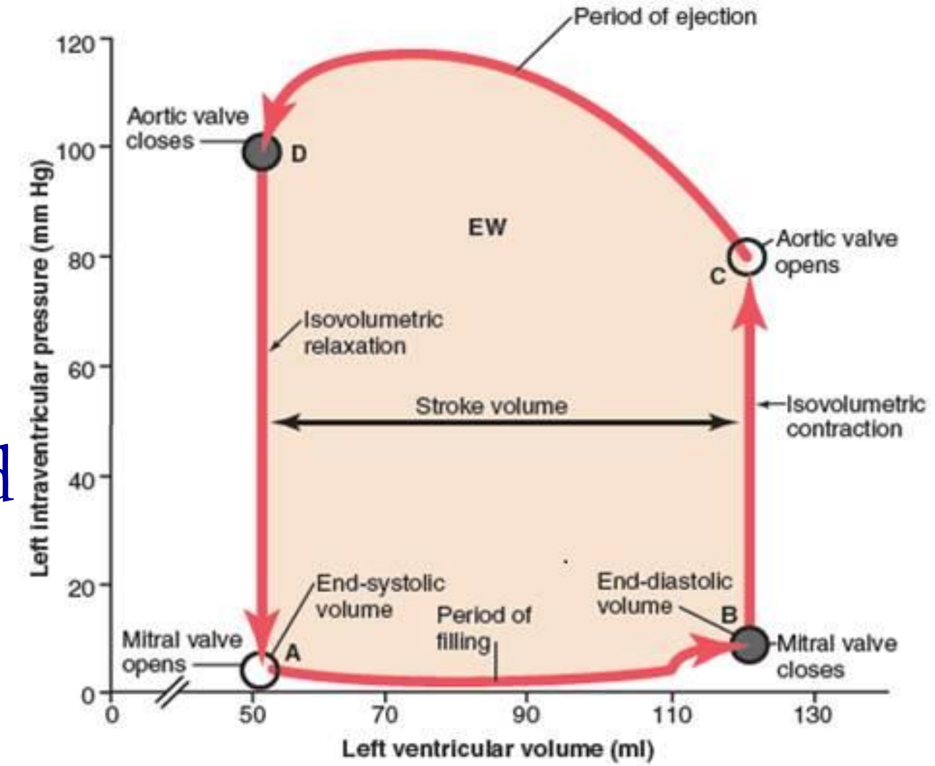


A – Mitral valve opens
B – Mitral valve closes
C – Aortic valve opens
D – Aortic valve closes



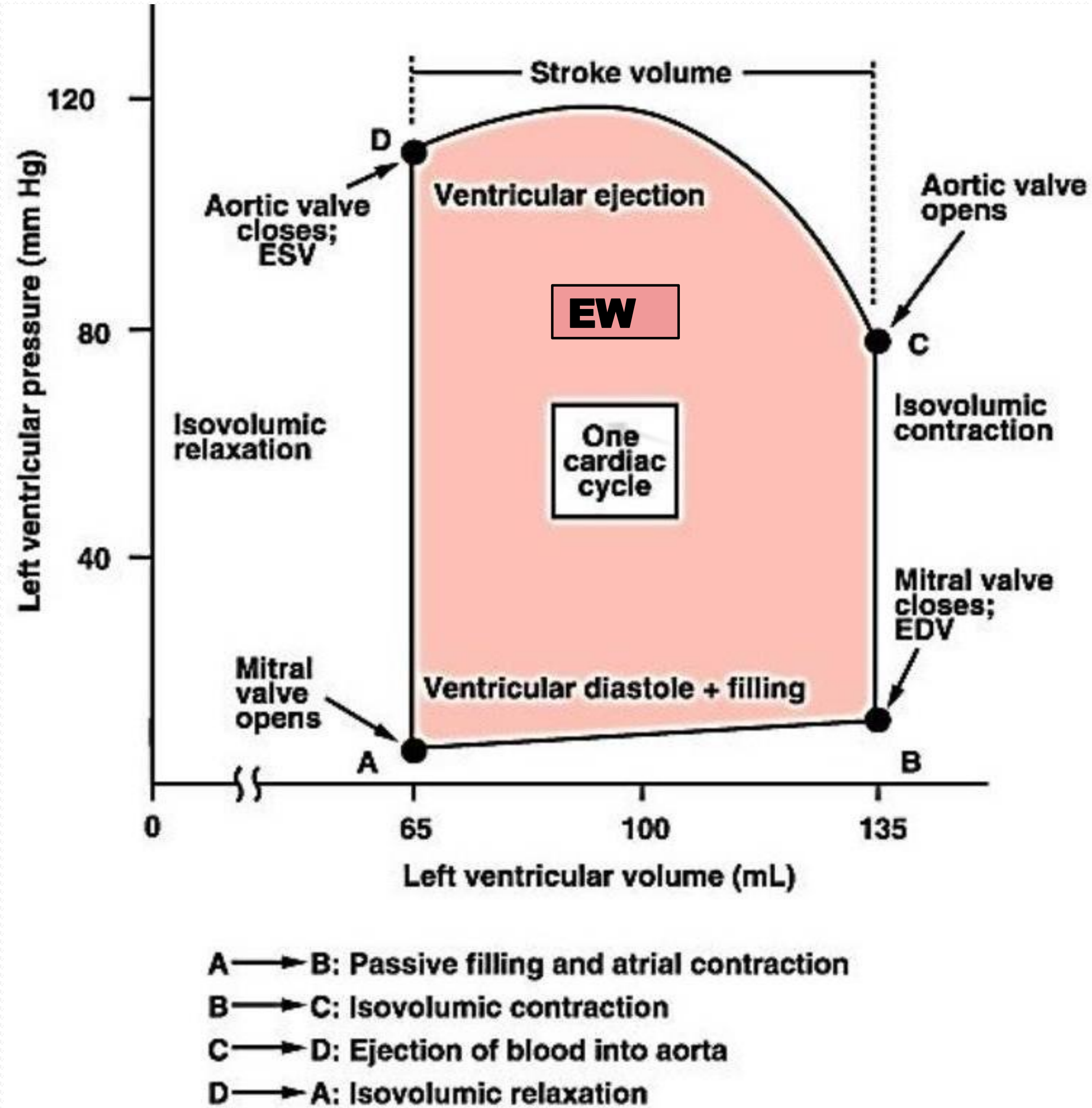
What you should remember about Pressure – Volume loop?

