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Current Understanding and Problems of Early Diagnosis of Cardiorenal Syndrome in Military Personnel: A Comprehensive Review

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Abstract: Cardiorenal syndrome (hereinafter referred to as CRS) is a complex pathophysiological condition involving bidirectional dysfunction of the heart and kidneys, which has serious consequences in terms of the progression of cardiovascular diseases, increased mortality and increased health care costs. In military personnel, the prevalence and impact of cattle is of particular concern due to occupational risk factors, including high levels of chronic psychoemotional stress, irregular physical activity, sleep disorders, and exposure to various extreme conditions. This review examines current concepts of bovine cattle classification, pathophysiological mechanisms, and approaches to its early diagnosis, with a particular focus on its use in military medicine. Recent advances in biomarker research have identified promising early markers, including NT-proBNP, NGAL, KIM-1, and cystatin C, that may make it easier to detect subclinical organ damage before traditional indicators deviate from the norm. Additional factors such as post-traumatic stress disorder, combat participation, and operational stress need to be considered in the strategy for assessing risk in military populations. This review summarizes current data and highlights existing knowledge gaps that require further study, in particular regarding the validation of biomarker panels in military cohorts and the development of population-specific screening algorithms.

Key words: Cardiorenal syndrome, military medicine, biomarkers, early diagnosis, pathophysiology, risk factors.

INTRODUCTION

The complex relationship between cardiac and renal function has long been recognized in clinical medicine, but the formal conceptualization of cardiorenal syndrome (CRS) as a separate clinical entity is a relatively recent achievement. The National Heart, Lung, and Blood Institute (NHLBI) originally defined CRS in 2004 as a condition resulting from interactions between the kidneys and other circulatory compartments that increases the volume of circulating blood and worsens the symptoms of heart failure [1]. Since then, this definition has expanded to encompass the complex bi-directional nature of heart-kidney interactions, recognizing that dysfunction of

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either organ can trigger or exacerbate dysfunction of the other [2].

The clinical significance of cattle is difficult to overestimate. Data from epidemiological studies show that 20-30% of patients hospitalized with acute decompensated heart failure develop acute renal injury (hereinafter referred to as AKI), while 40-60% of patients with chronic heart failure show some degree of chronic kidney disease (hereinafter referred to as CKD) [3]. This bidirectional relationship significantly worsens the prognosis, and mortality rates in patients with combined heart and kidney dysfunction are significantly higher than in patients with isolated damage to one organ [4].

In military populations, cattle become particularly important because of occupational risk factors that can accelerate the development and progression of both cardiac and renal dysfunction. Military personnel are exposed to chronic psychoemotional stress, irregular sleep patterns, extreme physical exertion, and, in some cases, combat-related injuries – all of which can activate neurohormonal pathways, promote systemic inflammation, and contribute to endothelial dysfunction [5,6]. In addition, special requirements and specific conditions of military service often limit access to a comprehensive medical examination, which makes early detection of subclinical organ dysfunction particularly difficult.

The purpose of this paper is to provide a comprehensive overview of current concepts of the pathophysiology of cattle, classification and approaches to early diagnosis, with special attention to aspects that are important for military medical practice. Summarizing recent advances in biomarker research and identifying knowledge gaps that require further study, this review aims to contribute to the development of improved screening and prevention strategies for bovine cattle in military personnel.

Classification of cardiorenal syndrome

At the consensus conference of the initiative group on acute dialysis (ADQI) in 2008, a generally accepted classification system for cattle was established, dividing the syndrome into five different phenotypes based on the time sequence of organ damage and the severity of the process [1]. This classification has proven to be valuable for clinical practice and research, making it easier to understand the underlying mechanisms of cattle and identify therapeutic approaches.

Type 1: Acute cardiorenal syndrome

Type 1 cattle are characterized by acute deterioration of cardiac function leading to AKI. Common provoking factors include acute decompensated heart failure, cardiogenic shock, and acute coronary syndrome [7]. Pathophysiology includes hemodynamic changes, in particular a decrease in cardiac output and the development of venous congestion, in combination with neurohormonal activation. Mullens and colleagues in a study of 145 patients with decompensated heart failure demonstrated that elevated central venous pressure is strongly correlated with impaired renal function, which highlights the importance of venous congestion beyond simple hypoperfusion [8].

