Robotic LV Epicardial Lead Placement: Indications and Technique

Sandhya K. Balaram, M.D., Ph.D.
Division of Cardiothoracic Surgery
St. Luke's-Roosevelt Hospital Center
Assistant Professor of Clinical Surgery
Columbia University College of Physicians and Surgeons

Cardiac Resynchronization Therapy

- CRT improves functional status and cardiac performance in patients with CHF and intraventricular conduction delay:
  - Ventricular function
  - Exercise capacity
  - Quality of life
  - Mortality
- Response rate ranges from 69-72%

Percutaneous Coronary Sinus Cannulation

Advantages

- Local anesthesia
- Same access as right-sided lead

Percutaneous Coronary Sinus Cannulation

Disadvantages

- 10-15% procedural failure rate
- Limited by coronary venous anatomy
- 5-10% late failure rate
- **Site on LV is limited**
- Long fluoroscopy time

Surgical LV leads: Is there a need ?

- 2 million patients with NYHA class III-IV CHF
- 30-50% have widened QRS (600,000-1,000,000)
- CS failure rate of 15% (90,000-150,000)
- Lead dislodgement rate of 7% (42,000-70,000)

Alternative Approaches to Percutaneous LV Pacing

- Sternotomy
- Thoracotomy
- Mini-thoracotomy
- Thoracoscopy
- Robotic

Thoracotomy

- Most common incision used for CS lead failure
- Morbidity includes:
  - Postoperative pain
  - Respiratory complications
  - Atelectasis/pneumonia
  - Several days of recovery

