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Phase analysis using gated myocardial perfusion single photon emission computed tomography imaging for evaluating cardiac dyssynchrony

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Short title: Defining cardiac dyssynchrony

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Electrocardiography (ECG)-gated myocardial perfusion single-photon emission computed tomography (SPECT) is one of the most frequently performed and established methods in patient care for the detection of myocardial ischemia, risk stratification, infarct size and viability [1-2]. The assessment of left ventricular (LV) myocardial mechanical dyssynchrony using gated SPECT has recently been introduced making it possible to assess myocardial perfusion and dyssynchrony simultaneously [3].

The heart is a muscular pump composed of cardiac myocytes which play an important role in LV contractile function. The normal myocardium contracts in a coordinated way so that most of the myocardial segments are nearly the same phase. The ischemic burden results in the inability of myocytes to generate sufficient tension. Consequently the dissipation and wasting of some energy are produced by normal segments. Cardiac dyssynchrony also occurs during periods of post-stress myocardial ischemia. LV regional discordance in contractility is considered to be a predominant mechanism for dyssynchrony in ischemia and fibrosis. LV dyssynchrony in patients with heart failure involves different regions of the LV mass to produce intraventricular dyssynchrony which is reported to be related to patient survival [4-5].

The unique feature of phase analysis using gated myocardial perfusion single photon emission computed tomography (GMPS) is its temporal ability to focus on the timing of myocardial contraction and its spatial distribution. The phase analysis technique is considered to have sufficient temporal resolution for measuring LV dyssynchrony [6]. Previous studies have shown that the histogram bandwidth and phase standard deviation (SD) show good correlation with LV dyssynchrony. Other studies have demonstrated that phase analysis using GMPS such as phase SD or bandwidth could detect ischemia-induced dyssynchrony [7-8].

There are other non-invasive imaging techniques to evaluate LV mechanical dyssynchrony, such as echocardiography [9], and magnetic resonance imaging. The advantages of the nuclear cardiology technique over echocardiography in measuring LV dyssynchrony are its automation, its high repeatability and reproducibility [10]. Even if the data are processed by different observers or in different institutions, obtained quantitative data should have the same result in the same location. Phase analysis by SPECT has widespread availability, simplicity and applicability to the past data.

In evaluating LV dyssynchrony, the phase analysis of GMPS could be

performed by different types of software, including quantitative gated SPECT (QGS) software of Cedars Sinai Medical Center [10], SyncTool of Emory University [3], and cardioGRAF which processes pFAST (perfusion and function assessment by means of gated SPECT) data files [11-13]. A phase distribution can be extracted from GMPS imaging, identifying the regional onset of mechanical contraction of the LV. GMPS studies are usually acquired using 8 to 16 frames per cardiac cycle. A higher temporal resolution may be better obtained by 16 frames per cardiac cycle. Figure 1 illustrates the phase analysis technique in patients with cardiac resynchronization therapy (CRT) using GMPS of 16 frames per cardiac cycle. Recent analysis using multiple Fourier harmonic functions in phase analysis focuses on diastolic phase [3].

Assessment of myocardial perfusion imaging alone underestimates the magnitude of left main coronary artery disease (CAD) due to balanced ischemia [14]. To overcome this drawback in perfusion imaging, a gated-SPECT parameter such as wall thickening, wall motion, and post-stress cardiac function was reported to be useful to identify balanced ischemia. The scintigraphic markers of lung uptake, diffuse slow washout or transient ischemic dilatation were also used to detect multi-vessel CAD. In this issue of the Journal, a clinical investigation by Hida et al. focuses on the evaluation of LV mechanical dyssynchrony of 30 min after exercise in patients with suspected or confirmed CAD [15]. In their study of 278 patients using GMPS of 8 frames per cardiac cycle, the combination of post-stress increases in phase SD, histogram bandwidth, transient ischemic dilatation and summed stress score were found to be better markers to identify patients with multi-vessel CAD. When the ischemic area was larger, the extent of LV mechanical dyssynchrony would be greater especially in patients with multi-vessel CAD [15]. Dyssynchrony analysis has a possibility to shed light on the nuclear evaluation on multi-vessel CAD. On the other hand, a recent study of 20 patients with reversible perfusion defects did not reveal that large reversible perfusion abnormalities altered the phase SD and histogram bandwidth, when it was taken one hour after the stress [7]. Therefore further investigation is needed to clarify the mechanism of ischemia affecting LV mechanical dyssynchrony in multi-center, randomized and prospective research.

