THE ECHOCARDIOGRAPHIC ASSESSMENT OF VENTRICULAR DYSSYNCHRONY – A POWERFUL TOOL TO SELECT THE CANDIDATES FOR CARDIAC RESYNCHRONIZATION THERAPY

E. BELU[1], SIMONA GUSTI[2]

[1,2]*University of Medicine and Pharmacy Craiova*

Keywords: *heart failure, biventricular pacing, cardiac resynchronization*

Abstract: *Cardiac resynchronization therapy (CRT) is a relatively new therapy for the patients with symptomatic heart failure resulting from the systolic dysfunction. CRT is achieved by simultaneously pacing both the left and right ventricles. Biventricular pacing resynchronizes the timing of global left ventricular depolarization and improves mechanical contractility and mitral regurgitation.*

Cuvinte cheie: *insuficenţă cardiacă, pacing biventricular, resincronizare cardiacă*

Rezumat: *Terapia de resincronizare cardiacă (Cardiac Resynchronization Therapy - CRT) a fost introdusă relativ recent ca parte componentă al tratamentului pacienţilor cu insuficienţă cardiacă simptomatică, secundară unei disfuncţii sistolice severe. Se realizează atât prin stimularea ventriculului stâng (VS) cât şi a celui drept, fapt ce duce la resincronizarea timpului global de depolarizare al VS şi la îmbunătăţirea contractilităţii mecanice precum şi la ameliorarea gradului de regurgitare mitrală.*

Cardiac resynchronization therapy (CRT) is a relatively new therapy for the patients with symptomatic heart failure resulting from the systolic dysfunction. CRT is achieved by simultaneously pacing both the left and right ventricles. Biventricular pacing resynchronizes the timing of global left ventricular depolarization and improves mechanical contractility and mitral regurgitation.

Current selection criteria for cardiac resynchronization therapy (CRT) include severe heart failure (New York Heart Association (NYHA) functional class III or IV), depressed systolic function (left ventricular ejection fraction (LVEF) < 35%), and wide QRS complex (> 120 ms). In general, cardiac resynchronization therapy included patients with sinus rhythm, and optimal medical treatment for heart failure, including β-blockers, angiotensin-converting enzyme inhibitors or angiotensin receptor blockers and diuretics.

Currently, the patients are selected mainly on electrocardiogram criteria (wide QRS complex, left bundle branch block configuration). Echocardiography is a useful tool for the quantitative measurement of the severity of dyssynchrony in these patients before and after CRT. Various echocardiographic techniques in the assessment of systolic dyssynchrony include M mode measurement of septal-to-posterior wall delay, tissue Doppler imaging for septal-to-lateral wall delay, the measurement of standard deviation of peak contraction time over the 12 left ventricular segments, delayed longitudinal contraction, and maybe the three dimensional echocardiography. In particular, tissue Doppler imaging may allow further identification of the potential responders to CRT, based on the assessment of inter- and intraventricular dyssynchrony. Tissue Doppler imaging was also used to demonstrate the interventricular resynchronization. Yu et al. showed a large mechanical delay between the free right ventricular wall and the lateral wall of the LV, which was completely reversed after CRT.(1)

An optimized atrioventricular (AV) interval can maximize the benefits of cardiac resynchronization therapy (CRT). There are many echocardiographic techniques for AV optimization but there is no universally accepted gold standard. The optimal AV delay varies with time, requiring periodic re-evaluation.(2)

Systolic and diastolic parameters can also be obtained with conventional Doppler echocardiography and include: aortic velocity-time-integral, diastolic filling time, myocardial performance index (Tei), E/A ratio, E-deceleration time, isovolumetric relaxation, and pulmonary vein flow. Some of these parameters were improved after CRT, although their interpretation also depends on how relevant the post-implant atrioventricular optimisation is.(3)

Several studies using colour Doppler imaging have shown a reduction in mitral regurgitation after CRT.(4). In particular, Breithardt et al. have elegantly demonstrated that the effective regurgitant orifice area decreased immediately after CRT.(5) Additional studies demonstrated significant reverse remodelling after CRT.(6)

Data from the MIRACLE trial (172 patients) showed a 30% reduction in LV end-diastolic volume and end-systolic volume after six months of CRT.(4) The data regarding the improvement in geometry (sphericity index) and reduction in LV mass are contradictory.(3)

Restoring the optimal AV timing may improve systolic performance by optimizing LV preload after resynchronization. The acute hemodynamic benefits can be monitored noninvasively by Doppler echocardiography. An increase in the aortic velocity time and a prolongation of the diastolic filling time at the mitral valve level by at least 10% to 20% from baseline certifies the systolic improvement. In 1995, an echocardiographic algorithm was proposed for the optimization of AV delay in the patients with high degree AV block who underwent pacemaker implantation.(7)

The authors proposed that the optimal AV delay should provide the longest LV filling time without premature truncation of the A-wave by mitral valve closure. This approach is widely accepted as an easy method for AV optimization, although it has not yet been validated in the patients with left-ventricular-based pacing. It is currently not clear whether AV

