Effect of cardiac resynchronization therapy on septal perfusion and septal thickening: Association with left ventricular function, reverse remodelling and dyssynchrony

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Background. **We evaluated the effect of cardiac resynchronization therapy (CRT) on septal perfusion and thickening at 6 months post implantation assessed on Tc99m-MIBI Gated myocardial perfusion SPECT (GMPS).We also studied the association of change in septal perfusion and thickening with primary outcome defined as at least one [improvement in ≥1NYHA class, left ventricular ejection fraction (LVEF) by ≥ 5%, reduction of end-systolic volume (ESV) by ≥ 15%, and improvement ≥ 5 points in Minnesota living with heart failure questionnaire (MLHFQ)].**

Method. **One hundred and five patients underwent clinical and GMPS evaluation before and at 6 months post CRT.**

Result. **Post CRT there was significant improvement in mean normalized septal perfusion uptake and in septal thickening (*P* value = 0.001, both). There was no significant relation between**

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improvement in septal perfusion and primary outcome. However, improvement in septal thickening was statistically significant with favorable primary outcome (P = 0.001).There was no significant correlation between improvement of septal perfusion and improvement in LVEF, reduction in End diastolic volume (EDV), ESV, and Left ventricular Dyssynchrony (LVD). But, there was significant correlation between improvement of septal thickening and these parameters.

Conclusion. **Improvement in septal thickening was associated with reverse remodeling, improvement in LVEF, and reduction of LVD. (J Nucl Cardiol 2020;27:1274–84.)**

Key Words: Heart failure • SPECT • dyssynchrony

Abbreviations	
CRT	Cardiac resynchronization therapy
HF	Heart failure
LBBB	Left bundle branch block
LVEF	Left ventricular ejection fraction
GMPS	Gated myocardial perfusion SPECT
LVD	Left ventricular dyssynchrony
MLHFQ	Minnesota living with heart failure questionnaire
PSD	Phase standard deviation
RBBB	Right bundle branch block
OSEM	Ordered subset expectation maximization

See related editorial, pp. 1285–1287

INTRODUCTION

Cardiac resynchronization therapy (CRT) is now an established treatment in patients with refractory heart failure (HF) with widened QRS associated with left bundle branch block (LBBB) and impaired left ventricular (LV) function. Several trials have demonstrated the benefits of CRT in these patients in terms of improved quality of life, functional status, exercise capacity, morbidity, and mortality.[1–5] Also, various parameters like left ventricular ejection fraction (LVEF) and ventricular volumes have been evaluated as end points post CRT.[2,3,6,7] However, there is scanty information on the effect of CRT on septal perfusion and septal thickening on Gated myocardial perfusion SPECT (GMPS). In this study, we have prospectively evaluated patients submitted to CRT on Tc99m-MIBI GMPS and assessed the change in septal perfusion and septal thickening at 6 months after CRT. We also studied the association of change in septal perfusion and thickening with LVEF, LV volumes and LV dyssynchrony (LVD) post CRT. The working hypothesis of this post-hoc analysis is that LBBB patients who improve post treatment are associated with an improvement in their septal relative perfusion and thickening on SPECT thus promoting the homogeneity of their LV regional perfusion and thickening.

METHOD

This is a POST-HOC analysis of a prospective, non-randomized, multinational, multicenter study. This study is a part of International Atomic Energy Agency (IAEA) funded trial ''Value of intraventricular synchronism assessment by gated-SPECT myocardial perfusion imaging in the management of HF patients submitted to CRT'' (IAEA VISION-CRT). The trial involved ten centers from eight countries (Brazil, Chile, Colombia, Cuba, India, Mexico, Pakistan, and Spain). All patients underwent clinical evaluation and Tc99m-MIBI GMPS prior to CRT (baseline) and 6-month post CRT (follow-up).

Each center recruited patients and collected the demographic, clinical, and GMPS data at baseline and at follow-up. The baseline and follow-up clinical data for each patient included NYHA class and Minnesota living with heart failure questionnaire (MLHFQ)®. The demographic and clinical data were submitted by each center to the core clinical management center in IAEA headquarters, Vienna. The baseline and follow-up GMPS data were analyzed by the imaging core lab at Emory University, Atlanta, (USA) blinded to clinical information. Statistical analysis of the acquired data was carried out at the All India Institute of Medical Sciences, New Delhi (India).

The main objective of the study was to evaluate the effect of CRT on septal perfusion and septal thickening at 6 months post implantation. The secondary objective was to determine whether the change in septal perfusion and/or septal thickening affected the primary outcome post CRT. The outcome was defined as at least one of the following 4 points at 6 months: improvement by at least 1 NYHA class, improvement of LVEF by $\geq$ 5%, reduction of end-systolic volume (ESV) by $\geq$ 15% as marker of reverse remodeling, and improvement of at least 5 points in MLHFQ. We also evaluated correlation between change in septal perfusion and thickening with LVEF, ESV, end diastolic volume (EDV), and Phase standard deviation (PSD) to quantify LVD.

Additionally, we also evaluated the effect of CRT on perfusion and thickening of anterior, inferior and lateral wall and whether the change in perfusion and thickening of these walls is related with primary outcome post CRT.

