Quantum Chromodynamics

Comprehensive cardiac care

A TEXT FOR NURSES, PHYSICIANS, AND OTHER HEALTH PRACTITIONERS

Edited by

KATHLEEN GAINOR ANDREOLI, B.S.N., M.S.N., D.S.N., F.A.A.N.

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PREFACE

The fifth edition of *Comprehensive Cardiac Care* continues the mission of the former editions, that is, to bring readers advances in cardiac research, technology, and patient care in relation to coronary artery disease. Recognizing the magnitude and complexities of this growing body of knowledge, we invited a multidisciplinary group of experts to contribute chapters. Nineteen contributing authors participated in the first team effort to produce *Comprehensive Cardiac Care*. The team consists of cardiologists, exercise physiologists, clinical nursing specialists, family nurse practitioners, physician assistants, psychologists, medical sociologists, researchers, and health administrators from academic medical centers. This national group of authors is from the east, west, midwest, and southwest areas of the United States.

A number of changes appear in this edition. The general format has been changed to incorporate the appendix of former editions into the body of the text. The number of chapters has expanded from eight to fifteen, and six of these are completely new. The remaining chapters have dramatic revisions. Chapters 1 and 2 on anatomy and physiology of the heart and pathogenesis of coronary artery disease reflect these changes. A new Chapter 3 presents the important role of prevention of coronary artery disease with an emphasis on risk factor reduction and health promotion. Patient assessment has been divided into three chapters in order to give full coverage to the process, procedure, and implications of data collection through the history and physical examination (Chapter 4), laboratory studies (Chapter 5), and electrocardiography (Chapter 6).

The problems associated with the onset of coronary artery disease are covered in the next three chapters as complications (Chapter 7), arrhythmias (Chapter 8), and sudden death (Chapter 9). Numerous new examples of arrhythmias appear in Chapter 8, and Chapter 9 brings an important dimension to the book.

Therapeutic approaches to the patient with coronary artery disease are included in the updated Chapter 10 on cardiovascular drugs, a new Chapter 11 on artifical cardiac pacemakers, and an updated Chapter 12 on care of the cardiac patient.

The last three chapters are new and broaden the therapeutic perspective of the patient experiencing acute myocardial infarction. For example, in former editions the psychologic and rehabilitative considerations for cardiac patients were incorporated into the nursing care chapter. The importance of these areas influenced their conversion to single units, Chapters 13 and 14, respectively. Furthermore, the area of death and dying, briefly mentioned in former editions, was recognized as deserving of full coverage in Chapter 15.

Although the chapters follow a reasonable sequence for learning about patients with coronary artery disease, it is important to note that each chapter can serve as an independent resource for learning or reinforcement in that subject area. Throughout the book the reader is referred to supplementary relevant information in other sections.

The fifth edition of *Comprehensive Cardiac Care* represents a meaningful combination of the old and the new. The style and pertinent information from former editions have been retained, but new authors, content, illustrations, and tables have been carefully selected and added.

Organizing this multidisciplinary project was challenging, and we extend our sincere thanks to all who helped in the production—contributing authors, typists, illustrators, and especially you, our readers. Your support and feedback continues to inspire us to move forward.

Kathleen Gainor Andreoli
Virginia Kliner Fowkes
Douglas P. Zipes
Andrew G. Wallace

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1

ANATOMY AND PHYSIOLOGY OF THE HEART

Miriam C. Morey
F. Paul Koisch

This chapter briefly reviews the anatomy and physiology of the heart. It is intended not to be a detailed discussion but merely to serve as a general background.

