EDITORIAL

Non-contact mapping of the left ventricle and new insights into the mechanisms for success of biventricular pacing

R J Schilling

Heart 2004;90:3-4

Results from cardiac resynchronisation therapy are likely to improve as methods for identifying likely responders and the optimum site for lead placement become more refined

Clinical trials have now convincingly demonstrated the benefits of cardiac resynchronisation therapy (CRT) in patients with severe heart failure and evidence of uncoordinated ventricular contraction by biventricular pacing.¹ The preliminary results of the as yet unpublished companion studies implies a reduction in hospitalisation in patients prescribed CRT²; following the results of MADIT (multicenter automated defibrillator implantation trial) II³ it appears that many patients who require CRT devices probably need to have the capacity to defibrillate, increasing the cost to health service providers. The prescription of CRT is growing and when a patient responds the results are heartening. However, this is tempered by the disappointment when a patient undergoes an expensive, potentially long, and dangerous invasive procedure and does not respond. Indeed approximately 30% of patients in published series fail to respond to CRT.⁴

IDENTIFYING SUITABLE PATIENTS FOR CRT

Identification of patients likely to respond to CRT has conventionally been based on the width of the QRS of the ECG, although the presence of significant mitral regurgitation (MR) is also useful. Both acute and chronic studies have demonstrated a relation between the QRS width and improvement in systolic function with CRT,^{5,6} but there is considerable scatter in this relation. Furthermore CRT can have benefit even when it results in a widening rather than narrowing of the QRS duration.⁷

Clinical studies have therefore shown that QRS duration is a crude but cheap and easy tool for predicting response to CRT, but they do not explain why prolonged electrical activation does not correlate with prolonged or dysynchronous mechanical ventricular activation, and how we might more accurately predict those who are likely to respond to CRT.

NON-CONTACT MAPPING

It is an interesting reflection on the development of medical therapy that technologies like biventricular pacing are conceived and successfully applied before we truly understand the precise mechanism of how and when they work. In the

case of biventricular pacing, apart from the obvious pressures of clinical need (and commercial development), the reason for the lack of mechanistic data has been the limitation of tools able to examine detailed electrical and mechanical activation in the intact but failing human ventricle.

Non-contact mapping was the first tool that allowed global, simultaneous, percutaneous cardiac mapping, and since the first clinical validation studies⁸ it has been widely accepted as a useful addition to our methods for unravelling the complexities of electrical activation of the diseased human heart. This technology has allowed us to demonstrate that the appearance of the surface ECG is not a reliable method for determining left ventricular activation patterns. In many patients with left bundle branch block the presence of left bundle activation can be demonstrated with non-contact mapping, and conversely the absence of left bundle branch block does not mean that the left ventricle is activated by a left bundle or that endocardial activation is rapid.⁹

ECHOCARDIOGRAPHY

Echocardiography has shown that there is evidence of uncoordinated ventricular contraction in heart failure patients, both with (80%) and without (28%) left bundle branch block (LBBB).¹⁰ The development of tissue Doppler echocardiography has provided a sensitive method for examining ventricular myocardial movement¹¹ and has been used to characterise mechanical activation of the left ventricle in patients with left bundle branch block and the response to biventricular pacing.¹²

MECHANISMS FOR OUTCOME OF CRT

In this issue two papers have used these technologies to investigate the mechanisms by which CRT changes electrical activation and the potential reasons for patients failing to respond to CRT. Lambiase and colleagues¹³ examine the relation between endocardial activation determined by non-contact mapping and the acute response determined by cardiac output and dP/dt in patients who had undergone biventricular pacemaker implantation up to two weeks previously. The use of pacing from deflectable endocardial catheters allowed the authors to make some assessment of the utility of different pacing sites and their association with endocardial activation as determined by non-contact mapping.

The data presented are complex and although the patient numbers are limited to 10 the results

Correspondence to:
Dr Richard Schilling, St
Bartholomew's Hospital,
West Smithfield, London
EC1A 7BE, UK;
r.schilling@qmul.ac.uk

have some potentially important implications for our clinical practice. A key finding was that patients with dilated cardiomyopathy had a significant response to CRT but those with ischaemic heart disease did not. The authors suggest that the reason for this is that four out of five patients with dilated cardiomyopathy had homogenous cardiac conduction, but all patients with ischaemic heart disease and one with dilated cardiomyopathy had slow conduction and the CS leads were sited in these regions. This prevented uniform or rapid activation of the left ventricle during biventricular pacing because of local latency. The implication is that positioning the left ventricular lead in regions of fractionated and late potentials may actually produce a poorer outcome than positioning it in regions of healthy electrograms. As has been shown in previous studies narrowing of the QRS did not predict response.

