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Endocardial Pacing: how to do it and when to choose it

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M. Cerini

October 16 - 18
14th EDITION 2015

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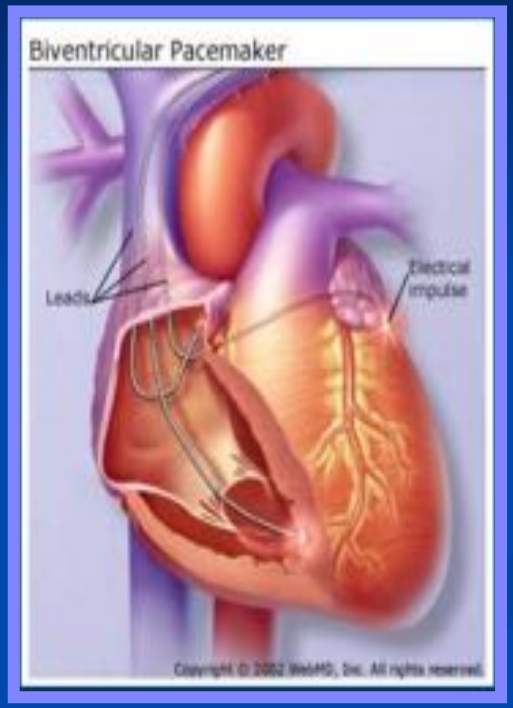
NO CONFLICT OF INTEREST TO DECLARE

Cardiac Resynchronization Therapy

Widely accepted for treatment

- Pts with systolic heart failure
- Impaired LVEF
- Electrical asynchrony



It improves

- Systolic LV function
- Peak oxygen uptake
- Exercise tolerance
- NYHA Class
- Reverses the remodeling
- Neurohormonal changes accompanying HF.

Large randomized trials also showed improved survival with CRT

MIRACLE (n=453)	CONTAK-CD (n=490)	COMPANION (n=1520)	CARE-HF (n=813)	REVERSE (n=610)	MADIT-CRT (n=1820)	RAFT (n=1798)

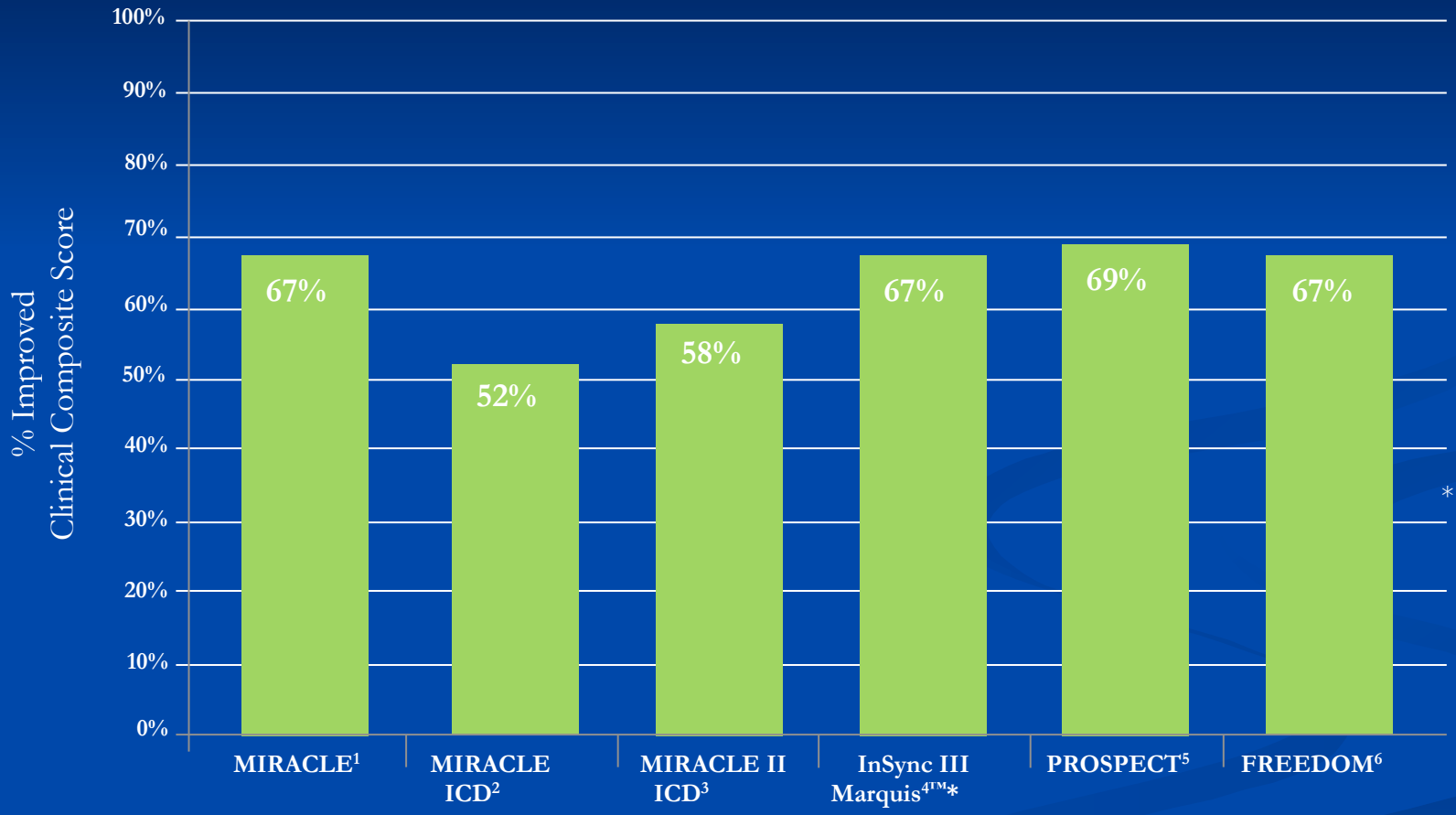
CRT Objective:
Stimulate both ventricles simultaneously

Methods:

Transvenous Approach

- Well-established technique (thousands of patients already treated
- Possibility of using the catheter that best suits the patient's anatomy.

