A Hybrid Approach to Cardiac Resynchronization Therapy

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Background: CRT (atrial-synchronized bi-ventricular pacing) has been shown to significantly improve the quality of life and exercise tolerance in patients with moderate-severe heart failure and an interventricular conduction delay (>120 msec) when compared to controls. Traditionally it has been performed by cardiologists in electrophysiology laboratories. In the event that the left ventricular lead cannot be positioned percutaneously the procedure is aborted and the cardiac surgeon consulted. The subsequent intervention by the surgeon, typically on another day, requires reexploration of the pocket, a thoracotomy, which results in an increase in length of stay (LOS), and an increase in infection risk. The objective of this study was to demonstrate that CRT could routinely be performed in a surgical operating room (OR) as a single rather than a staged procedure.

Methods: Between 1/1/06 and 7/1/06 18 patients (17 male and 1 female) with an average age of 56 years (range 36–79) underwent CRT. Transthoracic echo (TTE) revealed that all had left ventricular ejection fractions (LVEF) <30% (range 8%–28%). Five of the 18 had moderate-severe mitral regurgitation (MR). The etiology of the cardiomyopathies was ischemia in 4 and non-ischemia in 14. All had QRS intervals >120 msec (range 120–200 msec) and all were maintained preoperatively on their conventional therapy for heart failure (B-blockers, ± diuretic, ± ACE-I or ARB) and all were either New York Heart Association (NYHA) functional class III or IV. Every case was performed under general anesthesia with an arterial line and Foley catheter in the semi right lateral decubitus position. Nine of the 18 patients underwent a left anterolateral mini-thoracotomy for epicardial left ventricular (LV) lead placement. All hardware included defibrillation technology (ICD).

Results: All 18 patients left the OR with successful bi-ventricular pacing in an average time of 170 minutes (range 140–200 min). The average epicardial lead pacing threshold was 0.9v (range 0.4–1.5v) while the average endocardial (transvenous) threshold was 0.4v (range 0.2–0.7v) at a pulse width of 0.5 msec. TTE at 1 month demonstrated an improvement in LVEF in 14/18 patients with an average increase of 5% (range 2%–9%). Four of the 5 patients with moderate-severe MR were reduced to mild. The average length of stay (LOS) following the procedure, in those patients who did not undergo a thoracotomy, was 4 days (range 3–6 days) while it was 7 days (range 6–10 days) in those who underwent a thoracotomy.

Conclusion: These data clearly indicate that CRT can be successfully performed as a single-staged procedure in a cardiac OR. Although transvenous LV lead placement avoids a thoracotomy, the epicardial LV lead thresholds, in this series, are competitive with the transvenous results. We propose that in the spirit of cost containment, fee bundling, decreasing reimbursement, pay-for-performance, and infection control, these complex interventions should be performed in multipurpose interdisciplinary hybrid cardiac OR’s, now available in most major medical centers, with designated time limitations and role assignments.
Introduction

Twenty-five to thirty percent of patients with congestive heart failure (CHF) have left-bundle branch block (LBBB). In fact, the risk of sudden death is significantly higher at one year in those with LBBB than those in CHF without LBBB. Experimental and clinical evidence have clearly shown that dysynchronous contraction of the 2 ventricles is mechanically inefficient which is manifested by a decreased left ventricular ejection fraction (LVEF) and cardiac output.

Typically, biventricular pacing leads are placed percutaneously by a cardiologist in an electrophysiology lab and connected to a generator where pacing is timed to coordinate electrical activation. Simultaneously the right atrium is also paced, with a shortened atrioventricular pacing delay, to ensure consistent ventricular pacing, since sinus beats override the beneficial effect of biventricular pacing.

Placement of the left ventricular (LV) lead fluoroscopically via the coronary sinus can be technically challenging. In the event this lead cannot be secured, the electrophysiologist consults a cardiac surgeon who, on the next available opportunity, and under general anesthesia, performs a thoracotomy to position the LV lead with direct vision.

In this report, we review the experience of a single surgeon (RLQ) in CRT (placement of all leads) and present our recommendations on how the performance and results of this complex technical procedure could be enhanced.

Methods

Patients

During a 6-month period in 2006 (1/1/06–7/1/06), 18 patients (17 males and 1 female) with an average age of 56 years (range 36–79) underwent CRT performed by one surgeon (RLQ).

To qualify for the procedure, all patients had a LVEF, as measured by transthoracic echo (TTE), <30% (range 8%–28%) with a QRS interval >120 msec (range 120–200 msec). Five of 18 had moderate-severe mitral regurgitation (MR). The etiology of the cardiomyopathies was non-ischemic in all but 4 of the patients. All patients were compliant yet refractory to their conventional therapeutic regimen for CHF (B-blockers, diuretic, +/- Angiotensin I converting enzyme (ACE-I) or Angiotensin II receptor blockers (ARB) and were either New York Heart Association (NYHA) functional class III or IV.