The study was approved by the ethical committees of each participant country and complies with the Declaration of Helsinki. Written informed consent was obtained from all participants and patient anonymity was maintained during data analysis.

PATIENT POPULATION

One hundred and five patients were included in this study. All patients underwent CRT as per the standard selection criteria which included NYHA functional class II, III or ambulatory IV HF for at least 3 months before CRT, despite receiving optimal tolerated medical therapy according to current guidelines; LVEF $\leq$ 35%, measured according to the usual procedure at the participating center; intrinsic QRS duration of $\geq$ 120 ms, with morphology of LBBB.

Patients with arrhythmias that prevented the gated acquisition; major co-existing illness affecting survival less than 1 year; right bundle branch block (RBBB); pregnancy or breast-feeding; acute coronary syndromes, coronary artery bypass grafting, or percutaneous coronary intervention and structural heart diseases were excluded. In addition for this study, patients with history of coronary artery disease (CAD) and previous myocardial infarction(MI) were also excluded.

GATED MYOCARDIAL PERFUSION SPECT

Acquisition

All the patients underwent resting GMPS within four weeks before CRT and at 6 ± 1 month after implantation. The study was performed after intravenous administration of 10 to 20 mCi (370-740 MBq) of Technetium99m-Sestamibi (Tc99m-MIBI). SPECT images were acquired on a dual head Gamma Camera with patient in supine position and arms raised straight above the head. A symmetric 20% energy window was kept, with center at 140 keV, using Low-energy high-resolution parallel hole collimators and images acquired in 64 × 64 matrix. Acquisition parameters included a 180° rotation (90° for each detector head of dual head camera) from right anterior oblique to left posterior oblique view in L-mode around a non-circular, body contoured orbit, in step-and-shoot acquisition mode. Imaging was performed with electrocardiographic synchronization in auto tracking mode. ECG-gated SPECT was performed with a frame rate of 8 frames per cardiac cycle using 100% beat acceptance. No attenuation correction or scatter correction algorithms were used.

Image Processing

All images were reconstructed using Ordered subset Expectation Maximization (OSEM) with 3 iterations and 10 subsets and filtered by a Butterworth filter (power 10, and a cut-off frequency of 0.4 cycles/mm).The reoriented slices were processed at the core imaging lab at Emory University, Atlanta, (USA). Both the baseline and the follow-up studies were processed using Emory cardiac Toolbox (ECTb Version 4) to obtain quantitative perfusion and gated parameters. For the assessment of perfusion parameters, the images were analyzed using 17 segment model and normalized uptake was registered for each of the segment. Segments 2, 3, 8, 9, 14 were assigned to septum, 1, 7, 13 to anterior wall, 4, 10, 15 to inferior wall and 5, 6, 11, 12, 16 to lateral wall. Segment 17, representing apex was not considered. The normalized uptake of all the segments assigned to each wall was added and the mean normalized uptake value (expressed as percentage) was calculated for the septal, lateral, anterior and inferior wall. Also, the Fast Fourier transform method was used to automatically derive septal thickening that was recorded for each study.[8,9] The other gated parameters analyzed on GMPS were PSD, LVEF, EDV, and ESV. All the studies were acquired with patient in sinus rhythm.

Statistical Analysis

Statistical analysis was carried out using Stata 12.0 (StataCorp LP, College Station, Texas, USA). Data were presented as number, percentage (%), and mean ± SD/median (min-max) as appropriate. Changes in clinical and GMPS parameters before and after CRT were compared using paired *t*-test or Wilcoxon signed rank test (when the variable was not normally distributed). Changes in septal uptake and septal thickening with primary outcome were compared using unpaired *t*-test and Wilcoxon rank sum test respectively. Correlation between improvement in septal thickness and changes in LVEF, LVD, ESV, and EDV were calculated using Spearman rank correlation coefficient. The difference in median change in wall thickening and perfusion between improved and not improved patients of NYHA, LVEF, ESV, and MLHFQ was compared using Wilcoxon rank sum test. A P value < 0.05 was considered statistically significant.

RESULTS

One hundred and five patients were found eligible for this study based on the inclusion and exclusion criteria. All the patients underwent CRT as per the standard selection criteria. The baseline QRS duration was 156.8 ± 24.2 ms (mean ± SD), LVEF was 24.6 ± 6.2% (mean ± SD) (measured according to the usual procedure at the participating center for selection of patients for CRT). All the patients underwent CRT successfully and had no post implantation complications. Demographic and baseline parameters of patients are given in Table 1.

All the patients had follow-up clinical evaluation and GMPS at 6 months post CRT. Compared to baseline, the 6-month post CRT follow-up showed statistically significant improvement in all the clinical and GMPS parameters. Post CRT, there was improvement in NYHA class and MLHFQ score, increase in LVEF, decrease in both EDV and ESV, and decrease in LVD as reflected by decrease in PSD values. A comparative assessment of clinical and GMPS parameters at baseline and follow-up is given in Table 2.

