

# Evaluation and Comparison of Left Ventricular Functions by Cardiac MRI and 2D Transthoracic Echocardiography

Bahar Yilmaz Cankaya<sup>1</sup> , Mecit Kantarci<sup>1</sup> , Fuat Gundogdu<sup>2</sup> 



## ABSTRACT

**Objective:** It is important to measure left ventricular function (LVF) accurately in the diagnosis and follow-up of cardiovascular diseases. Different imaging algorithms and mathematical calculations have been developed for the evaluation of LVF in cardiac magnetic resonance imaging (MRI), and numerous studies are still being carried on this. In our study, LVF was calculated by two different measurement methods in MRI and were compared with transthoracic echocardiography (TTE) to assess the correlation and the consistency of these with TTE.

**Materials and Methods:** In this study, 31 patients with left ventricular dysfunction due to different etiologies were evaluated with simultaneous TTE and MRI. In the Cine MR images, LVF parameters of ejection fraction, end-diastolic volume, end-systolic volume, and myocardial mass were measured using short axis images (short axis method) and short axis plus four chamber and two chamber images (combined method). The results were compared with the results from TTE.

**Results:** We found that the combined and the short axis-based calculations of ejection fraction, end-diastolic volume, end-systolic volume, and myocardial mass in cardiac MRI showed correlation and consistency with those calculated via echocardiography. We also determined that the short axis-based calculations in cardiac MRI showed better correlation with the echocardiography compared with the combined method.

**Conclusion:** Because our results revealed that the cardiac MRI results obtained from the short axis method better correlate with the TTE, we recommend using short axis-based measurements in the evaluation left ventricular dysfunction.

**Keywords:** Left ventricular function, cardiac MRI, echocardiography

## Introduction

According to a report from the World Health Organization, the most common cause of adult deaths are cardiovascular diseases [1]. It is important to measure left ventricular function (LVF) parameters accurately in the diagnosis and follow-up of cardiovascular diseases. Ejection fraction, calculated by echocardiography, is the most important parameter used to demonstrate the left ventricular systolic function [2].

In addition to echocardiography, various imaging modalities such as computed tomography, magnetic resonance imaging (MRI), and digital subtraction ventriculography are used to evaluate LVF. MRI also allows the functional evaluation with the morphology of the cardiovascular system. MR images obtained by using SSFP (Steady State Free Precession) or gradient echo sequences are very reliable in determining the ventricular function, the myocardial contractility, and the myocardial mass [3]. For the evaluation of LVF in cardiac MRI, measurements can be made using different images and plans. The measurements can be performed with using only short axis images from the top of the heart to the mitral valve along the cycle in cine MR images or can be used vertical and horizontal long axes.

In this study, we aimed to calculate the LVF by using two different cardiac MRI methods and compare the results with those calculated via echocardiography for determining the correlation and consistency of these methods with that of echocardiography.

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<sup>1</sup>Department of Radiology, Ataturk University School of Medicine, Erzurum, Turkey

<sup>2</sup>Department of Cardiology, Ataturk University School of Medicine, Erzurum, Turkey