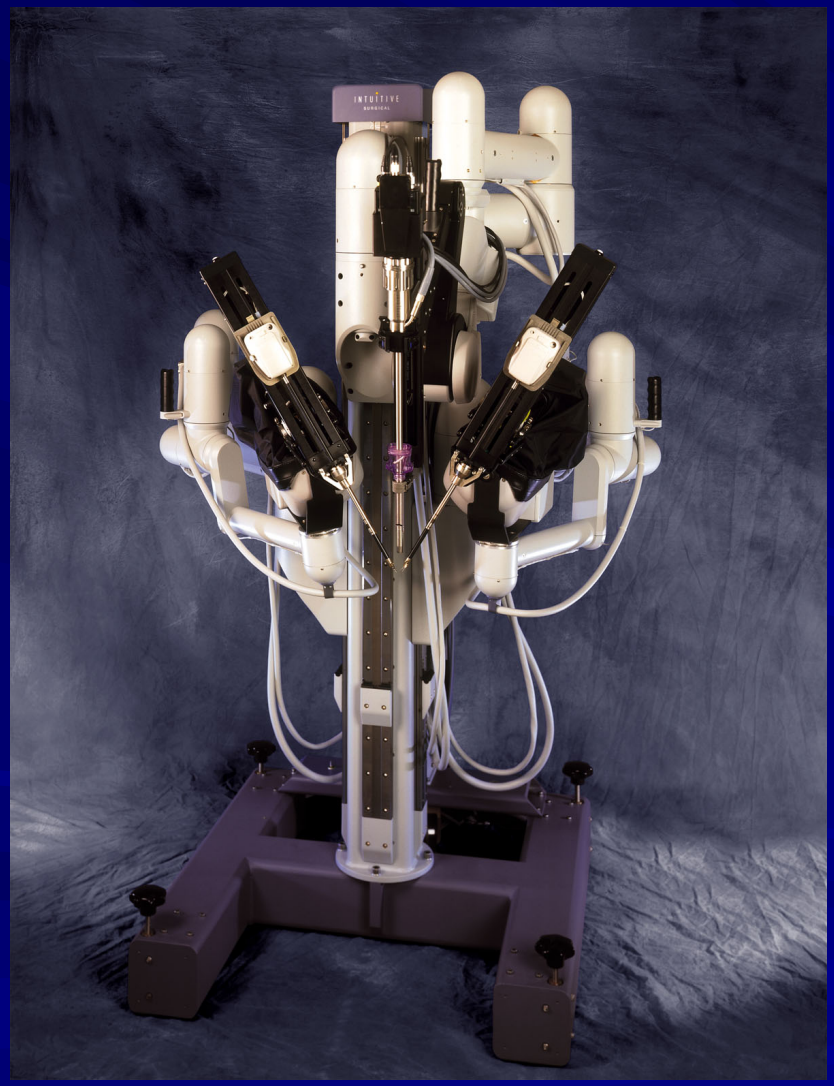
Limited Thoracotomy/Sternotomy

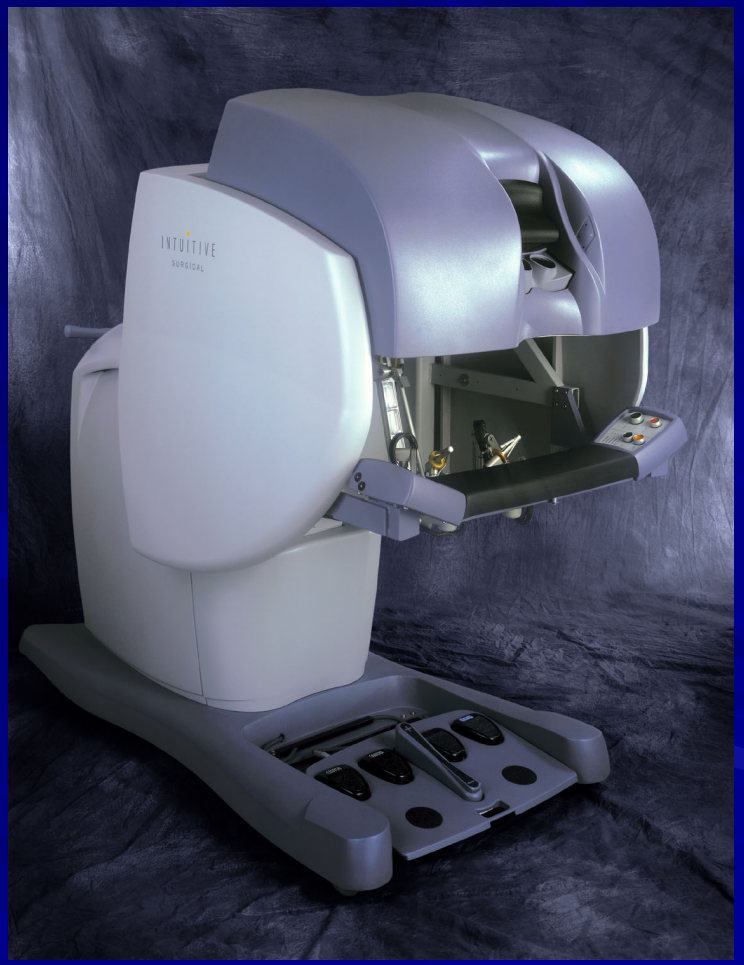
- Minimally invasive method
- Difficult to access posterolateral wall
- Ability to use screw in leads with minimal cardiac displacement

Thoracoscopy

- Eliminates chest wall retraction, thereby decreasing postoperative pain and splinting
- Shortens postoperative recovery
- Technology support with screw in tools
- Good visualization
- Difficult to access entire heart, especially in the presence of cardiomegaly or adhesions

DaVinci™ Robot






INTUITIVE
SURGICAL
da Vinci

Robotic LV Epicardial Leads

Advantages

- Direct placement on any portion of the LV
- Minimally invasive
- Site-directed approach

