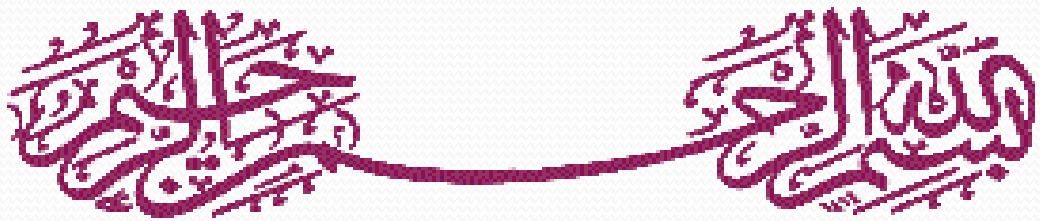

السلام عليكم ورحمة الله وبركاته

Cardiovascular System Block

Cardiac Cycle- 2

(Physiology)

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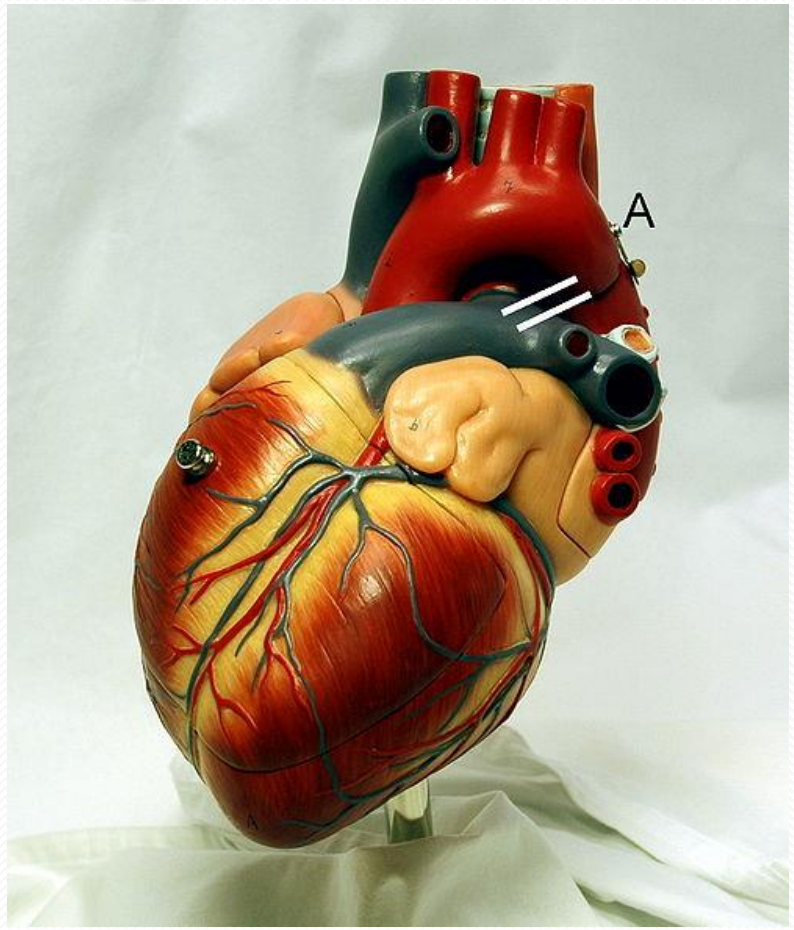


Learning Objectives

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

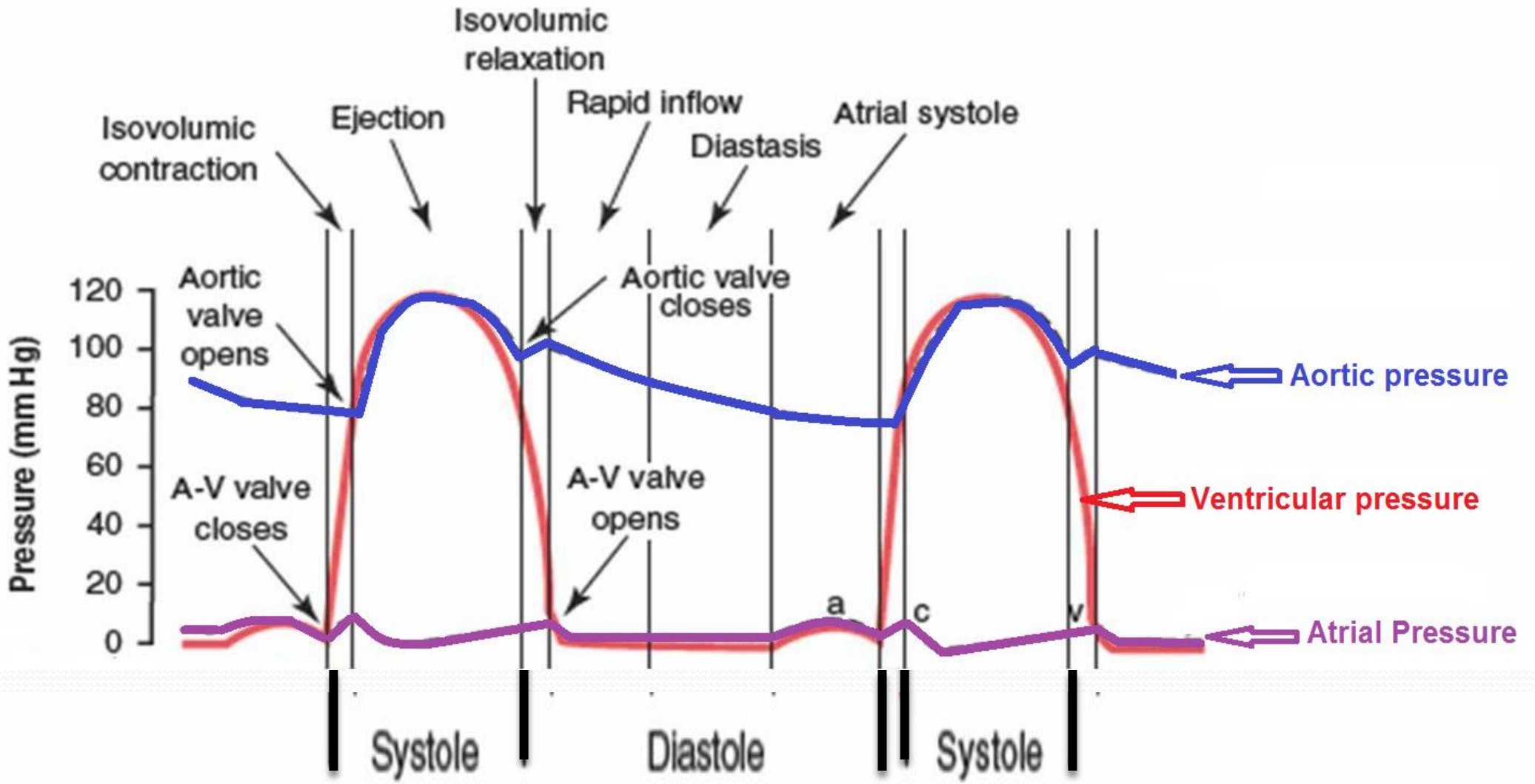
Events in the cardiac Cycle

1. Mechanical events
2. Ventricular Volume Changes
3. Pressure Changes
4. Heart Sounds
5. **Electrical Events (ECG)**

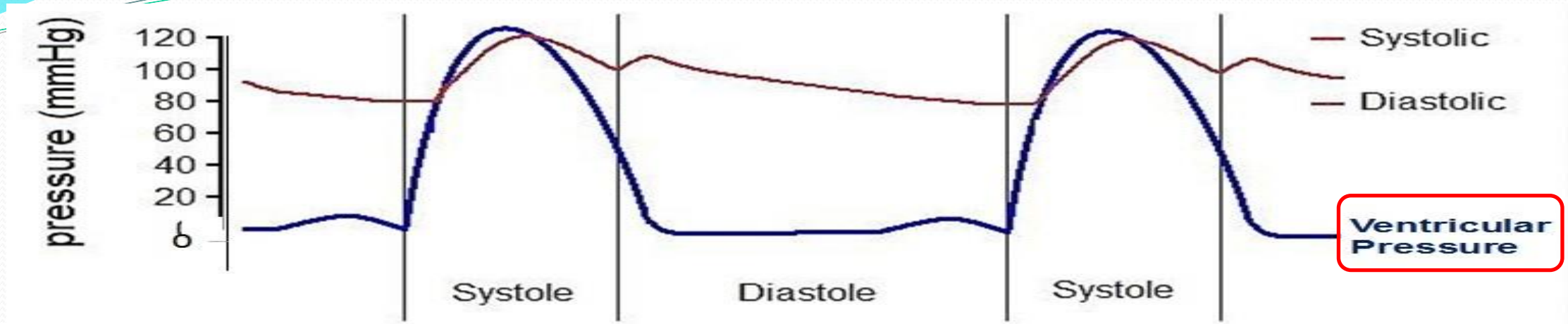
Recorded Pressure Changes During Cardiac Cycle

