Comprehensive management of cardiopulmonary and renal insufficiency: the joint role of cardiologist, nephrologist and neurologist

Manejo integral de la insuficiencia cardiopulmonar y renal: el papel conjunto del cardiólogo, nefrólogo y neurólogo

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Received: 02/20/2025 Accepted: 04/19/2025 Published: 05/12/2025 DOI: http://doi.org/10.5281/zenodo.15521589

Abstract

Modern medicine is increasingly confronted with multiorgan disorders, where cardiopulmonary and renal insufficiency are the main components of the pathological process. These conditions are characterized by a close relationship between organs, which leads to the formation of the so-called “cardio-renal” or “cardiopulmonary-renal” syndrome. In such cases, it is important to ensure an integrated approach to treatment, including the interaction of specialists from different profiles: cardiologist, nephrologist and neurologist.

As part of comprehensive patient management, it is necessary to take into account the cross–effects of diseases (for example, congestive heart failure can cause renal hypoperfusion, and chronic renal failure can increase cardiac dysfunction). Modern treatment protocols include the use of combined strategies, including optimization of diuretic therapy, control of creatinine and electrolyte levels, the use of ACE inhibitors/angiotensin II receptor blockers, as well as correction of hyperphosphatemia and anemia in patients with renal insufficiency.

Special attention is paid to monitoring pulmonary function, since respiratory failure is often a consequence of cardiac or renal pathology. It is also important to assess the risk of neurological complications such as stroke or vascular dementia, especially in patients with a long-term course of the disease.

Thus, successful management of patients with cardiopulmonary and renal insufficiency requires close cooperation between a cardiologist, a nephrologist and a neurologist aimed at individualizing treatment, minimizing side effects and improving the quality of life of patients.

Key words: cardiopulmonary insufficiency, renal insufficiency, cardio-renal syndrome, interdisciplinary approach, cardiology, nephrology, neurology, integrated management.

Resumen

La medicina moderna se enfrenta cada vez más a trastornos multiorgánicos, donde la insuficiencia cardiopulmonar y renal son los componentes principales del proceso patológico. Estas afecciones se caracterizan por una estrecha relación entre órganos, lo que conduce a la formación del llamado síndrome cardiorrenal o cardiopulmonar-renal. En estos casos, es importante asegurar un enfoque terapéutico integral, que incluya la interacción de especialistas de diferentes perfiles: cardiólogos, nefrólogos y neurólogos.

Como parte del manejo integral del paciente, es necesario considerar los efectos cruzados de las enfermedades (por ejemplo, la insuficiencia cardíaca congestiva puede causar hipoperfusión renal, y la insuficiencia renal crónica puede aumentar la disfunción cardíaca). Los protocolos de tratamiento modernos incluyen el uso de estrategias combinadas, como la optimización del tratamiento con diuréticos, el control de los niveles de creatinina y electrolitos, el uso de inhibidores de la ECA/antagonistas de los receptores de angiotensina II, así como la corrección de la hiperfosfatemia y la anemia en pacientes con insuficiencia renal. Se presta especial atención a la monitorización de la función pulmonar, ya que la insuficiencia respiratoria suele ser consecuencia de una patología cardíaca o renal. También es importante evaluar el riesgo de complicaciones neurológicas, como ictus o demencia vascular, especialmente en pacientes con una evolución prolongada de la enfermedad.

Por lo tanto, el manejo exitoso de los pacientes con insuficiencia cardiopulmonar y renal requiere una estrecha colaboración entre cardiólogos, nefrólogos y neurólogos, con el fin de individualizar el tratamiento, minimizar los efectos secundarios y mejorar la calidad de vida de los pacientes.

Palabras clave: insuficiencia cardiopulmonar, insuficiencia renal, síndrome cardiorrenal, enfoque interdisciplinario, cardiología, nefrología, neurología, manejo integrado.

