The role of real time three dimensional echocardiography to guide optimal lead positioning and improve response to cardiac resynchronization therapy: A prospective pilot study

Doaa Ahmed Fouad a,*, Randa Mohamed Shams Eldeen b

a Cardiology Department, Assiut University Hospital, Assiut University, Egypt
b Public Health and Community Medicine Department, Faculty of Medicine, Assiut University, Egypt

Received 2 February 2012; accepted 10 March 2012
Available online 28 July 2012

Abstract  Aims: A non-optimal resynchronization lead (RL) position is a possible cause of poor CRT response. The study aims to test the value of real-time-three-dimensional-echocardiography (RT3DE) for individual assessment of LV dyssynchrony and prospective evaluation of CRT response after RL implantation at the pre-determined segment of maximal delay (SMMD) whatever the method of CRT used.

Methods: Seventeen HF patients were prospectively included in the study. RT3DE data were obtained before and after 1, 3, 6 months of CRT. Time/volume curves and parametric imaging were applied for pre-implant identification of SMMD and for individual assessment of CRT response. Delta-time delay (delta-t) and selective parameters between tmsv of the latest and earliest activated segments were calculated.

Results: All patients received CRT according to accessibility of the SMMD. We used bifocal right ventricular pacing (BFRVP) in 5 patients with septal SMMD; biventricular pacing (BVP) in 12 patients with LV SMMD. The RL was successfully implanted at the SMMD or nearest segment in 14 (82.4%) initial responders (5 BFRVP, 9 BVP). Twelve of them were still responders after 6 months. CRT response was comparable in BFRVP and BVP. A moderate correlation was found between % change of EF and that of SDI ($r = -0.406$), delta-t ($-0.497$). Baseline delta-t showed a stronger correlation with % change of EF ($r = -0.718^*, P = 0.009$) than that of SDI ($r = -0.509, P = 0.091$).

* Corresponding author. Tel.: +20 88 2356753 (work), mobile: +20 10085828; fax: +20 88 2356755.
E-mail address: fouaddoaa@yahoo.com (D.A. Fouad).

Peer review under responsibility of Egyptian Society of Cardiology.
1. Introduction

Although CRT was proved beneficial for patients with symptomatic HF associated with LV asynchrony, about 1/3 of patients are inadequate responders. Thus, accurate determination of mechanical dyssynchrony has become increasingly important. In this respective, positioning of the LV lead at the site of latest mechanical activation may result in maximum CRT benefit. This optimal lead position has been proposed to provide the greatest resynchronization and hemodynamic benefit. Meanwhile, BFRVP was reported to be successfully used to achieve cardiac resynchronization and improve clinical manifestations in patients with severe HF. This was found on acute and short-term as well as long-term follow-up. Accordingly, we thought that using BFRVP can induce more optimum CRT if the SMMD was septal.

Meanwhile, RT3DE provides a powerful tool for qualitative and quantitative assessments of the LV. The clinical use of RT3DE has been established and validated against angiography, radionuclide angiography, and MRI for assessment of LV volumes and functions. Regional correspondence of the maximum contraction is used as an indicator for dyssynchrony. A systolic dyssynchrony index derived from the regional volumes has been proposed and preliminarily validated as a method of quantifying global LV mechanical delay. In addition, whether or not a patient benefits from CRT can often be determined by comparing the regional volume curves derived from pre- and post-CRT RT3DE datasets.

2. Aims

The purpose of this study was to test the value of RT3DE for individual assessment of LV mechanical dyssynchrony, determination of SMMD, and for prospective evaluation of CRT response when the RL is positioned at the pre-determined SMMD whether the method of CRT used was BIVP or BFRVP.

3. Patients and methods

3.1. Patients

Seventeen HF patients scheduled for CRT in our cardiology department were prospectively included in the study starting from 2008 till 2010. All patients fulfilled the following inclusion criteria: advanced HF (NYHA class III or IV) despite optimal medical treatment, EF ≤ 35% defined by modified Simpson’s method, QRS ≥ 120 ms in LBBB pattern, and SDI ≥ 5 by RT3D. Patients were excluded if they were ≤ 18 years, had valvular disease, reduced life expectancy, ischemic episode during last 6 months, other pacemaker indication, and unsuitable equisetic window. Written consents were obtained from patients before participation in the study. The investigational protocol was approved by the Ethical Committee.