- Diastolic filling occurs between points A & B.
- Ejection occurs between points C & D.
- Mitral valve open at the beginning of filling phase (point A) and close at its end (point B)
- Aortic valves open at the beginning of ejection phase (point C) and close at its end (point D)



Importance of Ventricular Volume-Pressure Loop

- This diagram is used for calculating cardiac work output.
- The shaded area, labeled "EW" represents the net <u>external work output</u> of the ventricle during cardiac cycle.
- When the heart pumps large quantities of blood, the area of the work diagram becomes much larger. As during sympathetic stimulation.



Effects of changes in (A) preload, (B) afterload, and (C) contractility on the Ventricular Volume-Pressure Loop

A. Increased preload: → increased width of the PV loop

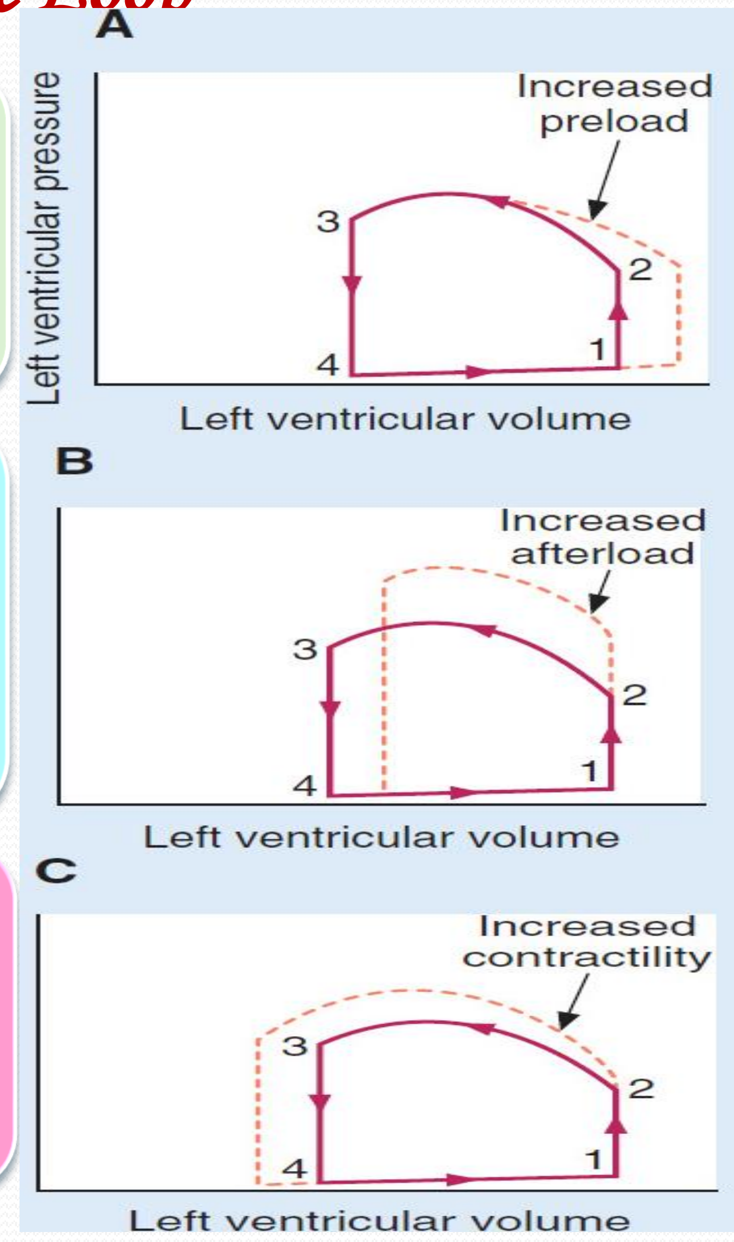
- ■ Refers to an ↑ in EDV and is the result of ↑ VR
- ■ Causes an ↑ in SV based on the Frank–Starling relationship.