Introduction

Introduction. Modern clinical practice is increasingly faced with patients suffering from multiorgan disorders, where cardiopulmonary and renal insufficiency occupy a central place. Such conditions are characterized by a complex relationship between organs, forming the so-called “cardio-renal” or “cardiopulmonary-renal” syndrome. A malfunction of one of these organs can lead to the development of pathological changes in others, creating a vicious circle of progressive disease.

For example, congestive heart failure can cause renal hypoperfusion, which leads to impaired fluid excretion and accumulation of toxic metabolites[1]. On the other hand, chronic renal failure contributes to the development of arterial hypertension, volume overload of the heart and the progression of cardiomyopathy[2]. In addition, respiratory failure, which can be either a consequence of cardiac pathology (for example, with pulmonary hypertension), or an independent factor that aggravates the general condition of the patient.

In addition, such patients are at high risk of developing neurological complications such as stroke, vascular dementia, or metabolic encephalopathy due to circulatory disorders, hypoxia, or electrolyte disorders[3]. This requires special attention from neurologists for the timely diagnosis and correction of these complications.

Thus, effective management of patients with cardiopulmonary and renal insufficiency is impossible without an interdisciplinary approach, where a cardiologist, nephrologist and neurologist play a key role. The joint work of specialists allows us to develop a comprehensive treatment strategy aimed at improving the function of all affected systems, minimizing side effects of therapy and improving the quality of life of patients.

Materials and methods

While writing this paper, a systematic review of scientific publications, clinical recommendations and international guidelines was conducted, data on the relationship between cardiopulmonary and renal insufficiency, including the mechanisms of development of cardiopulmonary syndrome, was studied, as well as a comparison of various strategies for managing cardiopulmonary and renal insufficiency used in cardiology, nephrology and neurology.

Combining data from different fields of medicine (cardiology, nephrology, neurology) allowed us to create a holistic picture of the disease. Conclusions are also formulated based on the analysis of literature sources and clinical experience, and key risk factors, disease progression mechanisms, and possible complications are highlighted. The potential of an interdisciplinary approach to improve prognosis in patients with multiorgan insufficiency is assessed.

Results

The cardiovascular, respiratory, and renal systems play a special role in multiorgan pathology. A malfunction of one of the links in this triad can trigger a chain reaction that exacerbates the condition of other systems. For example, congestive heart failure can cause a decrease in blood flow in the kidneys, which leads to fluid retention and the development of electrolyte disturbances, further exacerbating the work of the heart[4]. In turn, chronic renal failure contributes to increased blood pressure, volume overload of the myocardium and the progression of cardiac pathology[5]. By adding respiratory failure, which can be either a consequence of heart disease (for example, with pulmonary hypertension) or an independent risk factor, an extremely complex clinical picture can be obtained.

It is especially important to note that patients with such conditions are at high risk of developing neurological complications such as stroke, vascular dementia, or metabolic encephalopathy. Such complications may occur due to cerebral circulatory disorders, hypoxia, or electrolyte imbalance[6]. This requires careful monitoring by neurologists to identify and correct possible problems in a timely manner.

Successful treatment of such patients requires an integrated approach that involves close collaboration between specialists from different fields – cardiologists, nephrologists and neurologists. Each of them performs its own unique task: a cardiologist focuses on restoring the functioning of the cardiovascular system, a nephrologist focuses on normalizing kidney function and water-electrolyte balance, and a neurologist is responsible for the diagnosis and treatment of neurological complications. The joint work of these specialists allows us to develop a comprehensive therapy plan aimed at improving the condition of all affected systems, minimizing side effects of treatment and improving the patient's quality of life.

Accordingly, effective management of patients with cardiopulmonary and renal insufficiency requires a deep understanding of the mechanisms of interaction between various organs, as well as the use of modern treatment methods adapted to the specifics of each specific case. An interdisciplinary approach is becoming a fundamental element in the treatment of these complex conditions, allowing not only to stabilize the current situation, but also to prevent further development of the disease. The roles of the cardiologist, nephrologist, and neurologist in the integrated management of cardiopulmonary and renal insufficiency are presented in table 1.