3.2. Methods

Patients were assessed before CRT regarding examination of 12-lead surface ECG, clinical evaluation of NYHA functional class score and echocardiographic evaluation. Using Philips IE 33 device, preliminary 2-D echocardiography was performed to obtain LV end diastolic and systolic volumes, and EF% (LVEDV, LVESV, EF%) by modified Simpson’s method. Full volume RT3DE data were then obtained from apical window to assess the same parameters in addition to definition of the SMMD and LV dyssynchrony parameters. Evaluation was repeated after 1, 3 and 6 months of CRT.

3.2.1. RT3DE protocol

a. Data acquisition and analysis

Echocardiographic evaluation was done using Philips iE 33 devices, software level 2.1.0.507 equipped with scan-head s5-1. Pure wave crystal x3-1 4D matrix array transducer was used to obtain full-volume 3D data. These data were obtained from the apical window while the patient is in left lateral position. A full volume scan was acquired in harmonic mode from 3 R wave triggered volumes during an end-expiratory breath.

Analysis of RT3DE datasets were performed on a QLAB workstation using Philips version 6.0, 3D-Advanced quantification software. LV quantification was performed to generate a LV 3-D model subdivided into 17 different colors so that regional and global volume curves were analyzed. LVEDV, LVESV, and EF% were generated automatically by the software (Fig. 1a). LV segmentation was performed according to a 17-segment model where tmsv was calculated in the 16 segments (excluding the apex) to obtain time/volume curve. The QLAB automatically calculates the SDI defined as the standard deviation of tmsv of the 16 segments corrected for R–R duration and displayed as a percentage (tmsv16 SD %) (Fig. 1b). Patients were only included if they had SDI ≥ 5. Moreover, the QLAB software allows manual selection of any number of segments.

b. Determination of the latest mechanical activation

This was performed using both time/volume curves and parametric imaging.

– Time/volume curve. Based on segmental time/volume curves, the segment (segments) with the latest tmsv was pre-operatively defined as the SMMD. The segment with the earliest tmsv (usually opposite to the SMMD) at the 17-segment model was also defined. Individual measurement of delta-t, selective tmsv SD (tmsv sel SD), selective tmsv difference (tmsv sel dif), the % of tmsv sel SD (tmsv sel SD %), and the % of tmsv sel difference (tmsv sel dif.%)
between tmsv of these 2 opposite selected segments was then performed to assess individual mechanical dyssynchrony.

After CRT, determination of the new tmsv point of the SMMD and its relation to the tmsv of the opposite segment was done. The same parameters were recalculated to assess the efficacy and extent of resynchronization. In responders, the SMMD is resynchronized so that its tmsv becomes earlier and in harmony with other segments including the previously earlier opposite segment. Fig. 2 shows parametric imaging and time/volume curve of 2 of our responders.

### 3.2.2. Implantation technique

Patients were meant to receive CRT so that the RL would be positioned at the pre-identified SMMD or the nearest possible segment. If more than one segment had the same tmsv, both segments are considered SMMD.

Twelve of the 17 patients had the SMMD at the free LV wall. These patients received conventional BIVP. Meanwhile, we used BFRVP in 5 patients with pre-identified septal SMMD.

For BIVP, coronary sinus venogram was obtained using a balloon catheter, followed by insertion of the LV lead into a cardiac vein corresponding to the SMMD or nearest segment. BFRVP patients received dual chamber pacemaker systems. An active fixation lead was screwed to the interventricular septum also at or nearest to the SMMD. An atrial lead was connected to the atrial channel of the pacemaker, 2 ventricular leads (apical and septal) were connected to the ventricular channel by a Y-shaped lead adaptor. Before discharge, all patients were programmed in the DDD mode with optimal AVD allowing maximum LV diastolic filling with separation of E and A waves of the mitral valve. LV and RV stimulation was simultaneous with no VV optimization.

### 3.2.3. Response to CRT

Clinical response was considered if there was ≥ 1 NYHA class improvement. Reversed remodeling was considered if there was ≥ 15% reduction of ESV.

### 3.2.4. Statistical analysis

Data were entered and cleaned in excel 2007 sheet then we used SPSS software package version 16 for data analysis. Non parametric tests were done where descriptive statistics (mean and SD) were calculated. Mann Whitney test, sign test and spearman rank correlation were used. The probability of < 0.05 (p-value) was used as cut off point for all significant tests.

