Cardiovascular

(CVS)

By

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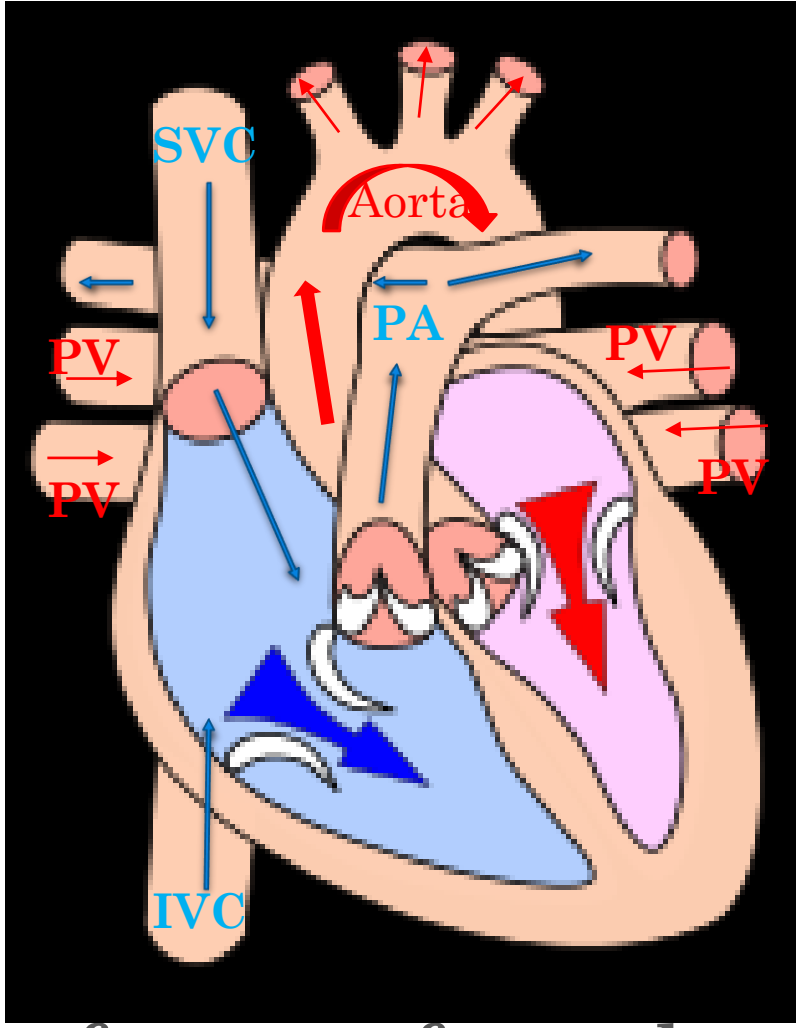
Cardiac cycle



- The period of time and sequence of events from the beginning of one beat to the beginning of the next one.
- Includes cardiac **Systole** and **Diastole**

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Duration of the cardiac cycle

- **During resting conditions:**
  - The HR is about 75 beats/min
  - Duration of the whole cardiac cycle is 0.8 sec:
  - Systole duration is 0.3 sec (1/3 cardiac cycle)
  - Diastole duration is 0.5 Sec (2/3 cardiac cycle)
- HR and cardiac cycle duration are inversely proportionate. The higher the HR is, the shorter the duration will be. The diastolic duration will be more shortened than that of Systole.

Duration of the cardiac cycle

HR	75 b/min	200 b/min
Duration of Cardiac cycle	0.8 sec	0.3 sec
Duration of ventricular systole	0.3 sec	0.15 sec
Duration of ventricular diastole	0.5 sec	0.15 sec

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Sequence of events during Cardiac cycle

1. Atrial systole (Late diastole)
2. Isometric or Isovolumetric contraction phase
3. Maximum ejection phase
4. Reduced ejection phase
5. Proto-diastolic phase
6. Isovolumetric relaxation phase
7. Rapid filling phase
8. Reduced filling phase

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Diastole 0.5 sec	Systole 0.3 sec
Proto-diastolic phase 0.04sec	Isovolumetric contraction 0.05 sec
Isovolumetric relaxation 0.06 sec	Maximum ejection 0.15 sec
Rapid filling 0.1 sec	Reduced ejection 0.1 sec
Reduced filling 0.2 sec (Mid- diastole)	
Atrial systole 0.1 sec (late diastole)	

During cardiac cycle phases we can record: DVP S ECG

1. Duration of each phase
2. Valves condition
3. Volume changes
4. Pressure changes
5. Heart sounds
6. ECG waves

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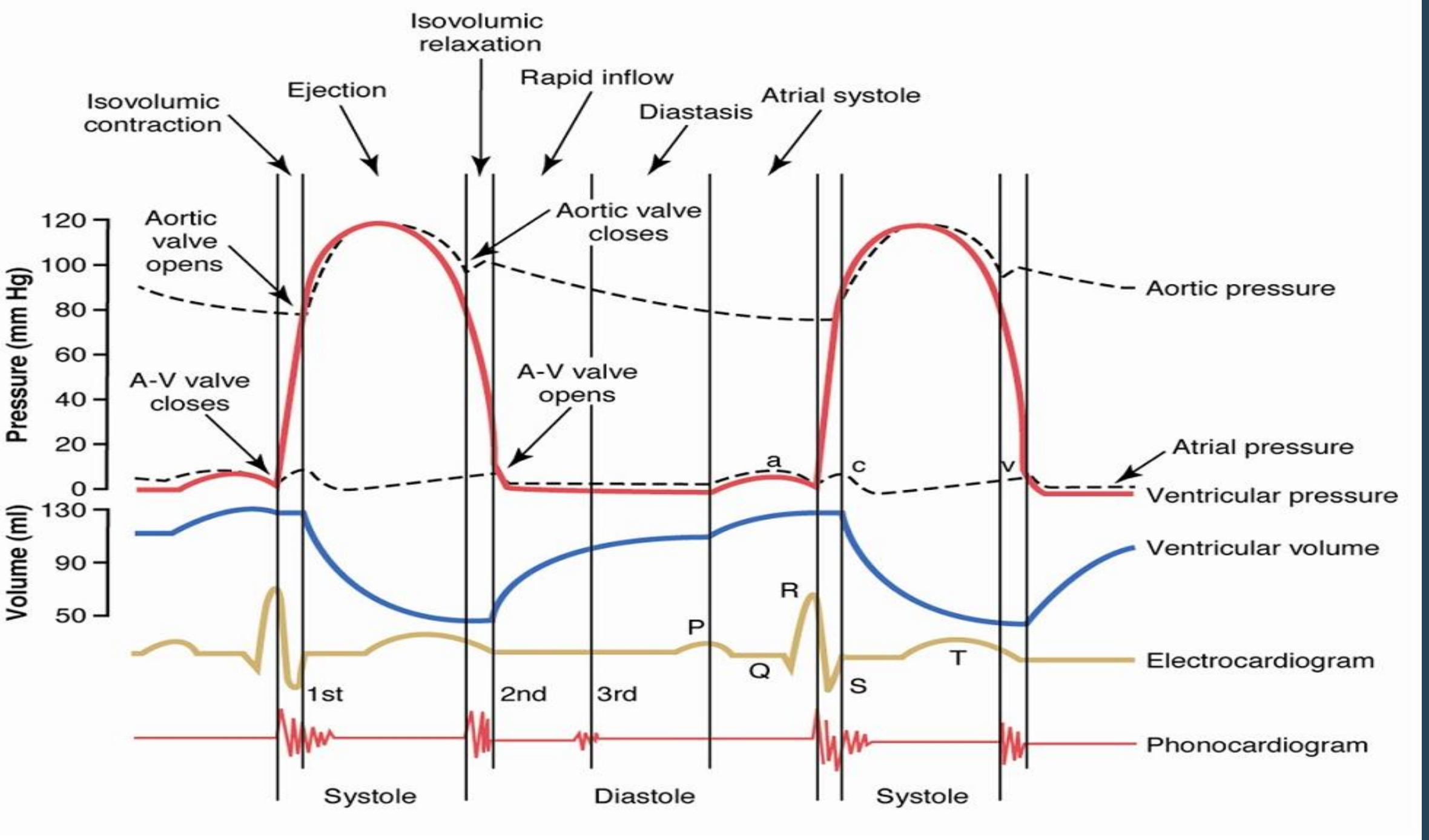

https://www.printablediagram.com/wp-content/uploads/2017/08/wiggers-diagram-cardiac-cycle.jpg

1. Atrial systole

- Duration: 0.1 sec
- When SAN discharges its impulse that spreads over both atria (atrial depolarization = P wave of ECG)
- Atrial contraction will follow leading to:

1. Increased intra-atrial pressure
2. 30% of the blood volume of venous return (VR) will be pumped to ventricles
3. Through opened AV valves and closed semilunar valves

1. Atrial systole

4. Aortic (80mmHg) and pulmonary (10mmHg) pressures decreased due to escape of the blood to the periphery

5. Ventricular volume increases

6. Intra-ventricular pressure increases minimally (Rt ventricle 4mmHg and Lt ventricle to 8 – 9 mmHg)

7. The volume of the ventricle at the end of the ventricular diastole is End Diastolic Volume (EDV)

8. 4^{th} heart sound: due to contraction of the atria and ejection of blood into the ventricles (it is faint and not heard normally by stethoscope.