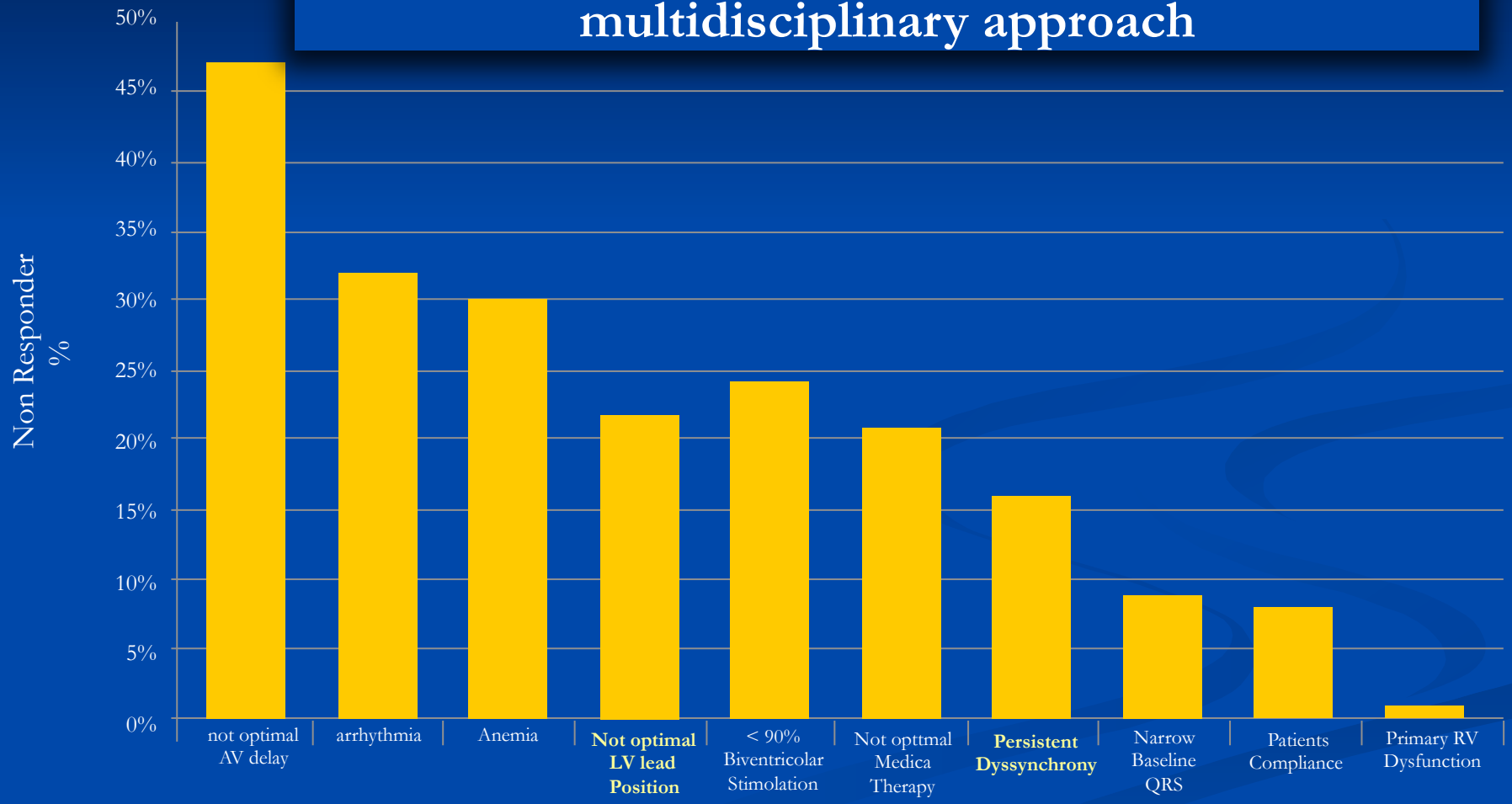
Left ventricular (LV) reverse remodelling is achieved in only 60–70% of patients.



[1] Abraham WT, et al. *N Engl J Med.* 2002;346:1845-1853.
[2] Young JB, et al. *JAMA.* 2003;289:2685-2694.
[3] Abraham WT, et al. *Circulation.* 2004;110:2864-2868.
[4] Abraham WT, et al. *Heart Rhythm.* 2005;2:S65.
[5] Chung ES, et al. *Circulation.* 2008;117:2608-2616.
[6] Abraham WT, et al. *Late-Breaking Clinical Trials.* HRS 2010.

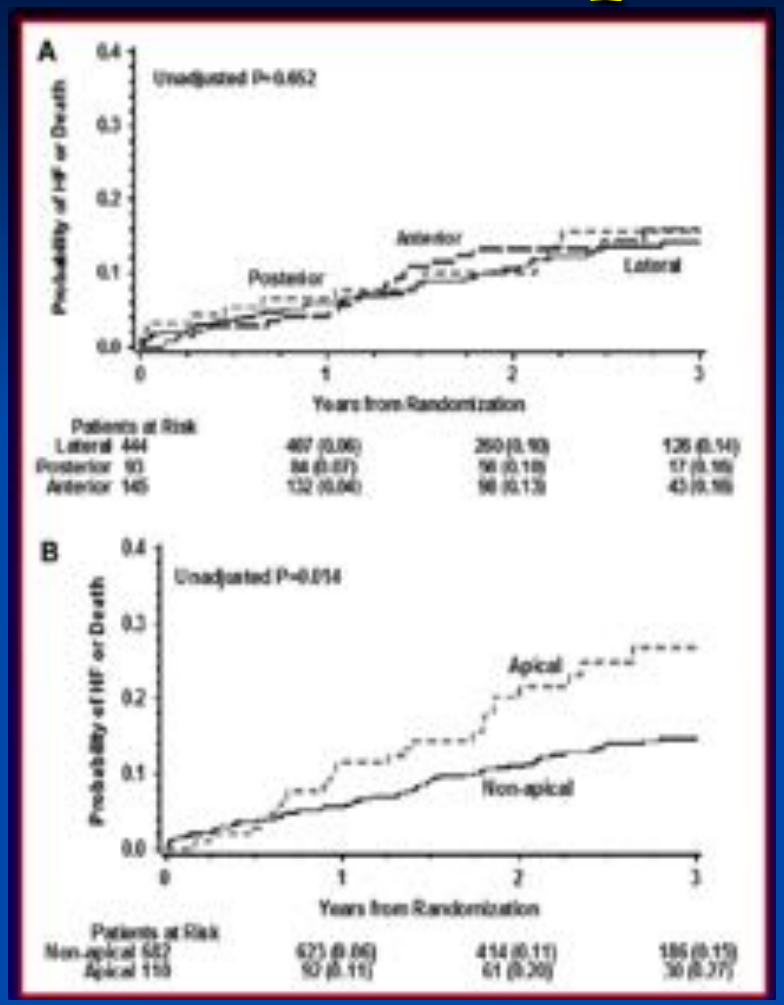
Factor in Non-Response

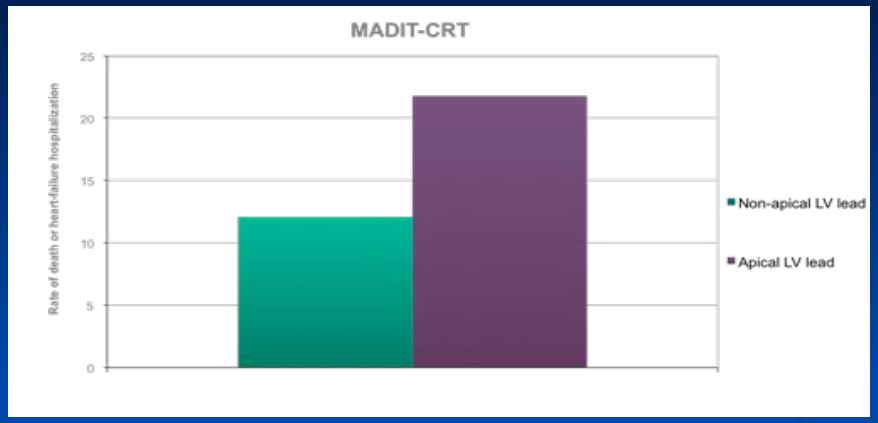
Maximising the response to CRT requires a multidisciplinary approach

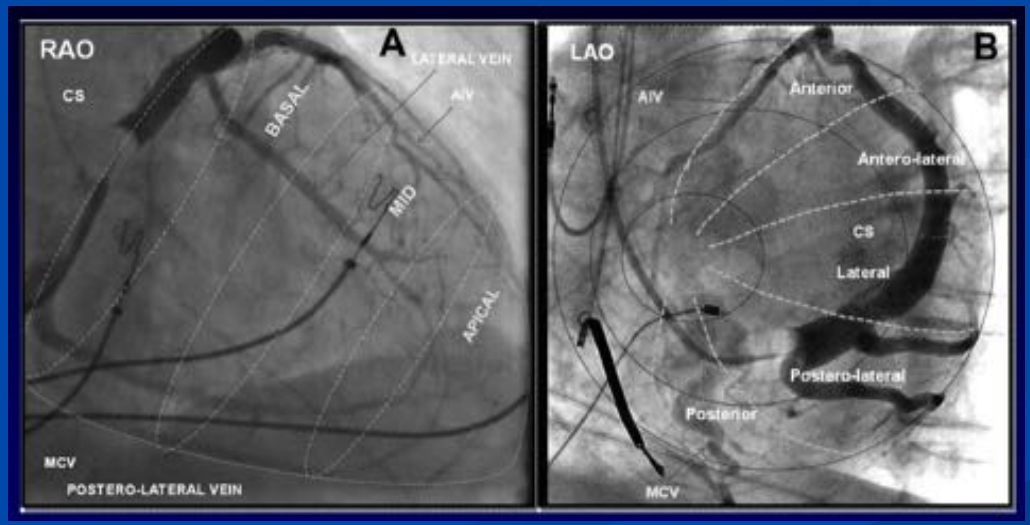


Mullens W, et al. JACC. 2009;53:765-773.