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

Left Ventricular Pressure Changes … 120/3-12 mmHg



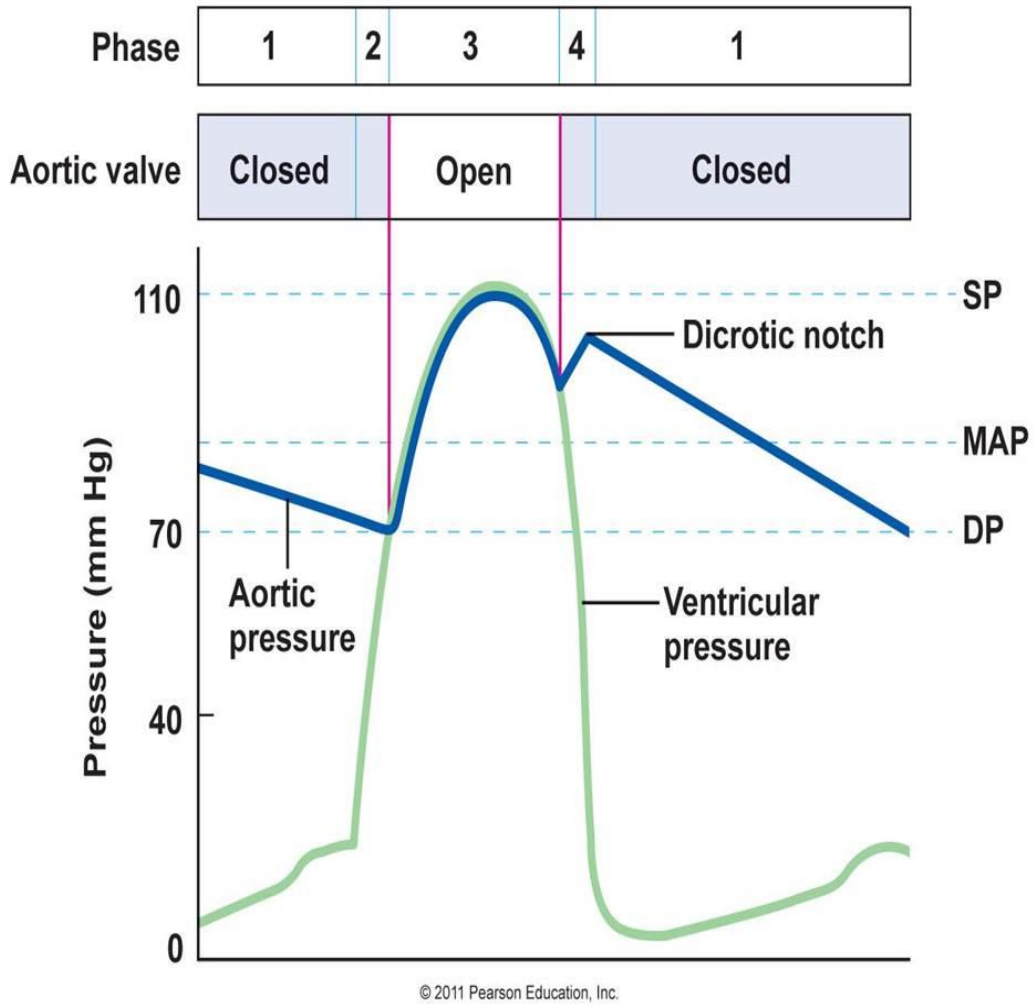
Left Ventricular Pressure Changes During Cardiac Cycle



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 mmHa

- ***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.

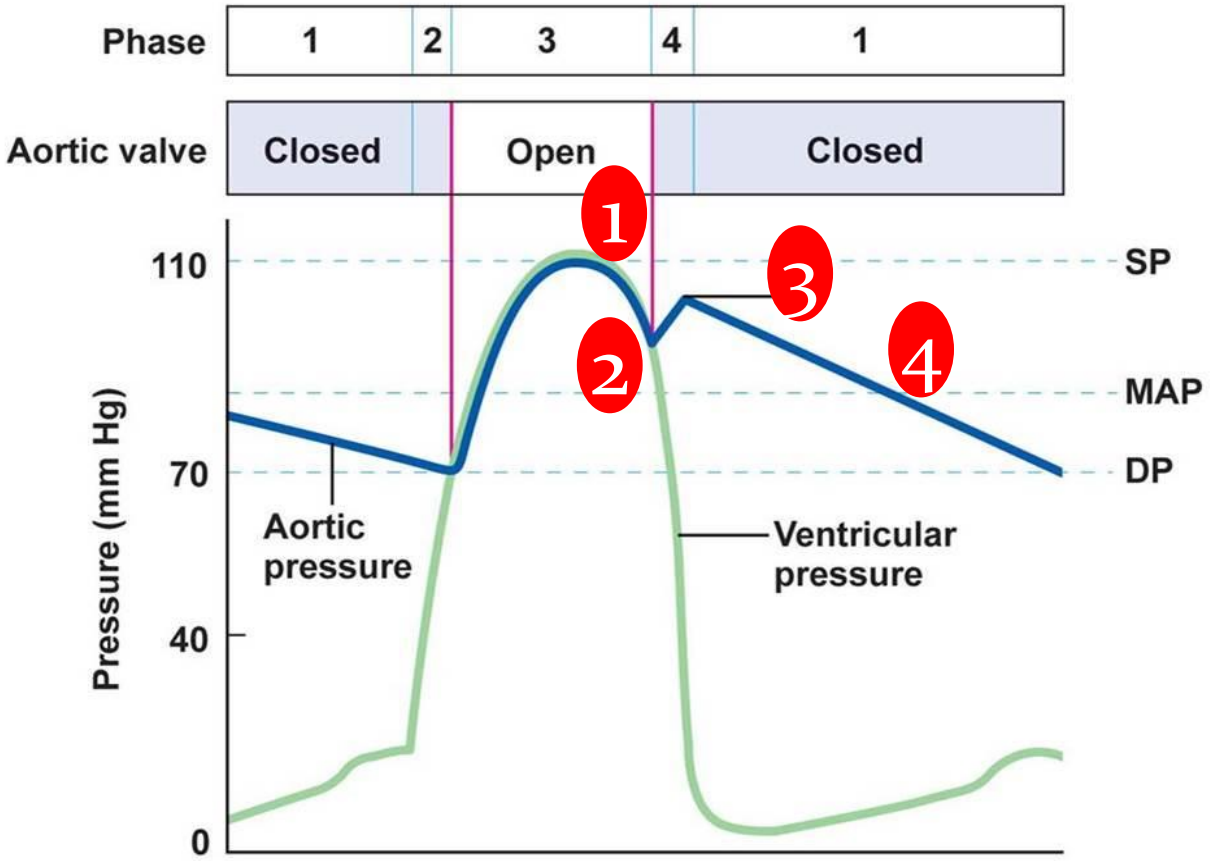
3. **Dicrotic wave:**

   Slight ↑ in aortic pressure.

   Due to elastic recoil of the aorta.

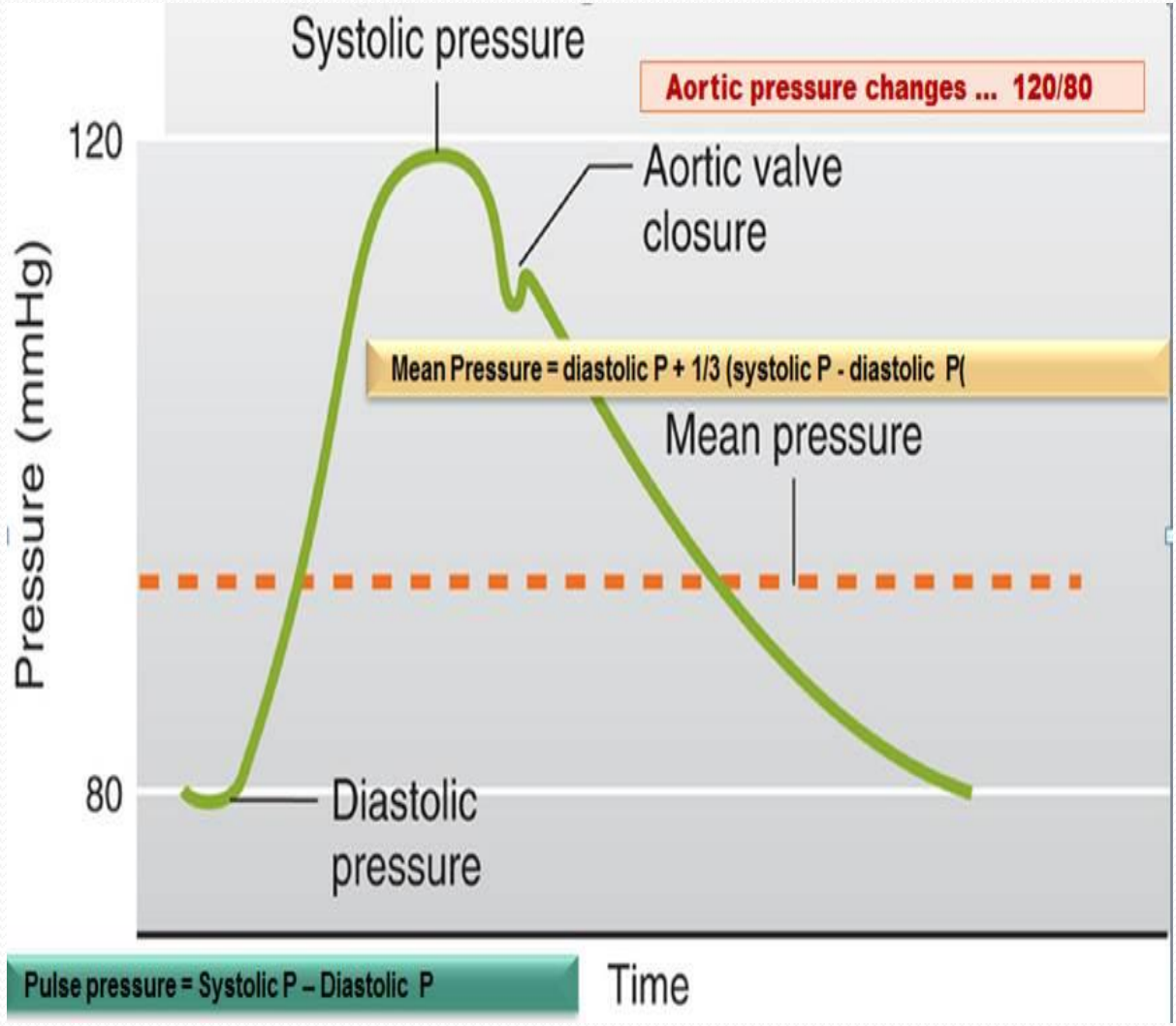
4. **Slow ↓ aortic press:** down to 80 mmHg.

