Ventricular Interdependence

While the deeper layers of myocardial fibres of the LV and RV are separated, superficial fibres encircle both the LV and RV. The function of the two ventricles is therefore linked. As a result the size, shape, and compliance of one ventricle affects the size, shape, pressure and volume of the other ventricle; this is referred to as ventricular interdependence. In particular, normal RV contractile performance is significantly dependent on the contractile performance of the LV with approximately 20% to 40% of the RV systolic pressure and stroke volume resulting from LV contraction.

Table 2.1 **Distinguishing Anatomic Features of the Left and Right Ventricles**

	Right Ventricle	Left Ventricle
Geometry	Complex shape From the side it appears triangular; in cross-section it appears crescent-shaped	Ellipsoid shape Interventricular septum convexes into the RV cavity
Ventricular Components	Inlet and outlet components are separated by a muscular arch	Continuity between the inlet and outlet components
Trabeculations	Heavily trabeculated at the apex; Moderator band	Fine trabeculations at the apex
Atrioventricular valves	Trileaflet configuration of the tricuspid valve with septal papillary attachments Apical displacement of the septal tricuspid leaflet relative to anterior mitral leaflet	Bileaflet mitral valve with no attachments to the interventricular septum
Papillary muscles	Multiple (> 3) papillary muscles	2 prominent papillary muscles
Tendinous chords	Multiple attachments of chords from the septal leaflet to the interventricular septum	No cordal attachments to the interventricular septum
Wall thickness	3-5 mm base to mid (RV mass 1/6 of LV mass)	10-12 mm at base Gradual thinning from base to apex
Myofibre Architecture	2 layers only: 1. superficial (subepicardial) 2. deep (subendocardial)	3 layers: 1. superficial (subepicardial) 2. middle 3. deep (subendocardial)

Basic Cardiac Physiology

Ventricular systole is defined from closure of the AV valves to the closure of the semilunar valves (Fig. 2.9). On the electrocardiogram (ECG), systole is defined from the R wave to the end of the T wave. Ventricular systole is comprised of: (1) an isovolumetric contraction phase, (2) a rapid ejection phase and (3) a reduced ejection phase.

Phases of Systole

Isovolumic Contraction

Isovolumic contraction is the period between AV valve closure and semilunar valve opening. During this phase of the cardiac cycle, the ventricular volumes at end-diastole are maximal and the ventricular pressure rises rapidly without a change in the end-diastolic volume (EDV).

The EDV does not change during this phase of the cardiac cycle because all valves are closed so there is no blood entering or leaving the ventricles. Therefore, contraction at this stage of the cardiac cycle is isovolumic ("iso" meaning equal and "volumic" meaning volume). So even though the pressure is rapidly rising within the ventricles, there is no ejection of blood from the ventricles. The rate of pressure rise in the ventricles during isovolumic contraction is determined by the rate of contraction of the muscle fibres.

Rapid Ejection (Acceleration) Phase

When the pressure within the ventricles exceeds the pressure within the respective great arteries, the semilunar valves snap open. This results in the rapid ejection of blood from the ventricles into the aorta and pulmonary artery. As a result, ventricular volumes also rapidly decline. Rapid ejection occupies approximately the first half of systole.

Reduced Ejection (Deceleration) Phase

Approximately 200 ms after the onset of ventricular contraction, ventricular repolarization occurs. Repolarization leads to a decline in the rate of ejection and ventricular emptying. Ventricular pressure falls slightly below the pulmonary artery and aortic pressures; however, some ejection still occurs due to kinetic (or inertial) energy of the blood flow. During this phase of the cardiac cycle, the ventricular volumes continue to decline but at a slower rate than during rapid ejection. The ventricular volume at the end of ejection (end-systole) is the smallest ventricular volume.

