

Heart failure biomarkers: Advances in early detection and prognosis.

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Introduction

Heart failure (HF) is a global health burden affecting millions of individuals worldwide. It is a complex syndrome characterized by the heart's inability to pump blood efficiently, leading to inadequate oxygen delivery to tissues. Early detection and effective management are critical to improving patient outcomes and reducing healthcare costs. Biomarkers have emerged as powerful tools for diagnosing heart failure, assessing disease progression, and guiding therapeutic decisions. These molecular indicators provide insight into the pathophysiology of heart failure and help differentiate it from other cardiac and non-cardiac conditions. This article explores the significance of heart failure biomarkers, their classification, and their role in improving patient care. [1,2].

Heart failure biomarkers can be classified into several categories based on their biological function and clinical utility. These peptides are secreted by the heart in response to increased wall stress and volume overload. Elevated levels indicate heart failure severity and are widely used in diagnosis and prognosis. A vasodilatory peptide that reflects endothelial dysfunction and predicts adverse outcomes in HF patients. Though primarily used for detecting myocardial infarction, elevated levels of troponins are also indicative of ongoing myocardial damage in heart failure. A marker of oxidative stress, inflammation, and cardiovascular disease progression. These markers signal systemic inflammation, which plays a role in the progression of heart failure. [3,4].

Associated with cardiac remodeling and worsening of heart failure symptoms. Implicated in myocardial fibrosis and adverse cardiac remodeling, making it useful for risk stratification in HF patients. A biomarker of myocardial stress and inflammation, predicting mortality and hospitalization in heart failure patients. Biomarkers like BNP and NT-proBNP have high sensitivity and specificity in diagnosing heart failure. Elevated levels aid in distinguishing heart failure from other causes of dyspnea, such as chronic obstructive pulmonary disease (COPD) or pulmonary embolism. Serial measurements of biomarkers provide valuable information about disease trajectory. For instance, persistently high BNP levels suggest worsening heart failure, prompting clinicians to adjust treatment strategies. Biomarkers can guide personalized therapy. NT-proBNP levels help determine the effectiveness of heart failure medications, such as angiotensin receptor-neprilysin inhibitors (ARNIs), beta-blockers, and diuretics. Patients with persistently elevated galectin-3 or sST2 may benefit from more aggressive intervention. [5,6].

Biomarkers such as high-sensitivity troponins and soluble ST2 are strong predictors of mortality and rehospitalization. Elevated levels indicate a higher risk of cardiovascular events, helping clinicians prioritize high-risk patients for intensive management. Advances in molecular biology and genomics have led to the discovery of novel biomarkers with potential clinical applications. Some promising candidates include: Small, non-coding RNAs involved in gene regulation. Certain miRNAs, such as miR-423-5p, have been linked to heart failure and may serve as early diagnostic markers. [7,8].

These lipid-bound particles carry proteins and RNA signatures reflective of cardiac health. They offer a new frontier in biomarker research. Changes in metabolic profiles, including alterations in amino acids and lipids, are being investigated for their role in heart failure pathophysiology. The future of heart failure biomarkers lies in integrating multiple markers into predictive models. Machine learning and artificial intelligence (AI) are playing a crucial role in analyzing complex biomarker data to improve diagnostic accuracy and treatment outcomes. [9,10].

Conclusion

Heart failure biomarkers have transformed the landscape of cardiovascular medicine by enhancing early diagnosis, risk stratification, and treatment monitoring. Established biomarkers like BNP, troponins, and galectin-3 continue to be invaluable in clinical practice, while emerging biomarkers hold promise for even greater precision in managing heart failure. As research advances, the integration of biomarker panels with AI-driven analytics is expected to further refine heart failure management strategies.

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