Left Ventricular Dyssynchrony Parameters Measured by Phase Analysis of Post-stress and Resting Gated SPECT Myocardial Perfusion Imaging

Yanli Zhou, The First Affiliated Hospital of Nanjing Medical University
Dianfu Li, The First Affiliated Hospital of Nanjing Medical University
Jianlin Feng, The First Affiliated Hospital of Nanjing Medical University
Donglan Yuan, The First Affiliated Hospital of Nanjing Medical University
Zenic Patel, Emory University
Kejiang Cao, The First Affiliated Hospital of Nanjing Medical University
Ji Chen, Emory University

Journal Title: World Journal of Nuclear Medicine
Volume: Volume 12, Number 1
Publisher: Medknow Publications | 2013, Pages 3-7
Type of Work: Article | Final Publisher PDF
Publisher DOI: 10.4103/1450-1147.113931
Permanent URL: https://pid.emory.edu/ark:/25593/s2cr3

Final published version: http://dx.doi.org/10.4103/1450-1147.113931

Copyright information:
© World Journal of Nuclear Medicine

Accessed December 26, 2023 3:44 PM EST
Introduction

Phase analysis has been developed to assess left ventricular (LV) dyssynchrony based on gated single photon emission computed tomography (SPECT) myocardial perfusion imaging (MPI). It has been shown that the LV dyssynchrony parameters (phase standard deviation (PSD) and phase histogram bandwidth (PHB)) measured by phase analysis correlate well with those measured by tissue Doppler imaging, and predicted response to cardiac resynchronization therapy (CRT) in heart failure (HF) patients. Recently, phase analysis has shown to be able to identify the site of latest mechanical activation as the optimal LV pacing lead position. In the above validation studies, all gated SPECT images were acquired using resting Technetium-99m sestamibi (MIBI) MPI protocol, where gated SPECT data were acquired at 60 min post injection of the radiotracer. LV dyssynchrony parameters at post-stress and at rest were calculated and compared using paired t-test. There were no significant differences in the LV dyssynchrony parameters between post-stress and resting in all cohorts. No patient showed differences in the LV dyssynchrony parameters between the post-stress and resting scans significantly greater than the reported variations in these parameters between serial resting scans. There was no significant difference in dyssynchrony parameters measured at rest and 60 min after stress on MPI gated images.

Keywords: Left ventricular dyssynchrony, myocardial perfusion imaging, phase analysis.

Left Ventricular Dyssynchrony Parameters Measured by Phase Analysis of Post-stress and Resting Gated SPECT Myocardial Perfusion Imaging

Yanli Zhou¹, Dianfu Li², Jianlin Feng², Donglan Yuan², Zenic Patel³, Kejiang Cao¹, Ji Chen³

¹Departments of Cardiology, ²Nuclear Medicine, The First Affiliated Hospital of Nanjing Medical University, Nanjing, Jiangsu, China, ³Department of Radiology, Emory University, Atlanta, GA, USA

Abstract

Phase analysis has been validated to measure left ventricular (LV) dyssynchrony from resting gated SPECT myocardial perfusion imaging (MPI). In 1-day rest/stress protocols, often only post-stress gated data are acquired. The purpose of this study was to determine whether LV dyssynchrony parameters measured at post-stress significantly differ from those measured at rest. Sixty normal subjects, 40 patients with stress-induced ischemia but normal LV function, and 29 patients with LV dysfunction were included in this study. All patients were scanned using a 2-day Technetium-99m sestamibi (MIBI) MPI protocol, where gated SPECT data were acquired at 60 min post injection of the radiotracer. LV dyssynchrony parameters at post-stress and at rest were calculated and compared using paired t-test. There were no significant differences in the LV dyssynchrony parameters between post-stress and resting in all cohorts. No patient showed differences in the LV dyssynchrony parameters between the post-stress and resting scans significantly greater than the reported variations in these parameters between serial resting scans. There was no significant difference in dyssynchrony parameters measured at rest and 60 min after stress on MPI gated images.

Keywords: Left ventricular dyssynchrony, myocardial perfusion imaging, phase analysis.
volume and end-diastolic volume increased in patients with stress-induced ischemia. However, the effect of ischemia on the difference between post-stress and resting LV function measurements was modest and rarely exceeded the confidence limits in normal patients undergoing 2-day protocols. There is a recent study enrolling 20 patients with reversible perfusion defects involving >10% of the LV myocardium and 20 normal subjects to show that there was no significant change from rest to stress in the LV dyssynchrony parameters between the two groups. It is important to note that all of the subjects in this study had normal LVEF. The impact of stress on LV dyssynchrony parameters was not evaluated in patients with LV dysfunction.

The purpose of this study was to determine whether LV dyssynchrony parameters (PSD and PHB) measured at post-stress significantly differ from those measured at rest in normal subjects, patients with stress-induced ischemia but normal LVEF, and patients with LV dysfunction.

