Case report

HEART FAILURE AND ISCHEMIA

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Rezume Heart failure is a complex and progressive syndrome. It is marked by the heart's inability to pump enough blood to meet the body's metabolic needs. Ischemia, a condition where blood and oxygen supply are restricted, is a major factor in the development and worsening of heart failure. Over 64 million people worldwide live with congestive heart failure. Ischemic heart disease is a factor in 41.5% of men and 22.1% of women with this condition. Chronic or repeated myocardial ischemia leads to cell death, scar tissue, and weaker heart muscle function. These changes can start heart failure. The chance of heart failure after a heart attack ranges from 14% to 36%. Ischemia in patients with existing heart failure can worsen symptoms, raise hospital admission rates, and lower prognosis. Knowing how ischemia contributes to heart failure is crucial for better diagnosis, more targeted treatments, and improved patient health.

Key words: Heart Failure; Coronary artery disease; Ischemia; Myocardial Infarction; Antianginal Drugs; Myocardial Hypertension.

INTRODUCTION

Heart failure is a clinical syndrome that develops when the heart fails to supply the body with a sufficient amount of blood to meet its metabolic demands. This change may be accompanied by structural and/or functional pathology manifested by a reduced cardiac output and/or increased intracardiac pressure. Heart failure is characterized by multiple symptoms that reduce a person's quality of life and decrease life expectancy: shortness of breath, lower leg edema, dyspnea, fatigue, pulmonary edema, ascites, hepatojugular reflux, etc [1, 2].

Based on modern data, more than 64 million people worldwide have heart failure [3, 4]. Echocardiographic screening has revealed that the prevalence of any heart failure in developed countries is 11.8% [5].

Heart failure can be divided into three classes based on left ventricular ejection fraction (LVEF), which measures the percentage of blood pumped from the left ventricle with each heartbeat. These are: heart failure with reduced ejection fraction (LVEF less than 40%), heart failure with moderately reduced ejection fraction (LVEF 40–49%), and heart failure with preserved ejection fraction (LVEF 50% or greater) [6].

Patients with heart failure can be assigned different classes and/or stages of heart failure. The New York Heart Association (NYHA) defines four classes of heart failure:

Class I: No physical limitation; ordinary physical activity does not cause symptoms of heart failure;

Class II: No symptoms at rest, but ordinary physical activities cause symptoms of heart failure;

Class III: No symptoms at rest, but less than ordinary physical activity causes symptoms of heart failure;

Class IV: Symptoms of heart failure at rest [7].

The prognosis worsens over time. In a study of 900,000 heart failure patients, survival rates were 81.3% at 1 year, 51.5% at 5 years, and 29.5% at 10 years [8]. This sharp decline highlights the need for timely and adequate treatment.

One of the main factors linked to heart failure and its worsening over time is ischemia. Ischemia means the heart muscle does not get enough blood or oxygen. The biggest cause is coronary artery disease (CAD).

Congestive heart failure is a common problem caused by ischemic heart disease. After high blood pressure, ischemic heart disease is the next biggest cause of congestive heart failure. Ischemic heart disease appears in 41.5% of men and 22.1% of women with congestive heart failure [9].

In ischemic heart disease, there is often a problem with the heart's ability to pump blood (pump function). This can be caused by several diseases or disorders, including: heart attack (myocardial infarction), brief episodes of reduced blood supply (acute transient ischemia), right ventricular dysfunction (problems with the right lower heart chamber), cardiogenic shock (severely reduced heart pumping leading to low blood pressure), sudden severe leakage of the mitral valve (acute mitral regurgitation), hole in the wall between the lower chambers (ventricular septal perforation), rupture of the heart wall (ventricular wall rupture), weakened heart muscle due to ongoing poor blood supply (ischemic cardiomyopathy), bulging of the heart wall (ventricular aneurysm), and complications from medical interventions (iatrogenic interventions) [10].

