A simplified technique for implantation of left ventricular epicardial leads for biventricular resynchronisation using video-assisted thoracoscopy (VATS)

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Received 13 May 2005; received in revised form 23 August 2005; accepted 23 August 2005; Available online 7 November 2005

Abstract

Objective: Cardiac resynchronisation therapy for treatment of heart failure requires transvenous insertion of both a right ventricular and left ventricular pacing lead. Implantation of the latter by way of the coronary sinus often fails. Therefore, alternative techniques for insertion are required. We applied a simple video-assisted surgical technique (VATS) using only two ports for the insertion of left-ventricular screw-in electrodes.

Methods: Fifteen patients (M: 10; F: 5; mean age: 62.2 years; range: 46—76 years) with heart failure meeting the ACC/AHA guidelines for implantation of biventricular pacing underwent transvenous insertion of the right atrial sensor lead and the right ventricular pacing lead. In all of them transvenous implantation of the left ventricular pacing lead failed, and they were planned for VATS. In right-lateral decubitus position and under single-lung ventilation a camera port and a flexible instrumentation port were inserted in the forth intercostal space. By using routine instruments, a T-shaped incision was made lateral to the phrenic nerve and an electrode was screwed in. The lead was guided subcutaneously to the pacemaker.

Results: Mean skin-to-skin operating time was 55 ± 16 min, no conversion to thoracotomy was necessary. All patients were extubated in the operating room and remained in the intensive care unit for less than 24 h. Chest tubes were removed after a mean of 1.6 ± 0.5 days and the patients were discharged after a mean of 4 ± 1.3 days. Intraoperative and postoperative pacing thresholds at 1 and 7 months were satisfactory in all cases and there was no lead dislocation. All but two patients had an improvement of their NYHA function class. There was neither surgical morbidity nor mortality.

Conclusions: Video-assisted thoracoscopy over two ports seems to be an excellent alternative procedure for epicardial lead implantation. It is readily available and produces good pacing results at a short intervention time and tolerable stress for the patients.

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Keywords: Biventricular resynchronisation; VATS; Heart failure; Epicardial lead

1. Introduction

Despite tremendous improvements in pharmacological treatment, many patients with heart failure have severe and persistent symptoms and their prognosis remains poor [1,2]. Cardiac resynchronisation therapy, a pacemaker-based therapy for advanced heart failure, enhances cardiac performance and quality of life in patients with congestive heart failure (CHF), who do not have a standard indication for the implantation of a pacemaker. The intent of the therapy is to resynchronise the ventricular activation sequence and to improve coordination of both atrio-ventricular timing and pumping efficiency.

Ventricular desynchronisation results in a delay in the contraction of the left ventricle free wall in relation to the septum, causing underuse of the energy generated by the heart and systolic and diastolic dysfunction. Left ventricular pacing or biventricular pacing enables mechanical resynchronisation of the septum and the free wall. This is achieved by stimulating the atria and both ventricles with three leads inserted under fluoroscopic control into the right atrial appendage and the ventricular apex, respectively, and, by way of the coronary sinus, into a left ventricular epicardial vein [3,4].

The latter technique is difficult, requiring a long learning period and carrying a failure rate of about 8% [5]. This has caused interest in alternative techniques, such as implanting epicardial leads into the left ventricle over a small thoracotomy.

Minimally invasive endoscopic techniques are currently used in a wide range of surgical procedures. They combine
the advantages of small incisions and less postoperative pain with an excellent visualisation. First attempts of its use for cardiac resynchronisation therapy using both conventional VATS and robotic assist have been published [6—9].

We present our experience with a very simple, effective technique of surgical implantation of left ventricular epicardial leads using video-assisted thoracoscopy (VATS).

