Review Article

# Assessment of Left Ventricular Function by MAPSE (Mitral Annular Plane Systolic Excursion): Main Clinical Applications

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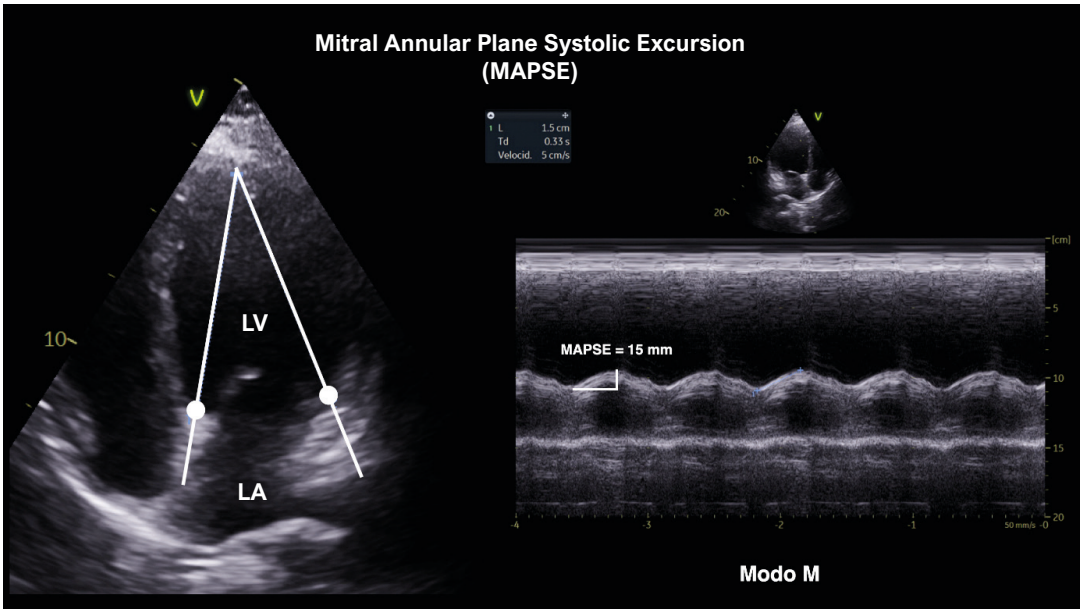
**Central Illustration: Assessment of Left Ventricular Function by MAPSE (Mitral Annular Plane Systolic Excursion): Main Clinical Applications**

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*LV: left ventricle; LA: left atrium.*

## Abstract

Mitral annular plane systolic excursion (MAPSE), a parameter that can be obtained from transthoracic echocardiography or nuclear magnetic resonance (NMR), is capable of reflecting the longitudinal systolic function of the left ventricle (LV) and may change earlier than the LV ejection fraction (LVEF), estimated by usual methods. Furthermore, it also presents a correlation with global longitudinal strain (GLS), assessed by speckle tracking in two-dimensional (2D) echocardiography. The importance of MAPSE extends to the ease with which it can be obtained and reproduced, especially in patients with poor image quality, for whom LVEF and GLS may be inaccurate. This review intends to clarify the evidence available in the literature on MAPSE, which, despite its applicable usefulness in the context of various heart diseases, is an underused index in clinical practice.

## Keywords

Função Ventricular; Ecocardiografia; Valva Mitral

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## Introduction

Mitral annular plane systolic excursion (MAPSE) is an ultrasound parameter obtained from motion mode (M-mode) over the lateral aspect of the mitral valve annulus. It evaluates its movement during the cardiac cycle (Figure 1). It also presents a good correlation with left ventricular ejection fraction (LVEF), is easy to use, and is readily available. It is also a simple and reproducible index.

The American Society of Echocardiography and European Association of Cardiovascular Imaging Guidelines recommend

its use as a surrogate parameter when LVEF or global longitudinal strain (GLS) cannot be accurately obtained in patients with poor image quality, as both methods require left ventricular (LV) endocardial tracking, which is highly dependent on adequate visualization.[1]

MAPSE can quantitatively reflect LV longitudinal systolic function, as the longitudinal movement of the mitral valve annulus leads LV pumping, unlike the apex, whose position is relatively stationary.[2] Therefore, its measurement only requires the visualization of the mitral annulus, with no need to define the LV endocardial limit, which is essential in performing the other methods mentioned above.

