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EARLY DETECTION OF LEFT VENTRICULAR DIASTOLIC DYSFUNCTION AS A PREDICTOR OF HEART FAILURE WITH PRESERVED EJECTION FRACTION

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ABSTRACT

Heart failure with preserved ejection fraction (HFpEF) has emerged as one of the most challenging and rapidly increasing cardiovascular syndromes worldwide. Despite normal or near-normal left ventricular ejection fraction, patients experience significant morbidity, reduced quality of life, and high mortality rates comparable to heart failure with reduced ejection fraction. Recent clinical evidence suggests that left ventricular diastolic dysfunction (LVDD) represents a pivotal pathophysiological substrate in the development of HFpEF. The early identification of diastolic abnormalities, therefore, plays a crucial role in preventing disease progression and improving long-term outcomes. This article reviews contemporary diagnostic approaches to early LV diastolic dysfunction, including echocardiographic markers, myocardial deformation imaging, and biomarker assessment. Particular emphasis is placed on the integration of Doppler echocardiography, tissue Doppler imaging, and speckle-tracking techniques in routine clinical practice. The clinical implications of early detection, therapeutic decision-making, and risk stratification are discussed. The findings underscore the importance of proactive screening strategies in high-risk populations to mitigate the global burden of HFpEF.

Keywords: diastolic dysfunction, HFpEF, echocardiography, left ventricle, early diagnosis

INTRODUCTION

Cardiovascular diseases remain the leading cause of mortality worldwide, with heart failure constituting a major public health challenge. In recent decades, heart failure with preserved ejection fraction has gained increasing attention due to its rising prevalence, particularly among elderly individuals, patients with hypertension, diabetes mellitus, obesity, and metabolic syndrome. Unlike systolic heart failure, HFpEF is characterized by impaired ventricular relaxation and increased myocardial stiffness rather than reduced contractility. This pathophysiological distinction complicates diagnosis and delays timely intervention.Left ventricular diastolic dysfunction is widely recognized as an early and often subclinical stage preceding overt HFpEF. At this stage, patients may remain asymptomatic or present with nonspecific complaints such as exertional dyspnea or fatigue, leading to underdiagnosis in primary care settings. Traditional diagnostic paradigms focused predominantly on systolic parameters have proven insufficient for identifying early diastolic impairment. Consequently, there is a growing need to emphasize advanced imaging modalities and functional markers capable of detecting subtle myocardial changes before irreversible structural remodeling occurs.From a clinical perspective, early identification of LV diastolic dysfunction offers a unique opportunity to implement preventive strategies, optimize risk factor control, and potentially delay or prevent progression to symptomatic heart failure. Given the increasing socioeconomic burden associated with HFpEF, especially in aging populations, the development of standardized, accessible, and accurate diagnostic algorithms is of paramount importance. This article aims to explore the contemporary understanding of LV diastolic dysfunction, its diagnostic criteria, and its prognostic significance in the context of HFpEF.