Avoid apical lead placement







Patients in which the LV lead was placed distally had a 1.64 increased risk of death or heart failure hospitalization and a 2.6 increased risk of mortality

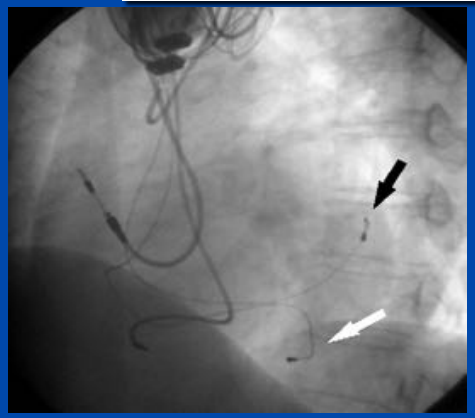
Singh et al – Circulation 2011;123:1159-1166

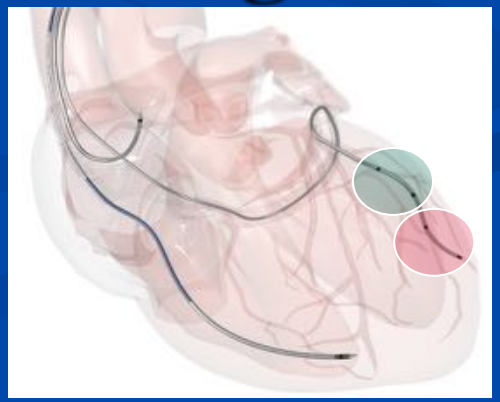
The Best Place to Pace

- Some acute hemodynamic studies suggest that the mid-lateral wall of the left ventricle is the optimal pacing site, but other studies indicate that the optimal site may vary and be patient specific.
- Various methodologies to determine the optimal pacing site are
  - invasive measurement (dP/dt)
  - Expensive (MRI)
  - Time consuming (TDI)
- All remain unproven or too difficolt for routine clinical use.

Biventricular pacing

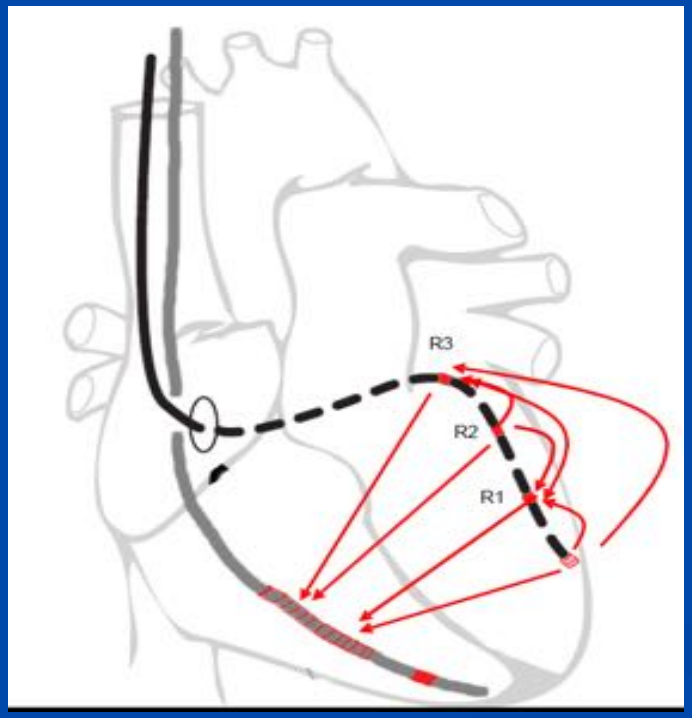
- In non responder PTS, any technique which could increase the response rate of resynchronization would be crucial for CRT candidates.
- Has been recently proposed as a safe and efficient method of resynchronization:
  - Multi Site/ Multi Point Pacing

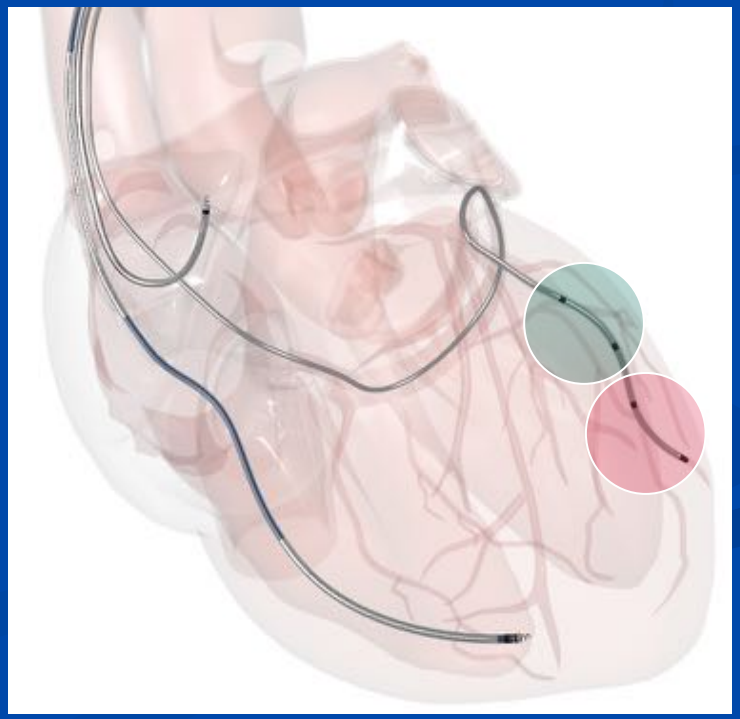




Specifically designed LV lead multipoints pacing

- Providing options to manage PNS and high pacing thresholds at implant and follow-up to minimize lead revision
- Enabling LV pacing at the preferred site without compromising lead stability



