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Original Article

Cardiac Magnetic Resonance Imaging Findings of the Sigmoid-Shaped Interventricular Septum

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ABSTRACT

Objective: Sigmoid-shaped interventricular septum may have effects on cardiac contractility functions. This study aims to investigate the relationship between basal septal thickness and ejection fraction rates in patients with sigmoid-shaped interventricular septum.

Methods: From February 2015 to June 2020, consecutive patients who had undergone cardiac magnetic resonance imaging were analyzed in this retrospective study. Basal, mid-, and apical septal thicknesses of these patients were measured, and ejection fraction rates were calculated. Spearman correlation analysis was performed to determine the relationship.

Results: A total of 550 patients were analyzed, and 15 (7 men, 8 women) of them were found to have sigmoid-shaped interventricular septum. The mean age was 64 ± 16 years. A moderate correlation ($r_s = 0.533$) was found between basal septal thickness and ejection fraction. We also found moderate ($r_s = 0.487$) and high ($r_s = 0.698$) correlation of mid-septal and apical septal thicknesses with ejection fraction, respectively.

Conclusion: The basal septal thickness of the patients with sigmoid-shaped interventricular septum is related to the ejection fraction rates. The measurement of these thicknesses is important for the changes in the ejection fraction rates, which is one of the cardiac prognostic criteria.

Keywords: Cardiac imaging techniques, magnetic resonance imaging, sigmoid septum, ventricular ejection fraction

INTRODUCTION

Cardiac magnetic resonance imaging (CMR) is increasingly used in the characterization of myocardial diseases and changes by evaluating their effects on anatomical and functional features. As the use of CMR expands, incidental or asymptomatic findings will be encountered more often. The sigmoid-shaped interventricular septum (SS), or sigmoid septum, is a morphological change characterized by localized thickening of the basal septum. It has been also named as ventricular septal bulge, discrete upper septal thickening, or basal septal hypertrophy. This change has been considered to be the result of aging and higher systolic blood pressure.[1] Its prevalence ranges from 1.5% to 17.8% in different studies, and generally, it has no clinical significance.[2]

The protrusion of the basal septum into the outflow tract of the left ventricle may cause left ventricular outflow obstruction. Thus, certain patients with SS may have complaints of dyspnea and syncope.[3,4] The consideration as "normal variant" for the SS has been called into question because of these associated complications.[2] There were no CMR studies about SS and cardiac functional changes in the English literature that we were able to reach. Echo studies are available. This study evaluates the appearance characteristics of SS with CMR and its effect on cardiac function. The morphologic

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criteria of the SS can be measured and also functional data such as ejection fraction (EF) can be calculated with CMR. Ejection fraction is a prognostic indicator for heart disease.

The aim of this study is to investigate the change of EF with basal septal thickness in non-obstructive SS patients.

METHODS

This study was designed as a single-center, retrospective study and conducted according to the Helsinki Declaration principles. Ethics committee approval was received for this study from the ethics committee of İzmir Katip Çelebi University (Date: July 2, 2020, Number: 783). Informed consent was waived as the committee did not require it for the retrospective studies.

Study Population

A total of 614 patients (332 men, 282 women), who had undergone CMR for several etiologies between February 2015 and June 2020, were analyzed. Patients with a history of cardiac operation or intervention, late gadolinium enhancement on magnetic resonance imaging (MRI), wall motion abnormality, and severe cardiac valve insufficiency were excluded (64 patients: 41 men, 23 women). As a result, 550 patients (291 men, 259 women) were studied. Ten patients had repetitive examinations and only the first examinations of these were included. A cardiac imaging board-certified radiologist with 6 years of experience in CMR interpreted all examinations. The patients' data were retrieved from the local picture archiving and communication systems. Radiology reports and images were retrospectively reviewed.