PATHOPHYSIOLOGY OF LEFT VENTRICULAR DIASTOLIC DYSFUNCTION

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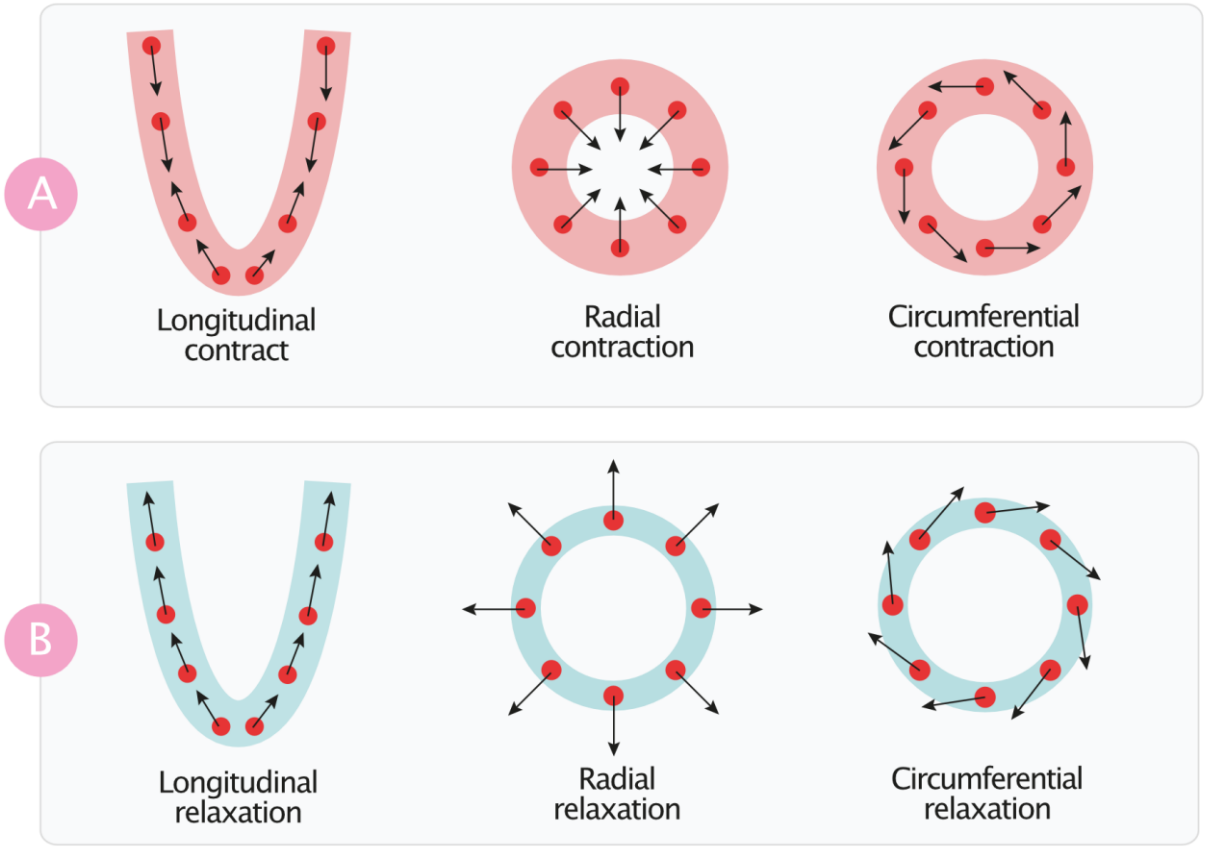
Systole and diastole



