

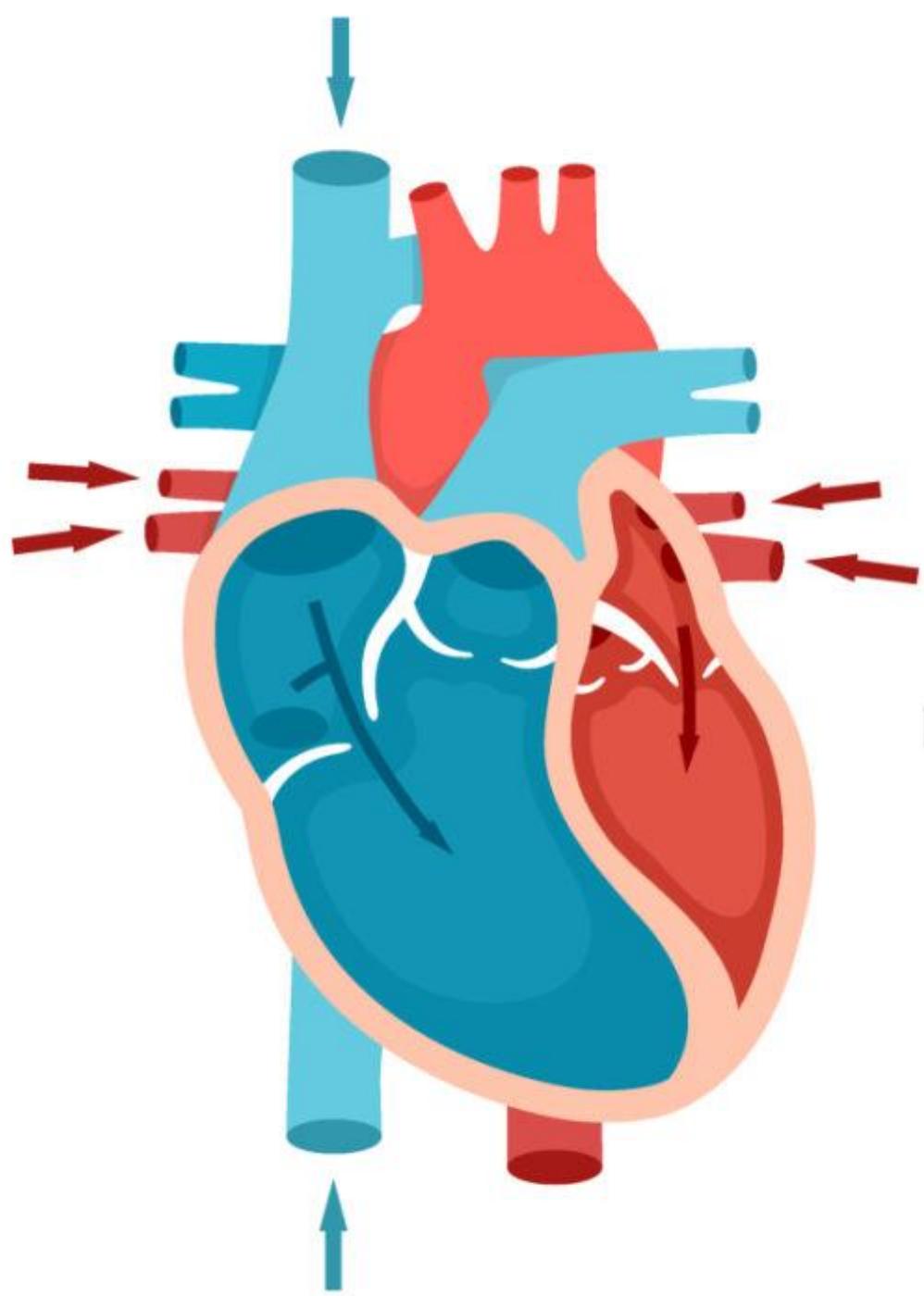
# Cardiac Cycle

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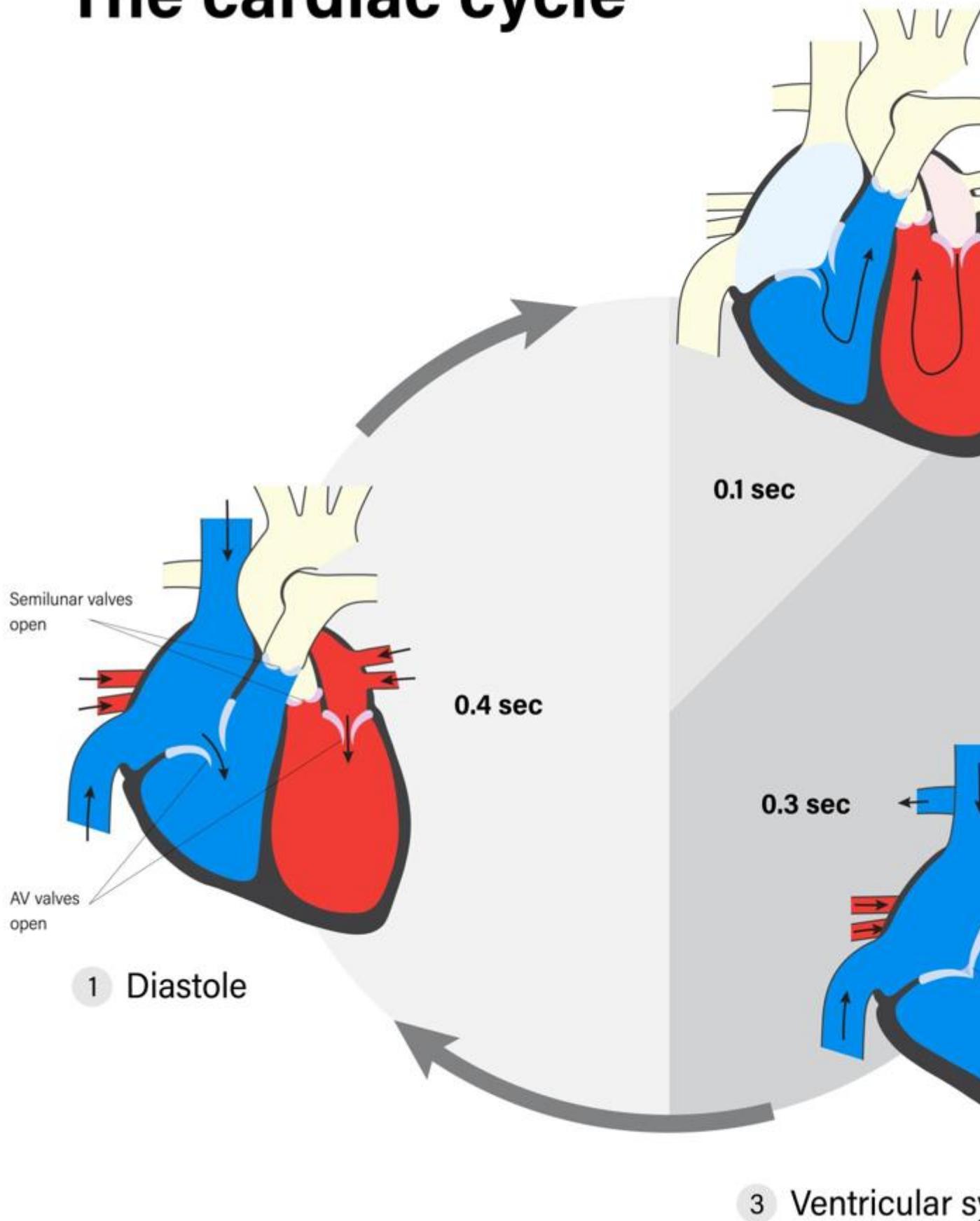
## Cardiac Cycle

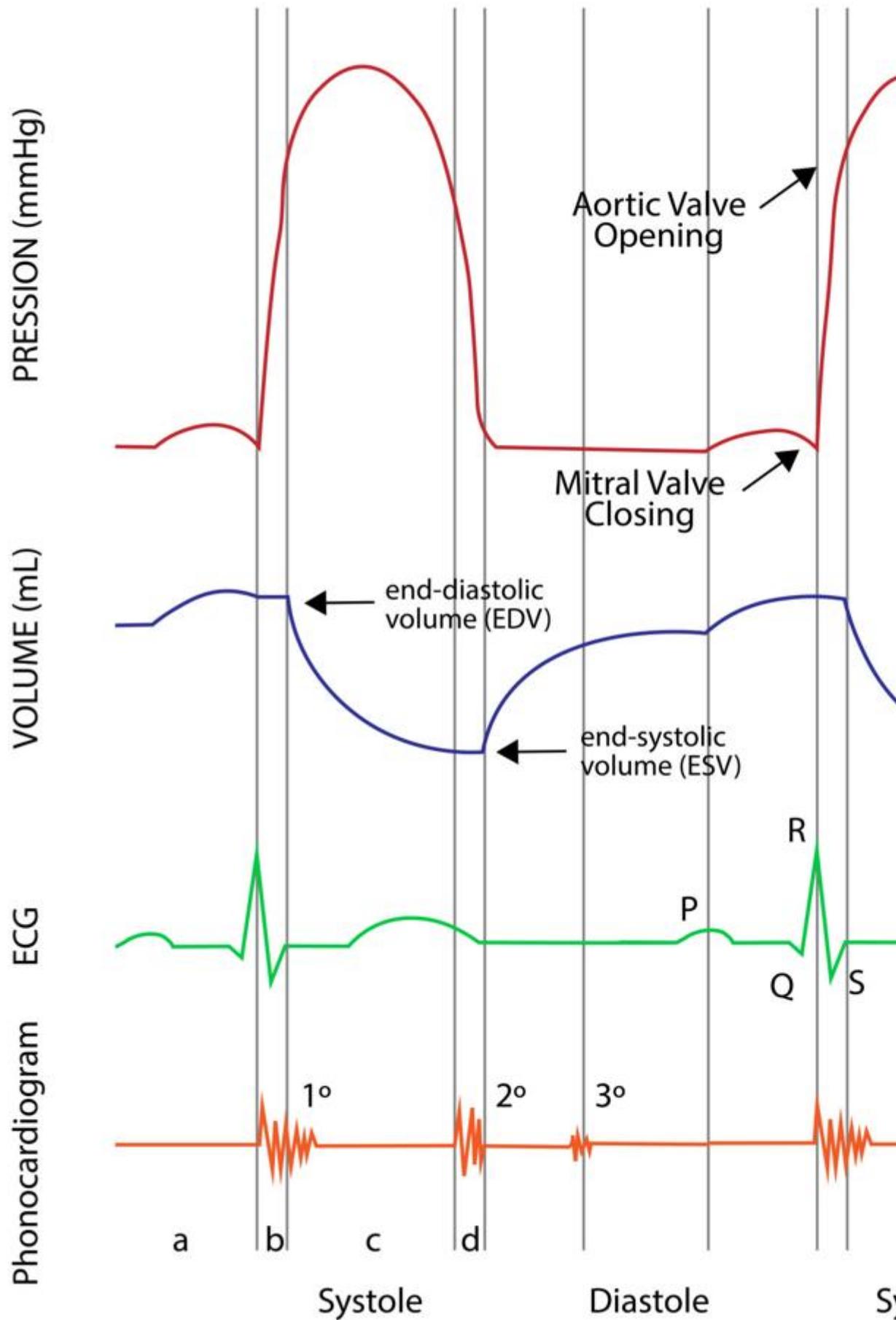
### Introduction

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# The cardiac cycle





- **Definition of cardiac cycle**

- The **cardiac cycle** refers to the **sequence of mechanical and electrical events that occur in the heart during one complete heartbeat.**

- **Sequence of mechanical events during one heartbeat**

- It includes **alternating contraction and relaxation of the atria and ventricles**, resulting in **movement of blood through the heart and into the circulation.**

- **Includes systole and diastole of atria and ventricles**

- **Systole** refers to the **phase of contraction**, while **diastole** refers to the **phase of relaxation and filling** of the heart chambers.

- **Begins with atrial contraction and ends before next beat**

- The cardiac cycle typically **begins with atrial systole**, followed by **ventricular systole and ventricular diastole**, and ends just before the next heartbeat begins.

