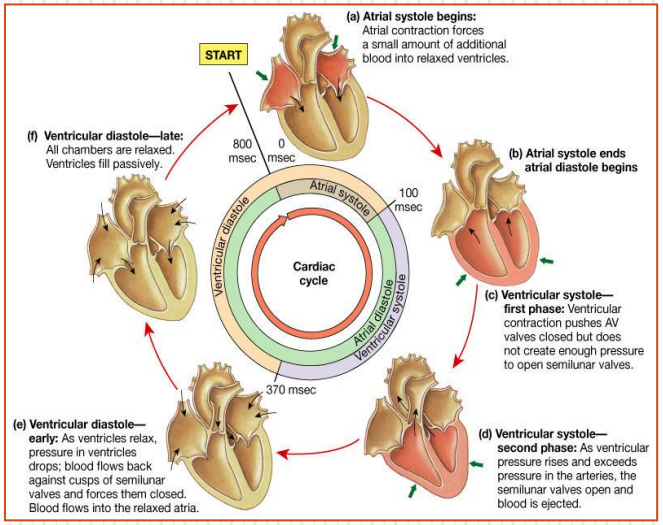
# Cardiovascular Physiology
# The Cardiac Cycle
# Fall 2019-2020

## Part 7-8

## Dr. Khalid Maseer



# The cardiac cycle

- In the normal heart, cardiac activity is repeated in a **regular cyclical manner.**

- The atria and ventricles alternately contract and relax, forcing blood from areas of higher pressure to areas of lower pressure. As a chamber of the heart contracts, blood pressure within it increases.

- A single cardiac cycle consists of **systole and diastole of the atria** plus **systole and diastole of the ventricles**.
  - ✓ Systole - muscle stimulated by action potential and contracting
  - ✓ Diastole - muscle reestablishing $Na^{+}/K^{+}/Ca^{++}$ gradient and is relaxing