Materials and Methods

Patients

The study retrospectively analyzed gated SPECT MPI data acquired from July 2008 to January 2010. Sixty normal subjects (30 underwent exercise stress and 30 underwent adenosine stress), 40 patients with stress-induced ischemia but normal LV function (LVEF >50%, 20 underwent exercise stress and 20 underwent adenosine stress), and 29 patients with LV dysfunction (LVEF <50%, 19 underwent exercise stress and 10 underwent adenosine stress) were included in this study. Stress-induced ischemia was considered in the presence of reversible myocardial perfusion defect at stress. Among the 29 patients with LV dysfunction, 14 had ischemic cardiomyopathy (including 10 patients with myocardial infarction) and 15 patients had non-ischemic cardiomyopathy. The study protocol was approved by the institutional review board (IRB).

Acquisition and processing

A 2-day MIBI SPECT MPI protocol was used in this study. Patients who had exercise stress underwent a symptom-limited treadmill test using standard Bruce protocol. MIBI was intravenously injected when a ≥85% heart rate was achieved. Exercise was continued at the workload for 1.5-2.0 min when possible. Patients who had adenosine stress were infused with adenosine at 140 µg/kg/min for 5 min and MIBI was injected at the end of the second minute. Tc-99m Sestamibi doses ranged from 25 to 30 mCi depending on the patients’ weight or body mass indices.

A Philips CardioMD system (Philips Medical Systems, Milpitas, CA, USA) was used to acquire all post-stress and resting scans with 20% energy windows around 140 keV. A total of 64 projections (24 sec/projection, total acquisition time of 14 min) were obtained over a 180° circular orbit. The gated SPECT data were acquired as eight frames per cardiac cycle. Data were stored in a 64–64 matrix with 6.4 mm/pixel. All of the gated SPECT data were reconstructed using a manufacturer-provided filtered backprojection program (AutoSPECTPlus™, Philips Medical Systems). All reconstructed data were reoriented to generate gated short-axis images and then submitted to phase analysis to calculate PSD and PHB. The post-stress and resting images were processed side-by-side by an experienced technologist, who was blinded from this research project.

Statistical analysis

Paired t-test (two-tailed) and Bland–Altman plot were used to compare the post-stress and resting PSD and PHB in the three cohorts, respectively. A P < 0.05 was considered statistically significant.

Results

Table 2 shows the LV dyssynchrony parameters in the three cohorts. In normal subjects, although it showed a trend that LV dyssynchrony parameters acquired from stress scans were smaller than those from resting

### Table 1: Patient characteristics

<table>
<thead>
<tr>
<th></th>
<th>Normal subjects (n=60)</th>
<th>Patients with ischemia (n=40)</th>
<th>Patients with LV dysfunction (n=29)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>60.3±18.3</td>
<td>60.9±10.2</td>
<td>61.8±9.5</td>
</tr>
<tr>
<td>Male (%)</td>
<td>55</td>
<td>67.5</td>
<td>82.5</td>
</tr>
<tr>
<td>Diabetes mellitus (%)</td>
<td>8.9</td>
<td>17.5</td>
<td>12.5</td>
</tr>
<tr>
<td>Hypertension (%)</td>
<td>45</td>
<td>63</td>
<td>57.5</td>
</tr>
<tr>
<td>MI/non-MI (%)</td>
<td>NA</td>
<td>7.5/92.5</td>
<td>34.5/65.5</td>
</tr>
<tr>
<td>Ischemic/non-ischemic (%)</td>
<td>NA</td>
<td>NA</td>
<td>48.2/52.8</td>
</tr>
<tr>
<td>QRS duration (msec)</td>
<td>100±18.7</td>
<td>101.5±20.9</td>
<td>102.5±20.9</td>
</tr>
<tr>
<td>SSS</td>
<td>NA</td>
<td>6.1±3.9</td>
<td>13±12</td>
</tr>
<tr>
<td>SDS</td>
<td>NA</td>
<td>4±2.9</td>
<td>1.9±2.1</td>
</tr>
</tbody>
</table>

MI: Myocardial infarction; SSS: Summed stress score; SDS: Summed difference score
scans, the differences were not significant. Figure 1a-c shows the Bland–Altman plots that compared the LV dyssynchrony parameters between the post-stress and resting scans in the three cohorts. The mean differences in the LV dyssynchrony parameters were very small, indicating there were no systemic differences in these parameters between the post-stress and resting scans. There were no outliers that showed clinically important differences in the LV dyssynchrony parameters between the post-stress and resting scans, indicating the two scans yielded equivalent results. Figure 2a and b shows two example patients with anterior and inferior ischemia post-stress, respectively. Both patients had comparable LV synchrony at post-stress and at rest. Figure 3 shows an example patient with severe LV dysfunction ($LVEF = 24\%$) and myocardial infarction (summed stress score = 33). Even though severe reduction in perfusion uptake in the infarct region might impact the phase measurement, the global LV dyssynchrony parameters were not significantly different between the post-stress and resting scans, indicating that phase analysis was a robust tool to measure LV dyssynchrony in patients with severe LV dysfunction and myocardial infarction.

