Longitudinal 2D strain imaging in patients with sigmoid-shaped interventricular septum

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Purpose

Peak systolic longitudinal 2D strain (PSLS) imaging is a relatively new method to evaluate the left ventricular (LV) wall motion and mechanical function. An algorithm of automated functional imaging (AFI) can be applied for quantitative measurement of global and segmental PSLS.

Sigmoid-shaped interventricular septum implies the protrusion of its basal segments into the left ventricular outflow tract (LVOT) (refer to figure 1). The increase of the aorto-septal angle (i.e. the angle between the interventricular septum and the ascending aorta) is typical of the sigmoid-shaped septum: normally this angle is $93^\circ \pm 14^\circ$, but in case of the sigmoid-shaped septum, it can increase up to $145^\circ \pm 7^\circ$ [3].

Traditionally, sigmoid-shaped interventricular septum is considered to be a part of normal aging process, and bears little clinical significance [1,2]. However, latest reports have shown that it may lead to the dynamic left ventricular outflow tract obstruction, even without the left ventricular hypertrophy (LVH) [3,4]. Left ventricular outflow tract obstruction is usually associated with LVH or hypertrophic cardiomyopathy. But recent studies [3,4] report, that, in some cases, sigmoid-shaped septum may cause significant narrowing of the LVOT with its consequent dynamic obstruction and the increase of the LV pressure, especially if followed by the LVH, physical exercise, general anesthesia, acute myocardial infarction, dehydration, overeating or intensive hypertension treatment [5,6,7]. Many authors also state that dynamic LVOT obstruction is often followed by the increase of the global LV contractility [3].

Increased turbulence of the blood flow through the narrowed LVOT also leads to the intensified degeneration and calcification of the aortic valve, especially its non-coronary cusp, that also results in the increase of the aorto-septal angle [8].

Many authors report the increase of global LV contractility in patients with the sigmoid-shaped septum [3,4], but we failed to find any reports about the evaluation of the segmental PSLS in this group of patients. The purpose of this study is to find out whether there is an increase of the septal PSLS in patients with the sigmoid-shaped septum and normal ejection fraction.

Images for this section:
**Fig. 1:** 2D grey scale image demonstrating the sigmoid-shaped interventricular septum in 72-year-old female patient.
Methods and Materials

Patients

The subjects were 30 patients (14 male, 16 female, mean age 63±13 yrs.) with normal ejection fraction. The patients were classified into two groups: group 1 (patients with sigmoid-shaped septum, n=9) and group 2 (control group, n=21).

17 patients had hypertension and received antihypertensive therapy, sigmoid-shaped septum was found in two of them. Four patients had LVH, one of them was diagnosed with the sigmoid-shaped septum. All patients showed no signs of heart failure.

The inclusion criteria during this study were as follows:

1. Normal ejection fraction (60% or more), measured with the Simpson’s method
2. Intact aortic valve.

The exclusion criteria were poor acoustic window, arrhythmias (atrial fibrillation, frequent premature heartbeats, second- and third-degree atrioventricular block, sinus bradycardia with heart rate # 50), significant aortic stenosis or insufficiency, previous myocardial infarction or verified LVOT obstruction.

Echocardiographic protocol

Transthoracic 2D echocardiography was performed with a 1.5-4.3 MHz transducer in all patients and involved measurements of cardiac dimensions, volumes, LV ejection fraction, segmental contractility evaluation, and pulse wave, constant wave and color Doppler measurements. 2D grey scale images in the apical long-axis, four-chamber, and two-chamber views were acquired for the global and segmental PSLS analysis. Strain analysis was performed offline by the same investigator using EchoPAC® (BT 06.6.1.0, GE Vingmed; Horten, Norway) with AFI. In the apical long-axis view, aortic valve closing time was defined to verify the end-systolic period. In each following apical view, three endocardial points were marked: two points were at the base of the LV at both sides of the mitral annulus, and the third one was at the LV apex. The region of interest was adjusted to include entire myocardium, and then it was automatically evaluated by the speckle tracking algorithm and the segmental PSLS was presented in the bull’s eye display. Global PSLS was defined as an average value of all segmental PSLS rates.

