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Structure and Function of the Normal Heart and Blood Vessels

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DEFINITION

The circulatory system comprises the heart, which is connected in series to the arterial and venous vascular networks, which are arranged in parallel and connect at the level of the capillaries (Fig. 2-1). The heart is composed of two atria, which are low-pressure capacitance chambers that function to store blood during ventricular contraction (systole) and then fill the ventricles with blood during ventricular relaxation (diastole). The two ventricles are high-pressure chambers responsible for pumping blood through the lungs (right ventricle) and to the peripheral tissues (left ventricle). The left ventricle is thicker than the right, in order to generate the higher systemic pressures required for perfusion.

There are four cardiac valves that facilitate unidirectional blood flow through the heart. Each of the four valves is surrounded by a fibrous ring, or annulus, that forms part of the structural support of the heart. Atrioventricular (AV) valves separate the atria and ventricles. The mitral valve is a bileaflet valve that separates the left atrium and left ventricle. The tricuspid valve is a trileaflet valve that separates the right atrium and right ventricle. Strong chords (chordae tendineae) attach the ventricular aspects of these valves to the papillary muscles of their respective ventricles. Semilunar valves separate the ventricles from the arterial chambers: the aortic valve separates the left ventricle from the aorta, and the pulmonic valve separates the right ventricle from the pulmonary artery.

A thin, double-layered membrane called the pericardium surrounds the heart. The inner, or visceral, layer adheres to the outer surface of the heart, also known as the epicardium. The outer layer is the parietal pericardium, which attaches to the sternum, vertebral column, and diaphragm to stabilize the heart in the chest. Between these two membranes is a pericardial space filled with a small amount of fluid (<50 mL). This fluid serves to lubricate contact surfaces and limit direct tissue-surface contact during myocardial contraction. A normal pericardium exerts minimal external pressure on the heart, thereby facilitating normal movement of the interventricular septum during the cardiac cycle. Too much fluid in this space (i.e., pericardial effusion), can cause impaired ventricular filling and abnormal septal movement. Please refer to Chapter 77, "Pericardial Diseases," in *Goldman-Cecil Medicine*, 25th Edition.

CIRCULATORY PATHWAY

The purpose of the circulatory system is to bring deoxygenated blood, carbon dioxide, and other waste products from the tissues to the lungs for disposal and reoxygenation (see Fig. 2-1A). Deoxygenated blood drains from peripheral tissues through venules and veins, eventually entering the right atrium through the superior and inferior venae cavae during ventricular systole. Venous drainage from the heart enters the right atrium through the coronary sinus. During ventricular diastole, the blood in the right atrium flows across the tricuspid valve and into the right ventricle. Blood in the right ventricle is ejected across the pulmonic valve and into the main pulmonary artery, which bifurcates into the left and right pulmonary arteries and perfuses the lungs. After multiple bifurcations, blood reaches the pulmonary capillaries, where carbon dioxide is exchanged for oxygen across the alveolar-capillary membrane. Oxygenated blood then enters the left atrium from the lungs via the four pulmonary veins. Blood flows across the open mitral valve and into the left ventricle during diastole and is ejected across the aortic valve and into the aorta during systole. The blood reaches various organs, where oxygen and nutrients are exchanged for carbon dioxide and metabolic wastes, and the cycle begins again.

The heart receives its blood supply through the left and right coronary arteries, which originate in outpouchings of the aortic root called the *sinuses of Valsalva*. The left main coronary artery is a short vessel that bifurcates into the left anterior descending (LAD) and the left circumflex (LCx) coronary arteries. The LAD supplies blood to the anterior and anterolateral left ventricle through diagonal branches and to the anterior interventricular septum through septal perforator branches. The LAD travels anteriorly in the anterior interventricular groove and terminates at the cardiac apex. The LCx traverses posteriorly in the left AV groove (between left atrium and left ventricle) to perfuse the lateral aspect of the left ventricle (through obtuse marginal branches) and the left atrium. The right coronary artery (RCA) courses down the right AV groove to the *crux* of the heart, the point at which the left and right AV grooves and the inferior interventricular groove meet. The RCA gives off branches to the right atrium and acute marginal branches to the right ventricle.

The blood supply to the diaphragmatic and posterior aspects of the left ventricle varies. In 85% of individuals, the RCA bifurcates at the crux to form the posterior descending coronary artery (PDA), which travels in the inferior interventricular groove to supply the inferior left ventricule and the inferior third of the interventricular septum, and the posterior left ventricular (PLV) branches. This course is termed a *right-dominant circulation*. In 10% of individuals, the RCA terminates before reaching the crux, and the LCx supplies the PLV and PDA. This course is termed a *left-dominant circulation*. In the remaining individuals, the RCA