CARDIAC CYCLE

SYSTOLE AND DIASTOLE

PHASES:

A. RAPID FILLING
B. DIASTASIS
C. ISOVOLUMETRIC CONTRACTION
D. RAPID EJECTION
E. ISOVOLUMIC RELAXATION
Cardiac Cycle

Systole
Muscle is Contracting
A contracting “sphere” generates Pressure
Pressure causes a change in Volume
This is measured by CONTRACTILITY
This is affected by
Function of Muscle
Initial Volume (PRELOAD)
Initial Pressure (AFTERLOAD)
Cardiac Cycle

Diastole
Muscle is Relaxing
Veins return blood to the heart
As the heart fills with blood, the absolute volume and pressure change
This relationship is measured by COMPLIANCE
This is affected by
Connective Tissue
Venous Pressure
Venous Resistance
Cardiac Cycle

Both systole and diastole can be divided into early and late phase.
Cardiac Cycle

Early Systole

The Pressure in the Ventricle is the same as in the great veins
The Ventricle contracts –
The AV valves close –
Since the Aortic and Pulmonic valves were already closed, the heart is a closed ball
As the heart contracts, the pressure in the ball rises at a fixed volume.
Cardiac Cycle

Late Systole

The Pressure in the Ventricles is the same as — in the great arteries
The A/P valves open —
Further contraction of the ventricles causes — blood flow at a relatively constant pressure

(this is because the aorta is compliant as well — and increase in volume causes only a small increase in pressure)
Cardiac Cycle

Early Diastole •
The Ventricles begin to relax –
As the Ventricular pressure falls below the –
great artery pressure, the A/P valves close
Since the AV valves were already closed, the –
heart is a closed ball
As the heart relaxes, the pressure in the ball –
falls at a fixed volume.
ISOMETRIC RELAXATION –
Cardiac Cycle

Late Diastole

When the pressure inside the heart falls – below the pressure of the great veins AND the papillary muscles have relaxed, the AV valves open.

The blood flows down its pressure gradient – and the ventricles fill passively at a fixed pressure (because the ventricle has compliance).

ISTONIC RELAXATION –
Cardiac Cycle

End Diastole •
Atrial Contraction –
Early Systole •
Isometric Contraction –
Late Systole •
Isotonic Contraction –
Early Diastole •
Isometric Relaxation –
Late Diastole •
Isotonic Relaxation –
End Diastole •
Cardiac Cycle

End Diastole •
Is unique because the atria contract –
This leads to an increase in pressure in three – places:
The great veins •
The atria •
The ventricles •
Pressure Volume Loop

Fig. 23-16 Pressure-volume loop of the left ventricle for a single cardiac cycle (ABCDEF).
Pressure Volume Loop

**Fig. 23-16** Pressure-volume loop of the left ventricle for a single cardiac cycle (ABCDEF).
Pressure Volume Loop

![Pressure-volume loop of the left ventricle for a single cardiac cycle (ABCDEF).](image)

Early Diastole
Pressure Volume Loop

Fig. 23-16  Pressure-volume loop of the left ventricle for a single cardiac cycle (ABCDEF).
Pressure-volume loop of the left ventricle for a single cardiac cycle (ABCDEF).

End Diastole
RELATIONSHIP OF ECG TO CARDIAC CYCLE
Figure 11-1. Normal electrocardiogram.
Figure 9-9. Relationship between left ventricular volume and intraventricular pressure during diastole and systole. Also shown by the red lines is the "volume-pressure diagram," demonstrating changes in intraventricular volume and pressure during the normal cardiac cycle. EW, net external work; PE, potential energy.

Note especially in the figure that the maximum systolic pressure for the normal left ventricle is between 250 and 300 mm Hg, but this varies widely with each person's heart strength and degree of heart stimulation by cardiac nerves. For the normal right ventricle, the maximum systolic pressure is between 60 and 80 mm Hg.
Therefore, in Figure 9-9 the curve labeled "III" or "period of ejection" traces the changes in volume and systolic pressure during this period of ejection.

Phase IV: Period of isovolumetric relaxation. At the end of the period of ejection (point D; Figure 9-10), the aortic valve closes and the ventricular pressure falls back to the diastolic pressure level. The line labeled "IV" (Figure 9-9) traces this decrease in intraventricular pressure without any change in volume. Thus, the ventricle returns to its starting point, with about 50 milliliters of blood left in the ventricle and at an atrial pressure of 2 to 3 mm Hg.

The area subtended by this functional volume-pressure diagram (the shaded area, labeled "EW") represents the net external work output of the ventricle during its contraction cycle. In experimental studies of cardiac contraction, this diagram is used for calculating cardiac work output.

When the heart pumps large quantities of blood, the area of the work diagram becomes much larger. That is, it extends far to the right because the ventricle fills with more blood during diastole, it rises much higher because the ventricle contracts with greater pressure, and contracts to a smaller volume.

For cardiac contraction to be considered complete, the ventricle must be the only place where the blood has become filled.

The afterload of the heart is the pressure in the aorta leading from the left ventricle to the aorta. Afterload is loosely defined as the pressure that the ventricle must overcome to contract and push blood through the circulation rather than just pushing blood out of the body.

The importance of the afterload is that in many models of the heart or circulation, the heart has a "safety valve" to prevent the ventricle from overloading. If the pressure in the ventricle becomes too high, the heart relaxes and fails. Thus, the afterload is a critical factor in determining the heart's ability to pump blood. For cardiac contraction to be considered complete, the ventricle must be the only place where the blood has become filled.