The incidence of type 1 cattle is significant, affecting 20-30% of patients hospitalized with acute decompensated heart failure [9]. Patients who develop this syndrome have significantly longer hospital stays and higher mortality rates compared to patients without kidney damage.

Type 2: Chronic cardiorenal syndrome

Type 2 CRS includes chronic cardiac dysfunction leading to progressive CKD. This is one of the most common forms of CRS: 40-60% of patients with chronic heart failure show some degree of renal failure [3]. Pathogenesis includes persistent hemodynamic disorders, chronic neurohormonal activation, systemic inflammation, oxidative stress, and progressive renal tissue fibrosis [10].

Experimental models have shown that coronary artery ligation in animals leads not only to cardiac dysfunction, but also to kidney infiltration by inflammatory cells, cytokine release, and interstitial fibrosis over time [11]. These changes can occur despite the initially preserved glomerular filtration rate (GFR),

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which underlines the importance of detecting subclinical renal damage.

Type 3: Acute renocardial syndrome

CRS type 3 describes a primary acute kidney injury that causes acute cardiac dysfunction. Causes include renal ischemia, exposure to nephrotoxins, and acute glomerulonephritis [12]. Mechanisms include volume overload, electrolyte disturbances, acidosis, and accumulation of uremic toxins that have cardio depressive effects. Studies show that 30-50% of patients with AKI may develop signs of cardiac dysfunction [13].

Type 4: Chronic renocardial syndrome

Type 4 CRS includes CKD leading to cardiac remodeling, left ventricular hypertrophy, and heart failure. The pathophysiological basis for this type is uremic cardiomyopathy, vascular calcification, anemia, and bone-mineral metabolism disorders [12]. Cardiovascular complications are the leading cause of death in patients with CKD, with mortality from cardiovascular causes exceeding that from progression to end-stage renal failure [14].

Type 5: Secondary cardiorenal syndrome

Bovine type 5 includes systemic diseases that simultaneously affect both the heart and kidneys. Examples include sepsis, diabetes mellitus, amyloidosis, and systemic lupus erythematosus [12]. In this phenotype, the underlying pathological condition causes parallel damage to both organs through common pathophysiological mechanisms.

Although this classification system has proven to be useful in clinical terms, it should be recognized that in practice, especially with the progression of diseases, the boundaries between phenotypes are usually blurred and combinations of them can occur. In addition, this classification does not fully reflect the complex interaction of neurohormonal, inflammatory, and fibrotic mechanisms that operate in all phenotypes [15].

Pathophysiological mechanisms

The pathophysiology of cattle includes consistent and complex interactions between hemodynamic changes, neurohormonal activation, endothelial dysfunction, oxidative stress, inflammation, and fibrosis. Understanding these mechanisms is very important for developing effective strategies for early detection and prevention of cattle.

Hemodynamic mechanisms

Traditional understanding has considered a decrease in cardiac output leading to renal hypoperfusion as the main driving factor of KRS. However, recent data have revealed the leading role of venous congestion. Elevated central venous pressure (CVP) increases renal venous pressure, increasing pressure in the interstitial and tubular vessels of the kidney, which counteracts glomerular filtration [16].

In a study of 2,557 patients who underwent cardiac catheterization, Damman and colleagues demonstrated a significant inverse correlation between CVP and calculated GFR ($p<0.0001$), independent of cardiac output [16]. This discovery allowed us to draw important conclusions in terms of clinical management of patients, suggesting that the elimination of venous congestion may be just as important as improving direct blood flow.

Cardiac output and cardiac index also play an important role. A reduced cardiac index cannot maintain adequate renal perfusion, which leads to activation of the renin-angiotensin-aldosterone system (hereinafter-RAAS). In patients with cardiogenic shock, a lower cardiac index and unfavorable hemodynamic profiles correlate with a higher incidence of AKI [8].

Neurohormonal mechanisms

RAAS and the sympathetic nervous system are central to the pathogenesis of cattle. Chronic activation of these systems, while initially compensatory, ultimately contributes to progressive organ damage. Angiotensin II has a differentiated constrictor effect on the bringing and carrying arterioles, increasing intra-glomerular pressure. In addition to hemodynamic effects, angiotensin II and aldosterone directly stimulate proliferative and fibrotic changes in cardiac and renal tissues [17].

