The Egyptian Journal of Critical Care Medicine (2016) 4, 105–112

The Egyptian College of Critical Care Physicians

The Egyptian Journal of Critical Care Medicine

http://ees.elsevier.com/ejccm
www.sciencedirect.com

ORIGINAL ARTICLE

Temporal changes of left ventricular synchronization parameters and outcomes of cardiac resynchronization therapy

Walid Ahmed [a,*], Wael Samy [b], Osama Tayeh [b], Noha Behairy [c], Alia Abd el Fattah [b]

[a] *Critical Care Medicine Department, Cairo University, 7110 Meerag city, Maadi, Cairo Postal code: 11435, Egypt*
[b] *Critical Care Medicine Department, Cairo University, Egypt*
[c] *Radiology Department, Cairo University, Egypt*

Received 2 January 2016; revised 21 March 2016; accepted 15 April 2016
Available online 26 April 2016

KEYWORDS

Cardiac resynchronization therapy;
Phase analysis gated SPECT;
Left ventricular dyssynchrony

Abstract *Background:* Left ventricular dyssynchrony plays an important role in predicting response to cardiac resynchronization therapy (CRT).

Methods: Thirty patients underwent CRT implantation. Assessment of left ventricular (LV) dyssynchrony was done through Gated SPECT LV phase analysis.

Results: Thirty patients received CRT (mean age 58.7 ± 9.0, 24 males). CRT implantation had a favorable prognosis on cardiac functions (LVEF preimplantation: 26.8 ± 4.7% versus 29.1 ± 6.4% post-implantation; $P = 0.002$). Reverse LV remodeling (⩾15%) was documented in 19 patients. Temporal changes in LV dyssynchrony parameters were correlated to LV reverse remodeling. Applying ROC curve for LV phase analysis showed that a cutoff value of 152° for histogram bandwidth had a sensitivity of 72.7% and specificity of 63.2% for predicting CRT non-response status. Also, a cutoff value of 54° for histogram standard deviation had a sensitivity of 81.8% and specificity of 63.2%.

Conclusion: Responders of CRT showed improved LV dyssynchrony profiles. Utilizing Gated SPECT LV analysis could provide predictors for CRT non-response. Reverse LV remodeling is associated with temporal improvements in LV dyssynchrony parameters.

* Corresponding author. Tel.: +20 1111632486.
E-mail address: walidkimowmmk@gmail.com (W. Ahmed).

Peer review under responsibility of The Egyptian College of Critical Care Physicians.

ELSEVIER Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.ejccm.2016.04.001
2090-7303

1. Background

Several studies, e.g. MUSTIC, MIRACLE, COMPANION and CARE-HF studies [1–4] have demonstrated benefits of cardiac resynchronization therapy in patients with end-stage heart failure (HF), provided by multisite pacing of right and left ventricles and improving intraventricular and interventricular dyssynchrony.

Accordingly, the American College of Cardiology/American Heart Association (ACCF/AHA) guidelines have incorporated CRT implantation in managing drug-refractory HF patients with prolonged QRS duration [5]. However, applying conventional criteria, 20–40% of patients fail to respond to CRT [6–11]. It was suggested that electrical dyssynchrony represented by prolonged QRS intervals is not necessarily related to mechanical dyssynchrony, which may explain why 2040% of patients who receive CRT do not show an acceptable response [12–14]. For optimal understanding of CRT response, additional information regarding mechanical LV dyssynchrony is probably needed. Several attempts have questioned mechanical LV dyssynchrony and its impact on CRT [15–19], using different modalities e.g. tissue Doppler imaging (TDI), Gated SPECT LV phase analysis, cardiac magnetic resonance (CMR) [18,22,19,23].

Gated SPECT LV phase analysis has been introduced in 2005 to evaluate LV dyssynchronization, which would also allow for the simultaneous assessment of LV perfusion, function, and mechanical dyssynchrony [18].