### 4. Results

The study included 17 HF patients (12 males, 5 females) aged 51.06 ± 19.64 years. Eleven of them had ischemic cardiomyopathy, 6 had idiopathic dilated cardiomyopathy. All patients were in sinus rhythm except for 2 (1 BIVP, 1 BFRVP). Six patients had mid-anterolateral, 4 mid-inferolateral, 1 basal-anterolateral, 1 mid-anterior, 2 mid-anteroseptal, 2 mid-inferoseptal, 1 basal inferoseptal SMMD.

#### 4.1. Response to CRT among the study population

Fourteen of 17 patients (82.4%) were initial responders after 1 month of CRT. Twelve patients (70.5%) maintained beneficial CRT response after 6 months compared to 5 non-responders. All baseline characters were comparable in responders and
non responders (Table 1). However, responders had non-significantly younger age, better EF%, and SDI than the non-responders. Meanwhile, delta-time was non-significantly higher in responders compared to non-responders.

4.1.1. Positioning of RLs in responders vs. non-responders

Guided by parametric imaging and time/volume curves, the RL could be implanted at the SMMD or the nearest possible segment of the same wall in 15 patients (10 LV leads and 5 RV septal leads).

A LV lead was implanted in a lateral tributary of the coronary sinus (CS) in 9 patients (4 inferolateral, 5 anterolateral). It was positioned at an anterior tributary in 1 patient where the SMMD was mid anterior. However, lateral SMMDs were technically non-achievable in 2 patients (one had no suitable CS tributaries corresponding to the pre-identified SMMD, the other developed diaphragmatic stimulation at the SMMD). So, the LV lead was positioned at a posterolateral branch remote from the SMMD in these 2 patients. A septal RV lead was positioned at or nearest to septal segment proved to be the SMMD in 5 patients.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Baseline clinical and RT3DE indices in responders vs. non-responders of the study population.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Responders (No. 12)</strong></td>
<td><strong>Non-responders (No. 5)</strong></td>
</tr>
<tr>
<td>Age</td>
<td>46.83 ± 20.79</td>
</tr>
<tr>
<td>Ischemic CM</td>
<td>7/12</td>
</tr>
<tr>
<td>QRS</td>
<td>165.21 ± 36.30</td>
</tr>
<tr>
<td>NYHA class</td>
<td>3.80 ± 0.447</td>
</tr>
<tr>
<td>EDV (ml)</td>
<td>282.25 ± 65.51</td>
</tr>
<tr>
<td>ESV (ml)</td>
<td>213.92 ± 42.05</td>
</tr>
<tr>
<td>EF (%)</td>
<td>24.28 ± 5.49</td>
</tr>
<tr>
<td>SDI</td>
<td>11.03 ± 5.15</td>
</tr>
<tr>
<td>Delta-t</td>
<td>0.171 ± 0.01</td>
</tr>
</tbody>
</table>

CM = cardiomyopathy, SDI = systolic dyssynchrony index, EDV, ESV = end diastolic and systolic volumes, Delta-t = delta time delay between tmsv of SMMD and tmsv of opposite segment.
After 1 month of CRT, 14 of the 15 patients with optimum RL position were initial responders (all the 5 BFRVP, 9 BIVP patients). At the end of follow-up, 12 of these 14 patients (8 BIVP, 4 BFRVP) were still responders. Thus, 12/15 (80%) of patients having optimal RL position maintained a beneficial CRT response at medium term.

Meanwhile, the SMMD could not be achieved in 2 non-responders, while 3 patients were non-responders despite optimum RL positioning.

4.2. Patients’ follow-up

Five patients (4 BIVP, 1 BFRVP) were non-responders. Two BIVP non-responders had a non-optimum RL position, while 2 were non-responders despite optimum RL positioning (one died after 1 month, the other most probably had scar tissue at the SMMD). Meanwhile, 1 BFRVP patient developed reduction of LV function on the second follow-up visit despite near-optimum RL position.

The 12 responders developed significant improvement after CRT without sex related significance. NYHA score decreased from 3.80 ± 0.447 to 1.55 ± 0.52 after 6 months (P < 0.001). This was associated with reversed LV remodeling; namely significant improvement of ESV (213.92 ± 42.05 ml–163.75 ± 38.41) and EF% (24.28 ± 5.49–42.44 ± 5.67%) (P < 0.05 for both). Non responders exhibited no improvement of cardiac function indices compared to baseline.