Table 1. The roles of cardiologist, nephrologist and neurologist in the integrated management of cardiopulmonary and renal insufficiency

Specialist	Main tasks	iagnostic methods
Cardiologist	-diagnosis and treatment of heart failure; -correction of arterial hypertension; -prevention of thrombosis; -volume overload management;	-echocardiography; -Holter ECG monitoring; -determination of biomarkers (NT-proBNP, troponin); - CT/MRI of the heart
Nephrologist	-correction of kidney function; -water and electrolyte balance management; -treatment of chronic kidney disease	-blood test (creatinine, electrolytes); -urinalysis; -Ultrasound of the kidneys -definition of glomerular filtration rate
Neurologist	-identification and treatment of neurological complications; -stroke prevention; -correction of metabolic encephalopathy	-Neuroimaging (CT/MRI of the brain) -EEG; -neurophysiological tests; -assessment of cognitive functions

A cardiologist plays a central role in the diagnosis, treatment, and prevention of complications in patients with cardiopulmonary and renal insufficiency. Its tasks are aimed at stabilizing the functioning of the cardiovascular system, minimizing the progression of pathology and preventing the development of severe complications.

The cardiologist uses modern diagnostic methods to detect congestive heart failure (CHF), including echocardiography, Holter ECG monitoring, biomarker detection (for example, NT-proBNP or troponin) and CT/MRI of the heart. Based on the examination data, the cardiologist determines the stage of heart failure according to the NYHA or ACC/AHA classification, which allows you to choose the most effective therapeutic strategy.

Treatment of CHF is aimed at reducing edema, improving peripheral blood circulation and increasing physical activity of the patient. Arterial hypertension is one of the main risk factors for the progression of heart and kidney failure[7]. The cardiologist selects individual treatment regimens, including ACE inhibitors, angiotensin II receptor blockers (ARBs), diuretics and beta blockers.

Constant monitoring of blood pressure helps to prevent the development of hypertensive crises and reduce the burden on the heart and kidneys. In patients with heart failure, the risk of blood clots increases, especially in cases of cardiac arrhythmia (for example, atrial fibrillation)[8]. A cardiologist prescribes anticoagulants or anticoagulants to reduce this risk. Blood clots forming in the heart can cause an ischemic stroke. Anticoagulant therapy plays a key role in the prevention of this complication.

One of the main problems in patients with heart failure is fluid retention caused by impaired heart and kidney function. The cardiologist prescribes diuretics to eliminate edema and reduce volume overload. The use of drugs such as beta blockers (carvedilol, bisoprolol) and mineralocorticoid antagonists (spironolactone) helps to improve heart function and reduce its energy costs. In chronic heart failure, an increase in peripheral vascular resistance is often observed. The cardiologist uses vasodilators to reduce the load on the left ventricle.

The cardiologist develops non-drug therapy programs that include limiting salt intake, weight control, regular physical activity, and giving up bad habits. Since heart failure is often combined with impaired renal function, the cardiologist works closely with the nephrologist to select safe diuretics and control electrolyte levels.

A cardiologist is a key figure in the integrated management of patients with cardiopulmonary and renal insufficiency. Its tasks cover a wide range of activities: from accurate diagnosis and correction of heart failure to blood pressure management, prevention of thrombosis and reduction of stress on the cardiovascular system. Thanks to modern diagnostic and therapeutic methods, as well as close cooperation with other specialists, the cardiologist contributes to a significant improvement in the quality of life of patients and reduces the risk of complications.

The nephrologist plays a key role in the diagnosis, treatment and prevention of complications in patients with renal insufficiency, especially when it is combined with cardiopulmonary pathology. Its tasks are aimed at restoring kidney function, correcting the water-electrolyte balance and preventing the progression of chronic kidney disease (CKD).

The nephrologist uses various diagnostic methods to assess the functional state of the kidneys, including blood tests (creatinine, urea), determination of glomerular filtration rate (GFR or GFR), urinalysis and ultrasound of the kidneys. Based on the examination data, the nephrologist determines the stage of chronic kidney disease according to the KDIGO classification (Kidney Disease: Improving Global Outcomes), which allows choosing the most appropriate therapeutic strategy.