2. Isovolumetric contraction phase:

- Duration: 0.05 sec
- Cardiac excitation wave spreads over both ventricles (ventricular depolarization = QRS complex of ECG)
- Ventricular contraction will follow leading to:

1. Rise of intraventricular pressure rapidly from 0 to 80mmHg in Lt ventricle and 10 mmHg in the Rt ventricle.

2. Isovolumetric contraction phase:

2. Closure of AV valves (due to increased ventricular pressure than intra-atrial pressure) while semilunar valves (pulmonary and aortic) are still closed (ventricles are closed chambers)

3. 1st heart sound due to closure of AV valves leading to turbulence of the blood flow.

4. Ventricular volumes remain constant

5. Intra atrial pressure rises slightly due to bulging of AV valves into the atria

3. Maximum ejection phase:

- Duration: 0.15 sec
- Ventricular systole leads to:

1. Increased intraventricular pressure exceeding that of aortic and pulmonary pressures respectively
2. Semilunar valves (aortic and pulmonary) opens and blood is rapidly ejected into aorta and pulmonary artery
3. AV valves are still closed

3. Maximum ejection phase:

4. Ventricular volumes decreases gradually

5. Increased aortic pressure up to 120 mmHg and pulmonary up to 25 mmHg

6. Decreased intra-atrial pressure due to contraction of papillary muscle leading to descent of AV valves and increase venous return (VR).

4. Reduced ejection phase

- Duration: 0.1 sec
- Less blood will be ejected
- Intraventricular pressure decreases gradually
- Volume of the ventricle decreases gradually
- Aortic and pulmonary pressure start to decrease
- Intra-atrial pressure is increasing due to accumulation of VR

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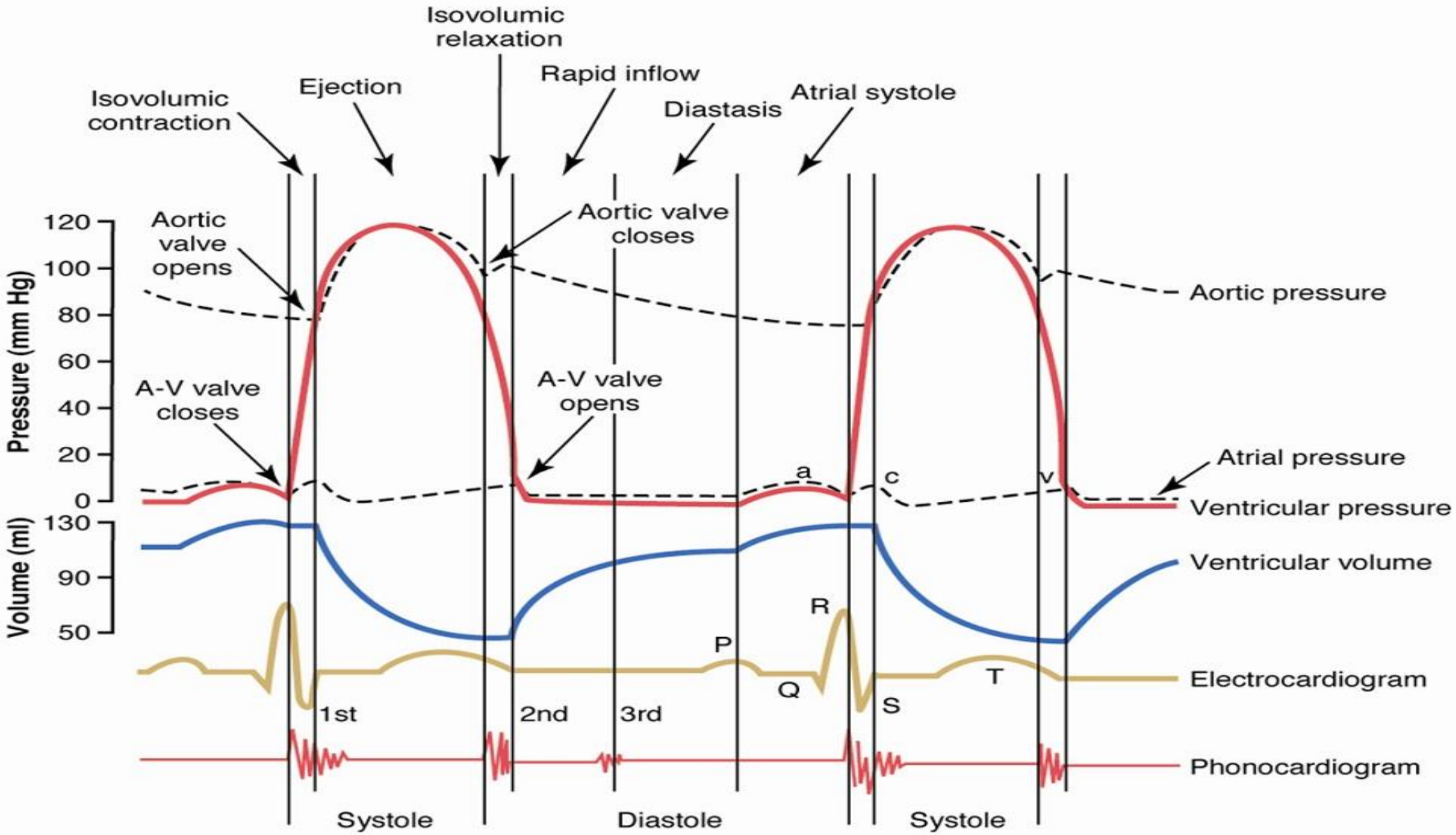
4. Reduced ejection phase

- Stroke volume (SV) = amount of the blood pumped by each ventricle per beat = 70 mL
- End systolic volume (ESV) = amount of the blood remain in the ventricle after the end of systole = 60 mL
- EDV = SV + ESV = 130 mL



5. Proto-diastolic phase

- Duration: 0.04 sec
- It is the period between the end of ventricular systole and beginning of closure of aortic and pulmonary valves
- Ventricular pressure decreases

6. Isovolumetric relaxation:

- Duration: 0.06 sec
- Ventricles start to relax leading to:

1. Intraventricular pressure decreases rapidly below aortic and pulmonary pressures leading to sudden closure of semilunar valves
2. 2nd heart sound: due to turbulence of blood as a result of closure of semilunar valves
3. AV valves are still closed

6. Isovolumetric relaxation:

4. Volume of the ventricle is the same (closed chamber)

5. Sharp fall in aortic pressure (incisure or diacrotic notch) followed by rise in aortic pressure (diacrotic wave) due to elastic recoil of aorta.

