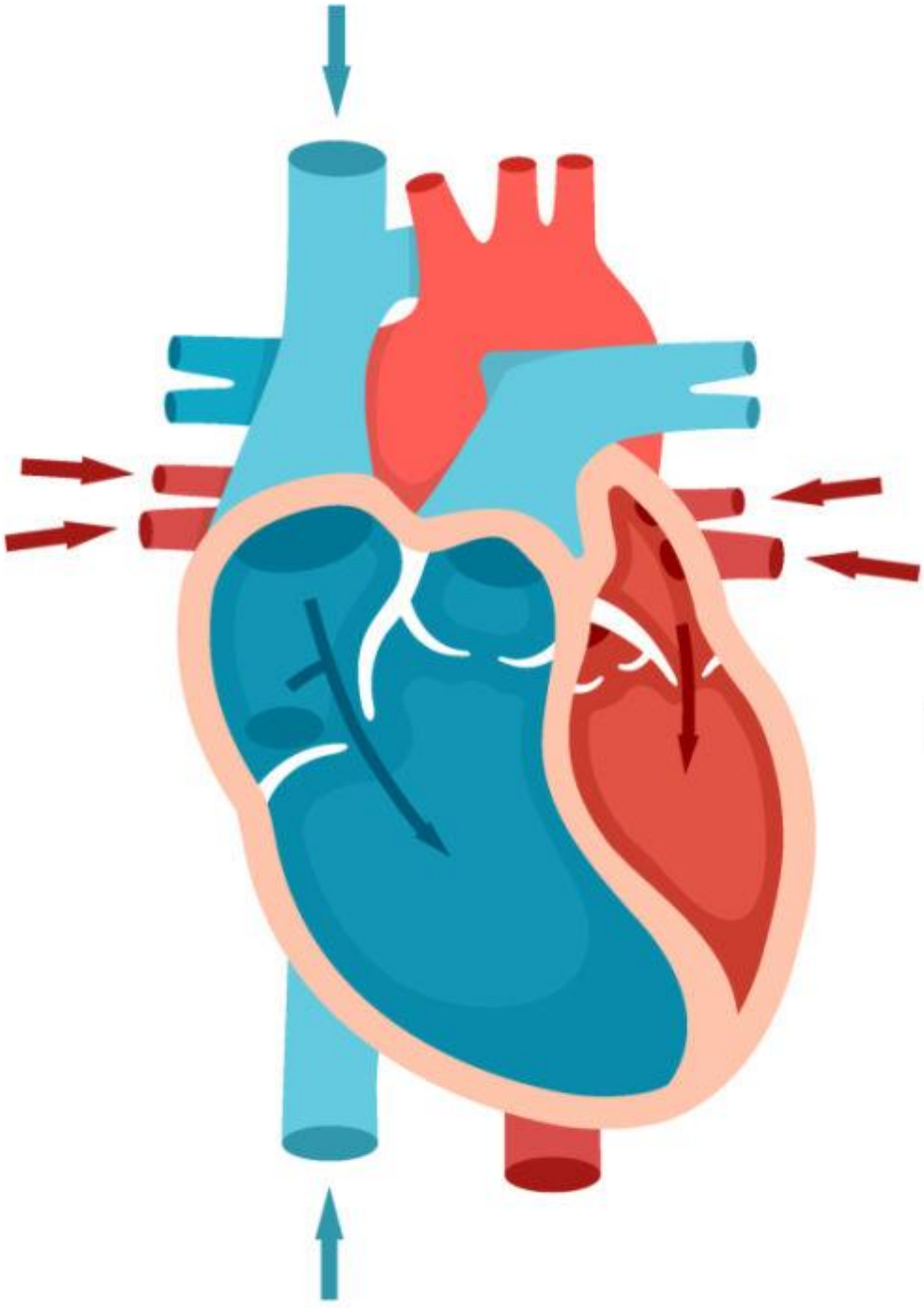
MEDICAL EDUCATION RESOURCE

Cardiac Cycle

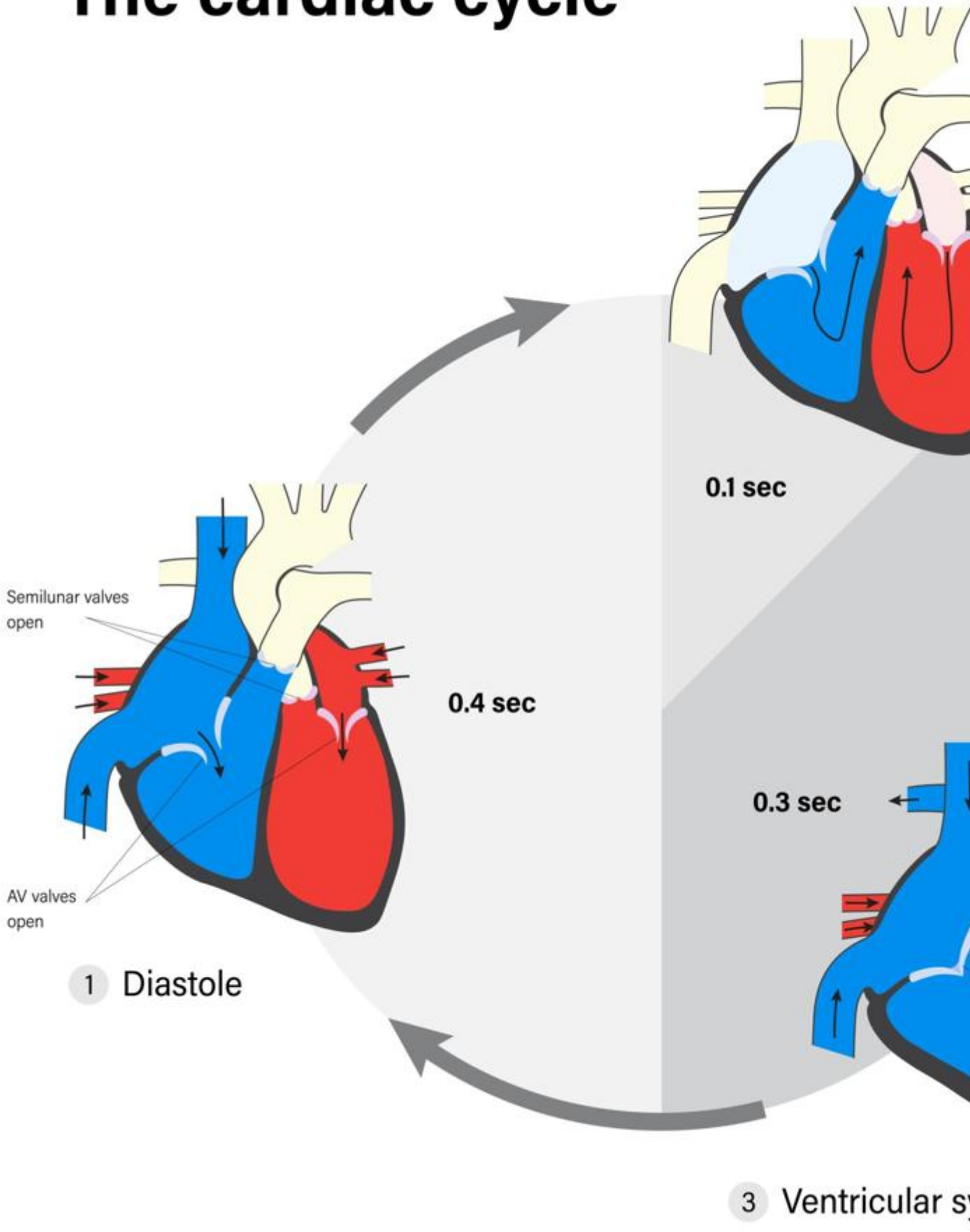
Cardiac Cycle

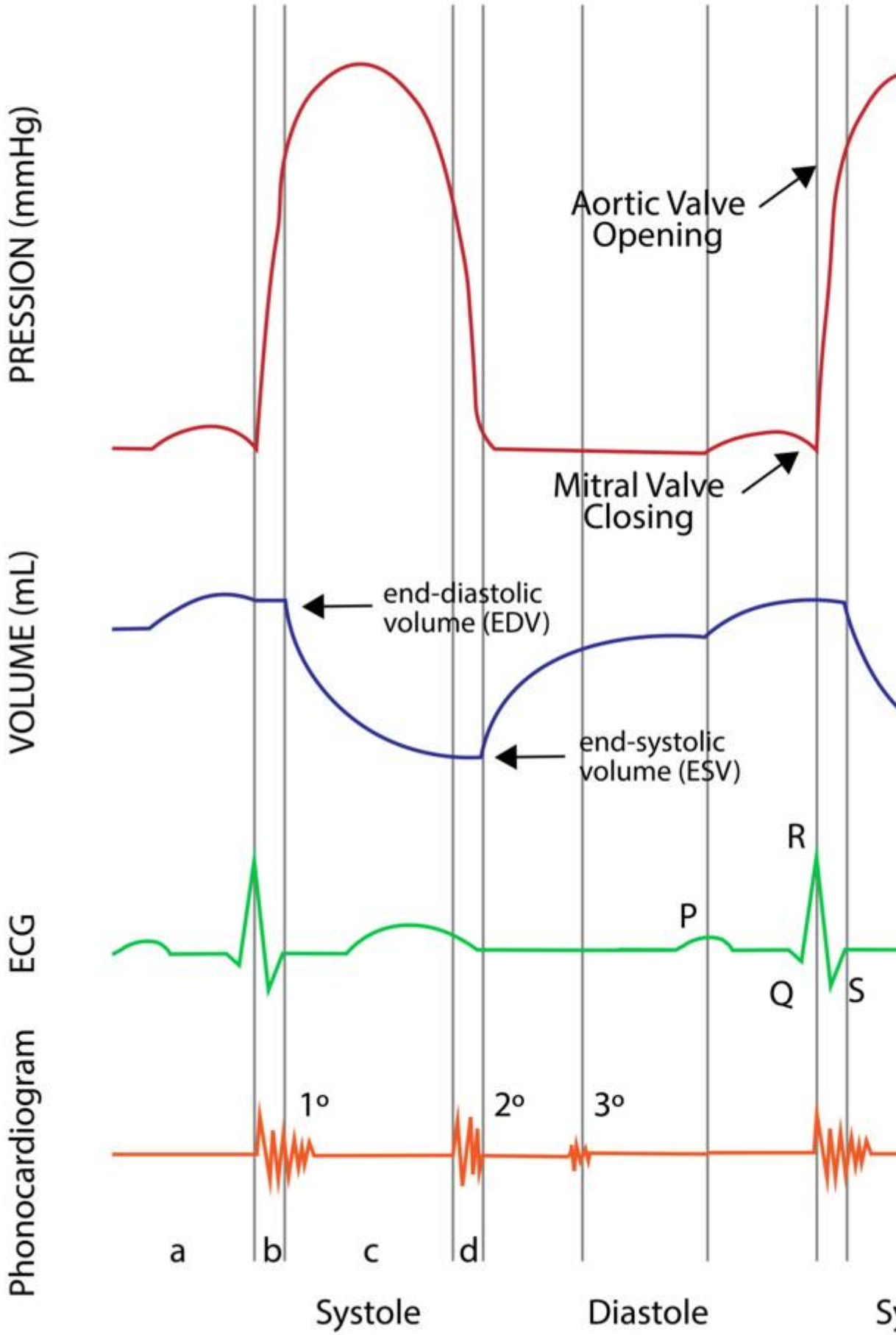
Introduction

CA



The cardiac cycle




PRESSION (mmHg)
Aortic Valve Opening
Mitral Valve Closing
VOLUME (mL)
end-diastolic volume (EDV)
end-systolic volume (ESV)
ECG
R
P
Q
S
Phonocardiogram
1°
2°
3°
a
b
c
d
Systole
Diastole

• **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.