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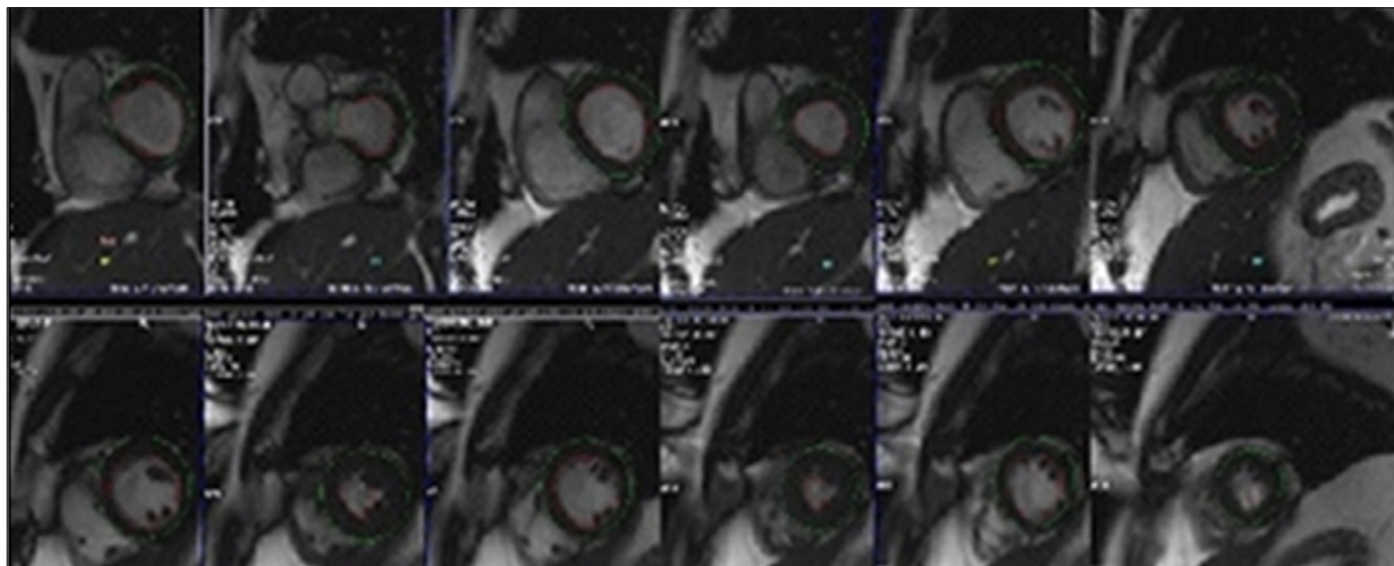
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Correspondence to: Bahar Yilmaz Cankaya  
E-mail: bahar.cankaya@atauni.edu.tr

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**Figure 1.** Cardiac cine images of the left ventricle show consequently acquired short axis images for the calculation of the short-axis based ejection fraction, end-diastolic volume, end-systolic volume and cardiac mass

## Materials and Methods

### Study population

The study included the data of 31 patients (12 females and 19 males) with a mean age of 43.4 years (range: 10–78 years) who applied to the Outpatient Cardiology Clinic of our hospital. All the patients had a diagnosis of left heart failure established by transthoracic echocardiography. Causes of left heart failure in our cases were coronary artery disease and myocardial perfusion disorder (n=13), cardiomyopathy (n=4), mass (n=5), valve disease (n=5), congenital heart disease (n=3), and malignant neoplasm metastasis (n=1).

The ethics committee of our institution approved the study (B.30.2.ATA.0.01.00/12). The patients were informed about the examinations and their approvals obtained.

### TTE and MRI application protocols

Echocardiography examination was performed in the parasternal view using a 3.5 MHz transducer in the left lateral decubitus position. Measurements were obtained from the apical vertical long axis (two chambers) and horizontal long axis (four chambers) volumes using the Simpson technique. Ejection fraction (EF), end-

diastolic volume (EDV), end-systolic volume (ESV), and myocardial mass were calculated.

In the cardiac MRI, images were obtained using a 1.5T-MR scanner (Siemens AG, Magnetom Avanto, 2008, Germany) using a four-element phased-array thorax coil and electrocardiographic-gated cardiac MRI protocol. Cine images, (TR: 36.12 ms, TE: 1.27 ms, FOV: 400 mm, matrix 128 × 256, slice thickness 6 mm, slice spacing 2 mm); short axis images of the entire left ventricle between the apex and mitral valve; vertical long axis images obtained parallel to the interventricular septum in short axis images, and horizontal long axis images obtained through the line passing through the middle of the mitral valve and the apex were acquired.

### Image evaluation and measurement

MR images of all cases were transferred to the workstation of Syngo Via Console (software version 2.0; Siemens AG Medical Solutions, Germany), and measurements were made with a special software program, Argus (Version 2002B, Siemens Medical Solutions). Measurements were taken using two different methods from cine MR images. In the first method, calculation was performed using short axis images (8–12 cross sections depending on the structure of the heart) taken from the apex of the heart to the mitral valve orifice throughout the cycle (Figure 1). In the second method, measurements were performed by adding vertical and horizontal long axis images from one section to the short axis images (Figure 2). In both methods, as much as possible, trabeculations and papillary muscles were

included in the left ventricular cavity, and the endocardial surface and epicardial contours were drawn semi-automatically. In cases where the drawn contours overflowed the endocardial and epicardial surfaces, manual corrections were made, and EF, EDV, ESV, and myocardial mass values were calculated.