Robotic LV Epicardial Leads

Disadvantages

- General anesthesia
- Single lung ventilation

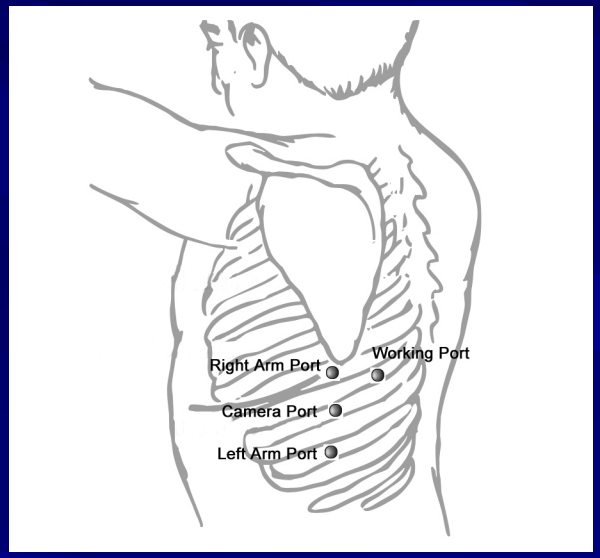
Indications For Robotic LV Lead Placement

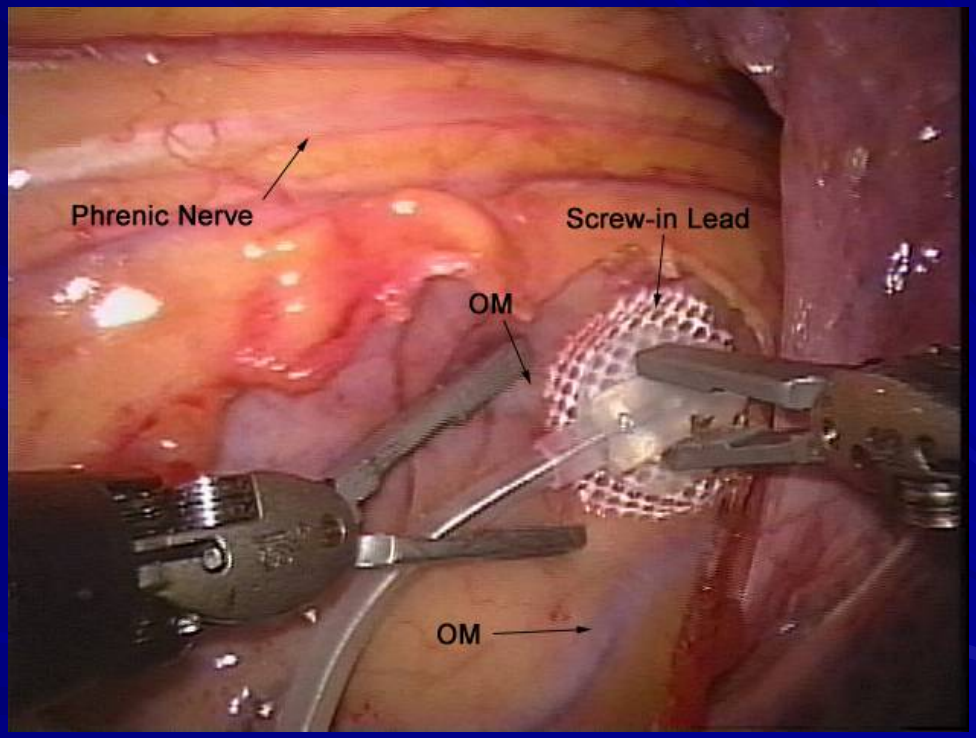
- Inability to cannulate CS
- Small CS venous tributaries
- Prior perforation
- Lead fracture or dislodgement
- High pacing threshold
- Primary implant