Septal Perfusion and Thickening on Gated MPS

We found significant improvement in septal perfusion and septal thickening at 6 months post CRT. On the baseline study the mean normalized uptake of septum was 52.9 ± 7.7 % which increased to 61.9 ± 8.3% (P value = 0.001) post CRT. There was improvement in the septal thickening post CRT compared to the baseline. Septal thickening improved from 10.5% to 19.2% (P value = 0.001). A significant correlation was noted between improvement in perfusion of the septal wall and its thickening ($r = 0.22$, $P = 0.025$) (Figure 1).

Improvement of Septal Perfusion and Thickening with Primary Outcome

We evaluated the relation between improvement of septal perfusion and thickening with primary outcome. The primary outcome was defined as at least one of the following 4 points at 6 months: improvement by at least 1 NYHA class, improvement of LVEF by $\geq 5\%$, reduction of end-systolic volume (ESV) by $\geq 15\%$, and improvement of at least 5 points in MLHFQ.

Septal perfusion improved in patients with favorable primary outcome compared to patients who did not; however, this was not statistically significant (8.8% vs 5.3%, $P = 0.148$) (Figure 2). Also, there was no relation between change in perfusion with any of the components of primary outcome [NYHA, (8.4% vs 8.8%, $P = 0.946$), LVEF (9.2% vs 7.2%, $P = 0.420$), MLHFQ (8.8% vs 8.8%, $P = 0.812$), and ESV (9.2% vs 7.4%, $P = 0.677$)].

Septal thickening improved in patients with favorable outcome and was statistically significant compared to patients who did not [9.8% vs 0.5%, $P = 0.001$] (Figure 3). Although, the improvement in septal thickening was not significant with improvement in NYHA [9.6% vs 6.5 %, $P = 0.214$] and MLHFQ [11.8% vs 5.7%, $P = 0.068$], it was statistically significant in

Table 1. Demographic profile and baseline clinical and GMPS parameters

Baseline variables	*n*	
Age (years)	104	59.0 ± 10.9 (23.8–81.0)
Sex	105	
Male		58 (55.2)
Female		47 (44.8)
NYHA class	105	
I		0 (0.0)
II		36 (34.29)
III		59 (56.19)
IV		10 (9.52)
LVEF (%)	104	24.6 ± 6.2 (9–35)
QRS duration (ms)	103	156.8 ± 24.2 (120–240)
MLHFQscore	78	47.1 ± 21.0 (6–92)
LVEF % (GMPS)	105	27.4 ± 10.3 (10–58)
PSD (degree)	105	52.6 ± 19.9 (15.6–100.7)
ESV (mL)	105	188.8 ± 96.9 (37–476)
EDV (mL)	105	249.5 ± 105.5 (68–550)

Data presented as mean ± SD (min–max) and number (%)
GMPS, Gated myocardial perfusion SPECT; NYHA, New York heart Association; LVEF, left ventricular ejection fraction; MLHFQ, Minnesota living with heart failure questionnaire score; ESV, end-systolic volume; EDV, end diastolic volume; ml, milliliters; ms, milliseconds

Table 2. Comparative assessment of baseline and post CRT clinical and GMPS parameters

Outcomes	Before CRT	After CRT	*P* value
NYHA class			0.001
I	0	40 (38.8)	
II	36 (35.0)	46 (44.7)	
III	57 (55.3)	16 (15.5)	
IV	10 (9.7)	1 (1.0)	
LVEF (%)	26 (20-35)	33 (22-42)	0.001
ESV (mL)	167.5 (124-234.5)	118 (74-229.5)	0.001
EDV (mL)	229 (167-308)	183 (125-280)	0.001
PSD (degree)	53.7 (37-68.1)	39 (19.6-56.6)	0.001
MLHFQ	46 (30-61)	22 (9-40.5)	0.001

Data presented as number (%) and median (IQR)

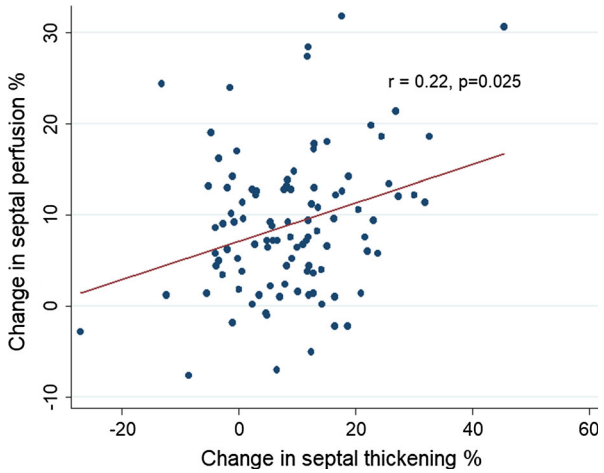

Figure 1. Scatter plot showing correlation between change in septal perfusion vs septal thickening.