The MAPSE value may be determined from four locations in the atrioventricular plane, equivalent to the septal, lateral, anterior, and posterior walls, viewed in the apical four- and two-chamber windows in M-mode. The cursor must be parallel to the LV walls (Figure 1). The measurement is calculated from the lowest point at the end of the diastole up to the aortic valve closure (Figure 2). In general, MAPSE should be obtained from the septal and lateral mitral annulus, with this value being slightly higher in normal hearts.

A large multicenter study[3] identified normal reference values for MAPSE, established according to age and sex, using M-mode and speckle-tracking 2D echocardiography (Table 1). Women exhibited slightly higher MAPSE values than men, and older individuals had lower values than younger individuals.

There are many studies on the usefulness of MAPSE in assessing LV longitudinal systolic function in heart failure (HF). However, recent publications also present it as a tool with prognostic value in the setting of ischemic heart disease, valvular heart disease, cardiomyopathies, septic shock, and cardio-oncology.[4] It is a sensitive marker of early LV dysfunction, also correlating with some diastolic function indices, such as the E/A ratio, septal e' wave, and lateral e' wave.[5]

In this sense, as this study will show, MAPSE may be altered in certain cardiac conditions even when the LVEF is still normal. Figure 3 illustrates a patient with amyloidosis, with preserved ejection fraction (supranormal), but, disproportionately, with a MAPSE value at the lower limit of normal (10 mm) and with reduced GLS (12.1%).

MAPSE can also be assessed by cardiac nuclear magnetic resonance (NMR) and is considered an important independent predictor of serious adverse cardiac events (death, non-fatal myocardial infarction, hospitalization for HF or unstable angina, and late revascularization). According to the study by Rangarajan et al. (2016),[6] patients with lateral MAPSE <1.11 cm (median value) had a significantly higher incidence of adverse events than did those with MAPSE ≥1.11 cm.

This review article will describe the main clinical applications available in the literature for MAPSE, a parameter that is easy to apply but often forgotten in practice.