Technical Aspects of Robotic Lead Placement

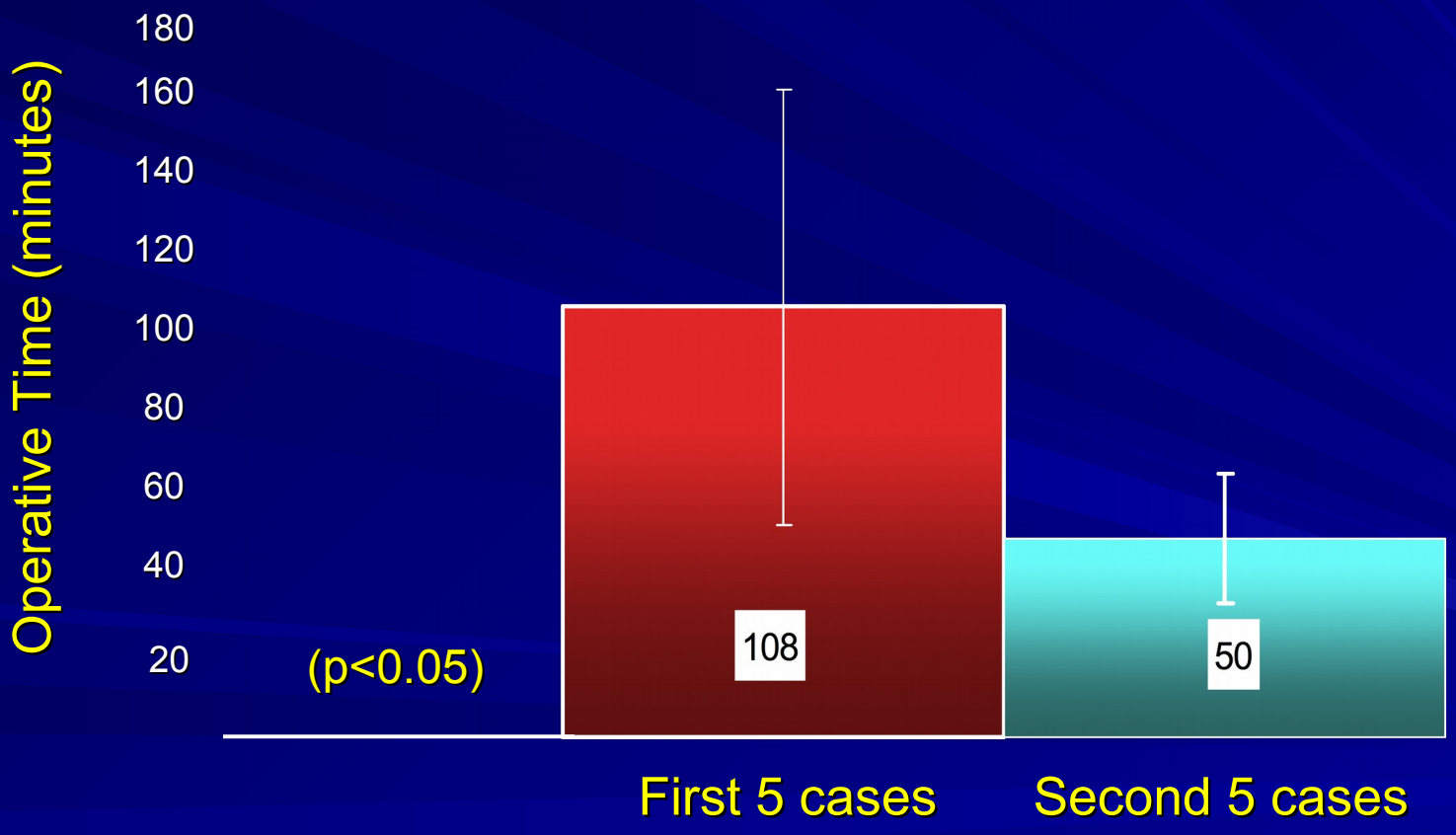
- Requires general anesthesia
- Selective single lung ventilation
- Preop pulmonary function tests
- Posterior approach
- Hold anticoagulation (coumadin)
- Lead surveillance similar to CS leads
- Back-up lead kept in device pocket