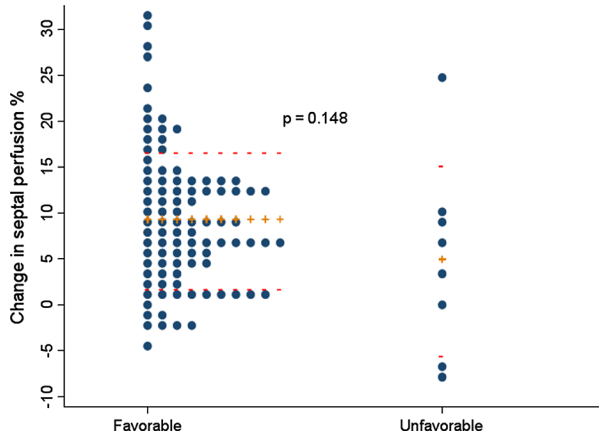

Figure 2. Dot plot showing change in septal perfusion vs outcome (+ sign indicates mean and lower and upper dotted lines indicate mean − SD and mean + SD, respectively).

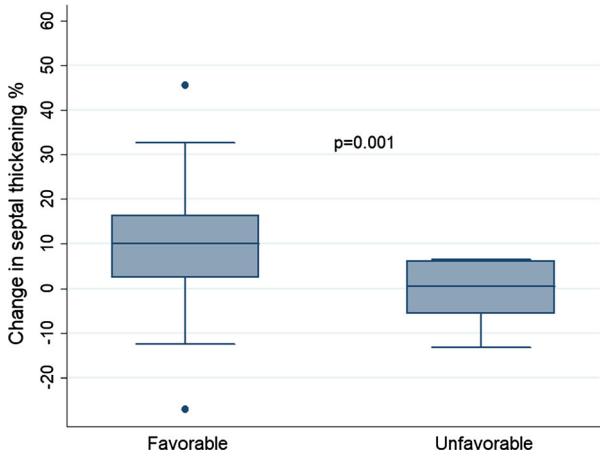

Figure 3. Box plot showing change in septal thickening vs outcome.

patients with improvement in LVEF [12.5% vs 3.5%, *P* 0.001] and ESV [11.9 vs 4.8%, *P* = 0.001] (Table 3).

There was no significant correlation between improvement of septal perfusion and improvement in LVEF and reduction in EDV, ESV, and LVD. However, there was significant correlation between improvement of septal thickening and increase in LVEF ($r = 0.650$, $P = <0.001$), reduction of ESV ($r = 0.447$, $P<0.001$), EDV ($r = 0.319$, $P = 0.001$), and LVD ($r = 0.475$, $P = < 0.001$) (Figure 4).

Change in Perfusion and Thickening in Rest of the Myocardium

Anterior, inferior, and lateral wall perfusion and thickening at baseline and post CRT was also evaluated.

Table 3. Relationship between change in wall thickening (expressed in %) and final outcomes

Outcomes	Septum	Anterior	Inferior	Lateral
NYHA				
Improved	9.6 (− 27.1 to 45.5)	5.4 (18.8 to 28.2)	3.8 (− 28.7 to 27.1)	− 3.7 (− 3.9 to 16.4)
Not improved	6.5 (− 13.2 to 23.1)	9.6 (− 31.5 to 17.4)	2.9 (− 10.3 to 14.7)	− 6.3 (− 22.7 to 8.0)
P value	0.214	0.158	0.382	0.085
LVEF				
Improved	12.5 (− 12.5 to 45.5)	9.6 (− 11.6 to 28.3)	7.2 (− 12.7 to 42.3)	− 2.0 (− 37.4 to 17.9)
Not improved	3.5 (− 27.1 to 24.5)	3.6 (− 31.5 to 27.4)	− 1.6(− 28.7 to 23.6)	− 6.7 (− 39.2 to 8.0)
P value	0.001	< 0.001	< 0.001	0.003
ESV				
Improved	11.9 (− 12.5 to 45.5)	7.3 (− 11.6 to 28.3)	6.9 (− 13.8 to 42.3)	− 2.4 (− 37.4 to 17.9)
Not improved	4.8 (− 27.1 to 24.5)	4.3 (− 31.5 to 27.4)	− 1.2 (− 28.7 to 23.6)	− 7.8 (− 39.2 to 11.2)
P value	0.001	0.007	0.001	0.002
MLHFQ				
Improved	11.8 (− 27.1 to 45.5)	7.2 (− 18.8 to 28.3)	4.5 (− 28.7 to 27.1)	− 3.9 (− 39.2 to 16.4)
Not improved	5.7 (− 13.2 to 32.7)	9.7 (− 11.6 to 24.6)	3.3 (− 6.9 to 14.3)	− 1.9 (− 18.7 to 6.5)
P value	0.068	0.753	0.883	0.748
Outcome				
Improved	9.8 (− 27.1 to 4.55)	6.7 (− 18.8 to 28.3)	4.0 (− 28.7 to 42.3)	− 3.7 (− 39.2 to 17.9)
Not improved	0.5 (− 13.2 to 6.6)	− 2.4 (− 31.5 to 28.3)	− 1.8 (− 10.3 to 8.4)	− 12.7 (− 21.5 to 3.7)
P value	0.001	0.051	0.077	0.016

Data presented as median (min-max)