Myocardial ischemia decreases intracellular concentrations of high-energy phosphates and reduces calcium volume in the sarcoplasmic reticulum. This results in slowed and incomplete relaxation, reduced strength, and, therefore, the ischemic area stretches less. The left ventricular

filling pressure increases [11]. The ischemic region stretches less, and the non-ischemic region stretches more. According to the Frank-Starling law, the regional contractility of the latter is greater. In other words, the non-ischemic area tries to compensate for and "maintain" stroke volume [12].

When blood supply to the heart is reduced (ischemia), heart failure can begin to develop within a few hours (see Figure 1).

MYOCARDIAL HIBERNATION

Research now shows that when the heart muscle experiences deep ischemia, it can enter a state of hibernation. In the right conditions, the muscle can then recover its function. This discovery is a major advance in understanding ischemic heart disease, but, despite this progress, many questions about myocardial hibernation remain [13,14,15]. We still do not fully understand the biological processes involved, nor do we have a complete picture of the biochemical and ultrastructural changes that occur. The full extent and duration of functional recovery after restoring blood flow to the hibernating heart muscle are also only partially understood.

We have learned more about how the heart works during both "silent" and painful ischemia. Pain happens late in ischemia. The first signs are problems with the heart relaxing, followed by trouble with pumping. Only after these changes do pain and ECG changes appear.

This sequence is supported by clinical studies using exercise testing to induce ischemia. The early indicators are often shortness of breath (dyspnea) and a distinct atrial gallop, followed by hypotension and ST-segment depression. In some cases, pulmonary edema and ventricular arrhythmias may occur before any pain is felt. The presence of a strong collateral network—a system of alternative blood vessels—can sometimes contain the ischemia, preventing ST-segment depression and myocardial dysfunction altogether.

Hibernation is a protective mechanism the heart uses in response to long-term and severe ischemia (lack of blood supply). The purpose of hibernation is to help preserve the heart muscle during reduced coronary perfusion (blood flow through the heart's arteries). This is different from the body's quick adjustment responses. During ischemia, the heart changes its movement to use less energy, allowing it to maintain basic metabolic functions. It is very difficult to measure the levels of energy-storage molecules (phosphocreatine and adenosine triphosphate) in the hearts of living patients. One promising method is nuclear magnetic resonance imaging. Glucose (sugar) handling by the heart muscle can be studied with positron emission tomography (PET). In the hibernating heart muscle, glucose metabolism continues, and there are still energy reserves of adenosine triphosphate.

The discovery of myocardial hibernation, a tissue with the potential to recover function, is a significant issue and is essential for determining the indications for aortocoronary bypass surgery.

The period from reperfusion to functional recovery depends on the content of inorganic phosphorus in cardiomyocytes. The recovery of function in an exhausted segment is a long process [16]. Clinical observations show that this dysfunction is dynamic. Non-fibrotic myocardial

