Improving cardiac function after cardiac surgery by biventricular pacing in patient selected by three-dimensional echocardiography

Stéphane Combes1*, Nicolas Combes2, Etienne Geoffroy1, Romain Eschalier1, Kasra Azarnoush1, Lionel Camilleri1, and Charles De Riberolles1

1Department of Cardiac Surgery, CHU Gabriel Montpied, 58 Rue Montalembert, BP 69, 63003 Clermont Ferrand, France; and 2Electrophysiology and Pacing/Defibrillation Department, Clinique Pasteur, Toulouse, France

Received 3 August 2008; accepted after revision 10 October 2008; online publish-ahead-of-print 7 November 2008

We present the case of a 57-year-old woman with severe aortic regurgitation and ventricular dysfunction (ejection fraction 34%) requiring surgical intervention. In pre-operative period, no left ventricular (LV) asynchrony was detected by QRS duration and current echocardiographic techniques, including tissue Doppler imaging. A new echocardiographic technology, the timing of regional volumetric changes by three-dimensional echocardiography (3DEcho), demonstrated an intraventricular mechanical asynchrony. Indeed, during surgery, epicardial leads were attached to the right atrium and the right ventricle as part of the standard management. Two additional epicardial leads were attached to the left ventricle on the most delayed wall localized precisely by 3DEcho on the inferolateral wall. In post-operative period, biventricular (BiV) pacing showed improvement in the LV mechanical synchronisation, resulting in improvement in the LV systolic function compared with right ventricular pacing or no pacing. This case shows the potential utility of 3DEcho in prediction of favourable response of the BiV pacing in patients with depressed LV systolic function ongoing cardiac surgery.

KEYWORDS
Biventricular pacing; Cardiac surgery; Three-dimensional echocardiography

Case report
A 57-year-old woman was referred to our institution for aortic valve replacement. She had a history of severe and symptomatic aortic valve regurgitation with depressed left ventricular (LV) function [ejection fraction (EF) = 34%]. The preoperative transthoracic echocardiography did not showed atrio-ventricular or intra-LV asynchrony with current echocardiographic techniques, including tissue Doppler imaging (TDI, Figure 1B). An opposing wall delay between the antero-septal to posterior wall or septal to lateral wall was < 65 ms (Figure 1B). On the electrocardiogram (EKG), QRS duration was < 120 ms (QRS duration = 90 ms, Figure 1A). Three-dimensional echocardiography (3DEcho) was applied to assess intraventricular mechanical synchrony. We calculated the degree of dispersion by measuring the standard deviation of the time to achieve minimum systolic volume (Tmsv) for each of the 17 segments described by the American Society of Echocardiography and then corrected that for the R-R interval (systolic dyssynchrony index, SDI). Time to minimum systolic volume is significantly delayed in the septal segment and on the parametric image (indicated in red colour) (SDI = 11.24%) (Figure 1C and D). For a visual summary of LV regional contraction timings, segments with a Tmsv about global Tmsv are coded in green and early segments are coded in blue, whereas late segments are coded in red (‘bulls eye’ Figure 1D). During surgery, epicardial leads were positioned on the right atrium and the right ventricle as part of the standard management. Because of depressed EF, two additional epicardial leads were positioned in this patient on the left ventricle. According to 3DEcho, these lead were attached on infero-lateral wall, in the opposite of late segments. At post-operative period, the haemodynamically stable patient was stimulated with an external constant-current dual-chamber demand pacemaker (Medtronic 5388, Medtronic Inc, Minneapolis, MN, USA). Biventricular (BiV) pacing was achieved by connecting ventricular leads to ventricular port of the pacemaker (BiV simultaneous pacing). The atrio ventricular (AV) delay was fixed at 150 ms. During the echocardiographic study, intravenous

* Corresponding author. Tel: +33 4 73 75 15 77; fax: +33 4 73 75 15 79. E-mail address: combesstephane@voila.fr

Published on behalf of the European Society of Cardiology. All rights reserved. © The Author 2008. For permissions please email: journals.permissions@oxfordjournals.org.
Figure 1  Pre-operative period. (A) Electrocardiogram showing narrow QRS. (B) Tissue Doppler imaging evaluation of intraventricular dysynchrony. Colour tissue Doppler sample placed at the middle of basal and mid of four ventricular segment in an apical four-chamber view. Maximal electromechanical delay was 35 ms and maximal electrosystolic delay was 30 ms. (C) The cast of the left ventricular that is obtained using semi-automated endocardial border tracking from the three-dimensional data set. It is automatically segmented into the standard 16 or 17 segments. It is possible to assess for each volumetric segment, the time taken to reach the minimum systolic volume expressed in percentage of cardiac cycle (Tmsv 16 SD). (D) Time to minimum volume is significantly delayed in the septal segment and on the parametric image (indicated in red colour).

Figure 2  Post-operative period. Electrocardiogram during right ventricular stimulation (A) and biventricular stimulation (B) with the same atrio ventricular delay (150 ms), resulting in a fusion with spontaneous rhythm. Parametric LV cast and ‘bulls eye’ display during right ventricular stimulation (C) and biventricular stimulation (D). (C) Time to minimum volume is significantly delayed in the lateral segments and on the parametric image (red colour). (D) Following biventricular pacing, most segments achieve minimum volume at the same time in the cardiac cycle and the parametric image displays a more homogeneous green colour and Left ejection fraction improved.
Improving cardiac function after cardiac surgery

Discussion

In this case, new modality of echocardiography with three-dimensional analysis identifies BiV pacing responder alone after cardiac surgery. Epicardial pacing is commonly indicated in cardiac surgical patients using right ventricular (RV) and/or right atrial (RA) pacing leads. In patients in sinus rhythm (SR), two RA and two RV epicardial wires are attached, resulting in dual-chamber or sequential atrioventricular pacing (DDD). Some studies are consistent with a deleterious effect of RV stimulation in the chronic phase with patient with depressed EF. Minimal data exist regarding BiV pacing in surgical patients. In these studies, patients were selected on the basis of an LVEF and wide QRS on the surface EKG. The peculiarity of this case is ventricular asynchrony undetected by normal QRS duration and usual echocardiographic techniques such as TDI currently considered the ‘gold standard’. Some studies in patients with heart failure have demonstrated that QRS duration is a poor indicator of mechanical dyssynchrony. Additionally, the use of TDI-based measurements of LV asynchrony do not appear to be a robust predictor of clinical response to CRT. An initial study by Kapetanakis et al. demonstrated promising results when real-time 3DEcho was applied in a small group of patients undergoing CRT. In this study, the value of 3DEcho for prediction of response to CRT and the assessment of LV volumes was evaluated in a group of patients with an arbitrary cut-off value defined as an SDI > 3 SD above the mean for a group of normal subjects (8.3%). Recently, Marsan et al. found an SDI of ≥5.6% as the optimal cut-off value with a sensibility of 88% and a specificity of 86% to predict an acute response to BiV pacing. In our case, 3DEcho was the only mean to detect intraventricular asynchrony, with a direct access to spatio-temporal synchrony with an SDI of >11%. The interest of this evaluation was supported by the hemodynamic improvement associated with correction of this asynchrony. A hemodynamic improvement can be interesting in this high-risk patient with low EF. But, prospective studies are necessary to determine whether all cardiac surgery patients with cardiac dysfunction must have BiV pacing in the post-operative period.

In conclusion, a new method for the measurement of LV synchrony by 3DEcho using regional volumetric changes can identify responders of BiV pacing, guided the site of LV leads. It can be used to quantify CRT effect on global LV function in patients with ventricular dysfunction in the post-operative cardiac surgery period.

References