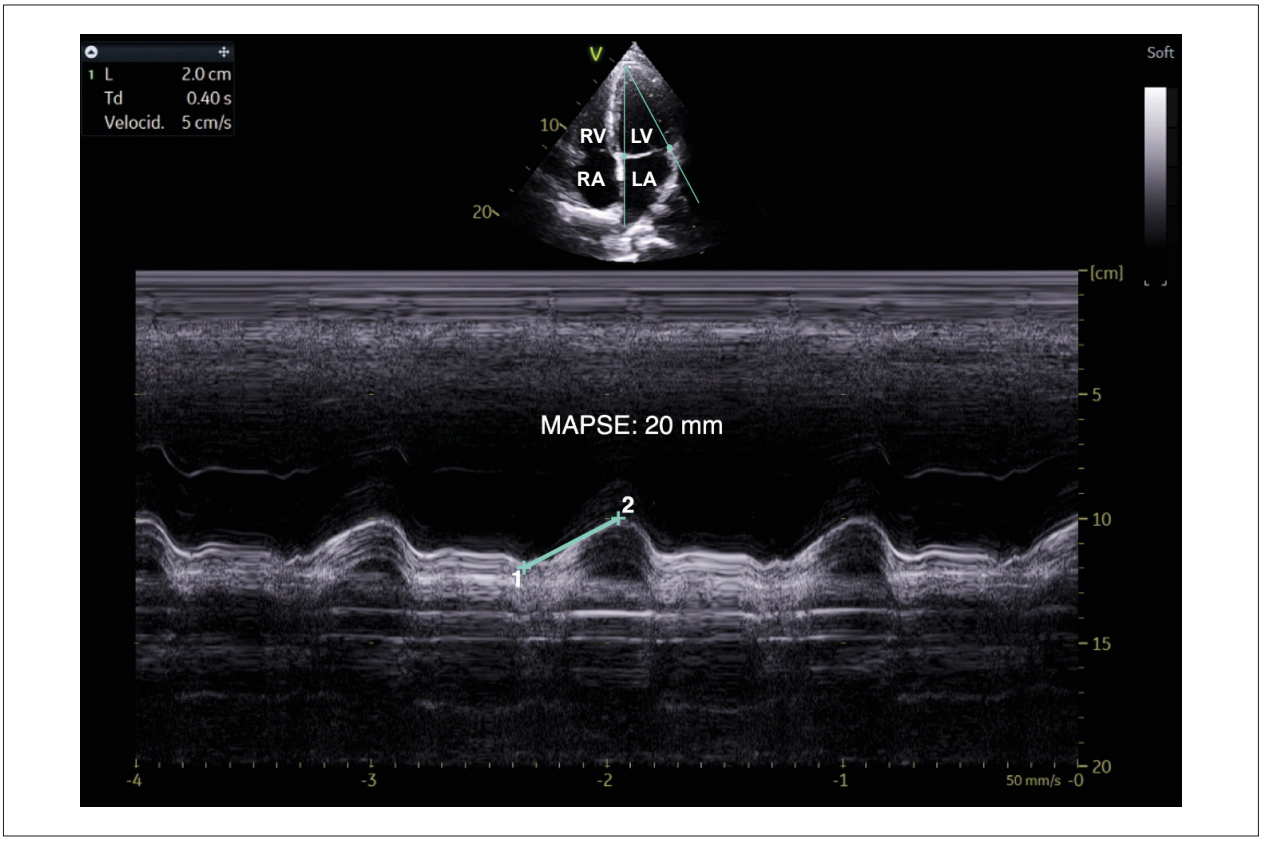


**Figure 1 –** *MAPSE calculated from M-mode in 2D echocardiography in an athlete patient, obtaining a value of 20 mm, considered normal. Source: created by the authors. RV: right ventricle; LV: left ventricle; RA: right atrium; LA: left atrium; MAPSE: mitral annular plane systolic excursion.*

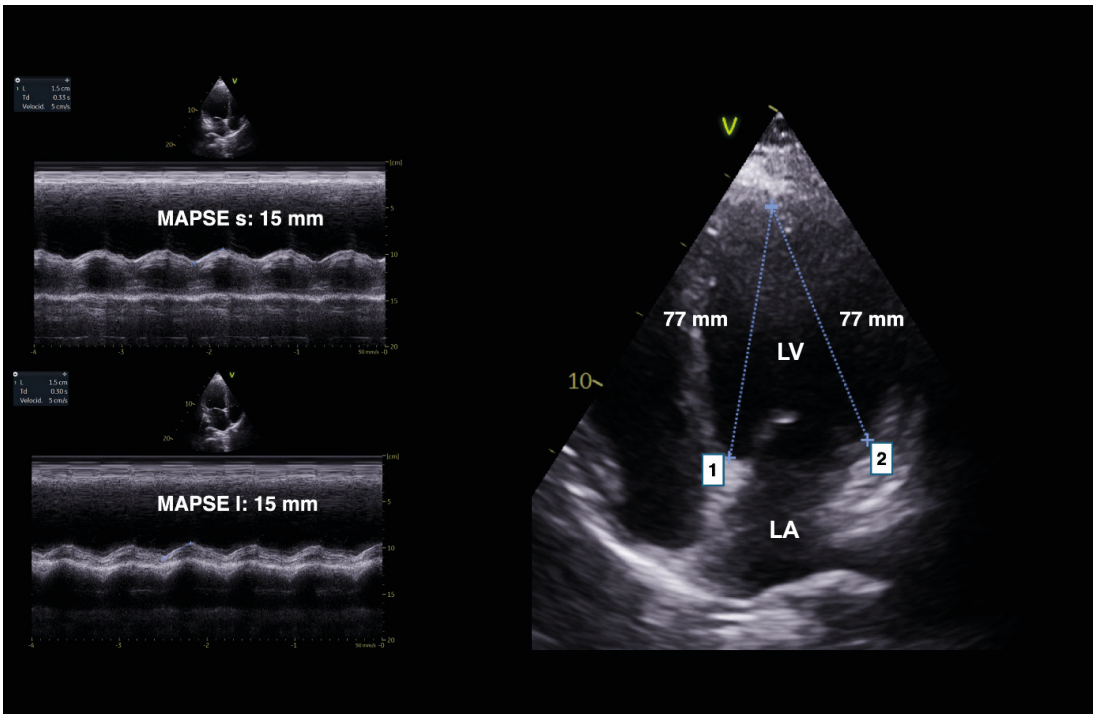


**Figure 2 –** *Demonstration of the locations where the cursor should be placed on the septal (1) and lateral (2) mitral rings in the apical 4-chamber window. On the left, the echocardiographic measurement in M-mode is observed (above, septal MAPSE; below, lateral MAPSE). MAPSE: mitral annular plane systolic excursion; LV: left ventricle. Source: created by the authors.*