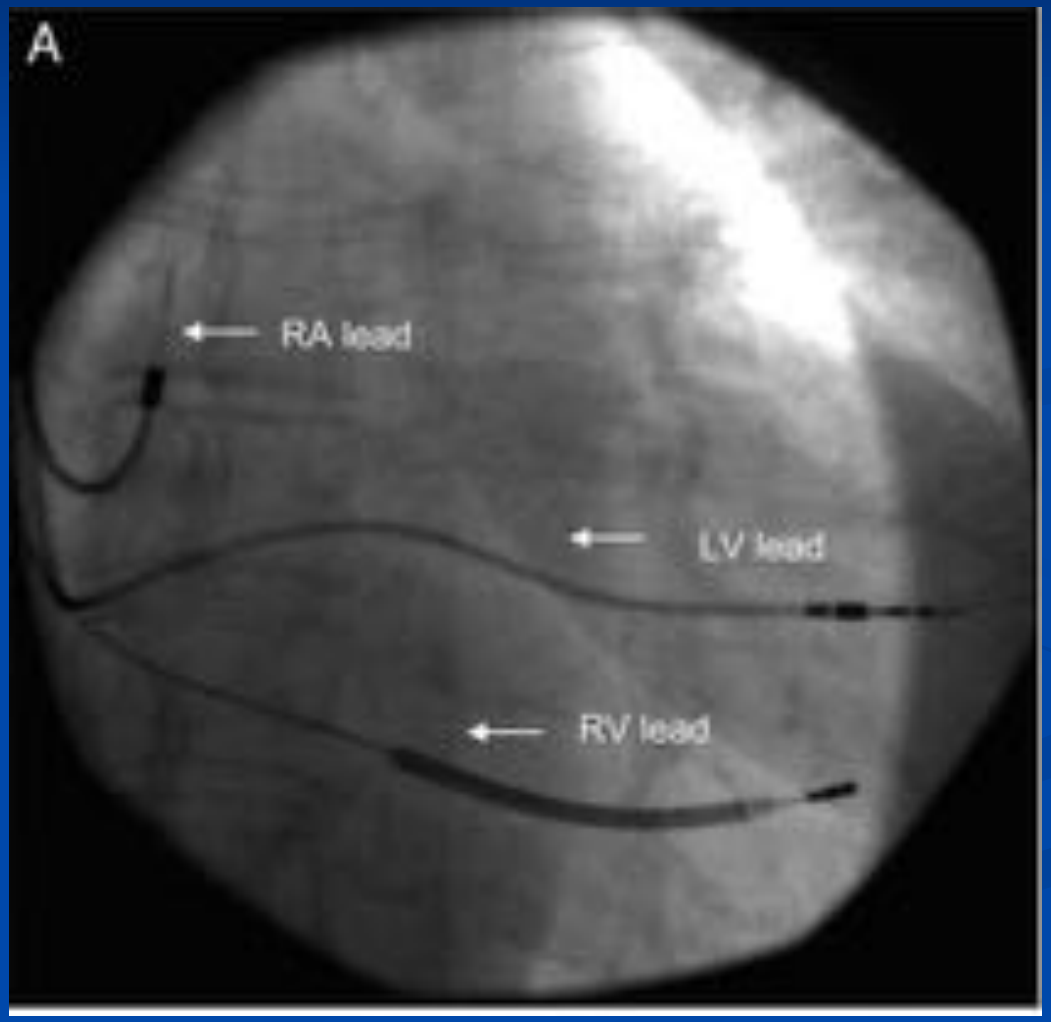


Failure of coronary sinus lead implantation: alternative approaches

- Epicardial Approach
  - Thoracotomy
  - Minithoracotomy
  - Video-assisted thoracoscopic and robotic
- Left Ventricular Endocardial Pacing
  - Transeptal (Superior, Inferior, Mixed Approach)
    -Inter-atrial or Inter-ventricular-
  - Transapical
  - Transaortic (in Pig model)

Transeptal Approach

The LV lead crosses the atrial septum, mitral valve and is actively fixed to the LV endocardial surface.



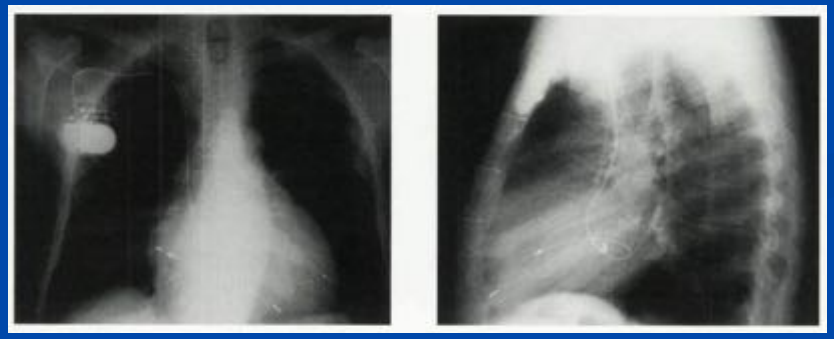
Transeptal Approach

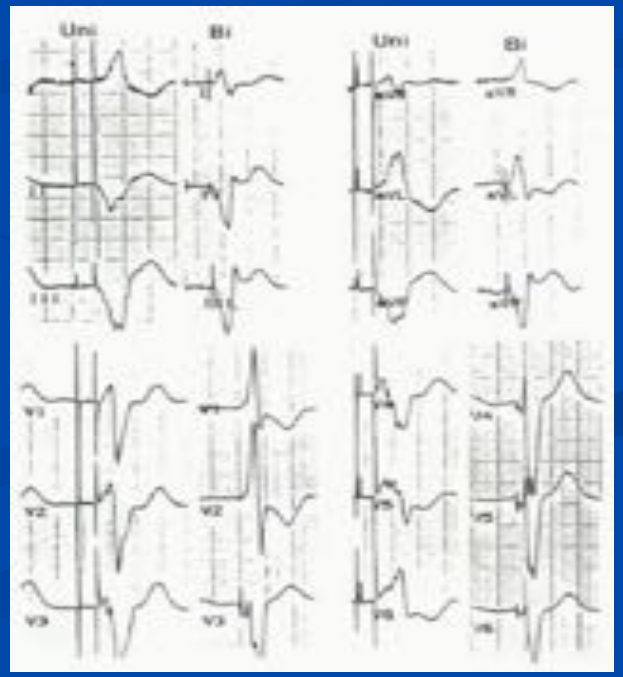
Endocardial Biventricular Pacing

PIERRE JAÏS, HERVÉ DOUARD, DIPEN C. SHAH, SERGE BAROLD*, JEAN-LOUIS BARAT, and JACQUES CLÉMENTY

From the Hôpital Cardiologique du Haut-Lévêque, Bordeaux-Pessac, France and *Mount Sinai Medical Center, Cleveland, Ohio.

JAIS, P., ET AL.: **Endocardial Biventricular Pacing.** *Simultaneous right and left ventricular pacing was performed in a 73-year-old man with coronary artery disease end-stage congestive heart failure and a DDD pacemaker implanted for sick sinus syndrome. An endocardial LV lead was introduced transseptally after unsuccessful attempts to enter the coronary sinus. This new approach for multisite pacing offers an alternative to epicardial LV from the coronary sinus or by thoracotomy.* (PACE 1998; 21[Pt. II]:2128–2131)





Transeptal Approach

Left Ventricular Lead Insertion Using a Modified Transseptal Catheterization Technique: A Totally Endocar
Biventri ilure

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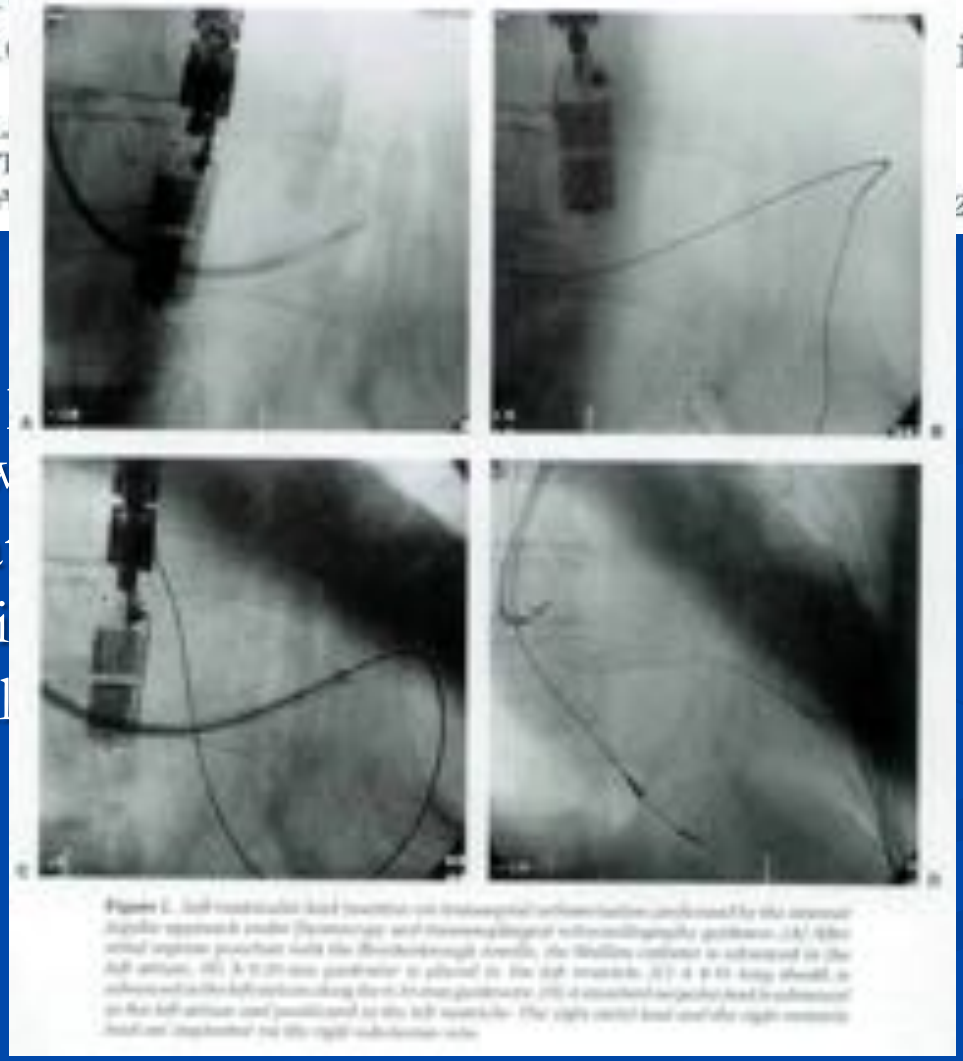