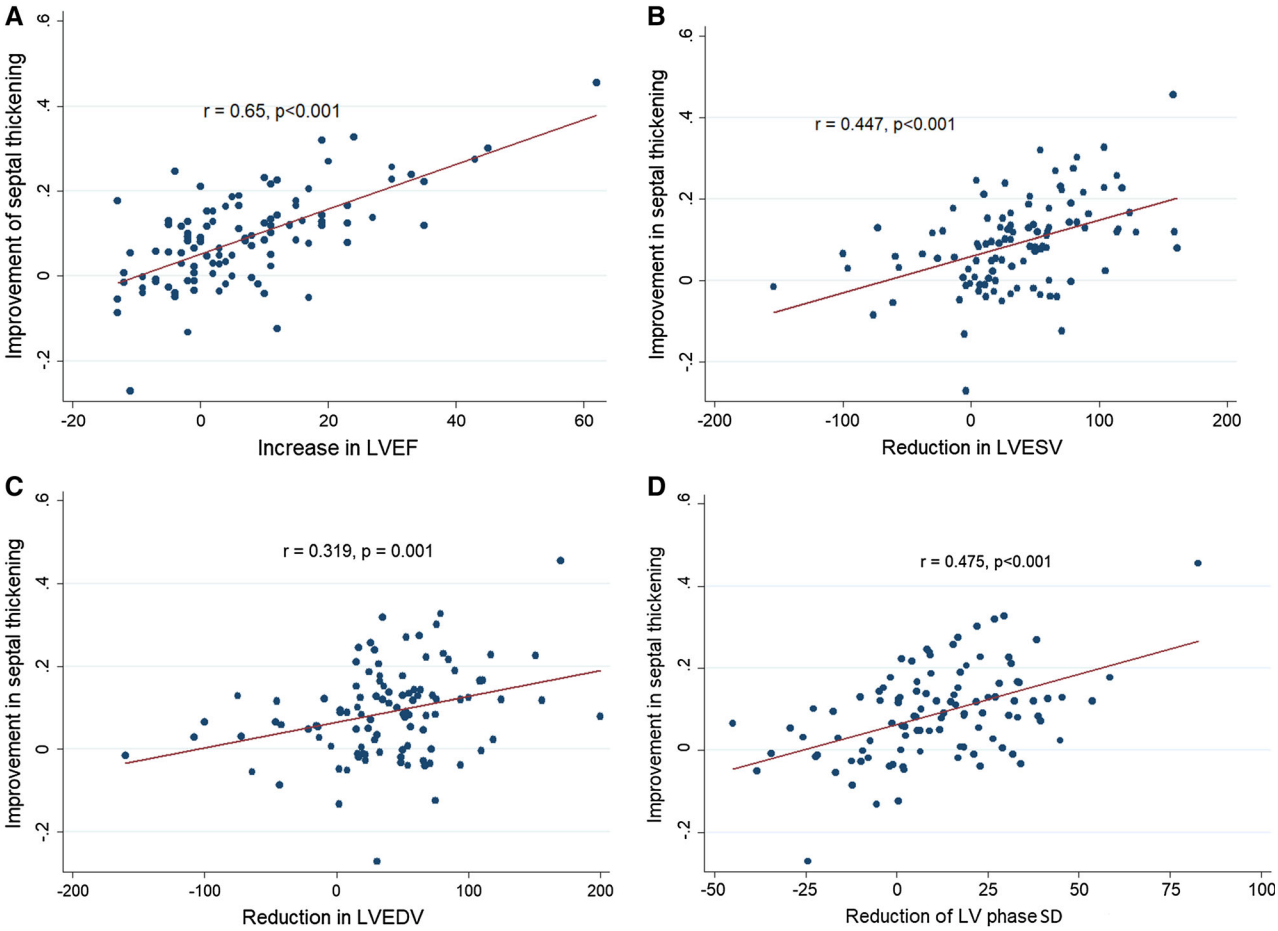

Figure 4. **A** Scatter plot showing correlation between improvement in septal thickening vs increase in LVEF. **B** Scatter plot showing correlation between improvement in septal thickening vs decrease in ESV. **C** Scatter plot showing correlation between improvement in septal thickening vs decrease in EDV. **D** Scatter plot showing correlation between improvement in septal thickening vs decrease in PSD.

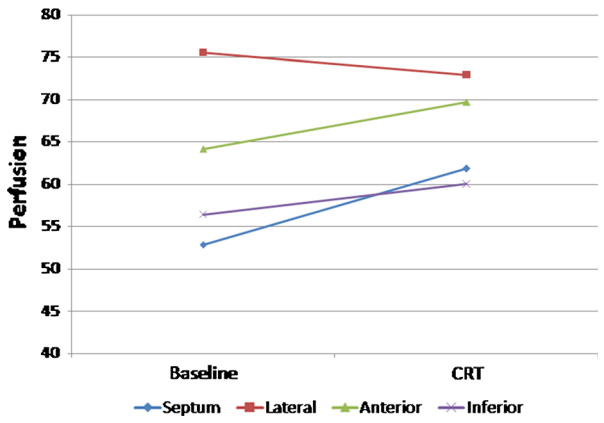

Figure 5. Graph showing change in perfusion of septal, anterior, inferior, and lateral wall post CRT.