B. Increased afterload: →decreased width & increased height of the PV loop

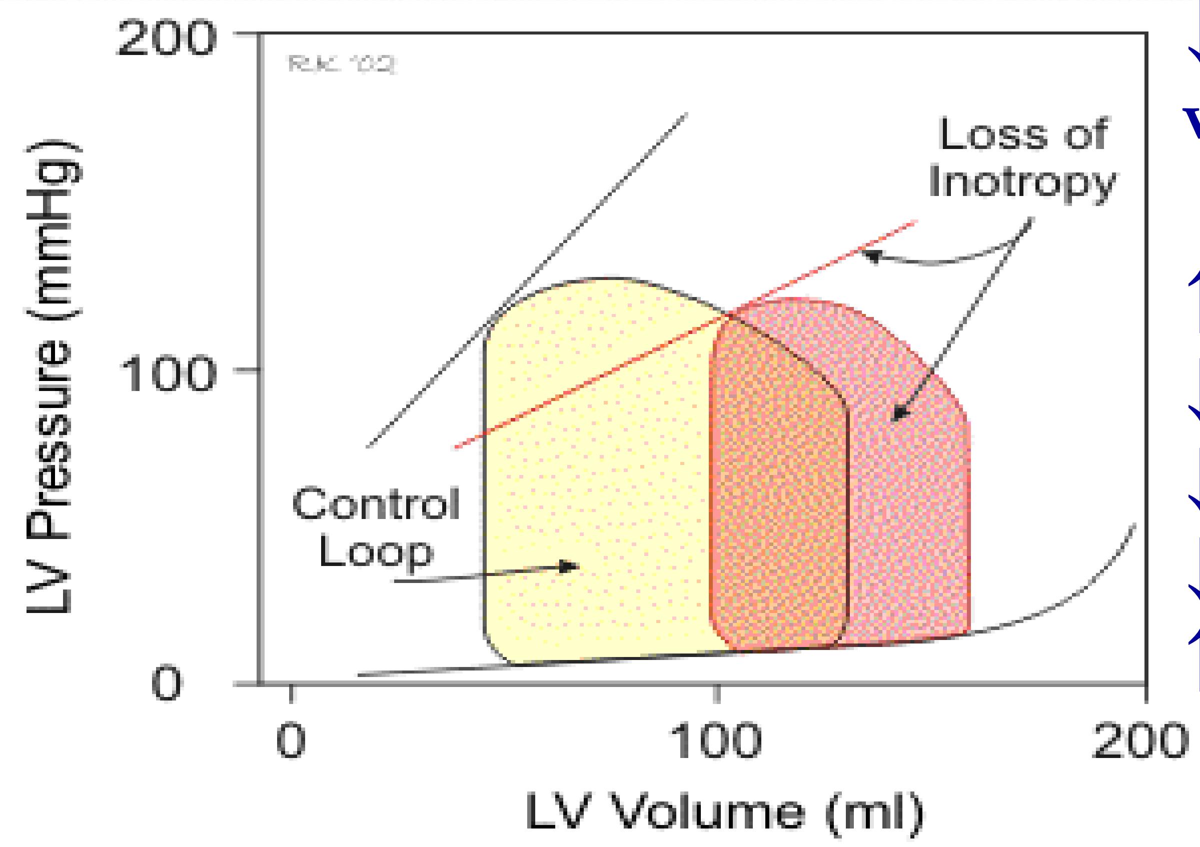
- ■ Refers to an ↑ in aortic pressure.
- ■ The ventricle must eject blood against a higher pressure, resulting in ↓ in SV, resulting in an ↑ in ESV.