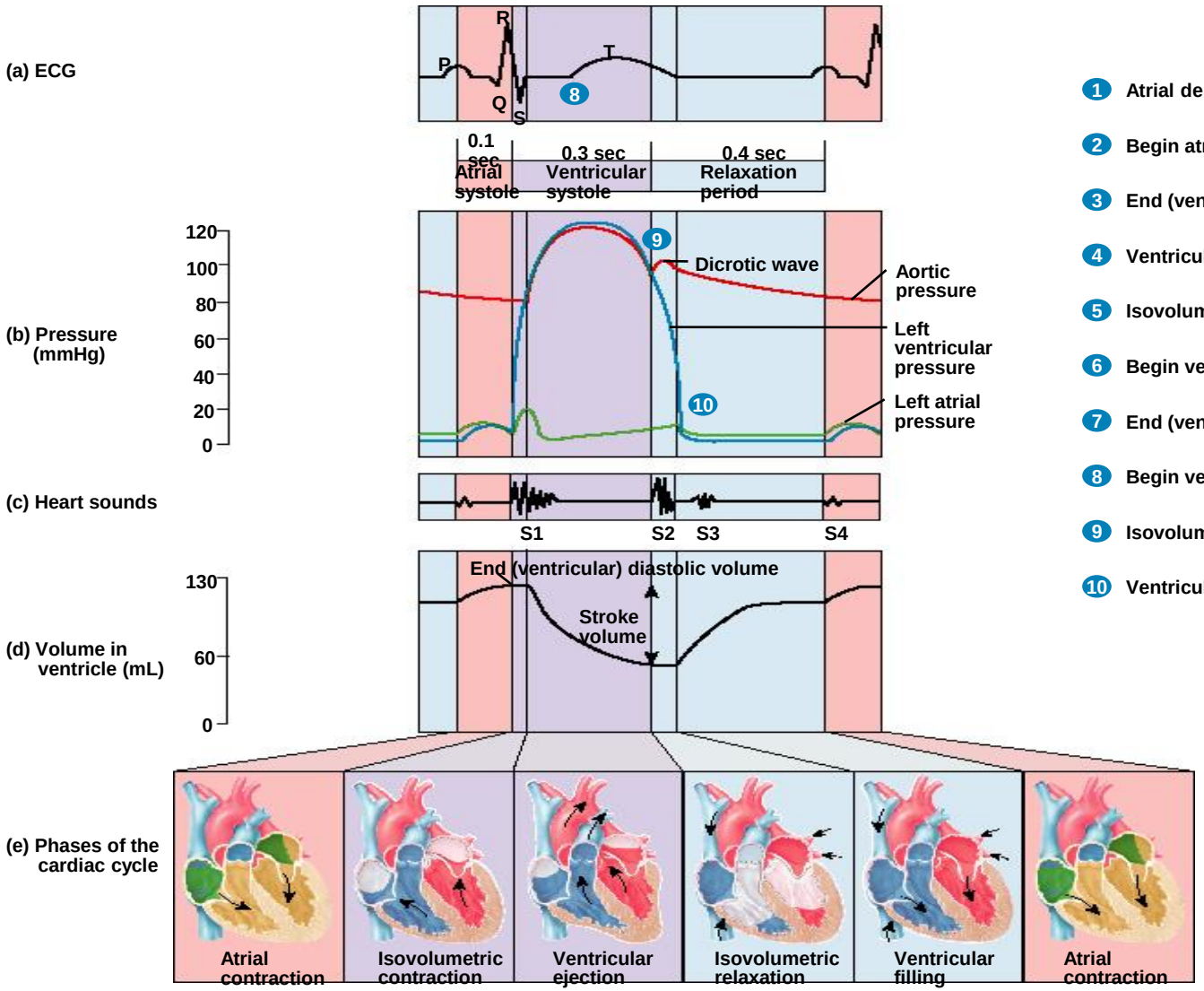
# The cardiac cycle

- With a resting heart rate of 75 beats/min, the duration of each cardiac cycle is **0.8 second**. During which we have the following phases:

1. **Atrial systole,**
2. **Ventricular systole, then**
3. **Diastole of the whole heart**