Pressure-Volume Loops

By combining the ventricular pressure and ventricle volumes, a pressure-volume (P-V) loop can be derived to more precisely describe the relationship between pressure and volume over the cardiac cycle. To generate a P-V loop for the LV, the LV pressure (LVP) is plotted against LV volume at multiple points throughout a single cardiac cycle (Fig. 2.10). The P-V loop for the LV is rectangular in shape. The point at mitral valve closure (MC) illustrates the LV pressure and LV volume at the end of ventricular filling (end-diastole); this correlates to the LV end-diastolic pressure (LVEDP) and the LVEDV.

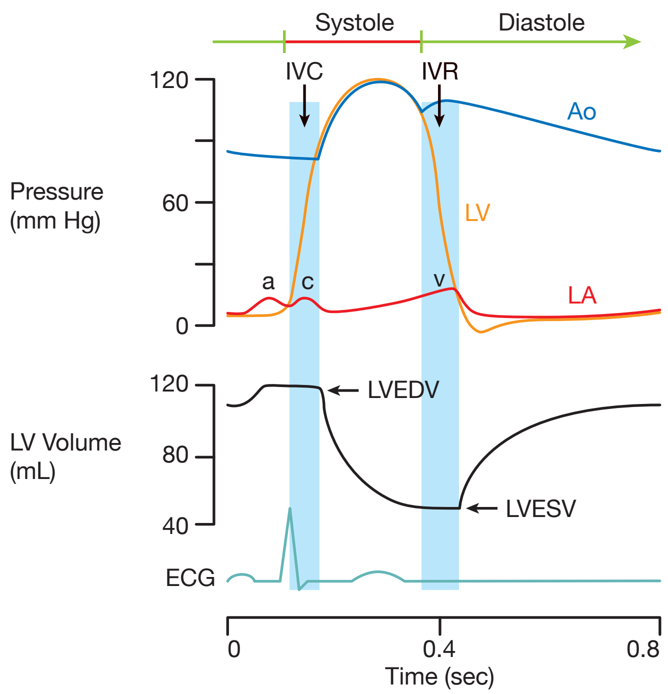

Figure 2.9 This schematic illustrates the various phases of the cardiac cycle for the left heart with respect to pressures and LV volumes (see text for details).
a = atrial pressure following atrial contraction; Ao = aorta; c = atrial pressure due to bulging of mitral valve leaflets back into left atrium; IVC = isovolumic contraction; IVR = isovolumic relaxation; LA = left atrium; LV = left ventricle; LVEDV = left ventricular end-diastolic volume; LVESV = left ventricular end-systolic volume; v = atrial pressure at the end of ventricular contraction.

The vertical line between MC and aortic valve opening (AO) represents isovolumic contraction. During isovolumic contraction, the LV begins to contract and the LV pressure increases but the LV volume remains the same because all valves are closed (no blood is entering the LV and no blood is leaving the LV).

When the LV pressure exceeds the aortic pressure, the aortic valve opens (AO) and systolic ejection begins. During the ejection phase the LV volume decreases as blood is ejected from the LV; at the same time the LV pressure continues to increase slightly to its peak systolic pressure and then LV pressure declines as the ventricle begins to relax.

At the end of ejection, when the pressure in the LV falls below the aortic pressure, the aortic valve closes (AC). The LV volume at this point in the cardiac cycle is the LV end-systolic volume (LVESV).

The vertical line between AC and mitral valve opening (MO) represents isovolumic relaxation (IVR). During IVR, the LV continues to relax and the LV pressure falls but the LV volume remains unchanged as all valves are closed (no blood is leaving the LV and no blood is entering the LV).

MO occurs when the pressure in the LV falls below the pressure in the left atrium (LA). At this point the LV begins to fill. Initially, the LV pressure continues to fall even as the ventricle fills because the ventricle is still relaxing. Once the LV is fully relaxed, the LV pressure gradually increases as the LV volume increases.