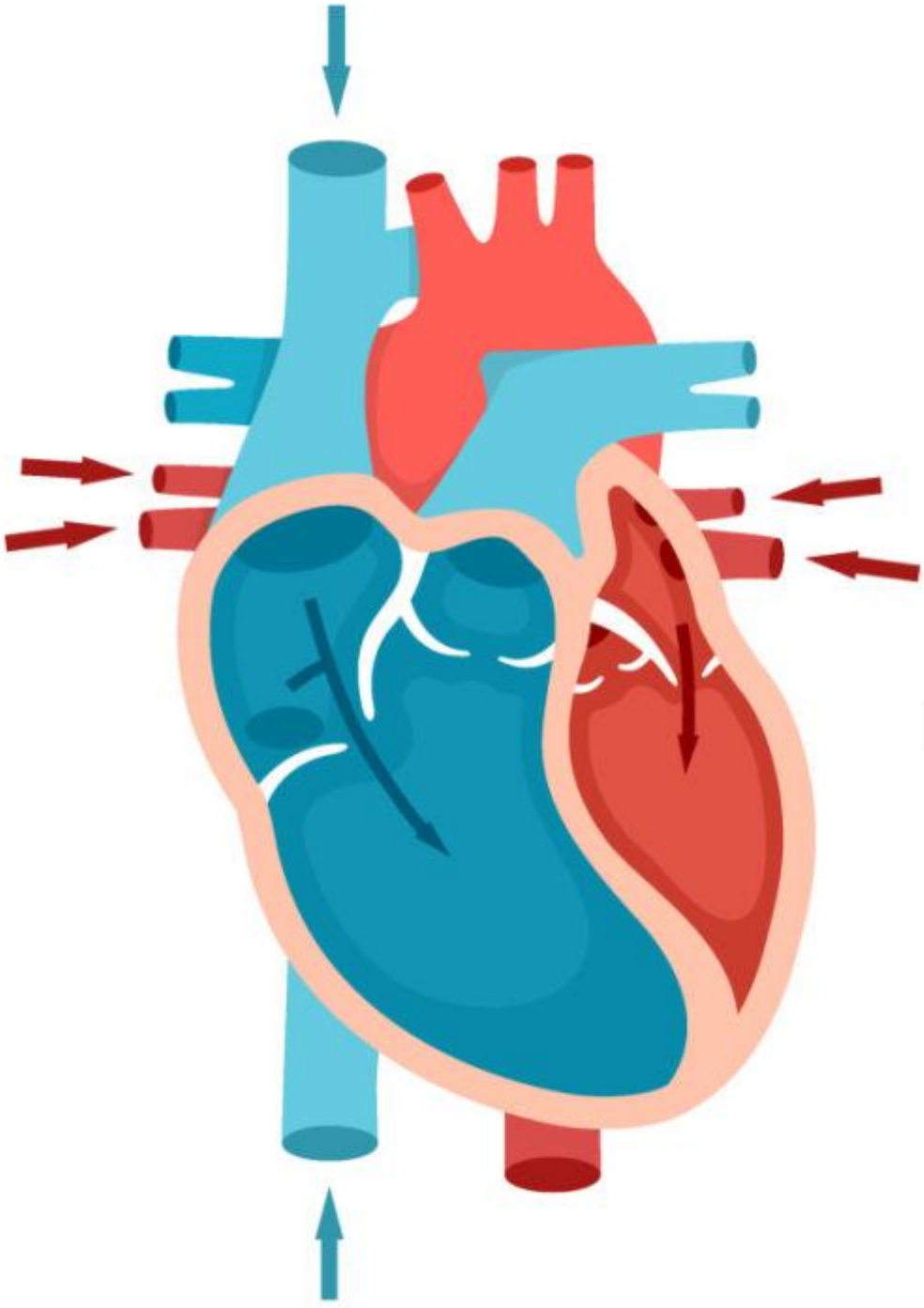
• **Importance in maintaining effective circulation**
• The coordinated events of the cardiac cycle ensure **efficient filling of the heart chambers and effective pumping of blood into the pulmonary and systemic circulation**.

• **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**.

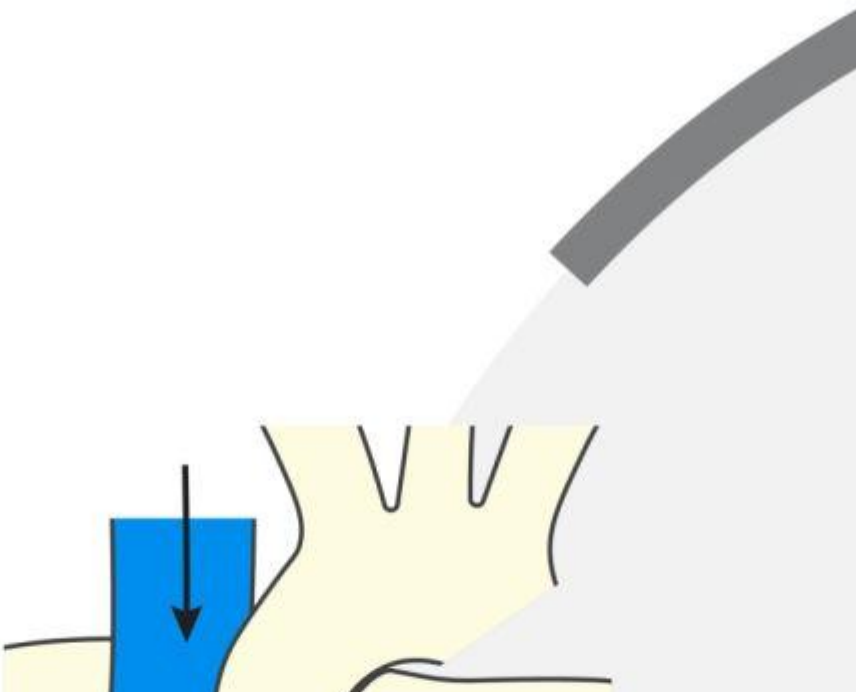
Cardiac Cycle Time

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The cardiac

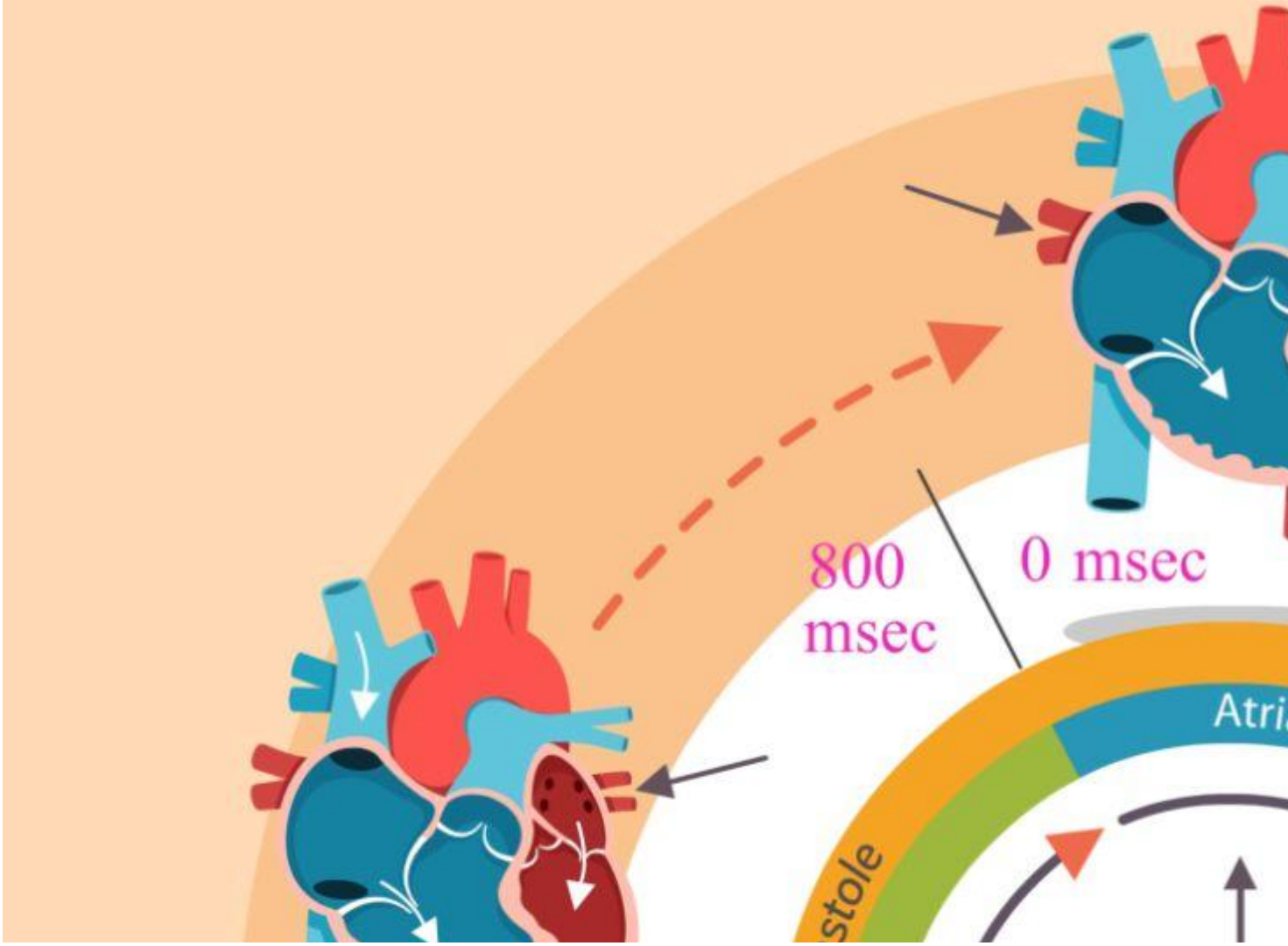


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• **Duration of one cardiac cycle at normal heart rate**
• At a normal resting heart rate of **about 75 beats per minute**, one cardiac cycle lasts approximately **0.8 seconds**.

• **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**.

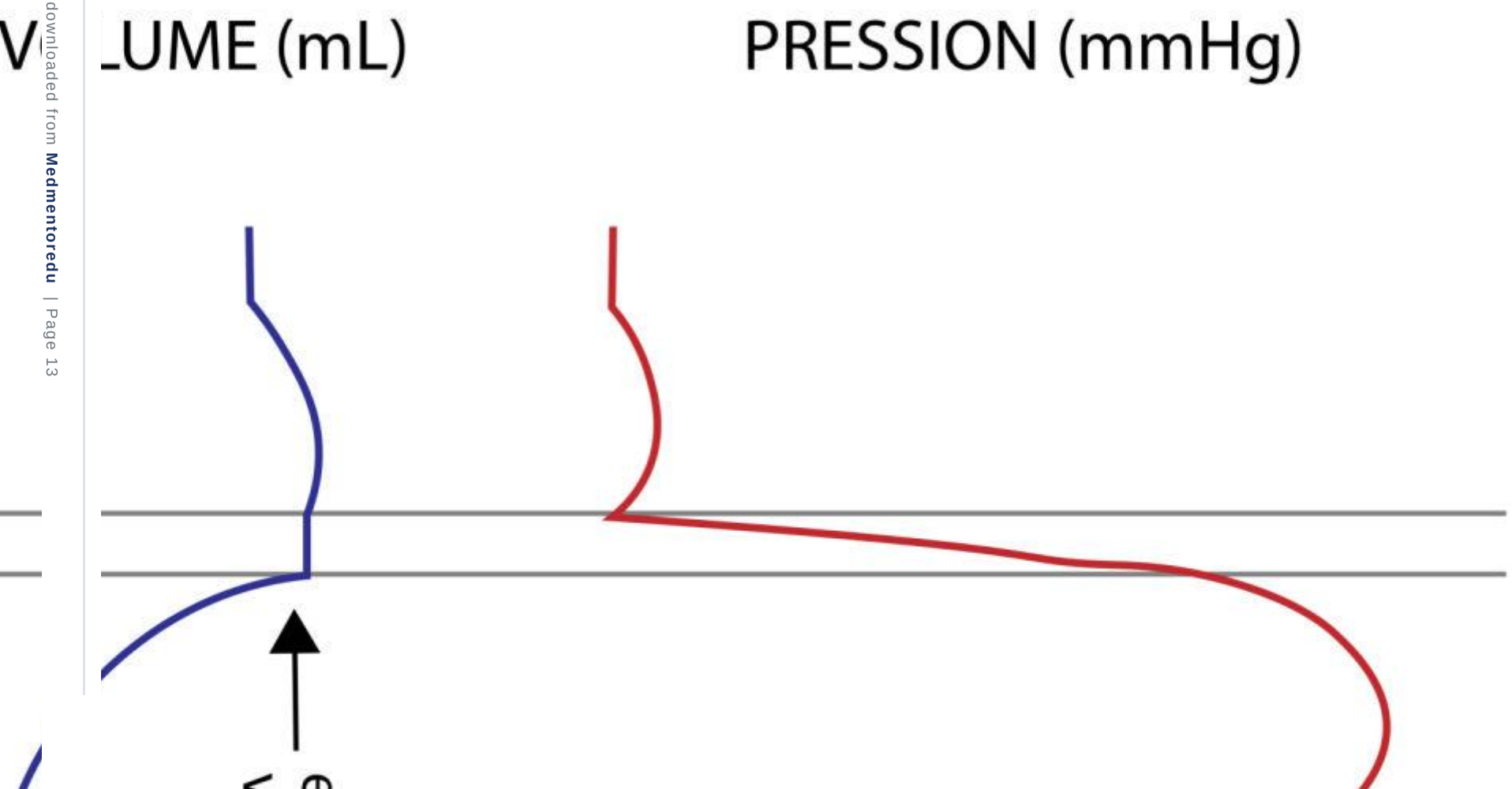
• **Duration of ventricular systole**
• Ventricular systole lasts about **0.3 seconds**, during which **blood is ejected into the pulmonary artery and aorta**.