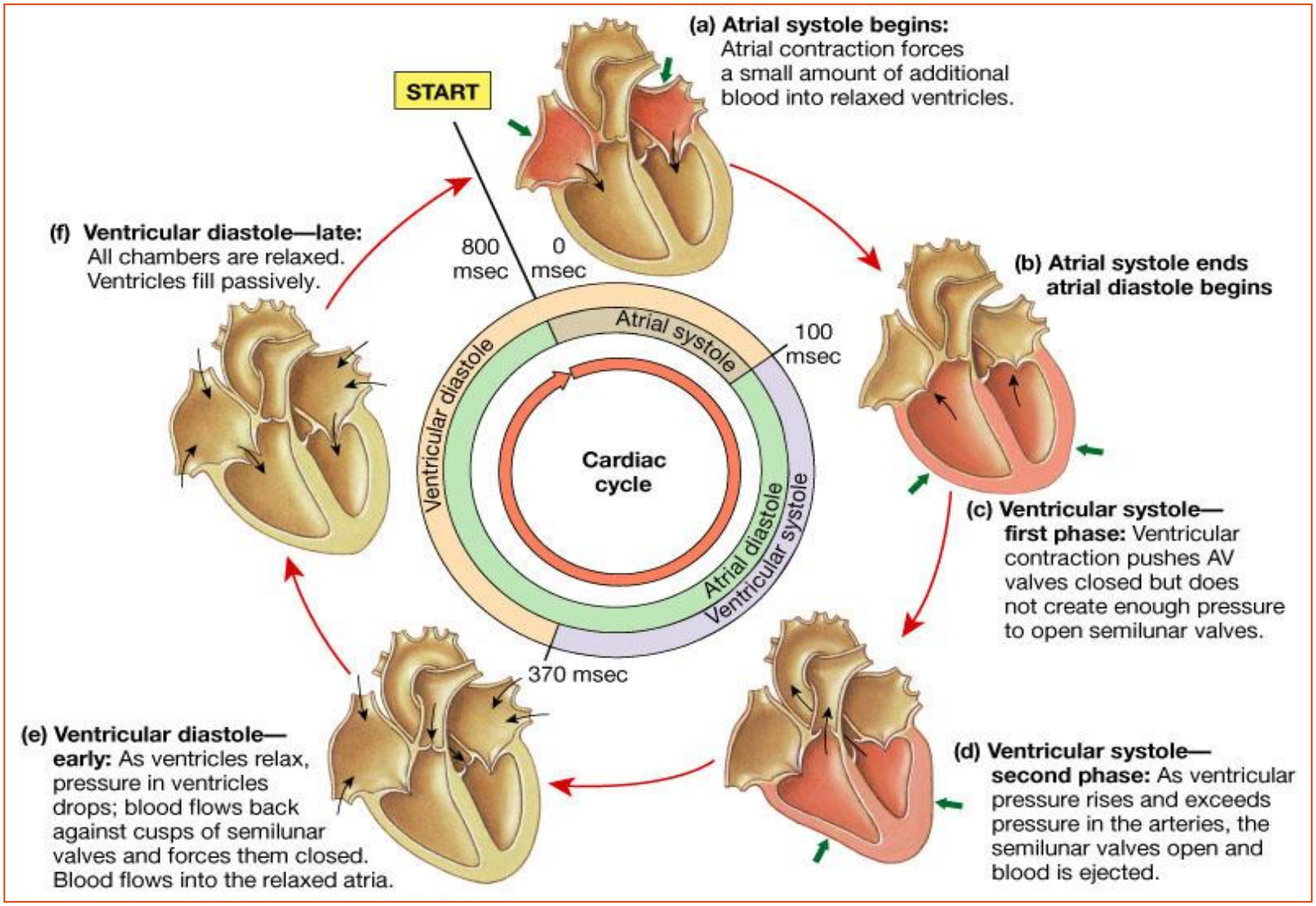
✓ Atrial and ventricular systoles do not occur at the same time, but their diastoles occur at the same time during the diastole of the whole heart.

# The cardiac cycle



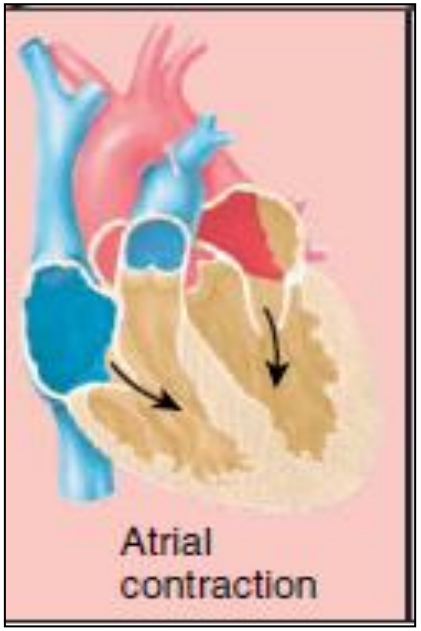

1. Atrial depolarization
2. Begin atrial systole
3. End (ventricular) diastolic volume
4. Ventricular depolarization
5. Isovolumetric contraction
6. Begin ventricular ejection
7. End (ventricular) systolic volume
8. Begin ventricular repolarization
9. Isovolumetric relaxation
10. Ventricular filling

# The cardiac cycle



# Atrial systole

- During **atrial systole**, which lasts about **0.1 sec**, the atria are contracting.
- At the same time, the ventricles are relaxed.




1. Depolarization of the SA node causes atrial depolarization, marked by the **P wave** in the ECG.

2. Atrial depolarization causes atrial systole. As the **atria contract**, they exert pressure on the blood within, which forces blood through the **open AV valves** into the ventricles.

