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Short Communication

Innovative Device-Based Therapies for Heart Failure: Advancing Care in Reduced Ejection Fraction

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ABSTRACT

Heart Failure (HF) remains a global health challenge despite advancements in Guideline-Directed Medical Therapy (GDMT). The high prevalence of morbidity and mortality necessitates novel treatment approaches. Recent innovations in device-based therapies provide new hope, particularly for HF with reduced Ejection Fraction (HFrEF). This study summarizes key device-based interventions in HF management, focusing on their mechanisms, clinical utility, and future directions.

Keywords: Congestive heart failure; Implantable catheters; Device; Minimally invasive surgery; Cardiac resynchronization

Abbreviation: BAT: Baroreflex Activision Therapy; CCM: Cardiac Contractility Modulation; CPNS: Cardiac Pulmonary Nerve Stimulation; CRT: Cardiac Resynchronization Therapy; EF: Ejection Fraction; FDA: Food and Drug Administration; GDMT: Guideline-Directed Medical Therapy; HF: Heart Failure; HFmrEF: Heart Failure mildly reduced Ejection Fraction; HFpEF: Heart Failure preserved Ejection Fraction; HFrEF: Heart Failure reduced Ejection Fraction; ICD: Implantable Cardioverter-Defibrillators; LV: Left Ventricle; LVAD: Left Ventricular Assist Device; RVAD: Right Ventricular Assist Device; TEER: Transcatheter Edge-to-Edge Repair; TMVR: Tendyne transcatheter Mitral Valve Repair

INTRODUCTION

Heart Failure (HF) is a syndrome characterized by impaired cardiac function and neurohumoral system activation, leading to progressive remodeling of the heart. Categorized by Ejection Fraction (EF), HF manifests as reduced (HFrEF), mildly reduced (HFmrEF), or preserved EF (HFpEF). HFrEF is associated with significant symptom burden and poor prognosis, with an estimated global prevalence of 56.2 million individuals [1].

While Guideline-Directed Medical Therapy (GDMT) has been the cornerstone of HF management, residual risks remain. About 30% of symptomatic HFrEF patients benefit from Cardiac Resynchronization Therapy (CRT), but many others remain unresponsive [1]. Emerging transcatheter and implantable devices aim to bridge this therapeutic gap, targeting specific patho-physiological processes in HF. Figure 1 demonstrates the therapeutic device options available for patients with HFrEF.

FDA approved devices for HFrEF

Various devices have been approved by the Food and Drug Administration (FDA) to be used for prevention of HF according to NYHA class and LVEF:

CRT and Implantable Cardioverter-Defibrillators (ICD): CRT improves cardiac efficiency by synchronizing ventricular contractions, benefiting about one-third of patients with prolonged QRS intervals and left bundle branch block. ICDs prevent sudden cardiac death by terminating life-threatening arrhythmias [2].

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Cardiac Contractility Modulation (CCM): The Optimizer device enhances myocardial contractility by delivering non-excitatory electrical signals during the absolute refractory period. Clinical trials such as FIX-HF-5C demonstrated improvements in exercise capacity, peak oxygen consumption and quality of life for patients with EF between 25%-45% [3].

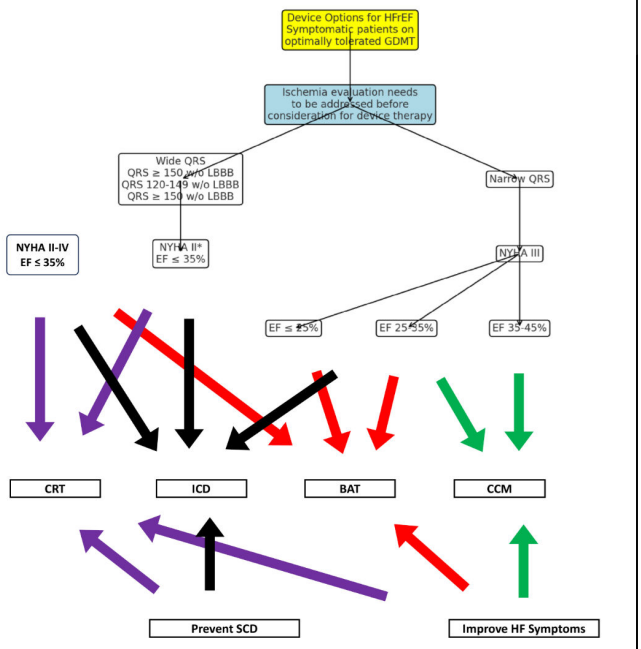

Figure 1: Therapeutic device options available for patients with HFrEF.

Baroreflex Activation Therapy (BAT): BAT, using devices like Barostim Neo, modulates autonomic activity by electrically stimulating baroreceptors, reducing sympathetic tone and increasing parasympathetic response. Trials such as HOPE4HF and BeAT-HF showed significant improvements in functional capacity and reductions in HF hospitalizations [3].

Transcatheter Edge-to-Edge Repair (TEER): TEER, using devices like MitraClip, addresses severe mitral regurgitation in patients with advanced HF and surgical contraindications. Trials such as Cardiovascular Outcomes Assessment of the MitraClip Percutaneous Therapy (COAPT) demonstrated survival benefits, whereas MITRA-FR highlighted its limitations in broader populations [4].

