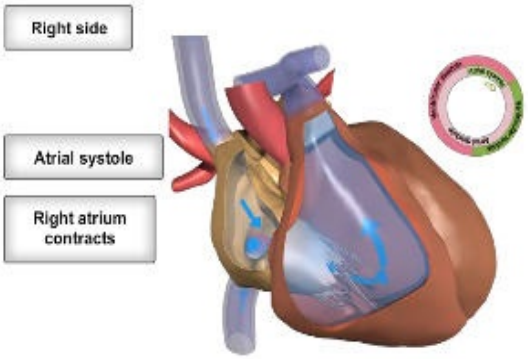
CARDIAC CYCLE

The ***cardiac cycle*** is the sequence of events that make up a ***heartbeat***. At rest, the heart beats 60-80 times a minute and functions to pump deoxygenated blood to the lungs and oxygenated blood around the body, with each cycle lasting on average 0.8 seconds (sec).

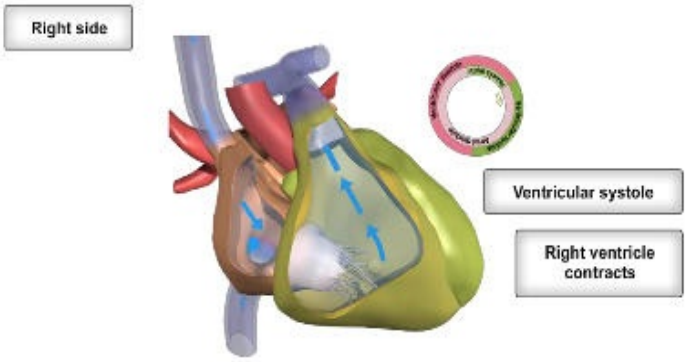
During the cardiac cycle, ***de-oxygenated blood*** enters the ***right*** side of the heart and is pumped to the lungs where it is oxygenated. The ***oxygenated*** blood then returns to the ***left*** side of the heart and is pumped to the entire body. These events occur simultaneously ensuring a continuous movement of blood.

Right atrial systole



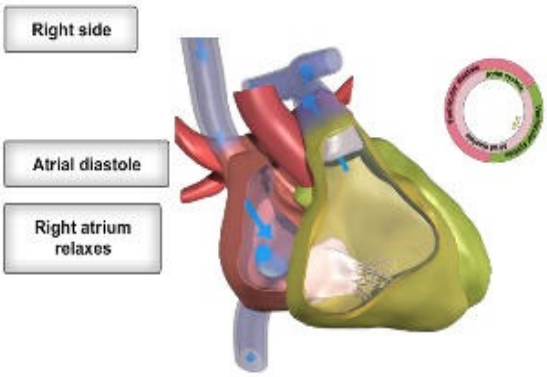
De-oxygenated blood from the superior and inferior vena cavae enters the relaxed right atrium, and blood flows passively through the open ***tricuspid valve*** into the right ventricle. During the phase called ***atrial systole***, the right atrium contracts, pushing the remaining blood into the right ventricle.

Right ventricular systole



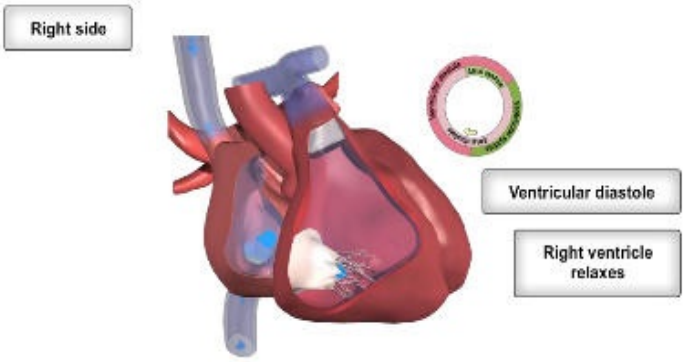
The right ventricle then contracts during ***ventricular systole***, forcing blood through the ***pulmonary valve*** into the pulmonary trunk. The pulmonary trunk divides into the right and left pulmonary arteries which carry the de-oxygenated blood to the lungs, where gas exchange occurs.

Right atrial diastole



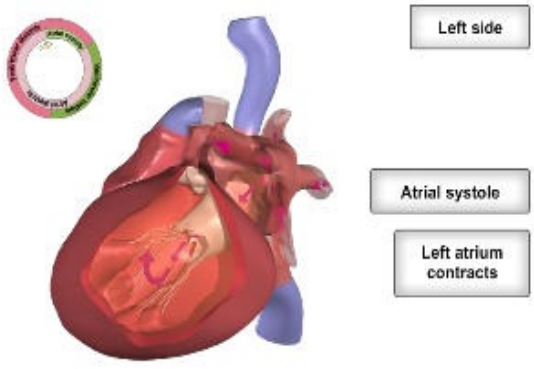
Whilst the heart is undergoing ventricular systole, the atrium also relaxes during ***atrial diastole*** and pressure increases in the right ventricle causing the tricuspid valve to close.