There was improvement in the perfusion of the anterior wall (64.2 ± 8.1% vs 69.8 ± 10.1%, *P* value = 0.001) and inferior wall (56.5 ± 10.1% vs 60.1 ± 11.5%, *P* value = 0.001), though it was less as compared to the septal wall. However, there was decrease in the uptake of the lateral wall from 75.6 ± 7.3% to 73.0 ± 9.9% post CRT (*P* value = 0.001).When changes in thickening was assessed, a statistically significant improvement was seen in the anterior wall (12.0% to 16.2%, *P* value = 0.001) and inferior wall (15.1% to 19.2%, *P* value = 0.001) thickening but it is relatively less compared to the improvement in the septal wall thickening. In contrast, there was a decrease in lateral wall thickening from 23.0% to 17.9% (*P* value <0.001) post CRT (Figures 5 and 6)

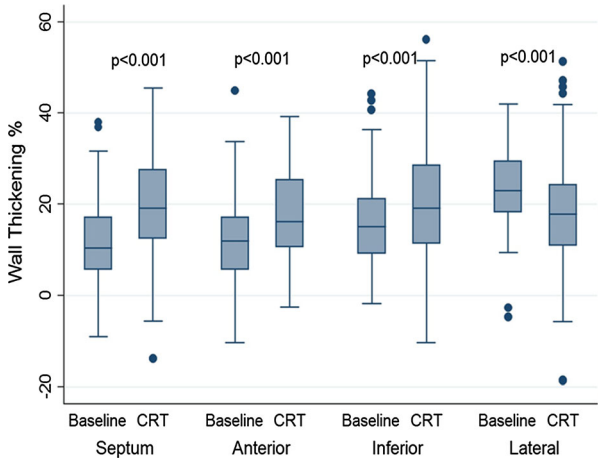

Figure 6. Regional LV % thickening at baseline and 6 months after CRT. Note increase in % thickening post CRT in the septal, anterior and inferior wall but a reduction in the lateral wall homogenizing the thickening in all walls in the LV.

A statistically significant correlation was noted between improvement in relative perfusion of the anterior and inferior wall with improvement in its thickening. ($r = 0.35$, $P = 0.001$ and $r = 0.226$, $P = 0.021$, respectively). Although there was correlation between decrease in lateral wall perfusion and decrease in its thickening, it was not statistically significant ($r = 0.172$, $P = 0.081$).

Change in Perfusion and Thickening of Anterior, Inferior, and Lateral Wall with Primary Outcome

As noted with the improvement in septal perfusion, improvement in the anterior wall and inferior wall and decrease in perfusion of lateral wall post CRT was not related to the primary outcome ($P = 0.069$, 0.089 and 0.101, respectively).

With respect to the change in wall thickening, decrease in lateral wall post CRT was related to the primary outcome ($P = 0.016$). On analyzing individual components of primary outcome with the improvement in anterior and inferior wall and decrease in lateral wall, no relation was noted with NYHA and MLHFQ. But change in thickening of these walls post CRT was statistically significant in patients with improvement in LVEF and ESV (Table 3).

Figure 7 illustrates the results reported here in a patient with a positive response and reverse remodeling post CRT.

DISCUSSION

There has been a significant research on myocardial perfusion in patients with LBBB, particularly because these patients show improvement with CRT.[10] However, there is limited literature on the effect of CRT on septal perfusion and thickening on GMPS.

We analyzed 105 patients who underwent CRT and all the patients underwent clinical evaluation and GMPS at baseline and at 6 months post implantation. The main objective of our study was to assess whether there is any change in the septal perfusion and thickening post CRT and its relation with primary outcome. We also evaluated the effect of CRT on the perfusion and thickening of the anterior, inferior, and lateral wall and its relation with primary outcome.

In our study, at baseline, the perfusion and thickening of septal wall was lowest and that of the lateral wall highest. The relative hypoperfusion of septum compared to the lateral wall in patients with LBBB has been documented in previous studies. Our findings are consistent with earlier study on canine model which suggested that the reduction in myocardial blood flow to the septum may be a result of reduced septal workload and conversely, increase in flow to the lateral wall due to increased workload.[11] However, different mechanisms for septal hypoperfusion have also been described in relation to SPECT. Claridge et al. had suggested that in LBBB there is reduced septal systolic wall thickening and hence with SPECT, the septal hypoperfusion could be due to partial-volume effect mimicking hypoperfused myocardium.[10] Nowak et al. demonstrated this aspect by comparing SPECT and PET perfusion of LBBB patients. They found that on PET the myocardial blood flow was homogenous in the LV compared with the heterogenous perfusion found on SPECT which showed septal hypoperfusion.[12] Higgins et al. suggested that a delay in LV septum contraction in LBBB, results in a postsystolic motion, potentially impairing diastolic coronary perfusion via diastolic compression of septal perforators.[13]

Post CRT, septal wall showed significant improvement in perfusion and thickening. This was relatively higher compared to the anterior and inferior walls, whereas it decreased in the lateral wall. Although, few SPECT studies have evaluated the effect of CRT on the myocardial perfusion, no studies in the past have determined its effect on wall thickening. Ogano et al in their study on 26 non-ischemic cardiomyopathy patients calculated septal perfusion index (perfusion counts of the septal ROI divided by the lateral wall ROI ratio) and observed significant improvement in septal