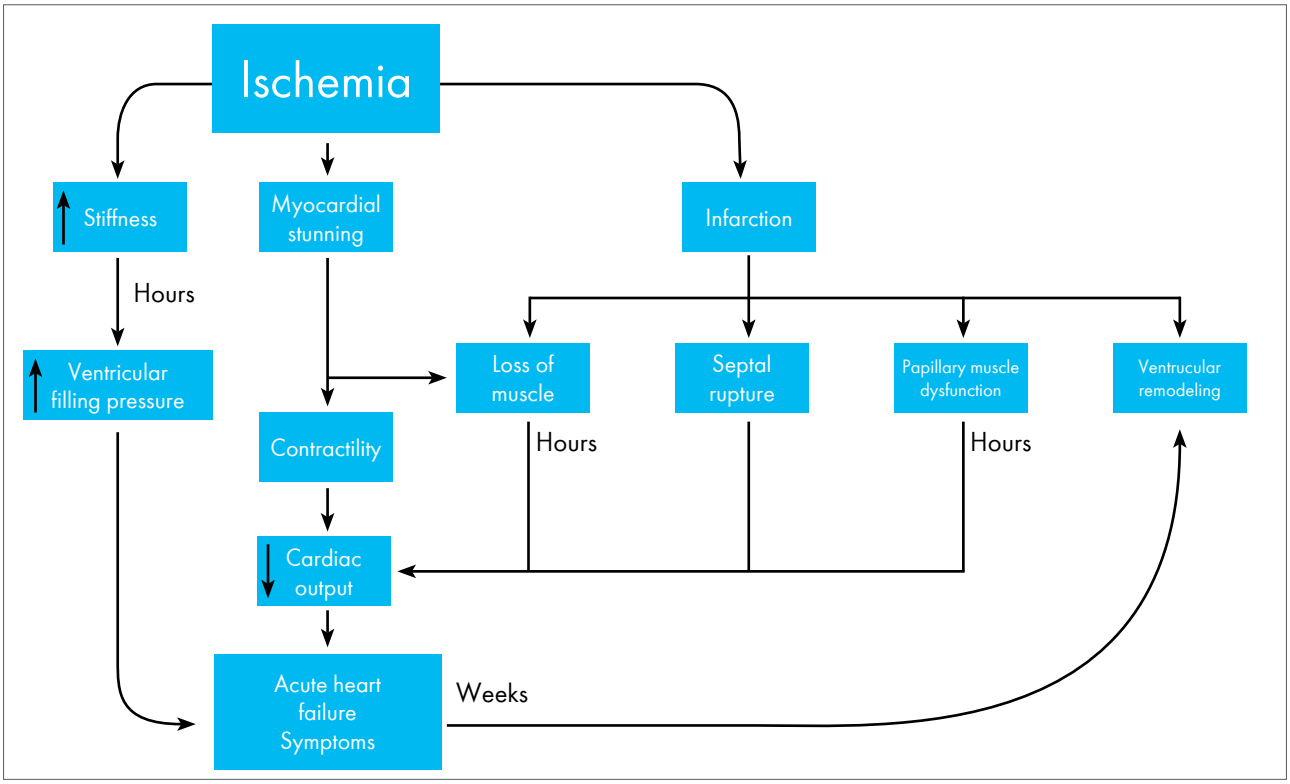

Figure 1. Factors contributing to the development of heart failure during ischemia

segments with normal histology but irreversible changes in the energy supply system may be in a state of permanent hibernation. This explains the discrepancy between the prevalence of the Q-wave and the zone of dysfunction. For example, it is known that the zone of dysfunction can be much more extensive than its corresponding Q-wave spread on the ECG. This has been demonstrated by positron emission tomography [17]. This same mechanism can explain the similar response of hibernating segments to the nitroglycerin test and revascularization processes [18]. The diagnosis of irreversible hibernation must be made with great caution, as functional recovery is possible long after reperfusion. The possibility of phased recovery has also been shown in animal experiments [13]. At the same time, it should be noted that the recovery of segments containing adenosine triphosphate is possible much sooner, which has been demonstrated by the results of transesophageal echocardiography performed during intraoperative examinations [19].

After blood flow is restored, the myocardium either recovers very quickly or remains stunned for a certain period, sometimes for a year or more. For reasons currently unknown, the myocardium lacks the ability to access the necessary substrate "within itself" to overcome total inactivation. The cause of this may be defects in enzymatic mechanisms or ultrastructural changes in the myocardium. The stages of development of dysfunctional myocardium are: [20, 21].

1) Myocardial Stunning

a) Myocardial stunning is a temporary dysfunction of the heart muscle that develops after a period of ischemia (reduced blood flow) but disappears once blood flow is restored.

b) This is similar to a skeletal muscle temporarily losing strength due to lack of oxygen and nutrients, but regaining strength when conditions improve.

c) Stunning is usually reversible within a few days, but repeated episodes can lead to hibernation.