### Statistical Analysis

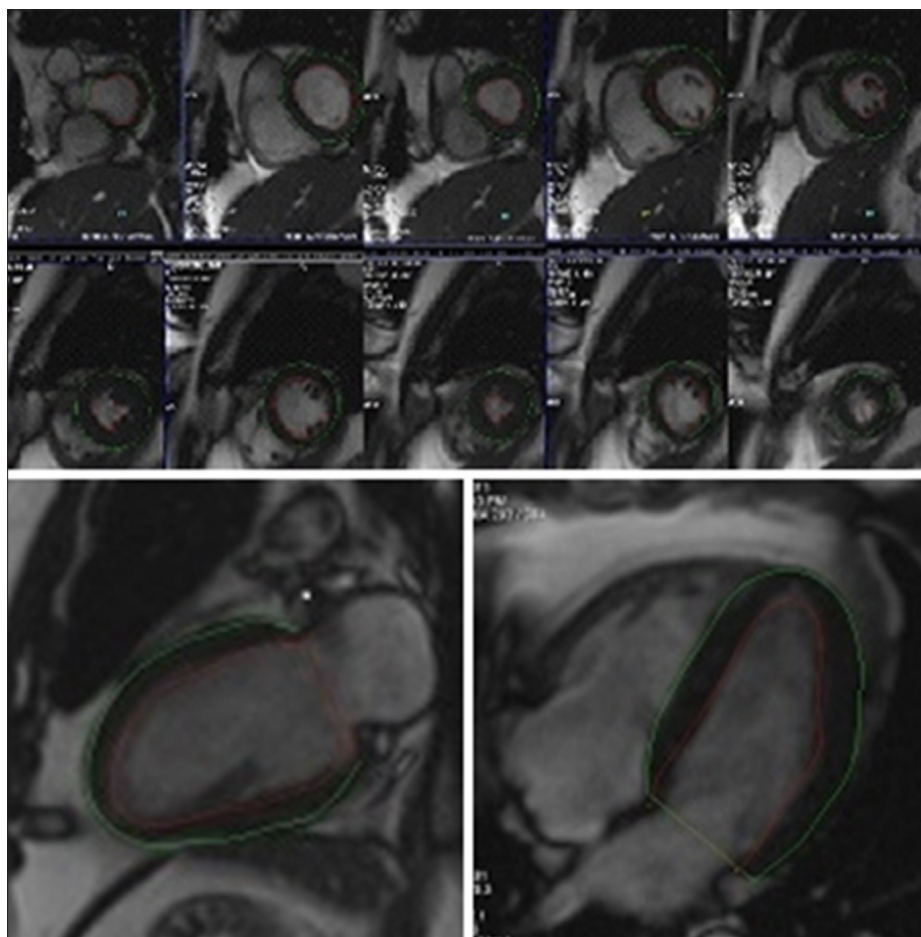
Normality of the calculated variables were assessed with Kolmogorov-Smirnov test. Variables with normal distribution presented as means±standard deviations. Comparison of data of more than three groups were performed using the repeated measure of ANOVA test. Bonferroni test was used for pairwise comparison as a post-hoc test. Bland-Altman plots were constructed to assess the consistency between MRI based and echocardiography-based calculations. T test was used to evaluate the difference between difference of means and average of means within the Bland-Altman plots. Linear regression analysis was used to determine the best correlation between MRI based and echocardiography-based calculations. All statistical analyses were conducted with the IBM Statistical Package for the Social Sciences (version 20) program (IBM Corp.; Armonk, NY, USA). Two-tailed p values lower than 0.05 were accepted as a statistically significant difference.

## Results

Mean age of the study population was 43.4 years (range: 10–78), and 19 out of 31 patients were male (61.3%). Data regarding the cardiac MRI and echocardiographic measurements and their respective p values are presented in Table 1.

### Main Points

- For the evaluation of LVF in cardiac MRI, measurements can be made using different images and plans.
- Short axis method are independent of geometric assumptions and closer to true results.
- Short axis measurement method correlates better with echocardiography.