## Clinical applications

### HF

Reduced MAPSE reflects the presence of impaired longitudinal function, providing complementary information to ejection fraction, which represents the overall result of longitudinal and circumferential contraction.[7] It was shown that patients with chronic HF resulting from dilated cardiomyopathy or myocardial infarction presented a significant reduction in MAPSE, which had a good correlation with ejection fraction.[8]

Patients with preserved LVEF were divided into three groups according to the value of lateral MAPSE: low (<12 mm), relatively preserved (12-15 mm), and high (≥15 mm). The diastolic dysfunction rate and all-cause hospitalization proved to be higher in the low and relatively preserved groups than in the high group, whereas the pro-BNP level and mortality rate were higher in the low group when compared with the relatively preserved and high groups.[9]

There is also evidence that MAPSE, measured at rest and during exercise (on a treadmill using the modified Bruce protocol), correlates well with more sophisticated measurements of ventricular function in patients with HF with preserved ejection fraction (HFpEF), and is, therefore, a useful measure for the early detection of left ventricular dysfunction, which in HFpEF is most evident during exercise testing.[10]

**Table 1 – Reference values for a MAPSE by M-mode and 2D-STE.**

| | Men | Women |
|---|---|---|
| Msep (mm) | 9-19 | 9-19 |
| Mlat (mm) | 10-20 | 10-21 |
| STEsep (mm) | 7-16 | 7-16 |
| STElat (mm) | 6-18 | 6-19 |
| STEm (mm) | 7-17 | 8-17 |
| nSTEm (%) | 8-19 | 9-21 |

*M-mode: motion mode; 2D-STE: speckle tracking by 2D echocardiography; Msep and Mlat: Septal and lateral MAPSE by M-mode echocardiography, respectively; STEsep, STElat, and STEmid: septal, lateral, and midpoint MAPSE measured by 2D-STE; nSTEmid: STEmid normalized by LV long axis length in end-diastole. Adapted from WANG et al. (2023).[3]*

### Systemic arterial hypertension

In the early stages of systemic arterial hypertension (SAH), before the appearance of symptoms related to HF or the reduction in LVEF (<50%), it is already possible to identify abnormalities in the longitudinal components of mechanical contractility and systolic dysfunction. In these patients, parameters were studied to determine the