C. Increased contractility:→increased width & height of the PV loop.

- ■ The ventricle develops greater tension than usual during systole, causing an ↑ in SV, resulting in a ↓ in ESV.



Effect of Left Ventricular Systolic Failure on Left Ventricular Pressure Volume Loop.



↓ slope of End-systolic pressure-volume relationship (ESPVR) i.e.↑ESV

Compensatory rise in preload i.e.

↑ EDV

↓ SV

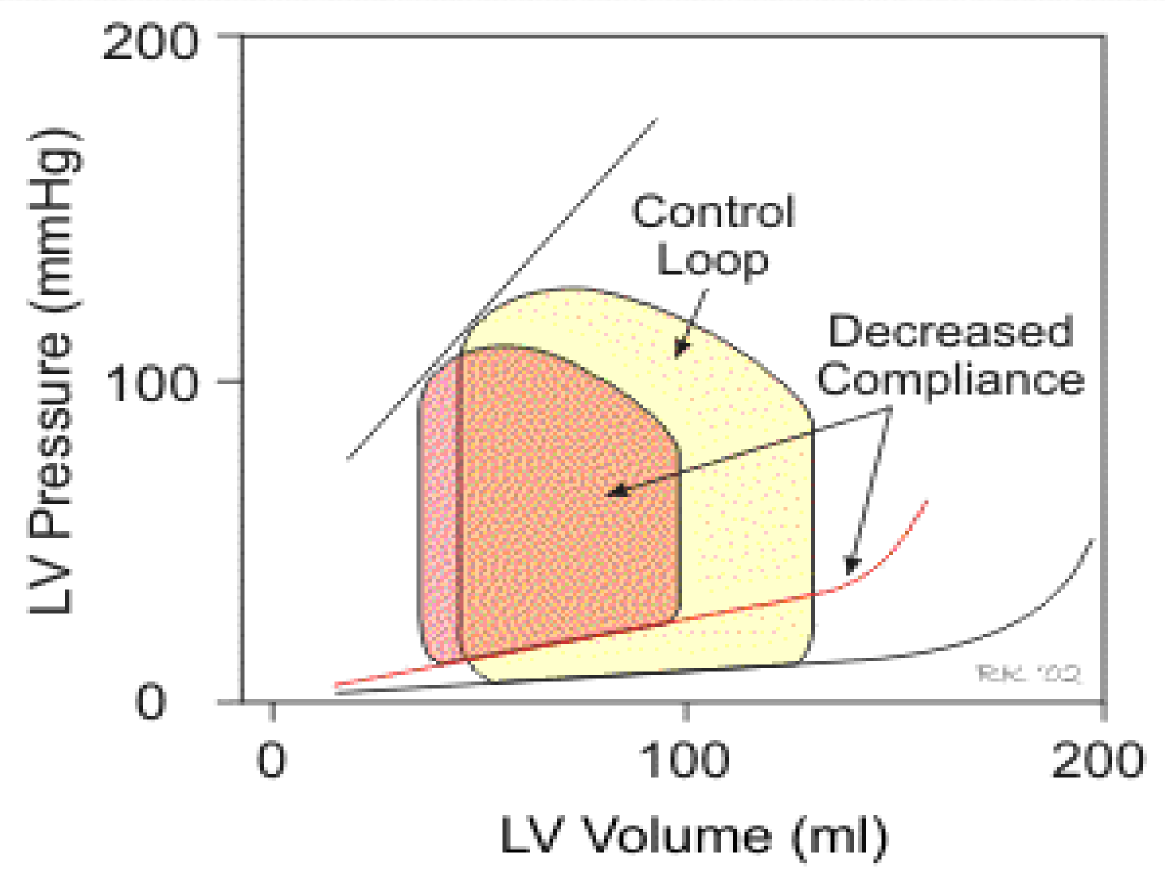
↓ EF

↓ External work output

↑ EDP

Heart rate is unchanged.

Effect of Left Ventricular Diastolic Failure on Left Ventricular Pressure Volume Loop.



↓ Ventricular compliance/relaxation (lusitropy).

↓ EDV

↓ SV

↓ or =EF

↓ External work output

↑ EDP

Heart rate, inotropy and systemic vascular resistance are unchanged.

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استغفرك وأتوب اليك