6. Atrial pressure is still increasing due to accumulation of VR

7. T-wave of ECG ends during this phase

7. Rapid filling phase

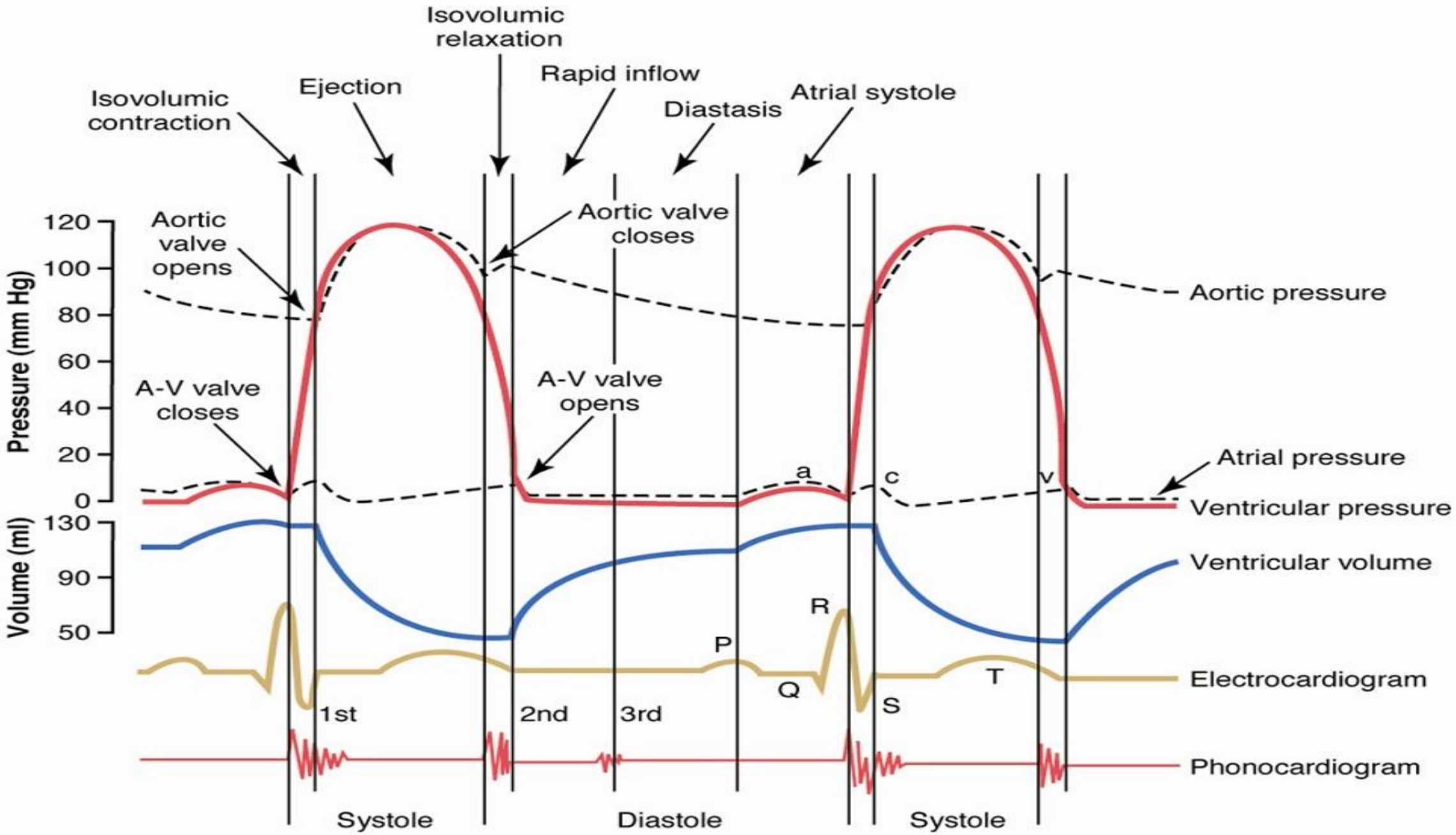
- Duration: 0.1 sec
- Intra-atrial pressure increases above ventricular pressure
- AV valves open while semilunar are closed
- Blood flows passively from atria to ventricles
- So, intra-atrial pressure slightly decreases

7. Rapid filling phase

- Aortic and pulmonary pressures decrease due to escape of blood to periphery
- Volume of ventricles increases rapidly
- 3rd heart sounds: due to flow of the blood in relaxed ventricles (faint and not heard normally by stethoscope)

8. Reduced filling phase

- Duration:0.2 sec
- AV valves are still open and semilunar valves are closed
- Blood continues to flow passively to the ventricles but at slower rate
- **Volume** of the ventricles increases gradually without increase in the pressure as they relax to accommodate the extra amount of blood coming to it
- Aortic and pulmonary pressures are still decreasing due to escape of blood to periphery



Cardiac cycle

- During Early and Mid-diastole, 70 – 75% of blood pass to the ventricle passively
- While, 30 – 25% of blood during atrial systole (late diastole)

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Comparison between Lt and Rt side heart pressures:

Pressure	During Systole	During Diastole
Lt ventricle	120 mmHg	0 mmHg
Aorta	120 mmHg	80 mmHg
Rt ventricle	25 mmHg	0 mmHg
Pulmonary artery	25 mmHg	10 mmHg

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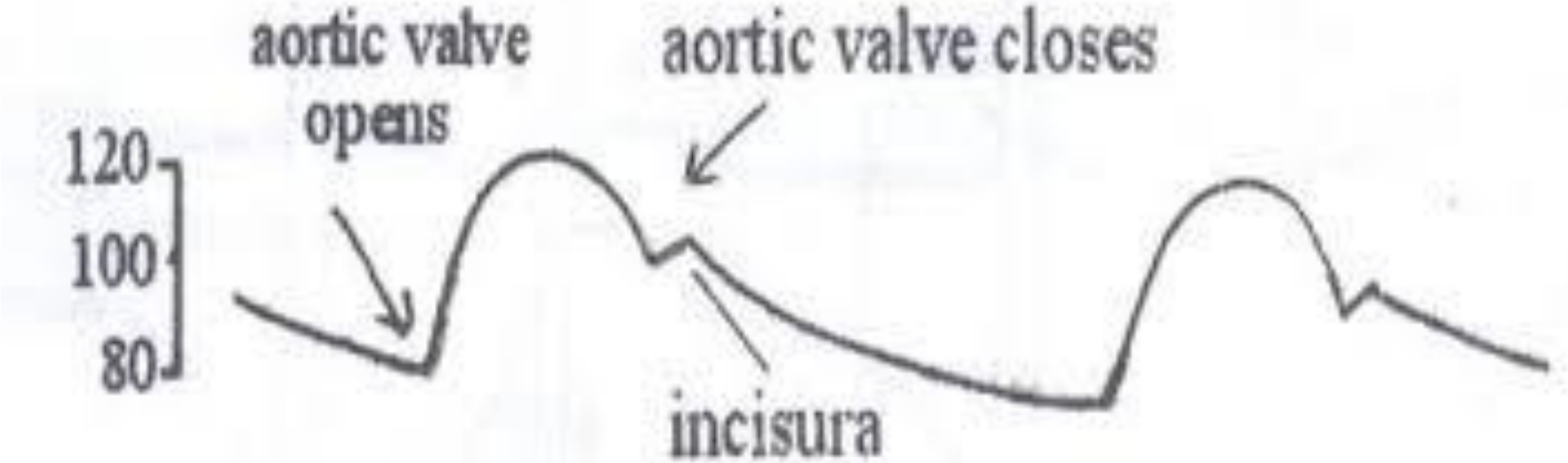
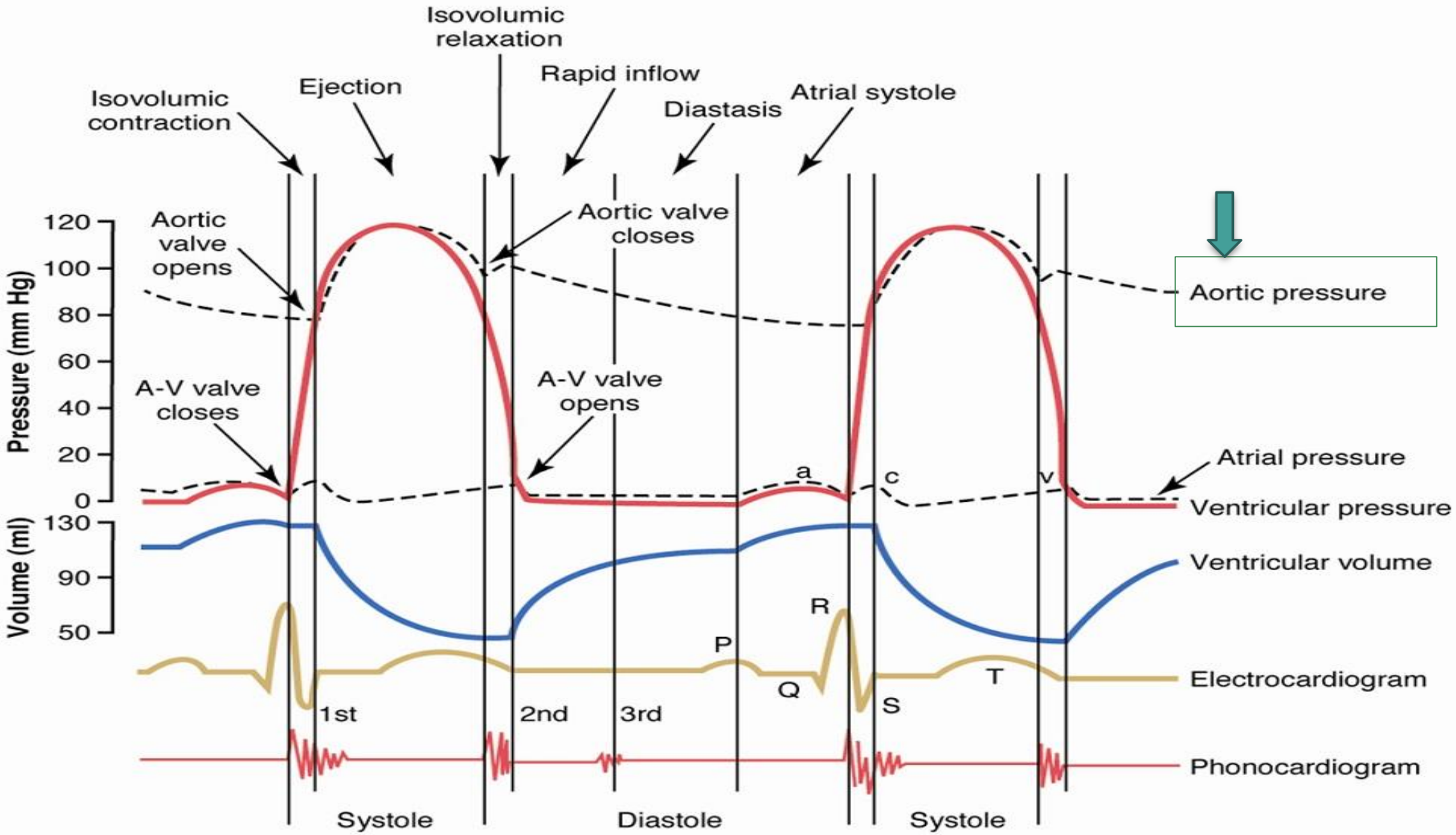
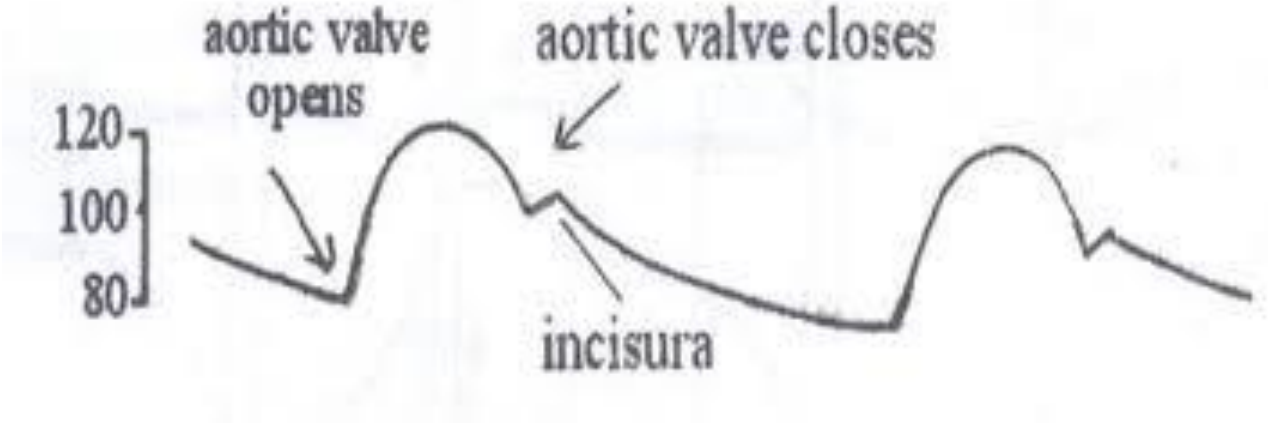