**Figure 2.** Images of the longitudinal view of the left ventricle were added to the short axis images for the calculation of the same parameters in Figure 1 using combined method

Table 1. Study data belonging to patient population				
	Short axis–based measurement	Combined measurement	Echocardiographic measurement	p value
Ejection fraction±SD (%)	43.4±11.1	53±9.2a	41.8±10.2	<0.001
End-diastolic volume±SD (mL)	141.5±70.7	147.2±46.6b	130.3±50.2	0.024
End-systolic volume± SD (mL)	83.5±51.9	69.6±29.5	79.7±36.7	0.078
Myocardial mass± SD (g)	154.1±27.1	152.4±23.1	156.6±33.8	0.917
SD, standard deviation Boldface indicates statistical significance. Pairwise analysis with Bonferroni correction; *significantly higher than short axis–based and echocardiographic measurement. bsignificantly higher than echocardiographic measurement				

Bland-Altman plots for short axis–based and combined calculations of EF, EDV, ESV and myocardial mass compared with echocardiographic data are shown in Figure 3. All calculated variables of EF, EDV, ESV, and myocardial mass with both combined and short axis–based method in MRI were comparable to echocardiographic imaging.

Scatter diagrams with regression lines are shown in Figure 4. Linear regression analysis showed that short axis–based calculations of EF, EDV,

ESV, and myocardial mass had higher correlation with echocardiography (Figure 4).

