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CARDIAC PATHOPHYSIOLOGY: STRUCTURE, FUNCTION, AND DISEASE MECHANISMS

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Introduction
Cardiac pathophysiology studies the pathological processes that disrupt the normal functions of the heart and lead to various heart diseases. The heart is one of the most important organs in the body, and its primary function is to ensure blood circulation and supply oxygen and nutrients to other organs. The proper functioning of the heart is essential for the proper functioning of all systems in the body. Pathological conditions of the heart are related to various mechanisms that lead to heart failure, ischemic heart disease, arrhythmias, and other conditions. This article provides detailed information on the main mechanisms of cardiac pathophysiology, the development of heart diseases, and their therapeutic approaches.
Keywords: Renin-Angiotensin-Aldosterone System (RAAS),Sympathetic Nervous System (SNS)

1. Normal Cardiac Physiology

The main function of the heart is to manage blood circulation, i.e., to deliver oxygen and nutrients to all organs of the body. The heart has four chambers: two atria and two ventricles. Blood circulates through the heart in the following sequence:

- Left atrium : Receives oxygen-rich blood from the lungs.
- Left ventricle : Pumps oxygen-rich blood throughout the body.
- Right atrium : Receives deoxygenated blood from the body.
- Right ventricle : Pumps deoxygenated blood to the lungs.

The heart's muscular tissue (myocardium) ensures blood circulation, which regulates the passage of blood through the heart.

2. Pathophysiology of Heart Diseases

The pathophysiology of heart diseases is primarily related to disturbances in the structure and function of the heart. The most common types of heart diseases include:

2.1. Ischemic Heart Disease (IHD) : Ischemic heart diseases occur due to a lack of oxygen in the heart muscle. IHD is often caused by the narrowing or complete blockage of the coronary arteries. This leads to a lack of oxygen supply to the heart muscle and results in:

- Angina pectoris (chest pain): Short-term oxygen deprivation of the heart muscle.
- Myocardial infarction (heart attack): Death of heart muscle due to blockage of coronary arteries.

Ischemia also worsens the heart's function through the activation of the renin-angiotensin-aldosterone system (RAAS) and the sympathetic nervous system (SNS). These systems' activation causes vasoconstriction, increased blood pressure, and further myocardial deterioration.

2.2. Heart Failure

Heart failure refers to the inability of the heart to perform its normal functions, resulting in insufficient oxygen and nutrient supply to the organs. The primary causes of heart failure include:

- Chronic ischemic disease : Reduced blood supply to the heart.

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- Weakening of the heart muscle tissue : Myocardial dysfunction.
- Structural changes of the heart : Changes in large heart vessels, such as cardiomyopathy.

As heart failure develops, the heart's contractile capacity decreases, leading to reduced circulation. This may result in right or left ventricular failure. Right ventricular failure manifests as shortness of breath, physical fatigue, and swelling in the legs. Left ventricular failure is associated with shortness of breath and high blood pressure.

2.3. Cardiac Arrhythmias

The rhythm and rate of the heart regulate blood circulation. Arrhythmias occur due to disturbances in the electrical system of the heart. Arrhythmias can take various forms:

- Supraventricular arrhythmias : Occur in the upper parts of the heart (atria).
- Ventricular arrhythmias : Occur in the lower parts of the heart (ventricles) and may lead to heart attacks.
- Fibrillation : Irregular and rapid contractions of the heart muscle. The most dangerous type is ventricular fibrillation , which results in the loss of the heart's ability to pump blood effectively.

Arrhythmias often arise from coronary artery disease or disturbances in the heart's electrical system. Poorly regulated electrical impulses lead to elevated blood pressure, decreased heart efficiency, and, ultimately, heart failure.

2.4. Heart Valve Diseases

Heart valves play a crucial role in ensuring the proper functioning of the heart. Valve abnormalities impede proper blood flow and can lead to enlargement of major vessels. The most common heart valve diseases include:

- Mitral valve prolapse : A rupture or incomplete closure of the mitral valve.
- Aortic valve stenosis : Narrowing of the aortic valve.

Valve dysfunction causes increased workload on the heart muscles, inefficient blood distribution, and the development of heart failure.

3. Pathophysiological Mechanisms

Several pathophysiological mechanisms contribute to the development of heart diseases. The most important mechanisms include:

- Renin-Angiotensin-Aldosterone System (RAAS) : Activation of RAAS leads to vasoconstriction, retention of water and sodium, increasing blood pressure and contributing to heart failure.
- Sympathetic Nervous System (SNS) : Increased heart rate and blood pressure place additional strain on the heart muscles.
- Inflammation : Heart diseases are often associated with inflammatory processes, which disrupt the normal functioning of the heart.

4. Treatment Approaches

A range of therapeutic methods are used to treat heart diseases:

- Pharmacotherapy : Beta-blockers, ACE inhibitors, statins, angiotensin II receptor blockers.
- Surgical treatment : Coronary bypass surgery, heart transplantation.
- Vascular dilation : Coronary angioplasty and stenting.
- Electrical stimulation : Restoring the heart's rhythm through devices like pacemakers or defibrillators.

Conclusion

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Cardiac pathophysiology helps to understand the mechanisms behind heart diseases and provides a foundation for improving treatment approaches. Early detection, prevention, and proper management of heart diseases are essential for reducing the burden of cardiovascular conditions on individuals and public health.

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