# Atrial systole

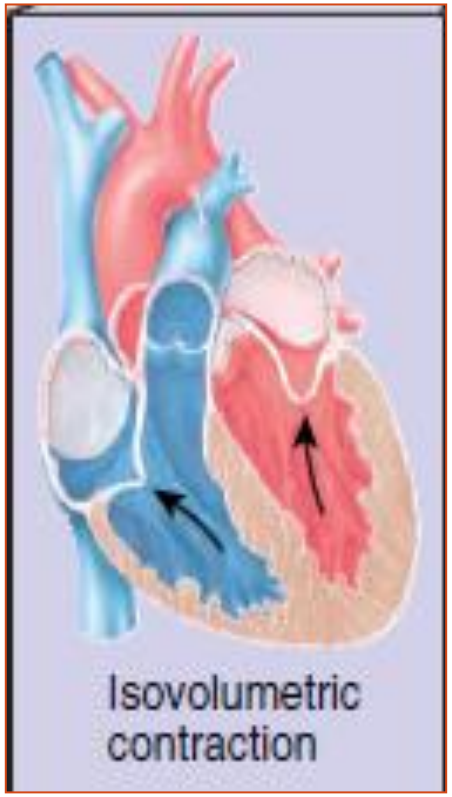
3. Atrial systole contributes a final 25 mL of blood to the volume already in each ventricle (about 105 mL).

- The end of atrial systole is also the end of ventricular diastole (relaxation). Thus, each ventricle contains about 130 mL at the end of its relaxation period (diastole). This blood volume is called the **end-diastolic volume (EDV)**.

4. The **QRS complex** in the ECG marks the onset of ventricular depolarization.

# Ventricular systole

- During **ventricular systole**, which lasts about **0.3 sec**, the ventricles are contracting.
- At the same time, the atria are relaxed in atrial diastole.




5. Ventricular depolarization causes ventricular systole. As ventricular systole begins, pressure rises inside the ventricles and pushes blood up against the atrioventricular (AV) valves, forcing them shut within **0.05 sec**. Because all four valves are closed, ventricular volume remains the same (isovolumic). This **early phase** of ventricular systole is called **isovolumetric contraction.**

# Ventricular systole

6. Continued contraction of the ventricles causes pressure inside the chambers to rise sharply, above the pressure of aorta and pulmonary trunk.


- Then both **SL valves open** and **ventricular ejection** (**late phase** of ventricular systole) occur which lasts for about **0.25 sec**.

# Ventricular systole

7. The left ventricle ejects about 70 mL of blood into the aorta and the right ventricle ejects the same volume of blood into the pulmonary trunk.
   - ✓ The volume remaining in each ventricle at the end of systole, about 60 mL, is the **end-systolic volume (ESV).**
   - ✓ **Stroke volume**, the volume ejected per beat from each ventricle, equals end-diastolic volume minus end-systolic volume: SV= EDV-ESV. At rest, the stroke volume is about 130 mL- 60 mL= 70 mL (a little more than 2 oz).

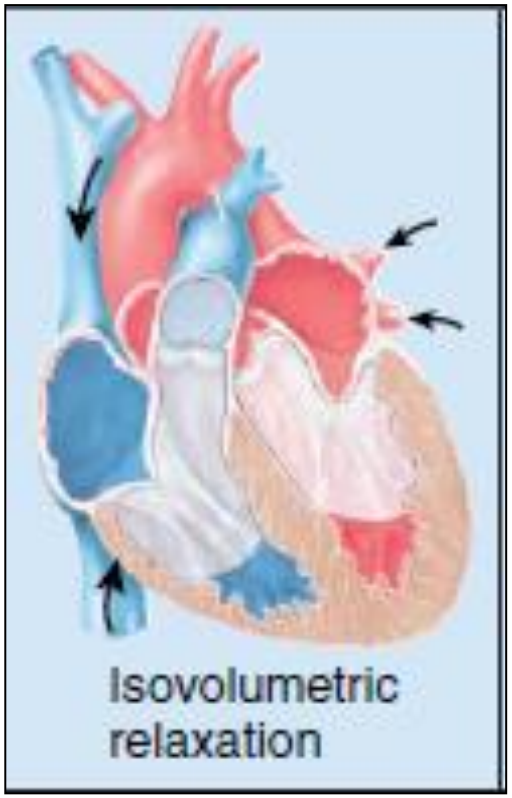
8. The **T wave** in the ECG marks the onset of ventricular repolarization.