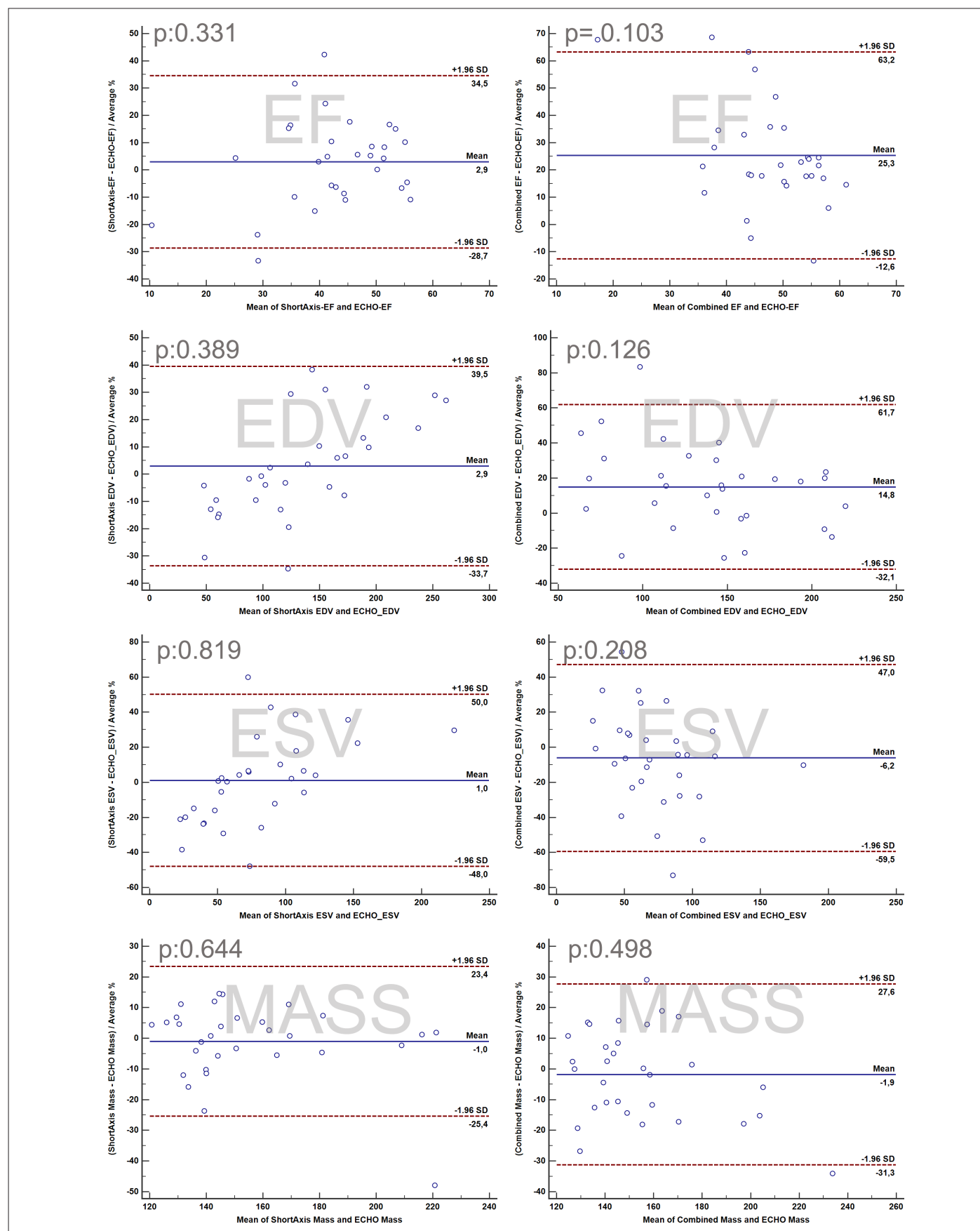
## Discussion

In our study, we found that combined and short axis–based calculations of EF and EDV, ESV, and cardiac mass in cardiac MRI were consistent with those calculated with echocardiography. Furthermore, short axis–based calculations in MRI showed better correlation with echocardiography than calculations with the combined method.

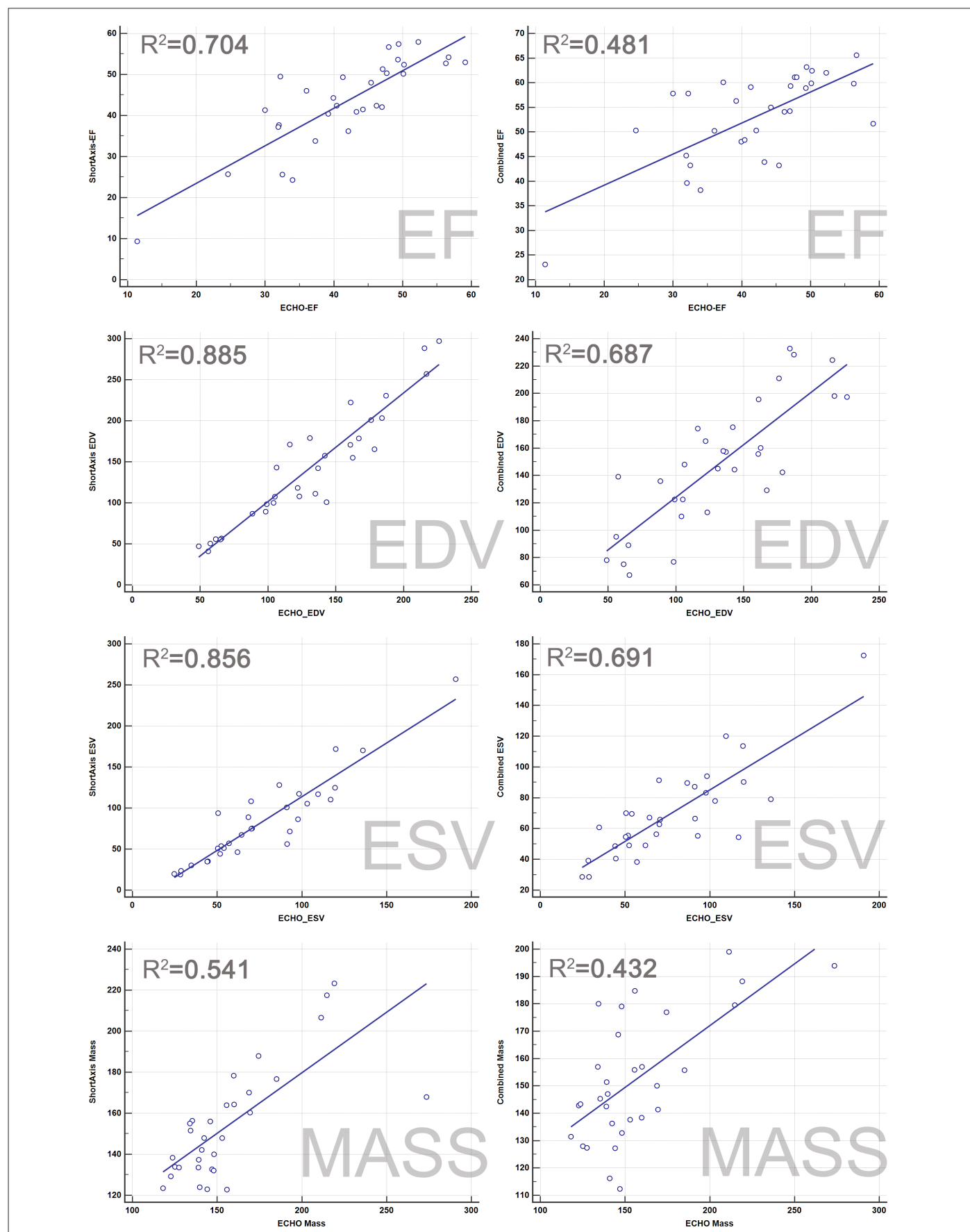
Accurate measurement of ventricular function in cardiac MRI is still a challenging problem because of reasons such as low image contrast at the border of the ventricle and artificial artifacts from cardiac motion [4]. In cardiac MRI, left ventricular volume and function can be evaluated using methods such as biplane ellipsoid model and hemisphere cylindrical model using multiple short axis images (Simpson method), single plan horizontal long axis, or vertical long axis images. Although it is accepted that most studies using short axis method have more accurate results than those using other measurement methods, there is no complete consensus on this subject. In our study, we made multi-plane measurements by adding single-plane horizontal and vertical axis images to short axis images.