The maximal pressure that can be developed by the ventricle at any given LV volume is defined by the end-systolic pressure-volume relationship (ESPVR), which represents the contractile state of the ventricle.

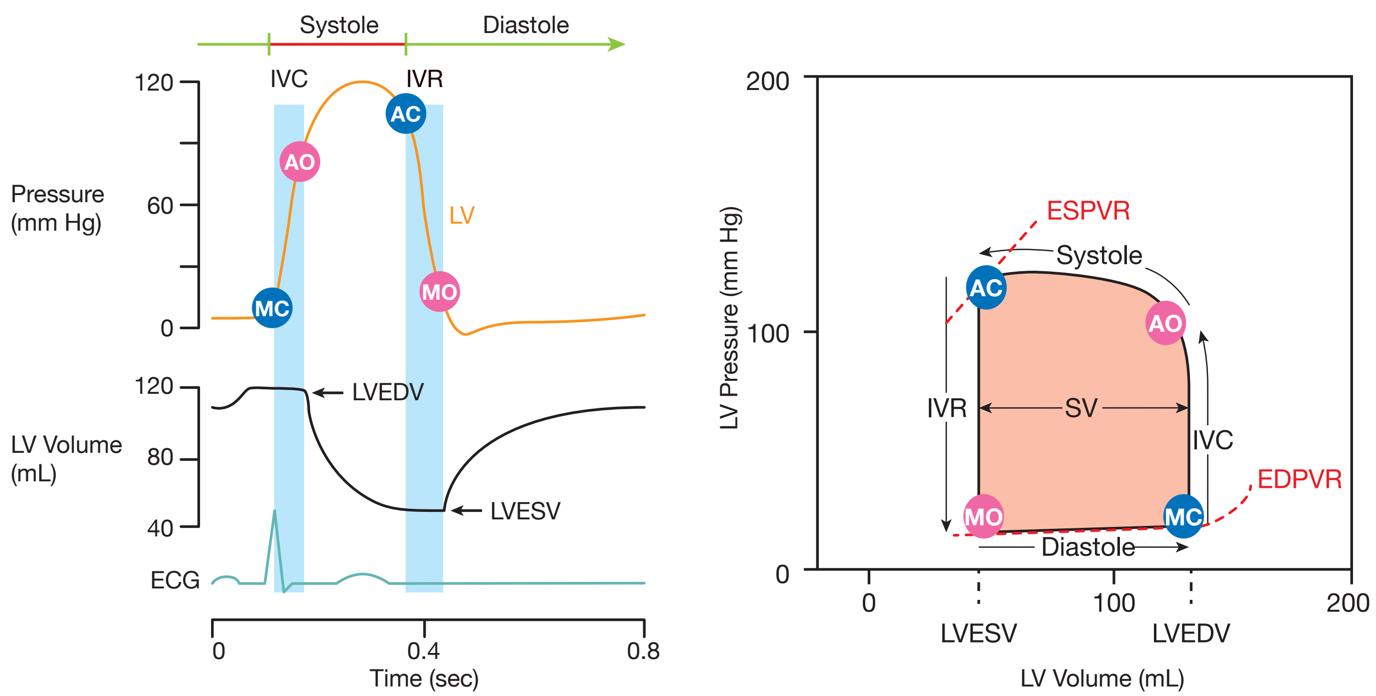

Figure 2.10 This schematic illustrates the various phases of the cardiac cycle for the left heart with respect to left ventricular pressure and left ventricular volumes *(left)* and the corresponding pressure-volume loop *(right)* (see text for details).
AC = aortic valve closure; AO = aortic valve opening; EDPVR = end-diastolic pressure-volume relationship; ESPVR = end-systolic pressure-volume relationship; IVC = isovolumic contraction; IVR = isovolumic relaxation; LVEDV = left ventricular end-diastolic volume; LVESV = left ventricular end-systolic volume; MC = mitral valve closure; MO = mitral valve opening; SV = stroke volume.