Robotic-Assisted Thoracoscopic Implantation of an Epimyocardial Lead for Biventricular Pacing

J.R.M. SANT´ANNA, P.R.L. PRATES, R.A.K. KALIL, P.R. PRATES, M. MORETTO, R. SANT´ANNA, I.A. NESRALLA
Serviço de Cirurgia Cardiovascular do Instituto de Cardiologia do Rio Grande do Sul/Fundação Universitária de Cardiologia, Porto Alegre, Brazil

Summary

When coronary sinus lead implantation is not feasible for biventricular pacing, alternative methods must be considered. This article reports on the robotic-assisted thoracoscopic implantation of a left ventricular lead in three patients with dilatative cardiomyopathy and severe heart failure. Under general anesthesia, three openings were made in the left thorax for instruments, lead introduction, and a voice-controlled robotic endoscope. The pericardium was opened and the epicardial "screw-in" lead was introduced through a 15 mm opening and fixated in the lateral wall of the left ventricle. The lead's connector end was advanced into the left pectoral area, where radioscopic implantations of transvenous right atrial and right ventricular leads had been performed (in two patients). One patient had a previously implanted pacemaker and the surgical procedure in this case consisted mainly of the implantation of the left ventricular lead, as the existing transvenous right ventricular lead could be used for biventricular pacing. Patients were extubated after the procedure and discharged from the intensive care unit in less than 12 hours. Electrophysiologic evaluations of the left ventricular lead performed during the implantation, three days after surgery, and one month after surgery, yielded satisfactory results (threshold < 1.5 V). Biventricular pacing was effective in all patients during the short-term evaluation conducted one month after surgery. Implantation of an epicardial left ventricular lead with a robotic-assisted thoracoscopy could be easily performed with minimal trauma to the patient and yields satisfactory short-term results. A subsequent long-term evaluation of the left ventricular lead will confirm the efficacy of the proposed technique.

Key Words

Dilatative cardiomyopathy, biventricular pacing, robotic surgery

Introduction

Biventricular pacing has been considered for the treatment of congestive heart failure secondary to dilatative cardiomyopathy and intraventricular conduction blocks [1]. In the majority of reported cases, the left ventricular lead is positioned via the coronary sinus (CS) [2]. However, the positioning of a CS lead is not always possible, due to anatomical conditions such as coronary sinus valves [3]; for technical reasons, such as an increased threshold and risk of lead displacement; and because of practical limitations, such as high costs and limited availability (in some countries). Previously implanted transvenous leads may also reduce the indication for an additional CS lead.

Alternative techniques for obtaining ventricular resynchronization have been performed using different sites, such as positioning a second ventricular lead in the right ventricular outflow tract [4], or the implantation of epicardial lead(s) [5]. Dual-site right ventricular pacing can be easily achieved, but the benefits of this are as yet inconclusive. The epicardial implant offers the opportunity to select the most appropriate area to pace the left ventricle, but it requires a thoracotomy, resulting in increased trauma to the patient. In the presence of severe heart failure, surgical trauma assumes a higher magnitude and increased risk.

Characteristic	Patient 1	Patient 2	Patient 3
Sex	Male	Male	Female
Age (years)	27	71	35
Ethiology of the cardiomyopathy	Idiopathic	Idiopathic	Idiopathic
Functional class (NYHA)	IV	III	III
Cardiac rhythm	Sinus (unstable atrium)	Atrial fibrillation	Sinus
Previous procedure	–	Transvenous pacemaker	–

Table 1. Clinical characteristics of the patients.

In order to reduce the trauma related to thoracotomy, we implanted the left ventricular epimyocardial lead by means of robot-assisted thoracoscopy. This lead, together with a right ventricular transvenous lead, produced biventricular pacing. The objective of this article is to present this new technique and its initial results.

Materials and Methods

Patients

Three patients were studied, two male and one female; 27, 35, and 71 years old respectively. All presented with congestive heart failure due to dilatative cardiomyopathy that was not responsive to medical treatment. Two patients were NYHA Class III and one was NYHA Class IV. The youngest patient experienced periods of atrial flutter, requiring electrical cardioversion prior to pacemaker implantation. The oldest patient had a previously implanted DDD pacemaker, currently programmed in VVI mode following the development of atrial fibrillation. All patients presented with left bundle block with a wide QRS (> 150 ms). A bi-dimensional Doppler echocardiogram and chest X-ray confirmed the diagnosis of dilatative cardiomyopathy. Table 1 illustrates some of the clinical characteristics of the patients.

