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# NEUROHUMORAL REGULATION IN HEART FAILURE: PHYSIOLOGICAL AND PATHOLOGICAL CHANGES

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**Abstract.** This article discusses the physiological and pathological changes of neurohumoral regulation in heart failure. Special attention is given to the role of the sympathetic nervous system, the renin-angiotensin-aldosterone system (RAAS), natriuretic peptides, and vasopressin in the pathogenesis of heart failure. Neurohumoral activation initially acts as a compensatory mechanism; however, chronic activation leads to maladaptive changes, including myocardial remodeling, fluid retention, and hemodynamic deterioration. Modern diagnostic approaches such as BNP and NT-proBNP biomarkers and functional cardiac assessment are also analyzed.

**Keywords:** heart failure, RAAS, sympathetic nervous system, BNP, aldosterone, vasopressin, myocardial remodeling.

**Introduction.** Heart failure (HF) is a complex clinical syndrome characterized by the inability of the heart to pump sufficient blood to meet the metabolic demands of the body. Neurohumoral systems play a central role in both the compensation and progression of this condition. Under physiological conditions, cardiac function is regulated by a balance between the sympathetic and parasympathetic nervous systems, the renin-angiotensin system, and natriuretic peptides. In heart failure, this balance is disrupted, resulting in chronic neurohumoral overactivation, which contributes to disease progression.

**Aim of the Study.** To analyze the physiological and pathological changes of neurohumoral regulation in heart failure and their clinical significance.

**Objectives**

1. To evaluate the role of the sympathetic nervous system in cardiac regulation.
2. To analyze the effects of RAAS activation on hemodynamics.
3. To assess the compensatory role of natriuretic peptides.
4. To study the role of vasopressin in fluid balance.
5. To determine the impact of neurohumoral dysregulation on myocardial remodeling.

**Main Body. Sympathetic Nervous System Activation.**

In early heart failure, reduced cardiac output activates baroreceptors, leading to increased sympathetic nervous system activity and catecholamine release (adrenaline and noradrenaline).

Initially, this response:

- increases heart rate
- enhances myocardial contractility
- maintains blood pressure

However, chronic activation leads to:

- myocardial toxicity
- arrhythmias
- β-adrenergic receptor downregulation

**Renin-Angiotensin-Aldosterone System (RAAS)**

Reduced renal perfusion activates renin release, initiating the RAAS cascade:

Renin → Angiotensin I → Angiotensin II

Angiotensin II causes:
- vasoconstriction
- increased afterload
- myocardial hypertrophy

Aldosterone promotes:
- sodium and water retention
- increased blood volume
- edema formation

**Natriuretic Peptide System**

BNP and ANP act as physiological antagonists of RAAS. They promote:
- vasodilation
- natriuresis
- inhibition of RAAS activity

However, in heart failure, their compensatory capacity becomes insufficient. BNP is widely used as a diagnostic and prognostic biomarker.

**Vasopressin (ADH)**

In heart failure, vasopressin secretion increases, leading to:
- enhanced water reabsorption
- volume overload
- hyponatremia

This further worsens cardiac workload and congestion.

**Myocardial Remodeling**

Chronic neurohumoral activation results in:
- cardiomyocyte hypertrophy
- interstitial fibrosis
- ventricular dilation

These structural changes contribute to progressive systolic and diastolic dysfunction.

**Results**

Clinical studies demonstrate that worsening heart failure is associated with:
- elevated BNP/NT-proBNP levels
- increased RAAS activity
- heightened sympathetic tone
- reduced ejection fraction

Neurohumoral overactivation correlates strongly with poor prognosis.

**Discussion.** Modern cardiology considers heart failure not only as a hemodynamic disorder but also as a neurohumoral disease. Persistent activation of RAAS and the sympathetic nervous system creates a vicious cycle of disease progression. Pharmacological blockade of neurohumoral systems using ACE inhibitors, ARBs, beta-blockers, and mineralocorticoid receptor antagonists significantly improves survival and quality of life in patients with heart failure.

**Conclusion**

1. Neurohumoral systems play both compensatory and pathological roles in heart failure.
2. RAAS and sympathetic activation increase cardiac workload.
3. BNP is an important diagnostic and prognostic biomarker.
4. Chronic neurohumoral activation leads to myocardial remodeling.
5. Neurohumoral blockade remains the cornerstone of heart failure therapy.

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