**Discussion**

This study compared LV dyssynchrony parameters measured by phase analysis of gated SPECT MPI between post-stress (either adenosine or exercise) and resting scans. No significant differences in these parameters were observed in normal subjects, patients with stress-induced ischemia but normal LV function, and patients with LV dysfunction. As the majority of clinical MPI data are acquired using 1-day Tc-99m protocol, where usually gated SPECT data are acquired only at post-stress, this finding supports the application of phase analysis to measure LV dyssynchrony.

<table>
<thead>
<tr>
<th></th>
<th>Normal subjects ($n=60$)</th>
<th>Patients with ischemia ($n=40$)</th>
<th>Patients with LV dysfunction ($n=29$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stress</td>
<td>Rest</td>
<td>Stress</td>
</tr>
<tr>
<td><strong>PSD</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>9.3</td>
<td>9.3</td>
<td>8.9</td>
</tr>
<tr>
<td>SD</td>
<td>2.0</td>
<td>1.9</td>
<td>2.9</td>
</tr>
<tr>
<td>P value</td>
<td>0.89</td>
<td>0.82</td>
<td>0.05</td>
</tr>
<tr>
<td><strong>PHB</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>28.5</td>
<td>29.5</td>
<td>28.4</td>
</tr>
<tr>
<td>SD</td>
<td>5.9</td>
<td>5.7</td>
<td>8.3</td>
</tr>
<tr>
<td>P value</td>
<td>0.23</td>
<td>0.74</td>
<td>0.06</td>
</tr>
<tr>
<td><strong>EF</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>76.1</td>
<td>76.2</td>
<td>61.5</td>
</tr>
<tr>
<td>SD</td>
<td>6.4</td>
<td>6.4</td>
<td>9.7</td>
</tr>
<tr>
<td>P value</td>
<td>0.83</td>
<td>0.004</td>
<td>0.12</td>
</tr>
</tbody>
</table>

**PSD:** Phase standard deviation; **PHB:** Phase histogram bandwidth; **SD:** Standard deviation; **LV:** Left ventricular

**Table 2: Post-stress and resting LV function parameters**

Figure 1: Bland–Altman plots for comparisons of the post-stress and resting LV dyssynchrony parameters in the (a) normal subjects, (b) patients with stress-induced ischemia but normal LV function, and (c) patients with LV dysfunction.
of phase analysis to post-stress Tc-99m gated MIBI SPECT MPI data to measure LV dyssynchrony, which is equivalent to that measured at rest.

Stress-induced ischemia is associated with post-stress reduction in LVEF and increased post-stress EDV and ESV. Stress-induced severe ischemia may lead to myocardial stunning and transient LV dilation, and possibly LV dyssynchrony. A few studies showed that physical effort might further increase LV dyssynchrony in patients with HF assessed by echocardiography during exercise. However, a recent study reported that even a large reversible perfusion defect does not significantly differ from those measured at rest in normal subjects, patients with stress-induced ischemia but normal LV function, and patients with LV dysfunction, in a 2-day Tc-99m MPI protocol. Phase analysis can be applied to post-stress Tc-99m gated SPECT MPI data to measure LV dyssynchrony, which is equivalent to that measured at rest.

Conclusion

The LV dyssynchrony parameters measured at 60 min after stress did not significantly differ from those measured at rest in normal subjects, patients with stress-induced ischemia but normal LV function, and patients with LV dysfunction, in a 2-day Tc-99m MPI protocol. Phase analysis can be applied to post-stress Tc-99m gated SPECT MPI data to measure LV dyssynchrony, which is equivalent to that measured at rest.

References


Source of Support: This study was supported in part by the Public Health Support Program of Jiangsu Province, CHINA (ZX07200907) and by an NIH-funded research project (1R01HL094438-01A1, PI: Ji Chen, PhD). The terms of this arrangement have been reviewed and approved by Emory University in accordance with its conflict-of-interest practice. Conflict of Interest: None declared.

Author Help: Reference checking facility

The manuscript system (www.journalonweb.com) allows the authors to check and verify the accuracy and style of references. The tool checks the references with PubMed as per a predefined style. Authors are encouraged to use this facility, before submitting articles to the journal.

- The style as well as bibliographic elements should be 100% accurate, to help get the references verified from the system. Even a single spelling error or addition of issue number/month of publication will lead to an error when verifying the reference.
- Example of a correct style
  Only the references from journals indexed in PubMed will be checked.
  Enter each reference in new line, without a serial number.
  Add up to a maximum of 15 references at a time.
  If the reference is correct for its bibliographic elements and punctuations, it will be shown as CORRECT and a link to the correct article in PubMed will be given.
  If any of the bibliographic elements are missing, incorrect or extra (such as issue number), it will be shown as INCORRECT and link to possible articles in PubMed will be given.