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

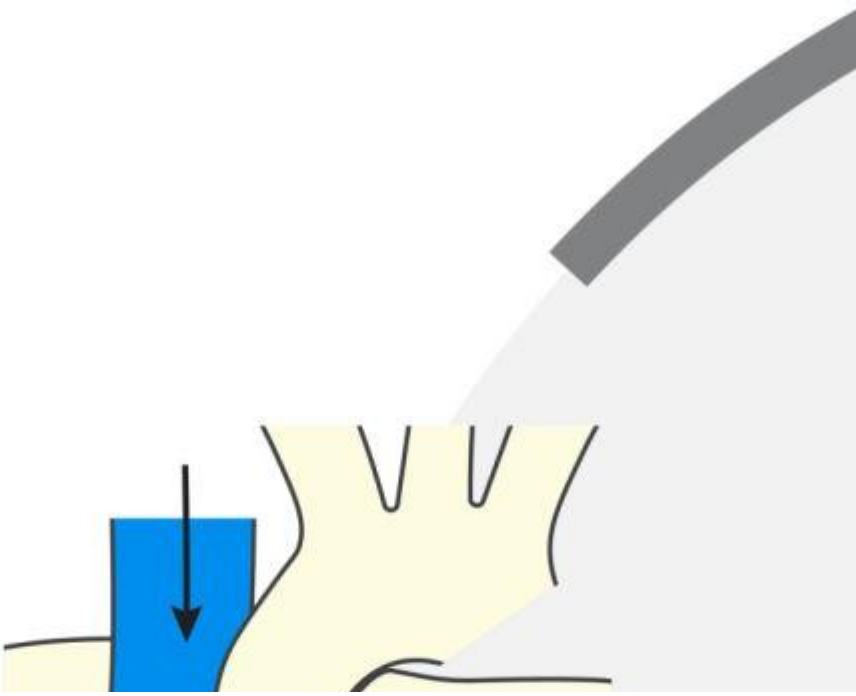
• **Variation with changes in heart rate**
• With **increased heart rate**, the **duration of diastole shortens more than systole**, which may reduce the time available for **ventricular filling and coronary perfusion**.

Interrelations of the Various Events in the Cardiac Cycle

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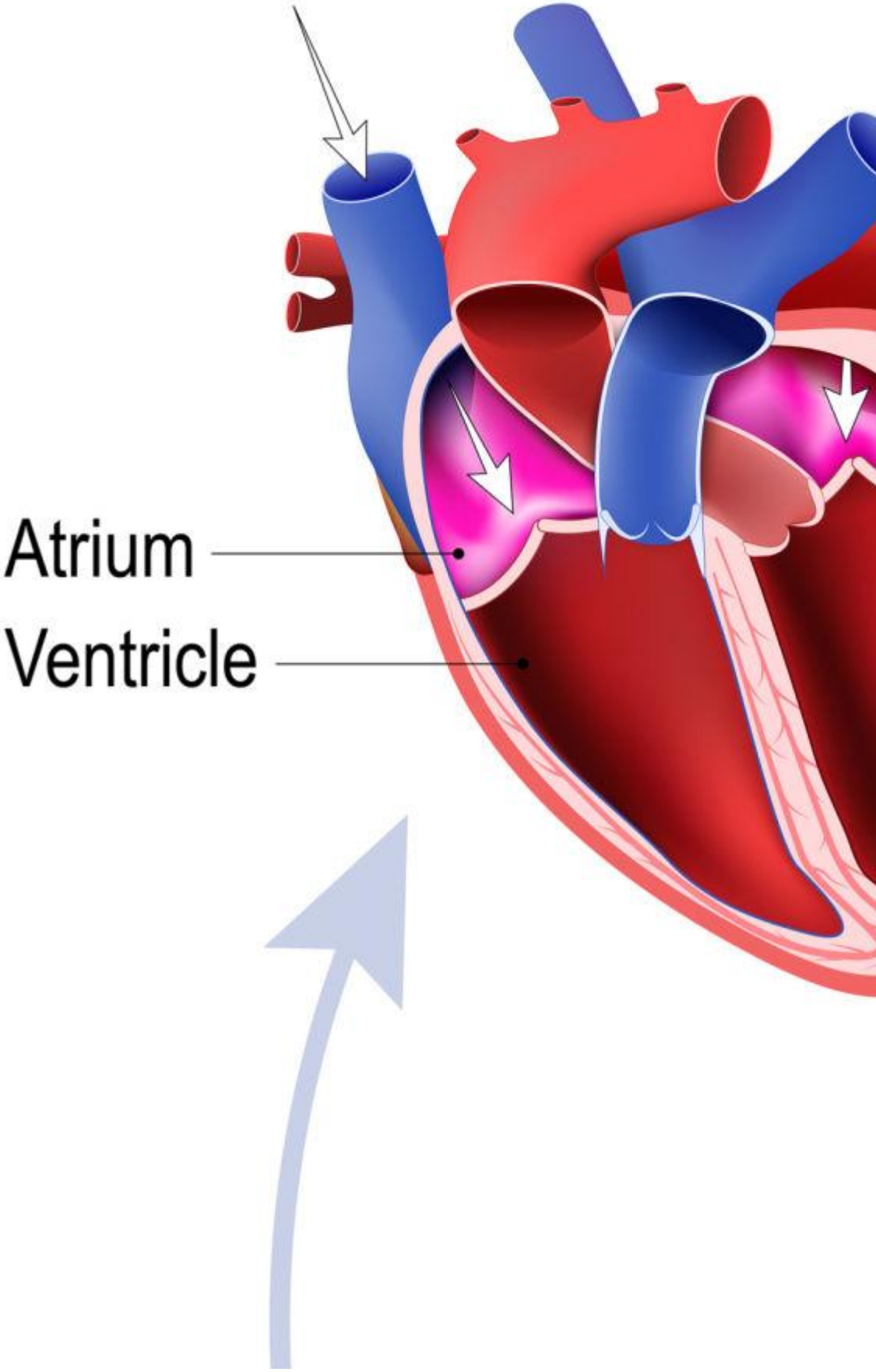


The cardiac



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Atrium
Ventricle

• **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**

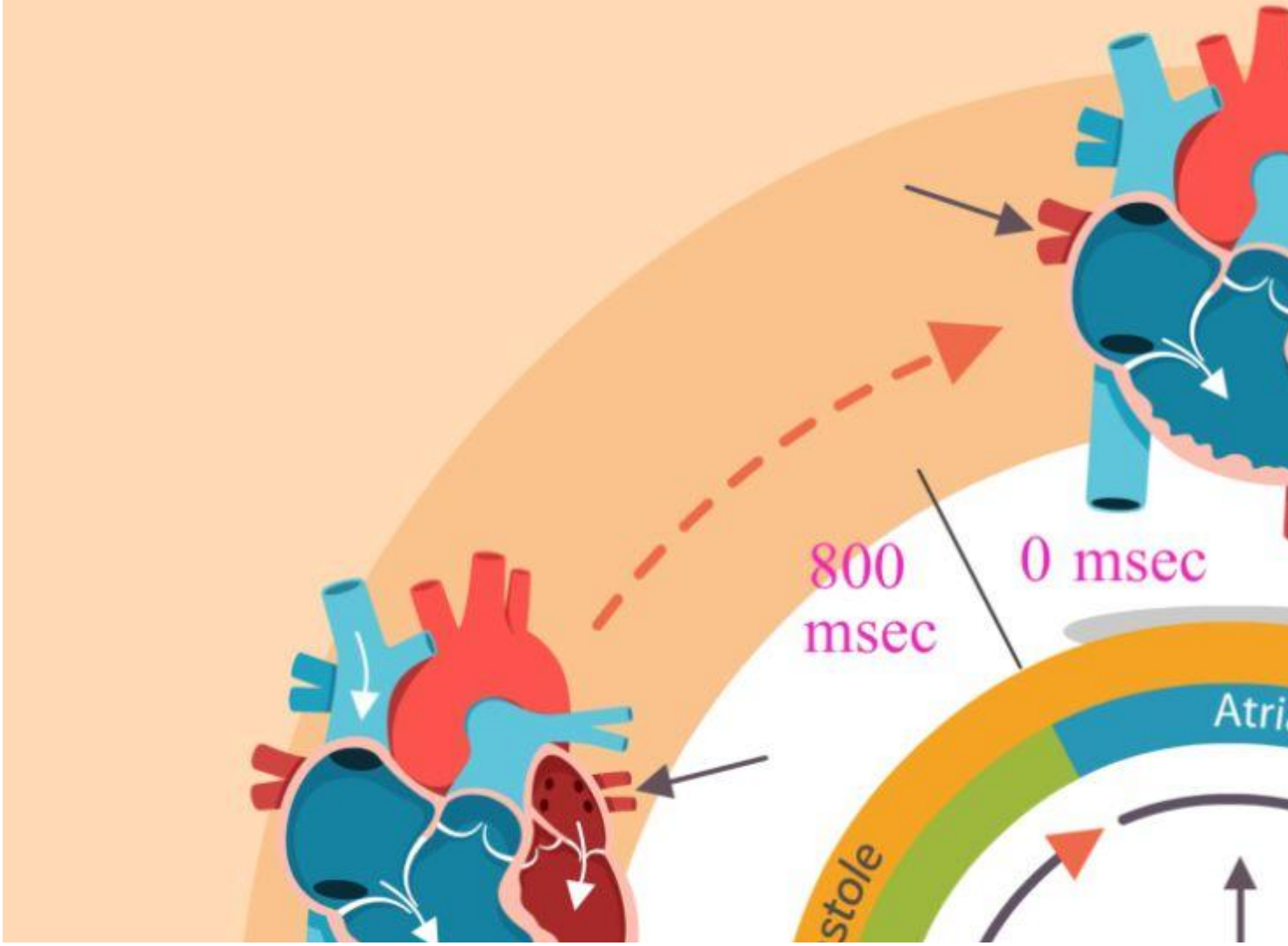
• **Blood flow through chambers**
• Blood flows sequentially from **atria ? ventricles ? great arteries**, ensuring efficient circulation.