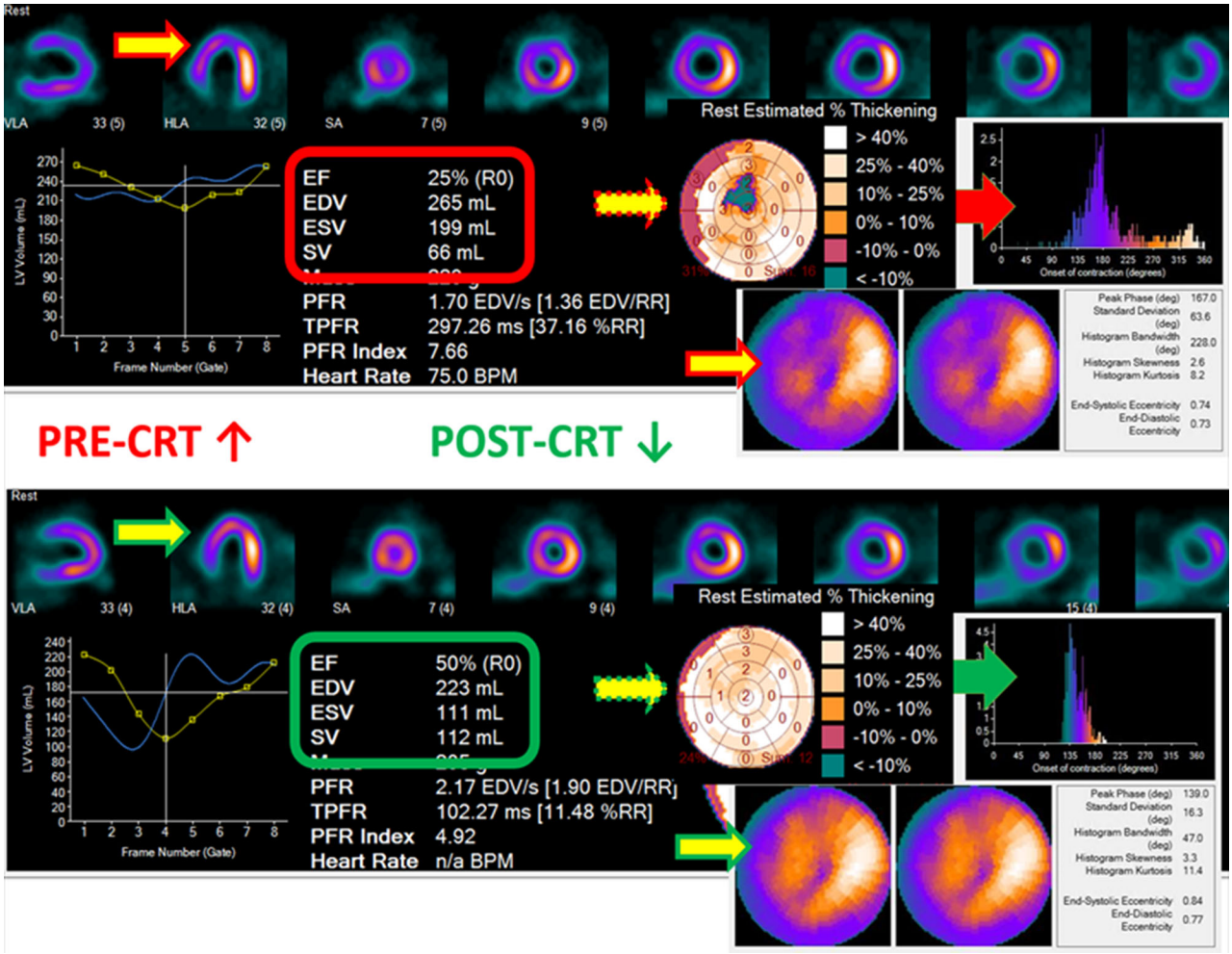

Figure 7. Example of pertinent measurements pre and post CRT in a patient that responded to therapy. Pre-CRT results are shown in the top panel. Post CRT results are shown in the bottom panel. Post CRT there was significant improvement in LVEF from 25% to 50% while both the ESV and EDV reduced demonstrating reverse remodeling in 6 months. Comparing the phase histograms before (solid red arrow) to 6 months after CRT (solid green arrow) shows clear improvement in dyssynchrony. Comparing septal counts in both the tomographic slices and relative perfusion polar maps before CRT (yellow arrow with solid red border) to 6 months after CRT (yellow arrow with solid green borders) shows clear improvement in relative perfusion. Finally comparing polar of LV % thickening before (yellow arrow with dotted red border) to after CRT (dotted green border) shows increase in thickening homogeneity after therapy.

perfusion in 73% patients at 6 months post CRT.[14] The perfusion of anterior and inferior wall was not evaluated in this study. Brandão et al. studied a group of 30 dilated cardiomyopathy (DCM) patients before and 3 months after CRT. The findings of this study were similar to our study and showed improvement in perfusion of anterior wall, septum and inferior wall with decrease in perfusion of the anterolateral wall.[15]