In our cardiac imaging lab, we utilized this technique to examine temporal changes in LV dyssynchrony parameters across the process of CRT implantation and to explore the role of LV dyssynchrony upon CRT outcome.

2. Methods

2.1. Patient population

Thirty patients participated in this study. Patients were eligible for CRT implantation according to ACCF/AHA guidelines for managing heart failure [5]. All patients had LVEF $\leqslant$ 35%, QRS prolongation > 120 m sec, NYHA III/IV. They were maintained on guidelines directed medical therapy (GDMT) [5]. Patients with ischemic cardiomyopathy were revised for revascularization with a period of 3–6 months of follow-up. Patients who remained symptomatic i.e. NYHA III/IV, were deemed candidates for CRT implantation. All patients consented to written consent forms for participation.

2.2. Exclusion criteria

Patients with recent myocardial infarction of less than 3 months duration or dysrhythmias that could result into gating artifacts e.g. atrial fibrillation and frequents premature complexes.

2.3. Echocardiographic examination

Each patient was examined using Phillips ATL-HDI 5000 colored echocardiograph machine, with a 2.5–3 MHz transducer. Two-dimensional (2-D) and M-mode echocardiography was performed to document volumetric LV measurements. Left ventricle contractility was assessed using Simpson's method.

2.4. Rest myocardial perfusion imaging (Gated SPECT)

Patients were intravenously injected with 20–25 mCi Tc-99 m SestaMIBI. Acquisition of SPECT images was performed within 1 h of the injection of the Tc-99 m SestaMIBI using dual head Siemens gamma camera (Symbia E) utilizing Cedars-Sinai software 1994–2009, (8 frames per cycle) [20]. Analysis of Gated SPECT images was performed using Syngo MI VA60A workstation (QGS, QPS and phase analysis).

Images were gated to the R-wave of the ECG, and image acquisition was interrupted for one beat if the R–R interval varied by 15% of the preceding R–R interval. Thirty-two views with 20 s each, over 180° arc, with the patient in the supine position head in. Then, processing and filtering of the SPECT images were done using back- projection technique to get the trans-axial image, then short axis, vertical long axis, and horizontal long axis slices. Global functions quantified from gated perfusion SPECT images included left ventricular ejection fraction (LVEF), end-diastolic volume (EDV) and end-systolic volume (ESV).

The seventeen segment model was used for quantitative analysis of radioactive tracer uptake. Segments were scored visually according to tracer uptake defect percentage into five categories; ((0) No tracer uptake defect; (1) 0–25% tracer uptake defect; (2) 25–50% tracer uptake defect; (3) 50–75% tracer uptake defect; (4) 75–100% tracer uptake defect). The highest attainable score is 68. Scar burden was calculated by summing all segment scores; summed rest score (SRS) and dividing SRS by 68. All images were interpreted by a consensus of 2 nuclear cardiology readers and controversial issues were judged by a senior nuclear cardiologist.

2.5. Phase analysis of gated SPECT

Throughout the cardiac cycle, amplitude and phase of systolic wall thickening were extracted from the regional LV count changes throughout the cardiac cycle. Imaging was done with ECG-gated SPECT by use of 8 frames per cardiac cycle. The analysis used first-harmonic fast Fourier transform to approximate the wall thickening data to calculate a phase angle for each region, with 0° corresponding to the peak of the R-wave and one R–R interval corresponding to 360° [18]. Histograms of the calculated phase arrays were obtained and the following quantitative indices were calculated from each phase array: *Histogram bandwidth (H. BW)*: includes 95% of the elements of the phase distribution in degrees, *Histogram Standard Deviation (H. SD)*: is the SD of the phase distribution in degrees.

2.6. Pacemaker implantation

CRT-P/D devices were implanted in the left infraclavicular region. The left ventricular lead was inserted via the coronary sinus.

After 6 months, all patients were subjected to transthoracic echocardiography (TTE) and Gated SPECT phase analysis assessment.