Constant monitoring of kidney function indicators helps to prevent the development of acute renal failure and slow the progression of CKD[9]. One of the main prob-

lems in patients with renal insufficiency is fluid retention, which can worsen heart failure. The nephrologist selects individual diuretic therapy regimens, taking into account the level of kidney function and the general condition of the patient.

Disorders of potassium, sodium, calcium, and magnesium levels are common in CKD. The nephrologist prescribes medications to correct these disorders, for example, phosphate binding agents for hyperphosphatemia or calcium supplements for impaired mineral metabolism. Hyperkalemia (elevated potassium levels) poses a serious threat to the life of patients with CKD. The nephrologist uses special medications (for example, sorbitol or patiromer) to reduce potassium levels.

The nephrologist develops dietary recommendations that limit protein intake in order to reduce the burden on the kidneys. ACE inhibitors and ARBs not only lower blood pressure, but also protect the kidneys from progressive damage. Such drugs are the mainstay of treatment for patients with CKD.

Anemia often develops in CKD due to a lack of erythropoietin[10]. The nephrologist prescribes erythropoietin-stimulating drugs (ESD) to increase hemoglobin levels. In severe CKD, the nephrologist prepares the patient for dialysis therapy by choosing the most appropriate option (hemodialysis or peritoneal dialysis). During dialysis, the nephrologist monitors the effectiveness of the procedure, adjusts the blood purification regime and prevents possible complications.

High blood pressure accelerates kidney damage[11]. The nephrologist works together with the cardiologist to achieve the target blood pressure values. In the presence of neurological complications such as metabolic encephalopathy, a nephrologist works with a neurologist to correct the disorders.

The nephrologist is an important link in the comprehensive management of patients with cardiopulmonary and renal insufficiency. Its tasks cover a wide range of activities: from accurate diagnosis and correction of kidney function to water and electrolyte balance management and prevention of CKD progression. Thanks to modern diagnostic and therapeutic methods, as well as close cooperation with other specialists, the nephrologist helps to improve the quality of life of patients and reduce the risk of complications.

A neurologist plays an important role in the diagnosis, treatment, and prevention of neurological complications in patients with cardiopulmonary and renal insufficiency. Such conditions can significantly affect the central and peripheral nervous system, causing serious problems such as stroke, vascular dementia, metabolic encephalopathy, or peripheral neuropathy.

Patients with cardiopulmonary insufficiency are at risk of developing ischemic or hemorrhagic stroke[12]. A neurologist performs an early diagnosis when symptoms appear (for example, weakness in the extremities, speech disorders, dizziness) using CT/MRI of the brain. Chronic hypoperfusion of the brain due to heart failure can lead to cognitive impairment[13]. A neurologist evaluates the state of memory, attention, and other cognitive functions using special tests. With renal insufficiency, electrolyte imbalance and accumulation of toxic substances can cause encephalopathy. A neurologist identifies symptoms (e.g., confusion, seizures) and coordinates therapy to correct them.

In collaboration with a cardiologist, a neurologist selects anticoagulants or anticoagulants to reduce the risk of thrombosis, especially in patients with atrial fibrillation. A neurologist helps control blood pressure, blood glucose, and cholesterol levels, which reduces the likelihood of stroke.

For the treatment of vascular dementia or mild cognitive dysfunction, a neurologist prescribes drugs that improve blood circulation in the brain (for example, piracetam, cinnarizine) and stimulate neuroplasticity. Individual rehabilitation programs (physical exercises, cognitive training, psychotherapy) help patients adapt to changes in cognitive functions[14].

Patients with renal insufficiency often develop diabetic or toxic peripheral neuropathy. The neurologist uses electrophysiological methods (EMG, NVT) to assess the condition of peripheral nerves. To relieve pain, the neurologist prescribes analgesics, antipsychotic drugs, or local remedies.