2. Materials and methods

Between October 2002 and December 2004, 15 consecutive patients (F: 5; M: 10; mean age: 62 years; range: 46—76 years) with advanced heart failure and widened QRS complex underwent cardiac resynchronisation treatment using video-assisted thoracic surgery (VATS) for implantation of the epicardial left ventricular lead. This corresponds to a total of 9% of patients who required resynchronisation therapy during the respective period. The inclusion criteria for resynchronisation therapy comprised NYHA C2 class III, QRS duration of >130 ms, left ventricular ejection fraction (LVEF) <35%, LV end diastolic dimension >55 mm and medical therapy unchanged for at least 1 month [3].

In each patient the first attempt of implantation of all leads had been done over the intravenous approach. The reasons for failure to implant the epicardial one had been a big Thebesian valve (2), a stenosis of the coronary sinus (1), very small cardiac veins (7), recurrent lead dislocation (2) and high pacing thresholds (3), respectively. In these cases only the intravenous bipolar leads were implanted in the right atrium and ventricle, respectively, and the patients were planned for VATS.

2.1. Surgical technique

The intervention was done under general anaesthesia using a double lumen tube for unilateral lung ventilation. Monitoring included electrocardiography, capnometry, pulse oximetry, central venous pressure and invasive and non-invasive blood pressure.

The patients were placed in a right-lateral decubitus position with the left chest tilted to about 60—70°. After deflation of the left lung, a 10 mm reusable port for the camera was inserted into the fourth intercostal space between the middle and posterior axillary line. A second flexible disposable port for instrumentation (FlexiPath®; Ethicon Endosurgery, Inc., 1993, Cincinnati, OH, USA) was positioned in the fourth intercostal space in the anterior axillary line. This port allowed the use of routine instruments for thoracic surgery, obviating the necessity of expensive tools (Fig. 1). The pericardium about the left lateral ventricle was grasped with an Overholt forceps and opened laterally to the phrenic nerve in a T-shaped fashion using scissors.

Once the lateral wall of the left ventricle was exposed and the marginal arteries identified, a fractal coated epicardial screw-in electrode (ELC-54-UP screw-in lead; Biotronic, Berlin, Germany) was inserted through the instrumentation port and placed into the lateral wall of the ventricle (video). To determine the actual position of the lead transoesophageal echocardiography was used. After taking threshold measurements (see Table 1) a 20—25 cm loop of the lead was loosely placed in the thoracic cavity to facilitate reexpansion of the lung without exerting traction to the lead. After removal of the port, the proximal end of the epicardial lead was passed through the medial incision and guided to the pacemaker pocket with the help of a rigid guide enabling subcutaneous tunnelling. The pocket was reopened and the lead was connected.

Upon completion of surgery, an intercostal suction drainage was introduced through the lateral incision, while the medial one was closed.

After extubation in the operating theatre the patients were transferred to the intensive care unit. Perioperative antibiotic prophylaxis with 3 × 2 g cefazolin was administered in all patients.

The postoperative follow-up was done on an outpatient basis, with subjective evaluation of the quality of life, NYHA function class, electrocardiographic and echocardiographic exploration after one and thereafter every 3 months.

3. Results

The procedure was well tolerated in all cases. There was neither surgical morbidity nor mortality.
Table 1
Acute and chronic pacing thresholds and development of NYHA function class