EXTRA-INVASIVE PROCEDURE

One of the problems with applying these data clinically might be the extra-invasive procedure (insertion of the non-contact balloon to the left ventricle) and the subsequent time and cost. Theoretically it would be very useful to perform non-contact mapping during the implant procedure in order to identify the area of latest activation not obstructed by conduction block and scar. This would also allow the operator to pass the catheter locator signal produced by the non-contact mapping system through the left ventricular lead and therefore steer it to that site. However, at the present time it is recommended that the patient is heavily anticoagulated while the non-contact balloon is in the left heart which would prevent safe implantation of the CRT system.

Fung and colleagues¹⁴ have gone some way to try and overcome this problem by comparing non-contact mapping data to tissue Doppler imaging. They found that latest activation on non-contact and tissue Doppler correlated well. They did not examine the results of placing leads at these sites and therefore have not been able to address the issue raised by Lambiase and colleagues¹³ that latest is not necessarily best. However, it seems likely that myocardium which thickens appreciably on tissue Doppler is also likely to conduct at reasonable velocities, so one's criteria for identification on tissue Doppler could be late and active muscle rather than just late, but this remains to be validated.

The results of CRT are likely to improve as methods for identifying likely responders and the optimum site for lead

placement become more refined. However, it is becoming apparent that the choice of one or two epicardial veins suitable for lead placement is just not good enough. Systems for delivering the lead to the epicardium directly (that is, without passing transvenously first) using percutaneous approaches may be the answer to this.

REFERENCES

- 1 Auricchio A, Stellbrink C, Sack S, *et al*. Long-term clinical effect of hemodynamically optimized cardiac resynchronization therapy in patients with heart failure and ventricular conduction delay. *J Am Coll Cardiol* 2002;**39**:2026–33.
- 2 Cleland JGF, Coletta AP, Nikitin N, *et al*. Update of clinical trials from the American College of Cardiology 2003. EPHESUS, SPORTIF-III, ASCOT, COMPANION, UK-PACE and T-wave alternans. *Eur J Heart Fail* 2003;**5**:391–8.
- 3 Moss AJ, Zareba W, Hall WJ, *et al*. Prophylactic implantation of a defibrillator in patients with myocardial infarction and reduced ejection fraction. *N Engl J Med* 2002;**346**:877–83.
- 4 Alonso C, Leclercq C, Victor F, *et al*. Electrocardiographic predictive factors of long-term clinical improvement with multisite biventricular pacing in advanced heart failure. *Am J Cardiol* 1999;**84**:1417–21.
- 5 Nelson GS, Curry CW, Wyman BT, *et al*. Predictors of systolic augmentation from left ventricular preexcitation in patients with dilated cardiomyopathy and intraventricular conduction delay. *Circulation* 2000;**101**:2703–9.
- 6 Oguz E, Dagdeviren B, Bilsel T, *et al*. Echocardiographic prediction of long-term response to biventricular pacemaker in severe heart failure. *Eur J Heart Failure* 2002;**4**:83–90.
- 7 Nelson GS, Curry CW, Wyman BT, *et al*. Predictors of systolic augmentation from left ventricular preexcitation in patients with dilated cardiomyopathy and intraventricular conduction delay. *Circulation* 2000;**101**:2703–9.
- 8 Schilling RJ, Peters NS, Davies DW. Simultaneous endocardial mapping in the human left ventricle using a noncontact catheter: comparison of contact and reconstructed electrograms during sinus rhythm. *Circulation* 1998;**98**:887–98.
- 9 Schilling RJ, Peters NS, Davies DW. Patterns of left ventricular activation during sinus rhythm in patients with ventricular tachycardia. *Circulation* 1997;**96**:1–586.
- 10 Makaryus AN, Arduini AD, Mallin J, *et al*. Echocardiographic features of patients with heart failure who may benefit from biventricular pacing. *Echocardiography* 2003;**20**:217–23.
- 11 Zamora J, Wallbridge DR, Ge J, *et al*. Non-invasive assessment of cardiac physiology by tissue Doppler echocardiography—a comparison with invasive haemodynamics. *Eur Heart J* 1997;**18**:330–9.
- 12 Yu CM, Chau E, Sanderson JE, *et al*. Tissue Doppler echocardiographic evidence of reverse remodeling and improved synchronicity by simultaneously delaying regional contraction after biventricular pacing therapy in heart failure. *Circulation* 2002;**105**:438–45.
- 13 Lambiase PD, Rinaldi A, Hauck J, *et al*. Non-contact left ventricular endocardial mapping in cardiac resynchronisation therapy. *Heart* 2004;**90**:44–51.
- 14 Fung JW-H, Yu C-M, Yip G, *et al*. Variable left ventricular activation pattern in patients with heart failure and left bundle branch block. *Heart* 2004;**90**:17–9.

Direct Access to Medline

Medline

Link to Medline from the homepage and get straight into the National Library of Medicine's premier bibliographic database. Medline allows you to search across 9 million records of bibliographic citations and author abstracts from approximately 3,900 current biomedical journals.

www.heartjnl.com