Seizures may occur due to electrolyte imbalance (for example, hyponatremia or hyperkalemia)[15]. The neurologist selects anticonvulsant medications and coordinates their use with the nephrologist. Correction of electrolyte disturbances and control of the level of toxic substances in the blood help to prevent the development of seizures.

A neurologist works with a cardiologist to manage stroke risks and control blood pressure. Since many neurological complications are associated with impaired renal function, the neurologist works closely with the nephrologist to correct metabolic disorders and prevent encephalopathy.

Accordingly, the tasks of a neurologist include the identification and treatment of neurological complications such as stroke, vascular dementia, metabolic encephalopathy and peripheral neuropathy. Thanks to modern diagnostic and therapeutic methods, as well as close cooperation with a cardiologist and a nephrologist, the neurologist helps to improve the quality of life of patients and reduce the risk of neurological complications.

In congestive heart failure (CHF), the main pathophysiological process is a decrease in cardiac output, which leads to disruption of normal blood circulation throughout the body. The kidneys are especially sensitive to a decrease in blood flow, since their functioning depends on stable perfusion[16]. A decrease in renal perfusion causes the activation of compensatory mechanisms, such as sodium and water retention, which contributes to the development of edema and a further increase in the volume of circulating fluid. This creates a vicious circle: excess fluid loads the heart, exacerbating CHF, and a decrease in renal perfusion prevents the excretion of sodium and water, which increases the problem (Table 2).

Table 2. Interrelation and management of cardio-renal insufficiency

Pathophysiological mechanism	Effects
Decreased cardiac output in CHF → decreased renal perfusion	Activation of the RAAS, sympathetic nervous system, sodium and water retention, edema development
Activation of the RAAS and sympathetic nervous system	Vascular spasm, increased blood pressure, deterioration of renal perfusion, myocardial energy depletion
Accumulation of uremic toxins in CRF	Diastolic dysfunction, myocardial fibrosis, impaired contractile function of cardiomyocytes
Electrolyte disturbances in CRF	Hyperkalemia → arrhythmias; hyperphosphatemia → calcification of the coronary arteries
Sodium and water retention in CRF → arterial hypertension	Myocardial hypertrophy, diastolic dysfunction
The effect of lung diseases on the kidneys	Hypoxia → decreased renal perfusion, oxidative stress
Neurological complications	Imbalance of the autonomic nervous system, dysregulation of blood pressure and peripheral vascular resistance
Anemia in CRF	Reduced oxygen delivery to the tissues, additional stress on the heart

Activation of the renin-angiotensin-aldosterone system (RAAS) and the sympathetic nervous system in CHF plays a key role in the progression of the disease. RAAS stimulates the secretion of angiotensin II, which causes vascular spasm and increased blood pressure, which further impairs renal perfusion, as the kidneys become less able to filter blood with increased vascular resistance. In addition, activation of the sympathetic nervous system increases vascular tone and stimulates the heart muscle, which can lead to energy depletion of the myocardium and further deterioration of its function[17].

In chronic renal failure (CRF), toxic substances accumulate, which are usually excreted by the kidneys. These substances can have a direct damaging effect on the myocardium, causing changes in its structure and function. For example, diastolic dysfunction (impaired relaxation of the heart) is common in patients with CRF. This is due to the accumulation of uremic toxins such as indole sulfonic acids and purine metabolites, which disrupt the contractile function of cardiomyocytes and contribute to the development of fibrosis.

Electrolyte imbalance is one of the most serious problems with chronic kidney disease. Hyperkalemia (elevated levels of potassium in the blood) can cause dangerous arrhythmias such as ventricular tachycardia or ventricular fibrillation. Hyperphosphatemia (increased phosphorus levels) and impaired calcium-phosphorus balance contribute to coronary artery calcification, which increases the risk of coronary heart disease and myocardial infarction[18]. These electrolyte disturbances significantly worsen the prognosis of patients with a combination of CRF and heart failure.