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



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

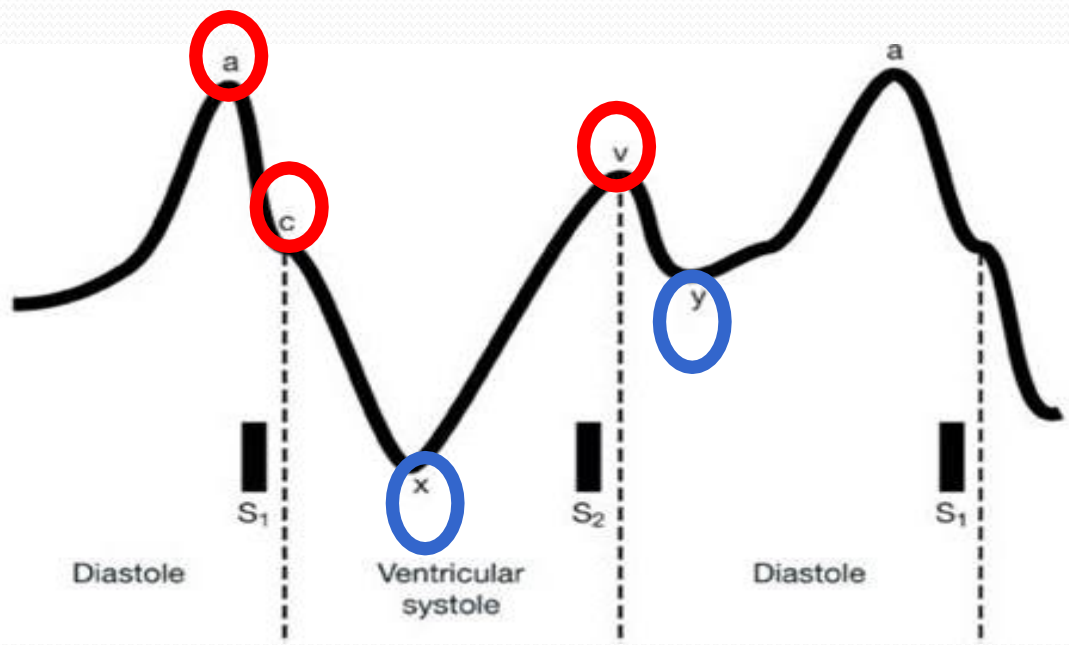
- Similar to aortic pressure waves, but **sharper.**
- Reflects a systolic peak pressure of 110-130 mmHg & a diastolic pressure of 70-85 mmHg.
- N.B Pulmonary artery pressure changes (25-30/4-12) mmHg are similar to aortic pressure changes, but with difference in magnitude.



Atrial Pressure Changes:

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***

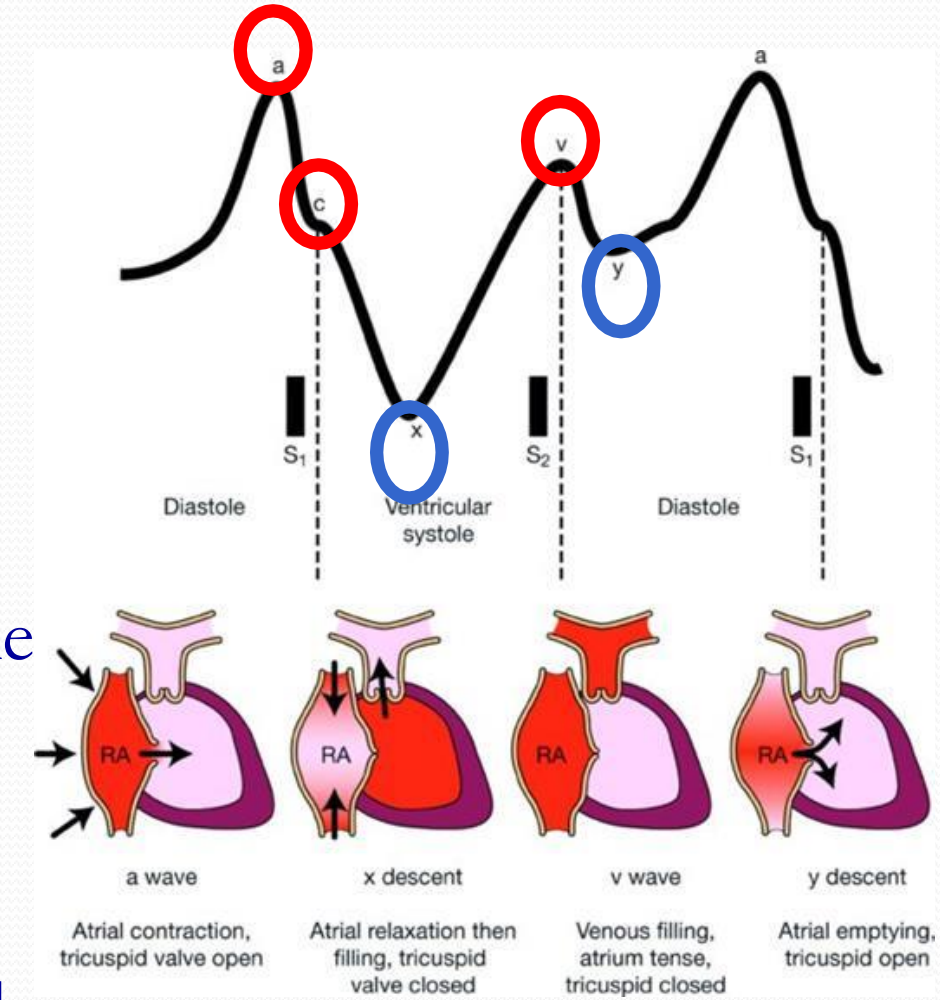
  +ve due to the bulging of A-V valves into the atria during 'isovolumetric contraction phase.'

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

- ***'v' wave:***

  +ve due to ↑ venous return during atrial diastole.

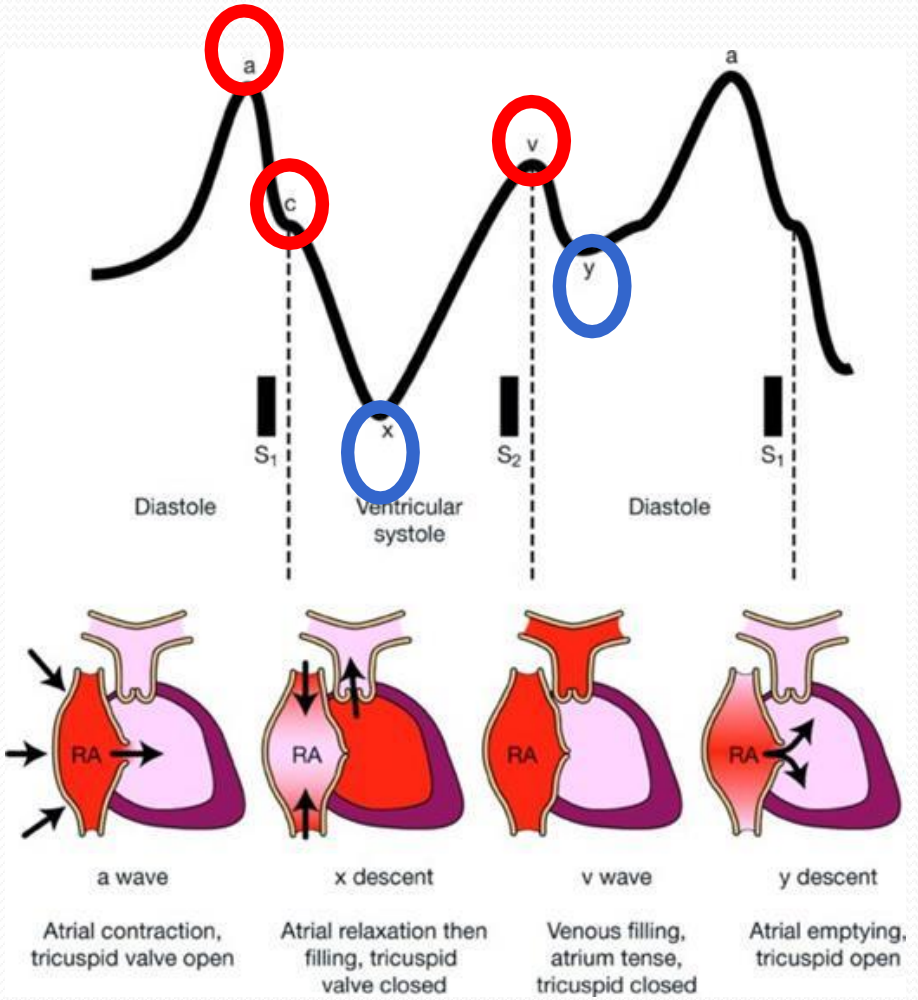
  -ve due to entry of blood into ventricles during 'rapid filling phase.'