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maximal

Transeptal Approach

CLINICAL RESEARCH

Transseptal Left Ventricular Lead Placement Using Snare Technique

GARY A. WRIGHT, M.B.Ch.B., DAVID R. TOMLINSON, M.D., IAN LINES, IBHRE (CEPS), EDWARD J. DAVIES, M.B.B.S., and GUY A. HAYWOOD, M.D.
From Plymouth Hospitals NHS Trust, Plymouth, UK

Background: *Coronary sinus (CS) lead placement for cardiac resynchronization therapy has a failure rate of ~5–10%. Here we describe a way of implanting an endocardial left ventricular (LV) lead via a transseptal puncture (TSP), using a GooseNeck snare and active fixation lead.*

Methods: *Three male patients (67–83 years) with failed or extracted epicardial LV leads implanted via the CS had an endocardial LV lead implanted. TSP was performed via a femoral vein. The active fixation pacing lead was advanced to the right atrium from a subclavian vein. A GooseNeck snare was passed via the TSP sheath and used to grasp the tip of the pacing lead. The sheath, GooseNeck snare, and pacing lead tip were then passed to the left atrium by sliding the system up the TSP guidewire and across the interatrial septum before deflecting the lead to permit implantation in the left ventricle.*

Results: *Successful implantation was performed in all patients with an LV implant time of 25–55 minutes.*

Conclusion: *The use of a GooseNeck snare via a deflectable transseptal sheath represents a reliable alternative method for endocardial LV lead placement in patients with failed CS LV lead implantation. (PACE 2012; 35:1248–1252)*

Transeptal- Ventricular Approach

Development of a Technique for Left Ventricular Endocardial Pacing via Puncture of the Interventricular Septum

Tim R. Betts, MD, FRCP; James H.P. Gamble, BMBCh, MRCP; Raj Khiani, MBBS, MRCP; Yaver Bashir, DM, FRCP; Kim Rajappan, MD, MRCP

(*Circ Arrhythm Electrophysiol.* 2014;7:17-22.)

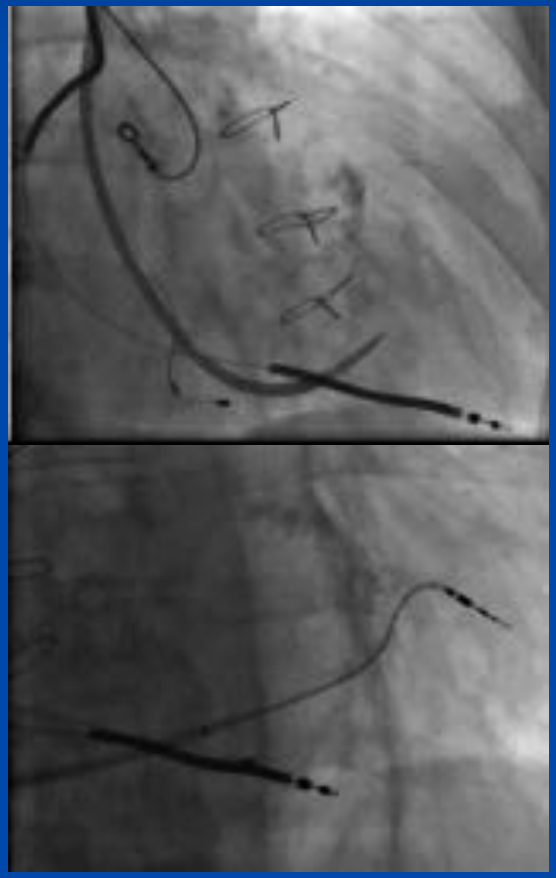
- 10 Patients with previous failed coronary sinus lead implant or with nonresponse to CRT
- Subclavian Vein Access
- Ventricular transseptal puncture (under fluoroscopic guidance) using a steerable sheath and
  - Standard transseptal needle
  - Radiofrequency needle
  - Radiofrequency energy delivered through a guidewire

Transeptal- Ventricular Approach

Development of a Technique for Left Ventricular Endocardial Pacing via Puncture of the Interventricular Septum

Tim R. Betts, MD, FRCP; James H.P. Gamble, BMBCh, MRCP; Raj Khiani, MBBS, MRCP; Yaver Bashir, DM, FRCP; Kim Rajappan, MD, MRCP

(*Circ Arrhythm Electrophysiol.* 2014;7:17-22.)



The ventricular septal approach avoids lead interaction with the mitral valve, potentially preventing worsening of mitral regurgitation and reducing the risk of mitral valve endocarditis.

Transaortic Approach

Left Ventricular Endocardial Pacing: A Transarterial Approach

MICHAEL REINIG, D.O.,* MELVIN WHITE, M.D.,* MARC LEVINE, M.D.,* RIDO CHA, M.D.,* ISMAIL CINEL, M.D., Ph.D.,† JASTI PURNACHANDRA, M.D.,† ROY GOLDFARB, Ph.D.,† ZHONGPING YANG, Ph.D.,‡ LARRY MULLIGAN, Ph.D.,‡ JOSEPH PARRILLO, M.D.,* and LAWRENCE GESSMAN, M.D.*

From the *Cooper University Hospital/Robert Wood Johnson Medical School, †Robert Wood Johnson Medical School, Camden, New Jersey, and ‡Medtronic Corporation, Minneapolis, Minnesota

Introduction: *We tested the feasibility of a new technique of direct left ventricular endocardial lead placement across the aortic valve in a chronic (six month) pig model. The potential for aortic valve damage, systemic embolization, and pacing lead maturation and function within the left ventricle are unknown.*

Methods: *Ten minipigs were successfully implanted with a transaortic left ventricular lead (Medtronic CapSureFix®, Minneapolis, MN, USA) placed in the left ventricular apex via the carotid artery. Each pig received either a polyurethane (n = 5) or silicone (n = 5) lead. Post implant each pig received clopidogrel and aspirin for seven days. After six months all surviving pigs underwent thorough necropsy.*

