Cardiac cycle

Learning Objectives:

- **Cardiac cycle.**
- **Heart sounds .**
- **Waveforms generated during cardiac cycle.**

The cardiac cycle refers to the sequence of mechanical and electrical events that occur with each heartbeat, allowing blood to circulate throughout the body.

The occurrence of a cardiac cycle is illustrated by a **heart rate**, which is naturally indicated as beats per minute.

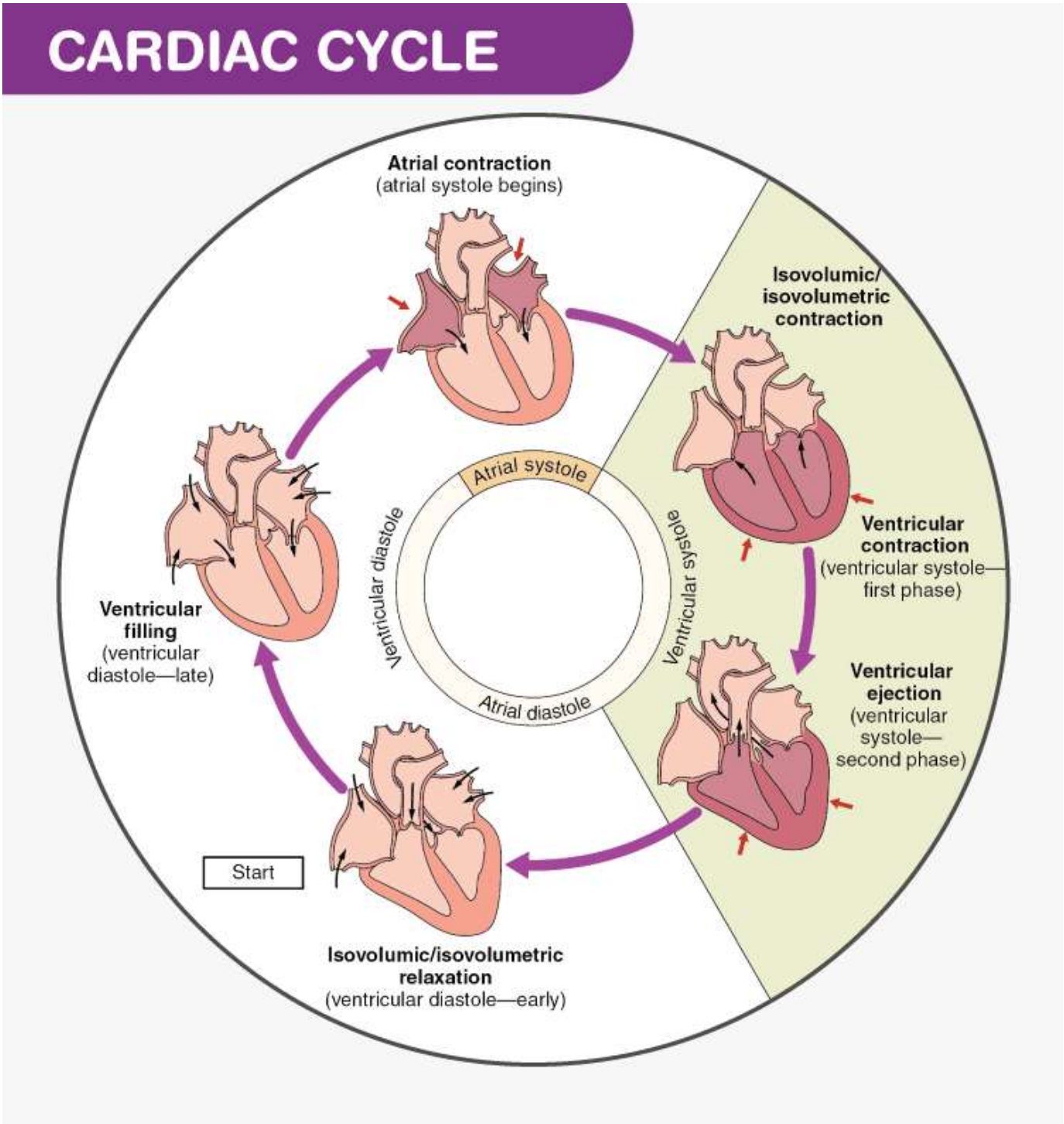
A healthy human heart beats 72 times per minute which states that there are 72 cardiac cycles per minute.

The cardiac cycle last approximately 0.8 seconds and **consists of two main phases: systole (contraction)** and **diastole (relaxation)**, both of which involve the atria and ventricles.

- **cardiac cycle** The period of time that begins with contraction of the atria and ends with ventricular relaxation.
- **Systole** the period of contraction that the heart undergoes while it pumps blood into circulation
- **Diastole** the period of relaxation that occurs as the chambers fill with blood.

Cardiac Cycle Phases:

The diagram below represents the different phases of the cardiac cycle. **The atrial systole, ventricular systole, atrial diastole, and ventricular diastole** are clearly mentioned in the cardiac cycle diagram given below.



1. **Atrial Diastole:** At the beginning of the cardiac cycle, both the atria and ventricles are **relaxed (diastole)**. Blood is flowing into the **right atrium** from **the superior and**

inferior venae cavae. Blood flows into the **left atrium** from the **four pulmonary veins.**

- The **two atrioventricular** valves, the tricuspid and mitral valves, are both **open**, so blood flows from the atria and into the ventricles. Approximately **80 percent** of ventricular filling occurs.
- **The two semilunar valves, the pulmonary and aortic valves, are closed**

2. **Atrial Systole:** Contraction of the atria follows depolarization, represented by the **P wave of the ECG**.
   - Atrial contraction forces blood into the ventricles, accounting for about **20%** of the ventricular filling.