2) Myocardial Hibernation

a) Myocardial hibernation is a condition in which the heart muscle is chronically underperfused, and its function at rest is persistently reduced.

b) This reduced function is a way for the heart muscle to adapt to the reduced blood supply and a survival attempt.

c) Myocardial hibernation can be reversed by revascularization (restoring blood flow).

d) If left unchanged, hibernating myocardium may turn into scar tissue.

3) Scar Formation (as a result of infarction)

a) Infarction is the irreversible death of heart muscle cells due to prolonged ischemia.

b) The damaged tissue is replaced by non-contractile scar tissue.

c) This is a permanent form of myocardial dysfunction.

d) Infarction can lead to heart failure if a sufficiently large area of the heart is damaged.

Myocardial hibernation can also occur in the presence of normal coronary arteries, due to toxic, inflammatory, or infiltrative processes, or as a result of long-term volume or pressure overload. This mechanism underlies secondary cardiomyopathies. The process of reducing the ejection fraction may later progress rapidly in cases of increasing aortic stenosis or insufficiency. Sometimes, an improvement in systolic function is noted long after surgical correction of the valvular apparatus. It is also possible to assume that hibernation occurs to limit myocardial oxygen consumption and restore the balance between oxygen supply and demand. Hibernation can also develop in hypertrophied myocardium when there is an imbalance between oxygen supply and consumption [22].

The issue of hibernation is a topic currently under discussion, with insufficient information available.

HEART FAILURE AND MYOCARDIAL INFARCTION

The probability of heart failure occurring after myocardial infarction ranges from 14% to 36% [23]., and it significantly impacts patient survival. Myocardial ischemia, infarct size, left ventricular remodeling, and myocardial hibernation all play a crucial role in the development of left ventricular systolic dysfunction and reduced ejection fraction [23].

A study involving 4825 patients showed that in-hospital mortality was 1.87 times higher in patients with newly developed myocardial infarction who also had symptoms of heart failure [25].

The Global Registry of Acute Coronary Events (GRACE) collected data on patients with acute coronary syndromes (ACS) from 1999 to 2009. The registry's main goal was to provide a comprehensive, real-world understanding of the management and outcomes for the full spectrum of ACS, including unstable angina, non-ST-segment elevation myocardial infarction (NSTEMI), and ST-segment elevation myocardial infarction (STEMI). A study involving 13707 hospitalized patients in the registry with symptoms of heart failure found that they had a 2.2 times higher mortality rate compared to patients without these symptoms [26]. Based on this registry, the Killip classification system was developed to assess the risk of mortality from heart failure (see Table 1).

The FAST-MI registry showed similar results: in patients hospitalized for myocardial infarction, the presence of heart failure symptoms increased the risk of in-hospital mortality from 3% to 12.2%, and this risk increased from 5.2% to 26.6% over one year. It is also worth noting that 37.5% of hospitalized patients in this registry had symptoms of heart failure [27].

During hospitalization for myocardial infarction, symptoms of heart failure can be triggered by fluid and/or contrast overload, existing kidney damage, cardiac tamponade, or taking a prolonged horizontal position in the catheterization laboratory. The primary cause of heart

Table 1. Killip System Classes and Their Associated Risk of In-Hospital Mortality

Killip class	Symptoms	In-hospital mortality risk (%)
1	No symptoms of heart failure are observed	6
2	Auscultation revealed S3 heart sound and wheezing	17
3	Pulmonary edema	38
4	Cardiogenic shock	81

failure symptoms resulting from these factors is the death of cardiomyocytes and the development of scar tissue.

The acute decrease in heart contractility following an infarction can be caused by oxidative stress that develops in the presence of a blocked or narrowed coronary artery. In such conditions, restoring blood flow can improve heart contractility. However, if reperfusion is delayed by more than three hours, restoring blood flow can cause secondary damage due to the release of reactive oxygen species (ROS) [28].

The events that follow a myocardial infarction can be divided into two broad classes:

- Rapidly developing events that play a beneficial/compensatory role and
- later-developing events, where compensatory mechanisms play an active role in the development of heart failure symptoms.