[1]Corresponding author: Eduard Belu, Str. Tabaci, Nr. 1, E-mail: edibelu@gmail.com, Tel: +40740 129404
Article received on 25.06.2012 and accepted for publication on 26.07.2012
ACTA MEDICA TRANSILVANICA September 2012;2(3):248-249

delay optimization is needed, or whether an AV delay of 100 to 120 ms would be sufficient for all patients. Interventricular dyssynchrony, as measured by IVMD, was reduced by 19% after CRT in the MIRACLE trial.(4)

The quantification of basal dyssynchrony and acute resynchronization from left or biventricular pacing may be performed by novel echo-contrast variability imaging. Tissue tracking and strain rate imaging have also proved useful in assessing longitudinal resynchronization. When the latter is interpreted as a decrease in percentage of the extent of LV basal segments displaying delayed longitudinal contraction (an active contraction after the closure of the aortic valve), it has been documented that CRT immediately reduced the extent of such diastolic contraction from 49 ± 16% to 23 ± 13% ($p < 0.01$).(6)

Another study used strain rate imaging to quantify the acute effects of CRT on myocardial deformation. In this study, CRT reversed the pathologic septal-lateral strain relation and reduced the incidence of early systolic prestretch in the late activated wall and of postsystolic shortening.(5) In addition, echocardiography may allow optimal LV lead positioning and follow-up after CRT. In addition, the use of echocardiography to guide LV lead positioning and follow-up after CRT are addressed. Studies using TDI have shown that the latest mechanical activity is frequently located in the lateral wall (35%), followed by the anterior and posterior regions (26% and 23%), whereas the inferior wall/septum infrequently show the latest mechanical activity (16%).

Because the aim of resynchronization is to actively pace the most delayed site(s) of the LV, the selection of the pacing site(s) is needed to maximize the effect of CRT. Accordingly, Ansalone et al. have demonstrated that optimal resynchronization was obtained when the (echocardiographically determined) region with the latest activity was paced; in addition, clinical response was superior in these patients. From this perspective, three-dimensional echocardiography may potentially allow the optimal identification of the location with the latest activity.(9)

Conclusions:

Cardiac resynchronization therapy is now considered an established therapy for the patients with severe heart failure, with good clinical results, although, 20% to 30% of patients do not respond to CRT. At present, patient selection is mainly based on QRS duration. Evidence shows that echocardiography may be the ideal technique to identify the responders to CRT.

In particular, TDI may allow the precise assessment of the interventricular and intraventricular dyssynchrony. Moreover, based on the assessment of the site of the latest activation in the LV, echocardiography can guide LV lead positioning and may be used to optimize AV delay and V-V delay. Finally, echocardiography allows the assessment of resynchronization and follow-up after CRT.

REFERENCES

1. Yu CM, Chau E, Sanderson JE, et al. Tissue Doppler echocardiographic evidence of reverse remodelling and improved synchronicity by simultaneously delaying regional contraction after biventricular pacing therapy in heart failure. Circulation. 2002;105:438-445.
2. Barold S, Ilercil A, Herweg B. Echocardiographic optimization of the atrioventricular and interventricular intervals during cardiac resynchronization, Europace (2008) 10, iii88–iii95 doi:10.1093/europace/eun220
3. Saxon LA, De Marco T, Schafer J, et al. Effects of long-term biventricular stimulation for resynchronization on echocardiographic measures of remodelling. Circulation. 2002;105:1304-1310.
4. St John Sutton MG, Plappert T, Abraham WT, et al. Effect of cardiac resynchronization therapy on left ventricular size and function in chronic heart failure. Circulation. 2003;107:1985-1990.
5. Breithardt OA, Sinha AM, Schwammenthal E, et al. Acute effects of cardiac resynchronization therapy on functional mitral regurgitation in advanced systolic heart failure. J Am Coll Cardiol. 2003;41:765-770.
6. Sogaard P, Egeblad H, Kim WY, et al. Tissue Doppler imaging predicts improved systolic performance and reversed left ventricular remodeling during long-term cardiac resynchronization therapy. J Am Coll Cardiol. 2002;40:723-730.
7. Kindermann M, Frolhig G, Doerr T, Schieffer H. Optimizing the AV delay in DDD pacemaker patients with high degree AV block: Mitral valve Doppler versus impedance cardiography. Pacing Clin Electrophysiol. 1997;20:2453-2462.
8. Breithardt OA, Stellbrink C, Herbots L, et al. Cardiac resynchronization therapy can reverse abnormal myocardial strain distribution in patients with heart failure and left bundle-branch block. J Am Coll Cardiol. 2003;42:486-494.
9. Ansalone G, Giannantoni P, Ricci R, Trambaiolo P, Fedele F, Santini M. Doppler myocardial imaging to evaluate the effectiveness of pacing sites in patients receiving biventricular pacing. J Am Coll Cardiol. 2002;39:489-499.