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MECHANISMS OF DISORDERS OF CORONARY CIRCULATION

Safarboyeva L. D.
Tashkent State Medical University

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Abstract: This article examines the pathophysiological mechanisms underlying disorders of coronary circulation. The reduction in myocardial blood flow resulting from atherosclerotic changes in the coronary arteries, thrombosis, and coronary vasospasm, as well as the development of ischemic processes, is analyzed. The effects of endothelial dysfunction, microcirculatory disturbances, and alterations in neurohumoral regulation on coronary blood flow are also discussed. Understanding these mechanisms is of significant scientific and practical importance for the early diagnosis of ischemic heart disease and for improving effective treatment strategies.

Keywords: ischemic heart disease (IHD), embolism, thrombosis, atherosclerosis, coronary circulation, microcirculatory disturbances, endothelial dysfunction.

Introduction

Cardiovascular diseases remain among the leading causes of mortality in many developed countries. Among them, ischemic heart disease (IHD) occupies a prominent position, and impaired coronary circulation plays a crucial role in its pathogenesis [7]. A reduction in blood flow reaching the myocardium through the coronary arteries leads to insufficient oxygen supply, resulting in metabolic and functional disturbances in the cardiac muscle. Therefore, an in-depth understanding of the mechanisms underlying impaired coronary circulation is essential for elucidating the etiology, progression, and clinical course of the disease.

Main Body

Lifestyle, occupational activity, living environment, sleep patterns, and dietary habits are considered important etiological factors contributing to the development of coronary artery disease [8]. Clinical observations indicate that excessive dietary cholesterol intake may contribute to the development of atherosclerosis. This, in turn, can lead to insufficient coronary blood flow, ischemic heart disease, and episodes of angina pectoris.

Coronary artery disease is a condition characterized by restricted blood flow due to atherosclerotic processes in the coronary arteries. In its early stages, the disease may remain asymptomatic; however, it may subsequently progress to stable angina, unstable angina, and myocardial infarction [3,4]. A stable atherosclerotic plaque narrows the lumen of the coronary artery, thereby reducing blood flow to the myocardium. As a result, the balance between myocardial oxygen demand and oxygen supply becomes disturbed, leading to myocardial ischemia. In addition, rupture or damage to an atherosclerotic plaque may result in thrombus formation and distal embolization, further impairing coronary blood flow and causing ischemia.

The endothelium of the coronary arteries plays an important role in regulating vascular tone. Under physiological conditions, the endothelium produces vasodilatory substances such as nitric oxide and prostacyclin, thereby adjusting myocardial blood flow according to tissue requirements. Under

pathological conditions, however, reduced nitric oxide synthesis and increased activity of vasoconstrictor substances, including endothelin-1, angiotensin II, and thromboxane A_2, may cause abnormal contraction of vascular smooth muscle. This process may result in coronary vasospasm and a reduction in coronary blood flow [3].

The severity of coronary artery stenosis is an important determinant of disease severity. Clinical manifestations generally become more apparent as the degree of stenosis becomes significant, particularly when it approaches or exceeds approximately 70% of the arterial lumen [11]. One of the principal clinical manifestations is intense retrosternal chest pain.

Ischemic heart disease is a pathological condition resulting from a reduction in coronary blood flow through the coronary arteries. Clinically, IHD represents a potentially serious condition that may progress to myocardial infarction and, in cases of delayed medical intervention, may result in death [2].

Myocardial infarction (MI) represents an acute manifestation of myocardial ischemia caused by an abrupt and sustained reduction or cessation of coronary blood supply. If adequate blood flow is not restored, prolonged ischemia results in irreversible myocardial injury and necrosis. Myocardial necrosis may be extensive or focal. Depending on its anatomical location, myocardial infarction may involve the anterior, lateral, or interventricular regions of the myocardium. In men younger than 60 years, myocardial infarction has historically been reported to occur more frequently than in women of the same age, which has been associated, among other factors, with earlier development of atherosclerosis in men [10].

Angina pectoris is characterized by transient and reversible myocardial ischemia resulting from an imbalance between myocardial oxygen demand and coronary oxygen supply. Atherosclerotic narrowing of the coronary arteries is a major cause of angina. Significant narrowing of the vascular lumen, particularly when stenosis reaches approximately 50–70% or more, may substantially reduce myocardial blood flow [9]. During physical exertion, emotional stress, or increased sympathetic nervous system activity, an increase in heart rate and myocardial contractility elevates myocardial oxygen demand and may precipitate ischemia [3].