Right ventricular diastole



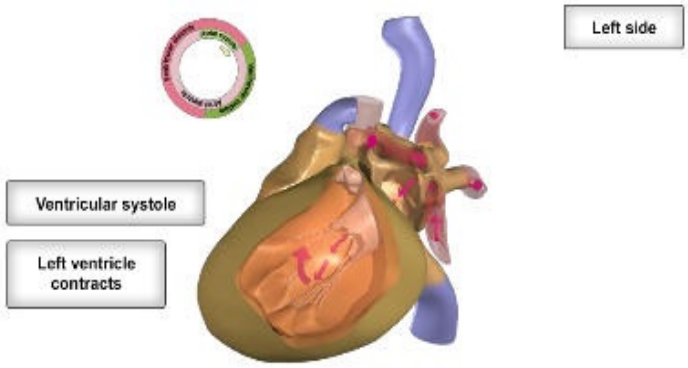
When the blood is ejected from the ventricle, it relaxes during ***ventricular diastole***. The atrium and ventricle fill with blood and the cycle begins again. At the same time, oxygenated blood produced during gas exchange enters the left side of the heart from the pulmonary veins.

Left atrial systole



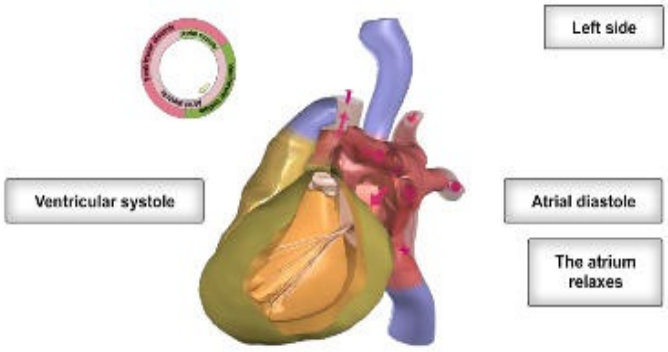
Oxygenated blood enters the heart from the pulmonary vein allowing blood to flow through the bicuspid valve into the left ventricle. During ***atrial systole***, the left atrium contracts pushing the remaining blood into the left ventricle.

Left ventricular systole



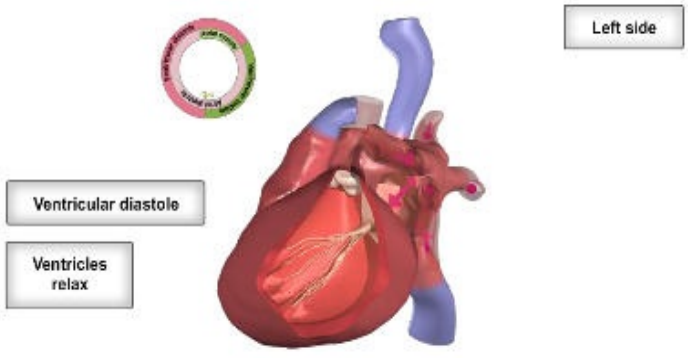
The left ventricle contracts during ***ventricular systole*** forcing the ***aortic valve*** to open, pushing blood into the ascending aorta. The ascending aorta continues to split into a number of branches, which carry the oxygenated blood to the entire body.

Left atrial diastole



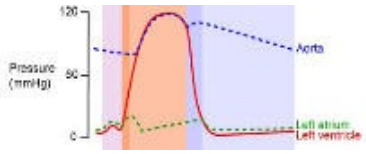
Atrial diastole and ventricular systole occur simultaneously, causing the atrium to relax and the bicuspid valve to close.

Left ventricular diastole



Ventricular diastole occurs and the ventricles relax. Blood flowing into the heart causes the aortic valve to close. The atrium and ventricles then fill with blood, and the cardiac cycle will begin again.

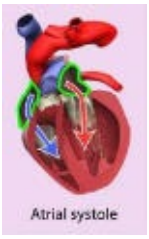
PRESSURE AND VOLUME CHANGES DURING THE CARDIAC CYCLE



During each cycle, both atria and ventricles relax and contract at different times, causing changes in pressure as blood is forced from the four chambers from an area of high pressure, to an area of low pressure.

Both atria and ventricles undergo periods of systole and diastole. ***Systole*** describes the period when a chamber is contracting and forcing out blood, and ***diastole*** describes the period when a chamber is relaxed and filling with blood.

Atrial systole



Atrial systole lasts about 0.1 sec, during which time the atria contract and the ventricles relax. About 25 ml of blood is added to the blood already in each ventricle. The end of atrial systole also marks the end of ventricular diastole, with each ventricle containing about 130 ml of blood, a volume referred to as the end-diastolic volume or EDV.

Isovolumetric contraction

Isovolumetric contraction marks the beginning of ventricular systole. During this period, as pressure increases, both sets of valves are closed but the ventricular walls are not yet fully contracted.