- **Importance in maintaining effective circulation**

- The coordinated events of the cardiac cycle ensure **efficient filling of the heart chambers and effective pumping of blood into the pulmonary and systemic circulation.**

- **Relationship with heart sounds and ECG**

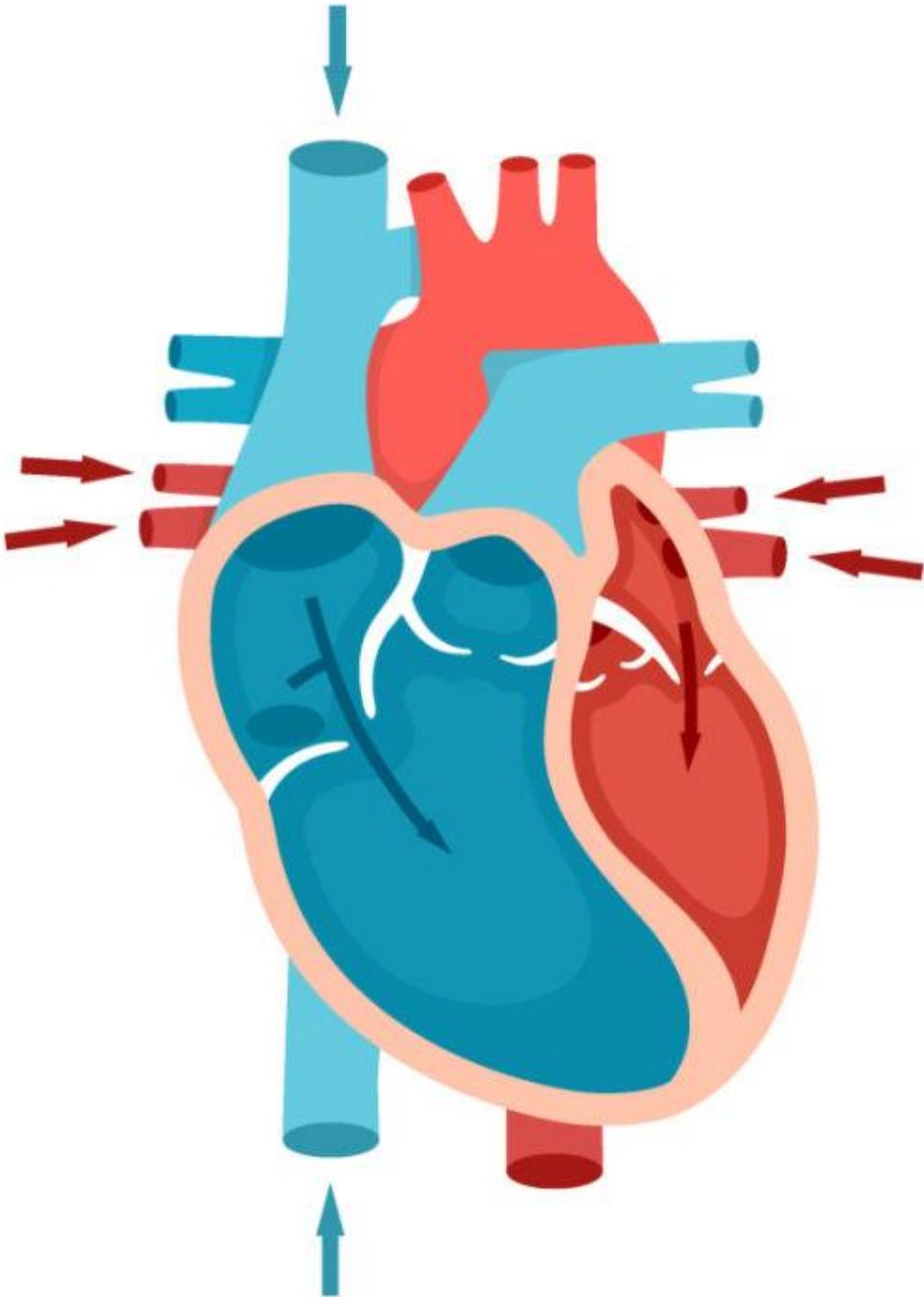
- Events of the cardiac cycle are closely related to **electrical changes recorded in the electrocardiogram (ECG)** and to **heart sounds produced by valve closure.**

- **Clinical relevance**

- Understanding the cardiac cycle is important for **interpreting heart sounds, ECG changes, and diagnosing various cardiovascular disorders.**

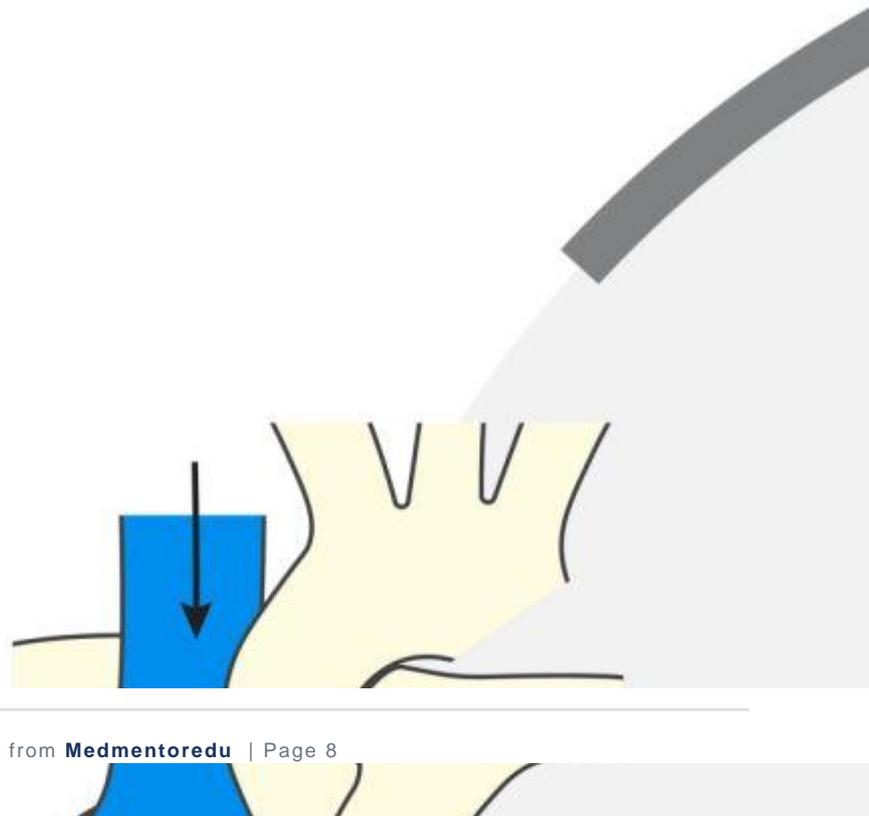
## Cardiac Cycle Time

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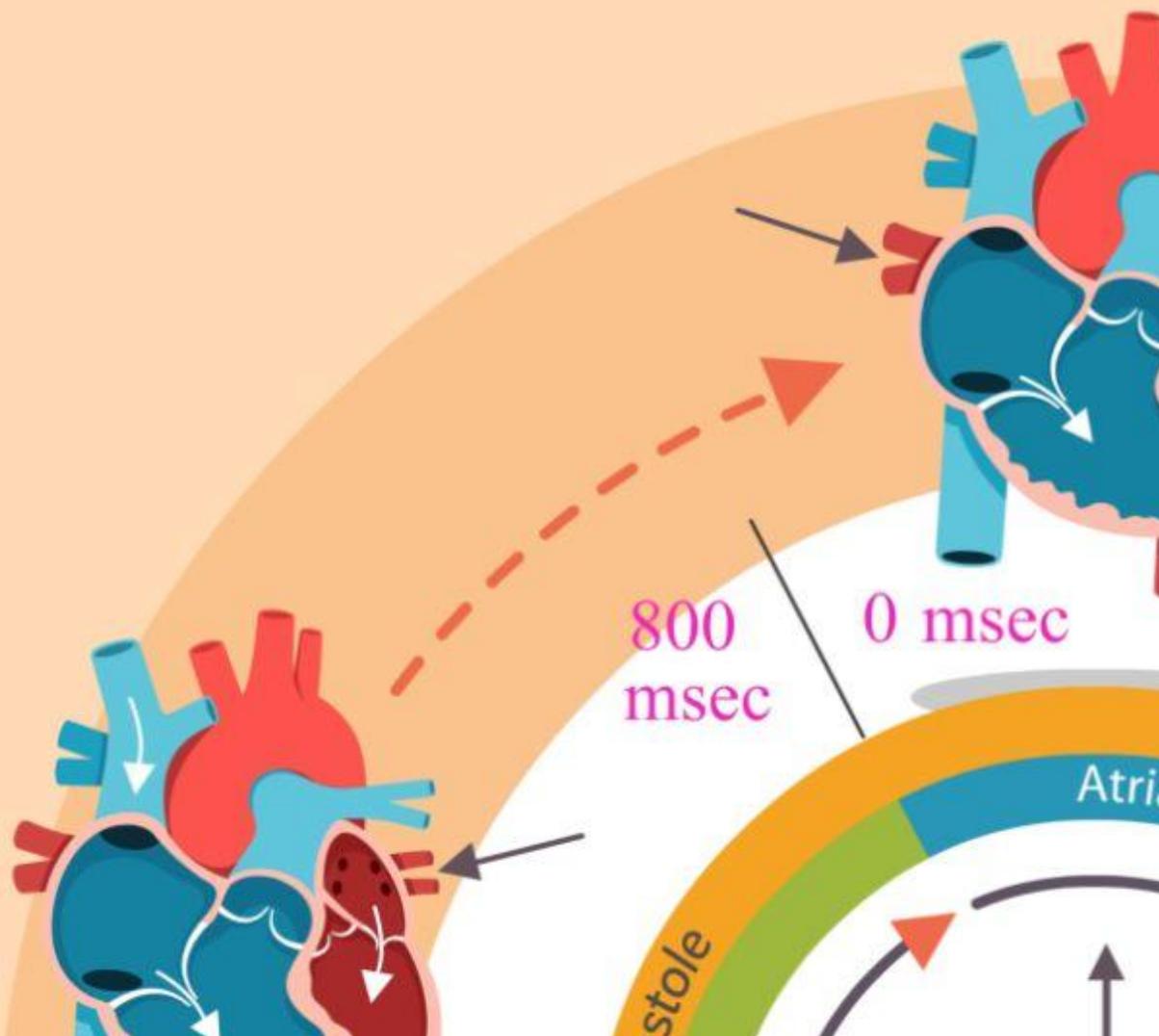


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- **Duration of one cardiac cycle at normal heart rate**

- At a normal resting heart rate of **about 75 beats per minute**, one cardiac cycle lasts approximately **0.8 seconds**.

- **Relationship with heart rate**

- The duration of the cardiac cycle is **inversely related to heart rate**.
- When **heart rate increases**, the **cardiac cycle becomes shorter**.
- When **heart rate decreases**, the **cardiac cycle becomes longer**.

- **Phases of cardiac cycle**

- The cardiac cycle includes **three main phases**:

- **Atrial systole**

- **Ventricular systole**

- **Ventricular diastole**.

- **Duration of atrial systole**

- Atrial contraction lasts about **0.1 second** and helps **complete ventricular filling**.

- **Duration of ventricular systole**

- Ventricular systole lasts about **0.3 seconds**, during which **blood is ejected into the pulmonary artery and aorta**.

- **Duration of ventricular diastole**

- Ventricular diastole lasts about **0.5 seconds**, allowing **ventricular relaxation and filling with blood**.

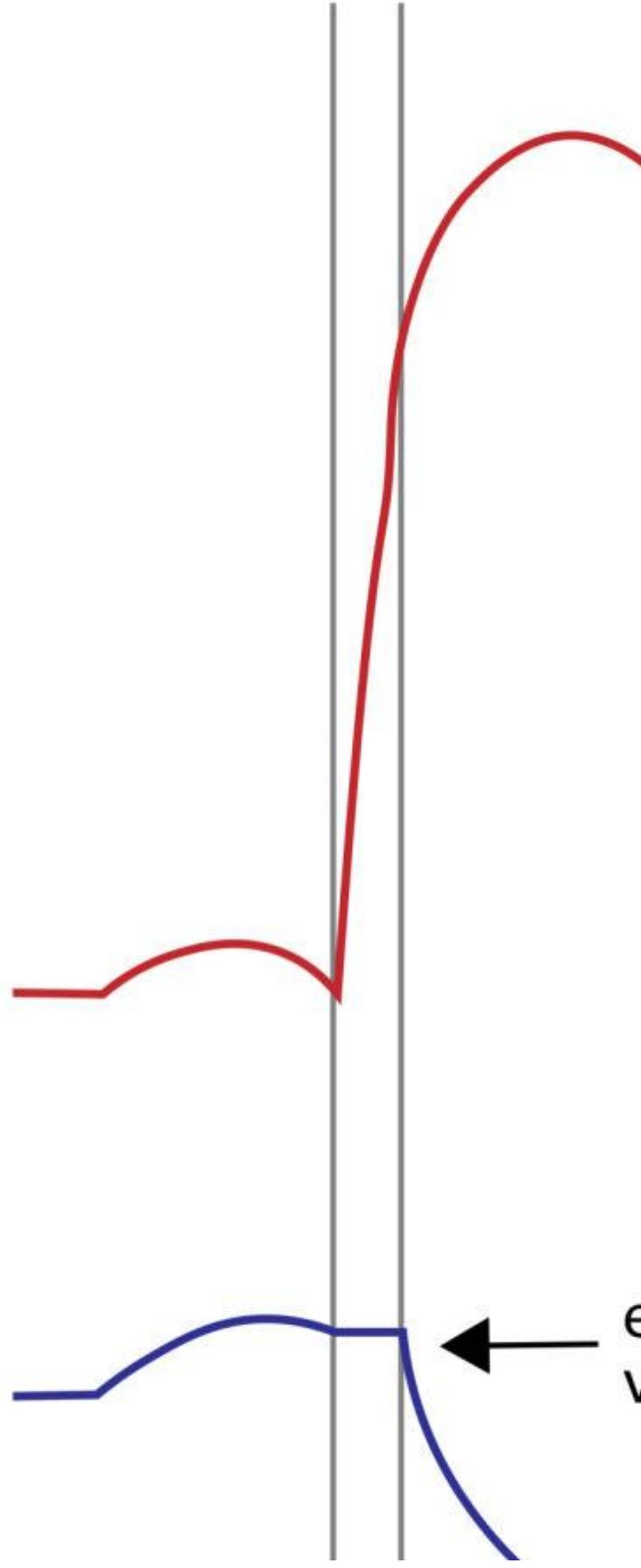
- **Variation with changes in heart rate**

- With **increased heart rate**, the **duration of diastole shortens more than systole**, which may reduce the time available for **ventricular filling and coronary perfusion**.