• **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

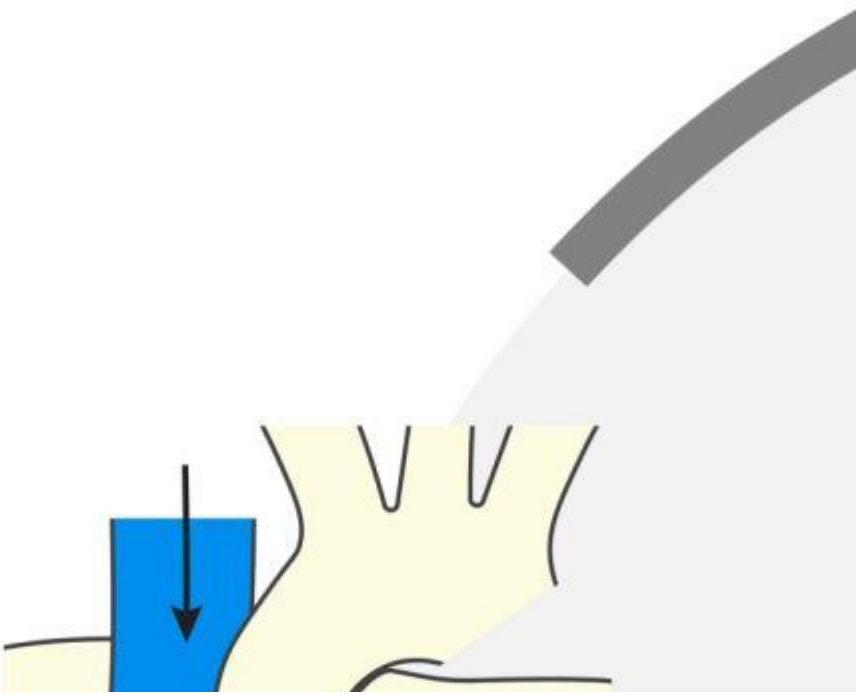
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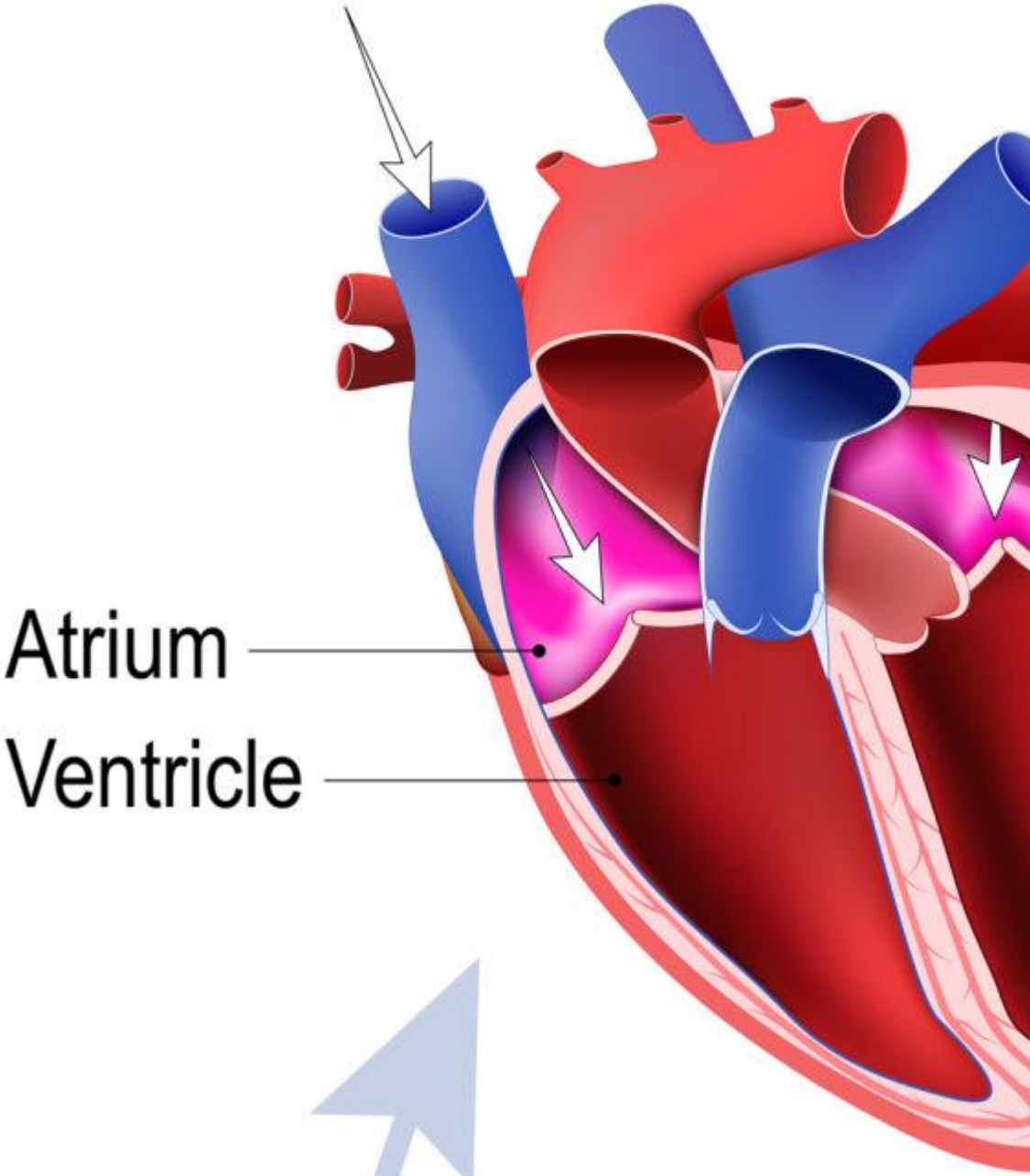
The cardiac



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Atrium
Ventricle

• **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)**.

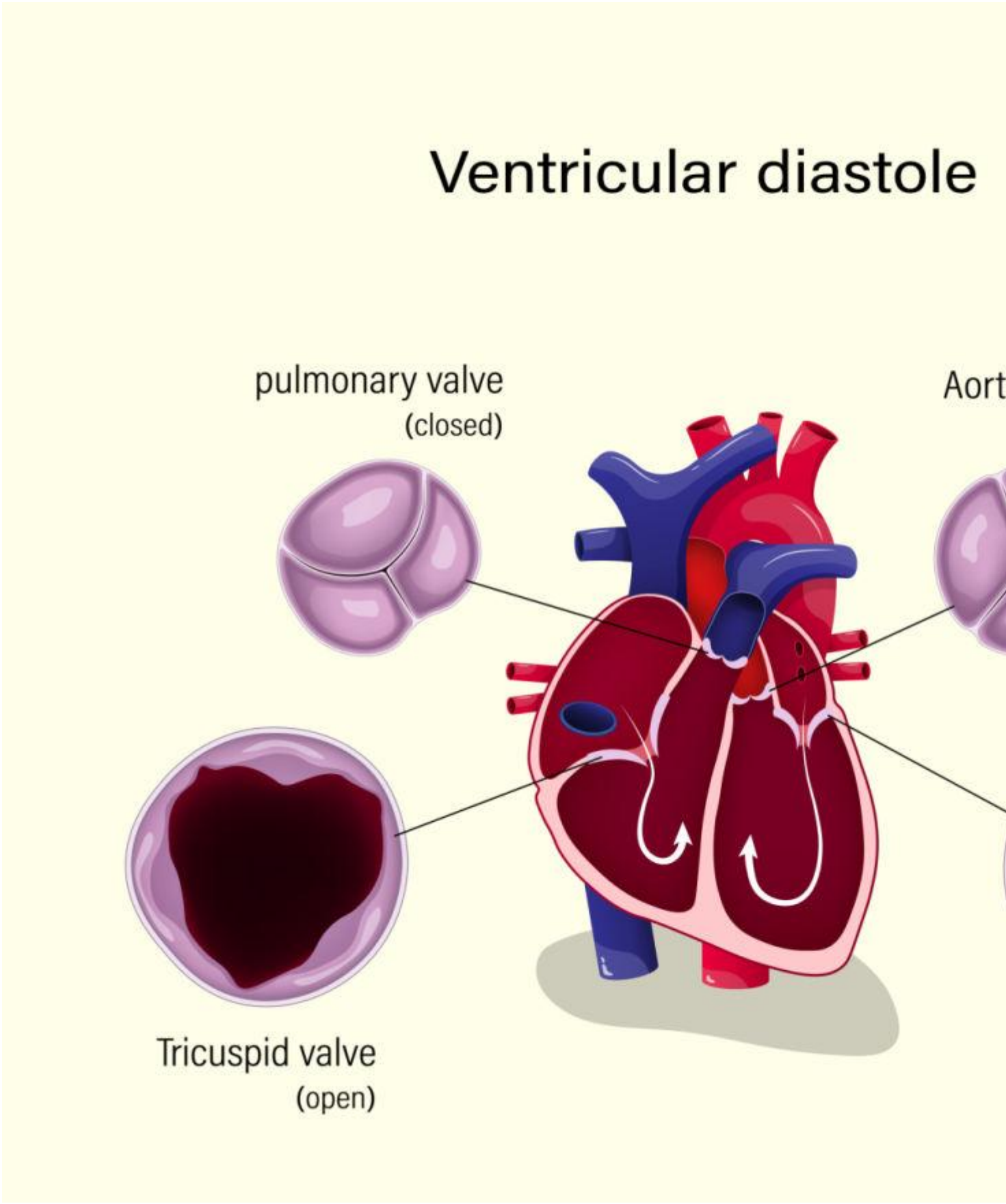
• **Outer ring showing ventricular contraction and relaxation**
• The **outer ring represents ventricular events**, including **ventricular systole and ventricular diastole**.

• **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**.

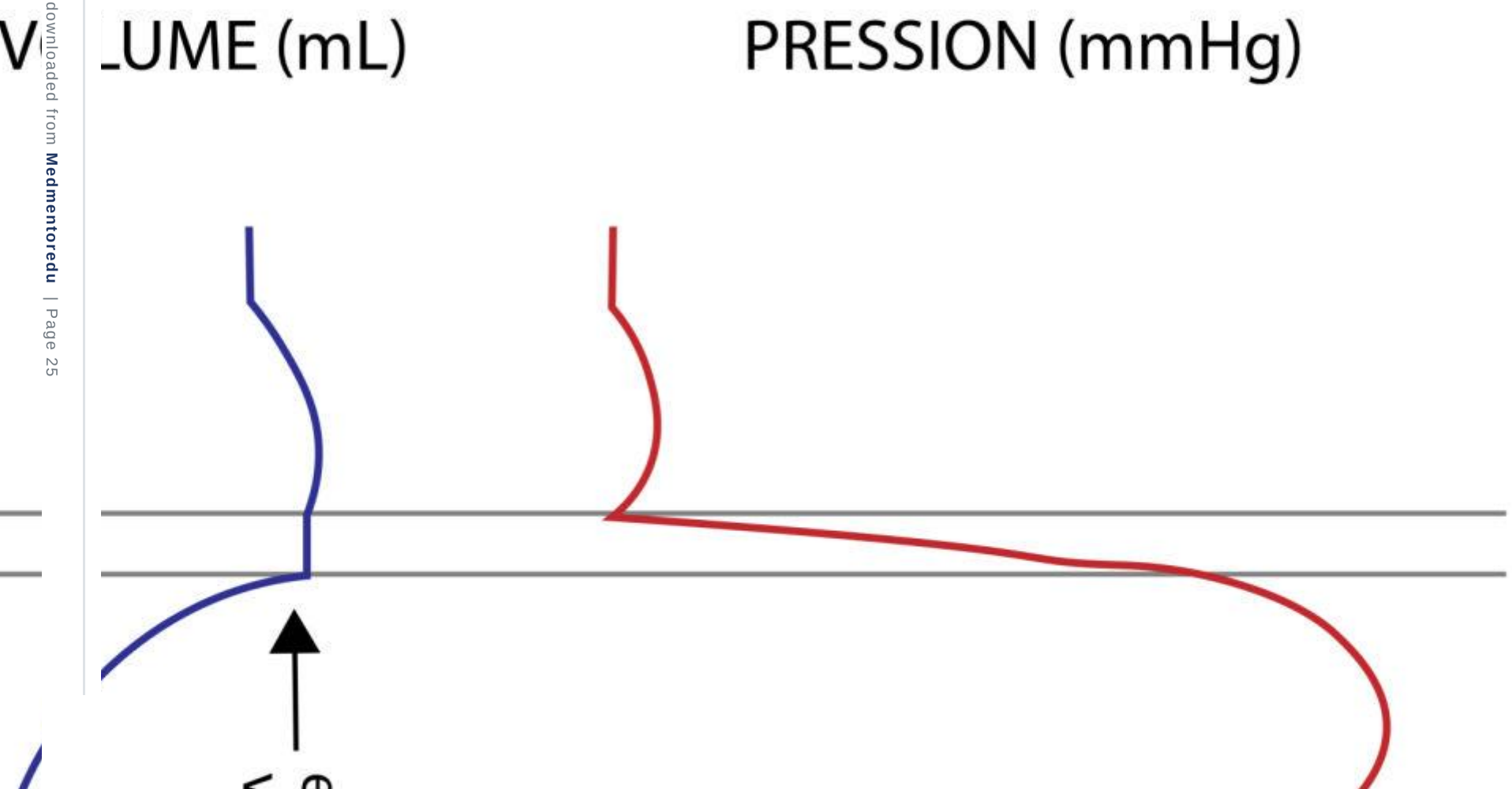
• **Visualization of synchronized cardiac activity**
• This representation helps visualize the **precise coordination between atrial and ventricular activities**, ensuring **efficient filling and pumping of blood during each heartbeat**.