The rapidly evolving events following an infarction aim to restore cardiac output and blood pressure and involve three compensatory mechanisms: the Frank-Starling mechanism, hyperactivation of the neurohumoral system, and activation of the renin-angiotensin-aldosterone system.

The Frank-Starling mechanism helps restore reduced cardiac output after an acute infarction. It is known that heart contractility changes with tissue stretch: when the tissue stretches, contractility increases; when it stretches too little or too much, contractility decreases. When the heart's pump function is disrupted and the ejection fraction is reduced due to a myocardial infarction, cardiac output also decreases, and left ventricular end-diastolic volume increases. Thanks to this change, the high end-diastolic volume activates the Frank-Starling mechanism, leading to an increase in the force of the subsequent contraction to restore cardiac output [29].

Hyperactivation of the neurohumoral system occurs due to baroreceptor stimulation from reduced systolic pressure. It includes the Bowditch effect, peripheral vasoconstriction, and blood redistribution. The Bowditch effect, also known as the Treppe phenomenon, is an increase in cytosolic calcium ion concentration associated with increased heart rate. This increase in calcium leads to increased contraction. In other words, each new contraction after a previous one is stronger, and as a result, this increased contractility is reflected as an increased cardiac output [30, 31]. The narrowing of peripheral blood vessels (both arteries and veins) leads to an increase in peripheral resistance, which increases blood pressure. This vasoconstriction also centralizes blood flow, increasing blood supply to vital organs [32, 33].

Activation of the renin-angiotensin-aldosterone system occurs somewhat later than the two mechanisms mentioned above because it involves protein synthesis. Upon activation of this system, the body's retention of sodium increases, leading to an antidiuretic effect [34].

The rapidly evolving events that follow a myocardial infarction help stabilize the body hemodynamically. However, these mechanisms are not designed for long-term effects, and their hyperactivation can lead to more detrimental later-emerging events. The prolongation of these mechanisms over time gradually leads to the development of heart failure and is directed toward the complete collapse of the cardiovascular system [35]. These mechanisms include: hyperactivation of the neurohumoral system, hyperactivation of the renin-angiotensin-aldosterone system, the formation of fibrous tissue, oxidative stress, heart remodeling, and heart hypertrophy [36, 37, 38].

Long-term hyperactivation of the neurohumoral system leads to progressive desensitization of beta-adrenergic receptors and a decrease in their concentration in the heart. The synthesis of specific proteins responsible for excitation-contraction coupling and intracellular calcium regulation is also inhibited. As a result, the contractile force of the tissue and cardiac output are reduced [39].

The angiotensin II released due to hyperactivation of the renin-angiotensin-aldosterone system activates AT1 receptors, causes cardiac hypertrophy, and promotes the synthesis of fibrosis-promoting substances (cytokines, collagen) [40, 41].

Collectively, long-term hyperactivation of these systems can lead to water retention in the body, increased left ventricular end-diastolic pressure, increased left ventricular wall stress, increased left ventricular filling pressure, the formation of fibrous tissue, cardiac hypertrophy, and reduced cardiac output, all of which are factors contributing to the development of heart failure.

IMPACT OF ANTIANGINAL DRUGS ON LEFT VENTRICULAR SYSTOLIC FUNCTION

Antianginal drugs can be divided into three main groups:

1. Medications that reduce myocardial oxygen consumption by altering myocardial function (beta-blockers).
2. Medications that reduce myocardial oxygen consumption by regulating preload and afterload (nitrates).

3. Medications that improve myocardial blood supply by blocking the development of spasms and reducing myocardial oxygen consumption through changes in peripheral circulation (Ca2+ antagonists).