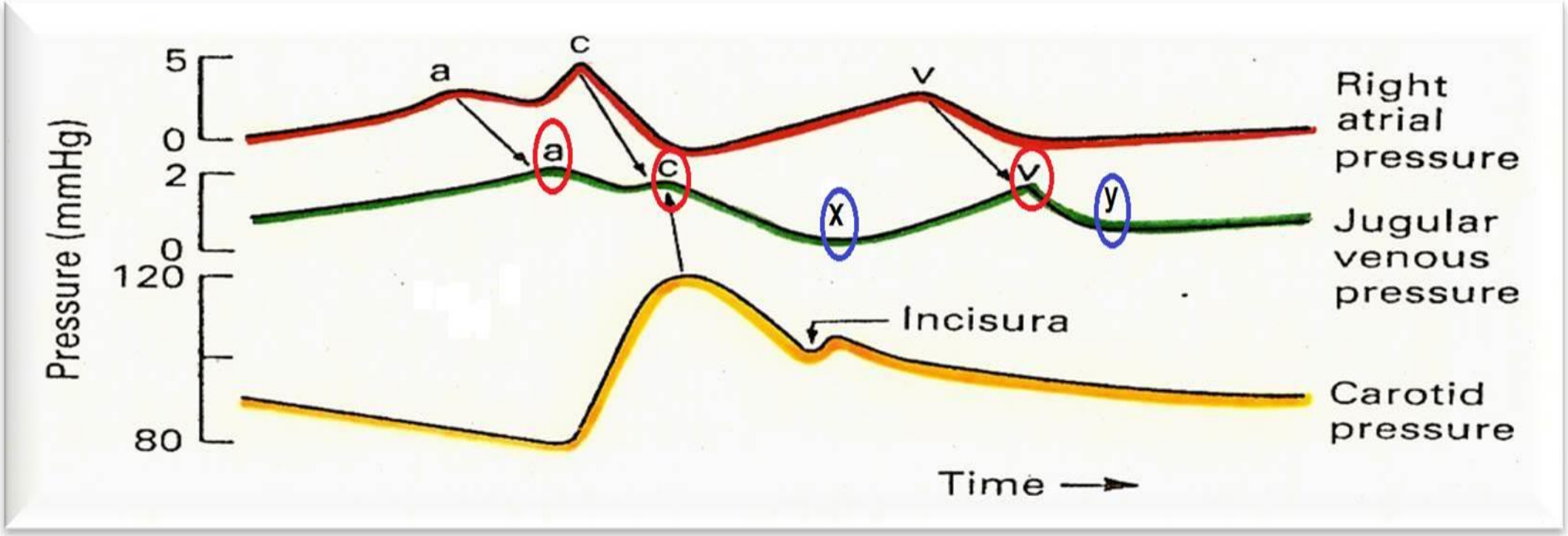
Causes of atrial pressure waves…..Cont.

- ***‘x’ descent:***
  Downward displacement of A-V valves during ‘reduced ejection phase.’

- ***‘y’ descent:***
  ↓↓ 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***

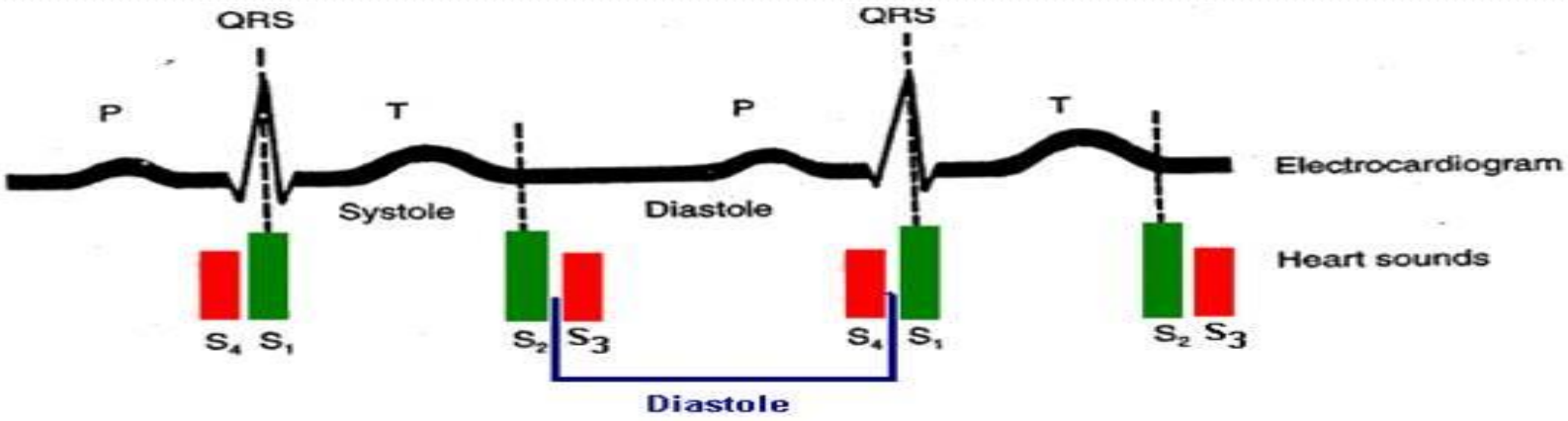
Events in the cardiac Cycle

1. Mechanical events
2. Volume changes
3. Pressure Changes
4. Heart Sounds
5. Electrical Events (ECG)

Heart Sounds

- Detected over anterior chest wall by:
  - Auscultation… (Stethoscope.)
  - Phonocardiography… (Sound recording device.)

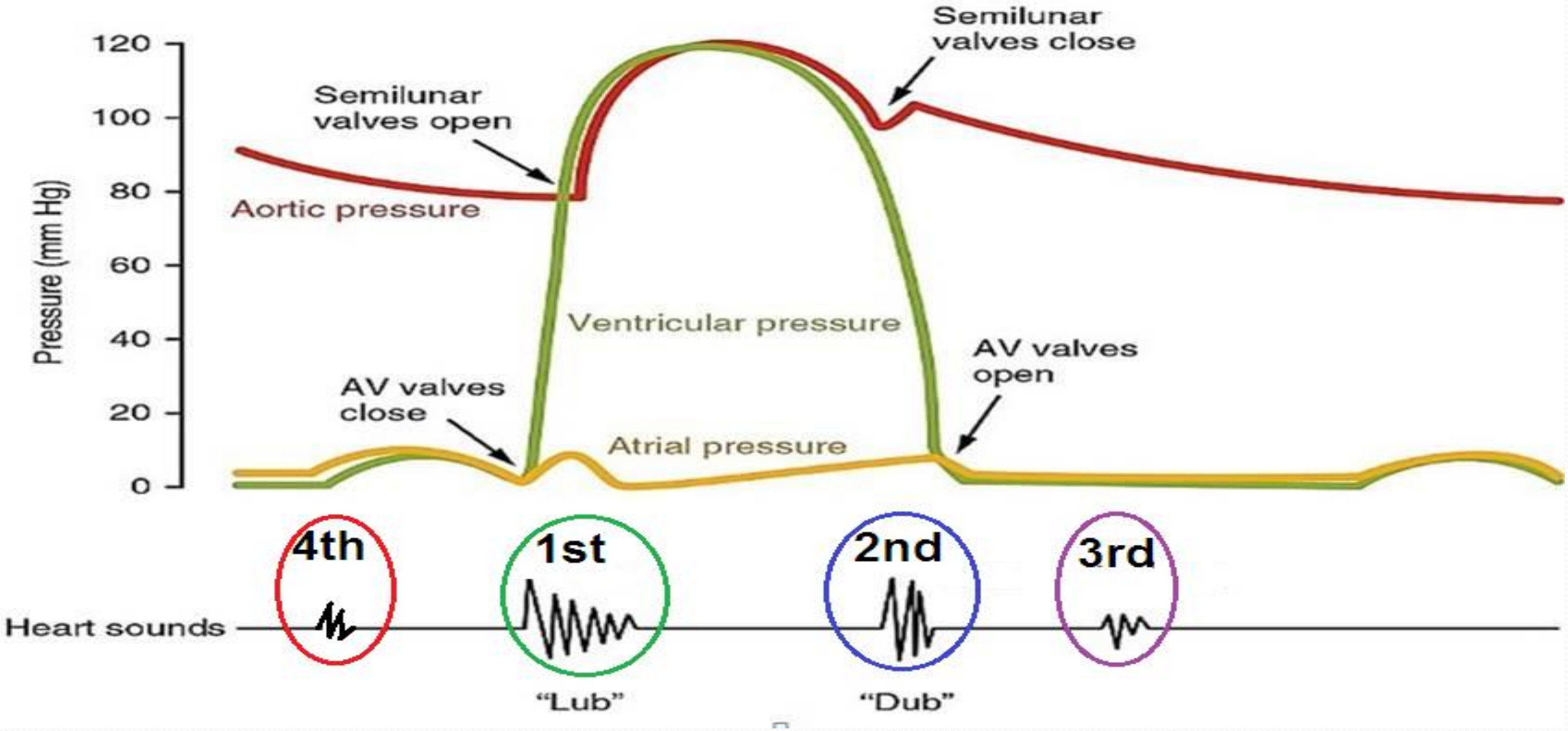
- Four heart sounds can be detected:
  - 1st & 2nd heart sounds … (usually audible)
  - 3rd & 4th heart sounds … (of low pitch, usually not audible)
- Important for diagnosis of valvular heart diseases (murmurs)