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In particular, aldosterone has been shown in experimental and clinical studies to stimulate the synthesis of myocardial collagen, contributing to fibrosis and diastolic dysfunction of the heart [16]. Activation of RAAS is also closely associated with oxidative stress and inflammation, and angiotensin II enhances the production of mitochondrial reactive oxygen species and activates NF-kB pathways that stimulate proinflammatory and profibrotic processes [17].

Inflammation and oxidative stress

Systemic inflammation plays a crucial role in the pathogenesis of cattle. Biomarkers such as neutrophil gelatinase-associated lipocalin (NGAL) and kidney damage molecule-1 (KIM-1) reflect the degree of inflammatory activity and facilitate early diagnosis of cattle [18]. NGAL is released from renal tubule epithelial cells at an early stage after ischemic or toxic damage, appearing 24-48 hours before elevated creatinine levels, and is a valuable marker for early detection of structural kidney damage in AKI.

The NF-kB signaling pathway and the NLRP3 inflammasome play a key role in inflammatory processes in cattle. Angiotensin II activates NF-kB, increasing the production of pro-inflammatory cytokines, including IL-1β, IL-6 and TNF-α. IL-1β, in turn, aggravates endothelial dysfunction and stimulates fibroblast proliferation [17]. Oxidative stress generates free radicals that promote lipid peroxidation of cellular and intracellular membranes, protein denaturation, and DNA damage, leading to cell apoptosis and tissue remodeling.

Endothelial dysfunction

Endothelial dysfunction is a central pathogenetic mechanism in cattle. A violation of the balance between vasodilators (nitric oxide, prostacyclin) and vasoconstrictors (endothelin-1) impairs microcirculation. RAAS activation, inflammation, and oxidative stress negatively affect endothelial function, increasing the thrombotic tendency and accelerating atherosclerotic processes [12].

Accumulation of an endogenous nitric oxide synthesis inhibitor, asymmetric dimethylarginine (ADMA), in renal dysfunction contributes to endothelial dysfunction, reducing the bioavailability of nitric oxide. The endothelial glycocalyx is important for glomerular filtration. Damage to the endothelial glycocalyx layer also negatively affects kidney function [18].

Fibrotic pathways

Fibrosis is the final overall outcome and the most severe stage of BOVINE cancer. The main mediator of fibrosis is the transforming growth factor β1(TGF-β1)/Smad signaling pathway. TGF-β1promotes the accumulation of extracellular matrix by stimulating the synthesis of collagen and fibronectin [19]. Recent studies have revealed dysregulation of the TGF-β1/Smad pathway and altered miRNA expression (miR-21, miR-29, miR-133) as new pathogenetic factors in the progression of cattle.

New mechanisms

Recent studies have identified additional mechanisms involved in the pathogenesis of cattle. Mitochondrial dysfunction reduces ATP production, increases the generation of reactive oxygen species, and activates apoptotic pathways [18]. Accumulation of uremic toxins in CKD, including indoxyl sulfate and p-cresyl sulfate, has a direct cardiotoxic effect, exacerbates endothelial dysfunction and stimulates fibrosis.

Еще однимContributory фактором признан Dysbiosis of the gut microbiome is recognized as another Contributing factor. With a decrease in kidney function, the intestinal microbiota changes, the number of pathogenic bacteria increases, and the number of symbiotic microorganisms decreases. This increases the permeability of the intestinal wall, allowing bacterial toxins to enter the systemic circulation, promoting systemic inflammation and accelerating cardiorenal damage [20].

Biomarkers for early detection

Early detection of Bovine diseases, especially at subclinical stages, provides the best opportunities to prevent or slow the

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progression to irreversible organ damage. The American Heart Association's conceptual framework for the staging of cardiovascular-renal-metabolic syndrome (SPM), presented in 2023, provides a structured approach to risk stratification [21]. This system classifies patients into five stages, from stage 0 (no risk factors) to stage 4 (established cardiovascular disease), which facilitates early intervention.