Beta-adrenergic receptor blockers reduce myocardial oxygen consumption by decreasing myocardial contractility, heart rate, and systolic pressure and by prolonging diastole. We know that in cases of acute coronary occlusion, propranolol reduces intraventricular pressure in both ischemic and non-ischemic areas. Intraventricular pressure decreases more sharply in normal areas than in ischemic areas [42]. It is also worth noting that the use of beta-adrenergic receptor blockers improves the contractility of ischemic myocardial areas during acute total coronary occlusion (see Table 2) [43].

A study involving 28039 patients with angiographically confirmed stable coronary artery disease, without heart failure or recent myocardial infarction, showed that beta-blockers were associated with a small but significant reduction in cardiovascular events after 5 years [44].

Research indicates that propranolol improves blood flow to the ischemic zone. The cardiodepressive effects of combined use of beta-blockers with glycosides and beta-blockers with nitroglycerin have been shown in patients with coronary occlusion [45]. It is also known that the cardiodepressive effect of beta-blockers is mediated by inhibiting endogenous sympathetic substances [46].

One study examined the results of intravenous administration of 5 mg of propranolol during cardiac catheterization in 10 patients. Four of them had angiographically confirmed coronary artery disease, while six did not have this pathology. Propranolol reduced the heart rate and cardiac index in all of them. In patients whose heart rate was under atrial stimulation control, the effect on end-diastolic pressure was variable. Two of the four patients with coronary disease and one patient with normal coronary arteries had an increase in end-diastolic pressure. End-diastolic pressure primarily increased, while the ejection fraction and the percentage of circumferential fiber shortening primarily decreased [47].

Studies also show that the ratio of the anginal period to the ejection period increased in patients with myocardial infarction under propranolol, from 0.377±0.1 to 0.409±0.03 ($P<0.001$) [48]. This effect is not exclusive to propranolol but is a general result of using beta-blockers [49].

The effect of beta-blockers on left ventricular hemodynamics is more pronounced during their acute use.

Radionuclide angiocardiography has shown that using increasing doses of propranolol (165 ± 13 mg) does not lead to a sharp change in the regional contractility of the left ventricular wall and ejection fraction [50]. It is also known that the ejection fraction and regional wall contractility do not change significantly after discontinuing propranolol before aortocoronary bypass surgery, at the peak of the drug action, and when it is used at an average dose 51].

The effect of labetalol on cardiovascular hemodynamics at rest and during physical exertion has also been studied in patients receiving long-term beta-blocker therapy. During the acute trial, there was a decrease in mean arterial pressure, heart rate, and cardiac index. The changes were even more pronounced during physical exertion. After 20 months of labetalol use, peripheral resistance was further reduced, while cardiac output improved (due to a relative increase in heart rate and an increase in stroke volume) [52].

Regarding nitrates, studies have shown that nitroglycerin does not alter or reduce stroke volume or cardiac output in patients with ischemic heart disease or healthy individuals (see Table 3) [53, 54, 55, 56].

The improvement in hemodynamics (stroke volume and cardiac output) with nitroglycerin is mainly dependent on the presence of left ventricular asynergy [56]. Hemodynamic improvement has been shown due to the disappearance of asynergic areas. The effect of nitroglycerin, like all other nitrates, is highly dependent on preload and afterload.

The effect of nitroglycerin on the global function of the left ventricle is variable. During oral administration, the hemodynamic effects of nitroglycerin are as follows:

Table 2. Effects of taking beta-blockers

General Parameter	Specific Parameter	Effect
Hemodynamic indicators	Heart rate	Decreases
	Left ventricular systolic pressure	Decreases
	Left ventricular end-diastolic pressure	Increases or does not change
	Stroke volume	Decreases
	Cardiac index	Decreases
Global functions of the left ventricle	Heart dimensions	Increases or does not change
	End-diastolic volume	Decreases
	Ejection fraction	Decreases
Regional functions of the left ventricle	Non-ischemic zone	Decreases
	Ischemic zone	Decreases or increases or does not change
	Left ventricular asynergy	Increases or does not change