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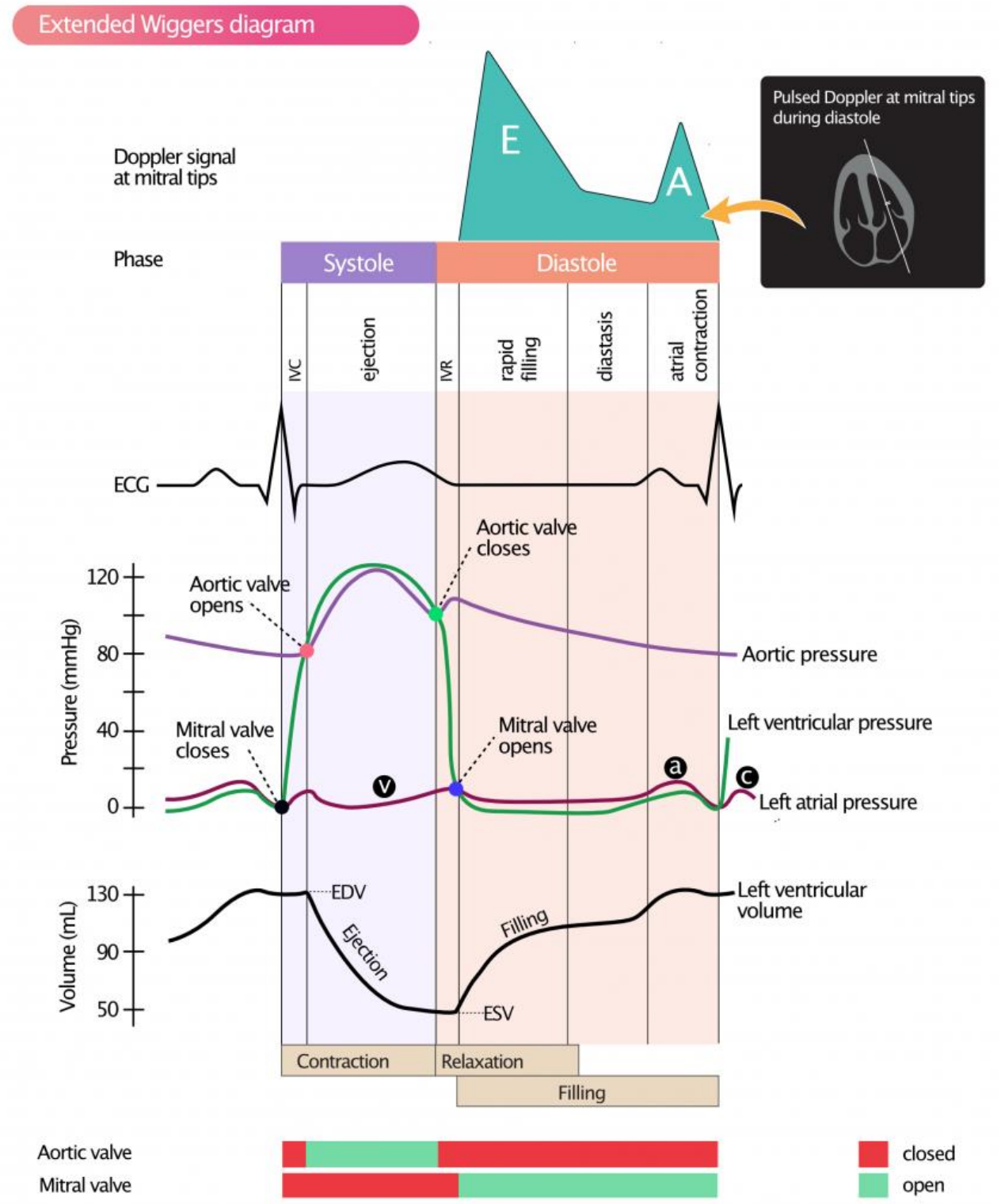

Diastolic function refers to the ability of the left ventricle to relax, fill, and accommodate blood during diastole at low filling pressures. Diastolic dysfunction arises from abnormalities in myocardial relaxation, ventricular compliance, or both. At the cellular level, impaired calcium reuptake by the sarcoplasmic reticulum and increased myocardial fibrosis contribute to delayed relaxation and increased stiffness. These changes result in elevated left ventricular end-diastolic pressure, which is transmitted retrogradely to the left atrium and pulmonary circulation.

Hemodynamically, diastolic dysfunction progresses through well-defined stages, beginning with impaired relaxation and advancing to pseudonormal and restrictive filling patterns. Early stages