3. **Ventricular Systole**

Ventricular systole follows the depolarization of the ventricles and is represented by the **QRS complex in the ECG**.

- At the end of atrial systole and just prior to atrial contraction, the ventricles contain approximately 130 mL blood in a resting adult in a standing position. This volume is known as the **end diastolic volume (EDV)** or **preload**.
- Ventricular systole divided into **two phases:**

a. Isovolumic Ventricular Contraction
b. Ventricular Ejection.

a. Isovolumic Ventricular Contraction also called isovolumetric contraction

The ventricles begin to contract, but no blood is ejected because the atrioventricular (AV) and semilunar valves are still closed.

b. Ventricular Ejection

Once the pressure in the ventricles exceeds that in the aorta and pulmonary artery, the semilunar valves open, and blood is ejected into the systemic and pulmonary circulations.

- Stroke volume depends on this phase which is the percentage of blood ejected from the ventricles.(60-80 ml)
- 50–60 mL of blood remaining in the ventricle following contraction. This volume of blood is known as the **end systolic volume (ESV)**.

4. Ventricular Diastole

Ventricular relaxation, or diastole, follows **repolarization** of the ventricles and is represented by the **T wave of the ECG**. It too is divided into two distinct phases

a. Isovolumetric Relaxation

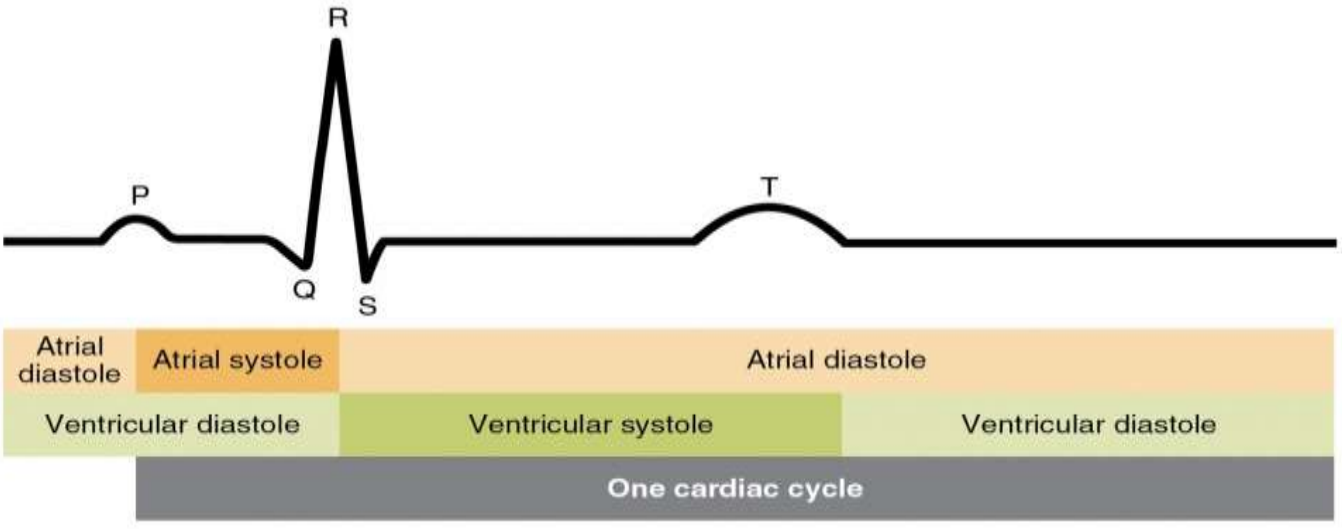
After the blood is ejected, the ventricles relax, and the pressure drops below that in the arteries. Both semilunar and AV valves remain **closed.**

- There is no change in the volume of blood in the ventricle

b. Ventricular Diastole (Filling Phase)

Once ventricular pressure falls below that in the atria

- The **two atrioventricular** valves, the tricuspid and mitral valves, are both **open**, so blood flows from the atria and into the ventricles. Approximately **80 percent** of ventricular filling occurs.
- **The two semilunar valves, the pulmonary and aortic valves, are closed**



Regulation and Control Mechanisms:

1. Autonomic Nervous System (ANS)

• **Sympathetic Stimulation:** Increases heart rate and contractility (positive inotropic and chronotropic effects), enhancing cardiac output.

• **Parasympathetic Stimulation (via the Vagus Nerve):** Slows heart rate and reduces contractility, conserving energy and maintaining baseline heart function.

2. Frank-Starling Law: Increased venous return stretches the ventricular walls, leading to stronger contractions and increased stroke volume

3. Vascular Resistance and Afterload: The pressure the ventricles must overcome to eject blood into the arteries. Increased afterload (e.g., from hypertension) can reduce stroke volume and strain the heart.

Heart Sounds (S1, S2)

heart sounds: sounds heard via auscultation with a stethoscope of the closing of the atrioventricular valves ("lub") and semilunar valves ("dub")

• **S1:** Closure of the AV valves (mitral and tricuspid) during the start of systole.

• **S2:** Closure of the semilunar valves (aortic and pulmonary) at the end of systole.

Clinical Relevance:

the cardiac cycle is a tightly regulated process that ensures effective blood circulation in response to the body's metabolic demands

• **Heart Failure:** Results from inadequate ventricular contraction or filling, leading to decreased cardiac output.

• **Arrhythmias:** Disruptions in the electrical conduction can affect the timing of the cardiac cycle, leading to inefficient pumping.

• **Valvular Disease:** Conditions like stenosis or regurgitation alter the flow of blood through the heart, affecting cardiac efficiency.