SDI decreased significantly from 11.03 ± 5.15 to 2.39 ± 1.18 after 6 m of CRT (P < 0.001) in the responders. On the contrary, SDI was worsened in the non-responders recording higher values than baseline (13.72 ± 4.33–14.87 ± 5.41; P > 0.05) (Fig. 3a). Selective dysynchrony indices exhibited significant and comparable reduction to SDI. After 6 m of CRT, tmsv sel SD decreased from 90.17 ± 32.97 to 5.50 ± 3.28, tmsv sel dif. from 141.00 ± 29.39 to 11.16 ± 6.86, tmsv sel SD % from 20.49 ± 10.42 to 5.50 ± 0.94, tmsv sel dif.% from 36.41 ± 23.53 to, and delta time from 0.171 ± 0.012 to 0.013 ± 0.00 (P < 0.0001 for all) (Fig. 3b). These parameters were not significantly changed in the non-responders.

Meanwhile, responders had a mild to moderate correlation between the % change of EF% and that of SDI (r = −.406), delta-t (−.497), tmsv sel SD (−.650), tmsv sel dif. (−.559), tmsv sel SD % (−.538), tmsv sel dif.% (−.503). Baseline delta-t showed a stronger correlation with % change of EF (r = −.718**, P = 0.009) than that of baseline SDI (r = −.509, P = 0.091) automatically obtained from RT3DE dataset (Table 2).

### Table 2  Correlation between dys synchrony indices and % change of EF%.

<table>
<thead>
<tr>
<th>Baseline indices</th>
<th>% Change of EF%</th>
<th>% Change of indices</th>
<th>% Change of EF%</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDI</td>
<td>r</td>
<td>P value</td>
<td>SDI</td>
</tr>
<tr>
<td></td>
<td>−0.509</td>
<td>0.091</td>
<td>r</td>
</tr>
<tr>
<td>Delta-t</td>
<td>r</td>
<td>P value</td>
<td>Delta-t</td>
</tr>
<tr>
<td></td>
<td>−.718**</td>
<td>0.009</td>
<td>r</td>
</tr>
<tr>
<td>Sel. SD</td>
<td>r</td>
<td>P value</td>
<td>Sel. SD</td>
</tr>
<tr>
<td></td>
<td>−0.322</td>
<td>0.308</td>
<td>r</td>
</tr>
<tr>
<td>Sel. SD %</td>
<td>r</td>
<td>P value</td>
<td>Sel. SD %</td>
</tr>
<tr>
<td></td>
<td>−0.462</td>
<td>0.131</td>
<td>r</td>
</tr>
<tr>
<td>Sel. dif.</td>
<td>r</td>
<td>P value</td>
<td>Sel. dif.</td>
</tr>
<tr>
<td></td>
<td>−0.455</td>
<td>0.138</td>
<td>r</td>
</tr>
<tr>
<td>Sel. dif.%</td>
<td>r</td>
<td>P value</td>
<td>Sel. dif.%</td>
</tr>
<tr>
<td></td>
<td>−0.007</td>
<td>0.983</td>
<td>r</td>
</tr>
</tbody>
</table>

Delta-t = delta time delay, sel SD = selective tmsv SD, sel dif = selective tmsv difference, sel SD % = the % of tmsv sel SD, sel. dif.% = the % of tmsv sel.

* p < 0.05.

** p > 0.01.

Figure 3  LV dyssynchrony parameters in responders and non-responders. (a) Changes of SDI and (b) changes of delta time.
Table 3  Serial clinical and RT3DE changes in responders of BIVP and BFRVP groups.