# Relaxation Period

- During the **relaxation period**, which lasts about **0.4 sec**, the atria and the ventricles are both relaxed.
- As the heart beats faster and faster, the relaxation period becomes shorter and shorter, whereas the durations of atrial systole and ventricular systole shorten only slightly.

# Relaxation Period

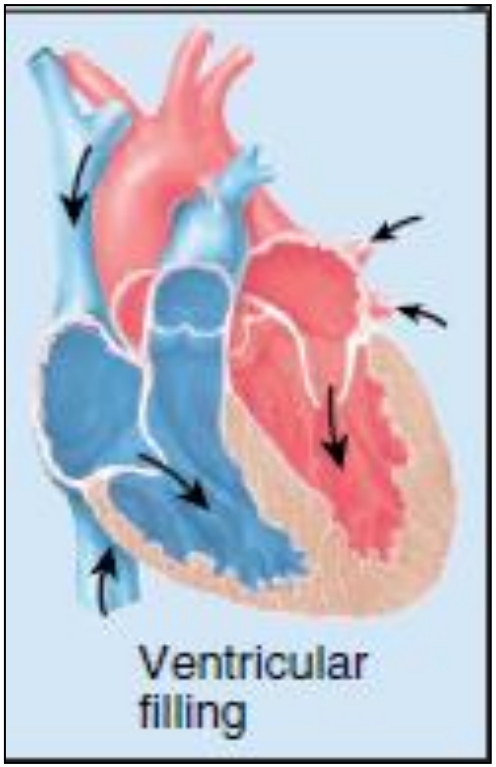
9. Ventricular repolarization causes **ventricular diastole**. As the ventricles relax, pressure within the chambers falls.




- This will cause a backflow movement of blood toward the regions of lower pressure in the ventricles, and consequently SL valves will close.
- After the SL valves close, there is a brief interval when ventricular blood volume does not change because all four valves are closed. This is the period of **isovolumetric relaxation** (**early phase**).