Table 3. Effects of taking nitrates. The effect depends on the presence of congestive heart failure, left ventricular end-diastolic pressure, and reversed zones of asymptomatic

General Parameter	Specific Parameter	Effect
Hemodynamic indicators	Heart rate	Increases or does not change
	Left ventricular systolic pressure	Decreases
	Left ventricular end-diastolic pressure	Decreases
	Stroke volume	Decreases or increases or does not change
	Cardiac index	Decreases or increases or does not change
Global functions of the left ventricle	Heart dimensions	Decreases
	End-diastolic volume	Decreases or increases or does not change
	Ejection fraction	Decreases
Regional functions of the left ventricle	Non-ischemic zone	Decreases or increases or does not change
	Ischemic zone	Decreases
	Left ventricular asynergy	Increases or does not change

within the first 2 minutes, it decreases total peripheral resistance and cardiac output due to significant changes in left ventricular filling pressure and systemic arterial pressure. Then the heart rate increases. A decrease in filling pressure characterizes the second phase and, later, after 5 minutes, a decrease in arterial pressure. The heart rate reaches its peak, cardiac output decreases, and systemic arterial pressure returns to control values [54, 57].

The effects of nitroglycerin and other nitrates on regional left ventricular function are of interest for the treatment of coronary disease [58, 59]. In patients with angiographically confirmed coronary artery disease, zones of local contractility disorders and asynergic areas were found in 60-75% of cases in the left ventricle [60]. Nitroglycerin causes an improvement in myocardial contractility and the disappearance of asynergic zones. This is explained by the fact that nitroglycerin reduces preload, thereby eliminating the imbalance between myocardial oxygen consumption and supply. This is used as a test during ventriculography [61]. The nitroglycerin test can be used to predict the potential improvement of contractility in dyskinetic and akinetic areas after aortocoronary bypass surgery [62]. The effect of nitroglycerin on the asynergic regions of the ventricle that developed during a physical exercise test in patients with ischemic heart disease is also known—under the control of radionuclide angiography, it is known that nitroglycerin eliminates these areas and improves contractility [63]. Similar results have been obtained with patients who took prolonged nitrates, e.g., isosorbide dinitrate and pentaerythritol tetranitrate [64].

Based on studies, we know that Ca2+ antagonists reduce the zone of myocardial necrosis and improve systolic function after experimental coronary artery occlusion [65]. This fact is realized by reducing afterload, reducing myocardial oxygen consumption, improving coronary blood circulation due to the expansion of the coronary arteries, and also by reducing myocardial damage during ischemia by reducing the increased concentration of intracellular Ca2+ [66].

Ca2+ antagonists are the drugs of choice for coronary spasms, for example, Prinzmetal angina. These drugs are also prescribed for atherosclerotic narrowing of the coronary arteries to prevent coronary spasm and for their antiatherogenic action (see Table 4; Table 5; Table 6) [67].

In vitro, nifedipine has a negative inotropic effect. However, it has been shown to increase contractility during ischemia. During partial coronary occlusion, intravenous or intracoronary administration of nifedipine improves segmental subendocardial contractility in the ischemic zone. The mechanism behind this lies in the reduction of afterload through vasodilation and/or increased coronary blood flow, as well as reduced ischemia.

It is known that Ca2+ accumulates in mitochondria. Nifedipine improves myocardial contractility in the isch-

Table 4. Effects of taking nifedipine

General Parameter	Specific Parameter	Effect
Hemodynamic indicators	Heart rate	Increases or does not change
	Left ventricular systolic pressure	Decreases
	Left ventricular end-diastolic pressure	Decreases
	Stroke volume	Decreases or increases or does not change
	Cardiac index	Decreases or increases or does not change
Global functions of the left ventricle	Ejection fraction	Decreases
Regional functions of the left ventricle	Non-ischemic zone	Decreases or increases or does not change
	Ischemic zone	Decreases