The retention of sodium and water, characteristic of CRF, leads to an increase in the volume of circulating blood and, consequently, to arterial hypertension. High blood pressure puts additional strain on the left ventricle of the heart, which can cause myocardial hypertrophy and, eventually, diastolic dysfunction. Thus, CRF increases heart failure through the mechanism of arterial hypertension.

Lung diseases such as pneumonia, acute respiratory infections, or chronic obstructive pulmonary disease (COPD) can significantly affect kidney function. Hypoxia that occurs in these conditions leads to a decrease in renal perfusion through the mechanism of vascular spasm and impaired renal cell metabolism. In addition, hypoxia can cause oxidative stress, which exacerbates damage to renal tissues[19]. This is especially important for patients with already impaired renal function, as even small changes can lead to significant deterioration.

Neurological complications such as stroke or encephalopathy can significantly alter the regulation of the cardiovascular system and renal blood flow. For example, a stroke can cause an imbalance in the functioning of the autonomic nervous system, which leads to impaired control of blood pressure and peripheral vascular resistance. This, in turn, can worsen renal hypoperfusion and put additional strain on the heart. Encephalopathy associated with uremia or hypoxia can also affect the central mechanisms of regulation of the cardiovascular system[20], which makes the management of these patients even more difficult.

Thus, the relationship between cardiopulmonary and renal insufficiency requires an integrated approach that takes into account all these cross-cutting mechanisms. Close collaboration between cardiologists, nephrologists, and neurologists allows for the development of an optimal treatment strategy aimed at improving the patient's quality of life and preventing disease progression.

Comprehensive management of patients with cardiopulmonary and renal insufficiency requires a careful approach to correcting various pathophysiological mechanisms. Diuretic therapy plays a central role in controlling the volume of circulating fluid, which is especially important in congestive heart failure and chronic renal disease. In this case, it is necessary to take into account the individual characteristics of the patient, since excessive use of diuretics can lead to a decrease in renal perfusion and the development of acute renal failure[21]. Therefore, the dosage should be selected taking into account the dynamics of renal function, including creatinine levels and glomerular filtration rate.

Monitoring of electrolyte levels is an equally important aspect of treatment. Electrolyte imbalance disorders such as hyperkalemia or hypokalemia can cause serious arrhythmias and other life-threatening conditions[22]. To prevent these complications, regular monitoring of blood concentrations of sodium, potassium, magnesium and calcium is required, as well as timely correction of detected disorders. This is especially important for patients with chronic renal failure, where electrolyte disturbances are more common.

The use of angiotensin converting enzyme (ACE) inhibitors or angiotensin II receptor blockers (ARB) is aimed at reducing the burden on the cardiovascular system and slowing the progression of renal pathology. These drugs help to dilate blood vessels, lower blood pressure and reduce proteinuria. However, their administration requires caution due to the risk of hypotension and acute kidney injury, especially in patients with already impaired renal function. In such cases, the doses of drugs should be adapted to specific clinical indicators.

Correction of hyperphosphatemia plays a key role in the management of mineral metabolism in patients with chronic renal failure. Elevated phosphorus levels in the blood can contribute to the development of cardiac fibrosis and calcification of the coronary arteries, which worsens the prognosis in heart failure[23]. The use of phosphate-binding drugs helps to normalize mineral metabolism and prevent these complications. In parallel, attention is being paid to the correction of secondary hyperparathyroidism, which often accompanies chronic renal failure.

Anemia associated with erythropoietin deficiency is another important problem that requires specific management. Anemia reduces oxygen delivery to the tissues, which further strains the heart and exacerbates the symptoms of heart failure. Recombinant erythropoietin and iron-containing drugs are used to correct anemia, which can improve the patient's general condition, improve his efficiency and quality of life. Thus, the integrated management of patients with cardiopulmonary and renal insufficiency includes a multidimensional approach that takes into account the interrelationship of various body systems and requires coordination of the efforts of doctors of different specialties.

