How-to-do-it

Minimal invasive epicardial lead implantation: optimizing cardiac resynchronization with a new mapping device for epicardial lead placement


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Abstract

To optimize resynchronization in biventricular pacing with epicardial leads, mapping to determine the best pacing site, is a prerequisite. A port access surgical mapping technique was developed that allowed multiple pace site selection and reproducible lead evaluation and implantation. Pressure–volume loops analysis was used for real time guidance in targeting epicardial lead placement. Even the smallest changes in lead position revealed significantly different functional results. Optimizing the pacing site with this technique allowed functional improvement up to 40% versus random pace site selection.

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1. Introduction

Biventricular pacing for cardiac resynchronization has become an established therapy following the favourable results of the Companian trial [1]. Ideal positioning of the left ventricular lead is an important determinant of improving cardiac function and is patient dependent [2]. Percutaneous lead implant in the coronary sinus or one of its branches is limited in this respect [3–5]. Upon failure of a percutaneous procedure, an epicardial surgical approach can be offered alternatively. However, a primary surgical approach may be justifiable if identifying the best possible lead position for superior functional results can be warranted. Such an approach should offer unlimited access to all the left ventricular free wall. In addition, mapping of the epicardial surface using a pacing catheter is indicated [6] (Fig. 1). To this end we developed a mapping mould that covers the ventricular surface from apex to the atrio-ventricular groove offering 12 potential lead implant sites (Fig. 2). The mould offers a perfect fit for both the pacing electrode and the lead electrode. This technique was initially evaluated in an anterolateral minithoracotomy approach and subsequently applied in endoscopic and Robot (Davinci, Intuitive Surgical Inc, Sunnyvale, CA) assisted procedures for unlimited access to the entire epicardial surface. Since the efficacy of lead positioning based on the QRS properties has been questioned we used pressure–volume loops monitoring for beat-to-beat analysis to find the best functional result. Improvement in synchrony, ejection fraction, dp/dt; and stroke work, are taken into account.

2. Method

The patient is in supine position with an inflatable balloon beneath the left thoracic cavity that elevates this part of the body during the endoscopic procedure. A conductance catheter (CD Leycom, Zoetermeer, The Netherlands) is placed under fluoroscopy in the left ventricle via catheterization of the right femoral artery. The catheter is connected to a CFL512 conductance console (CD Leycom, Zoetermeer, The Netherlands). Both surgical and analytical techniques have been described before [7].
After removal of the pacemaker or ICD, the in situ right atrial and ventricular leads are used for base line measurements. The left side of the patient is then elevated with the balloon to a 30–40° position and may be adapted during the procedure to allow proper access to the posterolateral and posterior part of the heart. The right arm instrument is in the third intercostal space of the anterior axillary line, the left arm in the seventh intercostal space of the anterior axillary line, and the endoscope is positioned in between in the fifth intercostal space in the mid-axillary line. A 0° scope is for most cases the best choice though a 30° scope may facilitate a more anterior or posterior approach. Following introduction of the endoscopic instruments the left phrenic nerve is identified. The pericardium is opened anterior and/or posterior of the nerve pedicle. One of the trocars is temporarily removed to introduce the mapping mould. Using suction the mould is attached to the anterior, lateral, and posterolateral epicardial surface of the heart, respectively. The temporary pacing electrode is subsequently placed in each of the 12 openings of the mould. The effect of biventricular pacing at each position is evaluated with online pressure–volume loops analysis and compared to unilateral pacing either on the right side or on the left side. The permanent lead electrode is then introduced in the pleural space through the pacemaker pocket and attached to the myocardium at the optimal pace site (type 4968, 4965, Medtronic, MN).

3. Results

The present mapping technique was used in 14 patients that were referred to our department after failure of a transvenous approach. Optimal surgical pace site selection increased stroke volume by 41% \( (P < 0.001) \), \((dP/dt)_{\text{max}}\) by 21% \( (P < 0.01) \) and synchrony by 5% \( (P < 0.05) \). If the worst pace site would have been selected, none of these parameters would have improved significantly, while deterioration of function would have occurred in five patients. A change in lead position of only 2 cm could make up the difference between a worst and a best position. The suction mapping mould device covered the epicardium from the atrio-ventricular groove to the apex. In general, apical positions gave worse functional results than mid or basal pace sites.

4. Comments

Ample experimental and clinical evidence has been provided that there exists an ideal position for the placement of a LV pacing lead in CRT [2,8]. Based on the mechanism of cardiac asynchronous contractions this would be in the area with the largest delay [2]. The high number of non-responders to CRT (30%) in the largest trial to date, may result from a sub-optimal position of the left ventricular lead during coronary sinus implantation [3,6].

Surgery offers the potential advantage of unlimited access to the left ventricular epicardium. To be competitive, this advantage should be used to its full extent. The proposed mapping technique fulfils these criteria in a systematically and reproducible way. In addition, it is compatible with the least invasive surgical approach available. Long-term follow up studies are needed to demonstrate whether surgery might become the preferred primary approach in this respect.

References

Appendix A. Conference discussion

Dr F. Mohr (Leipzig, Germany): Pressure–volume loop catheters are up to €5000.

Dr Maessen: 2000.

Dr Mohr: But still, transesophageal echo in the OR measuring exactly the volumes is less expensive and of course less complicated.

Dr Maessen: That’s right.

Dr Mohr: I really respect this study because I think it makes a lot of sense from a hemodynamic standpoint. On the other hand, you will have a huge increase in biventricular pacing. Do you believe this is a practical approach for everybody to do so? From an academic standpoint I can fully understand and support this approach to really document which is the optimal side.

Dr Maessen: I agree completely with you. Our hypothesis was that the asynchrony or the asynchrony index would be most informative about the improvement, and we try to relate the asynchrony index with the other parameters, volume parameters, and relate those to the parameters you can get with echo. With this information, of course, it is much better for the future to use echo as a routine procedure. There is in the echo literature a debate on this subject, and I think that the conclusion up to now is that tissue Doppler is actually the best methodology to screen these patients in a functional way.