Statistical analysis
Statistical analysis was performed using Statistica software (version 6.0 for Windows). Values were expressed as mean values ± standard deviation. Comparisons among data were performed with Student’s t test or Wilcoxon test, depending on whether the quantitative attribute would follow a normal distribution, p < 0.05.

Results

All patients were age- and sex-matched. The number of patients with hypertension was larger in group 2 than in group 1 (71% vs 22%, #<0.05).

The two groups were matched by the echocardiographic measurements of cardiac dimensions, volumes, myocardial mass and LV ejection fraction (see table 1).

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Group 1</th>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate, bpm</td>
<td>63±6</td>
<td>62±11</td>
</tr>
<tr>
<td>Myocardial mass, g</td>
<td>167±44</td>
<td>209±84</td>
</tr>
<tr>
<td>LV ejection fraction, %</td>
<td>62±3</td>
<td>62±3</td>
</tr>
<tr>
<td>LV EDD, mm</td>
<td>47±4</td>
<td>49±4</td>
</tr>
<tr>
<td>LV EDV, ml</td>
<td>73±21</td>
<td>82±16</td>
</tr>
<tr>
<td>Left atrial size, mm</td>
<td>33±4</td>
<td>36±4</td>
</tr>
<tr>
<td>Left atrial volume, ml</td>
<td>43±10</td>
<td>52±16</td>
</tr>
<tr>
<td>Right atrial volume, ml</td>
<td>39±7</td>
<td>42±17</td>
</tr>
</tbody>
</table>

Table 1: Echocardiographic measurements in Group 1 and Group 2

Segmental analysis showed that PSLS in group 1 was increased in two segments of the interventricular septum, compared to group 2 (basal anteroseptal segment (-21.1 vs -16.9, p=0.008) and mid posteroseptal segment (-22.9 vs -20.1, p=0.031), refer to figures 2 and 3). Global PSLS and PSLS rates in other 15 segments showed no significant differences (see table 2).

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Group 1</th>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global PSLS, LAX, %</td>
<td>-19.3±3.3</td>
<td>-20.4±3.2</td>
</tr>
</tbody>
</table>
Global PSLS, A4C, %  
-21.2±2.4  
-19.9±2.0

Global PSLS, A2C, %  
-22.1±3.4  
-20.5±3.2

Global PSLS, mean, %  
-20.9±2.6  
-20.6±2.9

**Table 2: Global longitudinal 2d strain rate values in groups 1 and 2.**

Images for this section:

**Fig. 2:** Segmental PSLS analysis in group 1 (patients with sigmoid-shaped septum) shows an increase of the longitudinal 2D strain rate in two segments of the interventricular septum, compared to group 2 (control group).
Fig. 3: Segmental PSLS analysis in group 2 (control group). 2D strain rate is lower in the interventricular septum.
Conclusion

In the present study, segmental PSLS in two septal segments was higher in group 1 (patients with the sigmoid-shaped septum), than those in the control group, which indicates their increased contractility [3,4]. It is worth mentioning that no significant differences were found between global PSLS rates in the two groups. The local increase of PSLS may result in the increase of the radial strain rates in the same segments, which may lead to hypermobility of the interventricular septum and result in the dynamic LVOT obstruction [3-5].

Study limitations

There are some limitations in the present study. A relatively small number of patients with the sigmoid-shaped septum was enrolled, and both groups were not matched by the hypertensive disease rate, which was higher in the control group. It was earlier shown that PSLS rates are in the inverse relationship with the severity of the LV hypertrophy [10]. However, it should be noted that in case of the LV hypertrophy, global PSLS is usually decreased. In the current study, an increase of the segmental septal PSLS rates was registered, and it did not influence the global PSLS. This may indicate that there is no relation between the LV hypertrophy and the increase of the segmental PSLS in patients with the sigmoid-shaped septum.

References


Personal Information