Aortic pressure curve

- It is formed of ascending **anacrotic limb** (upstroke) and descending **catacrotic limb** (down stroke)
- On the catacrotic limb there is **diacrotic notch (incisura)** and **diacrotic wave**

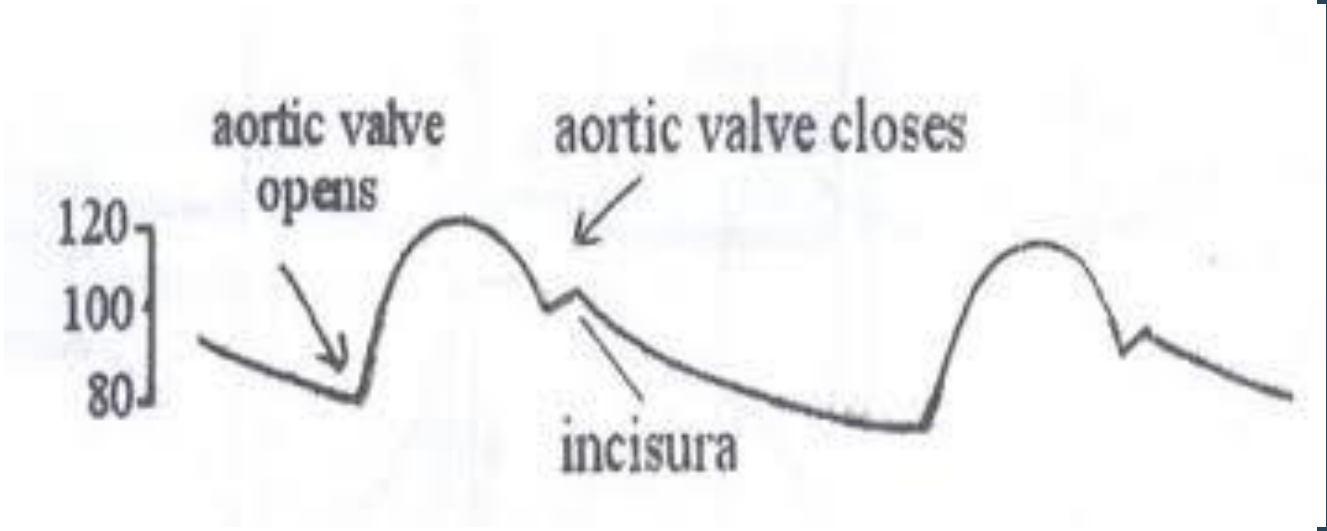


Anacrotic limb:



- Occurs during maximum ejection phase of Lt ventricle
- Pressure of the aorta increases reaching its max 120mmHg (systolic blood pressure) as blood coming to the aorta is more than that leaving it

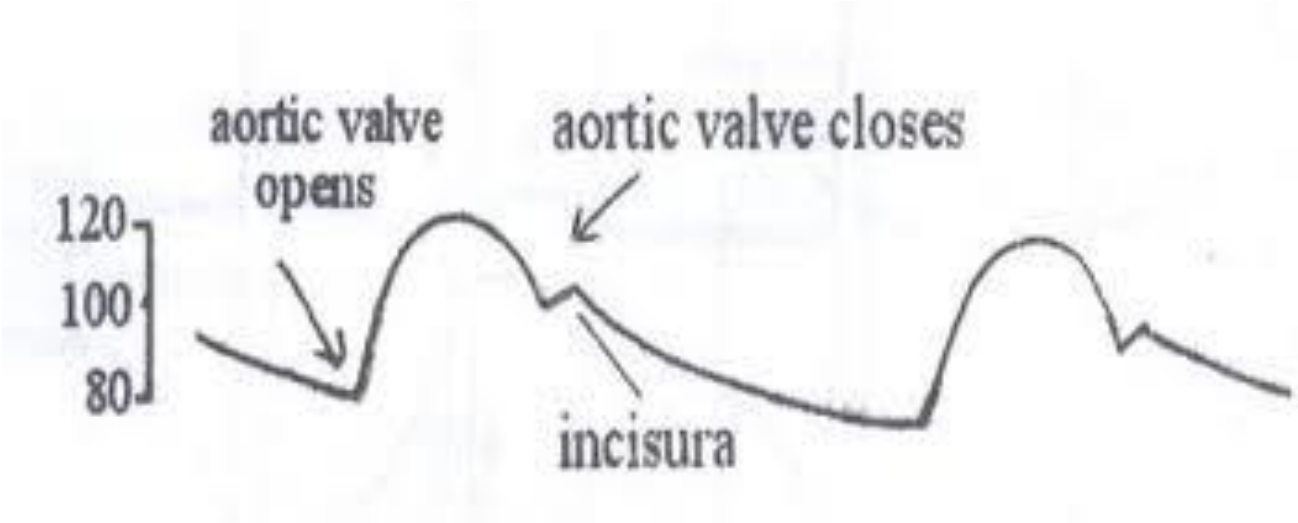
Catacrotic limb:



- Occurs during reduced ejection and proto-diastolic phases
- Pressure of aorta starts to decrease as blood coming to aorta is less than blood leaving.

