Benefit of cardiac resynchronization therapy to a patient with a narrow QRS complex and ventricular dyssynchrony identified by tissue synchronization imaging

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Abstract This report described an 81-year-old woman with severe symptomatic heart failure, reduced ejection fraction, mitral regurgitation, and an electrocardiographic QRS width of 118 ms who had ventricular dyssynchrony identified by echocardiographic tissue synchronization imaging. Because of her severe heart failure symptoms on maximal medical therapy, referral to implant a defibrillator, and mechanical dyssynchrony, she underwent cardiac resynchronization-defibrillator therapy with lateral left ventricular lead placement. This resulted in an immediate 30% increase in stroke volume and 35% decrease in mitral regurgitation. Echocardiographic tissue synchronization imaging may play a role in identifying mechanical dyssynchrony in patients with narrow QRS duration who may potentially benefit from cardiac resynchronization therapy.

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Clinical criteria for cardiac resynchronization therapy (CRT) currently include an electrocardiographic duration of at least 120–130 ms, severe symptomatic heart failure, and reduced ejection fraction. This report described an 81-year-old woman with non-ischemic cardiomyopathy, mitral regurgitation, and a QRS width of 118 ms who had ventricular dyssynchrony identified by echocardiographic tissue synchronization imaging. An average significant septal to posterior-lateral delay of 165 ms was demonstrated by time–velocity plot analysis. Because of continued severe symptoms on maximal medical therapy and referral to implant a defibrillator, coupled with echocardiographic dyssynchrony, she underwent CRT-defibrillator therapy with lateral left ventricular lead placement. CRT resulted in an immediate 30% increase in stroke volume and a 35% decrease in mitral regurgitation. Although long-term follow-up data were not available, this illustrates how tissue synchronization imaging may play a role in identifying mechanical dyssynchrony in patients with narrow QRS duration who may benefit from CRT.

Case report

An 81-year-old woman with non-ischemic cardiomyopathy (nonobstructive coronary disease by angiography) and New York Heart Association Functional Class IV heart failure was being considered for an implantable defibrillator because of depressed ejection fraction of 29% and ventricular tachycardia. She also had severe mitral regurgitation by quantitative two-dimensional and Doppler echocardiography. Her electrocardiogram demonstrated a QRS complex of 118 ms (Fig. 1). Her medications included digoxin, furosemide, enalapril, and carvedilol. Because of continued severe heart failure symptoms on maximal medical therapy and because she was at high risk for mitral valve surgery due to advanced age, she was referred for echocardiographic dyssynchrony analysis. Echocardiographic tissue synchronization imaging (Vivid 7 GE-Vingmed, Horten, Norway), was performed as we previously described in detail. Briefly, tissue synchronization imaging detects peak positive myocardial velocity over the scanned regions and color-codes this information based on the time-to-peak velocities. This time-to-peak color-coding is then superimposed on the two-dimensional images in real time. Normal time-to-peak velocity data are color-coded as green, moderate peak velocity delays are color-coded as yellow–orange, and severe peak velocity delays are color-coded as red within the interval which is manually fine-tuned to begin with aortic valve opening and extend to mitral valve opening to include post-systolic dyssynchrony. Color-coding is used to guide the region of interest for time–velocity plot

Figure 1 The 12-lead electrocardiogram in this patient before cardiac resynchronization therapy demonstrating a QRS width of 118 ms.
analysis off-line. Three digital cine-loops were obtained from apical 4-chamber, 2-chamber, and long-axis views and analyzed off-line as previously described (EchoPAC PC 3.0, GE-Vingmed). Dyssynchrony, which we defined as the difference in time-to-peak velocity of the septum to its opposing walls averaged from basal and mid segments was 175 ms in the 4-chamber view and 155 ms in the apical long-axis view (Fig. 2), with an average of 165 ms. Septal to free wall difference in time-to-peak velocities ≥ 65 ms has been shown to be predictive of acute response to CRT, previously. Accordingly with her continued severe symptoms with limited therapeutic options, a biventricular pacing-defibrillator system was implanted with the left ventricular lead positioned in a lateral branch of epicardial vein via the coronary sinus.

The patient subsequently had a repeat two-dimensional echocardiographic and quantitative Doppler study the day following CRT. Stroke volume and mitral regurgitation were compared using the volumetric method. A significant 30% increase in stroke volume was observed from 36 ml to 47 ml. (Fig. 3). Mitral regurgitation was also acutely reduced with regurgitant volume decreasing from 73 ml to 47 ml and regurgitant fraction decreasing from 61% to 50% (Fig. 4). She had some subjective improvement in her heart failure symptoms, although long-term follow-up data were not available.

**Discussion**

Cardiac resynchronization therapy (CRT) is an important advance for patients with severe symptomatic heart failure on optimal medical therapy. It can result in improvements in symptoms, quality of life, ejection fraction and potentially prolong survival. Current clinical criteria for implantation include an electrocardiographic QRS duration of at least 120–130 ms, along with severe

![Figure 2: Tissue synchronization images at end-systole (top panels) with the apical 4-chamber view (left) and apical long-axis view (right) before resynchronization therapy. Delayed time-to-peak velocity is color-coded dark orange in walls opposing the LV septum. Corresponding time-velocity plots (bottom panels) demonstrating delays in time-to-peak velocities with a 175 ms delay from inferior-septum to lateral wall (arrows) in the apical 4-chamber view (left) and 155 ms delay from anterior-septum to posterior wall in the apical long-axis view (right), consistent with significant dyssynchrony. AVO = timing of aortic valve opening.](image)
symptomatic heart failure (New York Heart Association Class III or IV) and depressed ejection fraction (≤35%). Most patients in CRT clinical trials have had a QRS duration of >160 ms and the most common pattern is that of left bundle branch block. However, several investigations have demonstrated that electrocardiographic QRS prolongation may not be a satisfactory marker for mechanical dyssynchrony. Furthermore, others and we have recently shown that mechanical dyssynchrony may be identified in heart failure patients with depressed ejection fraction with relatively narrow QRS duration. In particular, a pattern of septal to posterolateral delay which mimics left bundle branch block can be identified in a subset of these patients, and this appears to be important as potentially predictive of response to CRT. CRT also resulted in an immediate decrease in mitral regurgitation in this patient likely from improved coordination of papillary muscle forces, which supports the concept that dyssynchrony is mechanistically associated with mitral regurgitation. Improvement of interventricular dyssynchrony may also play a role, but intraventricular dyssynchrony appears to be a major factor for improvement with CRT.

Conclusion

CRT has proven to benefit patients with symptomatic heart failure, reduced ejection fraction and prolonged QRS duration. This report demonstrates that CRT can improve stroke volume and reduce mitral regurgitation in a patient with a narrow QRS who had dyssynchrony identified by echocardiographic tissue synchronization imaging. Although the application of CRT to heart failure patients with narrow QRS duration must be studied prospectively in a large clinical trial to conclude its

Figure 3  Doppler echocardiographic determination of stroke volume before and after cardiac resynchronization therapy (CRT). The time velocity integral (TVI) in the apical 5-chamber view was used to calculate stroke volume using left ventricular outflow tract diameter (D). Stroke volume acutely increased from 36 ml to 47 ml after CRT.
benefit, this case report illustrates how echocardiographic imaging techniques, and in particular tissue synchronization imaging, may play a role in quantifying ventricular dyssynchrony and identifying candidates for CRT.

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