Traditional markers

Estimated glomerular filtration rate (eGFR) and albuminuria remain key measurements for assessing renal function in cattle. An annual assessment of eGFR and urinary albumin/creatinine ratio (UACR) is proposed in high-risk individuals, including those with obesity, hypertension, diabetes, or metabolic syndrome [21]. These parameters can reveal early renal dysfunction before clinical manifestations appear.

At the same time, the calculation of eGFR based on endogenous creatinine clearance has limitations, especially in individuals with altered muscle mass, for example, in patients with sarcopenia or nutritional deficiencies. Cystatin C has advantages because it is independent of muscle mass and can more accurately reflect kidney function in such cases [18].

New biomarkers

NGAL and KIM-1 detect tubular damage at very early stages, with their urinary concentrations rising 24-48 hours before creatinine increases, making them valuable for predicting AKI [18]. Elevated levels of these biomarkers correlate with the risk of cattle and reflect active structural damage.

Symmetric dimethylarginine (SDMA) and TGF-β have shown promising results for the early diagnosis of cattle. In patients with hypertension and reduced eGFR, elevated levels of SDMA and TGF-β correlate with renal dysfunction [22]. Gallectin-3, a beta-galactose-binding lectin synthesized by macrophages, stimulates fibroblast proliferation and serves as a marker of fibrotic activity. Elevated levels of gallectin-3 predict poor outcomes in both chronic heart failure and CKD [18].

The N-terminal fragment of the brain natriuretic peptide precursor, remains one of the most important cardiac biomarkers in cattle. Its increase reflects the stress of the myocardial wall and has a strong prognostic value. In a study by Aletras and colleagues, the combination of NT-proBNP with markers of fibrosis and inflammation, including gallectin-3, sST-2, and GDF-15, provided high accuracy for the prognosis of cattle [18].

Cattle in military personnel: special aspects

Military personnel represent a unique population with respect to the risk of cattle due to occupational factors that can accelerate the development and progression of both cardiac and renal dysfunction.

Prevalence of risk factors

Despite the younger age and better physical fitness compared to the general population, the prevalence of cardiovascular risk factors among military personnel is quite high. In a comprehensive study of Brazilian military police officers (n=436), Palmieri and colleagues found that more than 80% of participants were overweight or obese, and 95% had high blood pressure or hypertension [23]. These indicators significantly exceed those in the general population. Gawron and colleagues reported the results of a study of Polish senior officers aged 40-58 years, 54% were found to have arterial hypertension, 83% were overweight or obese, and 65% had hypercholesterolemia (LDL >115 mg/dl) [24]. Sixty-two percent of officers had a high or very high 10-year cardiovascular risk on the SCORE2 scale, which demonstrates the accumulation of risk factors even among high-ranking personnel.

Psychoemotional stress

Military personnel experience chronic stress that profoundly affects their neurohormonal systems. In a study of Russian naval specialists, Sobolev and colleagues demonstrated that occupational stress is a significant risk factor for cardiovascular diseases [25]. Personnel operating deep-sea technical platforms were found to have a high level of stress, which negatively affected the functional parameters of their cardiovascular system.

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Interestingly, the control group showed higher correlations between stress factors and circulatory system parameters compared to the main group, which suggests that regular professional training and adaptation to stressful situations can increase resistance to stress and potentially reduce cardiovascular damage [25].

Environmental factors

Extreme climatic conditions create an additional cardiovascular load. Kryukov and colleagues, who studied military personnel serving in the Arctic region, found that cold climates, isolation, and limited communication opportunities increase cardiovascular risk [26]. Compared to personnel serving in temperate climates, Arctic personnel were more likely to experience negative psychosocial factors, including stress, excessive anxiety, and depression.

Arctic personnel also have a higher prevalence of arterial hypertension, mostly newly diagnosed, and elevated LDL cholesterol levels exceeding target values, which accelerates the risk of atherosclerosis. The authors emphasized the need for a thorough medical examination, including electrocardiography, echocardiography, lipid profile, and glucose assessment, when selecting personnel for Arctic deployments [26].

Sleep disorders

Irregular sleep patterns and sleep deprivation are common among military personnel due to shift work, night shifts, and operational requirements. Chronic sleep deprivation activates the sympathetic nervous system, increases blood pressure, reduces insulin sensitivity, and promotes inflammation. Petek and colleagues noted that “tactical athletes” often encounter unpredictable, explosive exercise patterns that create a sudden strain on the cardiovascular system, increasing the risk of acute cardiac events [6].