Preoperative Procedures

An electrocardiogram, chest X-ray, and coagulogram were performed prior to surgery. Preoperative procedures included shaving the thoracic and left axillary regions the morning of the surgery, nothing by mouth for six hours prior to the procedure, prophylactic antibiotic therapy, and pre-anesthesia medication.

The following equipment was available in the operating room: a portable radioscope, video-assisted thoracoscope with an 8 mm zero degree endoscope (Telescan DX NTSC), light source (Xenon Nova), a CO_2 insuflator (Electronic Endoflator, all products from Karl Strorz Endoscope, Germany), and an AESOP voice-controlled endoscope positioning robot with the HERMES Control Center (Computer Motion, USA). Surgical instruments for performing the thoracotomy were also available.

Patients were monitored and anesthetized. A Carlins endotracheal tube was introduced into the trachea in order to ensure selective ventilation of the right lung during the video thoracoscopy. Two patients (cases 1 and 3) were initially placed in the supine position for the implantation of transvenous leads in the right atrium and right ventricle using the left subclavian vein for access. After positioning was confirmed by electrophysiologic evaluation, the leads were fixed through the venous access and its connector ends were hidden in a subcutaneous pocket, the future location of the pacemaker. The skin was sutured and the incision protected. Taking into account the presence of the transvenous lead(s), the patients were placed in the left anterior oblique position, the left thorax being slightly elevated by a small pillow under the right axilla. In the sterile operating room the AESOP robot was situated on the right side of the surgical table, opposite to the surgeon. A 10 mm opening was made in the left anterior axillary line at the fourth intercostal space (for the thoracoscope) and the video thoracoscope was introduced and attached to the operational arm of the AESOP robot. Selective ventilation of the right lung was assured to improve the surgical field and to reduce the risk of pulmonary trauma. Visual evaluation of the pleural cavity and pericardium confirmed the viability of performing the procedure using the selected approach. Sub-sequently, a 5 mm opening was made in the left median axillary line at the sixth intercostal space (using the forceps) and a 15 mm opening was made in the left median axillary line at the sixth intercostal space (for the scissors, electrocautery, and epicardial lead), according to the proposed axillary approach for thoracoscopy [6].

A forceps and scissors were used to create a left pericardial window. Hemostasis was ensured. The implantation area of the epimyocardial sutureless lead (ELC 54, Biotronik, Germany) was selected, whereby a position perpendicular between the surface of the

Characteristic	Patient 1		Patient 2		Patient 3	
Period	Implant	1st month	Implant	1st month	Implant	1st month
Atrial stimulation threshold (V)	0.4	AFlut.	nc	AFib	0.5	0.8
P-wave (mV)	0.8	AFlut	nc	nd	1.2	1.1
Right ventricular stimulation threshold (V)	0.3	0.8	nc	1.1	0.5	0.9
Left ventricular stimulation threshold (V)	1.0	nd	0.6	1.1	1.1	nd

Table 2. Electrophysiologic measurement of electrodes. AFlut =s atrial flutter; AFib = chronic atrial fibrillation; nc = not considered, as the electrode was implanted > 6 years; nd = not available due to pacemaker characteristics.

heart and the longitudinal line, representing the axle of the lead holder, was considered ideal.The tip electrode was fixated in the cardiac muscle. The guiding catheter was removed and the electrode was fixated to the heart. A portion of the lead wire was introduced into the pericardial cavity with the aid of the forceps.

An electrophysiologic evaluation of the lead was performed. The opening corresponding to the lead was closed and the lead wire was sutured into the intercostal muscles, with a satisfactory length to avoid retraction as the left lung was ventilated. The thoracoscope was removed. A small drain was left in the pleural cavity through the opening corresponding to the forceps. The pacemaker pouch was opened to connect the lead, which passed through the subcutaneous tissue from the incision at the sixth intercostal space.