Randomized trials emphasize the importance of an interdisciplinary approach, demonstrating how collaboration between specialists from different fields can improve clinical outcomes and the quality of life of patients. Thus, a group of specialists studied the effect of anemia correction with recombinant erythropoietin (rHuEPO) on heart and kidney function in patients with chronic renal failure (CRF) and congestive heart failure (CHF). The aim of the study was to assess whether an increase in hemoglobin levels contributes to improving cardiovascular outcomes and preventing the progression of CRF. As a result of the study, the following results were obtained: correction of anemia led to a significant improvement in the subjective symptoms of CHF: shortness of breath and fatigue decreased in 65% of patients in the erythropoietin group (vs. 30% in the control group, $p < 0.01$).

Creatinine levels stabilized in 40% of patients in the erythropoietin group, compared with a progressive increase of 12% per year in patients in the control group ($p = 0.03$). The frequency of hospitalizations decreased by 30% in the group of patients receiving erythropoietin therapy, which corresponds to a 28% reduction in risk (95% CI: 15-40%, $p < 0.001$)[24]. Accordingly, the study emphasized the need for coordination between cardiologists and nephrologists to correct anemia, which improves the quality of life of patients and slows down the progression of CRF.

Another group of specialists studied the effectiveness of ACE inhibitors/angiotensin II receptor blockers (ARB) in the treatment of patients with cardiorenal syndrome. They set a goal to determine whether the use of ARB improves kidney function and reduces the frequency of CHF decompensation. It was found that in the group of patients treated with losartan (an angiotensin II receptor blocker), the rate of CRF progression decreased by 45% compared with the placebo group (0.5 ml/min/1.73 m2/year vs. 0.9 ml/min/1.73 m2/year, $p =0.02$). The frequency of hospitalizations due to decompensated CHF decreased by 25% in the ARB group (HR = 0.75, 95% CI: 0.60–0.94, $p = 0.01$). The combination of ARB with beta-blockers showed an additional effect: a 32% reduction in the risk of death (HR = 0.68, 95% CI: 0.52–0.88, $p = 0.003$)[25]. Thus, the importance of cooperation between cardiologists and nephrologists for optimizing drug therapy aimed at protecting the kidneys and heart was demonstrated.

Another study evaluated the effectiveness of various diuretic therapy strategies in patients with acute decom-

pensated CHF syndrome. The specialists planned to find out which method of furosemide dosing (standard or double dose) and the method of its administration (continuous infusion or intermediate intravenous infusions) is safer and more effective. According to the results of the study, a 2.5% increase in the furosemide dose led to a deterioration in renal function in 20% of patients (vs. 12% in the standard dosage group, p = 0.04). Continuous infusion of diuretics showed no advantages over episodic administration in terms of clinical outcomes, but was associated with a lower risk of acute renal failure (10% vs. 15%, p = 0.03)[26]. The overall frequency of repeat hospitalizations within 60 days was the same in both groups (35%). Thus, the need for close cooperation between cardiologists and nephrologists was emphasized in order to choose the optimal diuretic therapy strategy that minimizes the risk of negative effects on the kidneys.

It is also of interest to study the effectiveness of spironolactone in patients with systolic-preserved CHF, including those with combined CRF, which raised the question of whether spironolactone reduces the incidence of major cardiovascular events in patients with preserved ejection fraction. As a result, it was found that spironolactone reduced the risk of hospitalization due to CHF by 22% (HR = 0.78, 95% CI: 0.65–0.93, p = 0.005). At the same time, the risk of hyperkalemia increased by 35% in the spironolactone group (12% vs. 9%, p =0.02), which required regular monitoring of electrolytes. Nephrological monitoring made it possible to detect and correct hyperkalemia in a timely manner, reducing the associated complications[27]. Thus, the importance of coordinating the actions of cardiologists and nephrologists when prescribing mineralocorticoid antagonists was confirmed, especially in patients with an increased risk of electrolyte disorders.

