What do Cardiologists Expect from the Echocardiogram in Heart Failure with Reduced Ejection Fraction?

O que o Cardiologista Espera do Ecocardiograma na Insuficiência Cardíaca com Fração de Ejeção Reduzida?

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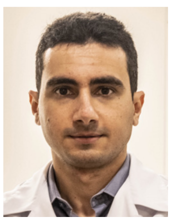

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Introduction

The echocardiogram plays a central role in assessments of patients with heart failure (HF), contributing to its classification, etiology definition, severity stratification, hemodynamic assessment, and clinical follow-up.[1] HF has been historically divided according to the echocardiographic parameter left ventricular ejection fraction (LVEF). The most recent classification divided it into preserved (≥50%), reduced (≤40%), and slightly reduced LVEF (41–49%).[1,2] Different societies have recently proposed a universal definition of HF that involves the presence of symptoms and signs caused by structural and/or functional cardiac changes associated with increased natriuretic peptide levels or objective evidence of congestion. The authors also highlight the importance of classifying HF according to LVEF.[2] (Figure 1) This article will describe the main parameters which the clinical cardiologist should pay attention on the echocardiogram of patients with HF with reduced ejection fraction (HFrEF) and how best to use them in clinical practice.

Keywords

Heart Failure; Stroke volume; Echocardiography.

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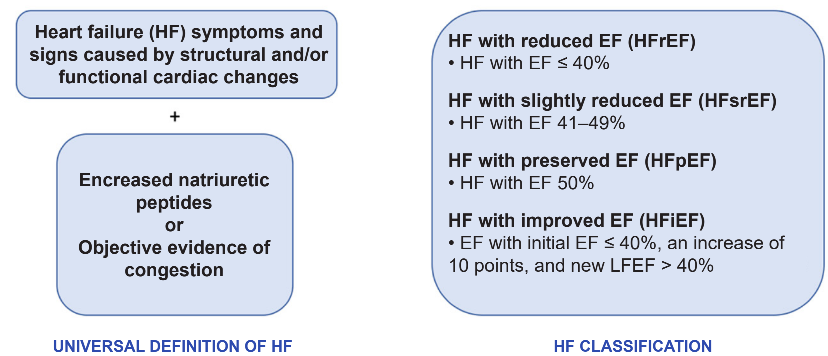
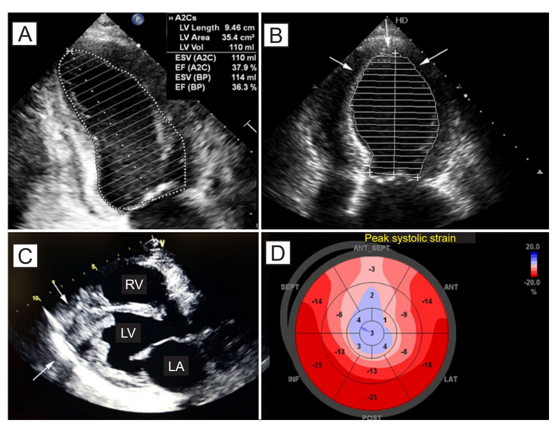
Etiological assessment

The echocardiogram may be the first method used to define the etiology of HFrEF (Figure 2). Segmental contractility changes suggest ischemic etiology, especially if associated with inactive electrical areas on the electrocardiogram. However, they can also occur in other heart diseases. Severe valvular dysfunction associated with morphological changes suggests a valvular etiology. The presence of a digitiform apical aneurysm, inferior or inferolateral contractility changes, and right ventricular dysfunction are frequent in Chagas heart disease. Echocardiographic parameters can also be useful to define the etiology of resctrictive cardiomyopathies, which may present with decreased LVEF in advanced stages. Right and left ventricular wall thickening and a myocardium with a granular aspect and preserved apical contractility are suggestive of amyloidosis. The presence of posterior and/or septal wall thickening with mitral regurgitation and a left ventricular outflow tract obstruction suggest hypertrophic cardiomyopathy, especially when the degree of hypertrophy is not explained by arterial hypertension. Finally, increased lateral and apical trabeculations are suggestive of noncompaction cardiomyopathy.



IC: insuficiência cardíaca; ICFER: insuficiência cardíaca com fração de ejeção reduzida; ICFElr: insuficiência cardíaca com fração de ejeção levemente reduzida; ICFEP: insuficiência cardíaca com fração de ejeção preservada; ICFEme: insuficiência cardíaca com fração de ejeção melhorada; FEVE: fração de ejeção do ventrículo esquerdo.