For the two patients for whom this was their first pacemaker implant, the transvenous and epicardial leads were connected to the Triplos LV pacemaker (Biotronik, Germany). For the patient with a previously implanted DDD pacemaker, the pacemaker was explanted and the transvenous right ventricular lead was used for biventricular pacing as follows: a Physios DR DDD pacemaker (Biotronik, Germany), programmed in DDT mode with a short atrioventricular delay (15 ms), was connected to the leads, with the ventricular channel connected to the epicardial lead. The pacemaker was introduced into the subcutaneous pouch and the incision was sutured.

A pleural drain was placed into the lower thoracic incision, and the other incisions were sutured and dressed. Left intercostal nerves connected to the incision were anesthetized with Marcaine 0.25%. The patients were extubated in the OR, kept in the intensive care unit (ICU) for six to 12 hours, and then moved out of the ICU after the chest drain was removed. Hospital discharge occurred three days after surgery.

Postoperative Evaluation

Before hospital discharge, the leads were subjected to a telemetric evaluation by the pacemaker. One month after surgery, clinical, radiologic, and pacemaker evaluations were performed.

Results

There was no intraoperative morbidity or mortality. The older patient developed left lung atelectasis, which was successfully treated with physiotherapy. After discharge from the ICU, the patient who had previously presented with an arrhythmia experienced an episode of supraventricular arrhythmia. Drug therapy (Amiodarone) was administered and the arrhythmia was reversed. Nevertheless, this arrhythmia reoccurred several times after the patient was discharged from the hospital.

Table 2 shows an intraoperative evaluation of the patients' pacemaker implants, along with an evaluation of the first post-operative month. Results for the epicardial lead implanted in the patient with a DDD pacemaker used for biventricular pacing were acceptable (pacing threshold of 1.1 V). A specific evaluation of the lead threshold could not be performed for the patients with a Triplos LV pacemaker.

Discussion

The use of video thoracoscopy for the implantation of epicardial leads has already been described [7-8]. Larger epicardial patches for implantable defibrillators were also implanted without performing a thoracotomy, resulting in reduced morbidity [9]. Such an improvement in the surgical results was logical, as the patches were implanted by means of a sternotomy or a large thoracotomy. With the development of thinner and more effective transvenous leads, the need for the transthoracic approach is reduced.

Video thoracoscopy has been used in several thoracic and cardiovascular interventions [10]. The develop-

ment of robotic surgery increased the use of video thoracoscopy [11] in cardiac surgery. Furthermore, the use of a robot may reduce the size of the thoracotomy (miniport operations) [12], facilitate using the internal thoracic artery in closed chest surgery for minimally invasive direct coronary artery bypass [13], and use of the internal thoracic artery or the anterior descending coronary artery as implantation sites during closed chest surgery, in experimental and clinical settings [14-15].

The authors were unable to find any documentation concerning the use of video thoracoscopy for the implantation of left epimyocardial leads for biventricular pacing or the implantation of epicardial leads with the aid of a robot. But this combination would certainly result in reduced surgical trauma, as compared to a thoracotomy, which still remains desirable for patients with severe cardiac disease. Such prospects motivated us to develop a video thoracoscopic, robotic-assisted technique to implant a single left ventricular lead; this lead was combined with a transvenous right ventricular lead for biventricular pacing.

The lead implantation yielded satisfactory results in terms of electrophysiologic monitoring in all patients and became easier to perform as experience with the technique increased. Surgical and post-operative morbidity were low and there were no specific complaints from the patients.

Some contraindications to the procedure may exist, such as severe pneumonopathy and prior cardiac surgery (resulting in pericardial or pleural adhesions). It should also be noted that the described surgical approach will not result in a successful lead implantation in the following cases:

- when coronary vessels, epicardial fat, or adhesions are found within the pericardial window;
- since the epicardial leads used were not developed for thoracoscopic implantation, the guiding catheter has a large diameter and irregular surface due to the parallel placement of the lead (causing difficulties with fixation).

A more suitable lead should be designed. Perhaps video thoracoscopic implantation will become an attractive technique. If the implantation of a left ventricular lead is not feasible with the video technique, it may be necessary to enlarge the pericardial window or perform a small thoracotomy (procedure conversion). This opening may be used as a starting point for a thoracic wall incision, and the thoracoscope would help visualize the direct open-chest implantation.