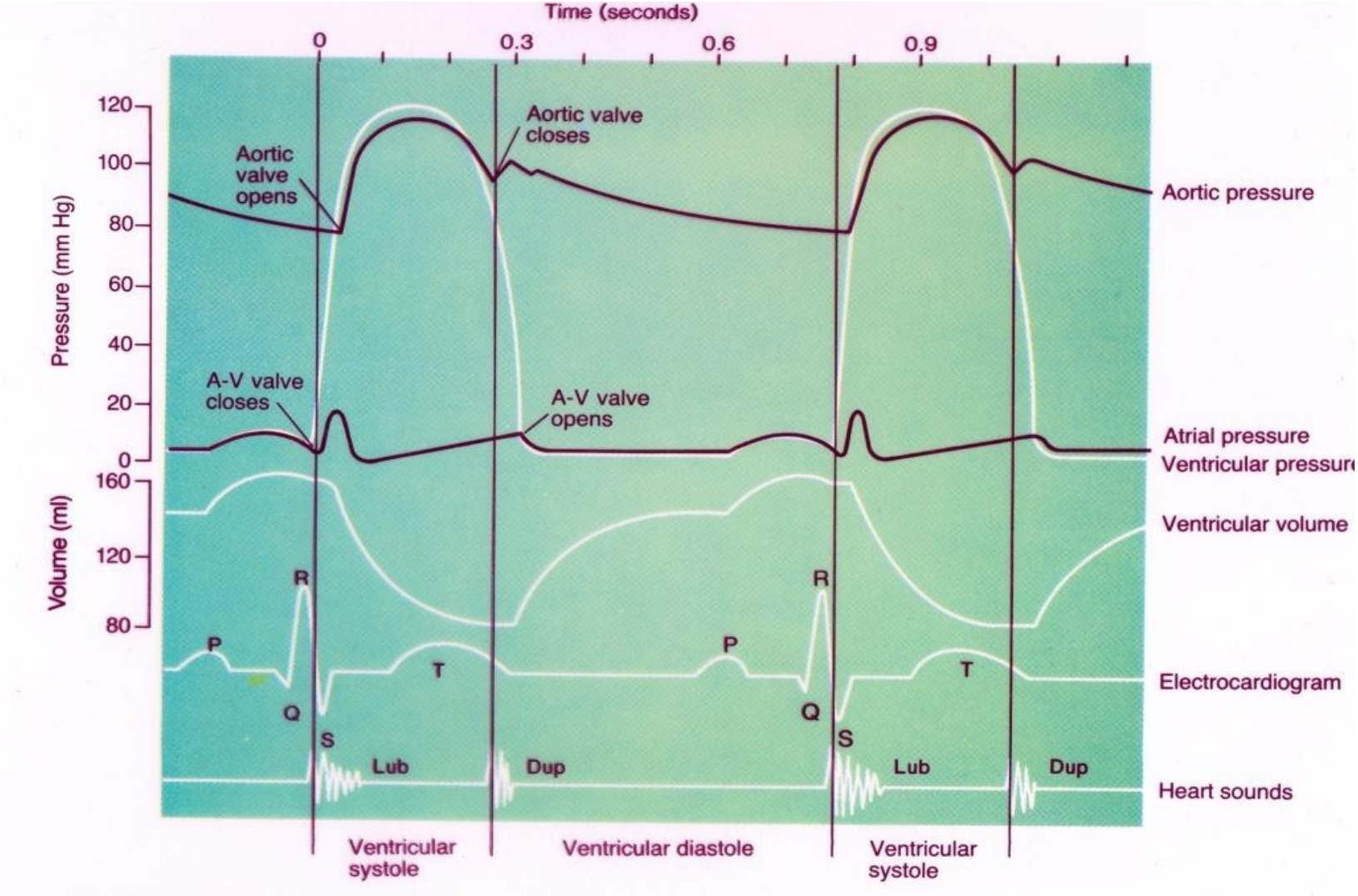
# Relaxation Period

10. As the ventricles continue to relax, the pressure falls quickly. When ventricular pressure drops below atrial pressure, the AV valves open, and **ventricular filling** (**late phase**) begins, where blood rushes rapidly into the ventricles.




- At the end of the relaxation period, the ventricles are about three-quarters full. The **P wave** appears in the ECG, signaling the start of another cardiac cycle.