Anatomy

The heart is a muscular pump that propels blood into the arterial (delivery) system and receives blood from the venous (return) system. As illustrated schematically in Fig. 1-1, the heart is divided into anatomically separate right and left sides. Each side has a receiving chamber (atrium) and a pumping chamber (ventricle). The right atrium receives unoxygenated venous blood from three sources: the inferior vena cava, which drains blood from the lower half of the body, the superior vena cava, which drains blood from the upper half of the body, and the coronary sinus, which drains blood from the heart muscle. The blood flows from the right atrium through the tricuspid valve to the right ventricle. The three leaflets of the tricuspid valve are attached by chordae tendineae to the papillary muscles that lie in the floor of the ventricle. Contraction of the papillary muscles prevents the leaflets from everting into the right atrium during ventricular contraction (systole). During ventricular systole, blood is ejected by the right ventricle through the pulmonary valve into the pulmonary artery and then into the lungs. The blood returning from the lungs enters the left atrium through four pulmonary veins. It passes from the left atrium through the mitral valve to the left ventricle. The two leaflets of the mitral valve are attached to the wall of the left ventricle by chordae tendineae, which connect to the papillary muscles. The left ventricle ejects blood through the aortic valve into the aorta, and the aorta distributes this cardiac output to peripheral tissues. Cardiac output (normally 3 L/minute/square meter) is the volume of blood pumped by the heart per minute.[1]

The right side of the heart collects blood from the systemic circulation and distributes it to the pulmonary circulation. As blood passes through the pulmonary capillaries, red blood cells exchange carbon dioxide for oxygen within pulmonary alveoli in preparation for returning to the systemic circulation. The left side of

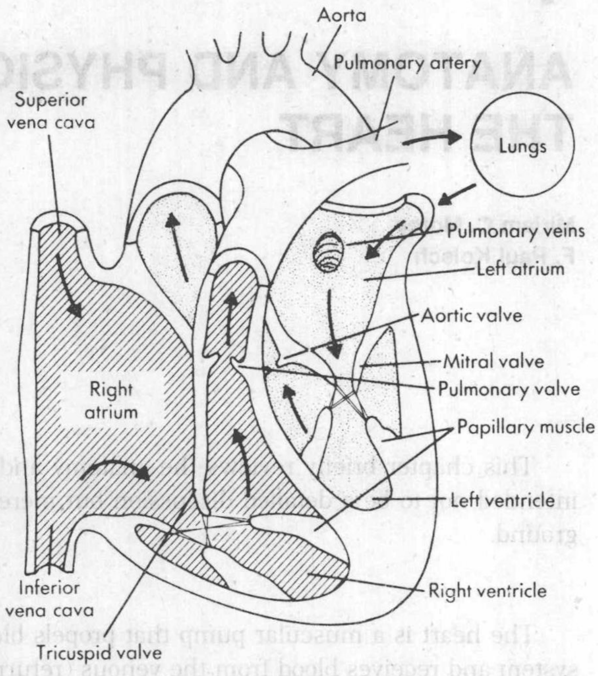

Fig. 1-1. Internal anatomy of the heart. (Modified from Guyton, A.C.: Function of the human body, ed. 3. Philadelphia, 1969, W.B. Saunders Co.)

Fig. 1-2. Fibrous rings connecting the four heart valves.

the heart collects blood from the pulmonary circulation and distributes it to the systemic circulation. As blood passes through the systemic capillary bed, which joins peripheral arteries and veins, the red blood cells surrender their oxygen to metabolizing tissues and accumulate carbon dioxide.

The heart has a skeleton made up of four fibrous rings (annuli) and nonconductive tissue that connects them into a single framework (Fig. 1-2). Each annulus is the supporting structure for one of the four valves of the heart and the connecting site of the muscular network that comprises the four chambers. Because the fibrous skeleton is nonconductive, the musculature of the atria normally is separated electrically from ventricular muscle. The specialized conduction system that coordinates the rhythm of atria and ventricles, the atrioventricular node and bundle of His, passes through the fibrous connective tissue.

Physiology

The major physiologic roles of the circulatory system are to deliver oxygen and other essential substrates to the tissues of the body, and to remove carbon dioxide and other products of cellular metabolism. Many of the substances carried to and from the tissues dissolve in plasma, and their transport depends on the volume of flow. Oxygen and carbon dioxide, however, are transported partially or almost entirely by red blood cells. The transport of these gases to and from tissues is affected not only by flow volume but also by the metabolic needs of specific tissues or organs at a given time; this is referred to as the local rate of metabolism. During exercise, for example, blood flow increases in areas involved in the activity—such as specific muscle groups and the skin—and decreases in areas of little metabolic activity—such as the kidneys, stomach, and intestines. Brain blood flow remains nearly the same at rest or during exercise. The local rate of metabolism is probably the most important determinant in the distribution of cardiac output.