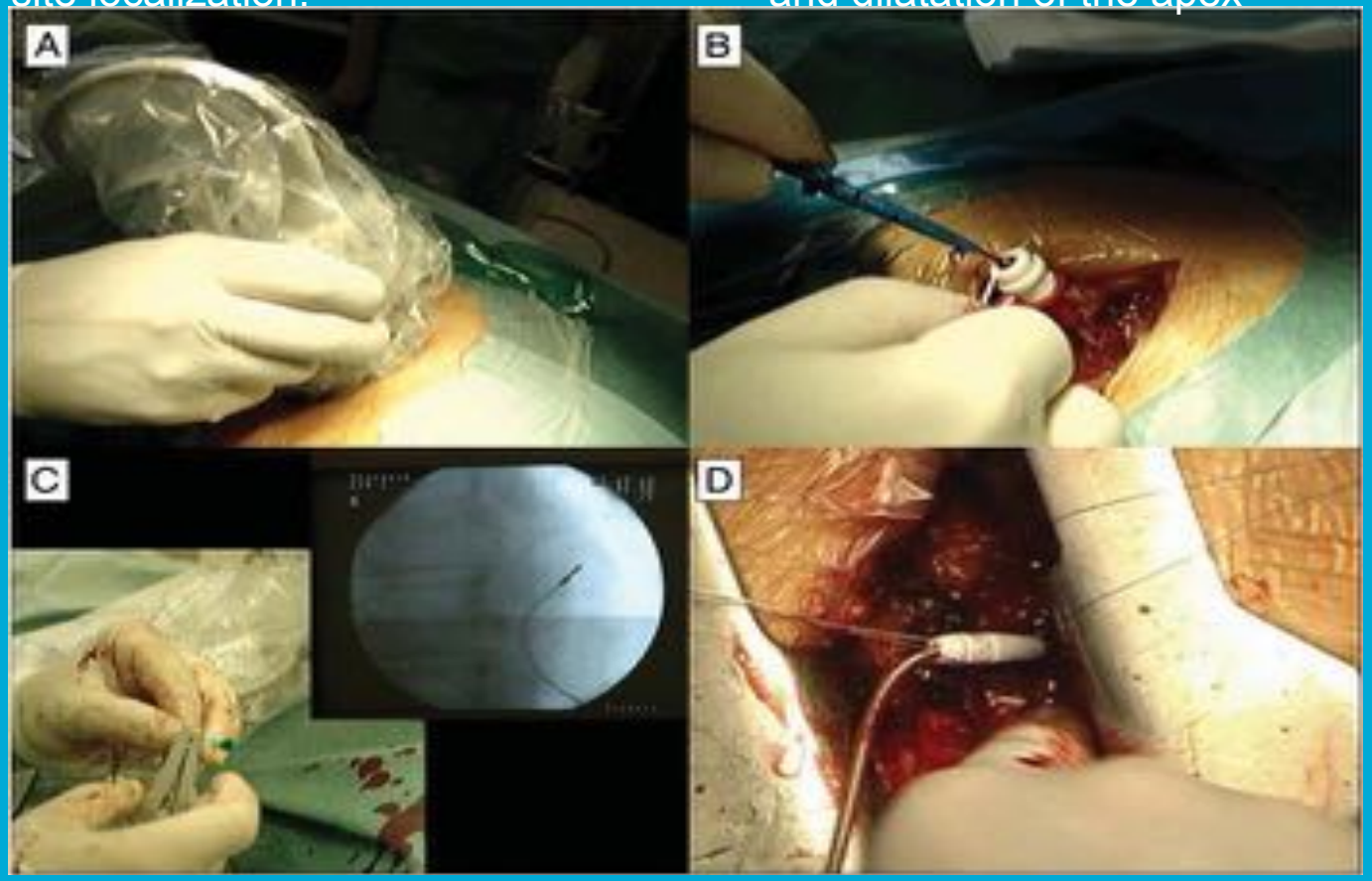
Results: *Each pig had adequate sensing (12.1 ± 4 mV) and pacing thresholds (0.79 ± 0.2 @ 0.5 V) at implant. Postoperatively two pigs died of a respiratory illness. One pig died postoperatively due to sepsis. At the six-month follow-up, all surviving pigs (n = 7) were in a healthy state. Of the pigs without dislodgement (n = 5) there was adequate sensing, but a rise in pacing thresholds. Echocardiography revealed a normal ejection fraction and only trace to mild aortic insufficiency in all pigs. Of the seven surviving pigs there were no thromboembolic events noted. One silicone lead was noted to have thrombus along the lead screw and shaft.*

Conclusion: *Direct transaortic placement of a left ventricular lead is feasible. After six months, there was no significant aortic regurgitation and no evidence of thromboembolism despite no anticoagulation. Lead function was acceptable and only one silicone lead (and no polyurethane lead) was noted to have significant thrombosis. (PACE 2007; 30:1464–1468)*

Transapical endocardial approach

Intraoperative transthoracic echocardiography for apex site localization.

Transthoracic two-stage Seldinger-type puncture and dilatation of the apex



Positioning and fixation of the lead under fluoroscopy guidance

Apex site fixation of the electrode via thoracotomy

Europace (2011) 13, 1653–1657

Comparison of Chronic Biventricular Pacing Between Epicardial and Endocardial Left Ventricular Stimulation Using Doppler Tissue Imaging in Patients With Heart Failure

Stephane Garrigue, MD, Pierre Jaïs, MD, Guillaume Espil, MD, Jean-Noel Labeque, MD, Meleze Hocini, MD, Dipen C. Shah, MD, Michel Haïssaguerre, MD, and Jacques Clementy, MD

(Am J Cardiol 2001;88:858–862)

23 Patient: 15 Epi group, 8 Endo group

slight increase has been observed. In the present study, we found that endocardial BVP resulted in much higher hemodynamic improvement than epicardial BVP in patients with end-stage heart failure, compared with RV pacing. In addition, we showed that endocardial BVP provides a more homogenous systole leading to longer

FIGURE 1. Percent changes in standard echocardiographic variables between RV pacing and BVP in the Epi and Endo groups. BVP with endocardial LV pacing shows a significantly higher LV shortening fraction, aortic maximal velocity, and aortic and mitral time-velocity intergral (TVI). In addition, the aortic preejection interval is even shorter with endocardial than with epicardial LV pacing.

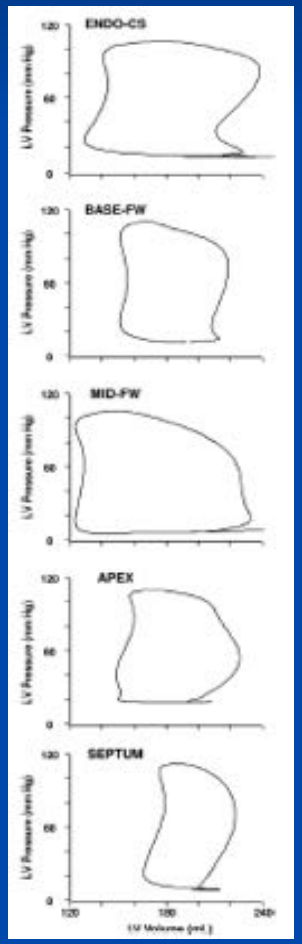
FIGURE 2. Percent changes in Doppler tissue imaging variables between RV pacing and BVP in the Epi and Endo groups. For the septal as well as the free LV wall, the systolic S-wave amplitude is significantly higher with endocardial than with epicardial LV pacing. In addition, the regional EMD is significantly shortened compared with endocardial LV pacing.

Acute Hemodynamic Effect of Left Ventricular Endocardial Pacing in Cardiac Resynchronization Therapy

Assessment by Pressure–Volume Loops

Luigi Padeletti, MD; Paolo Pieragnoli, MD; Giuseppe Ricciardi, MD; Laura Perrotta, MD; Gino Grifoni, MD; Maria Cristina Porciani, MD; Vincenzo Lionetti, MD, PhD; Sergio Valsecchi, PhD

(*Circ Arrhythm Electrophysiol.* 2012;5:460-467.)



