

The Normal Heart

The heart has two roles. First, it delivers oxygen-rich blood to all living tissues in the body. Second, it recirculates used blood (in which the oxygen has been replaced by carbon dioxide) through the lungs, where the carbon dioxide is exhaled and replaced by oxygen that has been inhaled.

Arteries carry blood away from the heart and veins return blood to the heart.

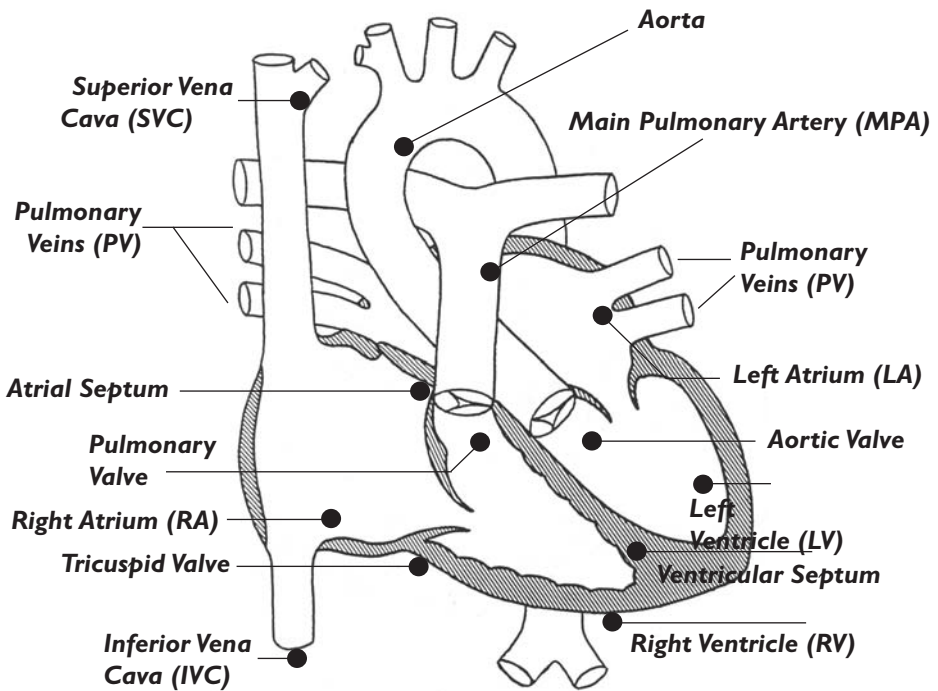


Development of the Normal Heart and Vessels

During the first seven weeks after conception, known as the *embryonic period*, the heart completes development from a single straight tube into a complicated four-chambered pump containing four valves. From then until the baby is born, the *fetal period*, the heart and the vessels grow in size. Until a newborn takes its first breath after clamping of the umbilical cord, the lungs are not functional and the mother's placenta serves as the lung while the baby is in the womb. The oxygen-rich (pink) blood from the placenta refreshes the oxygen-poor (blue) blood in the fetus and this mixed blood is then propelled through the heart to the fetus's body tissues. Although this mixed blood is low in oxygen, it is tolerated well by the fetus. After delivery, the lungs begin to function; the communication passages, or shunts, that allowed mixing of the blue and pink blood while the baby was still in the womb, close. The two blood streams – the blue and the pink, which were mixed while the baby was still in the womb – are then separated and the newborn turns pink.

Thus, circulation in the normal newborn consists of two completely separated paths: the right (blue or venous) side and the left (pink or arterial) side. The left side propels the fresh arterial blood to every living cell in the body in order to supply oxygen and nutrients, and to pick up carbon dioxide and waste products. The used venous blood turns dark (oxygen depleted, blue, cyanotic) and is re-circulated by the right side through the lungs. The blue blood passes through tiny blood vessels in the lung called capillaries where oxygen is drawn from air sacs and carbon dioxide is removed from the blood. The refreshed pink blood is picked up by the left side and propelled into all body tissues to sustain life.

Structure and Function of the Normal Heart and Vessels



Use this illustration of the normal heart to ask your child's physician about your child's defect and the necessary correction



Anatomy and Function of the Normal Heart

The normal heart (see figure) is composed of two muscular blood pumps, the right and left ventricles, joined by a common wall. The blood enters and exits the two pumps without crossing the wall and each pump supplies a separate system: (a) the lung, or pulmonary, circulation, and (b) the body, or systemic, circulation. The non-pumping components of the heart contribute to its efficiency as a forward pump.

Pulmonary Circulation

The right side of the heart is responsible for lung circulation. It consists of two large collecting veins, the superior and inferior vena cava (SVC and IVC), that return the oxygen-depleted blood to the right upper collecting chamber of the heart, the right atrium (RA). The blood then enters the right pumping chamber, the right ventricle (RV) and is propelled into the common lung artery, the main pulmonary artery (MPA), that divides into the right and left pulmonary artery branch. The branching continues within the lungs until tiny capillary vessels wrap around the air sacs where oxygen is exchanged for carbon dioxide.