Another group of specialists studied the effects of neurological complications (for example, stroke) on kidney and heart function in patients with CHF in order to assess how changes in the central nervous system affect the cardiorenal balance. Patients with a history of stroke had a 40% higher risk of CRF progression (HR = 1.40, 95% CI: 1.15–1.70, p =0.001). The incidence of CHF-related hospitalizations was 35% higher in patients with neurological complications (HR = 1.35, 95% CI: 1.10–1.65, p = 0.004). The joint work of neurologists, cardiologists, and nephrologists has reduced the risk of repeated hospitalization by 25% through the introduction of protocols for early detection and correction of disorders[28].

Monitoring of pulmonary function is an integral part of the comprehensive management of patients with cardiopulmonary and renal insufficiency, as respiratory failure often develops as a consequence of these pathologies. Congestive heart failure can lead to pulmonary edema, disrupting gas exchange and causing difficulty breathing[29]. Chronic kidney failure, in turn, contributes to fluid retention in the body, which also increases the load on the lungs. In addition, metabolic disorders such as hypokalemia or hyperkalemia can affect the functioning of the diaphragm, which further complicates respiratory function. Various examination methods are used for the timely diagnosis and correction of these disorders. Spirometry helps to assess the volume of inhalation and exhalation, identifying restrictive or obstructive disorders. Oximetry makes it possible to control the level of oxygen saturation in the blood, and a blood gas analysis makes it possible to measure the concentration of oxygen and carbon dioxide, which is important for evaluating the effectiveness of gas exchange[30]. Imaging techniques such as radiography or computed tomography of the lungs can help identify structural changes, such as signs of edema or pneumonia. Treatment of respiratory failure is aimed at correcting the underlying disease: the use of diuretics for pulmonary edema, the use of oxygen therapy to compensate for hypoxia and, if necessary, noninvasive ventilation.

In parallel with monitoring of pulmonary function, it is necessary to carefully assess the risk of neurological complications such as stroke or vascular dementia, especially in patients with a long-term course of the disease. These conditions can be triggered by circulatory disorders, hypoxia, or electrolyte disorders. Stroke, for example, often occurs against the background of atrial fibrillation or arterial hypertension, which are frequent companions of cardiovascular diseases[31]. Vascular dementia can develop as a result of chronic hypoperfusion of the brain, which is typical for patients with congestive heart failure. Metabolic encephalopathy caused by impaired renal function also poses a serious threat to the central nervous system[32]. Thus, early diagnosis and prevention of these complications require close collaboration between a cardiologist, a nephrologist and a neurologist to develop individual therapeutic strategies that take into account all aspects of the disease.

Conclusions

The integrated management of patients with cardiopulmonary and renal insufficiency is a complex task requiring an interdisciplinary approach and close collaboration between a cardiologist, a nephrologist and a neurologist. These conditions are characterized by a close relationship between the body's systems, where a violation of the function of one organ can lead to an aggravation of the pathology of another. Cardio-renal syndrome, respiratory failure, and neurological complications such as stroke or metabolic encephalopathy are examples of this interdependence.

Modern treatment protocols are aimed at using combined strategies, including optimizing diuretic therapy, controlling creatinine and electrolyte levels, using drugs

that affect the renin-angiotensin-aldosterone system (for example, ACE inhibitors or ARBs), as well as correcting hyperphosphatemia and anemia in patients with chronic kidney disease. Special attention is paid to monitoring of pulmonary function for timely detection and correction of respiratory failure, which is often a consequence of cardiac or renal pathology.

In addition, it is important to assess the risk of neurological complications such as stroke or vascular dementia, especially in patients with a long-term course of the disease. The neurological component requires early diagnosis and timely correction of disorders, which helps to prevent the progression of diseases and improve the quality of life of patients.

Thus, success in managing these complex conditions depends on the integration of the efforts of specialists of different profiles, the use of modern diagnostic and treatment methods, as well as a personalized approach to each patient, which contributes not only to stabilizing the current condition, but also to reducing the risk of complications, improving the prognosis and improving the quality of life of people with multiple organ disorders.

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