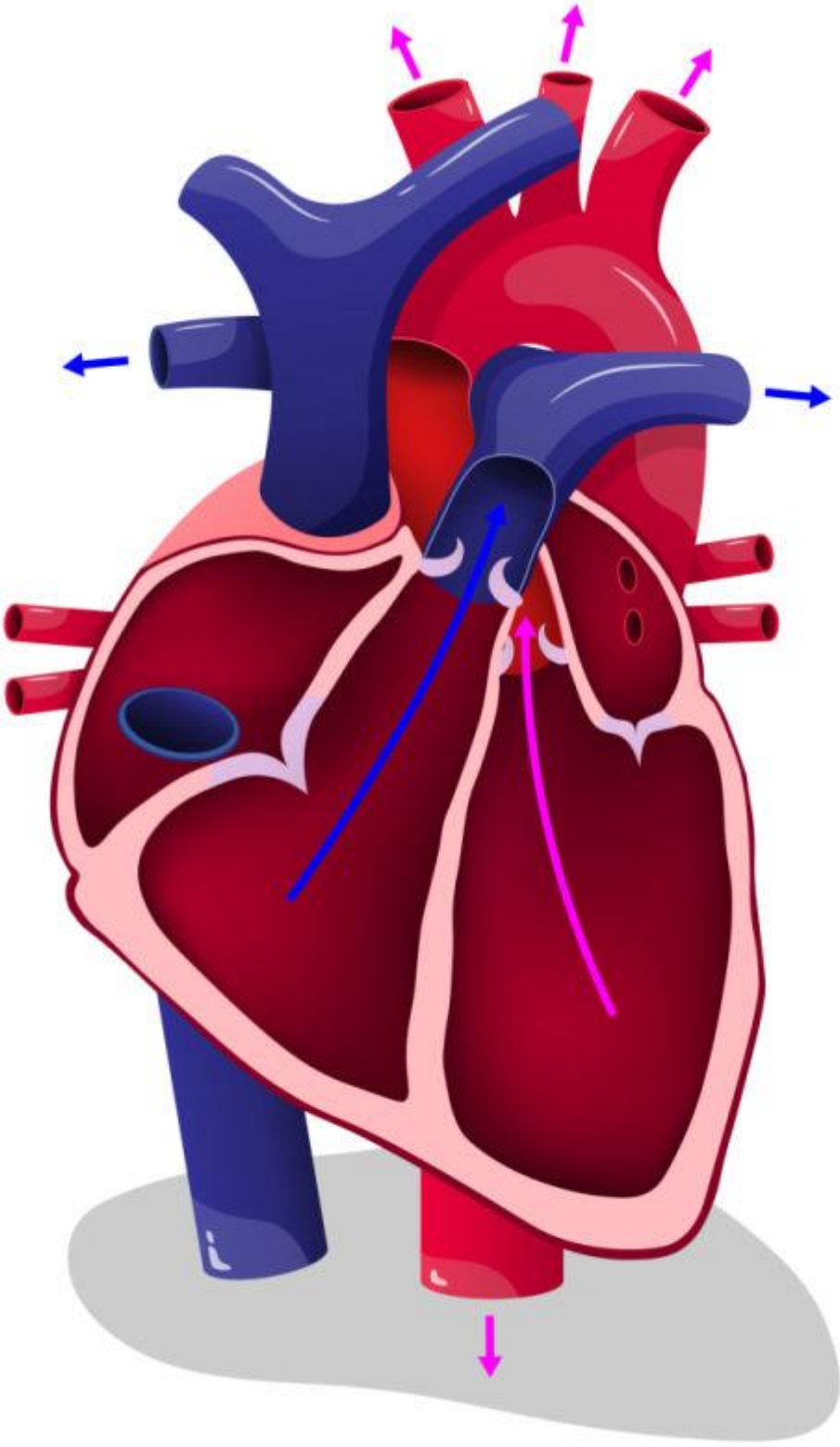
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Ventricular Events in the Cardiac Cycle (Outer Ring)


Ventricular diastole
pulmonary valve
(closed)
Aort
Tricuspid valve
(open)

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• **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**.

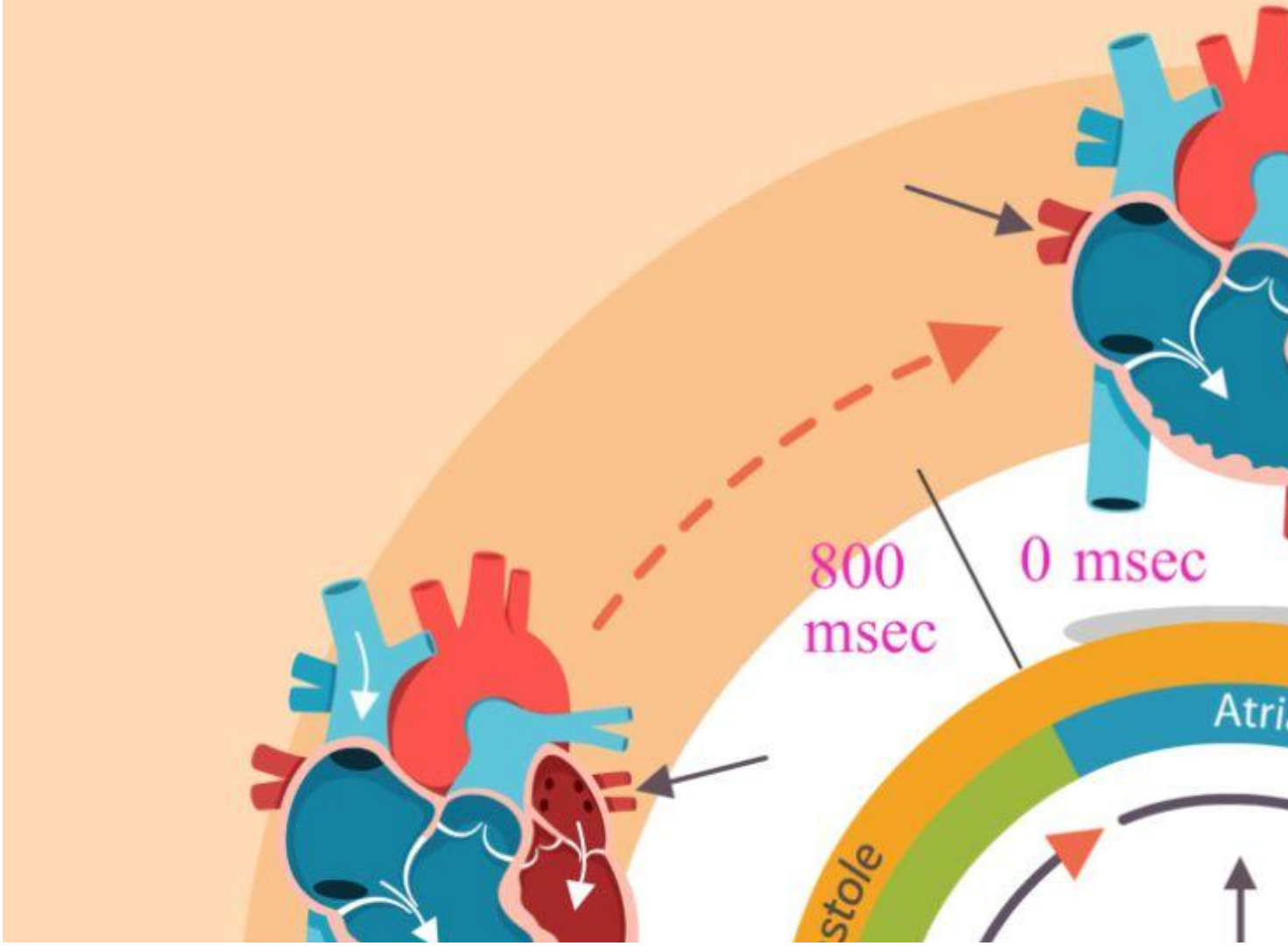
• **Beginning of ventricular ejection**
• Once the semilunar valves open, **blood is ejected from the ventricles into the pulmonary artery and aorta**, marking the **start of the ventricular ejection phase**.

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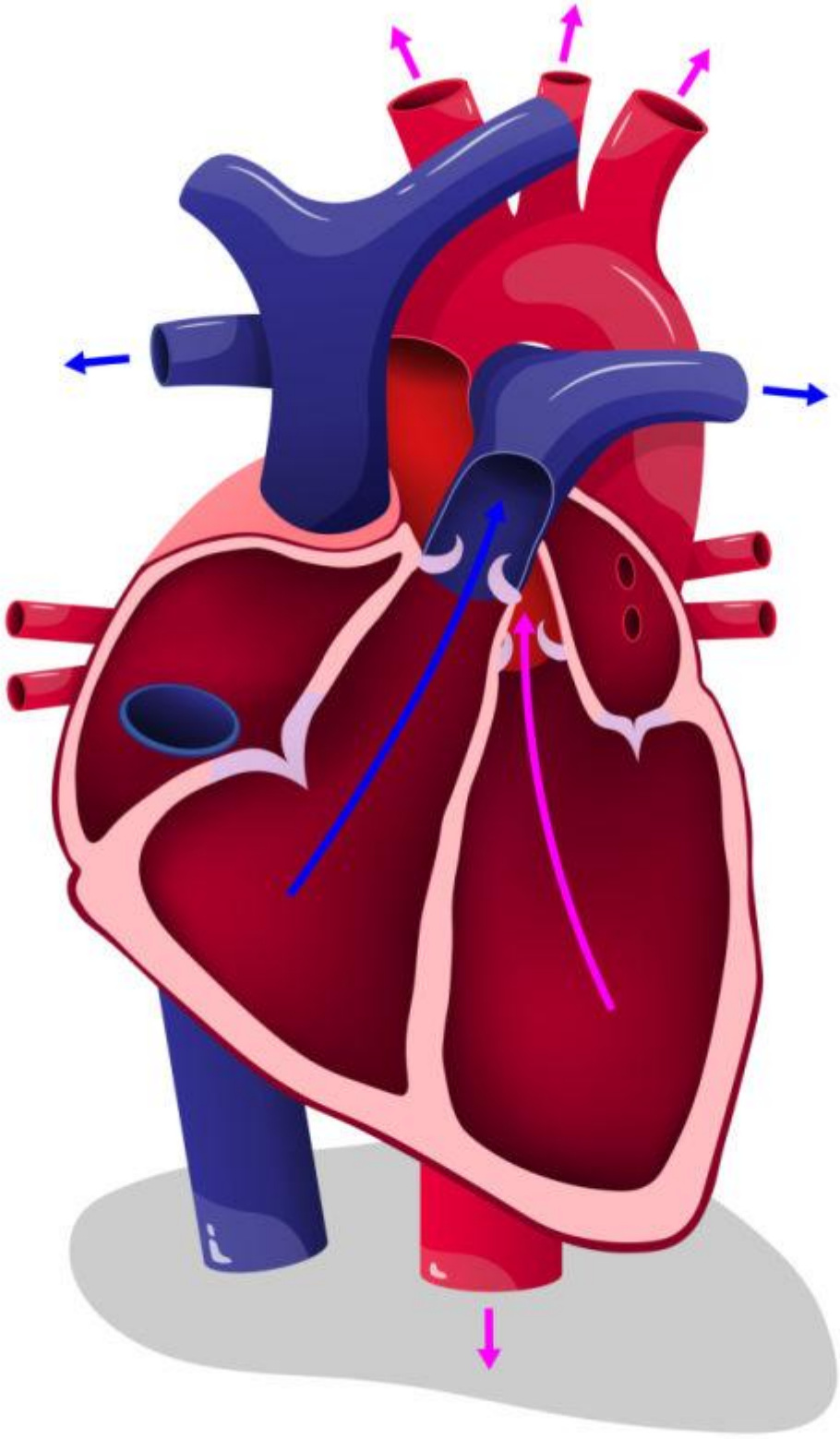
Ventricular Events in the Cardiac Cycle (Outer Ring – Ejection Phases)

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• **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.