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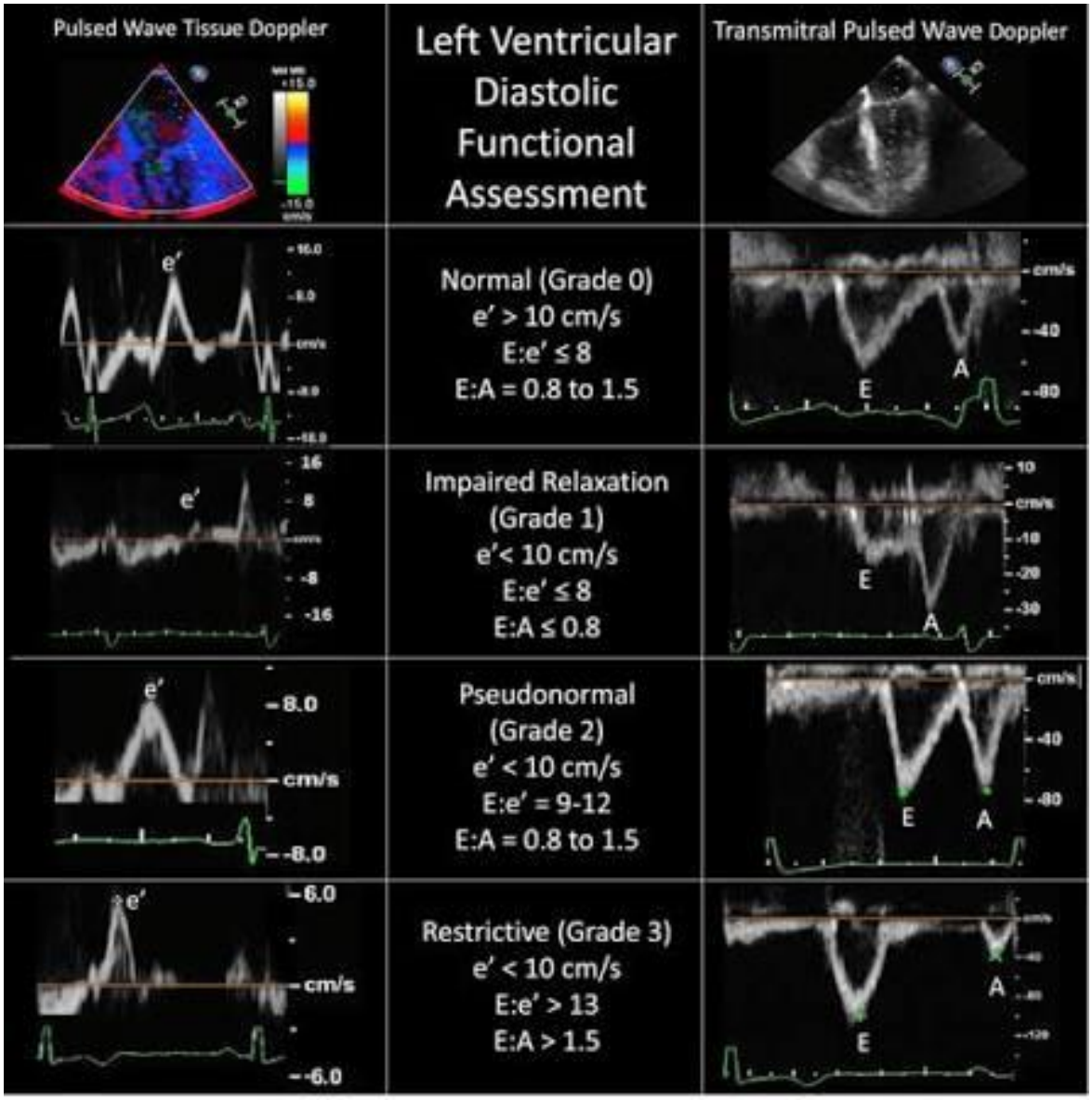
may be compensated by increased atrial contribution to ventricular filling, while advanced stages are associated with elevated filling pressures and pulmonary congestion. Importantly, systolic function may remain preserved throughout this process, masking the severity of underlying diastolic impairment.Systemic conditions such as hypertension induce concentric left ventricular hypertrophy, further exacerbating diastolic dysfunction by reducing ventricular compliance. Metabolic disorders, including diabetes mellitus, promote myocardial fibrosis and microvascular dysfunction, accelerating disease progression. Inflammatory pathways and endothelial dysfunction also play a contributory role, particularly in patients with obesity-related HFpEF. Understanding these mechanisms underscores the importance of early detection and targeted intervention.