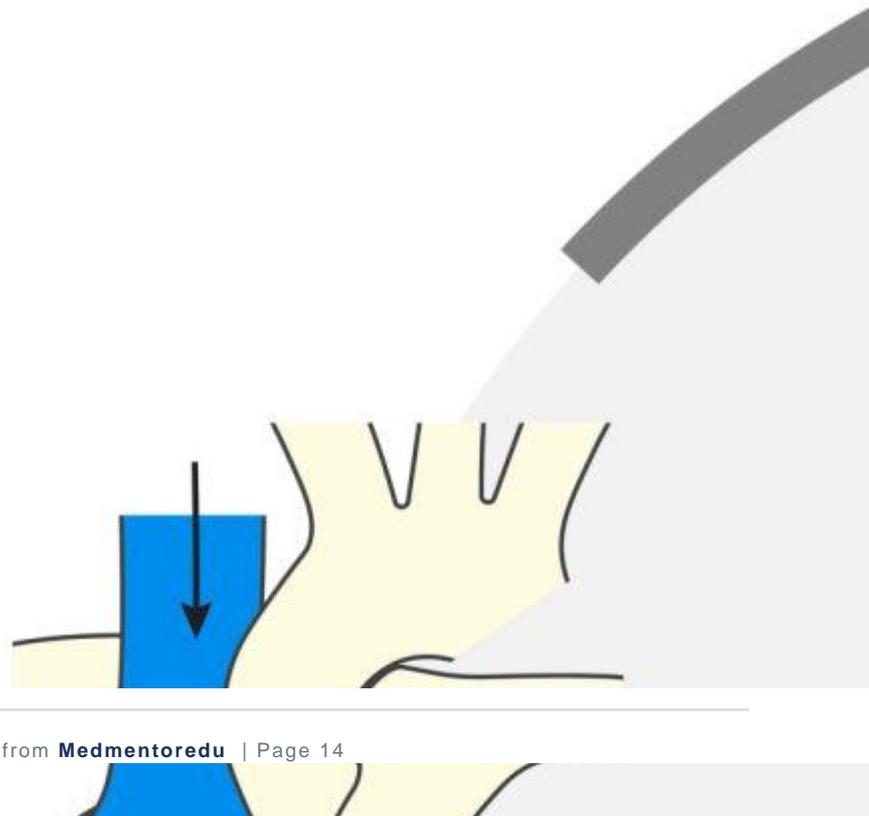
## Interrelations of the Various Events in the Cardiac Cycle

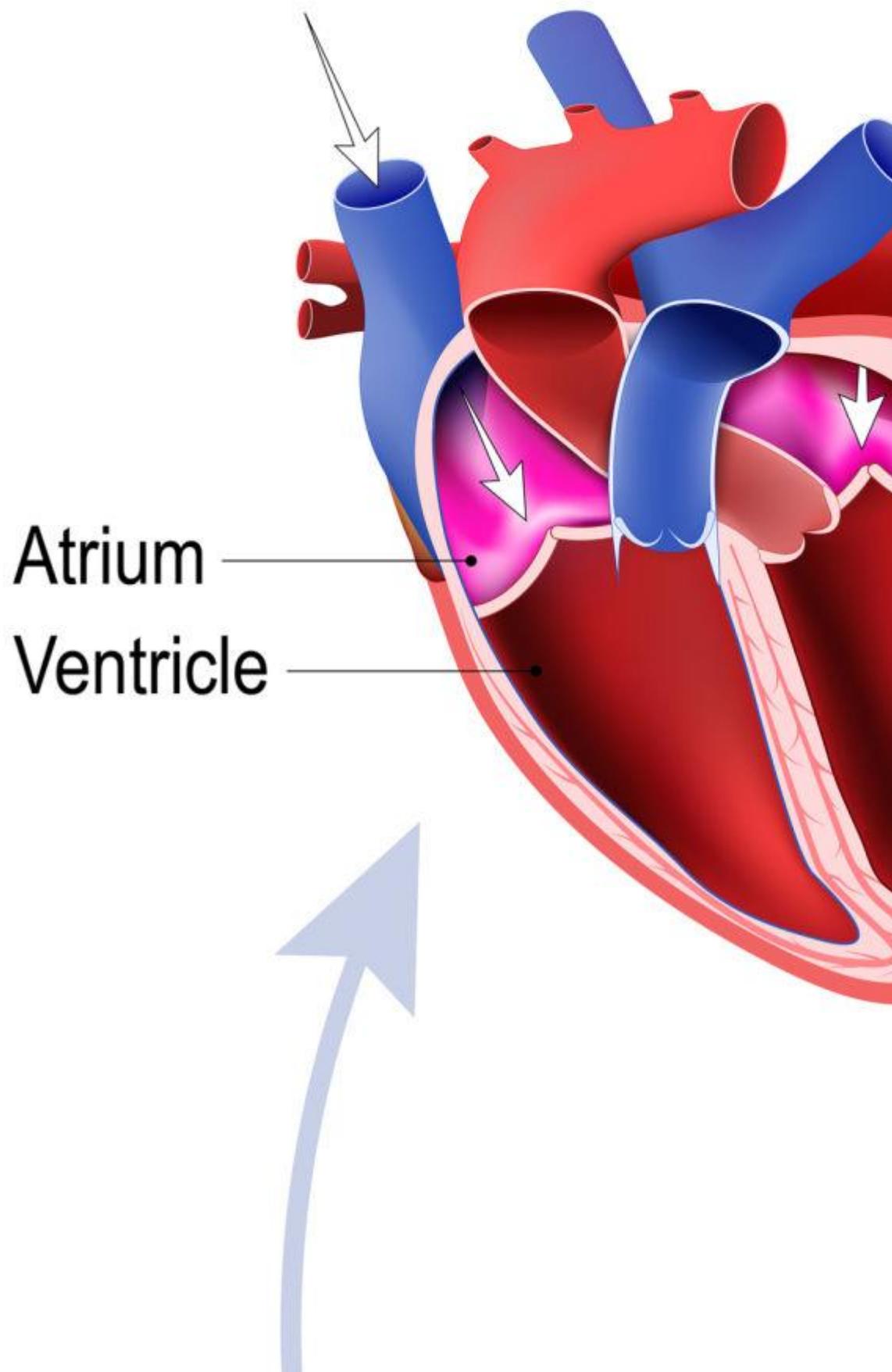
PRESSION (mmHg)

VOLUME (mL)



# The cardiac c

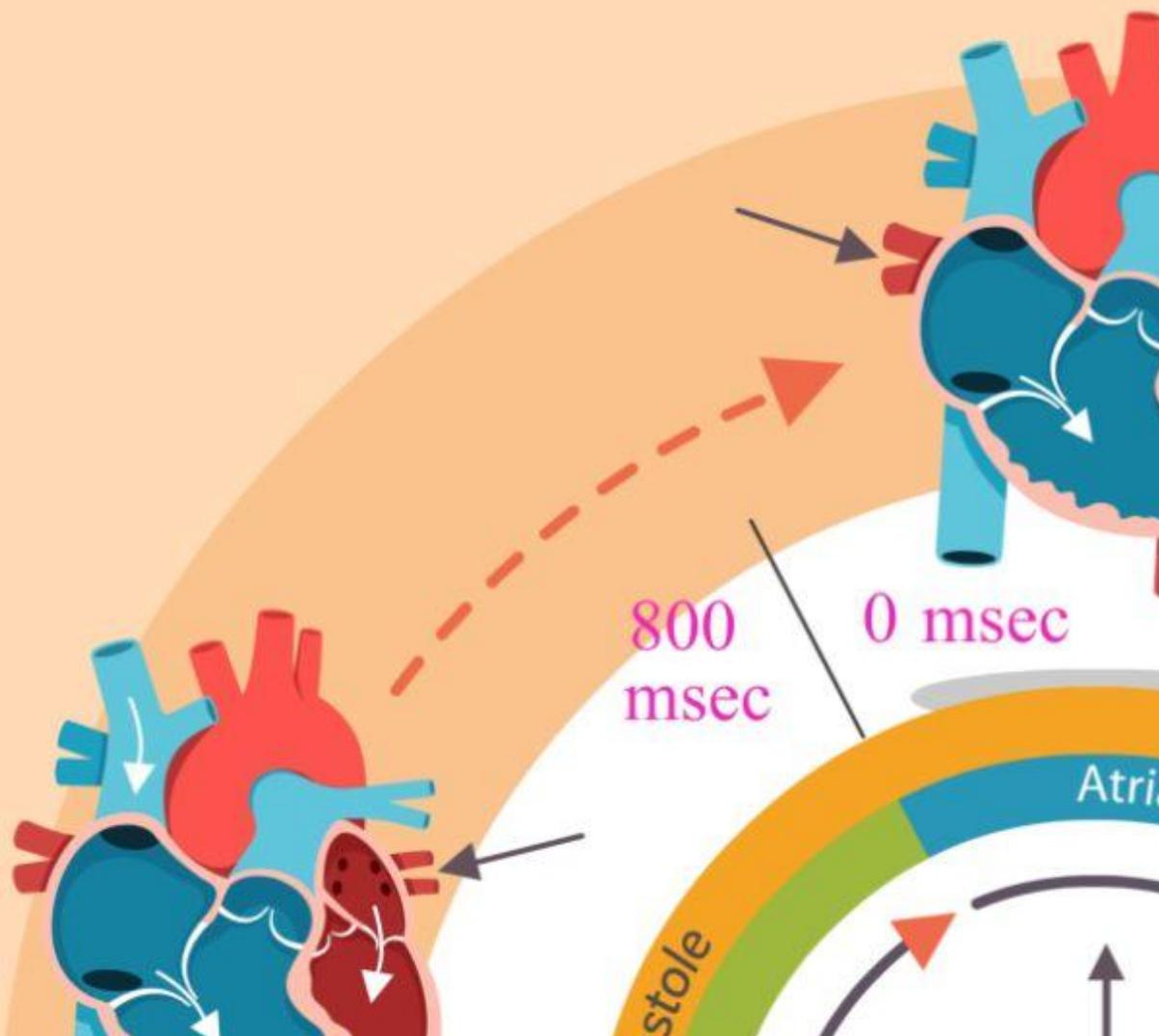




- **Relationship between atrial and ventricular events**
- The cardiac cycle involves **coordinated activity of atria and ventricles**.
- **Atrial contraction occurs first**, pushing blood into the ventricles, followed by **ventricular contraction to pump blood into the arteries**.
  
- **Pressure changes in atria and ventricles**
- During the cardiac cycle, **pressure in the heart chambers changes continuously**.
- Atrial pressure rises during **atrial systole**, while ventricular pressure rises sharply during **ventricular systole**.
  
- **Volume changes in ventricles**
- Ventricular volume increases during **ventricular filling in diastole**.
- During **ventricular systole**, the volume decreases as blood is **ejected into the pulmonary artery and aorta**.
  
- **Opening and closing of cardiac valves**
- Cardiac valves open and close depending on **pressure differences between chambers and vessels**.
- **Atrioventricular valves open during ventricular filling and close during ventricular contraction**
- **Semilunar valves open during ventricular systole and close during ventricular diastole**
  
- **Blood flow through chambers**
- Blood flows sequentially from **atria ? ventricles ? great arteries**, ensuring efficient circulation.
  
- **Correlation with heart sounds**
- Valve closure produces **heart sounds**.
- **First heart sound (S1)** occurs due to **closure of atrioventricular valves**, and **second heart sound (S2)** occurs due to **closure of semilunar valves**.
  
- **Coordination between electrical and mechanical events**
- Electrical activity recorded on the **electrocardiogram (ECG)** precedes mechanical events.
- **P wave** corresponds to **atrial depolarization and atrial contraction**, while **QRS complex** precedes **ventricular contraction**, and **T wave** corresponds to **ventricular repolarization**.