In conclusion, phase analysis of LV dyssynchrony using GMPS is feasible and has the potential for assessing LV dyssynchrony and detecting CAD.

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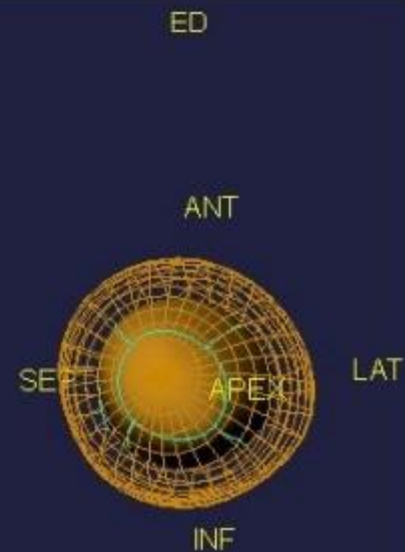
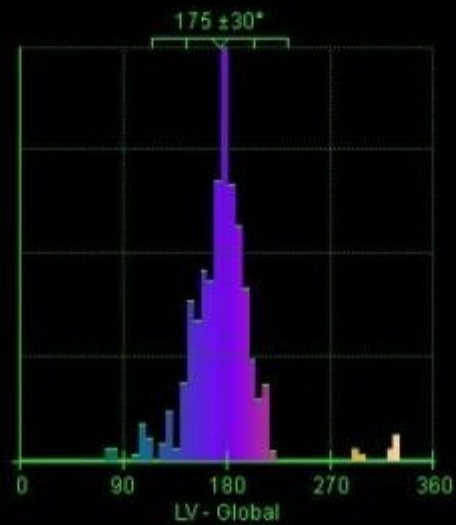
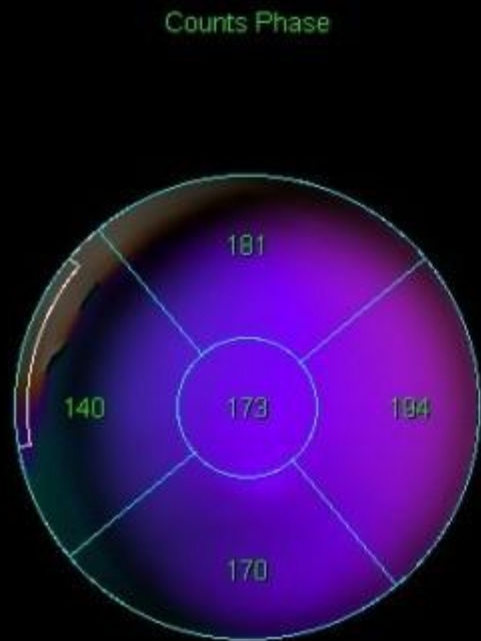
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Figure 1 Phase analysis of gated SPECT images.

A 62 year-old male with non-ischemic cardiomyopathy had New York Heart Association (NYHA) class III, depressed left ventricular ejection fraction (<30%), and prolonged QGS duration before cardiac resynchronization therapy (CRT) and improved to class I heart failure after CRT. Compared to the off-phase histogram (A), on-phase histogram (B) had a narrower and more peaked distribution. This patient had favorable acute response to CRT (phase standard deviation was reduced from 30° to 15°, and histogram bandwidth from 78° to 63°).

A  
OFF



B  
ON