The perfusion and thickening of septal wall were lowest and that of the lateral wall highest at the baseline. Post CRT septal wall showed highest improvement and there was decrease in perfusion and thickening of lateral wall. Similar improvement was also noted in anterior and inferior wall but it was relatively less than the septal wall. The results of our study suggest that CRT results in homogenization of the perfusion and thickening in the entire left ventricular myocardium. However, the findings of the available PET studies are contradictory. Some PET based studies have suggested that CRT has no influence on the LV distribution pattern of myocardial blood flow or change in the septum.[16–18] On contrary, our findings are similar to some of the PET

studies. Lindner et al. in their study demonstrated a normalization of regional perfusion; flow in the septal and anterior walls increased and decreased in the lateral wall, leading to smaller variability among the myocardial walls.[19] Vernooy et al. quantified myocardial perfusion in a canine model that had undergone LBBB ablation and demonstrated a reduction in septal wall and increase in the lateral wall myocardial blood flow from baseline. This shift in blood flow was reversed following the application of CRT.[20] Although these results are based on PET studies and have measured myocardial blood flow to suggest that post CRT the regional differences between myocardial flow parameters are balanced, the finding of our SPECT study have demonstrated achievement of relative balance in regional perfusion and thickening post CRT. Perfusion differences between SPECT and PET may be partially due to differences in spatial resolution and thus differences in the partial-volume effect.

We also evaluated the relation between improvement in septal perfusion and thickening with the primary outcome post CRT. We found no significant relation between improvement in septal perfusion with favorable primary outcome or with any of the parameters of primary outcome (NYHA, MLHFQ, LVEF, and ESV). Likewise, change in perfusion of the rest of the walls post CRT was also not related to the composite primary outcome.

However, there was significant relation between improvement in septal thickening with favorable primary outcome and two of its parameters (LVEF and ESV). A similar trend was also noted with change in thickening of anterior, inferior and lateral wall. In addition to the improvement in septal thickening, improvement in anterior and inferior wall and decrease in lateral wall thickening was statistically significant in patients with improvement in LVEF and ESV.

We then correlated the improvement in septal perfusion and thickening with improvement in LVEF, ESV, EDV, and LVD. There was no correlation between septal perfusion and these parameters. But, we found significant correlation between improvement of septal thickening with improvement in LVEF and reduction in PSD reflecting decrease in LVD post CRT. Also, there was positive correlation between reduction of ESV and EDV and improvement in septal thickening indicating that septal thickening is associated with reverse remodeling.

In our study, we found no relation between change in septal perfusion and perfusion of rest of the walls with LVEF and ESV. Our findings are contrary to Ogano et al. studies which found that the septal perfusion index positively correlated with ESV and LVEF measured on echocardiography post CRT.[14,21] In another study, Brandão et al. evaluated the changes in left ventricular uptake, dyssynchrony, and function on Tc-99m MIBI in DCM patients before and 3 months after CRT. Patients were divided into two groups based on the improvement in LVEF (increase of ≥ 5 points).Regional 99mTc-MIBI myocardial uptake increased significantly in the anterior, anteroseptal, and inferoseptal LV walls in patients who showed improvement in LVEF. However, the myocardial uptake also increased in the anteroseptal, inferoseptal, and inferior LV walls and showed a decrease in the anterolateral wall in patients who showed no improvement in LVEF. They concluded that independent of LVEF increase, LV remodeling and dyssynchrony improvement, CRT promoted significant increase in anteroseptal and inferoseptal myocardial wall 99mTc-MIBI uptake, and improved HF functional class in the majority of the patients.[14]

In our study, post CRT change in perfusion and thickening of the septum and rest of the walls did not show statistically significant association with the clinical outcomes most important to patients (NYHA class and MLHFQ). But improvement in septal thickening was related to the primary outcome and correlated with improvement in LVEF, reverse remodeling, and decrease in LV dyssynchrony.

NEW KNOWLEDGE GAINED

This is the first myocardial Tc99m-MIBI GMPS study that has assessed the effect of CRT on both the septal perfusion and wall thickening and the association of change in perfusion and thickening on clinical and functional parameters.

CONCLUSION

The perfusion and thickening of septal wall were lowest and that of the lateral wall highest at the baseline. Post CRT septal wall showed highest improvement and there was decrease in perfusion and thickening of lateral wall. Similar improvement was also noted in anterior and inferior wall but it was relatively less than the septal wall. This leads to smaller difference among the myocardial walls resulting in homogenization of perfusion and thickening in the LV myocardium post CRT. Whereas there was no significant relation between improvement in septal perfusion and primary outcome but improvement in septal thickening was associated with favorable primary outcome. We found no correlation between improvement in septal perfusion and

LVEF, EDV, ESV, and LVD. However, improvement in septal thickening was associated with reverse remodeling, improvement in LVEF, and reduction of LV dyssynchrony.

Disclosure

Dr Garcia receives royalties from the sale of the Emory Cardiac Toolbox used in this research. The terms of this arrangement have been reviewed and approved by Emory University in accordance with its COI practice. He is also a consultant for Syntermed Inc and GE Healthcare. There are no other relationships with industry.

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