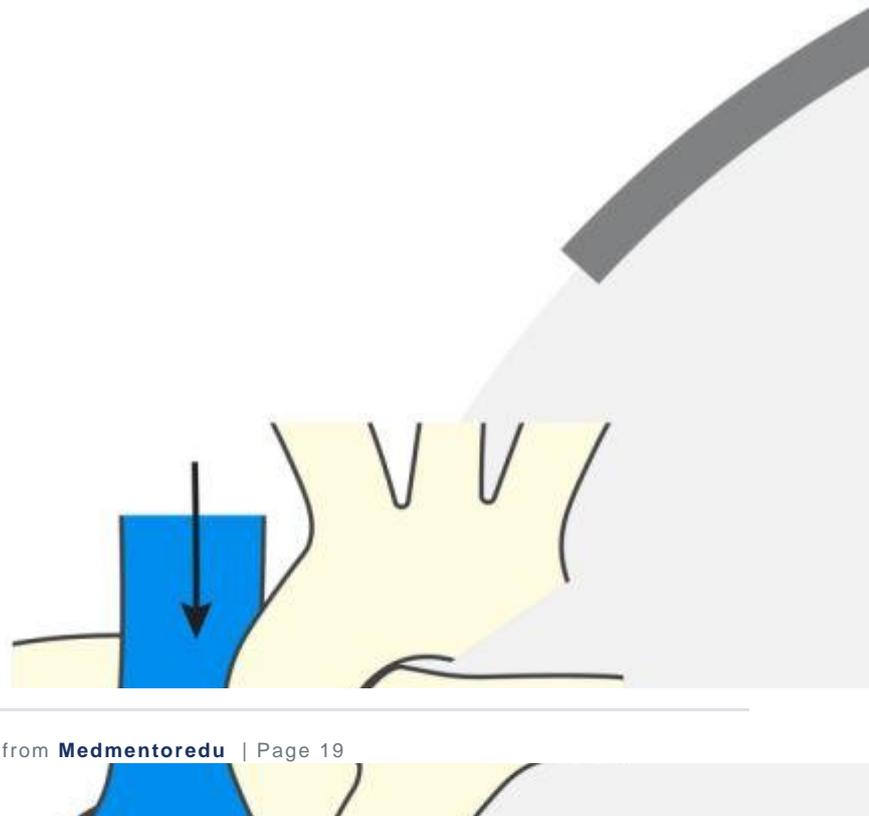
**The Inner Ring Represents the Atrial Events and the Outer Ring Represents Ventricular Events**

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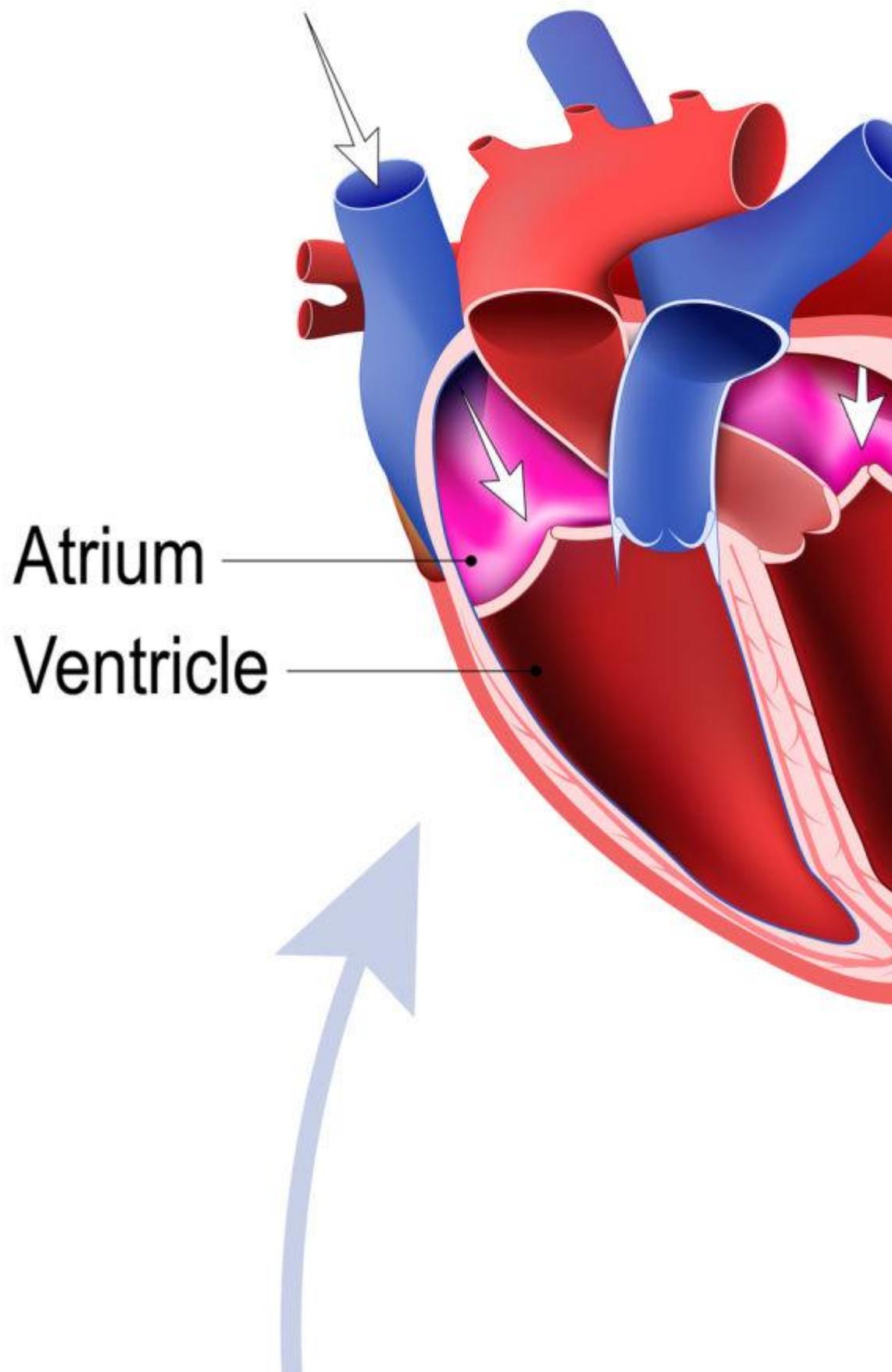




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- **Conceptual diagram representing cardiac cycle**

- The cardiac cycle is sometimes illustrated using a **circular diagram with two concentric rings** to show the sequence of atrial and ventricular events.

- **Inner ring showing atrial contraction and relaxation**

- The **inner ring** represents atrial events, including **atrial systole (contraction)** followed by **atrial diastole (relaxation)**.

- **Outer ring showing ventricular contraction and relaxation**

- The **outer ring** represents ventricular events, including **ventricular systole and ventricular diastole**.

- **Relationship between atrial and ventricular phases**

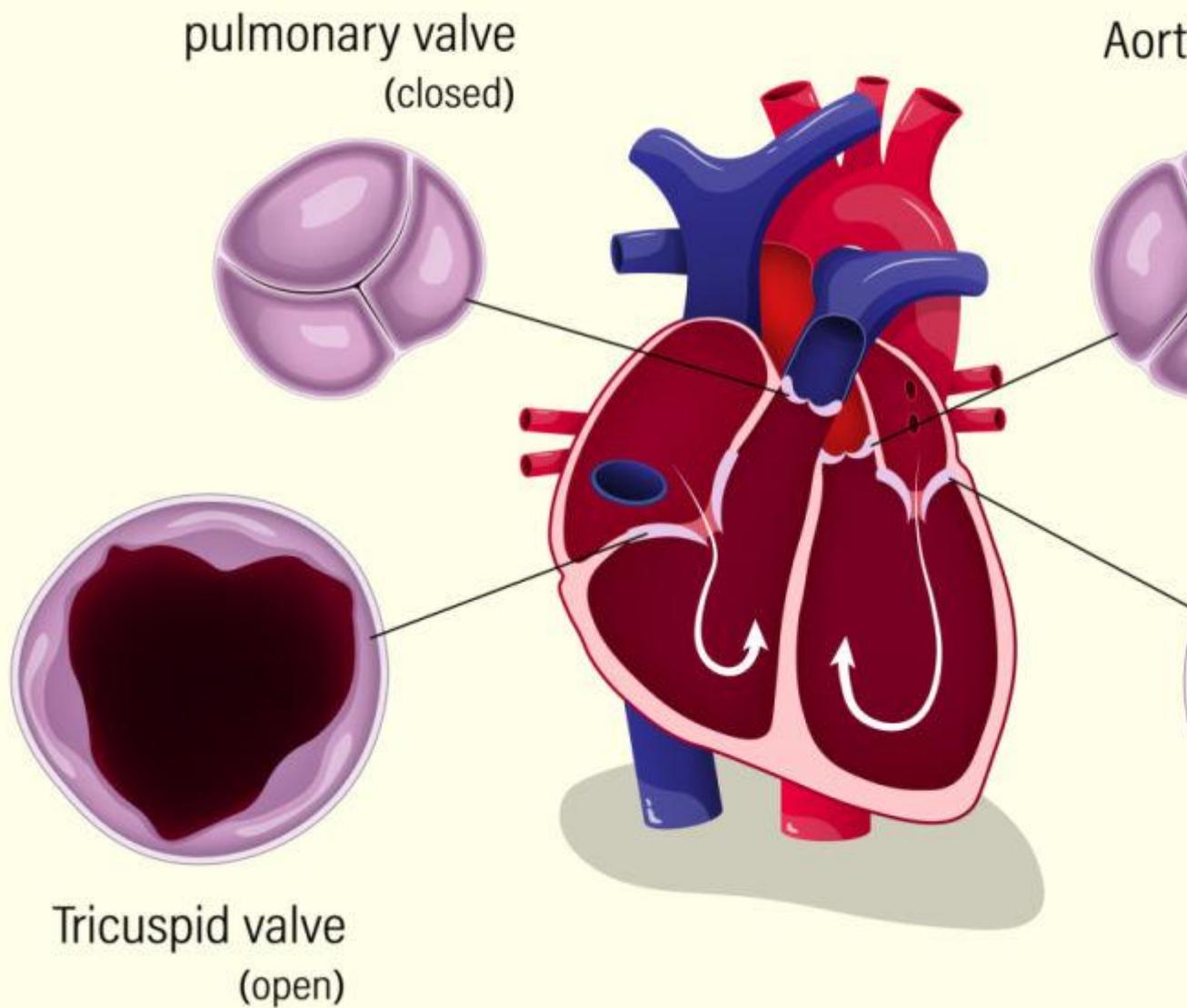
- The diagram shows that **atrial systole occurs slightly before ventricular systole**, allowing the atria to **push blood into the ventricles before ventricular contraction begins**.

- **Visualization of synchronized cardiac activity**

- This representation helps visualize the **precise coordination between atrial and ventricular activities**, ensuring **efficient filling and pumping of blood during each heartbeat**.

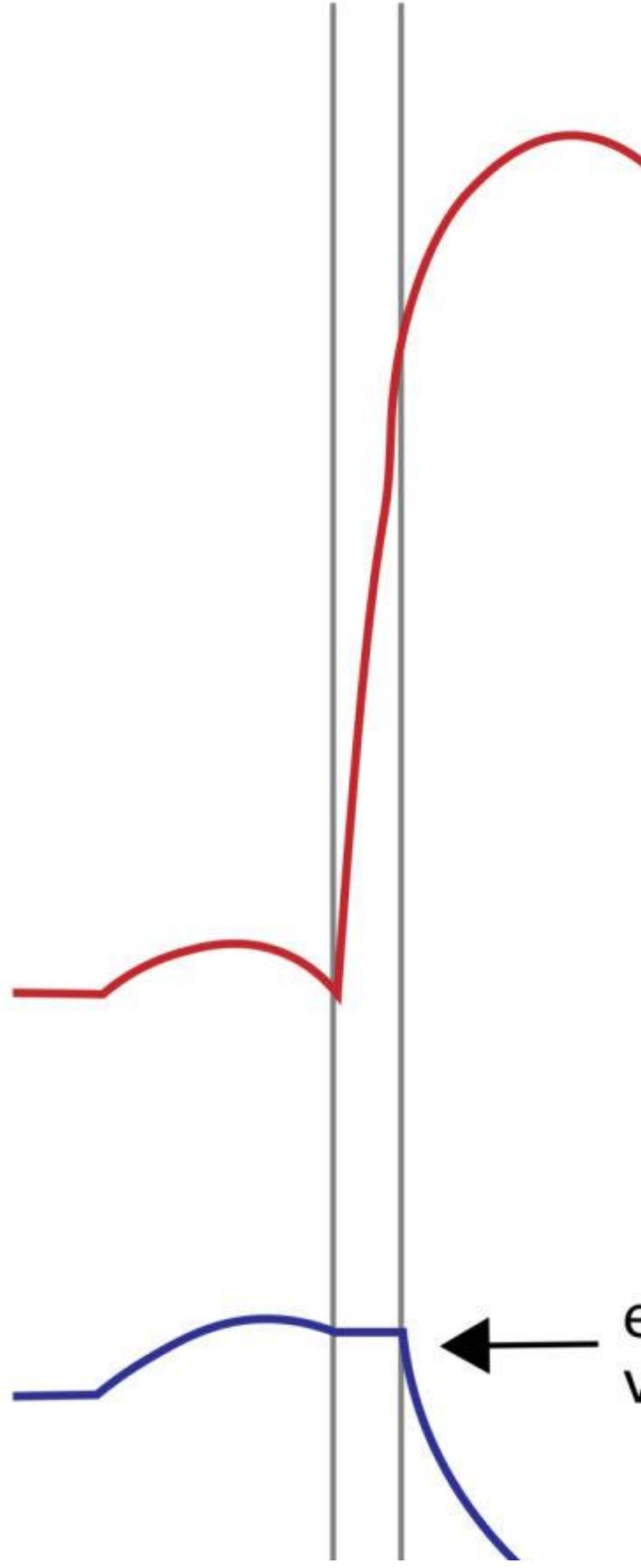
## Ventricular Events in the Cardiac Cycle (Outer Ring)