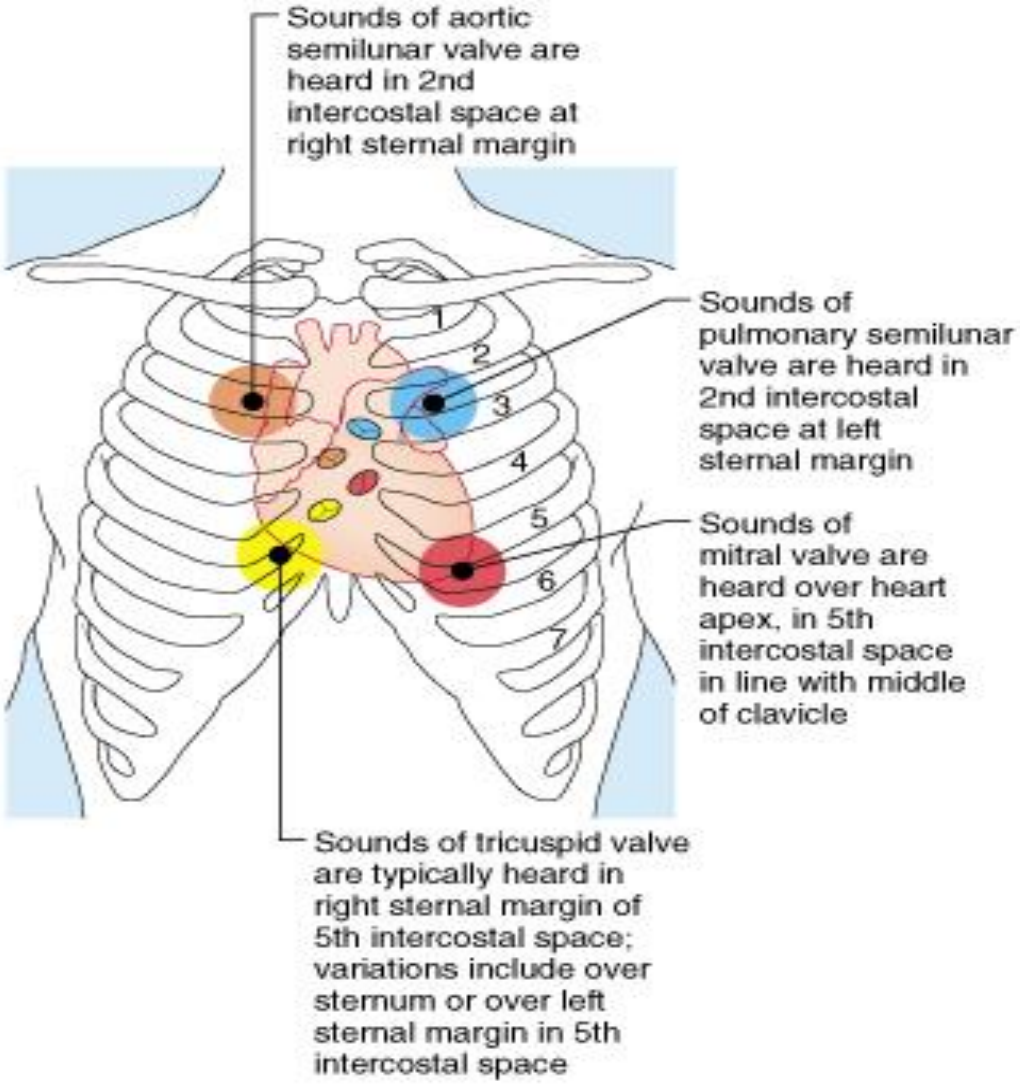
# The cardiac cycle



# Heart Sounds

- Auscultation – listening to heart sound via stethoscope

- Heart sounds (lub-dup) are associated with closing of heart valves

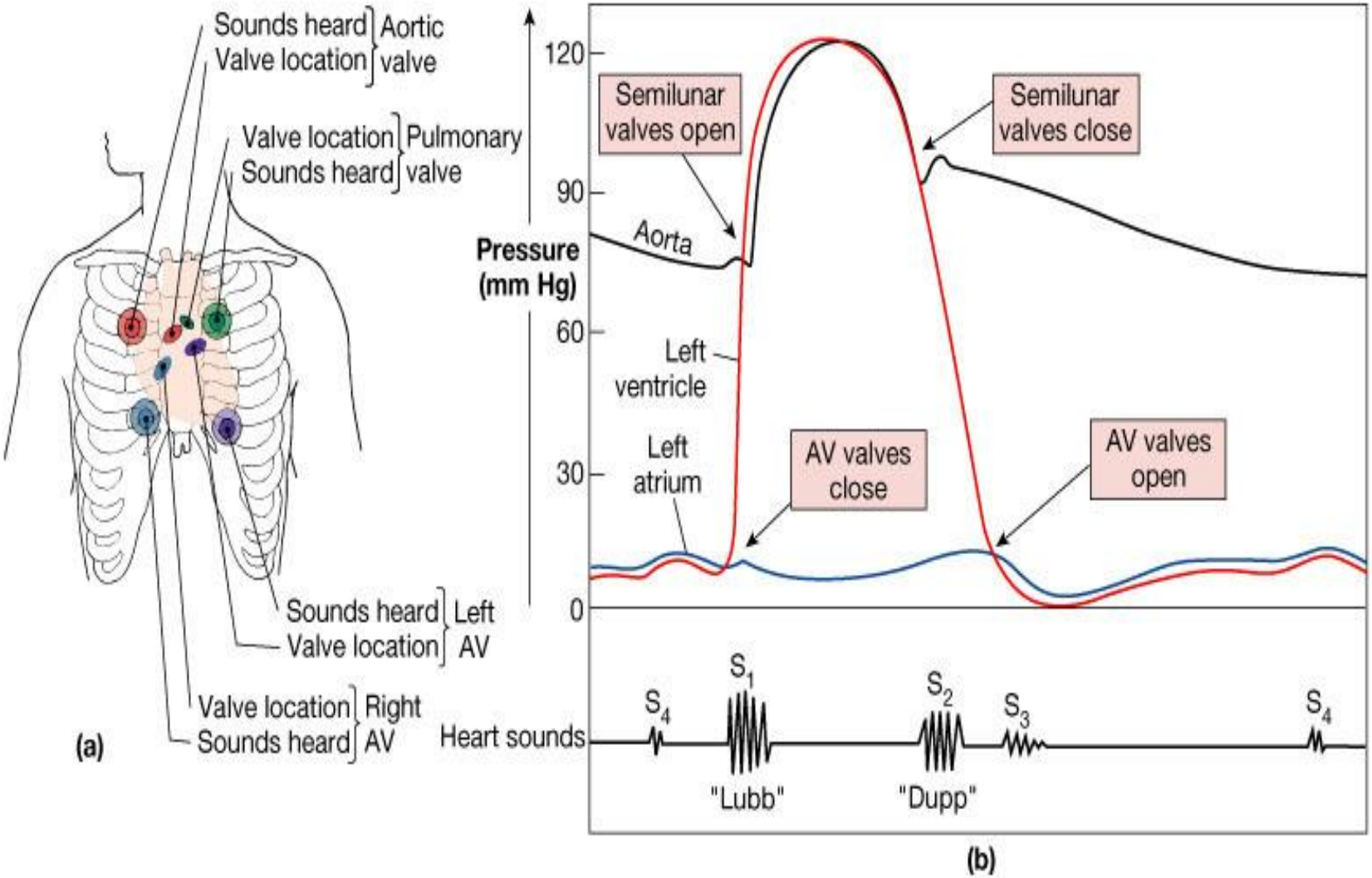


# Heart sounds

- Four heart sounds
  - ✓ **$S_1$ – "lubb":** caused by the closing of the AV valves
  - ✓ **S2 – "dupp":** caused by the closing of the semilunar valves
  - ✓ **S3:** a faint sound associated with blood flowing into the ventricles
  - ✓ **S4:** another faint sound associated with atrial contraction

- The interval between the first and second sound is shorter than the interval between the second and the next first heart sound.

# Heart Sounds



# Murmers

- **Cardiac murmurs** are abnormal heart sounds in the form of noises resulting from turbulent blood flow.

- Murmurs may be:

a) Systole murmurs, if they occur during systole.

b) Diastolic murmurs, if they occur during diastole

- Causes: The main factors causing cardiac murmurs include:

1) Stenosis (narrowing) of heart valves
2) Incompetence of heart valves
3) Increase of blood flow or decrease of blood viscosity (as in anemia).


Thank You