Systemic circulation

The systemic circulation is the continuous passage of blood from the heart through the arteries, arterioles, capillaries, venules, veins, and back to the heart. Its continuity depends largely on the different pressures, resistances, and rates of blood flow through the different portions of the systemic circuit.[2]

Pressure is highest at the arterial level. It progressively decreases until the blood reaches the right atrium. When blood is pumped from the left ventricle into the aorta, the aorta distends and creates a high arterial pressure. Depending on the pumping action of the heart, arterial pressure normally fluctuates between approximately 120 mm Hg (systolic pressure) and 80 mm Hg (diastolic pressure).

The arteries begin branching off at the arch of the aorta and continue branching until they become small arterioles. The arterioles have muscular walls that can dilate or constrict considerably, thus controlling the blood flow into the capillary bed. Vasodilatation or vasoconstriction is usually dictated by the needs of the tissues for oxygen or other nutrients. Vascular resistance is highest at this arteriolar level in the systemic circuit, causing a drop in pressure so that the blood entering the capillaries has a pressure of only about 30 mm Hg.[3]

Once the blood is inside the capillary bed, its rate of blood flow is at its slowest. This allows sufficient time for the blood and the interstitial spaces of tissues and organs to exchange fluid, gases, and nutrients. Capillary walls are very thin, and most exchanges occur by diffusion. The total surface area of the capillary walls is extensive enough to ensure adequate perfusion of all organs and tissues.

Blood flows from the capillaries into venules, which converge to form larger veins. At this level of the systemic circuit, pressure is very low (about 5 to 10 mm Hg) so as not to impede the return of the blood to the heart. Venous walls are thin and muscular, which allows them to accommodate their capacity to variations in total blood volume based on the needs of the body. The final step in the systemic circuit is the passage of blood from the largest veins, the superior and inferior venae cavae, into the right atrium.

Pulmonary circulation

The pulmonary circulation, like the systemic circulation, consists of a continuous circuit of blood flow. Blood flows from the right ventricle to the lungs through the pulmonary arteries, which branch off into pulmonary capillaries, where oxygen is absorbed into the blood and carbon dioxide is released from the blood. The pulmonary capillaries converge into pulmonary veins and return oxygenated blood to the left atrium.

Gas exchange between the pulmonary capillaries and the alveoli takes place through a thin tissue called the pulmonary membrane. The pores of the pulmonary membrane are large enough to ensure rapid diffusion of oxygen and carbon dioxide but small enough to prevent blood proteins from leaking out of the capillaries. When the body is at rest, blood usually traverses the pulmonary capillaries in about 1 second. When oxygen demand increases, the increased rate of blood flow through the pulmonary capillaries can shorten the diffusion time to less than half a second. The pulmonary circulation adjusts to the increased blood flow by opening additional capillaries to ensure adequate aeration.

An important feature of pulmonary circulation and distribution is the ability of the pulmonary blood vessels to regulate blood flow through the lungs. Since gas exchange is the major reason blood flows through the lungs, the pulmonary blood vessels must ensure that blood flows only through adequately ventilated areas. Therefore, if certain alveoli become blocked or damaged, the local pulmonary vessels normally constrict and force the blood through a properly aerated area of the lungs.

The pulmonary blood vessels are expansile and thin walled; these two characteristics allow fluctuating volumes of blood to flow freely into the lungs. The volume of blood flowing through the lungs is the same as the systemic blood volume (because the two circulations are in series). The lungs must therefore be prepared to accept as much as a fivefold increase in blood volume during strenuous exercise without putting additional strain on the right ventricle. A slightly elevated pulmonary arterial pressure, about 20 mm Hg, enhances blood flow into the lungs by stimulating pulmonary vessel expansion. The pressure gradually decreases as blood flows through the pulmonary capillaries and completes its circuit into the left atrium.