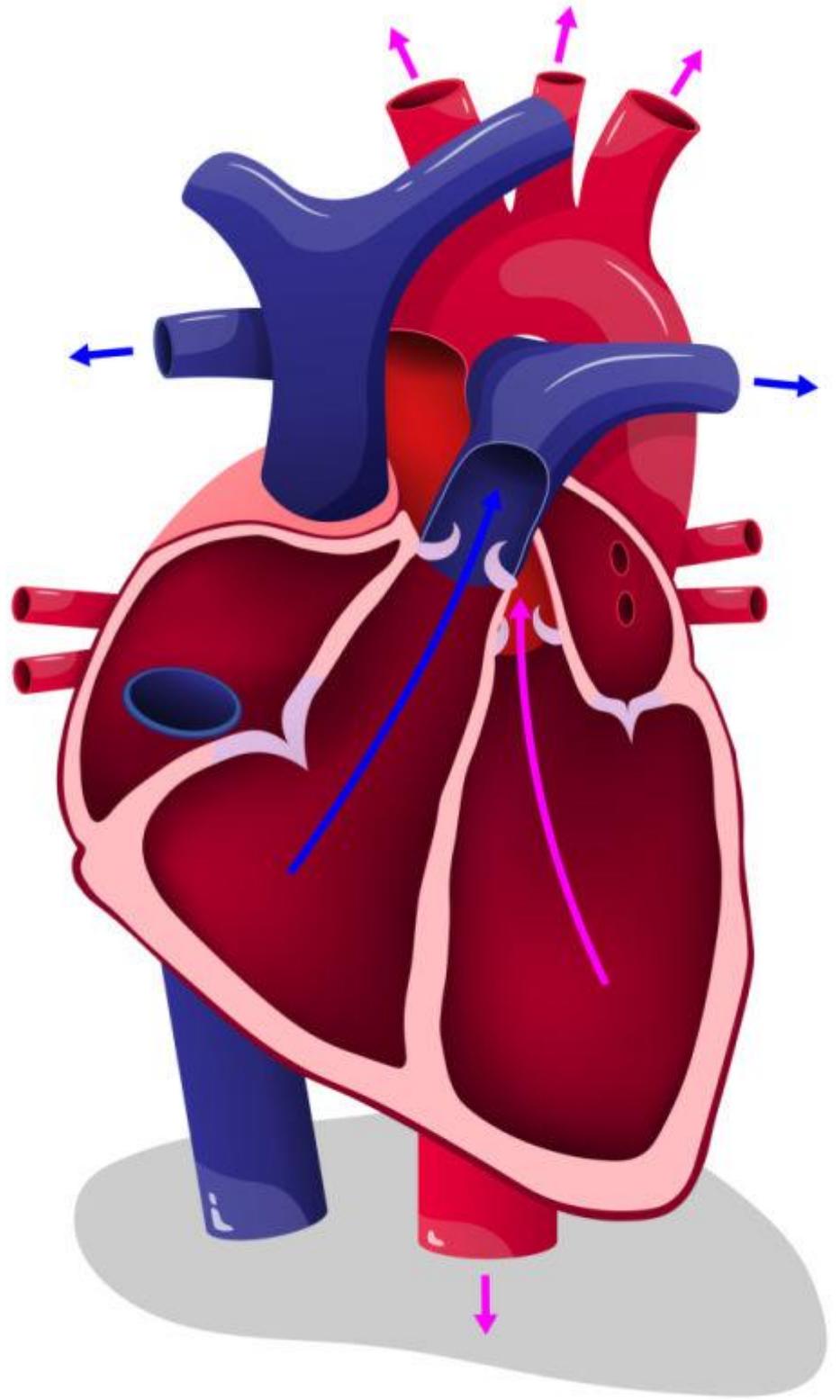
# Ventricular diastole



PRESSION (mmHg)

VOLUME (mL)





- **Beginning of ventricular systole**

- Ventricular systole begins when the **ventricular myocardium depolarizes following the QRS complex of the ECG**.
- This electrical activation initiates **contraction of the ventricular muscle fibres**.

- **Isovolumetric contraction phase**

- At the start of ventricular contraction, **all cardiac valves remain closed**.
- During this phase, the **ventricular muscle contracts but the volume of blood inside the ventricles does not change** hence the term **isovolumetric contraction**.

- **Closure of atrioventricular valves**

- As ventricular pressure begins to rise, it becomes **greater than atrial pressure**, causing the **atrioventricular valves (mitral and tricuspid) to close**.
- This valve closure produces the **first heart sound (S1)**.

- **Increase in ventricular pressure**

- With continued contraction, **ventricular pressure increases rapidly** because the ventricles are contracting against closed valves.

- **Opening of semilunar valves**

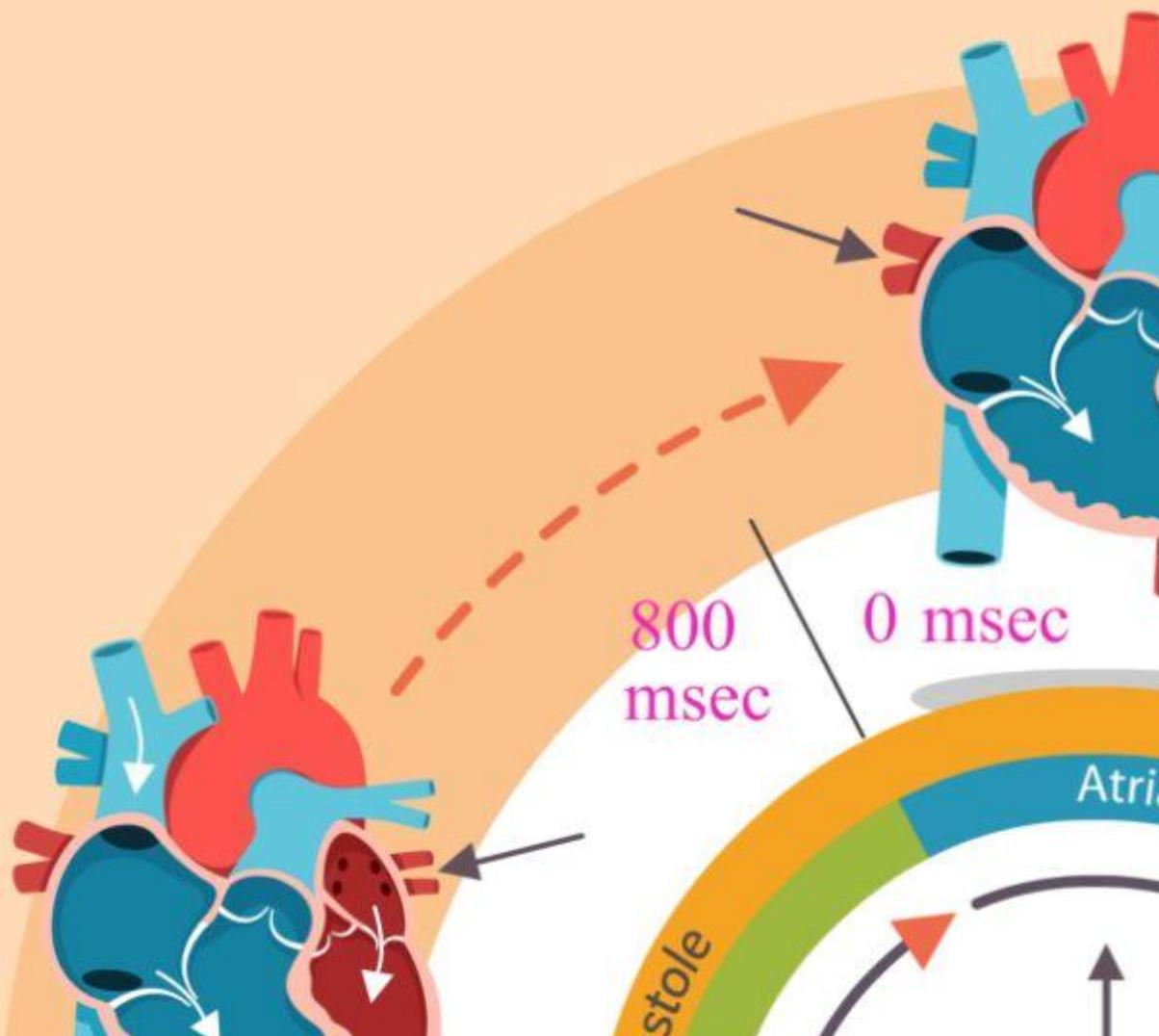
- When ventricular pressure **exceeds the pressure in the aorta and pulmonary artery**, the **semilunar valves (aortic and pulmonary valves) open**.

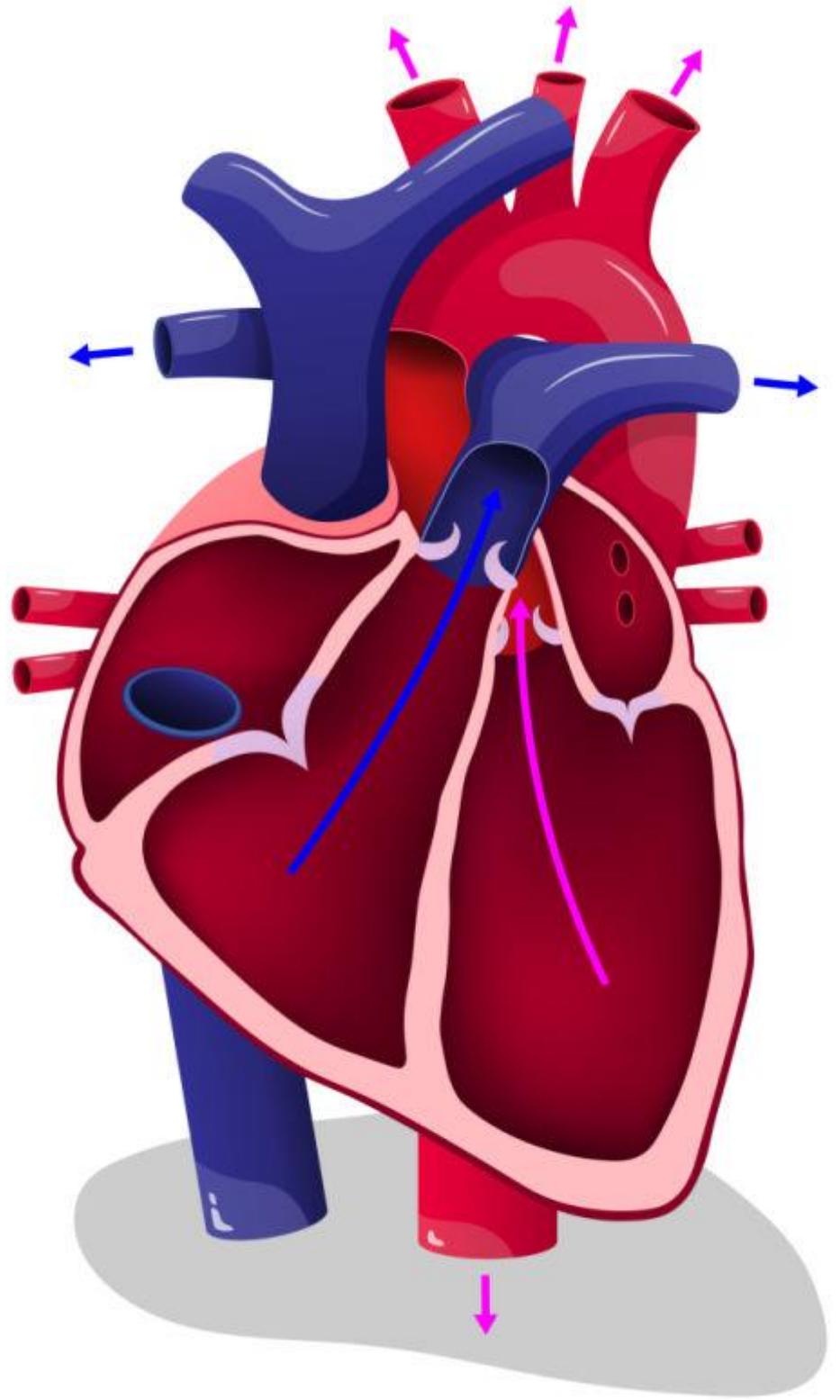
- **Beginning of ventricular ejection**

- Once the semilunar valves open, **blood is ejected from the ventricles into the pulmonary artery and aorta**, marking the **start of the ventricular ejection phase**.

## Ventricular Events in the Cardiac Cycle (Outer Ring – Ejection Phases)

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<https://www.researchgate.net/publication/274891250/figure/fig1/AS%3A267727919120399%401440842718632/Left-ventricular-volume-g>

- **Rapid ejection phase**

- After the **semilunar valves open**, blood is expelled quickly from the ventricles into the **aorta and pulmonary artery**.
- During this phase, **most of the ventricular stroke volume is ejected**.

- **Reduced ejection phase**

- As ventricular contraction begins to decline, the **rate of blood ejection decreases**.
- Blood continues to leave the ventricles but **more slowly compared with the rapid ejection phase**.

- **Decrease in ventricular volume**

- During the ejection phases, the **volume of blood inside the ventricles decreases significantly** as blood is pumped into the major arteries.