Microcirculatory disturbances involve impaired blood flow in the small coronary arteries and capillaries and may frequently occur in association with conditions such as diabetes mellitus and hypertension. Coronary circulation is influenced not only by external factors and lifestyle but also by alterations in central nervous system regulation. Increased sympathetic nervous system activity elevates the force and rate of cardiac contraction, thereby increasing myocardial oxygen requirements. At the same time, catecholamines may alter coronary vascular tone and increase the tendency toward vasospasm. Activation of the renin–angiotensin–aldosterone system further promotes vasoconstriction and may restrict coronary blood flow.

Insufficient coronary perfusion leads to a reduction in ATP synthesis in myocardial cells, impairment of ion pump function, and intracellular accumulation of calcium ions. These changes may result in impaired myocardial contractility and, ultimately, structural cellular injury [4].

Patients with impaired coronary circulation and abnormal cardiac function may experience

retrosternal pressure or pain, shortness of breath, nausea, and diaphoresis. The pain may radiate to the left arm, neck, jaw, epigastric region, or back. In addition to chest pain, patients may experience dyspnea, dizziness, weakness, excessive sweating, nausea, vomiting, and syncope.

Stable angina may be evaluated using exercise stress testing, cardiac imaging, and coronary catheterization when clinically indicated. Before initiating treatment, a comprehensive assessment of cardiac function is important for determining disease severity and selecting an appropriate therapeutic strategy.

Diagnostic methods commonly include:

- Electrocardiography (ECG);
- Echocardiography;
- Exercise stress testing;
- Coronary angiography;
- Computed tomography (CT);
- Laboratory blood tests.

Electrocardiography (ECG) is one of the most widely used diagnostic methods. Ischemic changes occurring during testing may provide important evidence for the diagnosis of coronary artery disease. Non-invasive computed tomography (CT) can provide information about the condition of the coronary arteries, while the coronary artery calcium score (CACS) can quantify the extent of coronary artery calcification. When non-invasive diagnostic methods are inconclusive or cannot be adequately performed, invasive coronary angiography may be considered [4].

Treatment includes secondary prevention measures such as smoking cessation and management of diabetes mellitus, hypertension, and dyslipidemia. Pharmacological therapy may include antiplatelet agents and antianginal medications, while revascularization procedures may be indicated in patients with severe or clinically significant coronary artery disease.

The main objectives of treatment are to reduce cardiovascular morbidity and mortality, relieve symptoms, and improve quality of life.

Antianginal medications, including beta-blockers, calcium channel blockers, and nitrates, may be used as part of pharmacological therapy [1]. The primary purpose of antianginal therapy is to reduce myocardial oxygen demand and/or improve myocardial oxygen supply. As part of secondary prevention, antiplatelet agents such as aspirin and clopidogrel may be prescribed when clinically indicated [5].

The treatment of ischemic heart disease generally involves several therapeutic approaches. Initially, efforts are directed toward relieving anginal symptoms, reducing the risk of thrombosis, and controlling elevated cholesterol levels. When adequate coronary perfusion cannot be restored through medical therapy alone, revascularization procedures may be required. These may include percutaneous coronary intervention with stent placement to maintain vessel patency. In selected patients, coronary artery bypass grafting may be performed using vascular grafts to create alternative pathways for myocardial blood flow.

Following treatment, adherence to a healthy lifestyle is essential. A diet low in saturated fat and excessive salt, regular physical activity, smoking cessation, maintenance of a healthy body weight, and stress management may reduce the risk of recurrent cardiovascular events. Long-term management is important for preventing disease progression and recurrence and for maintaining cardiovascular health.

Conclusion

In conclusion, impaired coronary circulation is a multifactorial pathophysiological process in which anatomical, functional, and metabolic factors interact closely. Major contributing factors may include unhealthy dietary habits, harmful lifestyle behaviors, and other cardiovascular risk factors. The development of ischemic heart disease is often gradual, and the disease may remain largely asymptomatic during its early stages, although patients may experience nonspecific subjective discomfort. Regular preventive medical examinations by a cardiologist or physician are important for the early detection of coronary artery disease [4].

A comprehensive and systematic understanding of the mechanisms underlying impaired coronary circulation is of significant scientific and practical importance for the early diagnosis of ischemic heart disease, prevention of its complications, and development of effective therapeutic strategies. Preventive and therapeutic measures based on these pathophysiological mechanisms may contribute to reducing morbidity and mortality associated with cardiovascular diseases.

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