<table>
<thead>
<tr>
<th>Age/sex</th>
<th>Intraoperative threshold (V/μs)</th>
<th>Threshold at 1 month (V/μs)</th>
<th>Threshold at 7 months (V/μs)</th>
<th>NYHA preoperative</th>
<th>NYHA at 7 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>57/M</td>
<td>0.6/0.5</td>
<td>0.7/0.5</td>
<td>0.8/0.5</td>
<td>III</td>
<td>I and II</td>
</tr>
<tr>
<td>76/M</td>
<td>1.0/0.5</td>
<td>2.8/0.5</td>
<td>2.4/0.5</td>
<td>III</td>
<td>II</td>
</tr>
<tr>
<td>71/M</td>
<td>0.7/0.5</td>
<td>0.9/0.5</td>
<td>1.3/0.5</td>
<td>III</td>
<td>II</td>
</tr>
<tr>
<td>49/M</td>
<td>0.7/0.5</td>
<td>3.0/1.0</td>
<td>2.0/1.0</td>
<td>IV</td>
<td>IV</td>
</tr>
<tr>
<td>56/F</td>
<td>1.0/0.5</td>
<td>1.1/0.5</td>
<td>2.2/0.5</td>
<td>III</td>
<td>II</td>
</tr>
<tr>
<td>62/F</td>
<td>0.5/0.5</td>
<td>1.0/0.5</td>
<td>2.5/0.5</td>
<td>III</td>
<td>II</td>
</tr>
<tr>
<td>62/M</td>
<td>1.2/0.5</td>
<td>1.8/0.5</td>
<td>3.8/0.5</td>
<td>III</td>
<td>II</td>
</tr>
<tr>
<td>63/M</td>
<td>0.8/0.5</td>
<td>2.0/0.5</td>
<td>2.5/0.5</td>
<td>III</td>
<td>II</td>
</tr>
<tr>
<td>53/F</td>
<td>1.0/0.5</td>
<td>1.6/0.5</td>
<td>2.4/0.5</td>
<td>III</td>
<td>II</td>
</tr>
<tr>
<td>46/M</td>
<td>0.8/0.5</td>
<td>1.3/0.4</td>
<td>1.5/0.5</td>
<td>III</td>
<td>II</td>
</tr>
<tr>
<td>74/M</td>
<td>1.2/0.5</td>
<td>1.6/0.5</td>
<td>1.8/0.5</td>
<td>III</td>
<td>II</td>
</tr>
<tr>
<td>57/F</td>
<td>1.0/0.5</td>
<td>2.0/0.5</td>
<td>2.2/0.5</td>
<td>III</td>
<td>II</td>
</tr>
<tr>
<td>70/M</td>
<td>0.7/0.5</td>
<td>2.0/0.5</td>
<td>4.0/0.5</td>
<td>III</td>
<td>III</td>
</tr>
<tr>
<td>69/F</td>
<td>0.6/0.5</td>
<td>1.4/0.5</td>
<td>1.6/0.5</td>
<td>III</td>
<td>II</td>
</tr>
<tr>
<td>69/M</td>
<td>0.8/0.5</td>
<td>1.0/0.5</td>
<td>1.8/0.5</td>
<td>III</td>
<td>II</td>
</tr>
</tbody>
</table>

Good intraoperative pacing thresholds were obtained in all cases (see Table 1). Mean skin-to-skin operation time was 55 ± 16 min and no conversion to thoracotomy was necessary, not even in one case that presented with extensive pleuropulmonary adhesions following pneumonia.

All patients were extubated in the operating room and remained in the intensive care unit for less than 24 h. The consumption of analgetics was minimal. The chest tubes were removed after a mean of 1.6 ± 0.5 days and the patients were discharged after a mean of 4 ± 1.3 days.

In the outpatient follow-up there was no intercostal neuralgia. Since only two small incisions were required for successful implantation, the cosmetic result was very good. The pacing thresholds at 3 and 7 months were satisfactory in all cases. In one patient, whose NYHA function class did not improve, the threshold was 4.0 V/0.5 ms, in all others it was between 0.8 and 3.8 V/0.5–1.0 ms (see Table 1). There was no lead displacement. At 7 months follow-up in all but two cases the NYHA function class had improved, correlating to subjective improvement felt by the patients.

4. Discussion

Transvenous, fluoroscopically guided insertion of the leads into the epicardial veins of the left ventricle has become the standard procedure in cardiac resynchronisation therapy. It has widely replaced the surgical implantation via thoracotomy because of high morbidity and mortality following the latter [4,10,11]. Unfortunately, the pathway over the coronary vein for lead implantation poses significant drawbacks, as it is totally dependent on the inconsistent venous anatomy and therefore can be very time consuming. In the case of small coronary veins it may be unfeasible, whereas in the case of large coronary veins it is often associated with changes in pacing thresholds [4,10]. In some instances the procedure requires long exposure to X-rays, which accounts for significant risk to the patient and the interventional teams. Moreover, life-threatening complications such as coronary sinus perforation may occur [7].