The technique described here may be useful for two groups of patients:

- patients with an indication for biventricular pacing when a CS lead implantation is not feasible, as illustrated in this paper;
- patients with an indication for conventional ventricular pacing, but with limitations to perform a transvenous implantation, such as tricuspid valve malformation or prosthesis, disease of the endocardium (myocardial fibrosis), or a multiple number of previously implanted leads that cannot be removed.

Conclusion

The intent of this article is not to demonstrate the advantages of epicardial biventricular pacing. However, from a clinical point of view, the two older patients definitely benefited from this procedure. The younger patient experienced several episodes of atrial flutter with increased ventricular response after being discharged from the hospital, which reduced the periods of biventricular pacing with adequate heart rate. Ablation of the atrioventricular node will be considered for this patient, because arrhythmia response to drug therapy is limited.

One should take into account that factors such as surgical experience, general anesthesia, selective pulmonary ventilation, equipment availability, specific epicardial leads, and unknown long-term results are important limitations of robotic-assisted implantation of epicardial leads, as is illustrated in this paper. However, this technique may be an appealing alternative in selected cases, and may become useful as suitable leads are developed and surgical experience increases.

References

[1] Stellbrink C, Auricchio A, Diem B. Potential benefit of biventricular pacing in patients with congestive heart failure and ventricular tachyarrhythmia. Am J Cardiol. 1999; 83: 143D-150D.

[2] Saxon LA, Boehmer JP, Hummel J. Biventricular pacing in patients with congestive heart failure: Two prospective randomized trials. Am J Cardiol. 1999; 83: 120D-123D.

[3] Corcoran SJ, Lawrence C, McGuire MA. The valve of Vieussen: An important cause of difficulty in advancing catheters into cardiac veins. J Cardiovasc Electrophysiology. 1999; 10: 804-808.

[4] Pachón Mateos JC, Pachón Mateos JC, Albornoz RN, et al. Estimulação elétrica na insuficiência cardíaca. Marcapasso ventricular direito bifocal. Reblampa. 2000; 13: 211-217.

[5] Peters RW, Gold MR. Pacing for patients with congestive heart failure and dilatative cardiomyopathy. Cardiol Clin. 2000; 18: 55-56.

[6] Frank MW, Backer CL, Mavroudis C, Joob AW. Axillary thoracoscopy. Ann Thorac Surg. 1998; 66: 590-591.

[7] Furrer M, Fuhrer J, Altermatt HJ, et al. VATS-guided epicardial pacemaker implantation. Hand-sutured fixation of atrioventricular leads in experimental seeting. Surg Endosc. 1997; 11: 1167-1179.

[8] Ohtsuka T, Kohno T, Hirata K, et al. Thoracoscopic implantation of a pacemaker lead: experimental study. Surg Laparosc Endosc. 1997; 7: 99-102.

[9] Obadia JF, Kirlorian G, Rescigno G, et al. Thoracoscopic approach to implantable cardioverter defibrillator patch electrode implantation. PACE. 1996; 19: 955-959.

[10] Colt Hg. Thoracoscopy: window to the plerual space. Chest. 1999; 116: 1409-1415.

[11] Kavoussi LR, Moore RG, Adams JB, Partin AW. Comparison of robotic versus human laparoscopic camera control. J Uro. 1995; 154: 2134-2136.

[12] Shennib H, Bastawisy A, Mcloughlin J, Moll F. Roter computer-assisted telemanipulation enhances coronary artery bypass. J Thorac Cardiovasc Surg. 1999; 117: 310-313.

[13] Mack M, Acuff T, Yong P, et al. Minimally invasive thoracoscopically assisted coronary bypass surgery. Eur J Cardio Surg. 1999; 12: 20-24.

[14] Carpentier A, Loulmet D, et al. Computer-assisted open heart surgery: First case operated on with success. C R Acad Sci. 1998; 321: 437-442.

[15] Tabaie FA, Reinbolt JÁ, Graper P, et al. Endoscopic coronary bypass (ECABG) procedure with robotic assistance. Heart S Forum. 1999; 2: 310-317.

Contact
João Ricardo M. Sant'Anna, MD
Instituto de Cardiologia do Rio Grande do Sul
Av. Princesa Isabel, 395
Porto Alegre – RS 90620-001
Brazil
Telephone: +55 (51) 3217 3018
Fax: +55 (51) 3217 1358
E-mail: tofani@ez-poa.com.br