Combat experience and injury

Combat injuries, injuries and blood loss are important factors in the development of cattle. Hypovolemic shock in severe trauma can trigger AKI. In addition, medications used in combat, especially non-steroidal anti-inflammatory drugs and some antibiotics, can have nephrotoxic effects.

Post-traumatic stress disorder (hereinafter referred to as PTSD), which develops after participating in combat operations, increases the cardiovascular risk by about 2.4 times [5]. Chronic fatigue syndrome, which is widespread in military populations, leads to persistent sympathetic activation, increased blood pressure, and endothelial dysfunction.

Subclinical cardiovascular changes

Petek et al. note that when assessing cardiovascular risk in tactical athletes, both the initial cardiovascular risk with possible latent disease and the risk of acquired cardiac conditions as a result of acute or chronic exposure should be taken into account [6]. Studies show that in different age groups of military personnel, the incidence of sudden cardiac death is slightly higher compared to the population of the corresponding age groups.

Early detection and prevention strategies

Screening approaches

The regular medical monitoring that military personnel are subjected to creates opportunities for systematic screening programs. The experience of Martin Army Hospital (USA) shows that annual medical examinations, including blood pressure measurement, weight control and assessment of cardiovascular risk factors, are the main tools for early detection of developing pathological conditions. “These examinations allow military medics to intervene at an early stage of cardiovascular diseases. Early intervention, in turn, helps prevent the transition of time constraints to permanent ones” [27].

China's new medical standards for military pilots, which came into force in 2026, prescribe 24-hour ECG monitoring to detect hidden rhythm disorders [28]. These updated standards also include revised anthropometric requirements that take into account the technical characteristics of modern aircraft.

Laboratory screening

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Current guidelines suggest annual assessment of eGFR and UACRUACR in high-risk individuals [21]. The use of cystatin C clearance to assess eGFR may provide advantages over estimates based on endogenous creatinine clearance, especially in individuals with altered muscle mass. New biomarkers, including NGAL and KIM-1, offer opportunities for even earlier detection of tubular damage, although their cost-effectiveness in routine screening requires further evaluation.

Pharmacological prevention

In recent years, significant advances have been made in pharmacological approaches to the prevention of cattle. SGLT2 inhibitors (2 (dapagliflozin, empagliflozin), originally developed for the treatment of type 2 diabetes, have demonstrated powerful cardiorenal protective effects. When used in combination with traditional RAAS inhibitors, they reduce the frequency of hospitalizations for heart failure and fatal cardiovascular outcomes, as well as slow the decline in eGFR [14].

GLP-1 receptor agonists (semaglutide, liraglutide) have been shown to be effective not only for controlling glycemia, but also for weight loss and reducing cardiovascular risk [29]. These drugs are especially relevant for military personnel with obesity and type 2 diabetes.

New mineralocorticoid receptor antagonists, such asfinerenone, have shown an advantage in slowing cardiovascular events and reducing renal function in patients with type 2 diabetes mellitus and CKD [30].

Lifestyle modification

Lifestyle modification remains fundamental for the prevention of cattle, in conjunction with pharmacological approaches. Current guidelines emphasize a healthy diet, regular physical activity, smoking cessation, and healthy sleep as key components of SPM prevention [29]. Military service environments offer unique opportunities for structured lifestyle interventions, given the organized nature of physical fitness and the potential for integration into daily activities.

Prospects for future research

Validation of biomarker panels in military cohorts should be a priority, with a particular focus on cost-effectiveness and feasibility in the context of military service. Studies should evaluate whether combinations of traditional and new biomarkers improve predictive accuracy compared to current approaches.

Developing population-specific risk prediction models that include military-specific factors (combat experience, deployment duration, operational stress) could improve the early identification of high-risk individuals. Such models should be validated against existing cardiovascular risk calculators.

Prospective cohort studies that follow military personnel throughout their careers would provide invaluable data on the evolution of risk factors and outcomes.

Interventional studies are needed to assess the effectiveness of lifestyle modification programs in military settings. The structured environment of military service provides opportunities for implementing and evaluating interventions that would be difficult to study in civilian populations.