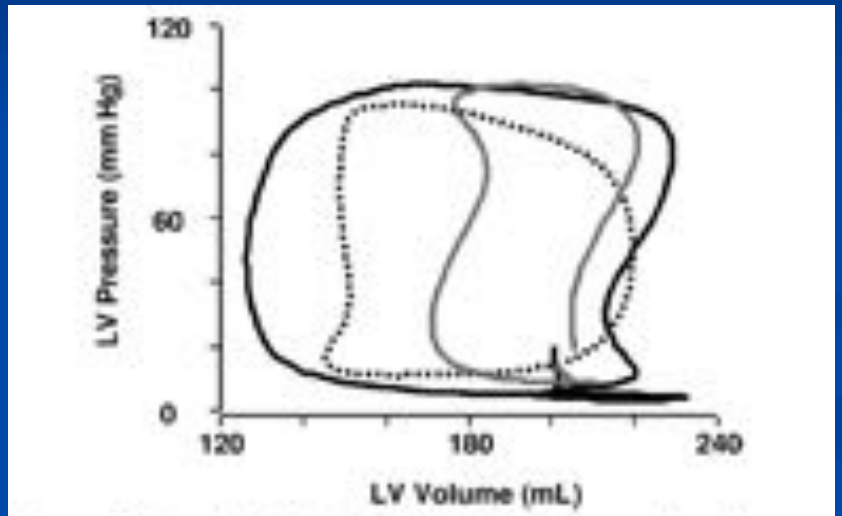


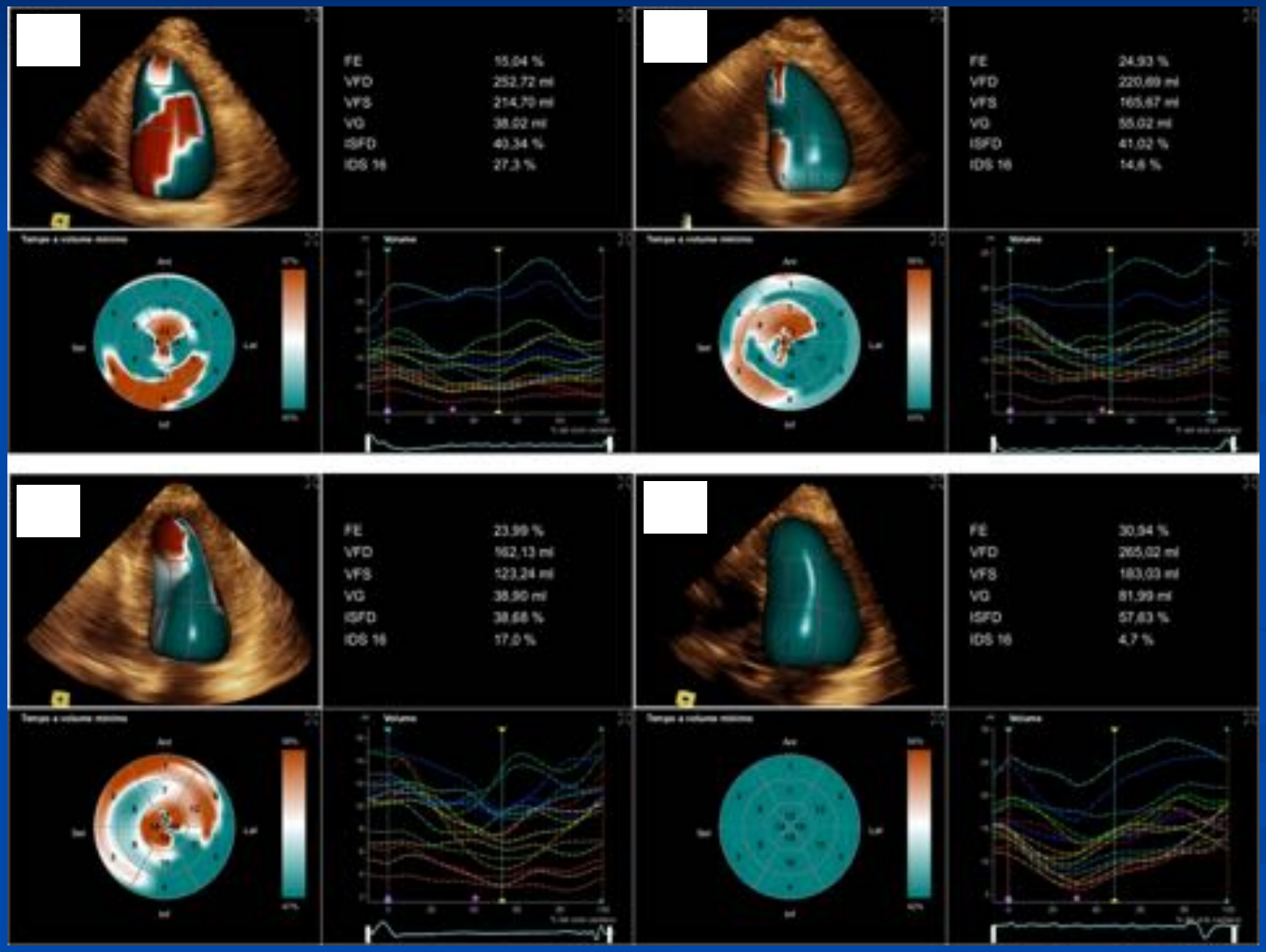
Figure 4. Example of left ventricular (LV) pressure–volume loops during atrial overdrive (**gray line**), cardiac resynchronization therapy (CRT) with standard epicardial LV pacing (epicardial coronary sinus; **dotted line**), and CRT with optimal endocardial LV pacing (**black line**).

The average stroke volume and stroke work significantly increased during endocardial LV pacing in the BEST-LV configuration in comparison with the standard EPI-CS CRT (Table 3 and Figure 4). LV synchrony during ENDO-CS pacing

3D Echocardiogram

Basal

LV-Endo



Patient A

Patient B

G. Mascioli

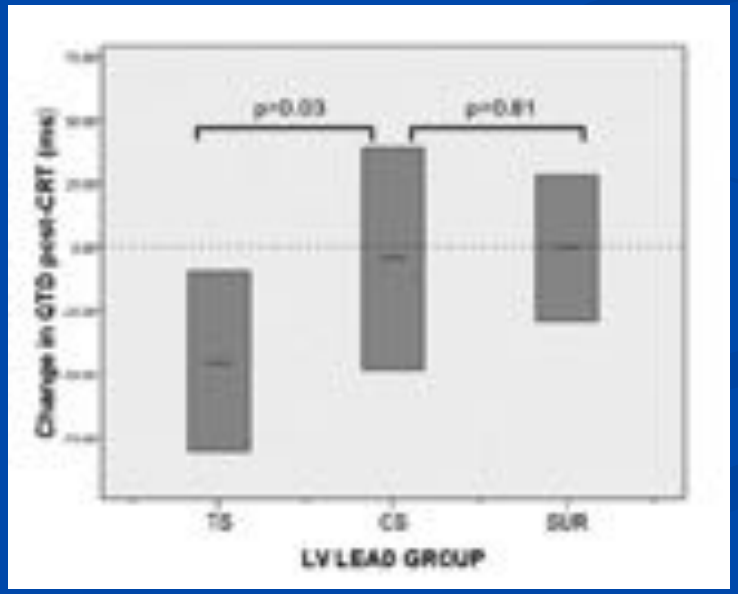
Transseptal Left Ventricular Endocardial Pacing Reduces Dispersion of Ventricular Repolarization

PAUL A. SCOTT, M.B.Ch.B.,*,† ARTHUR M. YUE, M.D.,* EDD WATTS,†
MEHMOOD ZEB, M.B.B.S.,*,† PAUL R. ROBERTS, M.D.,*,†
and JOHN M. MORGAN, M.D.,*,†

From the *Wessex Cardiothoracic Unit, Southampton University Hospitals NHS Trust, Southampton, UK; and †School of Medicine, University of Southampton, Southampton, UK