Surgical epicardial stimulation has a number of advantages: it enables direct visualisation of the epicardium, aids in choosing the most suitable surface and helps to avoid epicardial fat and areas of fibrosis that can cause changes in pacing thresholds. This is why the implantation failure rate is lower with surgical implantation than with the transvenous technique [6,12]. Thoracotomy, however, carries a considerable rate of related morbidity and mortality [6].

Video-assisted thoracoscopy (VATS) has become a routine procedure in thoracic surgery. Its advantages are clear visualisation of the operation field, less tissue trauma, less pain, a quicker recovery and a better cosmetic result [6]. In a series of 43 patients, it was documented that the left ventricular stimulation site is the key for achieving improvement in haemodynamics. Lateral free wall stimulation produces significantly better systolic performance compared with anterior stimulation [12]. The accurate positioning of the lead is enabled by VATS due to greater freedom of access to lateral and posterobasal segments of the left ventricle. Therefore, in cases where transvenous implantation of the left ventricular lead fails, VATS is an alternative.

Up to this time, only two series and two case reports about minimally invasive techniques for epicardial lead implantation have been published [6—9]. Only one author used routine VATS technique with the lung collapsed, requiring three ports, whereas the others advocated robotic technology such as the ‘da Vinci’ system (Intuitive Surgical Inc., USA). This system contributes advantages to standard video-assisted thoracoscopy, such as three-dimensional vision, tremor elimination and the possibility of stitching the lead in place. However, the considerable costs per intervention and the long operating times are definitive shortcomings [7,9]. Moreover, due to the capital equipment costs of the Robotic systems they are not available but in a few specialised centres.

In the present series a simplified technique, using only two ports, was applied. The right-lateral decubitus position enabled both a good vision and access for the instruments in spite of the enlarged heart. We preferred single-lung ventilation with collapse of the left lung to insufflation of CO2, because of the option of using standard instruments over a flexible instrumentation port. By using standard clamps and scissors the procedure was done very quickly and at a minimum of cost. The skin-to-skin operating time including the access to the pacemaker was considerably shorter than in the case of large coronary veins it is often associated with changes in pacing thresholds [4,10]. In some instances the procedure requires long exposure to X-rays, which accounts for significant risk to the patient and the interventional teams. Moreover, life-threatening complications such as coronary sinus perforation may occur [7].

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electrodes were satisfactory. There were no lead dislocations and the NYHA function class improved in all but 2 out of 15 patients. The positioning of the two ports in the same intercostal space may have contributed to the fact that the postoperative pain was minimal.

Nevertheless, VATS has also some disadvantages compared to the transvenous technique. It requires general anaesthesia, placing the patient in the lateral decubitus position, and maintaining single-lung ventilation for the operation. Though in the present series there were no complications or problems regarding anaesthesia, patients who do not tolerate single-lung ventilation may be unsuitable for standard VATS.

Intrathoracic manipulation of the instruments and the insertion of the lead can cause laceration in the epicardium and the lung requiring conversion to thoracotomy. The presence of pleural and/or pericardial adhesions can hinder the procedure and even force conversion to thoracotomy. This is why minithoracotomy is preferred in patients with a history of open heart surgery, especially after coronary artery bypass grafting with revascularisation of the lateral wall.

5. Conclusion

Video-assisted thoracoscopy using two ports seems to be an excellent alternative procedure for epicardial lead implantation. Due to its ready availability, the good pacing results, the short intervention time and the tolerable stress for the patients it should be considered for those cases in whom the standard transvenous technique fails.

References


Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.ejcts.2005.08.026.