Mini Review

BIOMEDICAL Journal of Scientific & Technical Research

ISSN: 2574 -1241

DOI: 10.26717/BJSTR.2026.65.010228

Heart Failure: Evolving Paradigms in Pathophysiology, Diagnosis, and Personalized Management

Rui Meng*

Department of Geriatrics, Aerospace Center Hospital, No. 15 Yuquan Road, Beijing 100049, China

***Corresponding author:** Rui Meng, Department of Geriatrics, Aerospace Center Hospital, No. 15 Yuquan Road, Beijing 100049, China

ARTICLE INFO

Received: April 15, 2026

Published: May 15, 2026

Citation: Rui Meng. Heart Failure: Evolving Paradigms in Pathophysiology, Diagnosis, and Personalized Management. Biomed J Sci & Tech Res 65(4)-2026. BJSTR. MS.ID.010228.

ABSTRACT

Heart Failure (HF) remains a leading cause of global morbidity and mortality, with over 64 million affected individuals worldwide. Recent years have witnessed transformative shifts in our understanding of HF pathophysiology, diagnostic precision, and therapeutic approaches. This mini-review synthesizes contemporary evidence from 2023–2024 clinical guidelines and emerging research, focusing on three key areas: (1) the redefined role of systemic inflammation and gut heart axis interactions in HF progression; (2) the evolution of phenotype based classification and diagnostic algorithms, particularly for Heart Failure with Preserved Ejection Fraction (HFpEF); and (3) the integration of novel pharmacotherapies (e.g., SGLT2 inhibitors across the ejection fraction spectrum) and digital health technologies for remote monitoring. We highlight how these advances are steering management toward more individualized, preventive, and technology enabled care models.

Abbreviations: HF: Heart Failure; HFPEF: Heart Failure with Preserved Ejection Fraction; GDMT: Guideline Directed Medical Therapy; RAAS: Renin Angiotensin Aldosterone System; EF: Ejection Fraction; TMAO: Trimethylamine N Oxide

Introduction

Heart failure is a complex clinical syndrome resulting from structural or functional cardiac impairment, leading to inadequate systemic perfusion [1]. Despite advances in Guideline Directed Medical Therapy (GDMT), hospitalizations and mortality remain unacceptably high. The 2024 updates to major international guidelines (ACC/AHA/HFSA, ESC) reflect a deeper integration of pathophysiological insights, biomarker driven diagnostics, and broad spectrum efficacy of newer drug classes. This review aims to provide a concise, evidence based overview of contemporary HF management, emphasizing practical implications for clinicians.

Pathophysiological Insights: Beyond Hemodynamics

The traditional hemodynamic model of HF has been supplemented by recognition of systemic metabolic and inflammatory crosstalk [2].

Myocardial Fibrosis and Metabolic Dysregulation

In HFpEF, microvascular inflammation and insulin resistance contribute to increased myocardial stiffness and diastolic dysfunction. Elevated filling pressures further promote pro fibrotic signaling, creating a vicious cycle of ventricular remodeling.

Neuroendocrine Immune Activation

Beyond the classic Renin Angiotensin Aldosterone System (RAAS) and sympathetic overactivation, macrophage mediated inflammatory responses accelerate myocardial injury [3]. Circulating cytokines (e.g., IL 6, TNF α) correlate with disease severity and prognosis.

The Gut Heart Axis

The "gut hypothesis" of HF posits that reduced cardiac output and venous congestion cause intestinal hypoperfusion, mucosal edema, and increased permeability ("leaky gut"). This allows translocation of bacterial products (e.g., lipopolysaccharide) into the circulation, triggering systemic inflammation and oxidative stress that further impair cardiac function [4]. Gut microbiota derived metabolites, such as trimethylamine N oxide (TMAO) and short chain fatty acids, have been implicated in HF progression, offering potential therapeutic targets.

Diagnosis and Phenotype Based Classification

The 2024 guidelines reinforce an Ejection Fraction (EF) based classification while incorporating comorbidities and biomarker profiles for finer stratification.

Updated EF Categories

HFrEF (EF ≤40%): Well established GDMT.

HFmrEF (EF 41–49%): Shares features of both HFrEF and HFpEF; GDMT for HFrEF is reasonable.

HFpEF (EF ≥50%): Diagnosis requires symptoms/signs of HF, elevated natriuretic peptides (NT proBNP >125 pg/mL in sinus rhythm), and objective evidence of diastolic dysfunction or structural abnormalities (e.g., left atrial enlargement, elevated E/e′ ratio).

Diagnostic Algorithms

The HFA PEFF and H_2FPEF scores integrate clinical, echocardiographic, and biomarker data to improve diagnostic accuracy for HFpEF. Invasive hemodynamic assessment (rest/exercise PCWP) remains the gold standard for ambiguous cases [5].