DIAGNOSTIC APPROACHES TO EARLY DIASTOLIC DYSFUNCTION



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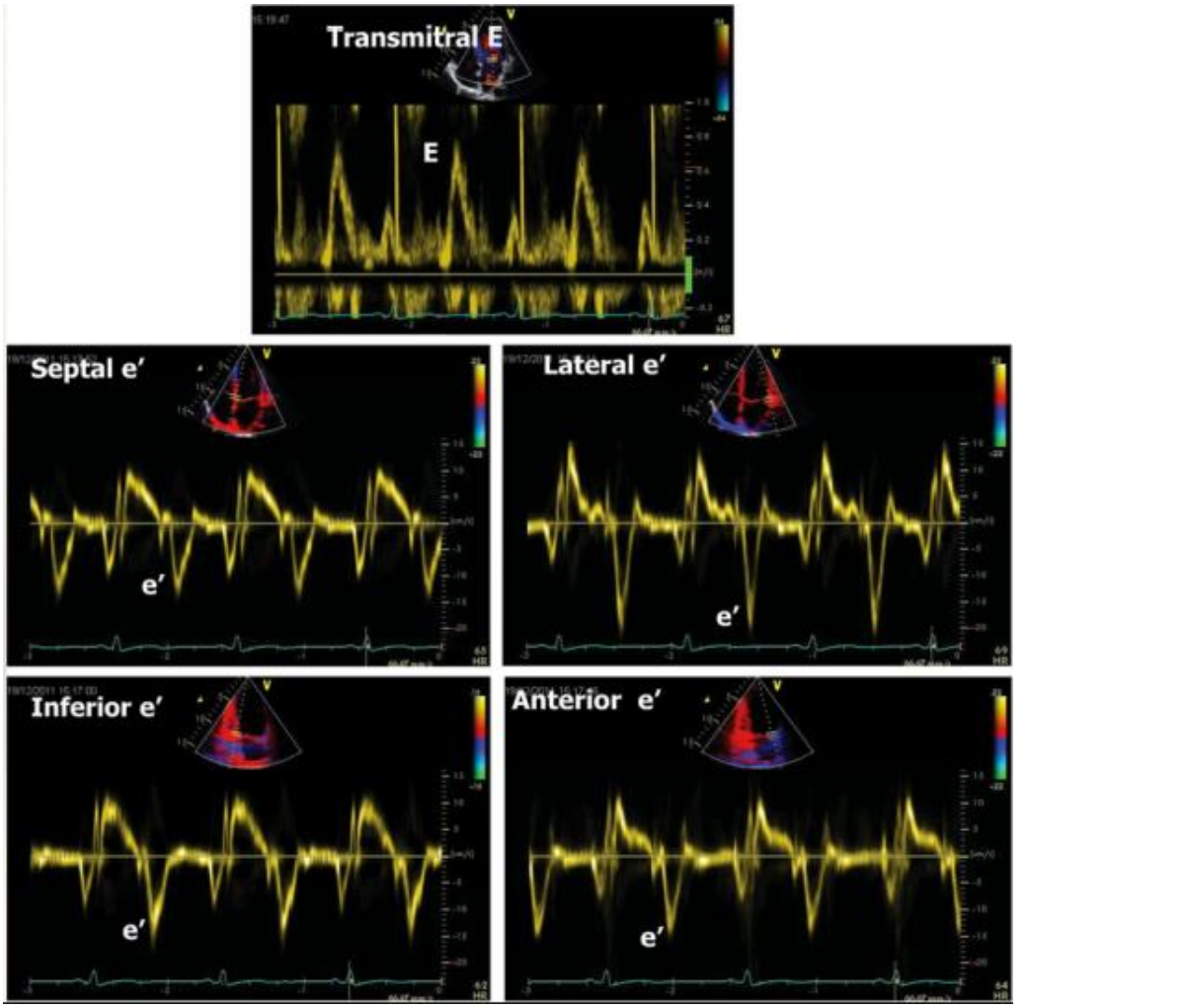