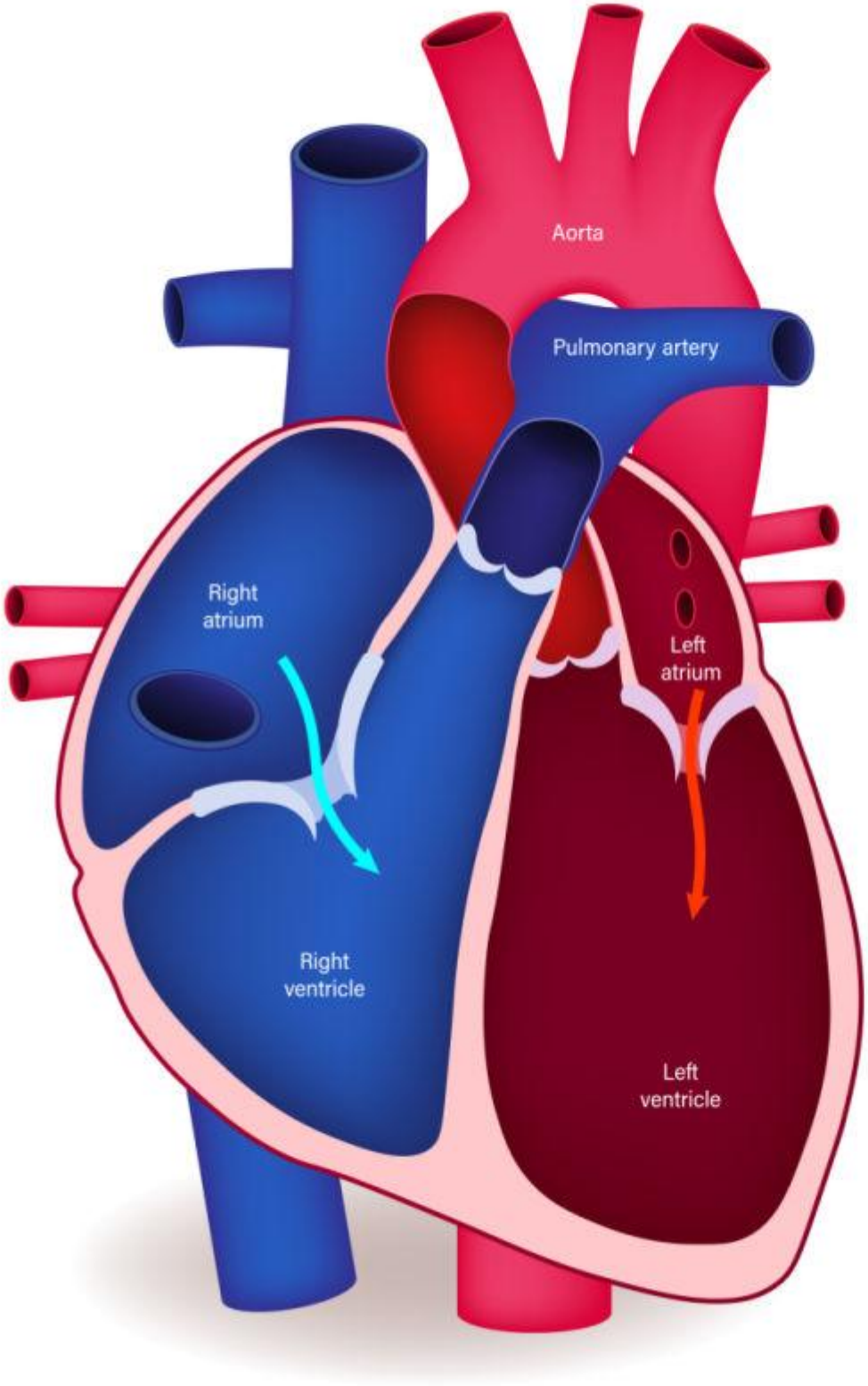
• **Continued ventricular contraction**
• Ventricular muscle fibres **remain contracted throughout the ejection phases**, maintaining the pressure required to push blood into the arteries.

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

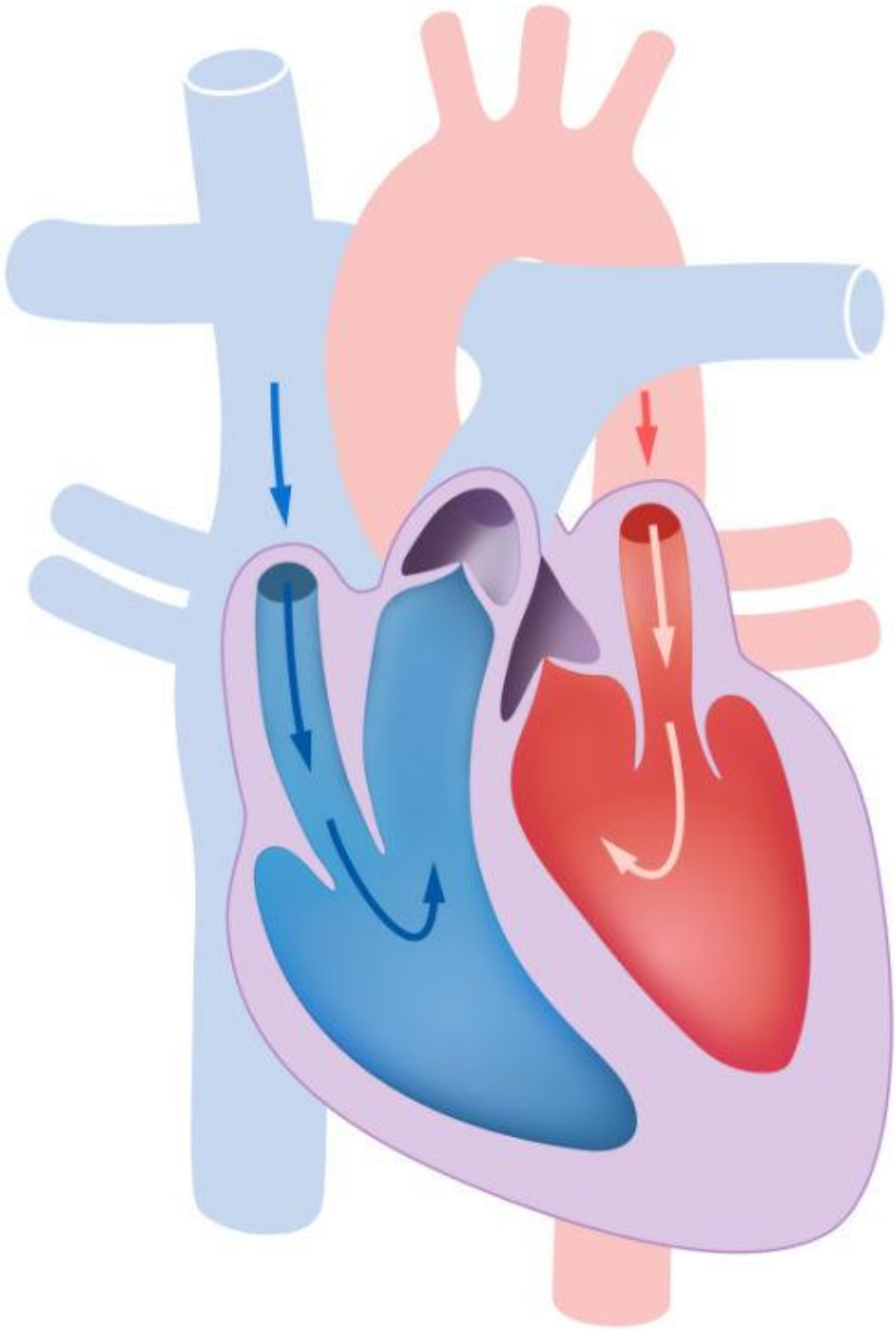
• **Blood flow into aorta and pulmonary artery**
• The **left ventricle pumps oxygenated blood into the aorta**, supplying the systemic circulation.
• The **right ventricle pumps deoxygenated blood into the pulmonary artery**, sending it to the lungs for oxygenation.

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Ventricular Diastole (Outer Ring of the Cardiac Cycle)


Aorta
Pulmonary artery
Right atrium
Left atrium
Right ventricle
Left ventricle

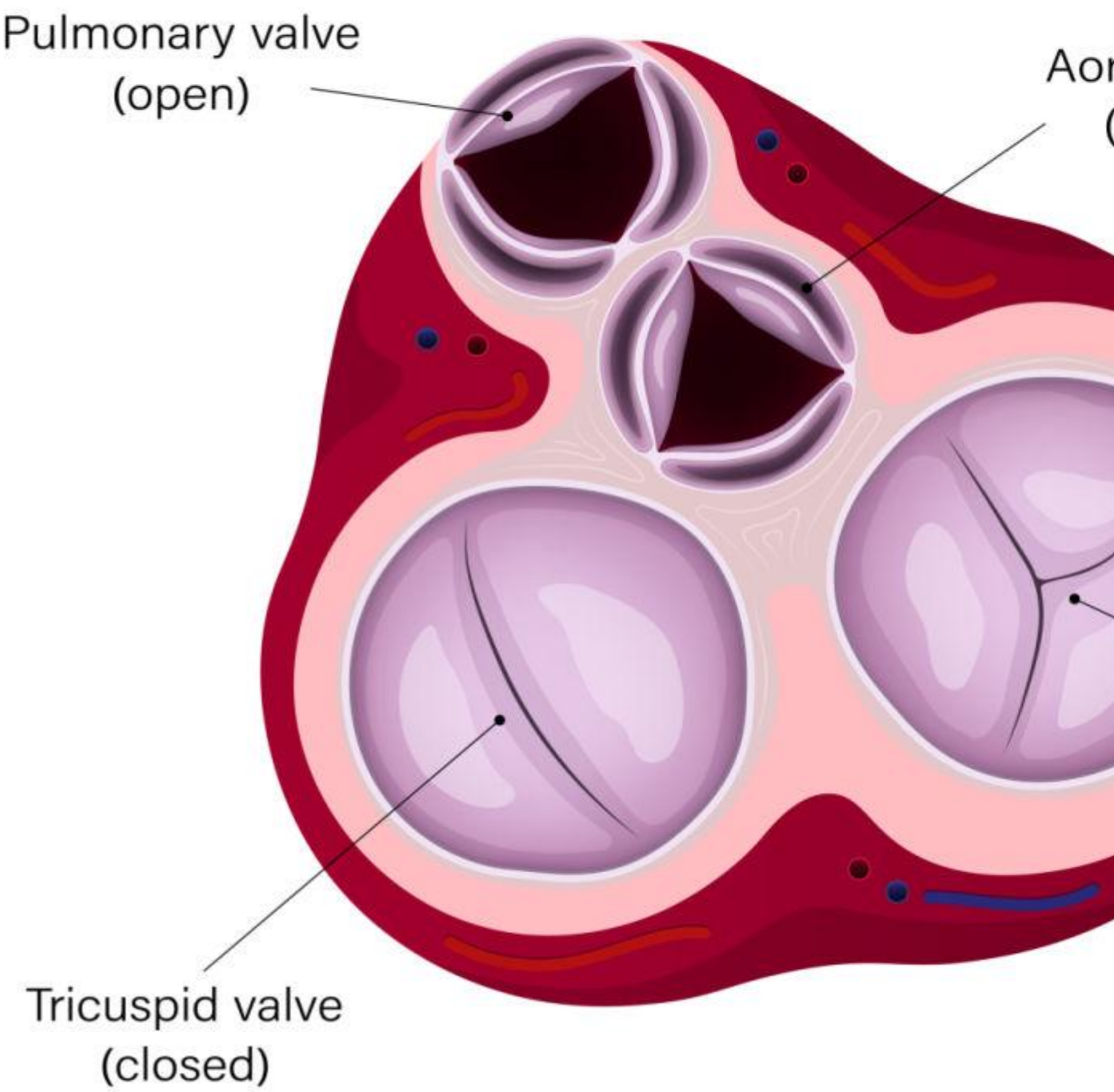
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Atrial

Ventricular systole



• **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**.