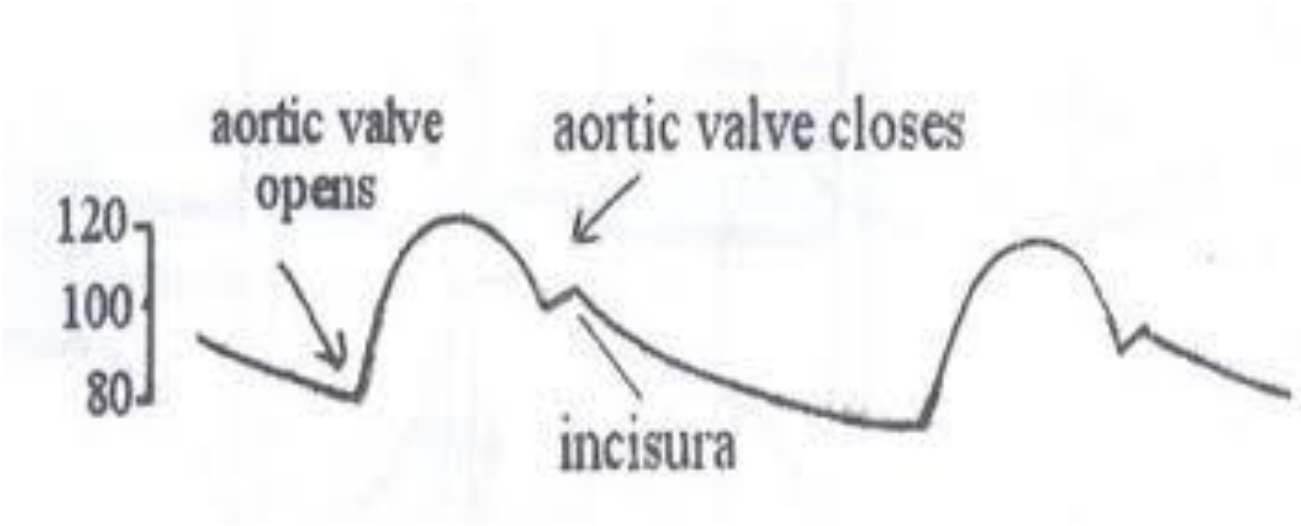
Diacrotic Notch (Incisura)

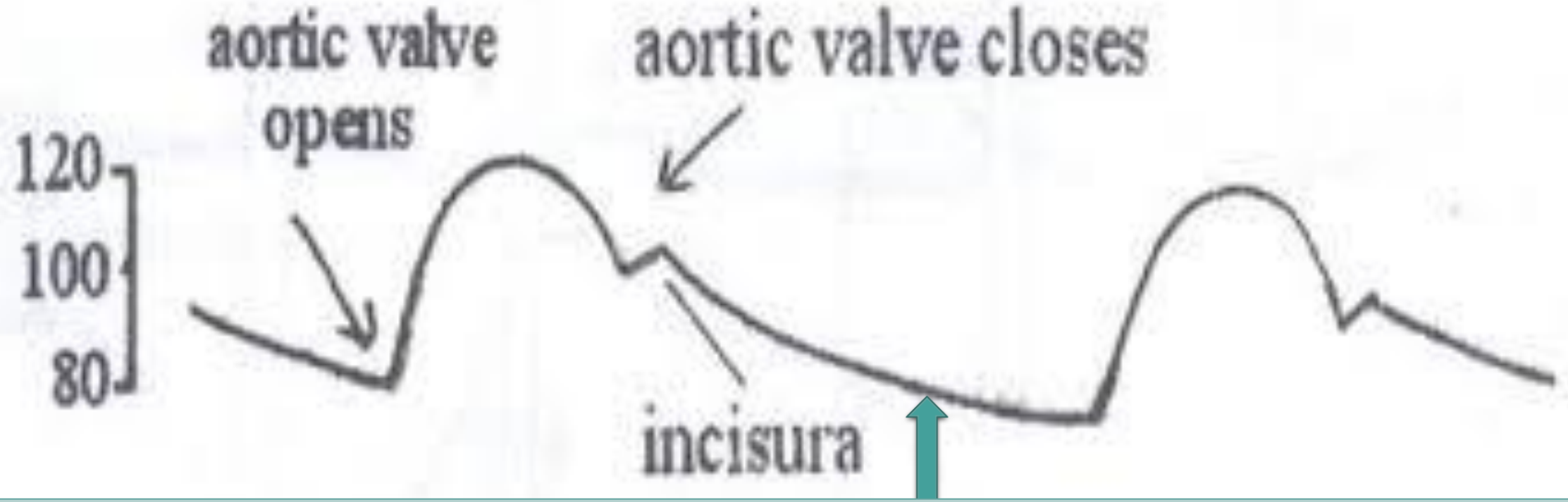
- Sharp small decrease in aortic pressure
- During Isovolumetric relaxation
- Due to sudden closure of the aortic valve behind blood flow tending to return back from aorta to the relaxed ventricle



Diacrotic Wave

- Rapidly follows diacrotic notch
- Due to rapid increase in aortic pressure
- This is because elastic recoil of the distending aorta increasing aortic pressure.



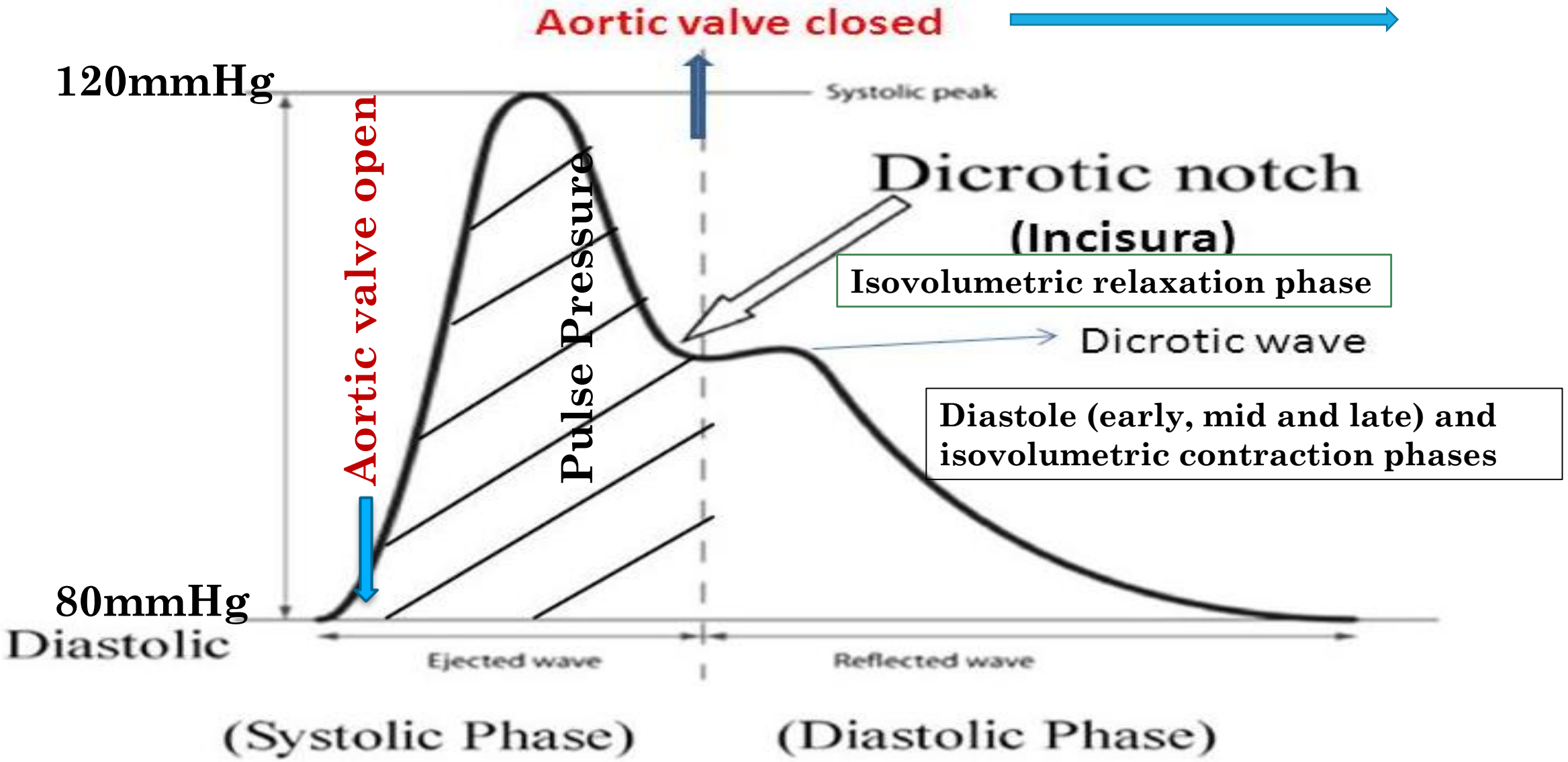


The remaining part of the catacrotic limb:

Aortic pressure starts to decrease gradually during early, mid, late diastole and Isovolumetric contraction phases reaching its minimum 80 mmHg (Diastolic blood pressure)

Dicrotic wave in aortic pressure curve

Rapid, reduced ejection and Protodiastolic Phases



Arterial pulse wave

- It is the transmission of aortic pressure wave as pulsation wave all over the arterial system
- It is similar in shape and causes to aortic pressure curve
- Can be recorded from superficial artery as radial artery

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Significance of radial pulse wave palpation:

1. Heart rate / minute
2. Cardiac Rhythm (regular or irregular)
3. Force of contraction (normal, strong or weak as in hemorrhage rapid week pulse)
4. Diagnosis of diseases
5. Detection of arterial wall state (cord-like in case of atherosclerosis)

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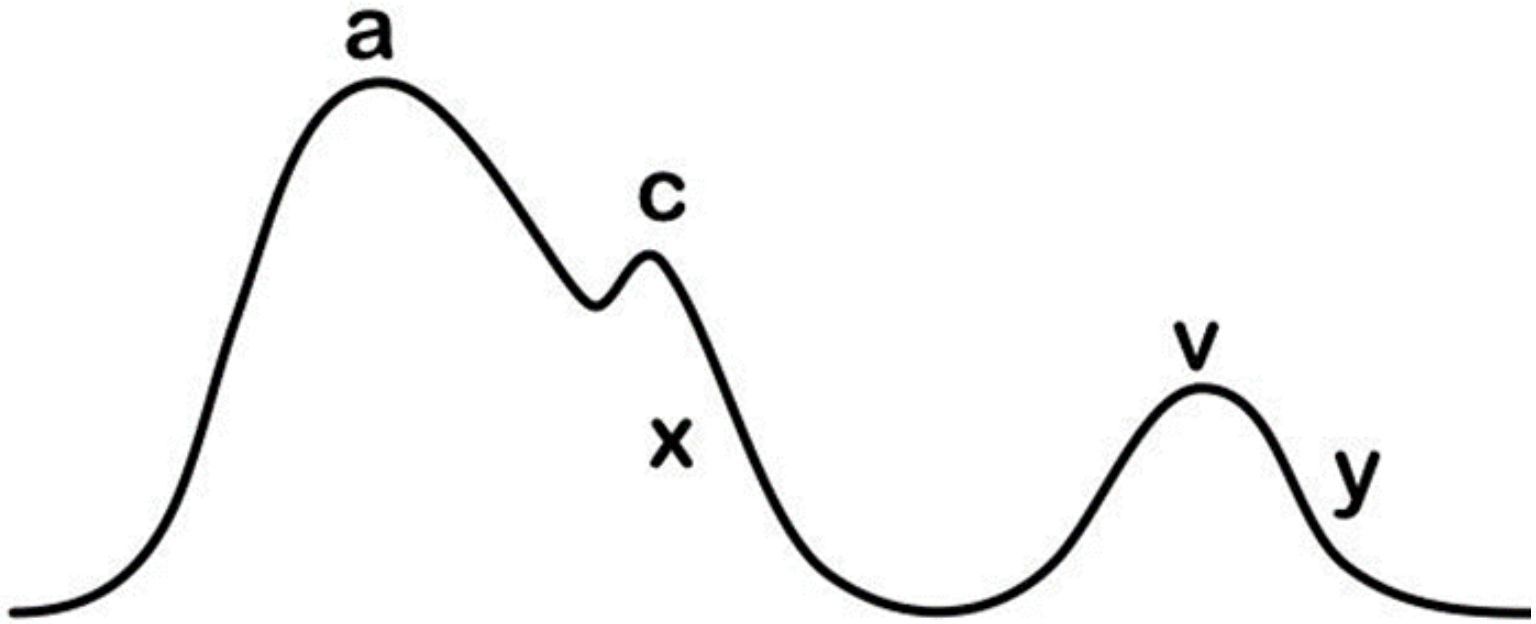
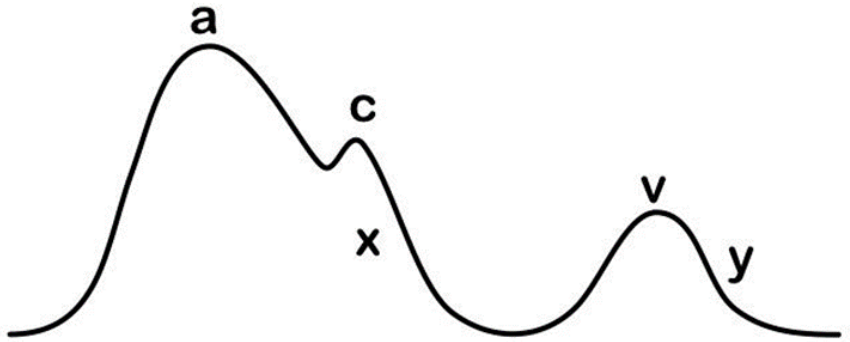
acv



Intra-atrial pressure curve

- It shows Rt atrial pressure changes that are transmitted directly to the superior and inferior venae cavae (SVC & IVC) and consequently to their branches because of absence of valves in between.
- So, right atrial pressure changes can be detected as the jugular venous pulse (JVP).

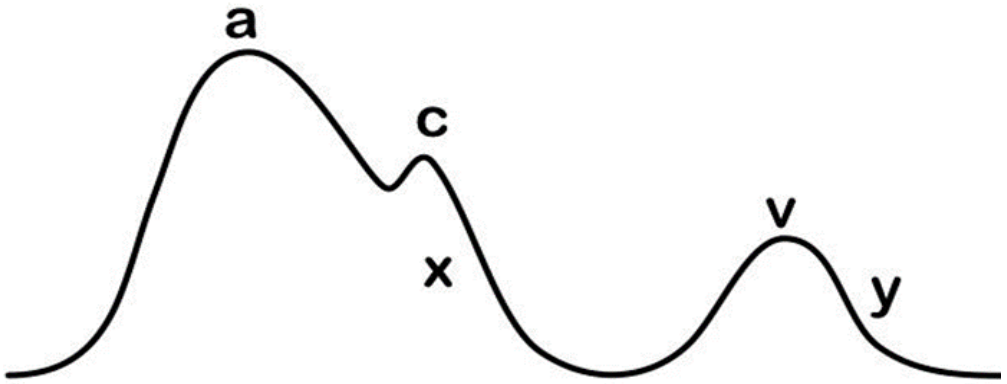
Rt atrial pressure curve



- **a wave:**

- Positive wave represents increased atrial pressure during atrial systole (late diastole).
- Negative part due to escape of blood to the ventricles
- Correlate to P-wave of ECG

Rt atrial pressure curve



- **c wave:**

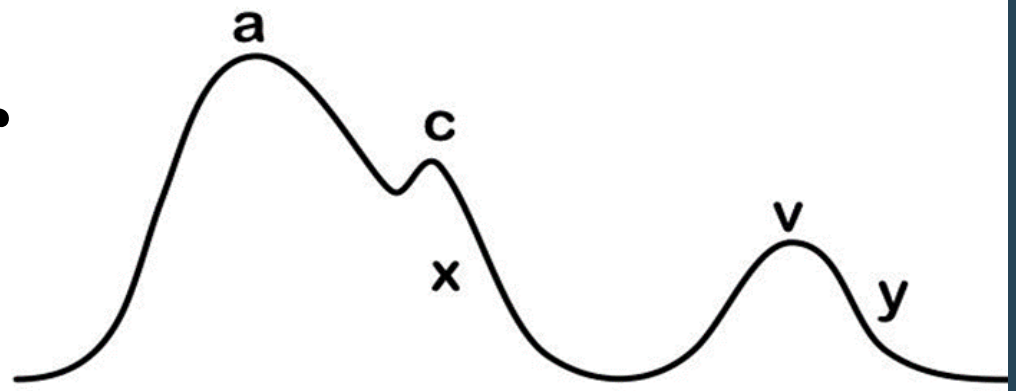
➢Small positive wave represents increased atrial pressure during the Isovolumetric contraction of the ventricles due to bulging of AV valves

The atrial volume decreases and its pressure increases

Correlates with the end of QRS of ECG

➢Negative c wave is sharp that occur at the beginning of maximum ejection phase due to downward descent of AV ring increasing the volume of atria and decreasing its pressure