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	

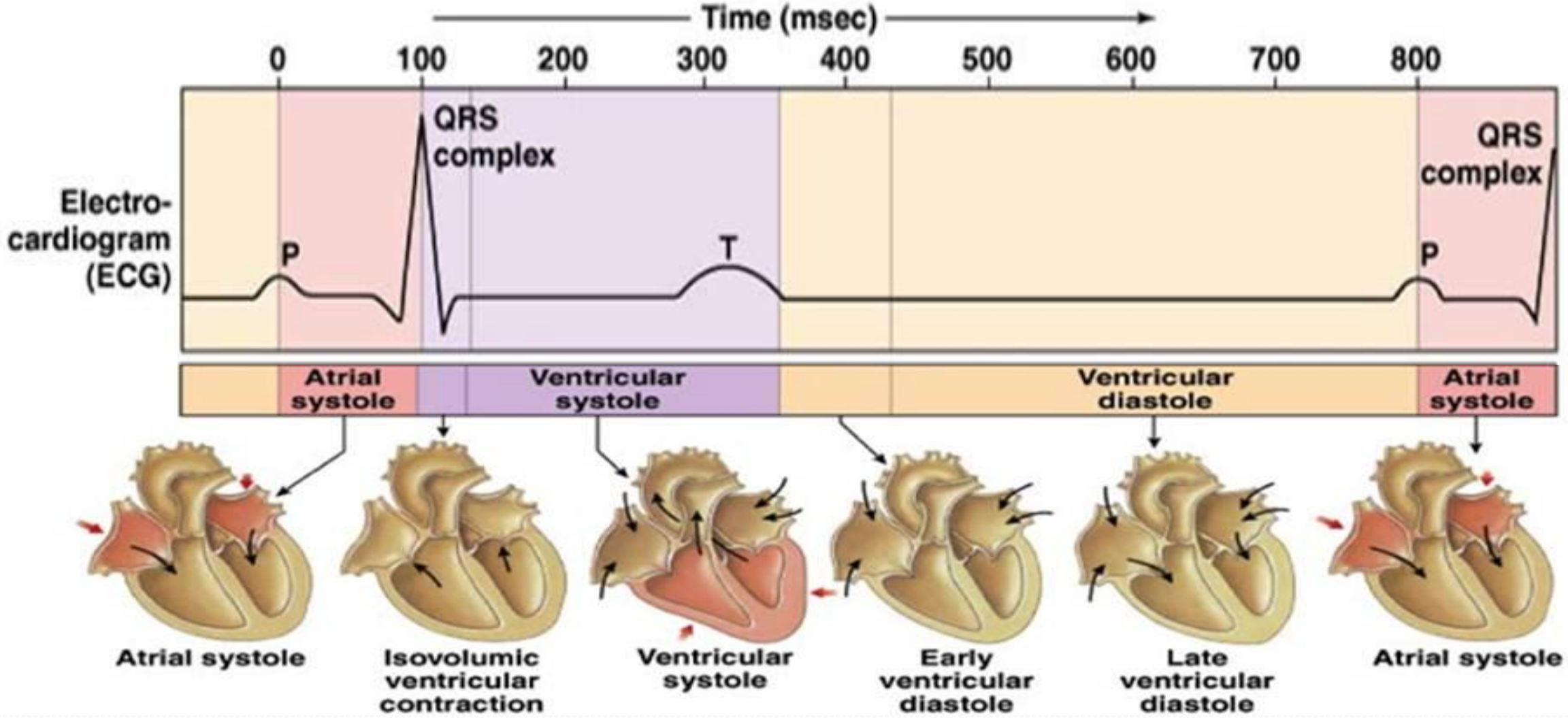
Cardiac Cycle VS Heart Sounds



Events in the cardiac Cycle

1. Mechanical events
2. Volume changes
3. Pressure Changes
4. Heart Sounds
5. **Electrical Events (ECG)**

ECG changes during the Cardiac cycle



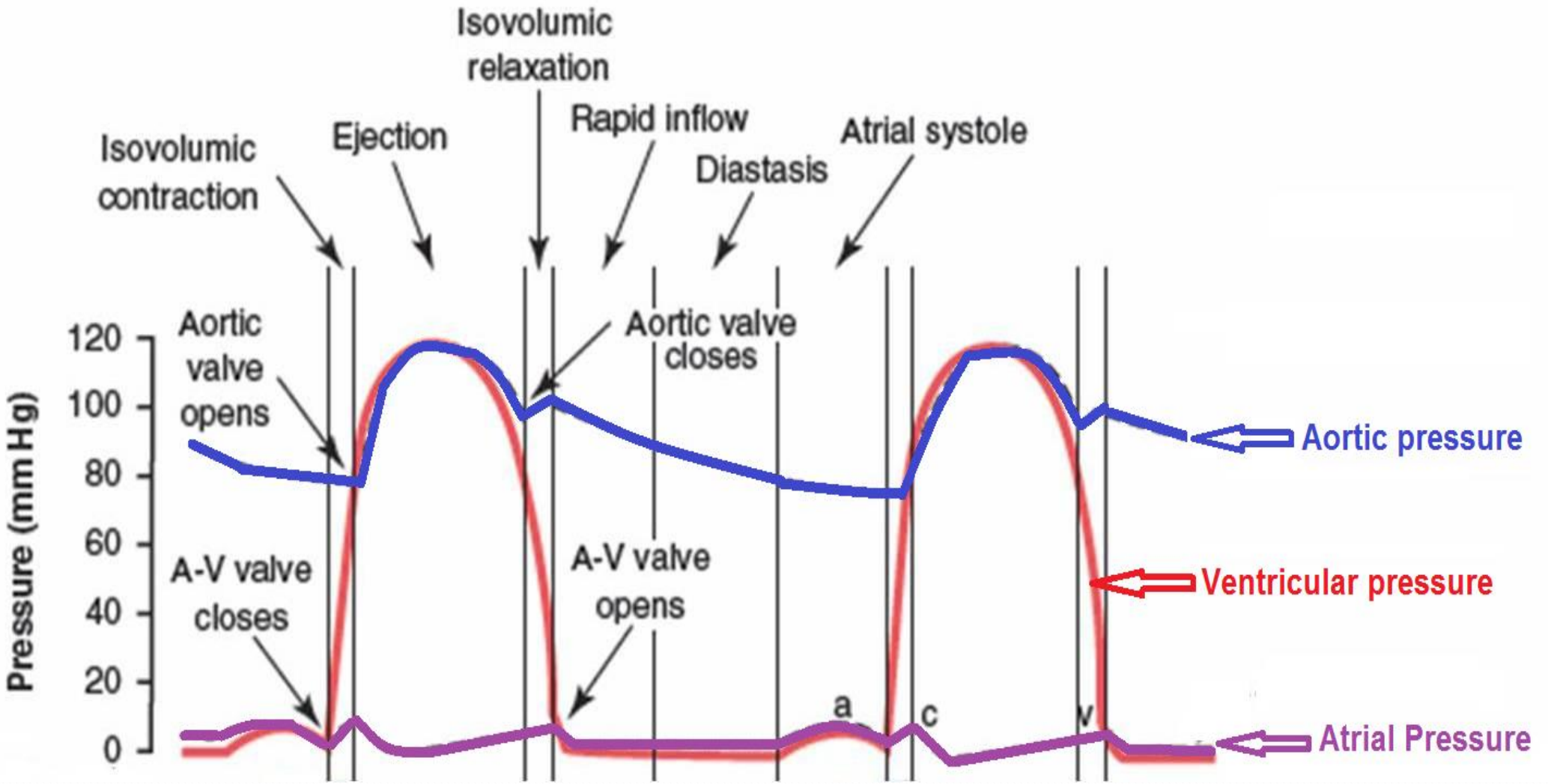
ECG changes during the Cardiac cycle

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)

Correlation of intra-ventricular volume & pressure changes that occur during one cardiac cycle

Left Ventricular Pressure – Volume Curve "The Complete Picture"



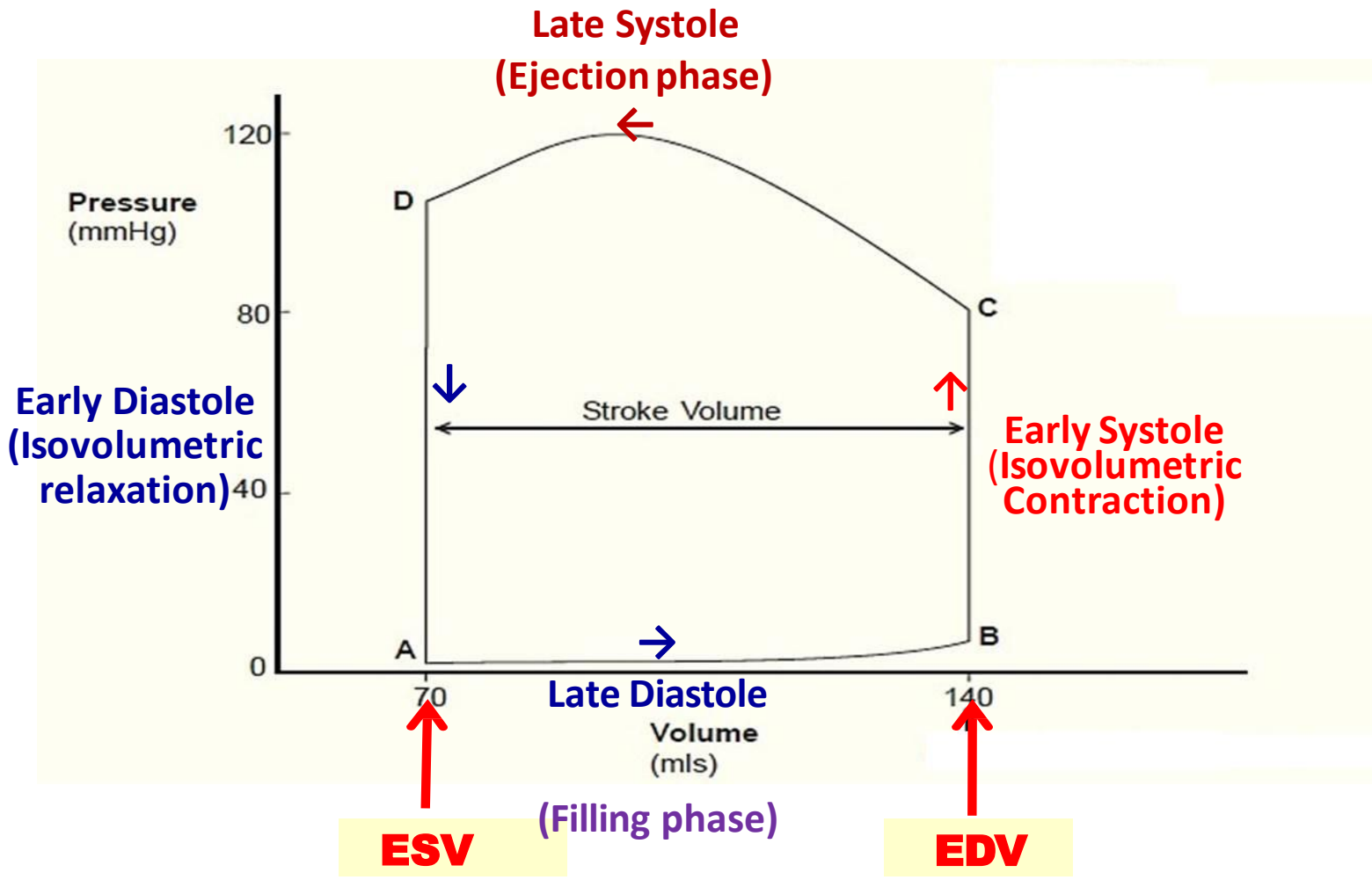
Basic Myocardial Muscle Mechanics:

- 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.'

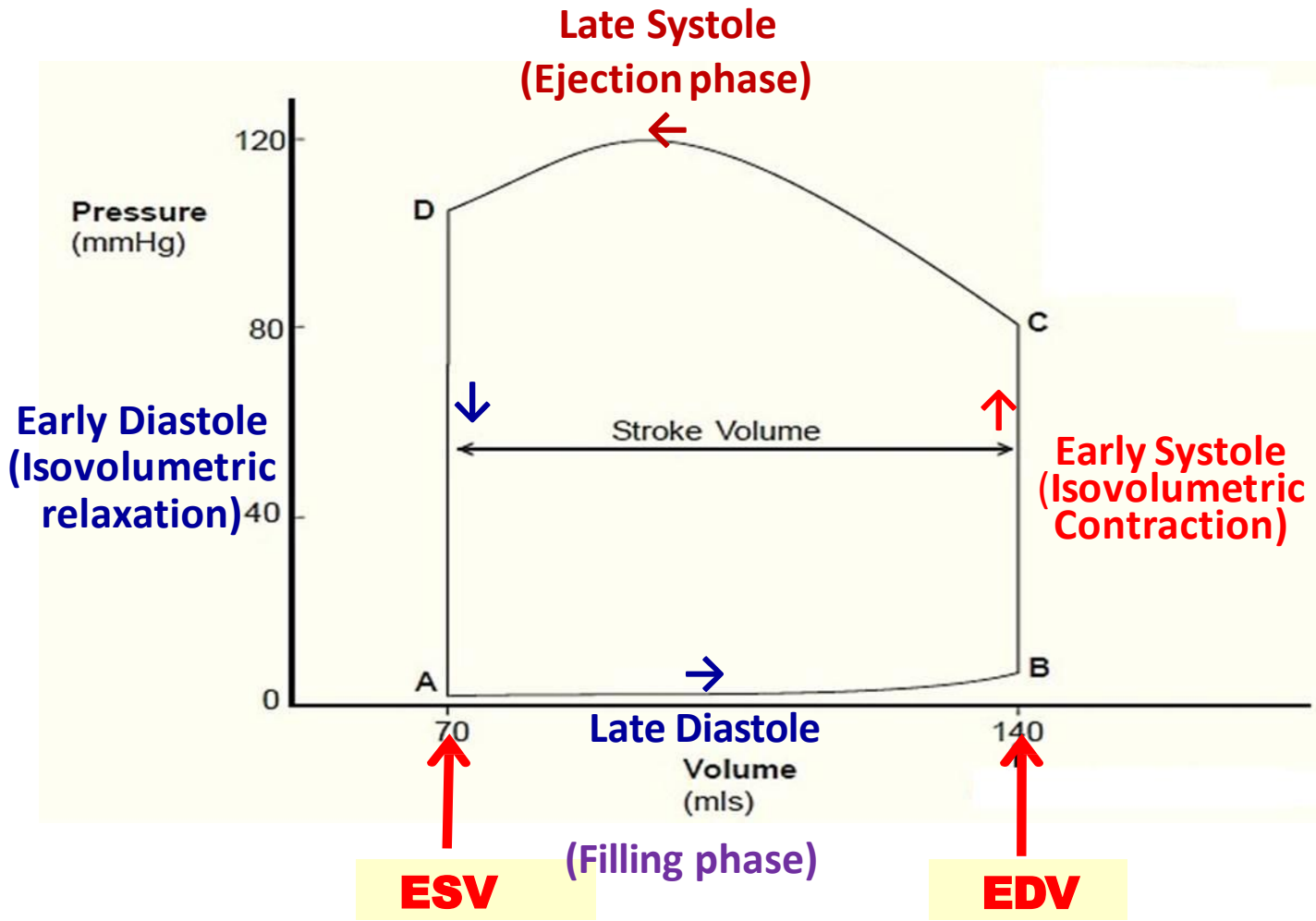
Ventricular Pressure - Volume Loop

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



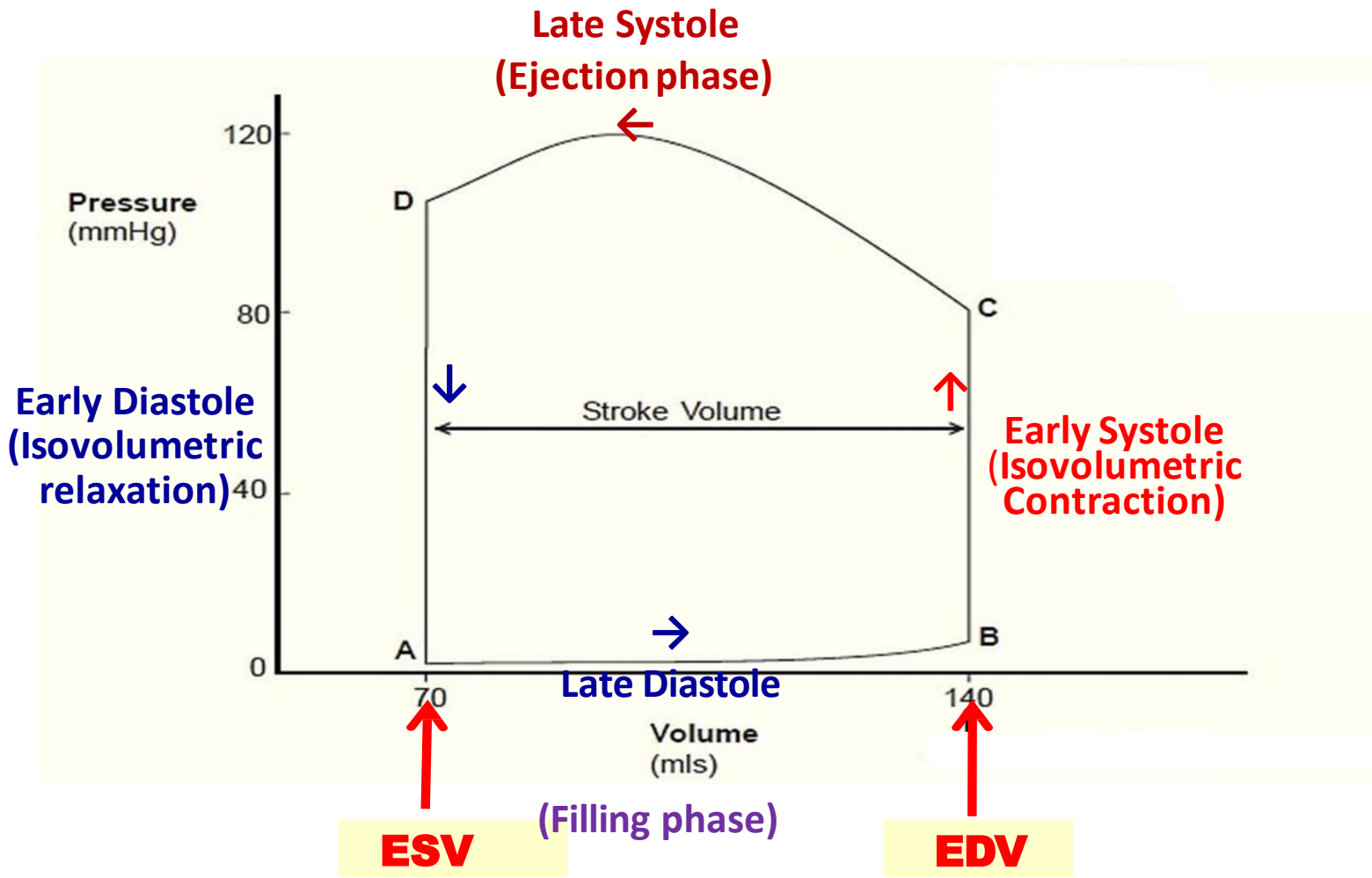
Ventricular Pressure - Volume Loop…..Cont

- ***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).