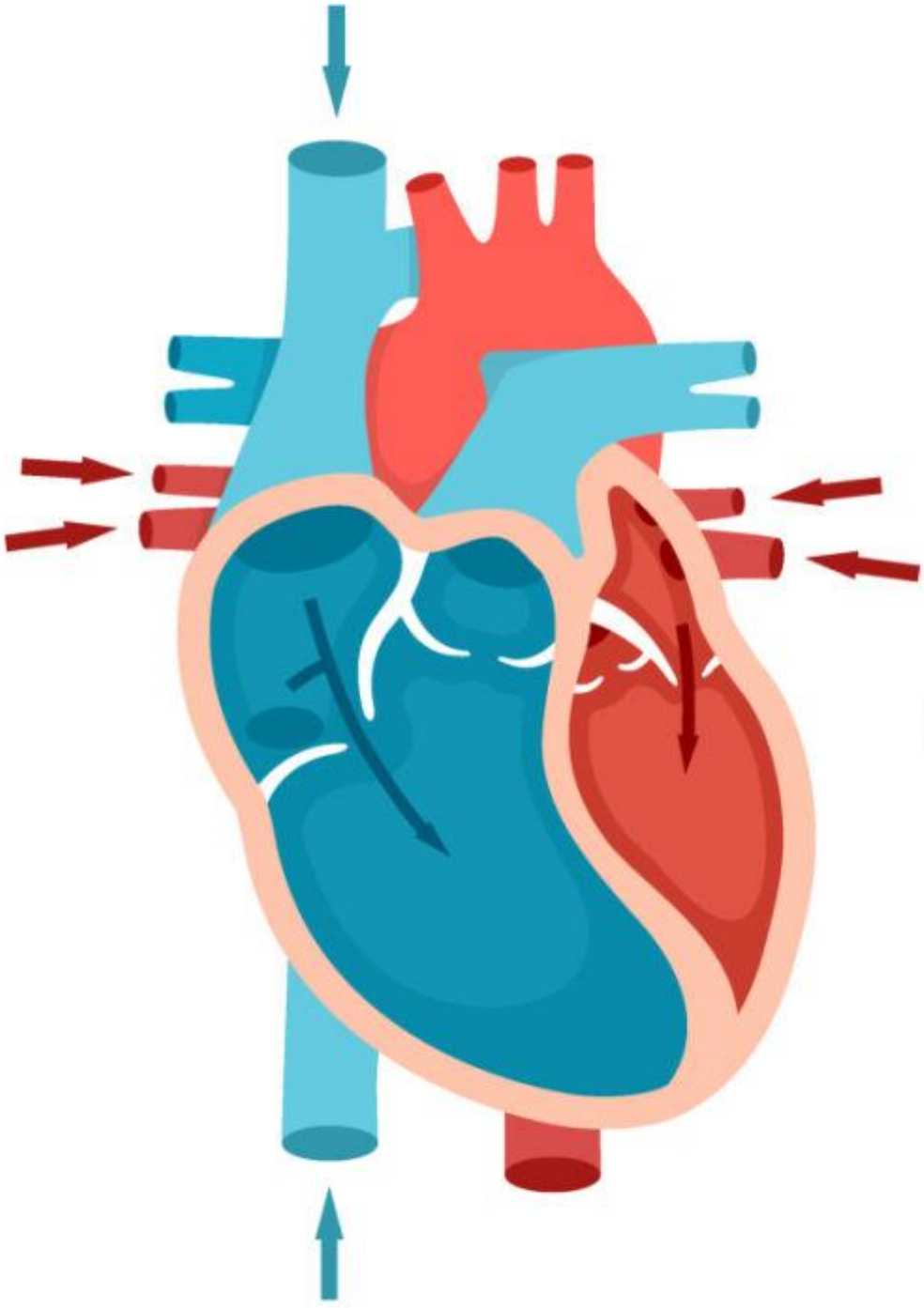
• **Rapid ventricular filling**
• Blood accumulated in the atria during ventricular systole **flows rapidly into the ventricles**, producing the **rapid filling phase**.

• **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**.

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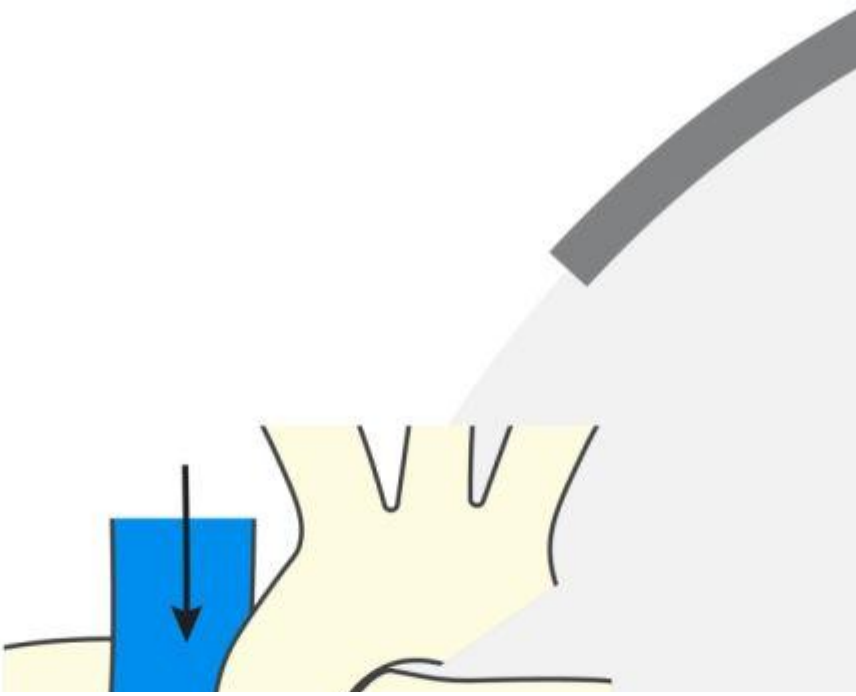
Summary of the Sequence of Events in Cardiac Cycle

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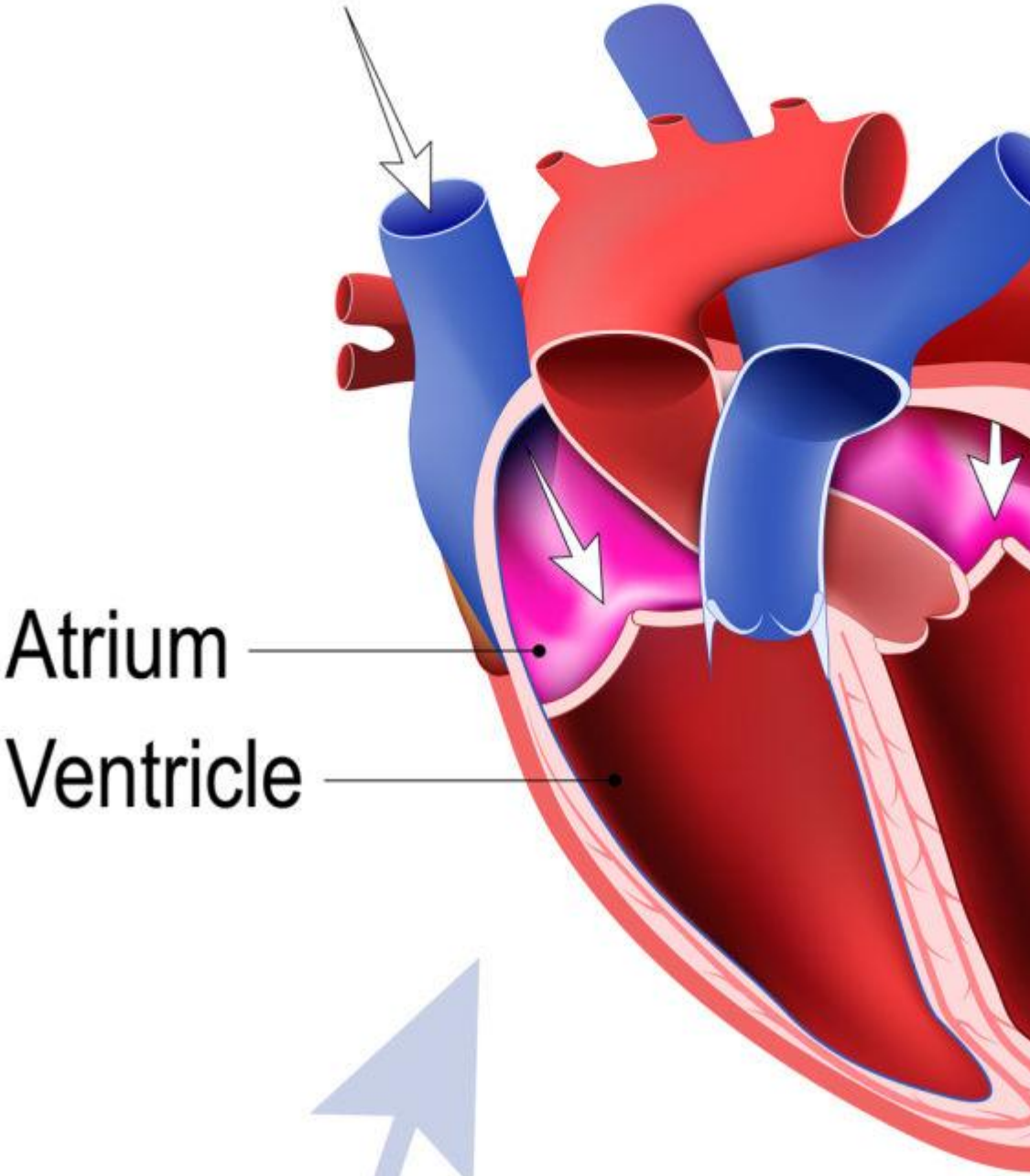


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The cardiac






Atrium
Ventricle

• **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**.