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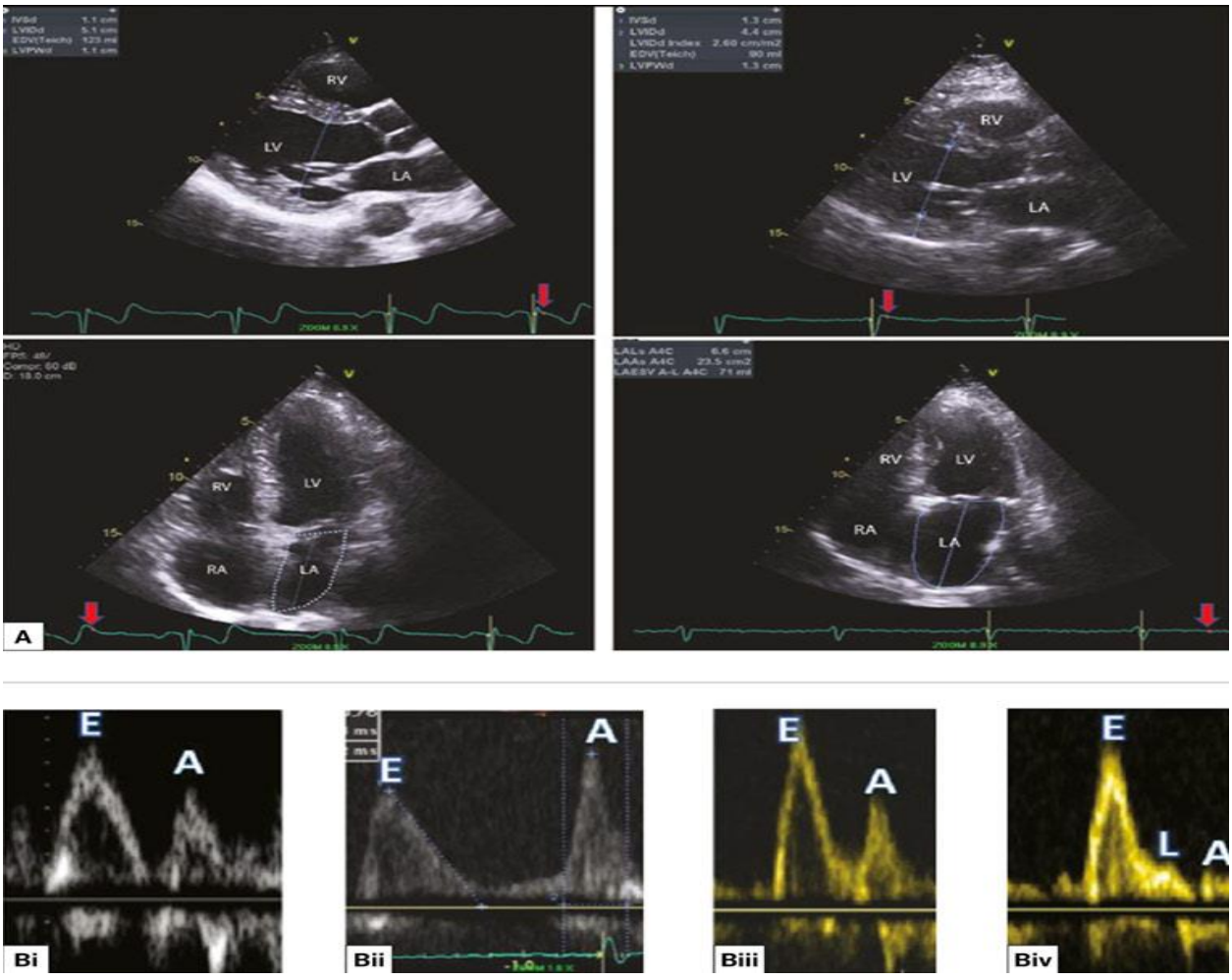
Echocardiography remains the cornerstone of diastolic function assessment due to its wide availability, non-invasive nature, and cost-effectiveness. Conventional Doppler parameters, including transmitral E and A wave velocities, E/A ratio, deceleration time, and isovolumic relaxation time, provide essential insights into ventricular filling dynamics. However, these indices are influenced by loading conditions and age, limiting their diagnostic accuracy when used in isolation.