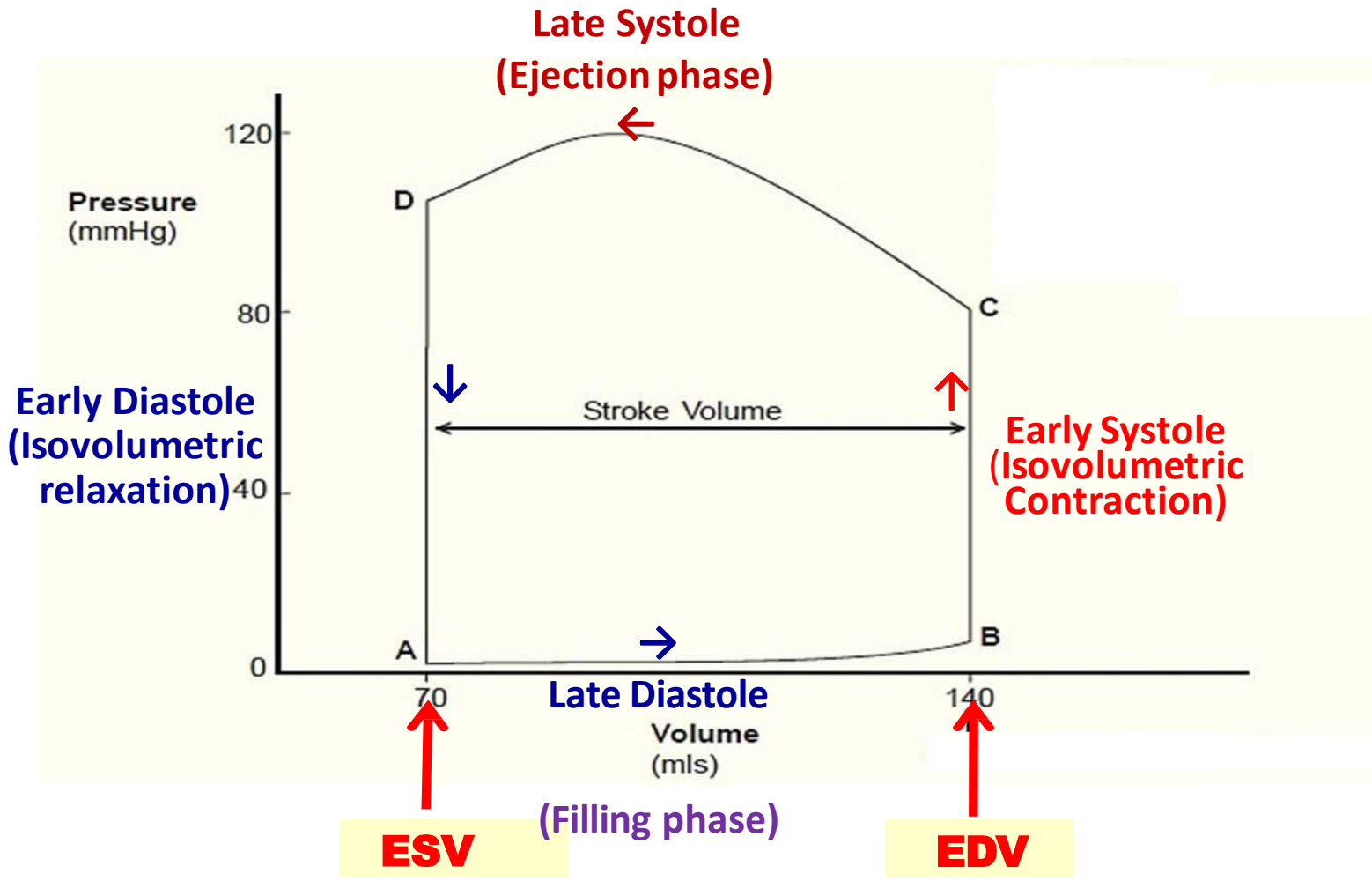
Ventricular Pressure - Volume Loop…..Cont

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



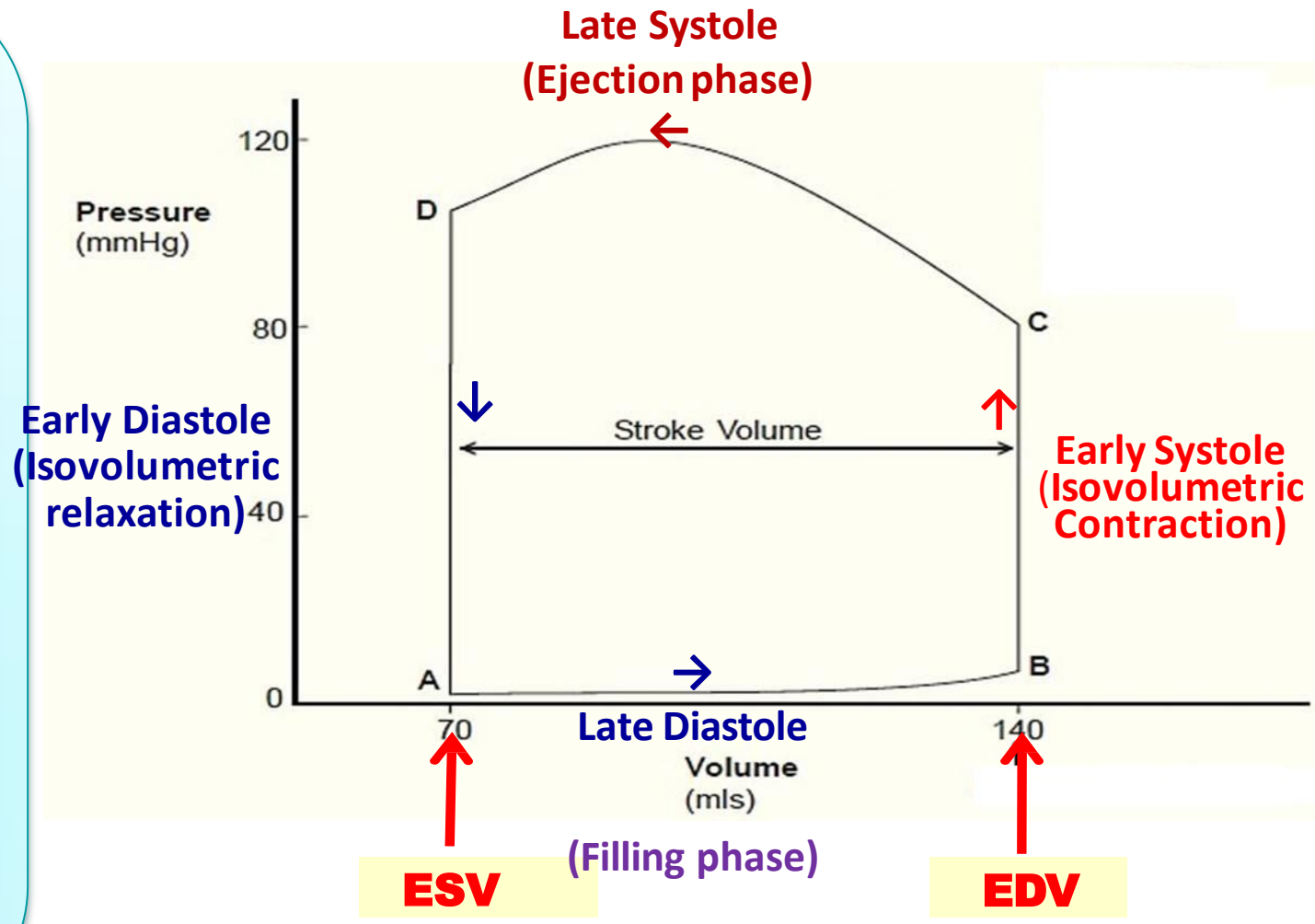
Ventricular Pressure - Volume Loop…..Cont

- ***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.