Left Ventricular Assist Devices (LVADs): LVADs offer mechanical support for end-stage HF, either as a bridge to transplant or as destination therapy. Devices like HeartMate 3 improve hemodynamics, reduce hospitalizations and enhance survival [5].

Tendyne Transcatheter Mitral Valve Repair (TMVR): TMVR system by Abbott is a self-expanding device designed to prevent paravalvular Mitral Regurgitation (MR) with its supra-annular cuff.

Right Ventricular Assist Devices (RVADs): Temporary-RVAD have emerged as a potential therapeutic option that can be used to reverse the adaptive modeling, impaired myocardial contractility and pathophysiological mechanisms involved in HF progression. The most commonly used RVAD devices are Impella RP, ProtekDuo, TandemHeart, and CentriMag.

Upcoming devices for HF

Some of the important devices of HF are mentioned below:

Implantable hemodynamic monitors: Devices like CardioMEMS and Cordella monitor pulmonary artery or left atrial pressures, facilitating early intervention. Trials such as CHAMPION demonstrated a 37% reduction in HF hospitalizations [4].

Neuromodulation systems: Experimental systems like the Harmony and VITARIA devices focus on vagal or aortic stimulation to restore autonomic balance. Initial trials show promising improvements in cardiac function and quality of life [5].

Left atrial decompression devices: Interatrial shunt devices such as Corvia interatrial shunt device alleviate left atrial pressure, reducing pulmonary congestion. Trials like Reduce Elevated Left Atrial Pressure Heart Failure (REDUCE-LAP-HF) suggest potential benefits but warrant further validation [5].

Left Ventricle (LV) restoration devices: Various methods like papillary muscle sling, Revivent TC system, and AccuClinch can be used for ventriculoplasty which addresses LV dysfunctioning arises from the molecular and cellular changes. Various other transcatheter solutions like Mitraclip, Monarc system and percutaneous transcatheter mitral annuloplasty device are designed to reduce LV volume in patients present with ischemic functional mitral regurgitation.

Device based therapy for cardiorenal syndrome: Various devices such as aortix percutaneous mechanical circulatory support system, Reitan catheter pump, secondary heart assist device, Doraya renal flow regulator, pre-cardia system, Transcatheter Renal Venous Decongestion™ (TRVD) system, reprieve system and Cardiac Pulmonary Nerve Stimulation (CPNS) can be used for the management of Cardiorenal syndrome.

Other therapeutic interventions for cardiorenal syndrome: Beyond the CPNS, the other interventions for Cardiorenal Syndrome (CRS) are being explored. CPNS can enhance renal perfusion and regulate myocardial contractility. The emerging WhiteSwell system is designed to boost lymphatic flow.

Challenges and future directions

While device-based therapies represent significant progress, their success hinges on patient selection, cost-effectiveness and long-term safety. Large-scale randomized trials are needed to establish definitive guidelines and expand indications. Additionally, integration with telemedicine and artificial intelligence could optimize device management and outcomes [4]. The central illustration provides a summary of HF management. The summary of HF management is shown in Figure 2.

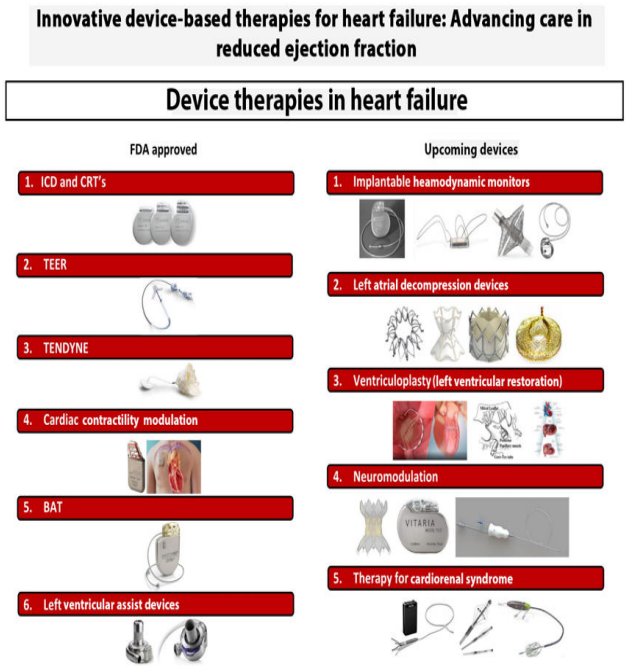

Figure 2: The summary of HF management.

CONCLUSION

Device-based therapies have ushered in a new era for managing HFrEF. From CRT and TEER to CCM and BAT, these interventions provide targeted solutions for patients unresponsive to GDMT. As technology evolves, these devices hold the potential to revolutionize HF care, offering personalized and effective treatment options for a challenging patient population.

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CONFLICT OF INTEREST

There is no conflicts of interest to disclose.

AVAILABILITY OF DATA AND MATERIALS

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval was not required since it is an accepted procedure.

CONSENT FOR PUBLICATION

Written consent has been obtained to publish the review article from the guardian. The consent copy is available with the authors and ready to be submitted if required.

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