Rt atrial pressure cur



- **x wave:**

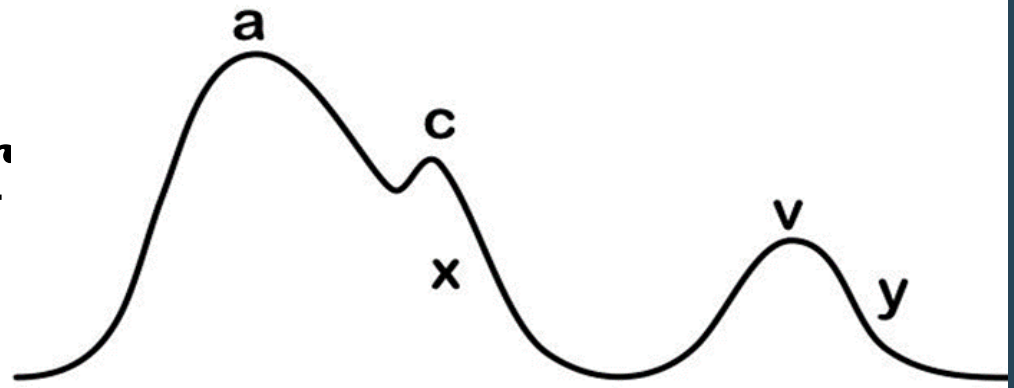
It shows the decreased atrial pressure due to contraction of the papillary muscles and descent of the cusps during the rapid ejection.

Occurs before T- wave of ECG

- **v wave:**

Its positive part represents gradual increased atrial pressure due to accumulation of venous return during atrial relaxation.

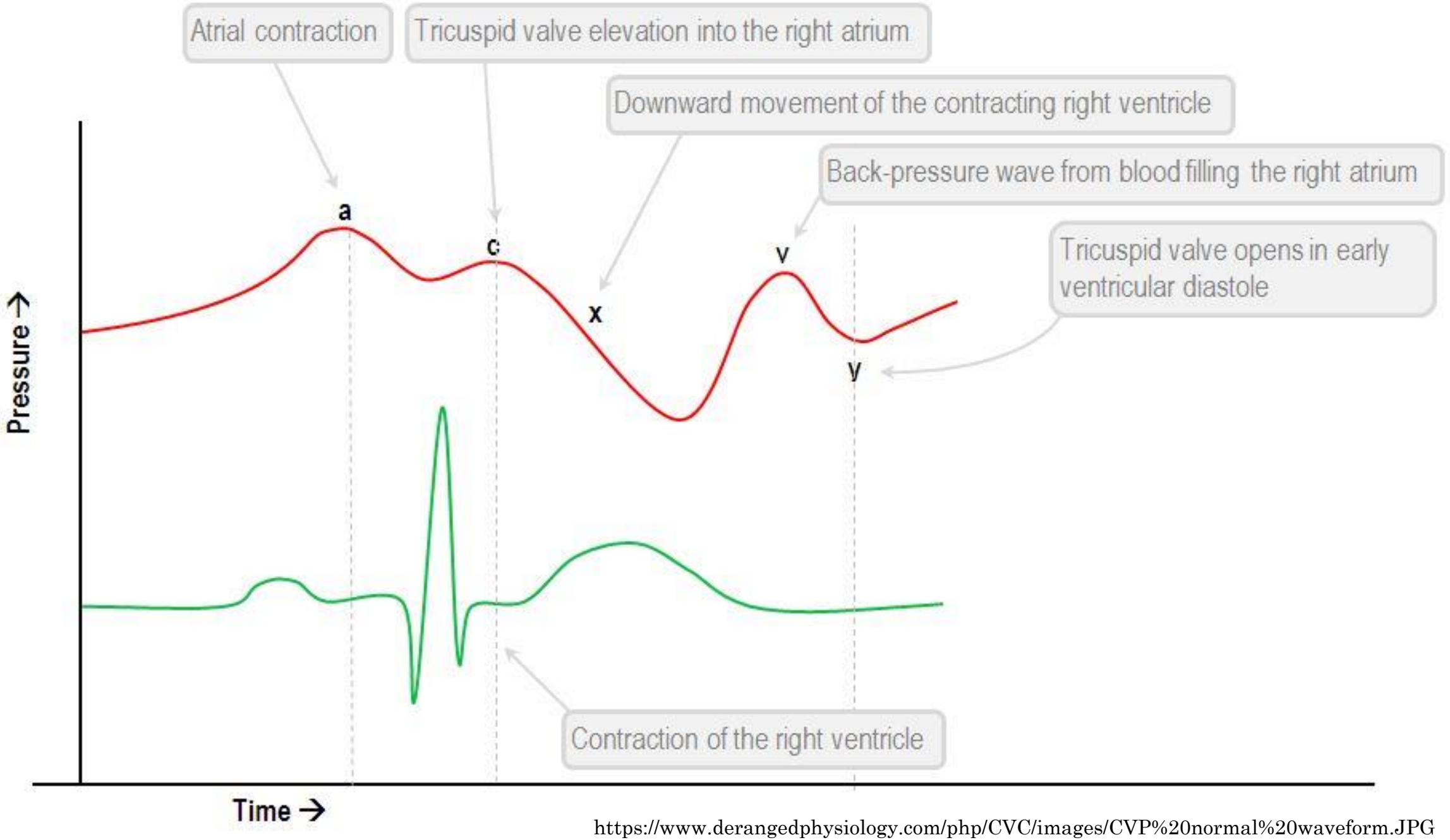
Rt atrial pressure cur



- **y wave:**

It shows sharp decrease in atrial pressure due to opening of tricuspid valve and rapid flow of blood to the right ventricle during ventricular rapid and reduced filling.

It occurs before P wave of ECG



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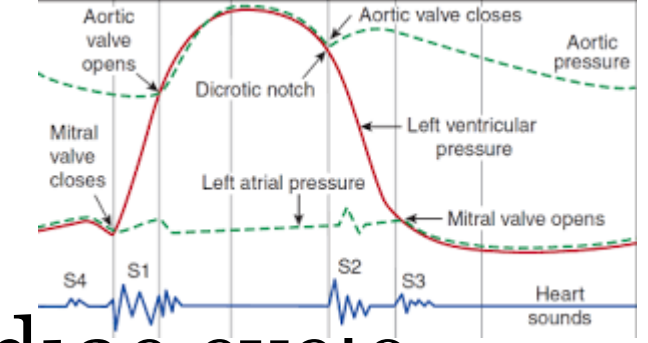
Heart sounds



- 4 heart sounds occur during the cardiac cycle.
- Normally, the 1st and 2nd heart sounds can be heard by stethoscope but not the 3rd and 4th heart sounds.
- Heart sounds occur either due to:

1- Closure of the cardiac valves that leads to brief vibration which is transmitted through blood to the cardiac wall then to the chest wall.

Or

2- Rapid turbulent blood flow through the opened valves.

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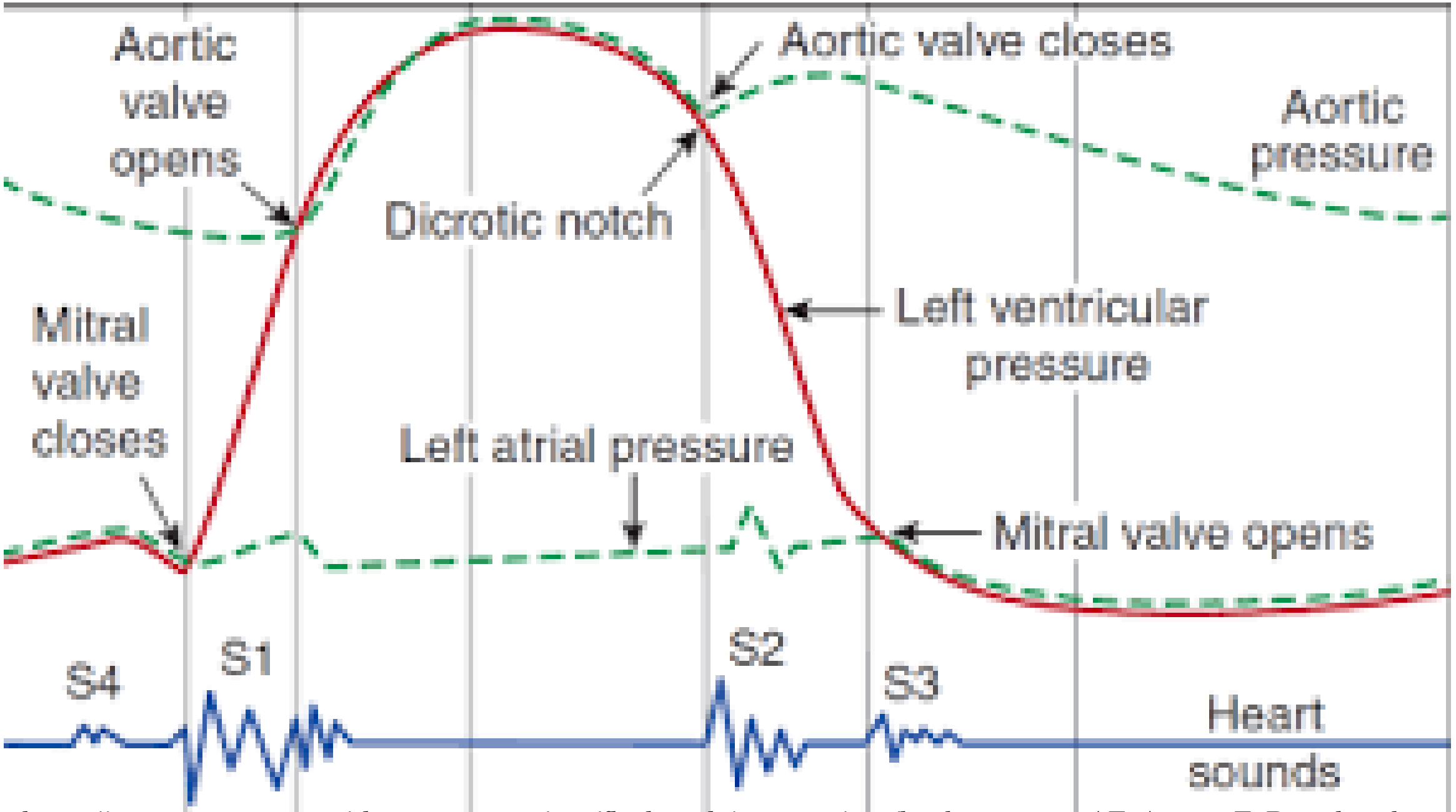