Cardiac Magnetic Resonance Imaging Examination

All patients were imaged with 1.5 T MRI scanner (Sonata and Symphony, Siemens Healthcare, Erlangen, Germany). Our MRI protocol was as follows: Multiplane steady-state free precession (SSFP) localizers, axial T1-weighted turbo spin echo black blood images, cine SSFP oriented 2-3-4 chambers and short axis ventricle images, short-tau inversion recovery black blood images in short axis and 4 chambers, dynamic T1-weighted turbo spin echo in short axis, phase contrast 2D, and phase-sensitive inversion recovery images performed 10-15 minutes after the intravenous of gadolinium administration (0.1 mmol/kg).

Two-chamber images were analyzed to measure ventricular wall thickness. The maximum thickness of the basal septal wall, mid-septal wall, and posterior wall of the left ventricle was measured. Our SS criteria were localized septal hypertrophy with a thickness of ≥13 mm in men and ≥12 mm in women, and more than 50% greater than the mid-septal wall thickness as mentioned in the literature[4,5] (Figures 1-3). Cases with an LV posterior wall thickness greater than 11 mm were not considered to be isolated SS since they may be compatible with hypertrophic cardiomyopathy (HCM) and may have an effect on EF. In our study, flow velocity measurements for the aortic outlet were not standard for evaluating subaortic stenosis secondary to the sigmoid septum, so flow velocity changes were not evaluated.

Ejection fraction was calculated automatically over functional sequences with the Syngo.via software (Siemens Healthcare GmbH, Erlangen, Germany) for MRI workstations.

Statistical Analysis

Statistical Package for Social Sciences 25.0 (IBM SPSS Corp., Armonk, NY, USA) package program was used for statistical analysis. Continuous variables were

MAIN POINTS

- Sigmoid-shaped interventricular septum is a local thickening of the base of the interventricular septum.
- The sigmoid-shaped interventricular septum may affect cardiac contractility.
- In our study, we found a moderate correlation between basal septal thickness and ejection fraction ($r_s = 0.533$).
- Basal septal thickness measurement is important for changes in ejection fraction rates, which is one of the cardiac prognostic criteria.

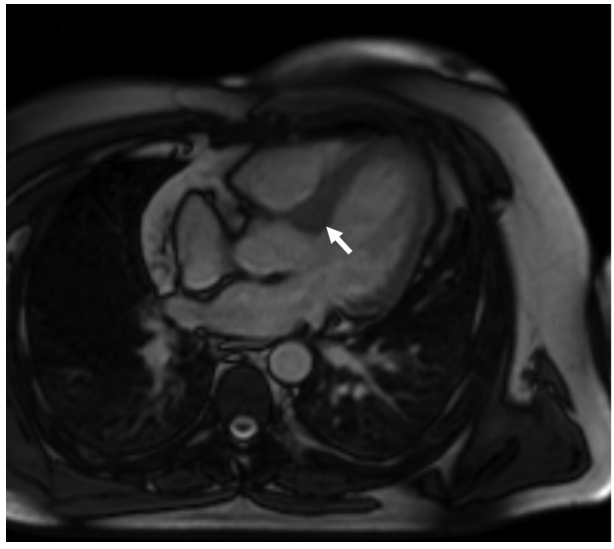

Figure 1. Four-chamber cine steady-state free precession image of a 40-year-old man shows sigmoid-shaped interventricular septum (arrow).

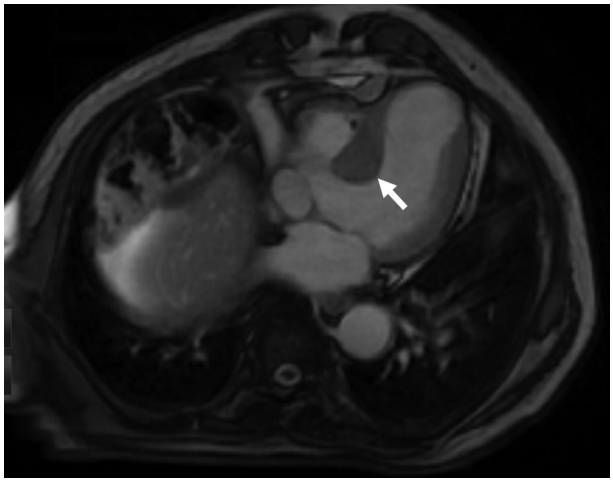

Figure 2. Four-chamber cine steady-state free precession image of an 82-year-old man shows dilated left ventricular apex and interventricular sigmoid septum (arrow).