Operative Technique:
The Posterior Approach



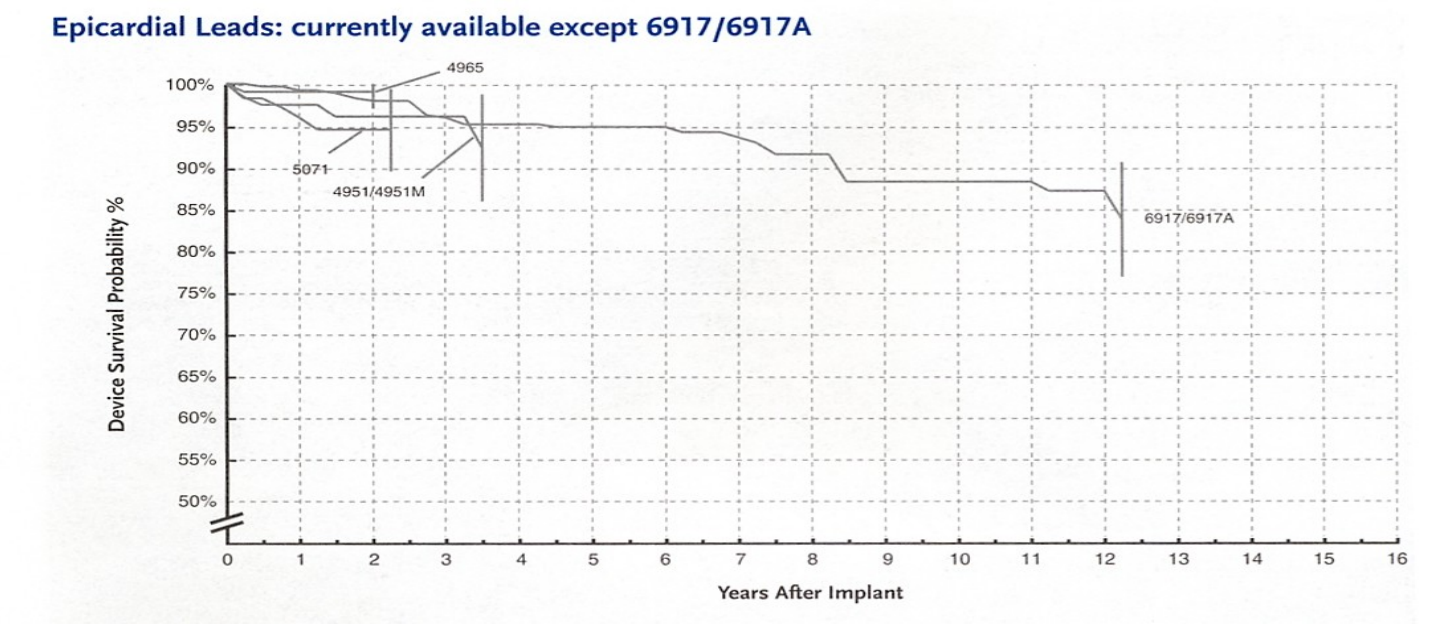


Operative Time for Robotic LV Lead Implantation



Types of Epicardial LV Leads

- Steroid-eluting, sew-in leads
- Screw in leads

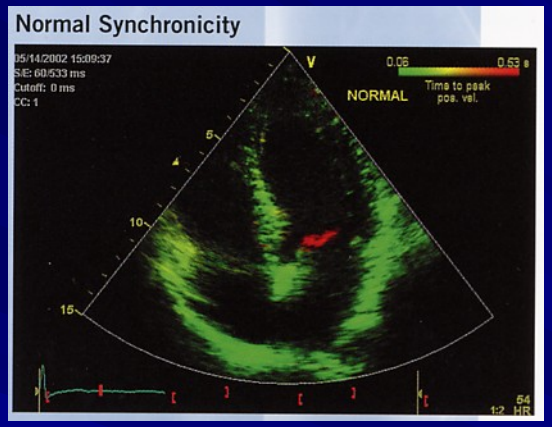


Can Robotic Pacing Improve Clinical Outcomes of CRT ?