The integration of digital health technologies, including mobile apps for risk assessment and monitoring, is worth exploring. Such tools could facilitate screening in a large-scale setting where access to comprehensive health care is limited.

CONCLUSION

Cardiorenal syndrome is a complex clinical condition that manifests itself as bidirectional dysfunction of the heart and kidneys through interrelated hemodynamic, neurohormonal, inflammatory and fibrotic mechanisms. The five-phenotype classification system provides a useful basis for understanding temporal relationships and primary organ damage, although in practice the boundaries between phenotypes may become blurred.

In military personnel, occupational risk factors, including chronic psychoemotional stress, irregular exercise, sleep disorders, and combat experience, create a unique risk profile that can accelerate the development of cattle. The high

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prevalence of traditional cardiovascular risk factors, including hypertension, obesity, and dyslipidemia, in military populations further exacerbates this risk.

Early detection of cattle at subclinical stages provides the best opportunities to prevent irreversible organ damage. Traditional markers, including eGFR and albuminuria, remain fundamental, while new biomarkers, including NGAL, KIM-1, cystatin C, and gallectin-3, show promise for even earlier detection of structural damage. NT-proBNP remains the most important cardiac biomarker, reflecting myocardial wall tension and providing strong prognostic information.

Future research should focus on validating biomarker panels in military cohorts, developing population-specific risk prediction models that include military-specific factors, and evaluating the effectiveness of lifestyle interventions and digital health technologies in military settings. Such efforts will support the development of improved screening and prevention strategies for bovine cattle in military personnel, ultimately maintaining combat readiness and extending active service.

REFERENCES

1. Ronco C, Haapio M, House AA, Anavekar N, Bellomo R. Cardiorenal syndrome. J Am Coll Cardiol. 2008;52(19):1527-39.
2. Ronco C, McCullough PA, Anker SD, Anand I, Aspromonte N, Bagshaw SM, et al. Cardio-renal syndromes: report from the consensus conference of the acute dialysis quality initiative. Eur Heart J. 2010;31(6):703-11.
3. Gembillo G, Visconti L, Giusti MA, Siligato R, Gallo A, Santoro D, et al. Cardiorenal syndrome: new pathways and novel biomarkers. Biomolecules. 2021;11(11):1581.
4. McCullough PA, Kellum JA, Haase M, Muller C, Damman K, Murray PT, et al. Pathophysiology of the cardiorenal syndromes: executive summary from the 11th ADQI consensus conference. Blood Purif. 2013;36(2):74-84.
5. Belyi DO, Koval OA, Tkachenko VI. Arterial hypertension in military personnel: prevalence, risk factors and features of the course. Ukr J Mil Med. 2024;5(1):23-31.
6. Petek BJ, Tso JV, Churchill TW, Guseh JS, Loomer G, Wasfy MM, et al. Cardiovascular health in tactical athletes: a review of epidemiology, risk assessment, and management strategies. J Am Coll Cardiol. 2025;85(12):1201-15.
7. Goh CY, Vizzi G, De Cal M, Ronco C. Cardiorenal syndrome: a complex series of combined heart/kidney disorders. Contrib Nephrol. 2011; 174:33-45.
8. Mullens W, Abrahams Z, Francis GS, Sokos G, Taylor DO, Starling RC, et al. Importance of venous congestion for worsening of renal function in advanced decompensated heart failure. J Am Coll Cardiol. 2009;53(7):589-96.
9. Ronco C, Cicoira M, McCullough PA. Cardiorenal syndrome type 1: pathophysiological crosstalk leading to combined heart and kidney dysfunction in the setting of acutely decompensated heart failure. J Am Coll Cardiol. 2012;60(12):1031-42.
10. Lekawanvijit S, Kompa AR, Wang BH, Kelly DJ, Krum H. Cardiorenal syndrome: the emerging role of protein-bound uremic toxins. Circ Res. 2012;111(11):1470-83.
11. Regenburgh De La Motte L, Bassani B, Trepiccione F, Capasso G, Bruno A, Ambrosio G. Preclinical models of cardio-renal syndrome: a systematic review. Am J Physiol Cell Physiol. 2025;329(6).
12. Rangaswami J, Bhalla V, Blair JEA, Chang TI, Costa S, Lentine KL, et al. Cardiorenal syndrome: classification, pathophysiology, diagnosis, and treatment strategies. J Am Coll Cardiol. 2019;73(15):1934-48.
13. Hatamizadeh P, Fonarow GC, Budoff MJ, Darabian S, Kovesdy CP, Kalantar-Zadeh K. Cardiorenal syndrome: pathophysiology and potential targets for clinical management. Nat Rev Nephrol. 2013;9(2):99-111.
14. Weir M, Iapoce C. Matthew Weir, MD: prioritizing cardiovascular risk in chronic kidney disease. HCPLive. 2024.
15. Díaz GEJ, Sánchez AR, Santibañez SV, Regules SS. Cardio-renal metabolic