presented as mean ± standard deviation for normally distributed variables or median (interquartile range) for non-normally distributed variables. Spearman correlation analysis was performed to determine the relationship between the thickness of the basal septum and other continuous variables with EF. Spearman correlation coefficient (r_s) value explanations are made as there is a very weak correlation between 0.00 and 0.19, a weak correlation between 0.2 and 0.39, a moderate correlation between 0.4 and 0.59, a high correlation between 0.6 and 0.79, and between 0.8 and 1 is considered to be a very high correlation.[6] Statistical significance was defined as a *P*-value < .05.

RESULTS

A total of 550 patients (291 men, 259 women) were evaluated. Fifteen patients (7 men and 8 women) met the SS measurement criteria. The prevalence of SS was 2.7%. In the SS patients, the mean age was 64 ± 16 years, ranging between 34 and 88.

Median basal septal thickness was 14 mm (interquartile range was 4 mm), median mid-septal thickness was 8 mm (interquartile range was 2 mm), and mean apical septal thickness was 5 ± 1 mm (ranges between 2 mm and 7 mm) in the SS patients. Ejection fraction rates were calculated in SS patients, and the median EF was 60% (interquartile range was 15%).

Correlation coefficients with EF were $r_s = 0.533$ for basal septal thickness, $r_s = 0.487$ for mid-septal thickness, $r_s = 0.698$ for apical septal thickness, and $r_s = 0.131$ for age. Except for age, other correlations with EF were statistically significant.

DISCUSSION

Accurate measurement of left ventricular walls and functional parameters are important for diagnosis, cardiovascular risk evaluation, prognosis, and treatment choice. Localized thickening of the base of the interventricular septum, in other words, sigmoid septum, has been morphologically described earlier. In this article, we analyzed if there is a correlation between EF and the basal septal thickness in SS patients and found a significantly positive correlation.

The SS term was first described by Goor et al[7] in 1969. They pointed out that the protrusion of the basal septum toward the left ventricle may have caused the blood flow to have a sigmoid-shaped route. They also suggested that the SS may have occurred with an age-related physiological decrease in cardiac output. The SS was asserted to be a normal age-related condition and should be differentiated from the asymmetric septal hypertrophy in the HCM.[5] Nagaraj et al[8] identified the SS as a benign entity. Despite these studies, some authors reported that left ventricular outflow tract (LVOT) obstruction can occur in SS patients.[9] We thought that this obstruction and altered myocardial tissue volume may have effects on the EF.

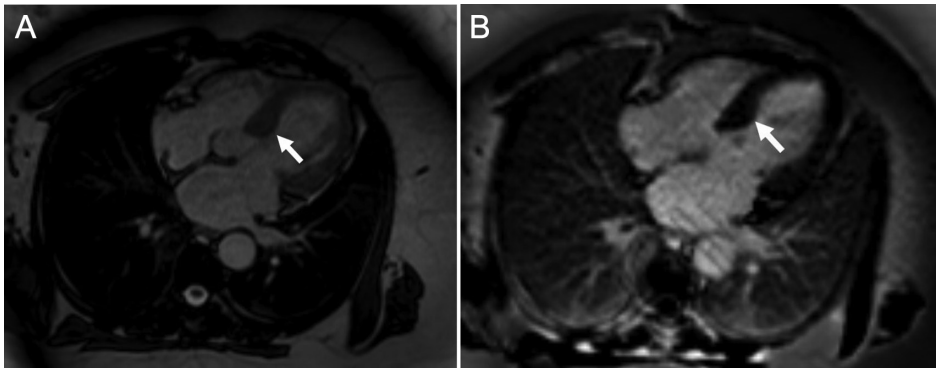

Figure 3. Cardiac magnetic resonance images on a 65-year-old woman. Four-chamber cine steady-state free precession (A) and phase-sensitive inversion recovery (B) images show the sigmoid-shaped interventricular septum.