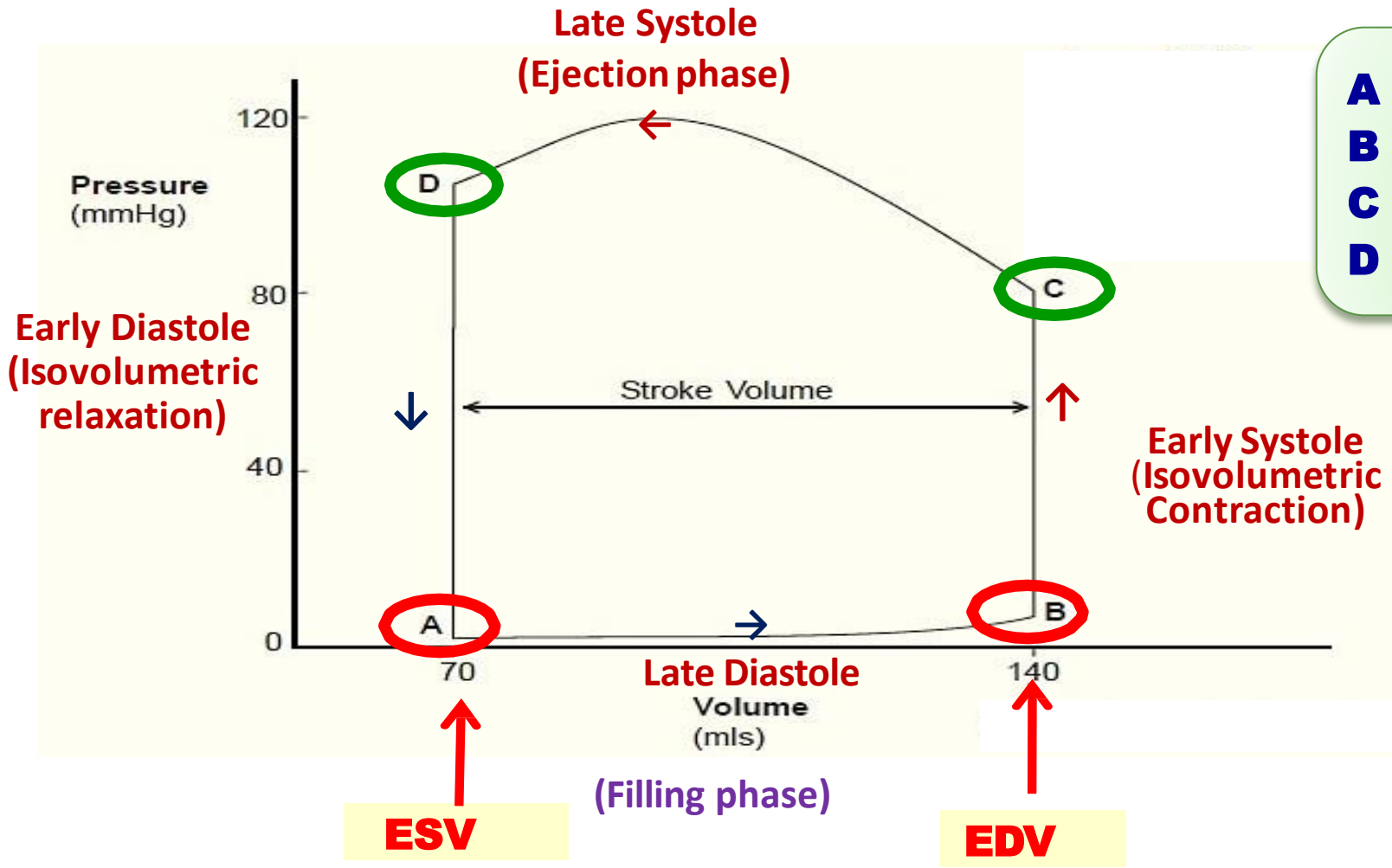


Ventricular Pressure - Volume Loop…..Cont

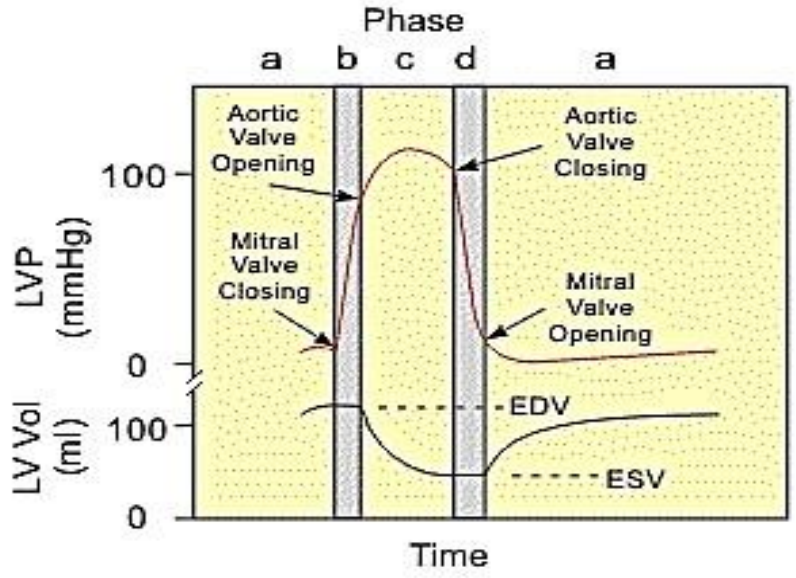
- ***Phase IV (Isovolumic relaxation phase):***
- At the end of ejection period (point D), the aortic valve closes
- Ventricular pressure falls back to the diastolic pressure level.
- The ventricle returns to its starting point (point A).



Ventricular Pressure - Volume Loop….Cont.

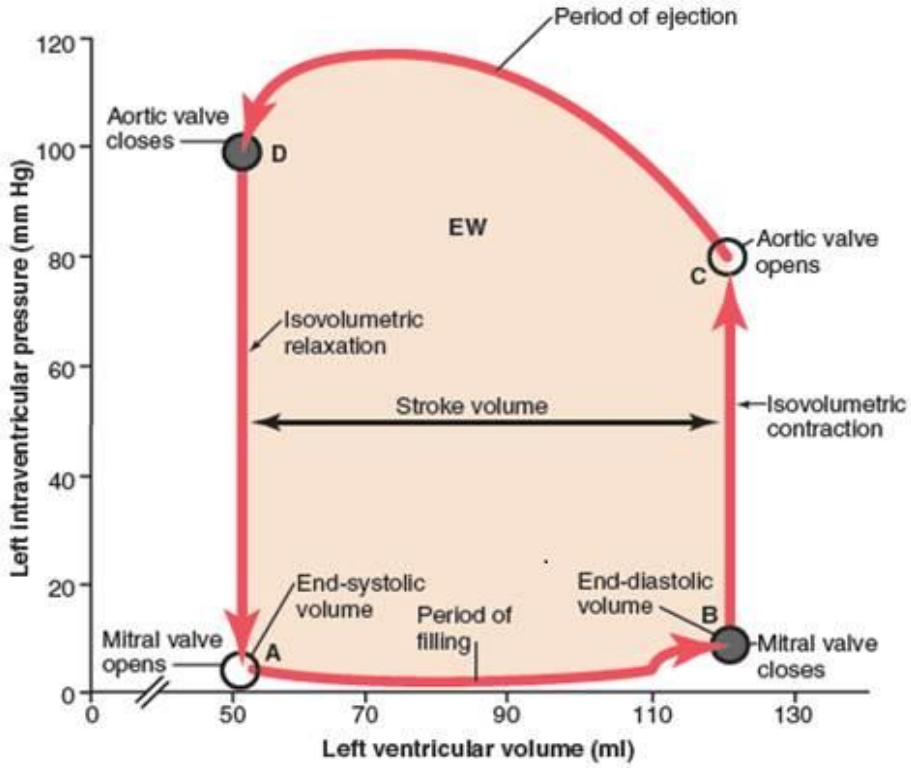


A – Mitral valve opens
B – Mitral valve closes
C – Aortic valve opens
D – Aortic valve closes



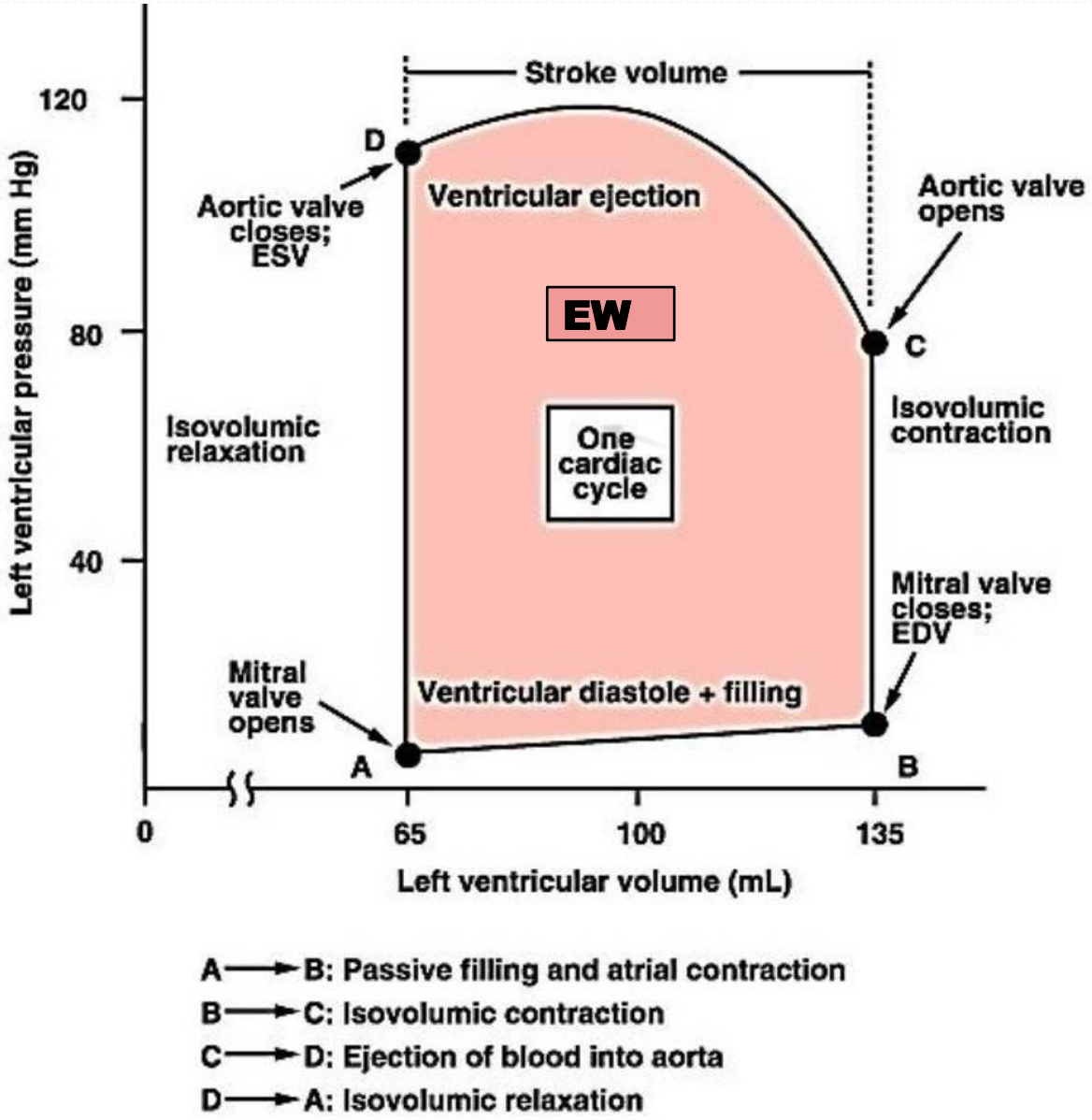
What you should remember about Pressure – Volume loop?

- 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 external work output 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.

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