Emerging Tools

Wearable sensors and artificial intelligence enhanced echocardiography are being validated for early detection and longitudinal monitoring. For example, a recent feasibility trial of an AI enabled 3 lead ECG patch demonstrated 95.7% accuracy in discriminating HFpEF from HFrEF.

Therapeutic Strategies: From Quadruple Therapy to Digital Health

Pharmacological Advances

(Table 1).

Table 1: Key Drug Recommendations in 2024 Guidelines.

Drug Class	Indication	Key Trial/Evidence
SGLT2 inhibitors (e.g., dapagliflozin, empagliflozin)	HFrEF, HFmrEF, HFpEF (independent of diabetes)	DELIVER, EMPERORPreserved; 20–30% reduction in HF hospitalization
ARNI (sacubitril/valsartan)	HFrEF (firstline or after ACEi/ARB)	PARADIGMHF; superior to enalapril in reducing CV death/HF hospitalization
Vericiguat (sGC stimulator)	Worsening HFrEF	VICTORIA; reduces composite of CV death/HF hospitalization
Semaglutide (GLP1 RA)	Obese HFpEF (with/without diabetes)	STEPHFpEF; improves quality of life and 6min walk distance

Non-Pharmacological and Device Based Approaches: Cardiac rehabilitation: Individualized exercise programs based on cardiopulmonary exercise testing improve functional capacity and quality of life.

Remote monitoring and digital health: Implantable hemodynamic sensors (e.g., CardioMEMS) and wearable patches (e.g., ADI's Sensinel CPM System, FDA cleared in 2024) enable early detection of decompensation . Mobile health (mHealth) platforms with gamification and financial incentives have shown improved adherence to weight and activity monitoring (95% vs. 72.2% in controls) [6]. Virtual wards and telehealth programs reduce 30 day readmissions by up to 76% in some studies.

Challenges and Future Directions

1. **HFpEF heterogeneity:** Biomarker and imaging based phenotyping (e.g., inflammatory, metabolic, fibrotic) may guide targeted therapies [7].
2. **Equity in access:** Digital health solutions must address disparities in rural and low income populations.
3. **Prevention focus:** Aggressive management of hypertension, diabetes, and obesity before HF onset is crucial.
4. **Integration of multi omics and AI:** Combining genomic, proteomic, and microbiome data with machine learning algorithms could enable truly personalized HF management [8].

Conclusion

The management of heart failure is evolving toward a more nuanced, phenotype driven, and technology integrated paradigm. SGLT2 inhibitors have emerged as foundational therapy across the EF spectrum, while digital tools offer unprecedented opportunities for early detection and remote management. Future efforts should focus on leveraging multi modal data, closing care delivery gaps, and embedding prevention into primary care.

References

1. Wei Y, Zhang Q, Chi H, Wang Z, Chang Q (2023) Effects of Recombinant Human Brain Natriuretic Peptide on Atrial Fibrillation After Coronary Artery Bypass Grafting. J Cardiovasc Pharmacol 81(1): 63-69.
2. Ziyao Wang, Yangyan Wei, Junyu Chen, Qian Zhang, Jiwen Tang (2022) Effect of recombinant human brain natriuretic peptide on acute kidney injury after coronary artery bypass grafting: a retrospective comparative cohort study. Ann Transl Med 10(18): 9738

3. Baracos VE, Arron C (2019) Cancer cachexia: the role of inflammation in muscle wasting. Nature Reviews Clinical Oncology 16(6): 323-325.

4. Jäger B, Kotanko P (2021) The Heart in Sarcopenia: A New Dimension in Heart Failure?. Journal of the American College of Cardiology 77(18): 2332-2346.

5. Lavie CJ, Milani RV (2020) Sarcopenia and Heart Failure: The Heart Muscle Connection. Heart Failure Clinics 16(2): 209-223.

6. Sainz de la Cuesta R, Knoll M (2022) The impact of sarcopenia on outcomes in heart failure: A systematic review. Advances in Clinical and Experimental Medicine 31(5): 593-600.

7. Muscaritoli M, Molfino A (2021) The interplay between heart failure and sarcopenia: clinical implications and therapeutic strategies. The Journal of Cachexia, Sarcopenia and Muscle 12(3): 549-553.

8. Boehm G, Maier J (2020) Sarcopenia in Heart Failure: Diagnosis and Management. Springer.

ISSN: 2574-1241

DOI: 10.26717/BJSTR.2026.65.010228

Rui Meng. Biomed J Sci & Tech Res

Submission Link: https://biomedres.us/submit-manuscript.php