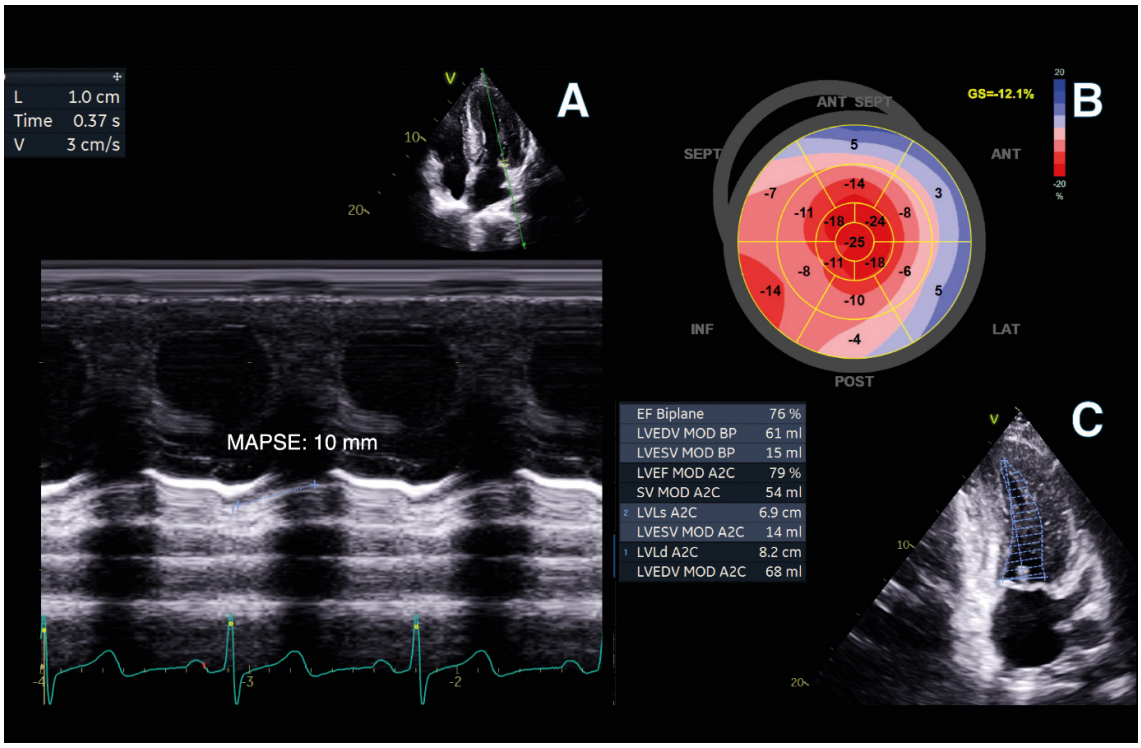


**Figure 3 –** *Patient with amyloidosis, who exhibits LVEF, MAPSE, and GLS values, respectively, of 76%, 10 mm, and 12.1%. LVEF: left ventricular ejection fraction; MAPSE: mitral annular plane systolic excursion; GLS: global longitudinal strain; EF: ejection fraction; LVEDV: left ventricular end-diastolic volume; MOD: modified; LVEF: left ventricular ejection fraction; BP: biplane; SV: systolic volume; LVL: left ventricular length; LVESV: left ventricular end-systolic volume; LVLd: left ventricular length diastolic. Source: created by the authors.*

transition between structural abnormalities and myocardial dysfunction early.[11]

LVEF was identical in hypertensive and healthy patients, while GLS and MAPSE were lower in the first group. Patients with moderate or severe ventricular hypertrophy (septum ≥13 mm) presented longitudinal systolic dysfunction, with GLS being reduced more than MAPSE even in the presence of small structural changes; conversely, LVEF was insensitive for detecting longitudinal myocardial dysfunction in patients with hypertension.[11] This finding shows that the compensatory increase in circumferential deformation may mask the reduced longitudinal deformation, leading to normal LVEF.

The prognostic value of MAPSE obtained by cardiac NMR was evaluated in a large multicenter population of SAH patients. The risk of death was significantly higher in patients with lateral MAPSE lower than 10 mm, even after adjustment for clinical and imaging risk factors, as well as in the subgroups of patients with preserved LVEF and those without a history of myocardial infarction.[12]

### Aortic stenosis

In patients with aortic valve stenosis, MAPSE changes earlier when compared to LVEF or other parameters that assess ventricular function, which may be normal. Furthermore, it has a lower value in symptomatic patients when compared to asymptomatic and severe patients. It is also useful in predicting the onset of symptoms.[13] MAPSE was able to differentiate low-gradient aortic stenosis into moderate or severe in the presence of preserved ejection fraction, using a cutoff value of 9 mm to distinguish them.[14]

### Intensive care units and emergency services

Bedside transthoracic echocardiography is essential for the diagnosis and treatment of left ventricular systolic dysfunction in critically ill patients, especially those with septic shock, for whom septic cardiomyopathy may be present in 40% of the cases.[15] Studies show that MAPSE reflects systolic and diastolic function in critically ill patients and is commonly related to ICU mortality when associated with TAPSE, LVEF, and lung ultrasound.[16]

Longitudinal systolic function may be more sensitive in detecting cardiac depression than LVEF. Therefore, when assessing cardiac function in patients with septic shock and normal LVEF, longitudinal function indices, such as MAPSE, should be taken into account.[17] A study with 90 patients, divided evenly between individuals with septic shock and those without sepsis, compared these echocardiographic parameters. No difference was found between groups for LVEF

(64.6% vs. 67.2%, p = 0.161), but a difference was observed for MAPSE, which was significantly worse in those with septic shock (1.2 cm vs. 1.5 cm, p <0.001).[17] Similarly, other authors found that MAPSE, but not LVEF, differed between patients with septic shock with and without myocardial injury, defined as high-sensitivity troponin T ≥45 ng/L upon ICU admission.[18]

A significant advantage, in the emergency or intensive care setting, is that MAPSE assessment does not require good image quality or an experienced operator. The decrease in value correlates with LV systolic dysfunction and may precede changes in LVEF during acute myocardial infarction. It also correlates with elevated levels of brain natriuretic peptides and isolated diastolic dysfunction.[9]

A study with 61 emergency physicians found that MAPSE measurement was easily performed with minimal training and excellent inter-user agreement. An <8 mm value had a moderate predictive value and high specificity for LVEF <50%, and was more specific for identifying a reduced LVEF than the commonly used qualitative assessment.[19]