The septal wall provides a channel between the left ventricle and the aorta. The base of the septum is in close proximity to the aortic valve and its hypertrophy could contribute to ventricular outflow obstruction and aortic peak systolic velocity. Goor et al[7] showed that the bulging of the proximal septum and accompanying rightward angulation of the aorta in the sigmoid septum patients narrowed the LVOT by an autopsy study. The guidelines recommend provocation testing to assess for latent LVOT obstruction in patients with HCM or isolated basal septal hypertrophy.[10] This obstruction at the LVOT due to decreased aorto-septal angle and increased basal septal thickness may be thought to reduce EF by blocking the blood flow. However, left ventricular contractility parameters including the EF rates were found higher in cases with SS compared with those without.[4] The comparison in these 2 studies was made by echocardiography and also was evaluated only for the presence of SS, not for the amount of basal septal thickness. In our study with CMR, we found a moderate correlation between EF and basal septal thickness ($r_s = 0.533$). This can be related to increased contractility due to increased basal septal thickness in patients with SS. We found a moderate correlation between EF and mid-septal thickness and also a high correlation between EF and apical septal thickness. These last 2 findings support the hypothesis of increased contractility due to increased septal myocardial volume.

The differentiation between HCM and SS is challenging, especially in elderly patients and asymmetric HCM cases. A family history of HCM or sudden cardiac death, septal thickness > 15 mm and posterior wall thickness > 11 mm, systolic anterior motion of the anterior mitral valve and LVOT obstruction, late gadolinium enhancement on CMR, a genetic mutation associated with HCM, an abnormal electrocardiogram, and myocyte disarray at endomyocardial biopsy are the supporting findings for HCM instead of SS.[2,9,11] Also, higher than 30 mmHg of the provocable LVOT gradient is compatible with HCM.[12] We think that the presence of posterior wall thickness > 11 mm and late gadolinium enhancement in patients with basal septal thickness > 15 mm are the practically distinguishing criteria in the CMR examination when it is not able to access more clinical information about the patient.

The relationship between the presence of SS and EF has been demonstrated by Canepa et al.[4] but there is no study evaluating the relationship between the measurement of basal septal thickness and EF. Performing these evaluations with CMR in our study eliminated the operator dependency of echocardiography and provided a more objective evaluation. This study demonstrates the clinical importance of basal septal thickness measurement in SS cases by showing that EF, which is a prognostic data in cardiac diseases, can change with basal septal thickness.

Our study has several limitations. First, we did not compare our results with a control group. Second, the number of SS cases was limited. Third, there is no consensus in the literature about the abnormal basal septal thickness. So, different thresholds can be used in different studies. Fourth, the limitation is that flow rate measurements could not be done. Lack of surgical or anatomical evaluation is another limitation. Last, this is a single-center retrospective study, and institutional limitations or evaluation bias of the MRI images could have been done.

The SS can be successfully diagnosed with CMR as a localized thickening at the base of interventricular septum. Decreased aorto-septal angle, LVOT obstruction, and increased left ventricular contractility can be seen in these cases. However, there is no consensus on the terminology and its clinical significance. This is the first study that analyzes the correlation between basal septal thickness and EF in SS cases with CMR and indicates a positive correlation. Expanding this study prospectively with a higher number of patients and with detailed clinical information will ensure that the results of the study become generalizable.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of İzmir Katip Çelebi University (Date: July 2, 2020, Number: 783).

Informed Consent: Consent was obtained from the hospital management regarding the analysis of cardiac magnetic resonance images.

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