Operative techniques

Every patient underwent general anesthesia with airway intubation after the placement of 2 wide-bore venous access catheters and a radial arterial line. A Foley catheter was placed after anesthesia induction.

All patients were positioned in a semi right lateral decubitus position, using a bean bag, and draped and prepped from chin to groin. A standard subcutaneous pocket was created for the device caudal to the left clavicle. Three (3) guidewires were directed, with fluoroscopic assistance, into the superior vena cava. Using the Seldinger technique the right ventricular (RV) lead, which also serves as the defibrillator lead, was placed with fluoroscopic assistance. It was secured and tested for pacing threshold. Similarly the LV lead was guided into the coronary sinus which was indentified with radiopaque dye after intubation with a guiding catheter. Pacing thresholds were then obtained in this lead, with care taken to avoid diaphragmatic stimulation (muscle relaxant used sparingly). The right atrial lead was placed similarly with the recording of thresholds. All leads were then connected to the device which was inserted into the aforementioned pocket and tested with a sterile wand.

All hardware included defibrillation technology.

In the event that the LV lead could not be positioned within 120 minutes, a small left anterolateral thoractomy was performed in the fifth intercostal space to expose the pericardium. A small (<2 cm) pericardiotomy was then performed with the phrenic nerve under direct vision. Two epicardial LV leads were then screwed into the LV myocardium and tunneled up to the subclavicular pocket. Thresholds were than taken and the higher lead was capped and buried in the pocket. The lower threshold lead was attached to the device, and the procedure continued as above. A small Jackson-Pratt drain was placed in the hemithorax, and the chest was closed as per routine.

Results

All 18 patients left the operation room (OR) with completed bi-ventricular pacing in an average time of 170 minutes (range 140–200 min). Table 1 compares the LV pacing thresholds between those patients paced endocardially to those paced epicardially.

TTE one month postoperatively demonstrated an average improvement of 5% (range 2%–7%) in LVEF in 14 of the 18 patients. Four of the five patients with moderate-severe MR had their valve pathology downgraded to mild MR.
The average length of stay (LOS), following the procedure, in those patients who did not undergo a thoracotomy, was 4 days (range 3–6 days) while it was 7 days (range 6–10 days) in those who underwent a thoracotomy.

Discussion

Although transvenous pacing was originally pioneered and popularized by a cardiac surgeon (Parsonnet 1978), the procedure soon was considered to be non-challenging and financially less rewarding than the more “glamorous” open-heart procedures. Consequently our colleagues in cardiology seized the opportunity to learn the implant procedure and for the last generation have performed the bulk of these “surgical cases.”

Coincident with the monopoly on pacemakers the cardiologists have developed successful percutaneous techniques to safely address coronary disease and are on the verge of doing the same with valvular disease. Consequently the volume of cardiac surgery cases has diminished significantly. Many cardiac surgeons are now retiring, retraining, or reactivating their general thoracic skills.

CRT is a relatively new procedure that, as this series indicates, can be performed by a cardiac surgeon in a cardiac OR. However CRT also represents a clear opportunity for a multidisciplinary approach to a clinical procedure where the synergy of the combined expertise of cardiology and cardiac surgery can easily result in a victory for all including hospital administration.

In a multipurpose interventional hybrid OR, equipped with digital imaging diagnostics, CRT could easily be performed by cardiologists and surgeons working together. Each specialist could do what they do best. The surgeon would oversee the sterile technique including the draping and prepping of the patient and create the pocket. The cardiologist would percutaneously place the leads. If the LV lead could not be positioned within a set time period (i.e. 30 min) the surgeon would perform an immediate mini-thoracotomy to screw in the tunneled epicardial LV leads. The administrator would benefit from the obvious decreased LOS, decreased procedure

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<tr>
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<tr>
<td>Epicardial (n = 9)</td>
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<td>Endocardial (n = 9)</td>
<td>0.4v</td>
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Table 1 LV lead pacing thresholds (pulse width = 0.5 msec) on all 18 patients comparing endocardial and epicardial leads

![Fig. 1](image1) Left anterior oblique fluoroscopic image of dye injected into the coronary sinus demonstrating coronary venous anatomy and possible target implant sites for LV lead.

![Fig. 2](image2) Fluoroscopic image of completed case indicating RA, RV, and LV leads secured in position.
time, and the resultant decreased risk of infection.

Rather than watching their surgical armamentarium shrink before their eyes surgeons should step up and offer their skills to a procedure that would not only benefit the “system” but most importantly the patient.

References