### Acute myocardial infarction

In the context of acute ST-segment elevation myocardial infarction (STEMI), the risk of cardiovascular complications after revascularization, including mortality, is considerable. It is suggested that MAPSE provides significantly greater prognostic validity than LVEF in this patient population.[20] Research shows that MAPSE has a significant incremental predictive value over LVEF; therefore, the combination of both can serve as a good alternative for LV-based risk assessment after STEMI, if GLS is not available.[21,22]

### Arrhythmias

In a study of 247 patients undergoing coronary artery bypass grafting surgery, MAPSE was able to predict the development of postoperative atrial fibrillation (AF), with an area under the Receiver Operating Characteristic (ROC) curve (AUC) of 0.831 (95% CI 0.761-0.901, p <0.001), in addition to sensitivity and specificity of 90% and 81%, respectively.[23]

In patients who underwent catheter ablation with pulmonary vein isolation, reduced MAPSE and increased left atrial volume index represented risk factors for AF recurrence.[24] In HFpEF, a reduced MAPSE was associated with right atrial dyssynchrony, a risk predictor for AF.[25]

### Oncology

Cardiotoxicity associated with cancer therapies is detected early through GLS and LVEF in echocardiography; however, ultrasound imaging may be affected, especially in postoperative patients with left breast cancer or those with high obesity. The European cardio-oncology guideline[26] recommends using surrogate parameters for evaluation, such as MAPSE.

In breast cancer patients treated with preoperative or postoperative chemotherapy (anthracyclines and trastuzumab), the following cutoff values were identified for septal MAPSE, lateral MAPSE, and mean MAPSE (septal and lateral), respectively: 11.7 mm (AUC = 0.65, p = 0.02; sensitivity 79%; specificity 45%), 13 mm (AUC = 0.82, p = 0.001; sensitivity 94%; specificity 96%) and 11.7 mm (AUC = 0.87, p < 0.001; sensitivity 83%; specificity 80%), respectively.[27]

In another study, MAPSE and peak mitral annular systolic velocity (S') showed good accuracy, sensitivity, and positive predictive value for detecting anthracycline therapy-related cardiac dysfunction (ATRCD), with GLS being used as the gold standard diagnostic test to define it. The authors stated that these conventional echocardiographic parameters may work as screening tools to detect subclinical ATRCD in resource-limited settings.

In patients who underwent neoadjuvant chemoradiotherapy for esophageal or esophagogastric junction cancer, no change was identified in LV GLS after treatment. However, septal MAPSE decreased significantly, showing that chemoradiotherapy appears to induce an acute negative effect on left ventricular systolic function, which was not observed for chemotherapy.[28]

### Mapse limitations

MAPSE has some disadvantages inherent to the method. It is not able, for instance, to detect regional dysfunctions in the myocardium, unlike GLS. Furthermore, there are no normalized values for variations in heart size between different patients, especially in children. Its value may also be influenced by moderate to large pericardial effusion, since the cardiac apex, which is relatively stationary under normal conditions, becomes mobile, interfering with the true MAPSE measurement. Similarly, paradoxical septum due to right ventricular dysfunction alters septal MAPSE, and in these conditions, lateral MAPSE should be used. Finally, it is not possible to perform a direct measurement on the mitral annulus when it has significant calcification; in this case, the measurement must be made slightly higher up in the myocardium.[7]

## Conclusion

In addition to being readily available and easy to use, MAPSE is a useful parameter in the clinical assessment of LV longitudinal systolic function in different contexts, such as HF, septic cardiomyopathy, and cardio-oncology, and may be altered even when LVEF is normal. Studies on its applicability are still scarce in the literature. Therefore, it is hoped that this review will allow more research to be carried out on MAPSE so that its use can be expanded in medical practice.

## Author Contributions

Conception and design of the research: Botelho LFB, Tavares M; acquisition of data: Carvalho AA; analysis and interpretation of the data: Carvalho AA, Carvalho WA, Tavares M; writing of the manuscript and critical revision of the manuscript for intellectual content: Carvalho AA, Carvalho WA, Botelho LFB, Tavares M.

**Potential Conflict of Interest**

No potential conflict of interest relevant to this article was reported.

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**Study Association**

This study is not associated with any thesis or dissertation work.

**Ethics Approval and Consent to Participate**

This article does not contain any studies with human participants or animals performed by any of the authors.

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