Figure 1 – *Universal definition and new classification of HF.*



GLS, global longitudinal strain; HF, heart failure; LA, left atrium; LV, left ventricle; LVEF, left ventricular ejection fraction.

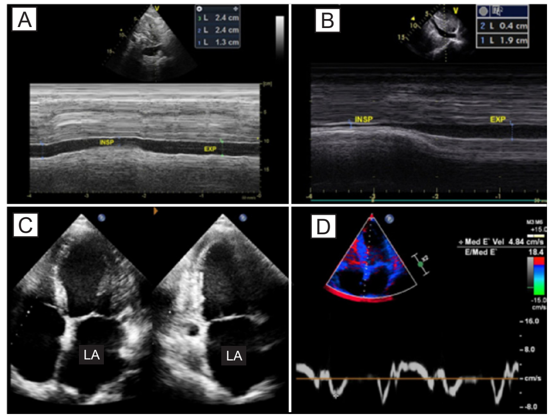
Figura 2 – *Use of echocardiography to classify and define the etiology of HF. A: LVEF calculation by the Simpson's method. Apical two-chamber view, final biplane LVEF of 36.3%. B, C, and D: Examples of the use of echocardiography to define HF etiologies. B: Apical two-chamber window demonstrating the apical "ballooning" pattern of a patient with Takotsubo syndrome. C: Long-axis parasternal window demonstrating apical obliteration in a patient with endomyocardial fibrosis. D: Left-ventricular GLS final polar map (bull's eye) demonstrating segmental heart disease in the territory of the anterior descending artery.*

Prognostic assessment

LVEF is one of the best-known prognostic factors for HFrEF. Several studies reported lower survival rates among patients with a lower LVEF.[3,4] A sub-analysis of patients in the Candesartan in Heart failure: Assessment of Reduction in Mortality and Morbidity (CHARM) program showed that the risk of death from all causes increased by 39% for every 10% decrease in LVEF, starting from a 45% LVEF.[4] An LVEF below 30% is also one of the criteria used by the European Society of Cardiology and the Brazilian Society of Cardiology to define advanced HF, i.e., it helps identify patients who would benefit most from treatments such as heart transplantation or long-term circulatory support devices.[5,6] Right ventricular dysfunction associated with HFrEF is also considered a marker of adverse prognosis and signals advanced-stage disease.[7,8] A recent study reported that right ventricular global longitudinal strain (GLS) was the best predictor of adverse outcomes, even compared to cardiac magnetic resonance imaging parameters.[7] On the other hand, simpler parameters such as the tricuspid annular plane systolic excursion (TAPSE) and the TAPSE/pulmonary artery systolic pressure (PASP) ratio are also related to worse prognosis and may be useful in clinical practice.[8] Cardiac chamber size, the presence of pulmonary hypertension, and secondary mitral regurgitation are also recognized predictors of adverse prognosis in HFrEF.[3,9-10]

Hemodynamic and fluid overload assessment

In addition to classification, signaling possible etiologies, and assessing prognosis, echocardiography plays a key role in hemodynamic assessments and por volemia definition in



LA, left atrium.

Figure 3 – *Use of echocardiography to define HF etiology. A: Two-dimensional M-mode echocardiogram demonstrating an inferior vena cava measuring 2.4 cm without significant inspiratory collapse suggestive of an increased right atrial filling pressure. B: Inferior vena cava collapsing on inspiration suggestive of a low right atrial filling pressure. C: Apical four- and two-chamber windows demonstrating left atrial dilation. D: Tissue Doppler demonstrating an increased E/e' ratio suggestive of an increased left atrial filling pressure.*

HFrEF (Figure 3). Right atrial pressure (RAP) can be estimated noninvasively by assessment of the diameter and respiratory variation of the inferior vena cava.[11] A diameter < 2.1 cm with a respiratory variation > 50% correlates with a RAP of 0–5 mmHg, while a diameter > 2.1 cm with a variation < 50% correlates with a RAP of 10–20 mmHg.[11] The absence of hepatic vein inspiratory collapse, right atrial dilation with left interatrial septum deviation, and tricuspid valve E/e' ratio > 6 are adjuvant parameters also correlated with a higher RAP.[11] These data may indicate systemic congestion in clinical practice and thus help with its clinical management.