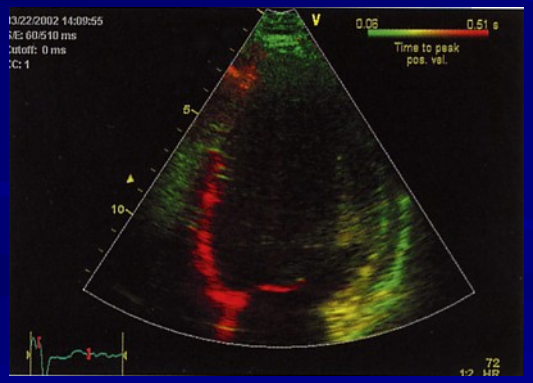
Determine Site of Latest Activation

- EKG
- Use of Pressure Volume Loops
- Tissue Doppler Imaging
- Tissue Strain Imaging
- Intraoperative Epicardial Site Testing
- Three-dimensional Mapping

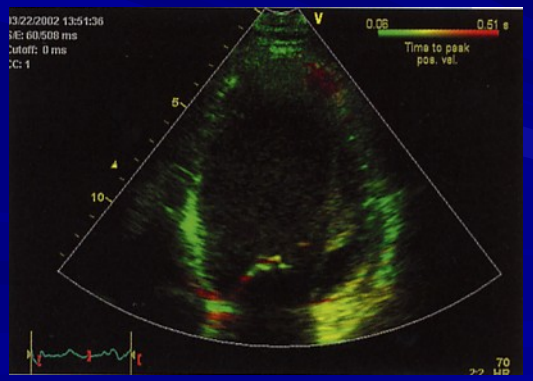
Echocardiographic Mapping: Tissue Doppler Imaging



Asynchrony



CRT



Importance of Intraoperative Mapping

- The anatomic landmark can vary from the site of latest activation in up to 37% of aptients
- Anatomy alone can result in non-response in up to 33% of patients

Edgerton JR, Edgerton ZJ, Mack MJ, Hoffman S, Dewey TM, Herbert MA. Ventricular epicardial lead placement for resynchronization by determination of paced depolarization intervals: technique and rationale. Ann Thorac Surg. 2007 Jan;83(1):89-92

Optimal Pacing Site

- 54 patients,
  Thoracoscopy/lateral thoracotomy
  TSI to identify area of latest peak systolic velocity
- Significant Improvement in reverse remodeling and systolic function
- BEST CLINICAL AND HEMODYNAMIC BENEFIT CAME TROM THEOSE PATIENTS WHO HAD TSI TO IDENTIFY THE AREA Of LATEST PEAK SYSTOLIC VELOCITY
- GRADED RESPONSE: Those patients whose LV lead was placed one segment away from the recommended area (site of maximal LV delay) had less remodeling and those >1 segment away showed no significant reverse remodeling

Murphy RT, Sigurdsson G, Mulamalla S, Agler D, Popovic ZB, Starling RC,Wilkoff BL, Thomas JD, Grimm RA. Tissue synchronization imaging and optimal left ventricular pacing site incardiac resynchronization therapy. *Am J Cardiol*. 2006 Jun 1;97(11):1615-21

Importance of LV mapping

- Measured distance between the site of latest activation and that determined by flouroscopy was the only independent predictor of improvement of LV volumes.
- Site of latest strain activation demonstrates marked improvement in ejection fraction and a marked decrease in left ventricular end-systolic and end-diastolic volumes.