- **Continued ventricular contraction**

- Ventricular muscle fibres **remain contracted throughout the ejection phases**, maintaining the pressure required to push blood into the arteries.

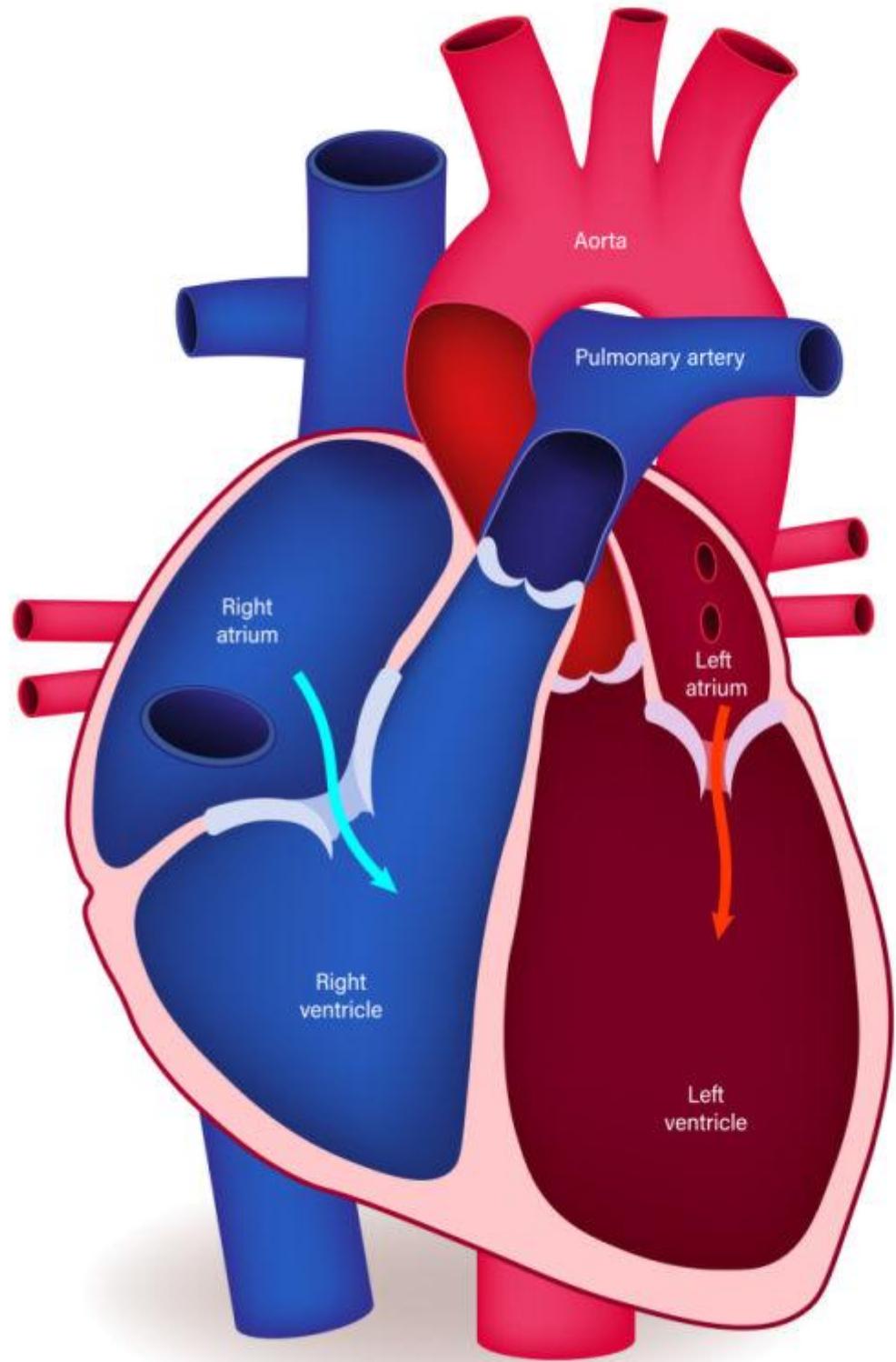
- **Changes in arterial pressure**

- As blood enters the **aorta and pulmonary artery**, the **pressure in these arteries rises**, producing the **systolic arterial pressure**.

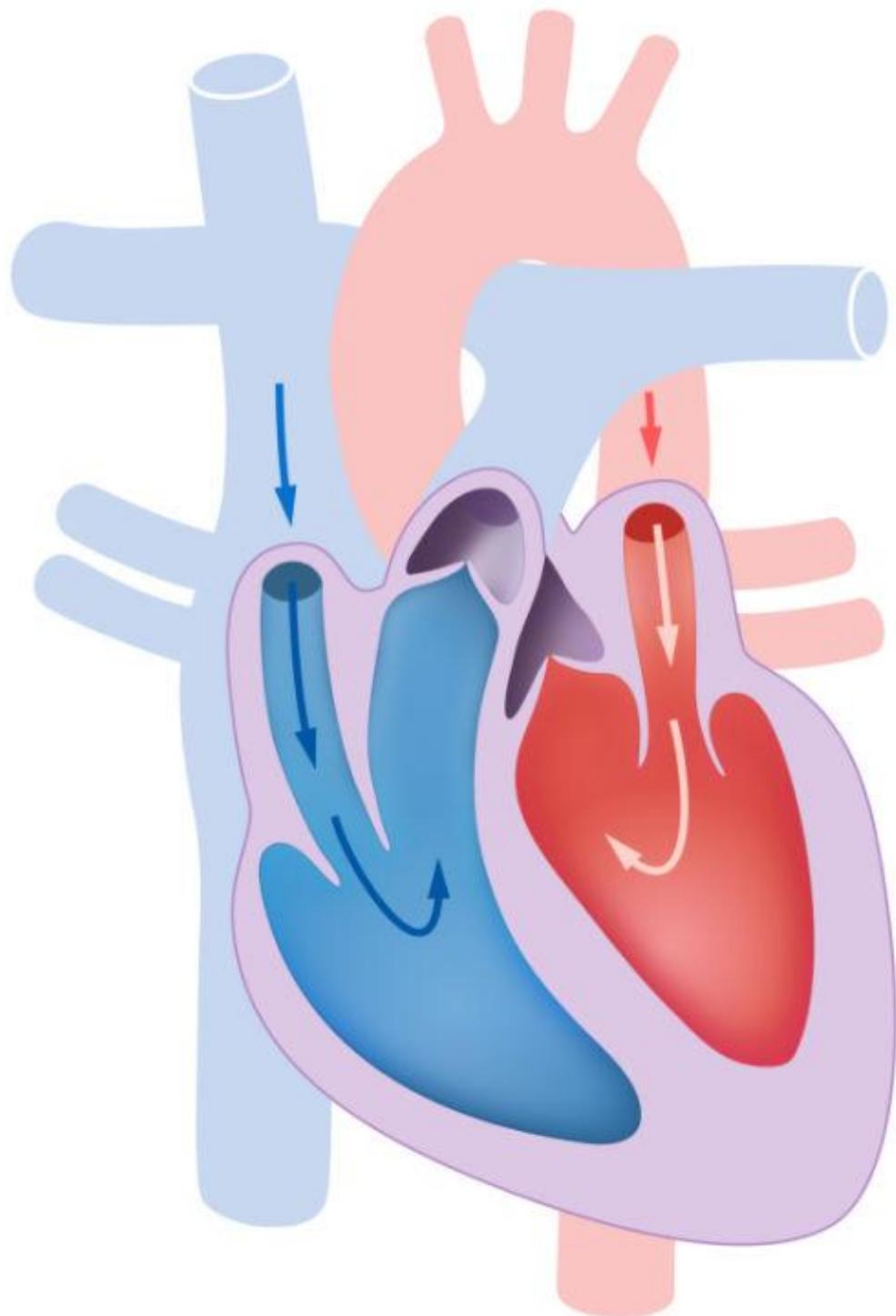
- **Blood flow into aorta and pulmonary artery**

- The **left ventricle pumps oxygenated blood into the aorta**, supplying the systemic circulation.
- The **right ventricle pumps deoxygenated blood into the pulmonary artery**, sending it to the lungs for oxygenation.

## Ventricular Diastole (Outer Ring of the Cardiac Cycle)



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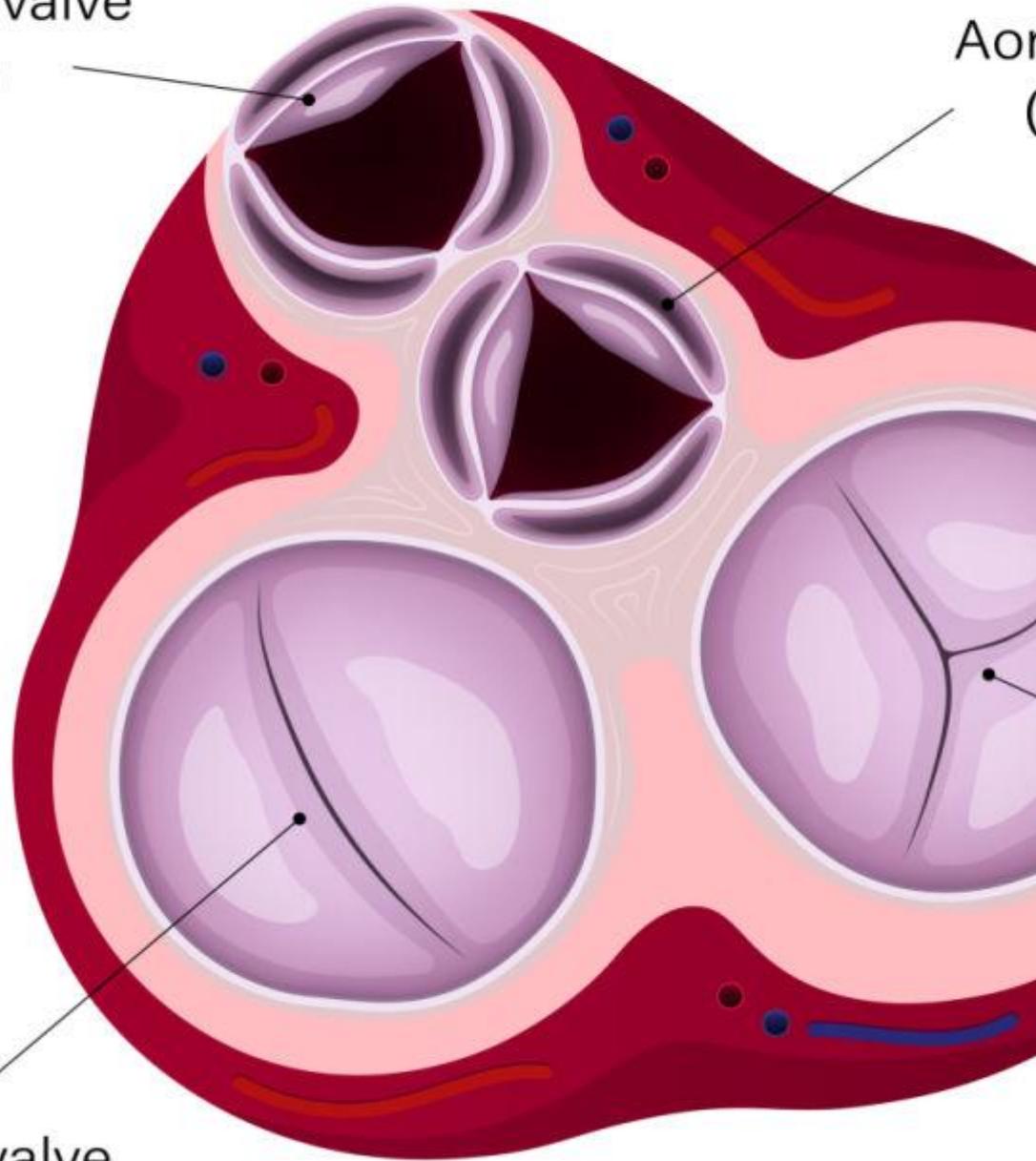
Atrial

# Ventricular systole

Pulmonary valve  
(open)

Aortic  
(

Tricuspid valve  
(closed)



- **Beginning of ventricular relaxation**

- Ventricular diastole begins when the **ventricular muscle fibres start to relax after systole**.
- This relaxation occurs following **ventricular repolarization represented by the T wave in the ECG**.

- **Closure of semilunar valves**

- As ventricular pressure falls below the pressure in the **aorta and pulmonary artery**, the **semilunar valves close**.
- This valve closure produces the **second heart sound (S2)**.

- **Isovolumetric relaxation phase**

- Immediately after semilunar valve closure, the ventricles relax while **all cardiac valves remain closed**.
- During this phase, **ventricular pressure decreases rapidly but ventricular volume remains constant**, hence the term **isovolumetric relaxation**.

- **Opening of atrioventricular valves**

- When ventricular pressure becomes **lower than atrial pressure**, the **atrioventricular valves (mitral and tricuspid) open**.