Increased left-atrial filling pressures suggest pulmonary edema and can be noninvasively estimated by echocardiography. A study of intensive care unit patients correlated a mitral valve E/e' ratio > 15 with a pulmonary capillary pressure (PCP) > 15 with 86% sensitivity and 88% specificity.[12] However, this method is less accurate in patients with valve disease or mitral calcification, left bundle branch block, or under resynchronization therapy. Anderson et al. developed an algorithm to estimate left-chamber filling pressures with better accuracy than the use of isolated variables alone.[13] In this algorithm, a mitral valve E/A ratio ≥ 2 or two changed parameters (maximum indexed left atrial volume > 34 mL/m^2, peak tricuspid regurgitation velocity > 2.8 m/s, E/e' > 14) have 87% accuracy for predicting a PCP > 12 mmHg[13]. In addition, cardiac output can be estimated by pulsed Doppler in the left ventricular outflow tract, which has been increasingly used at the bedside to assess and adjust cardiogenic shock therapy.[14]

New echocardiographic techniques

New techniques for potential use in HFrEF have recently been described. One such technique is the strain measurement or myocardial strain index. Some studies already showed that left ventricle GLS is a better predictor of mortality than LVEF and other echocardiographic parameters.[15,16] It can also be used for cardiotoxicity monitoring and the diagnostic evaluation of some cardiomyopathies (e.g., the standard apical-sparing pattern in amyloidosis can be easily identified through a strain echocardiogram). Three-dimensional echocardiography is also more accurate for determining cardiac chamber volumes and function, including from the right ventricle, which has limited assessment on two-dimensional echocardiography.[17,18] It has already been used in clinical practice for cardiotoxicity monitoring and during invasive procedures such as the MitraClip®.

Conclusion and perspectives

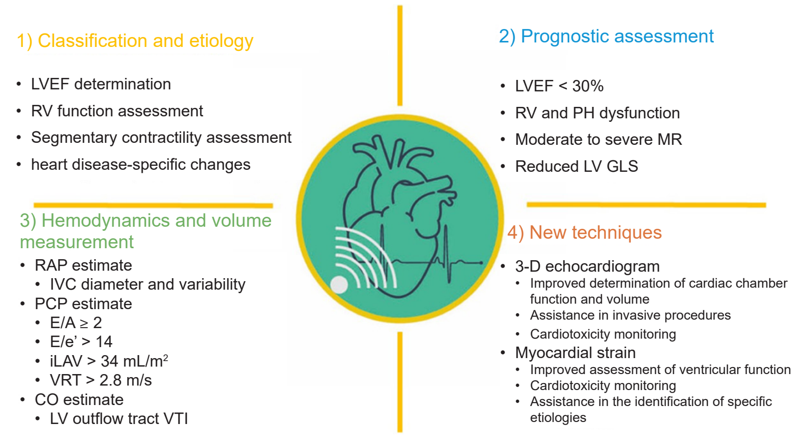
We believe that the role of echocardiography in HFrEF extends beyond LVEF and cavity size assessments (Figure 4). It is a widely available, noninvasive method that provides a vast set of information about the clinical condition of patients with HFrEF. The knowledge and correct interpretation of different echocardiographic parameters improves the diagnosis, prognostic assessment, treatment, and clinical follow-up of these patients.

Authors' contributions

Research creation and design: Marcondes-Braga, FG; Murad, CM. Data acquisition: Boleta, DB. Redação do manuscrito: Murad, CM; Marcondes-Braga, FG. Critical revision of the manuscript for important intellectual content: Marcondes-Braga, FG; Boleta, DB.

Conflict of interest

The authors have declared that they have no conflict of interest.



CO, cardiac output; E/A, early/late mitral transvalvular flow velocity; E/e', early transmitral velocity/early mitral annulus diastolic velocity; GLS, global longitudinal strain; iLAV, indexed left atrial volume; IVC, inferior vena cava; LV, left ventricular; LVEF, left ventricular ejection fraction; MR, mitral regurgitation; PCP, pulmonary capillary pressure; PH, pulmonary hypertension; RAP, right atrial pressure; RV, right ventricle; VRT, peak tricuspid regurgitation velocity; VTI, velocity time integral.

Figure 4 – *Central role of echocardiography in HF.*

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