Becker M, Kramann R, Franke A, Breithardt OA, Heussen N, Knackstedt C,
Stellbrink C, Schauerte P, Kelm M, Hoffmann R. Impact of left ventricular lead position in cardiac resynchronization therapy on left ventricular remodelling. A circumferential strain analysis based on 2Dechocardiography. Eur Heart J. 2007

Site-Directed LV leads

Target zone for LV lead placement should correspond to the latest point of both electrical and mechanical activation.

Rovner A, de Las Fuentes L, Faddis MN, Gleva MJ, Davila-Roman VG, Waggoner AD. Relation of left ventricular lead placement in cardiac resynchronization therapy to left ventricular reverse remodeling and to diastolic dyssynchrony. Am J Cardiol. 2007 Jan 15;99(2):239-41. Epub 2006 Nov 21

Epicardial vs. Percutaneous Leads

No prospective randomized trials as yet

Mair et al report a retrospective comparison of

- 79 patients with CS lead insertion
- 16 patients with epicardial lead placement through limited thoracotomy

Results:

- 100% patient with epicardial leads had posterolateral placement vs 70% in transvenous group
- No statistically different length of stay
- Percutaneous leads had higher thresholds over 16 month follow up.

Mair H, Sachweh J, Meuris B et al. Surgical epicardial left ventricular lead versus coronary sinus lead placement in biventricular pacing. *Eur J Cardiothorac Surg* 2005; 27: 235–242.

Transvenous lead placement vs Lateral Thoracotomy

81 patients

Results:

Lower incidence of re-intervention for surgical leads

Less clinical benefit and reverse remodeling for the 25 patients who had lateral thoracotomy

Note: 44% of the LV leads in the surgical group were positioned ANTERIORLY as compared to the transvenous group (4.5%)

Posteriorly-positioned epicardial leads are a key component in improved clinical and physiologic outcomes.

Koos R, Sinha AM, Markus K, Breithardt OA, Mischke K, Zarse M, Schmid M,Autschbach R, Hanrath P, Stellbrink C. Comparison of left ventricular lead placement via the coronary venous approach versus lateral thoracotomy in patients receiving cardiac resynchronization therapy. Am J Cardiol. 2004 Jul 1;94(1):59-63.

St. Luke's-Roosevelt Hospital: Robotic-Assisted CRT Program

- 84 patients with CHF and widened QRS > 140 ms
- All patients underwent intraoperative electrophysiologic mapping to determine the area of the LV with latest electrical activation
- TDI used pre- and intra-operatively to assess resynchronization

Patient Characteristics

N=84

Age	73 ± 9 yrs (43-87)
Inpatient	42%
Ischemic CM	68%
Idiopathic CM	32%
Prior CABG	56%
Multiple Re-op	17%

Results

- 100% epicardial lead placement success
- All patients extubated in the operating room
- 2% conversion to mini-thoracotomy
- Mortality 0%
- Morbidity 6%
- Length of stay 2.1 ± 1.6 days

Complications

- Pneumonia
- Ischemic Colitis
- Intercostal Neuropathy
- Renal Insufficiency (transient)
- LV lead failure (6 mos)

Results

	Baseline	6 mos post-op	p
LVEF	11 ± 6%	23.4 ± 13.6%	<0.001
LVEDD	7.2 ± 1.2 cm	7.1 ± 1.0 cm	NS
NYHA class	3.5 ± 0.5	1.8 ± 0.8	<0.001
QRS duration	184 ± 29 msec	151 ± 20 msec	<0.01

Response Rate: **85%**

Results- Lead Stability

F/U= 25 ± 8 months

	Threshold	Impedance
Intra-op	1.0 ± 0.5 V	1160 ± 248 Ω
Post-op	1.8 ± 1.1 V	310 ± 158 Ω
P value	NS	< 0.001

Summary

- Robotic LV lead implantation is safe and effective
- Excellent minimally invasive option for failed CS cannulation
- Optimal portion of myocardium can be targeted
- Posterior approach particularly useful for re-ops
- Epicardial leads are stable over time
- Role in primary implants awaits randomized trials