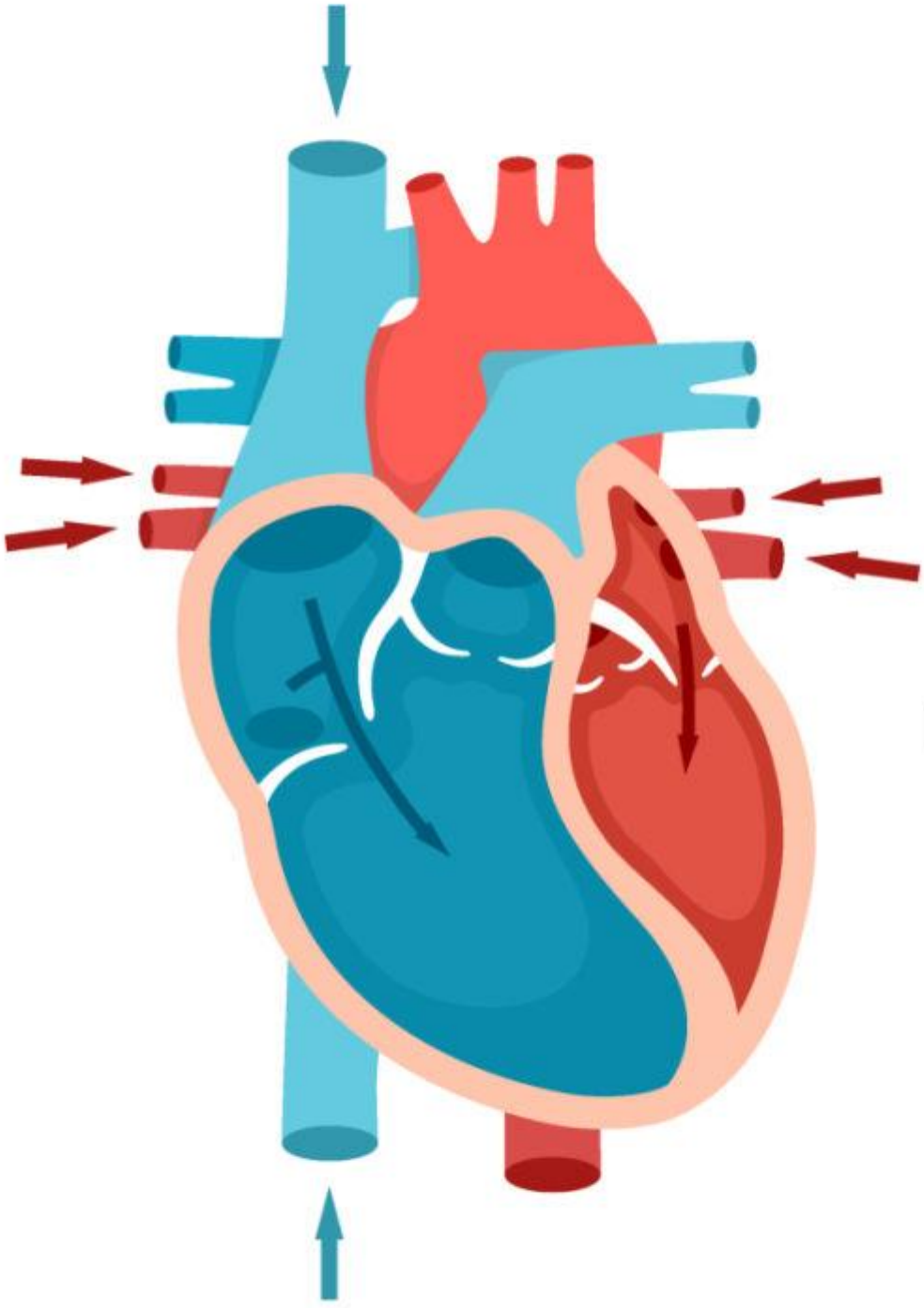
• **Reduced ventricular filling (diastasis)**
• Ventricular filling continues at a **slower rate during diastasis**, as blood gradually enters the ventricles.

• **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**.

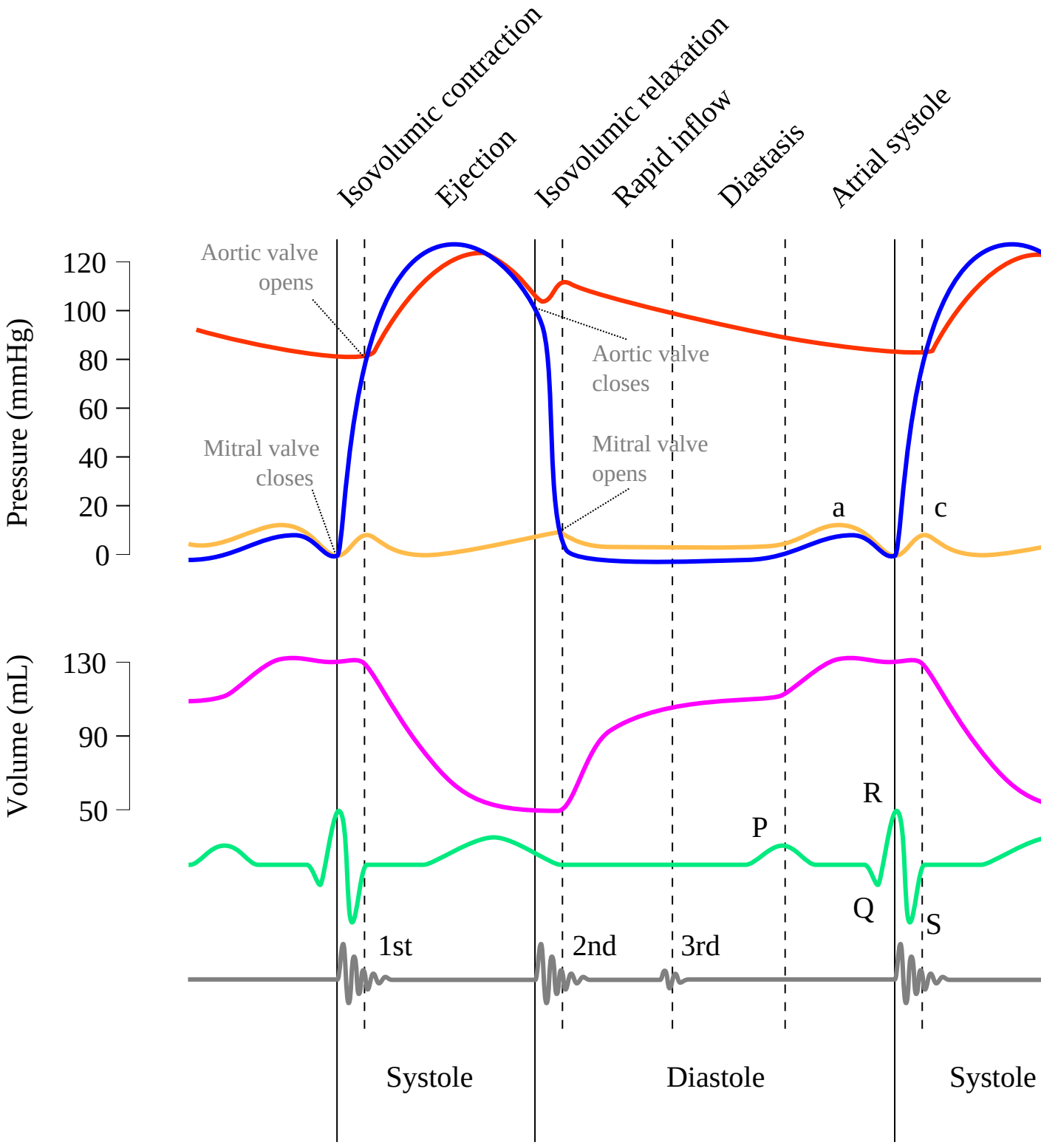
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Time Relations of the Various Events in the Cardiac Cycle

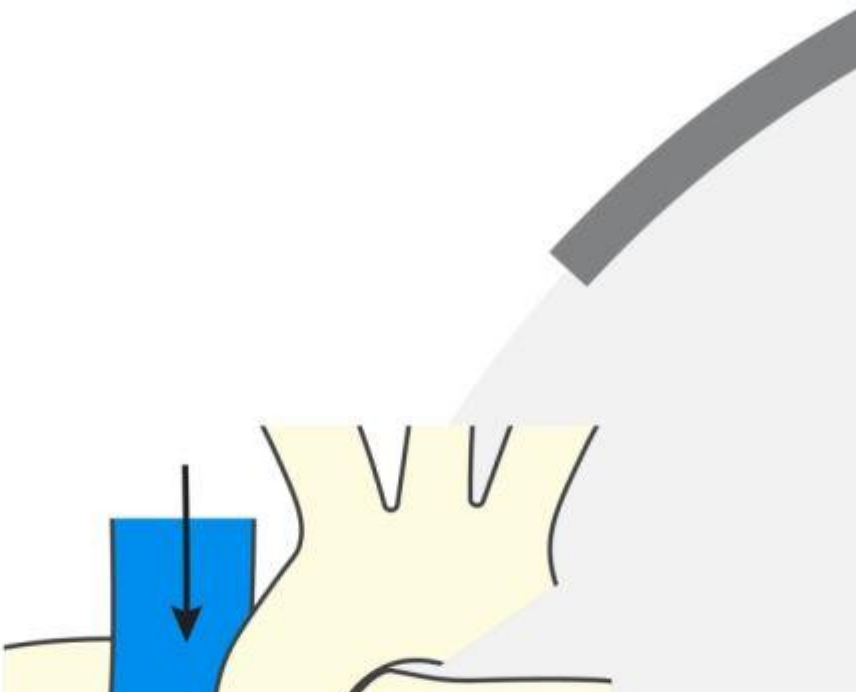
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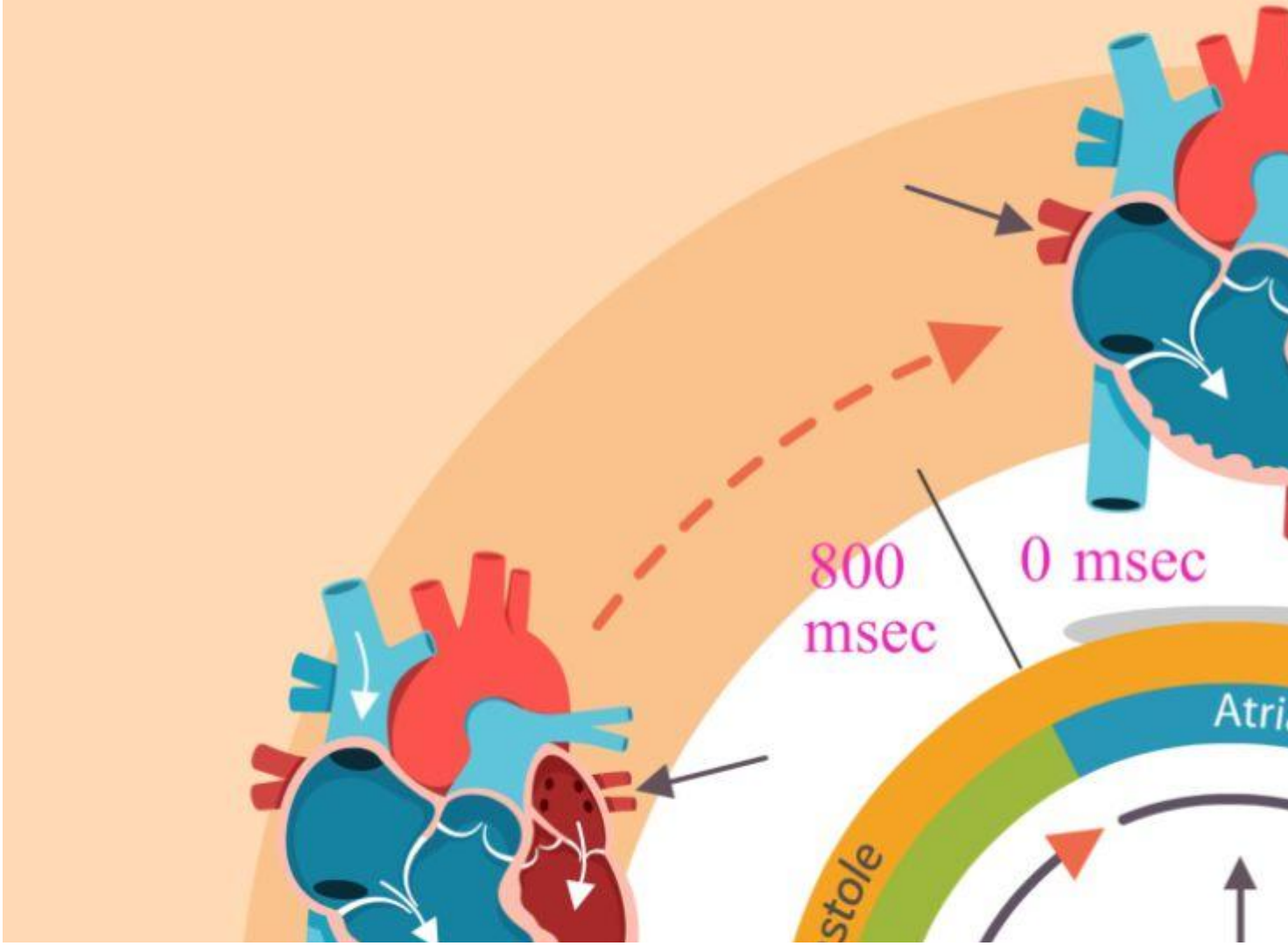

Isovolumic contraction
Ejection
Isovolumic relaxation
Rapid inflow
Diastasis
Atrial systole
Pressure (mmHg)
120
100
80
60
40
20
0
Aortic valve opens
Aortic valve closes
Mitral valve closes
Mitral valve opens
a
c
Volume (mL)
130
90
50
R
P
Q
S
1st
2nd
3rd
Systole
Diastole
Systole

The cardiac





CARDIAC



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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**.