syndrome: pathogenic mechanisms. Acta Med. 2025;23(4):361-6.

16. Damman K, van Deursen VM, Navis G, Voors AA, van Veldhuisen DJ, Hillege HL. Increased central venous pressure is associated with impaired renal function and mortality in a broad spectrum of patients with cardiovascular disease. J Am Coll Cardiol. 2009;53(7):582-8.
17. Vasquez F, Tiscornia C, Lorca-Ponce E, Aicardi V, Vasquez S. Cardiorenal syndrome: molecular pathways linking cardiovascular dysfunction and chronic kidney disease progression. Int J Mol Sci. 2025;26(15):7440.
18. Aletras GA, Bairaktari A, Ntalianis A, Christou K, Tellis C, Tselepis AD, et al. Integrating novel biomarkers into clinical practice: a practical framework for diagnosis and management of cardiorenal syndrome. Life. 2025;15(10):1540.
19. Zhao Y, Wang H, Li X, Zhang L. Pathophysiological mechanisms of cardiorenal syndrome: from inflammation to fibrosis. Front Cardiovasc Med. 2025;12:112-24.
20. Clark JM, Sanders S, Carter M, Honeyman D, Cleo G, Auld Y, et al. Improving the translation of search strategies using the Polyglot Search Translator: a randomized controlled trial. J Med Libr Assoc. 2020;108(2):195-207.
21. Ouatu A, Buliga-Finiș ON. Comprehensive management strategies for cardiovascular-kidney-metabolic syndrome. In: Floria M, Tanase DM, editors. Cardiovascular-Kidney-Metabolic Syndrome. Cham: Springer; 2025.
22. Khudyakova AD. Clinical and prognostic significance of cardiorenal interactions and biomarkers in chronic heart failure [dissertation]. Saint Petersburg; 2021.
23. Palmieri G, D'Amato M, Grimaldi MC, Ronco C, et al. Cardionephrology: from theory to clinical practice in the management of cardiorenal syndrome. J Am Coll Cardiol. 2025;85(6):721-35.
24. Gawron BM, Żyśko B, Gajek J, Skoczyński P, Witkowski A. Prevalence of cardiovascular disease risk factors among military senior officers -- an epidemiological analysis and preventive implications. Lek Wojsk. 2025;103(3):228-33.
25. Sobolev VI, Gorbanev AY, Grishin SA, et al. Professional stress and cardiovascular risk in naval specialists. Mar Med. 2021;7(3):45-53.
26. Kryukov EV, Potekhin NP, Fursov AN, et al. Cardiovascular risk factors in military personnel serving in the Arctic region. Mil Med J. 2021;342(5):4-11.
27. Martin Army Community Hospital. Preventive medicine programs: annual health assessments for military personnel. Fort Moore (GA): Martin Army Community Hospital; 2024.
28. Chinese Consensus Report on the assessment and management of obstructive sleep apnea in patients with cardiovascular disease: 2024 edition. Sleep Med. 2025; 126:248-59.
29. Fiuza-Luces C, Santos-Lozano A, Joyner M, Carrera-Bastos P, Picazo O, Zugaza JL, et al. Exercise benefits in cardiovascular disease: beyond attenuation of traditional risk factors. Nat Rev Cardiol. 2018;15(12):731-43.
30. Bakris GL, Agarwal R, Anker SD, Pitt B, Ruilope LM, Rossing P, et al. Effect of finerenone on chronic kidney disease outcomes in type 2 diabetes. N Engl J Med. 2020;383(23):2219-29.