Tissue Doppler imaging has significantly enhanced the evaluation of diastolic function by allowing direct measurement of myocardial velocities. The early diastolic mitral annular velocity (e′) reflects myocardial relaxation, while the E/e′ ratio serves as an indirect estimate of left ventricular filling pressures. Elevated E/e′ values have been consistently associated with adverse outcomes and are considered a key marker of diastolic dysfunction.

Speckle-tracking echocardiography represents an advanced modality capable of assessing myocardial deformation and strain. Global longitudinal strain, although traditionally associated with systolic performance, has demonstrated sensitivity in detecting early myocardial dysfunction in HFpEF patients. Reduced strain values may precede overt clinical manifestations, highlighting their potential role in screening high-risk populations.

CLINICAL IMPLICATIONS AND PROGNOSTIC SIGNIFICANCE



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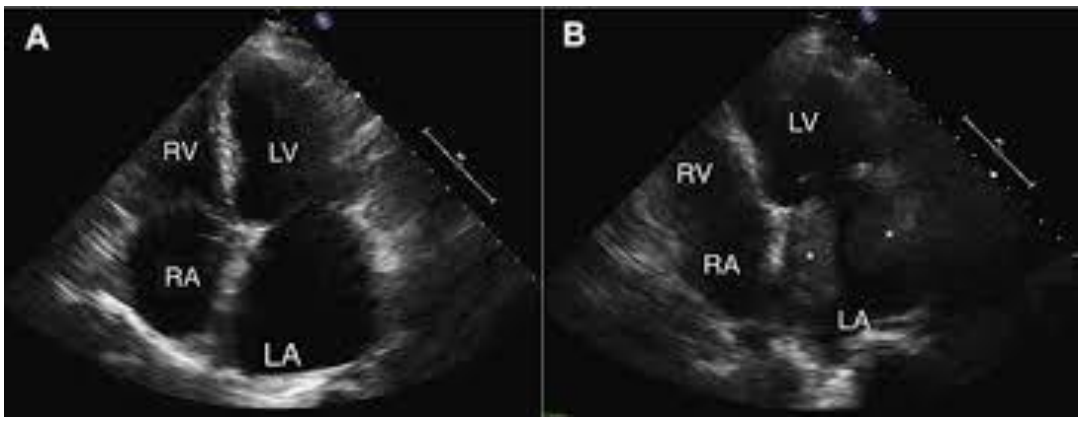

Early detection of LV diastolic dysfunction carries significant prognostic implications. Numerous studies have demonstrated that even mild diastolic abnormalities are associated with increased risk of heart failure hospitalization, atrial fibrillation, and cardiovascular mortality. In HFpEF, left atrial enlargement serves as a marker of chronic diastolic burden and correlates with disease severity and outcomes.

From a therapeutic standpoint, identifying diastolic dysfunction at an early stage enables clinicians to implement individualized management strategies. Optimal blood pressure control, glycemic regulation, weight management, and treatment of sleep-disordered breathing have been shown to improve diastolic parameters and patient outcomes. Although no therapy has yet demonstrated definitive mortality benefit in HFpEF, early intervention may attenuate disease progression and improve functional capacity.

Furthermore, early diagnosis facilitates patient education and lifestyle modification, empowering individuals to actively participate in disease management. In clinical practice, incorporating routine diastolic assessment into echocardiographic protocols can enhance risk stratification and guide long-term follow-up strategies.

CONCLUSION

Left ventricular diastolic dysfunction represents a critical early stage in the development of heart failure with preserved ejection fraction. Advances in echocardiographic techniques have significantly improved the ability to detect subtle myocardial abnormalities before the onset of overt clinical symptoms. Early identification of diastolic dysfunction offers a valuable window for preventive intervention, risk modification, and improved patient outcomes. Given the rising prevalence of HFpEF, particularly in aging and metabolically burdened populations, the integration of comprehensive diastolic assessment into routine cardiovascular evaluation is essential. Future research should focus on refining diagnostic criteria, identifying novel biomarkers, and developing targeted therapies aimed at modifying the underlying pathophysiological mechanisms of diastolic dysfunction.

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