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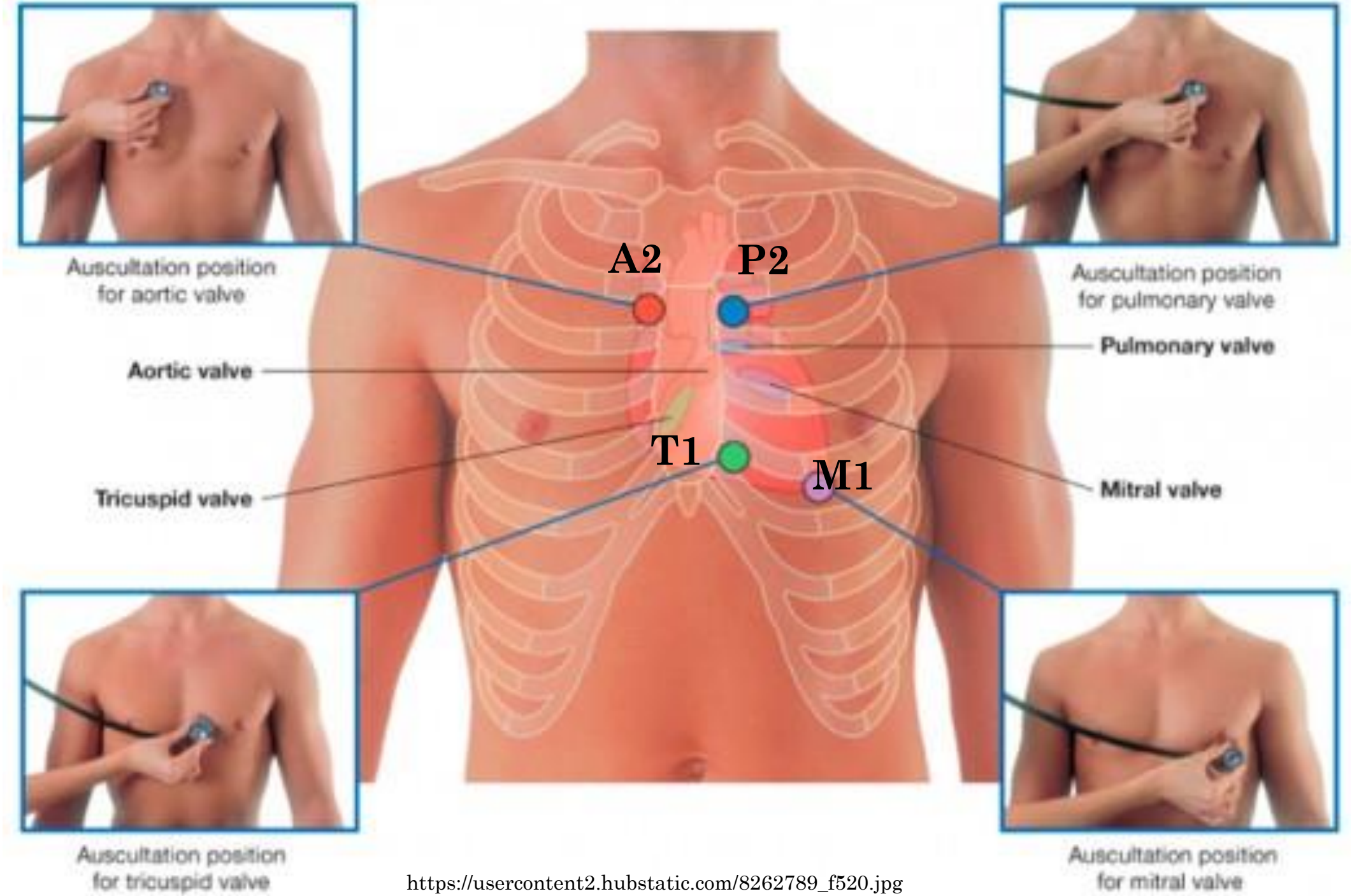
First heart sound (S1): LUPP

- Due to the vibration occurred as result of closure of AV valves (Mitral and Tricuspid) at the beginning of phase 2 of cardiac cycle (Isovolumetric contraction).
- It is soft, low pitched with long duration (0.15 sec)
- It is composed of two components:
- Mitral component which is best heard over the apex of the heart (5^{th} left intercostal space at the midclavicular line).
- Tricuspid component which is best heard at the lower end of the sternum (left sternal edge).

Second heart sound (S2): DUPP

- Due to the vibration occurred as result of closure of semilunar valves (aortic and pulmonary) at the beginning of phase 6 of cardiac cycle (Isovolumetric relaxation).
- It is harsh, high pitched, & has short duration (0.12sec).
- It is composed of two components:
  - Aortic component which is best heard at 2nd Rt intercostal space parasternal
  - Pulmonary component is best heard at 2nd Lt intercostal space parasternal.
- Normally, the aortic valve closes earlier than the pulmonary valve because the left ventricular ejection period ends before that of the right ventricle. (A_2 P_2)



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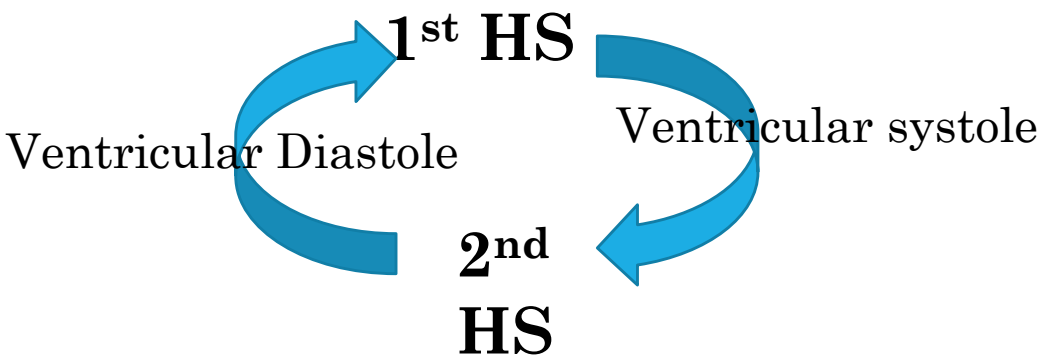
Third heart sound:

- It occurs due to rapid flow of blood from atria to ventricles during rapid filling phase and vibration of the ventricles
- Normally, it can be heard in children, but it is nonaudible in adults

Fourth heart sound:

- It occurs du to rapid flow of blood from atria to ventricles during atrial systole phase
- It is very faint to be heard by the stethoscope.

HS



Damaged valves → **Murmurs (abnormal HS)**

- **Stenosis (Cannot open properly)**
- **Regurgitation (Cannot close properly)**

- **Systolic murmur** Occurs bet. 1st & 2nd HS
- **Diastolic murmur** Occurs bet. 2nd & 1st HS


Thank
You