<table>
<thead>
<tr>
<th></th>
<th>BIVP (8)</th>
<th>BFRVP (4)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NYHA</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>3.75 ± 0.46</td>
<td>3.25 ± 0.50</td>
<td>NS</td>
</tr>
<tr>
<td>1 m</td>
<td>1.12 ± 0.35**</td>
<td>1.67 ± 0.57**</td>
<td>NS</td>
</tr>
<tr>
<td>3 m</td>
<td>1.25 ± 0.46**</td>
<td>1.33 ± 0.57**</td>
<td>NS</td>
</tr>
<tr>
<td>6 m</td>
<td>1.50 ± 0.53**</td>
<td>1.67 ± 0.57**</td>
<td>NS</td>
</tr>
<tr>
<td><strong>EDV (ml)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>283.63 ± 66.31</td>
<td>276.50 ± 73.67</td>
<td>NS</td>
</tr>
<tr>
<td>1 m</td>
<td>268.12 ± 54.42</td>
<td>254.50 ± 65.50</td>
<td>NS</td>
</tr>
<tr>
<td>3 m</td>
<td>272.62 ± 45.33</td>
<td>249.00 ± 46.23</td>
<td>NS</td>
</tr>
<tr>
<td>6 m</td>
<td>267.75 ± 30.82</td>
<td>252.00 ± 49.22</td>
<td>NS</td>
</tr>
<tr>
<td><strong>ESV (ml)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>213.50 ± 49.96</td>
<td>214.75 ± 25.64</td>
<td>NS</td>
</tr>
<tr>
<td>1 m</td>
<td>174.50 ± 39.12**</td>
<td>163.00 ± 40.14**</td>
<td>NS</td>
</tr>
<tr>
<td>3 m</td>
<td>165.00 ± 30.93**</td>
<td>158.75 ± 51.98**</td>
<td>NS</td>
</tr>
<tr>
<td>6 m</td>
<td>167.75 ± 30.82**</td>
<td>170.75 ± 73.53**</td>
<td>NS</td>
</tr>
<tr>
<td><strong>EF (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>23.89 ± 4.78</td>
<td>25.08 ± 7.47</td>
<td>NS</td>
</tr>
<tr>
<td>1 m</td>
<td>38.78 ± 5.48***</td>
<td>42.75 ± 2.50***</td>
<td>NS</td>
</tr>
<tr>
<td>3 m</td>
<td>42.26 ± 5.98***</td>
<td>45.15 ± 3.39***</td>
<td>NS</td>
</tr>
<tr>
<td>6 m</td>
<td>40.50 ± 5.90***</td>
<td>43.32 ± 2.54***</td>
<td>NS</td>
</tr>
</tbody>
</table>

** Significance is related to baseline measurement, p < 0.001.
*** Significance is related to baseline measurement, P < 0.0001.

Figure 4  LV dyssynchrony parameters in responders of BIVP vs. BFRVP. (a) Changes of SDI, (b) changes of tmsv selective SD and (c) changes of delta time.
At the end of the 6 months follow-up period, 8 of the 12 BIVP patients (66%) maintained beneficial CRT response vs. 4 of the 5 BFRVP patients (80%) (P = 0.582). The mean age of BIVP responders (5 males, 3 females) was 52.38 ± 21.45 vs. 45.75 ± 16.29 of BFRVP responders (3 males, 1 female); P > 0.05. Responders of both device groups had a comparable significant improvement of NYHA class and reversed remodeling parameters (Table 3).

4.3.1. Assessment of LV synchrony in responders of the 2 groups

Baseline dyssynchrony parameters were non-significantly (except for delta-t) higher in responders of BIVP compared to those of BFRVP. During follow-up, these parameters decreased significantly and comparably in the 2 groups. After 6 months, SDI of BIVP responders decreased from 11.14 ± 3.25 to 2.36 ± 1.13, sel SD from 96.63 ± 30.86 to 6.00 ± 3.62, sel dif from 148.88 ± 24.24 to 10.00 ± 7.07, delta-t from 0.177 ± 0.01 to 0.006 ± 0.0, sel SD % from 24.95 ± 9.96 to 1.33 ± 1.37, sel dif.% from 44.62 ± 25.15 to 2.56 ± 2.45. Meanwhile, SDI of BFRVP responders decreased from 10.79 ± 6.10 to 2.46 ± 1.46, sel SD from 77.25 ± 37.81 to 4.50 ± 2.64, sel dif from 125.25 ± 36.06 to 9.50 ± 6.45, delta-t from 0.159 ± 0.00 to 0.014 ± 0.0, sel SD % from 18.69 ± 4.85 to 0.90 ± 0.91, sel dif.% from 30.00 ± 4.05 to 1.48 ± 1.18, P < 0.05 for delta-t, P < 0.0001 for others (Fig. 4).

5. Discussion

The invasive nature of CRT, its high cost, and high rate (20–30%) of non-responsiveness, increasing to 40–50% when reverse LV remodeling is an end point, have made candidate selection a crucial issue. Optimal lead position was proposed to provide the greatest resynchronization and hemodynamic benefit. However, the site of SMMD may vary significantly. It was suggested to be within the lateral wall in 67–89% of patients, it may be found at different other regions. The single most delayed segment was septal in 12–16% of cases. Presently, there has not been any clinical study evaluating the role of RT3D echocardiography in guiding CRT or its association with cardiac outcomes. To our knowledge, this small study is the first prospective study evaluating the role of RT3DE to guide optimum RL position in CRT.

We used RT3DE for individual assessment of LV systolic dyssynchrony and pre-implant identification of the SMMD. Using time/volume curves and parametric imaging, the SMMD could be identified preoperatively in all of the 17 patients of the study. It was lateral in 11 (64.7%), septal in 5 (29.4%), and anterior in 1 patient.