Ventricular systole

Ventricular systole lasts about 0.3 sec, during which time the ventricles contract and the atria relax. Ventricular pressure increases, pushing blood up into the cusps and forcing the atrioventricular valves to close. As ventricular contraction continues, and ventricular pressure exceeds the pressure within the aorta and the pulmonary trunk, both semi-lunar valves (SL) are forced open and about 70 ml of blood is expelled from each ventricle; a period lasting about 0.25 sec described as ***ventricular ejection***. This lasts for about 0.25 sec, where left ventricular pressure continues to rise considerably higher than right ventricular pressure. At the end of ventricular systole, each ventricle holds about 60 ml of pooled blood.

Isovolumetric relaxation

Isovolumetric relaxation marks the beginning of ventricular diastole. Repolarization of the ventricles causes them to relax (ventricular diastole); the resulting decrease in pressure within the ventricles draws a small amount of blood back from the aorta and pulmonary trunk. This back flow of blood pools in the valve cusps of the SL valves causing them to close. Blood rebounding off the closed valves causes a ***dicrotic wave*** (a smaller, second peak) in aortic pressure.

Once again, both the atrioventricular (AV) and SL valves are closed for a short period time, where the ventricular blood volume remains stable. This state is described as ***isovolumetric relaxation***; the ventricular walls are not yet fully relaxed.

Ventricular diastole

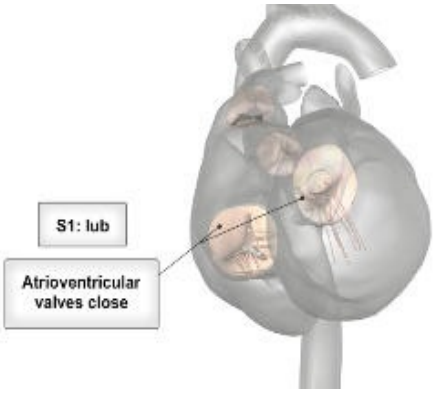
As ventricular relaxation continues, a drop in ventricular pressure below atrial pressure causes the atrioventricular valves to open the ventricles, filling them with blood to about three-quarters of their capacity, before the whole cycle begins again.

HEART SOUNDS

The normal beating heart produces two obvious sounds during each cardiac cycle. These are usually described as ***lub*** (first heart sound) and ***dub*** or ***dup*** (second heart sound) and are produced by the movement of blood associated with closure of the atrioventricular and semilunar valves, respectively.

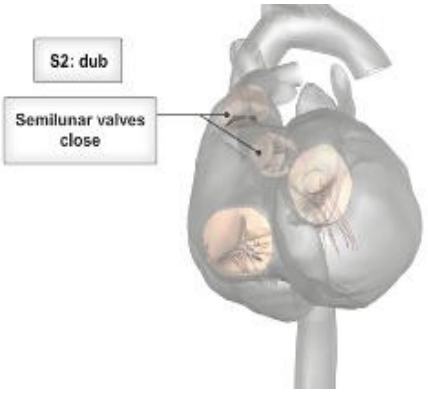
The act of listening to the heart is known as cardiac auscultation, where an examiner uses a stethoscope to listen to the heart sounds, or heartbeat. There are four heart sounds during each cardiac cycle, known as ***S1*** to ***4***; however, in a normal healthy heart, only two of these sounds, S1 and 2, can be heard clearly through a stethoscope.

First heart sound



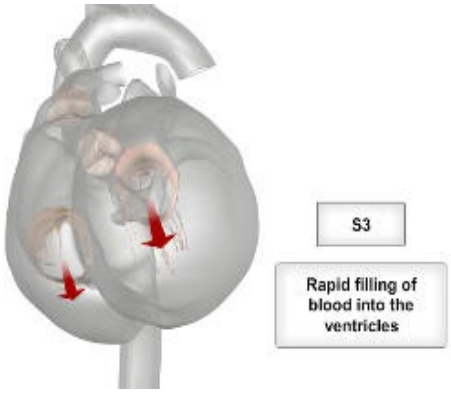
The first heart sound, S1, is described as 'lub' and is longer and louder than the second. It is caused by blood turbulence generated as the ***atrioventricular valves*** close shortly after the beginning of ventricular systole.

Second heart sound



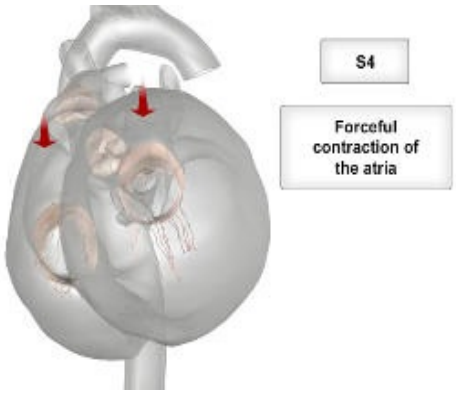
The second heart sound, S2, known as 'dub' or 'dup' is shorter and softer, and is caused by the sudden block of blood flow as the ***semilunar valves*** close at the beginning of ventricular diastole.

Third heart sound



The third heart sound, which cannot usually be heard, is produced during the rapid filling of blood into the ventricles from the atria.

Fourth heart sound



The fourth heart sound, which also cannot usually be heard, is produced by the forceful contraction of the atria.