Systemic Circulation

The left side of the heart is responsible for body, or systemic, circulation. The process begins with two right and two left pulmonary veins (PV) that collect the fresh blood from the lungs and fill the left upper collecting chamber of the heart, the left atrium (LA). The blood then enters the left pumping chamber of the heart, the left ventricle (LV), and is propelled into the largest body artery, the aorta (AO). The aorta branches into many smaller arteries that continue branching until, as tiny capillary vessels, they reach all body tissues, where they distribute oxygen and nutrients and pick up waste products. After this point, the oxygen-depleted capillaries turn blue, become veins and deliver the used blood to the right side of the heart. The process is repeated with each heart beat.

Valves

Four valves in the heart assure that the blood flows in the correct direction. The right inlet valve, called the *tricuspid valve*, between the right atrium and the right ventricle, opens to fill the ventricle and then closes to prevent the blood from flowing

backward, often referred to as regurgitation. The right exit valve, the *pulmonic valve*, between the right ventricle and the main pulmonary artery, opens to fill the pulmonary artery, in which the blood flows to the lung, and then closes to prevent regurgitation of the blood back into the right ventricle. The left inlet valve, the *mitral valve*, between the left atrium and the left ventricle, opens to fill the left ventricle and then closes to prevent backflow of the blood. The left exit valve, the *aortic valve*, between the left ventricle and the aorta, opens to fill the aorta and then closes to prevent regurgitation of the blood back into the left ventricle.

Aorta

The aorta is composed of three parts: the ascending aorta, which directs blood up toward the head; the aortic arch, which curves from upward to downward; and, the descending aorta, which directs blood down toward the lower body. Two coronary arteries arise from the ascending aorta, at the aortic root close to the heart, and supply the heart muscle with fresh blood.

Pulse

Each heartbeat, or pulse, consists of two separate ventricular activities: 1) systole (pronounced SIS-toe-lee) the contraction or squeezing that forces the exit valve to open, the inlet valve to close, and the blood to fill the artery; and 2) diastole (pronounced die-ASS-toe-lee) the relaxation of the heart that occurs when the inlet valve opens to permit the ventricle to refill and the exit valve closes. The arterial pulse, usually felt at the wrist is related to systole. The arterial blood pressure, usually measured in the upper arm, has a systolic value, the higher number, and a diastolic value, the lower number.

Natural Pacemaker

Each heartbeat is triggered by a faint electrical current generated by a natural pacemaker, a lifetime battery-like tissue, called the sinus node, at the top of the right upper chamber. A normal sinus node generates a slow heart rate at rest that can speed up when needed and is regular in rhythm, a normal sinus rhythm. The electrical current spreads from the right atrium to an area on the wall between the ventricles, called the atrio-ventric-

ular node, where it passes through invisible wiring, beginning as a common bundle and dividing into two-bundle branches, to the ventricles where it activates the muscles to contract, in systole.

Blood Pressure

The heart contracts to generate just enough tension, or systolic pressure, within the ventricles to maintain normal forward flow. The right exit valve, the pulmonary valve, related to the lung circulation, requires low pressure to open. Thus, the right ventricle pressure is normally low. The left exit valve, the aortic valve, related to systemic circulation, requires about four times as much pressure as the right valve requires to open, hence the normal left ventricular systolic pressure is relatively high. During ventricular refilling or diastole, when the chamber relaxes, the pressure drops to the low level that is present in the veins and upper chambers. This is the diastolic pressure. In the pulmonary artery and in the aorta, the systolic pressure is normally identical to that in the respective ventricles, whereas the arterial diastolic pressure is higher than the ventricular diastolic pressure to keep the exit valve closed while the ventricle is refilling.

Protective Layers

The heart is wrapped and separated from the surrounding organs by a double-layered, thin, smooth, and lubricated membrane called the pericardium. The inside of the heart chambers is lined with a thin membrane-like layer of cells called the endocardium. The muscular part of each ventricle is called the myocardium.

Types of Abnormal Heart Disease

There are two categories of heart abnormalities – congenital and acquired. Congenital heart disease means the child is born with an abnormally structured heart and/or large vessels. Such hearts may have incomplete or missing parts, may be put together the wrong way, may have holes between chamber partitions or may have narrow or leaky valves or narrow vessels. (See chapter on Congenital Heart Defects (CHD) for more discussion of various forms of CHD.) With acquired heart disease, the child is born with a normal heart that malfunctions at a later time in life. Such hearts may pump poorly, be too stiff, infected, or may beat too fast, too slowly or too erratically. While most acquired heart disease occurs in adults, such as coronary and hypertensive heart disease, some children acquire heart disease, usually due to bacterial or viral infections. (See chapter on Other Heart Conditions for more discussion of various forms of acquired heart disease.)