Because reaching the SMMD was the main goal of the present study and because BFRVP was a successful method of CRT with beneficial CRT response; we thought to use a RV septal lead as the RL in case of septal SMMD. Accordingly; BFRVP (using RV septal lead as RL) was chosen in 5 patients with pre-identified septal SMMD while BIVP was used in 12 patients with free LV wall SMMD. RT3DE facilitated positioning of the RL at or nearest to the SMMD in 15 (88%) patients (10 BIVP, 5 BFRVP). Twelve of these patients have constituted the responder group of patients after 6 months of CRT. Notably, 100% of responders had an optimum or near-optimum RL position while only 2/15 patients (13.3%) did not respond to CRT despite optimum lead positioning. Meanwhile, reaching septal SMMD was easily achieved in all BFRVP patients while it was more difficult in lateral SMMD. It was technically impossible in 2/12 of the BIVP patients. Similar results were reported from other studies.

Response to CRT was comparable among responders of both BFRVP and BIVP groups after optimum RL positioning. Responders of both groups developed comparable and excellent CRT response together with comparable and significant reduction of SDI and selective dyssynchrony indices. So that optimum RL positioning increased the percentage of CRT response up to 80% (12/15) as well as its extent.

Our results are in agreement with those of many studies emphasizing, although not prospectively, greater CRT response in patients paced at the site of SMMD and an increasingly worse response when the lead was placed more remote from the site of SMMD. Our results can also explain why candidates of CRT where the SMMD are found within the septum would be non-responders to traditional BVP.

SDI automatically derived from regional volumes of RT3DE was reported to be an excellent predictor of response to CRT. Kapetanakis et al., 2005 suggested a mean SDI of 3.5 ± 1.8% for normal subjects, 5.4 ± 0.8%, 10.0 ± 2%, and 15.6 ± 1% for mild, moderate, and severe systolic dysfunction respectively. Recently, the same authors identified a cutoff of 10.4% to predict improvement following CRT. However, some investigators questioned the value of RT3D-derived SDI in the evaluation of LV dyssynchrony. This was attributed to the inability of accurate detection of end-ejection in low-amplitude regional volume curves. Also, analysis of regional volume curves may not be sufficient to capture the unique features of CRT responders or non-responders and to predict the outcome of CRT. Alternative indices of dyssynchrony need to be developed to address this limitation.

RT3DE was the only method we used to assess LV synchrony before and after CRT. So, only patients with a SDI ≥ 5 were included in the present study. This in addition to the small sample size could explain our finding that baseline SDI was not significantly different in responders vs. non-responders. Attempting to avoid foreshortenings of the automatically obtained SDI, we used time/volume curves to measure selective dyssynchrony indices between tmsv of the SMMD and that of the earliest segment before and after CRT, so that individual mechanical response to CRT can be assessed. A moderate correlation was detected between % change of EF% and that of SDI and selective dyssynchrony parameters (Table 2). These results suggest that individual estimation of selective dyssynchrony parameters on time/volume curves can be useful for accurate and individual assessment of mechanical CRT response.

5.1. Clinical implications

RT3DE can be used to determine the SMMD and to assess individual LV mechanical dyssynchrony. Guided by RT3DE, positioning of the RL at the pre-identified SMMD can lead
to more optimum resynchronization effects (up to 80%) regardless the method of CRT used.

The use of septal RL can be a new, more reasonable and economic solution for the subset of patients having septal SMMD. This is a rather important issue in developing countries like Egypt.

5.2. Limitations

The small study population, due to limited fund, is the main limitation of the present study. However, the small number of patients enabled us to give patients better chance for optimum RL positioning on prospective basis. The absence of a gold-standard echocardiographic technique to evaluate LV dyssynchrony parameters capable of predicting response to CRT up till now is another limitation. Large multicenter studies are needed for accurate validation of LV dyssynchrony parameters obtained from RT3DE.

5.3. Recommendations

Every effort should be made to implant the RL at the SMMD whenever possible in order to achieve a more optimum CRT response. On the other hand, we can recommend the use of BFRVP with septal RL positioning in case of septal SMMD. However, further studies including larger number of patients are needed to clarify this issue.

6. Conclusions

The use of RT3DE for individual assessment of LV mechanical dyssynchrony and for optimal RL positioning at the pre-identified SMMD can provide more optimum CRT regardless the method of CRT used.

References