Table 5. Effects of taking verapamil

General Parameter	Specific Parameter	Effect
Hemodynamic indicators	Heart rate	Does not change
	Left ventricular systolic pressure	Decreases
	Left ventricular end-diastolic pressure	Decreases or does not change
	Stroke volume	Increases
	Cardiac index	Increases
Global functions of the left ventricle	Ejection fraction	Decreases or does not change
Regional functions of the left ventricle	Non-ischemic zone	Decreases
	Ischemic zone	Not studied

Table 5. Effects of taking Diltiazem

General Parameter	Specific Parameter	Effect
Hemodynamic indicators	Heart rate	Decreases
	Left ventricular systolic pressure	Decreases
	Left ventricular end-diastolic pressure	Decreases or does not change
	Stroke volume	Increases
	Cardiac index	Decreases or increases
Global functions of the left ventricle	Ejection fraction	Not studied
Regional functions of the left ventricle	Non-ischemic zone	Not studied
	Ischemic zone	Increases

emic zone due to Ca2+ blockade in the mitochondria. This effect is dose-dependent. The effect of nifedipine on normal, non-ischemic myocardium is different.

It is also known that Diltiazem increases stroke volume and cardiac output and decreases total peripheral resistance and systemic arterial pressure [68]. These facts are dependent on the dose of the drug. Compared to verapamil and nifedipine, Diltiazem has a more pronounced vasodilatory effect and a less pronounced negative inotropic effect [69].

In summary, the interplay between ischemia and heart failure is a dynamic process involving a spectrum of myocardial responses, from temporary stunning to irreversible infarction. A comprehensive understanding of these mechanisms is vital for effective diagnosis and the development of targeted therapeutic strategies, including antianginal drugs, to improve the prognosis and quality of life for millions of people worldwide.

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რეზიუმე

გულის უკმარისობა რთული და პროგრესირებადი სინდრომია, რომელიც ხასიათდება გულის უუნარობით, გადატუმბოს საკმარისი სისხლი ორგანიზმის მეტაბოლური მოთხოვნილებების დასაკმაყოფილებლად. იშემია, სისხლის მიმოქცევისა და ჟანგბადის მიწოდების შეზღუდვის მდგომარეობა, გულის უკმარისობის განვითარებისა და პროგრესირების ერთ-ერთი მთავარი ხელშემწყობი ფაქტორია. ბოლოდროინდელი ანალიზი აჩვენებს, რომ მსოფლიოში 64 მილიონზე მეტი ადამიანი გულის შეგუბებითი უკმარისობით ცხოვრობს. ამ პირებიდან გულის იშემიური დაავადება მამაკაცების 41.5%-ში და ქალების 22.1%-ში ხელშემწყობი ფაქტორია. ქრონიკული ან მორეციდივე მიოკარდიუმის იშემია იწვევს მიოციტების სიკვდილს, ფიბროზულ რემოდელირებას და პარკუჭების ფუნქციის დარღვევას, რაც საბოლოოდ გულის უკმარისობის განვითარებას იწვევს. მიოკარდიუმის ინფარქტის შემდეგ გულის უკმარისობის განვითარების ალბათობა 14%-დან 36%-მდე მერყეობს. გარდა ამისა, დადგენილი გულის უკმარისობის ფონზე იშემიას შეუძლია კიდევ უფრო გაამწვავოს სიმპტომები, გაზარდოს ჰოსპიტალიზაციის მაჩვენებლები და გააუარესოს პროგნოზი. გულის უკმარისობის პათოგენეზში იშემიის კრიტიკული როლის გაგება აუცილებელია დიაგნოზის გასაუმჯობესებლად, მიზნობრივი თერაპიის შემუშავებისთვის და საბოლოოდ პაციენტების მდგომარეობის გასაუმჯობესებლად.

საკვანძო სიტყვები: გულის უკმარისობა; კორონარული არტერიის დაავადება; იშემია; მიოკარდიუმის ინფარქტი; ანტიანგინალური პრეპარატები; მიოკარდიუმის ჰიბერნაცია