- **Rapid ventricular filling**

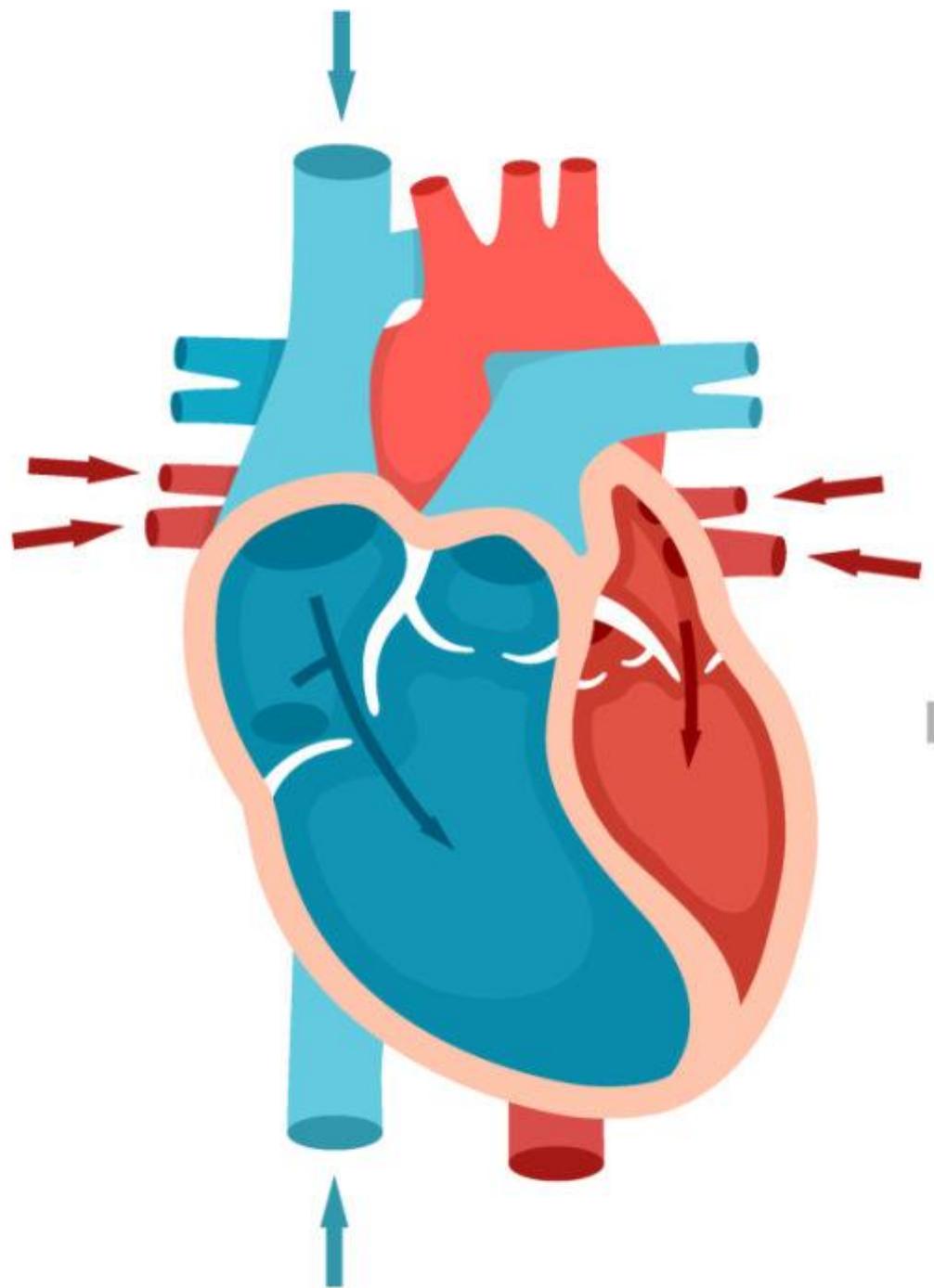
- Blood accumulated in the atria during ventricular systole **flows rapidly into the ventricles**, producing the **rapid filling phase**.

- **Reduced filling (diastasis)**

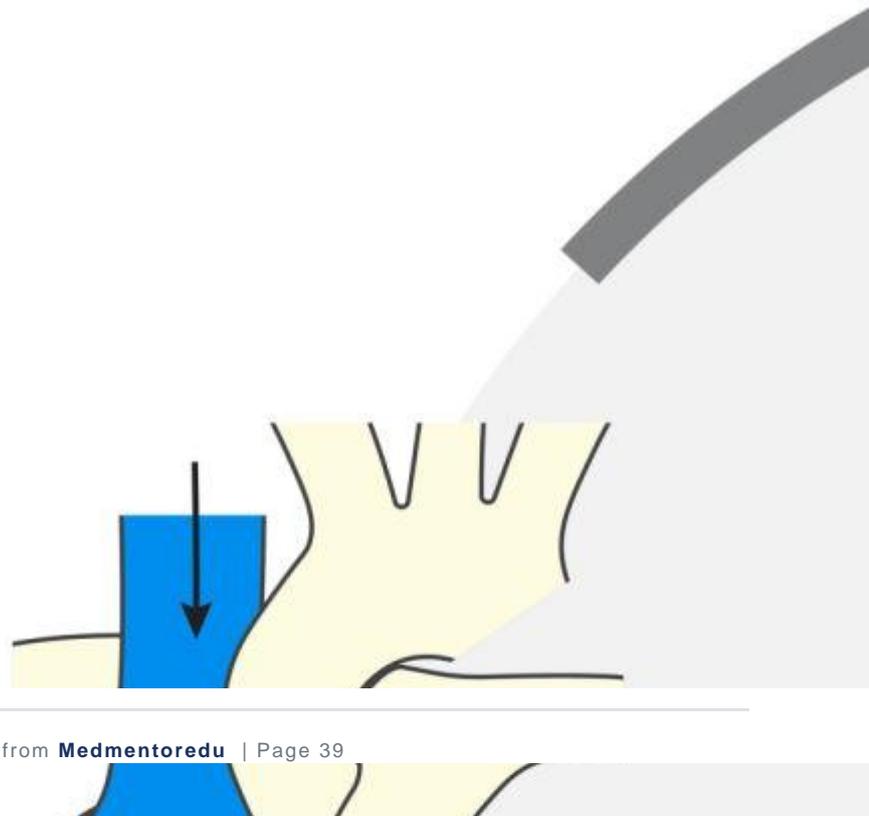
- After rapid filling, the rate of ventricular filling **gradually decreases**, entering a phase called **diastasis**, where **blood continues to flow slowly into the ventricles until the next atrial contraction begins**

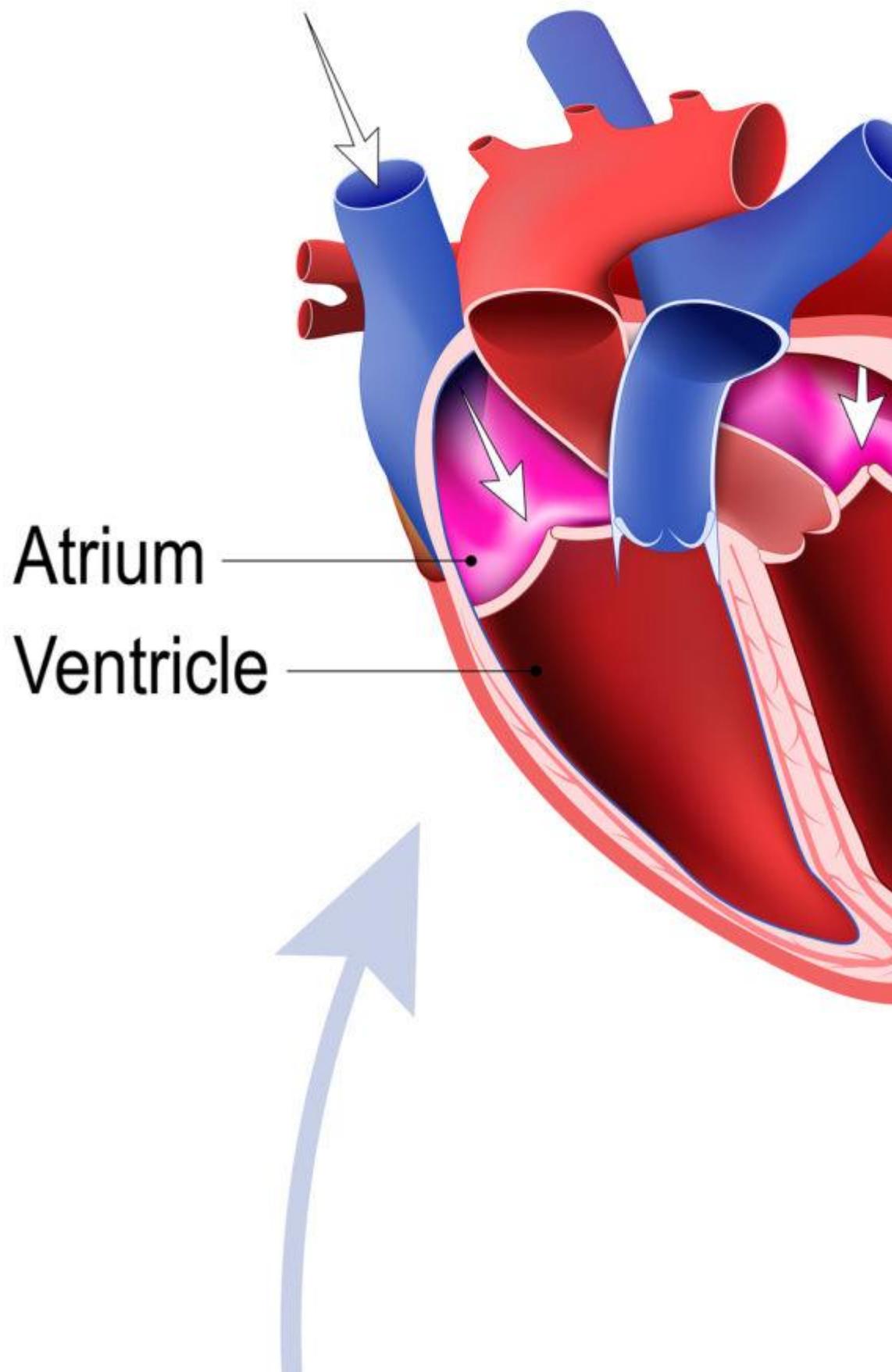
## Summary of the Sequence of Events in Cardiac Cycle

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- **Atrial systole**

- The cardiac cycle begins with **atrial contraction**, during which the atria **push the remaining blood into the ventricles**, completing ventricular filling.

- **Isovolumetric ventricular contraction**

- Ventricular contraction begins with **closure of the atrioventricular valves**.
- All valves remain closed, so **ventricular pressure rises rapidly without change in ventricular volume**

- **Rapid ventricular ejection**

- When ventricular pressure **exceeds the pressure in the aorta and pulmonary artery**, the **semilunar valves open**, allowing rapid ejection of blood from the ventricles.

- **Reduced ventricular ejection**

- As ventricular contraction begins to decline, **blood continues to be ejected but at a slower rate**.

- **Isovolumetric ventricular relaxation**

- Ventricular muscle begins to **relax after ejection**.
- Semilunar valves close and **all valves remain closed while ventricular pressure falls rapidly**.

- **Rapid ventricular filling**

- When ventricular pressure becomes **lower than atrial pressure**, the **atrioventricular valves open**, allowing blood to **flow rapidly from atria into ventricles**.

- **Reduced ventricular filling (diastasis)**

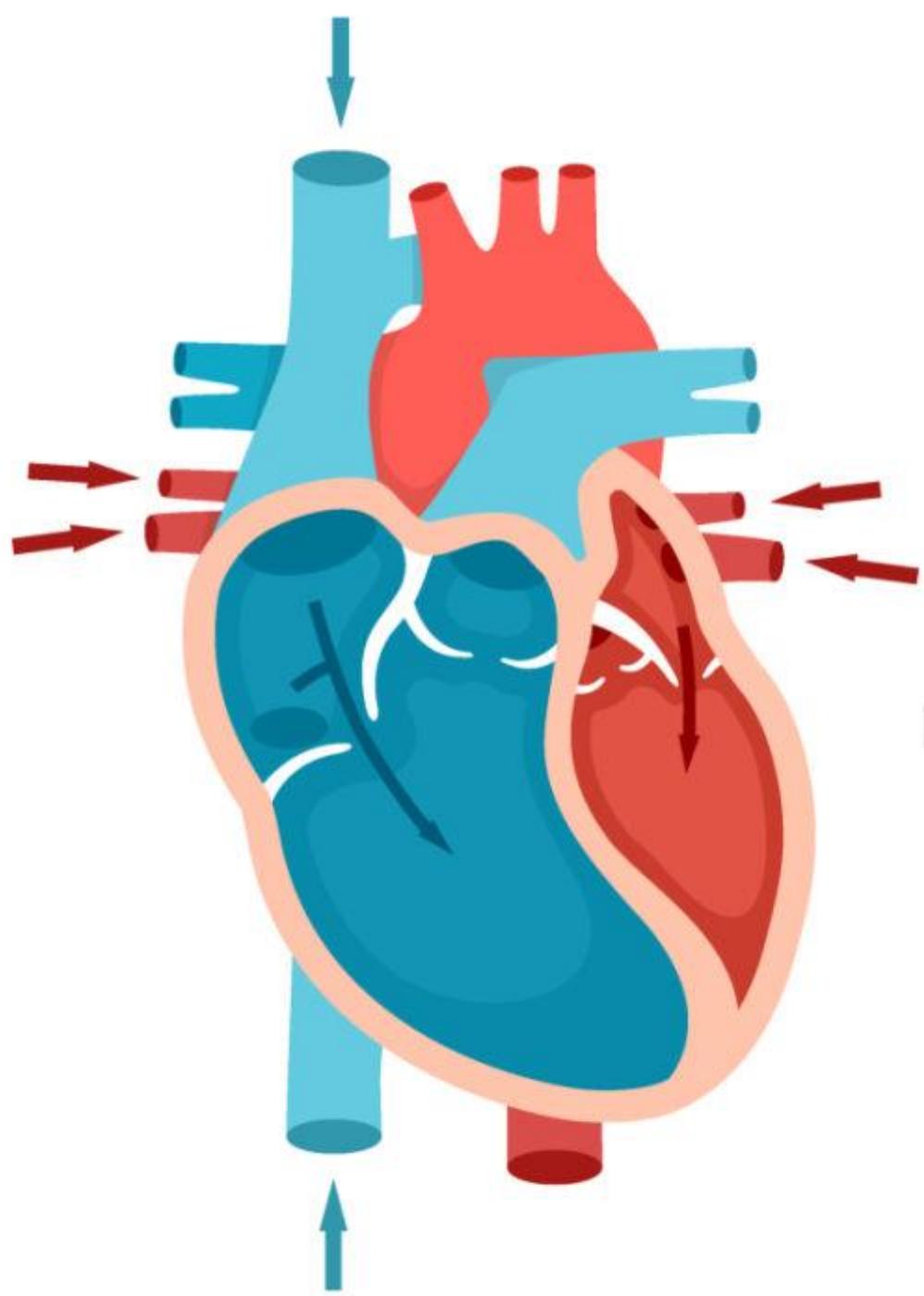
- Ventricular filling continues at a **slower rate during diastasis**, as blood gradually enters the ventricles.