It is suggested that the measurements by using the short axis method are independent of geometric assumptions and closer to true results [5, 6]. Huttin et al. [7] argued that EF measurements performed using biplane long axis images in cardiac MRI in patients with acute myocardial infarction showed better correlation with TTE compared with short axis measurements, and the measurement would take less time. In his recent study, O'Del compared different methods of LVF measurements in cardiac MRI, in which, methods involving multiple long axis views, the mitral valve ring, and the apical aspect of the left ventricle were more accurate than methods based on partial short axis image slices during the heart cycle [8]. In our study, assuming that the combined measurement method may be more favorable in evaluating LVF by reducing geometric assumption errors, we found that the results obtained from multiple short axis images correlated better with TTE. However, in our study, we combined single section long axis images and short axis images and compared the parameters with another geometric assumption in TTE examination. More realistic results can be achieved by a combination of multiple short axis images and multiple long axis images.

Bellenger et al. [9] reported that cardiac MRI had limitations in the evaluation of diastolic function; however, it has become the gold standard in imaging methods in the evaluation of normal and abnormal left ventricular systolic heart function. In our study, we could not compare the diastolic function parameters as they were not obtained in TTE. However, in systolic function parameters, we determined that the values obtained with both short axis measurement method and combined measurement method in cardiac MRI were compatible with echocardiography.



**Figure 3.** Bland-Altman plots were constructed against the echocardiographic calculations of the variables for both methods (p value stands for the result of the t test which compares the difference of means and average of means)



**Figure 4.** Scatter diagrams with regression lines show the correlation with MRI based calculations of variables with those calculated in echocardiography (p: 0.001 in all diagrams)

In a study conducted by Hazirolan et al. [10], EF and EDV values obtained from long axes in MRI were higher than those obtained from short axis measurement method and TTE. Similarly, in our study, we found that EF and EDV values were higher in the combined measurement method compared than in the other two methods. It is important to correctly determine the mitral valve level in the evaluation of left ventricular volumes. In long axis images, mitral valve level can be determined more easily and accurately than short axis images. In addition, endocardium and trabeculation are difficult to distinguish at the apex level, where trabeculations are intense in short axis images. Exclusion of trabeculations outside the ventricular cavity causes a decrease in EDV. For these reasons, we think that EDV and EF values are lower in the short axis measurement method.

Our study had some limitations. Our study group consisted of relatively few cases. The variety of causes of heart failure in our cases may have caused differences in mean parameters and standard deviations in some parameters.

As a result, in our study, left ventricular volume and function measurement values performed with TTE and MRI were found to be compatible with each other. In the evaluation of the LVF, measurements in cardiac MRI can be done by either method, but the short axis measurement method correlates better with echocardiography.

**Ethics Committee Approval:** Ethics committee approval was received for this study from the Ethics Committee of Ataturk University School of Medicine (B.30.2.ATA.0.01.00/12).

**Informed Consent:** Informed consent was obtained from the patients who participated in this study.

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**Conflict of Interest:** The authors have no conflict of interest to declare.

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