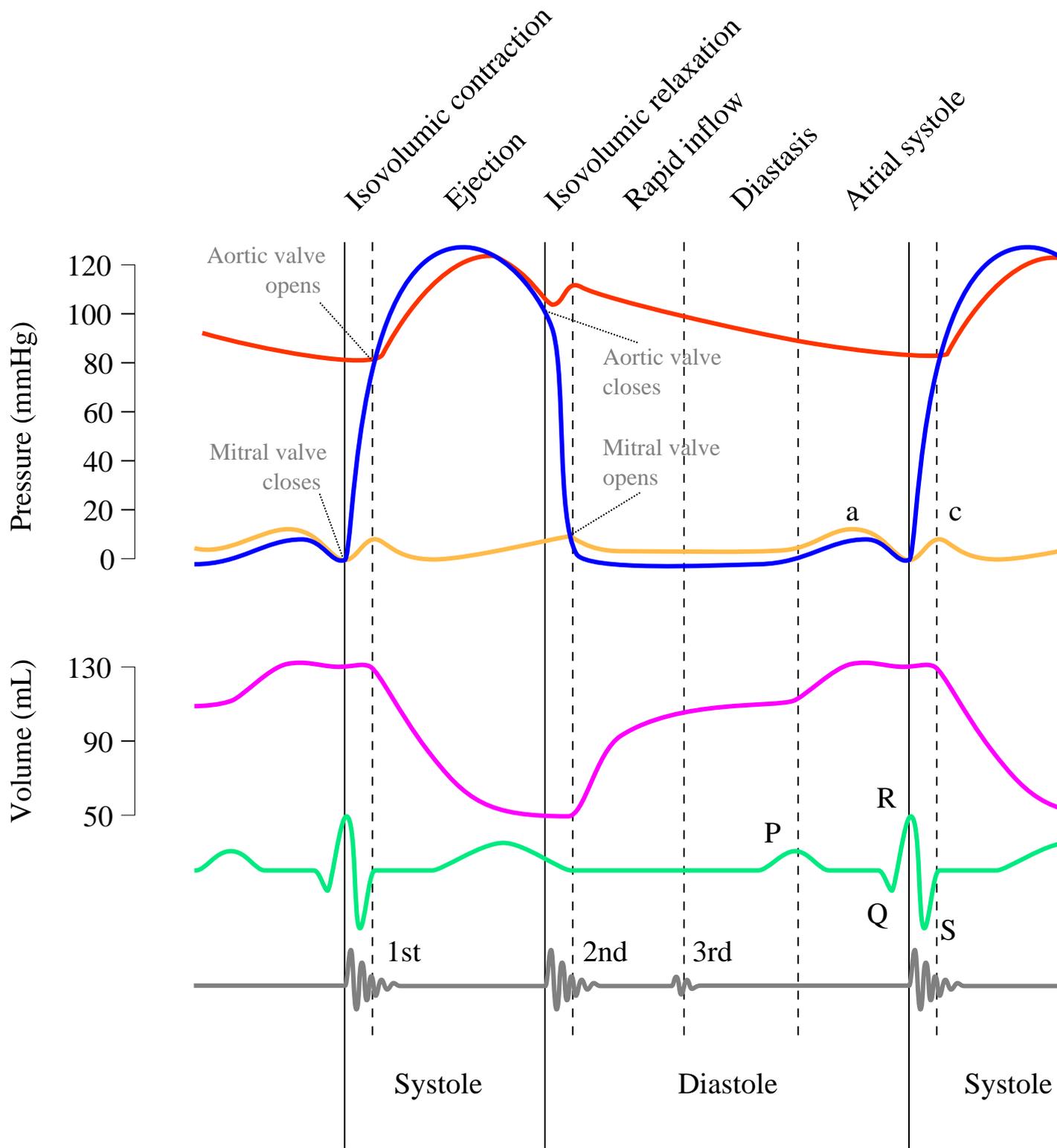
- **Preparation for next cardiac cycle**

- At the end of diastasis, the heart prepares for the **next atrial systole**, and the **cycle repeats with the next heartbeat**.

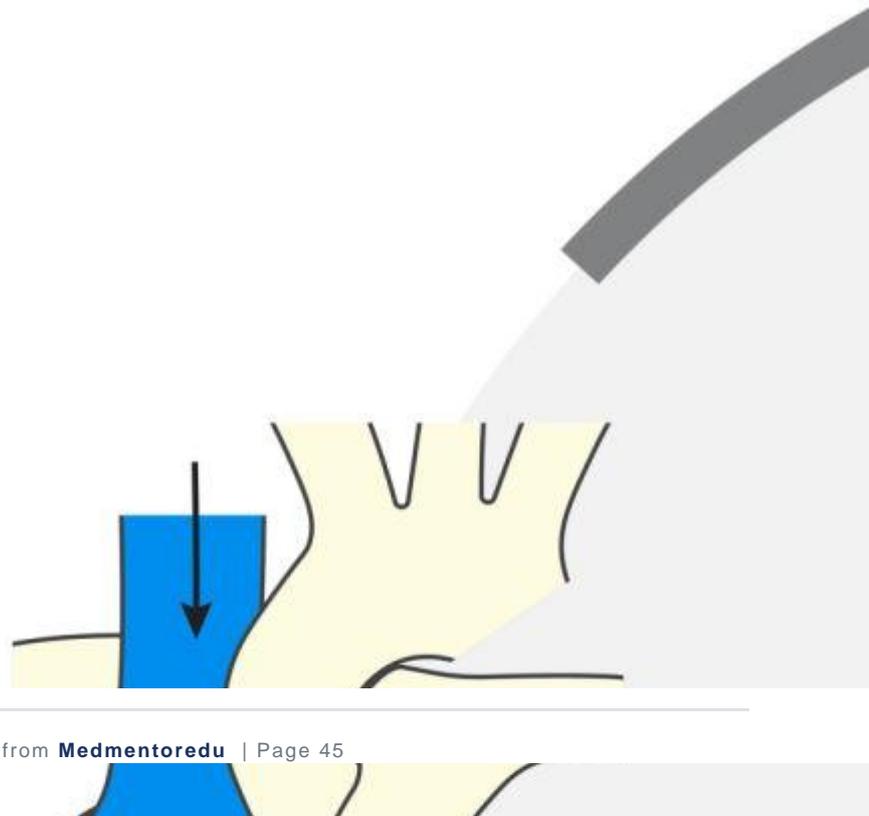
## Time Relations of the Various Events in the Cardiac Cycle

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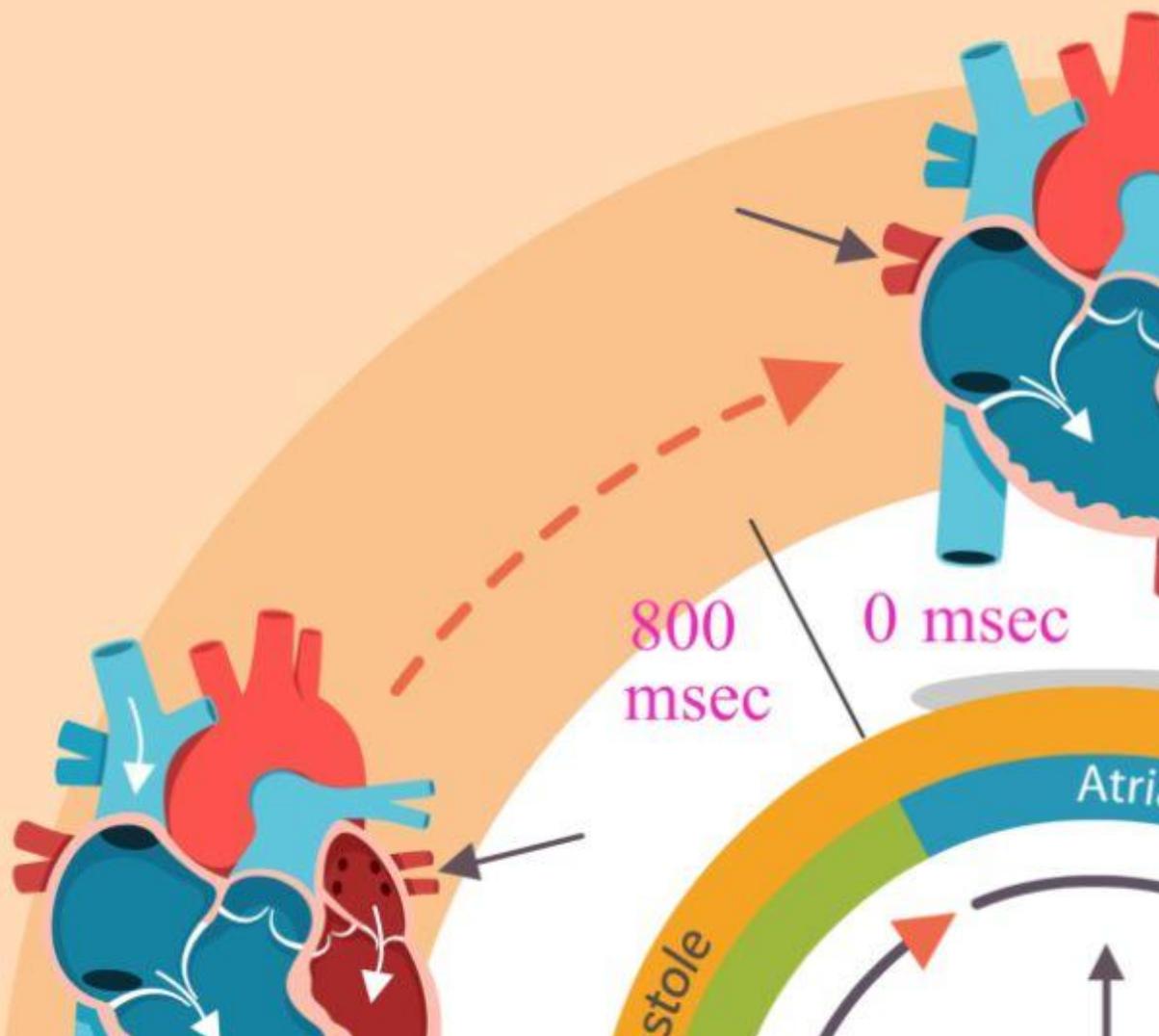




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- **Relative duration of each phase**

- The phases of the cardiac cycle occur in a **precise sequence with specific time relationships**, ensuring coordinated cardiac function.

- At a heart rate of about **75 beats per minute**, the total cardiac cycle lasts approximately **0.8 seconds**.

- **Atrial systole timing**

- **Atrial systole lasts about 0.1 second.**

- During this period, the atria contract and **push the remaining blood into the ventricles**, completing ventricular filling.

- **Ventricular systole timing**

- **Ventricular systole lasts about 0.3 seconds.**

- This phase includes **isovolumetric contraction followed by rapid and reduced ventricular ejection**

- **Ventricular diastole timing**

- **Ventricular diastole lasts about 0.5 seconds.**

- During this time, the ventricles **relax and fill with blood through rapid filling and diastasis**.

- **Changes during increased heart rate**

- When the **heart rate increases**, the **total duration of the cardiac cycle decreases**.

- The **diastolic period shortens more significantly than systole**, reducing the time available for ventricular filling.

- **Importance for ventricular filling**

- Adequate diastolic duration is important for **proper ventricular filling and optimal cardiac output**, especially during conditions such as **exercise or tachycardia**.