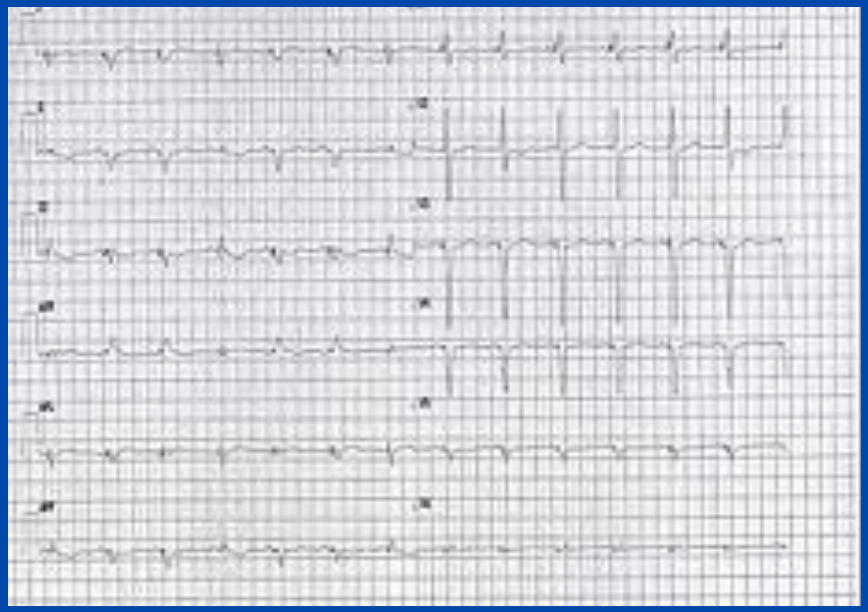
ECG Markers of repolarizationmesured in:

- 7 Pts with with transseptal LV endocardial leads (TS group)
- 28 Pts with coronary sinus (CS) LV leads (CS group)
- 8 Pts with surgical LV epicardial leads (SUR group)

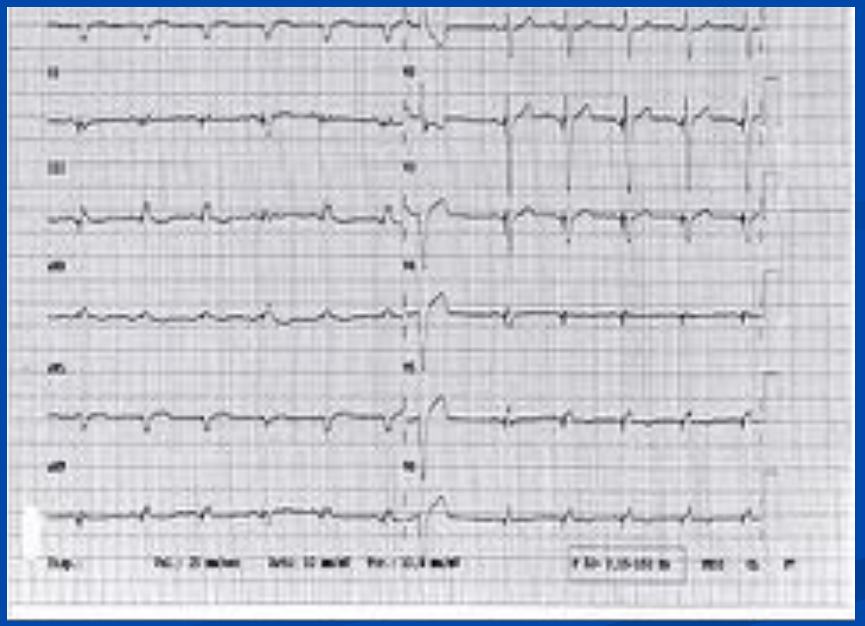


Standard ECG

Standard biventricular pacing



Endocardial left ventricular pacing



Mid-term Follow-Up of Endocardial Biventricular Pacing

PIERRE JAÏS, ATSUSHI TAKAHASHI, STÉPHANE GARRIGUE, TEIICHI YAMANE, MÉLÈZE HOCINI, DIPEN C. SHAH, SERGE S. BAROLD, ISABEL DEISENHOFER, MICHEL HAÏSSAGUERRE, and JACQUES CLÉMENTY

From the Hôpital Cardiologique du Haut-Lévêque, CHU de Bordeaux, France

JAÏS, P., ET AL.: Mid-term Follow-Up of Endocardial Biventricular Pacing. *Biventricular (BV) pacing is a promising treatment of end-stage heart failure. This article describes our experience with a strictly endocardial BV pacing system in patients with severe congestive heart failure. Three women and eight men (age 65 ± 9 years) with drug-resistant end-stage CHF underwent implantation of an endocardial BV pacing system. In the first seven patients, the left ventricular lead was placed via a combined femoral and internal jugular approach. In the last four patients, the transseptal puncture was directly performed via the right internal jugular vein with a dedicated kit. The procedure was successful in all 11 patients. The acute left ventricular and BV thresholds were 1.3 ± 0.6 V and 2.4 ± 1 V, respectively. The QRS duration decreased from 214 ± 57 to 176 ± 25 ms. A functional improvement was noted in ten patients with a decrease in mean NYHA functional class from 3.7 ± 0.5 before, to 2.6 ± 0.9 after system implantation. A significant decrease in pulmonary capillary wedge pressure and increase in cardiac output were measured in eight patients. During follow-up, four patients died from CHF (n = 3) or ventricular fibrillation (n = 1). Under oral anticoagulation, no thromboembolic event was observed but one transient ischemic attack occurred in one patient whose anticoagulation was interrupted. Endocardial BV pacing is technically feasible and appears safe, though further studies are needed before it is used on a larger scale. (PACE 2000; 23[Pt. II]:1744–1747)*

Long-Term Follow-Up of Biventricular Pacing Using a Totally Endocardial Approach in Patients with End-Stage Cardiac Failure

J.L. PASQUIÉ, M.D., PH.D., F. MASSIN, M.D., J.C. MACIA, M.D., R. GERVASONI, M.D., A. BORTONE, M.D., G. CAYLA, M.D., R. GROLLEAU, M.D., and F. LECLERCQ, M.D., PH.D.

From the Clinique des Maladies du Cœur et des Vaisseaux, Hôpital Arnaud de Villeneuve, Centre Hospitalo-Universitaire de Montpellier, France

6 Patients over a 85+5 month follow-up

- ✓ 2 underwent cardiac transplantation, 2 and 4 years after device implantation, respectively
- ✓ 2 died of end-stage heart failure 4 years after system implantation
- ✓ 2 were alive in functional class II

Conclusions: Long-term endocardial biventricular stimulation via a transseptal approach was safe and effective in this small population. This approach needs to be further compared with conventional epicardial pacing via the coronary sinus (PACE 2007; 30:S31–S33)

Alternate Site Cardiac Resynchronization (ALSYNC) study

- 138 Patients
- 16 centers in Europe and 2 in Canada

ALSYNC: LV Endocardial Pacing Could Help in CRT Nonresponse

End Points	All Patients (%)	Patients With Prior Failed CRT Implant (%)	Patients With Prior CRT Nonresponse (%)
LVESV ≥15% improvement	55	57	47
LVEF ≥5-point improvement	64	65	61
NYHA class ≥1 class improvement	60	63	52
Mitral regurgitation ≥1 class improvement	33	29	43

By the six-month follow-up, 60% of patients showed improved in NYHA class and 55% showed an improvement in LV end-systolic volume of at least 15%.

Heart Rhythm Society 2014 Scientific Sessions; May 9, 2014; San Francisco, CA. Abstract LB02-05.

LV-Endocardial Pacing Advantages

- ✓Easier and more "complete" access to left ventricle
- ✓Reduced dyssynchrony → Improved hemodynamics
- ✓Faster depolarization of the LV and reduced dispersion of repolarization
- ✓Lower pacing threshold and very low probability of phrenic nerve stimulation
- ✓The lead inside the LV could allow the direct measurement of LV contraction by a sensor

LV-Endocardial Pacing Issues

- ✓**Thromboembolic complications**
  The diagnosis of lead misplacement through a patent foramen ovale was made after thromboembolic complications in approximately 1/3 of cases
- ✓**Interaction with the mitral valve**
  Increased risk of insufficiency
- ✓**Infections**
  May promote the development of mitral valve endocarditis, exposing the patient to systemic embolization of vegetations
- ✓**Risks associated with leads extraction**
  Standard instrumentation available is poorly adapted to extract LV endocardial leads (with lack of valves to prevent the introduction of air during the procedure)

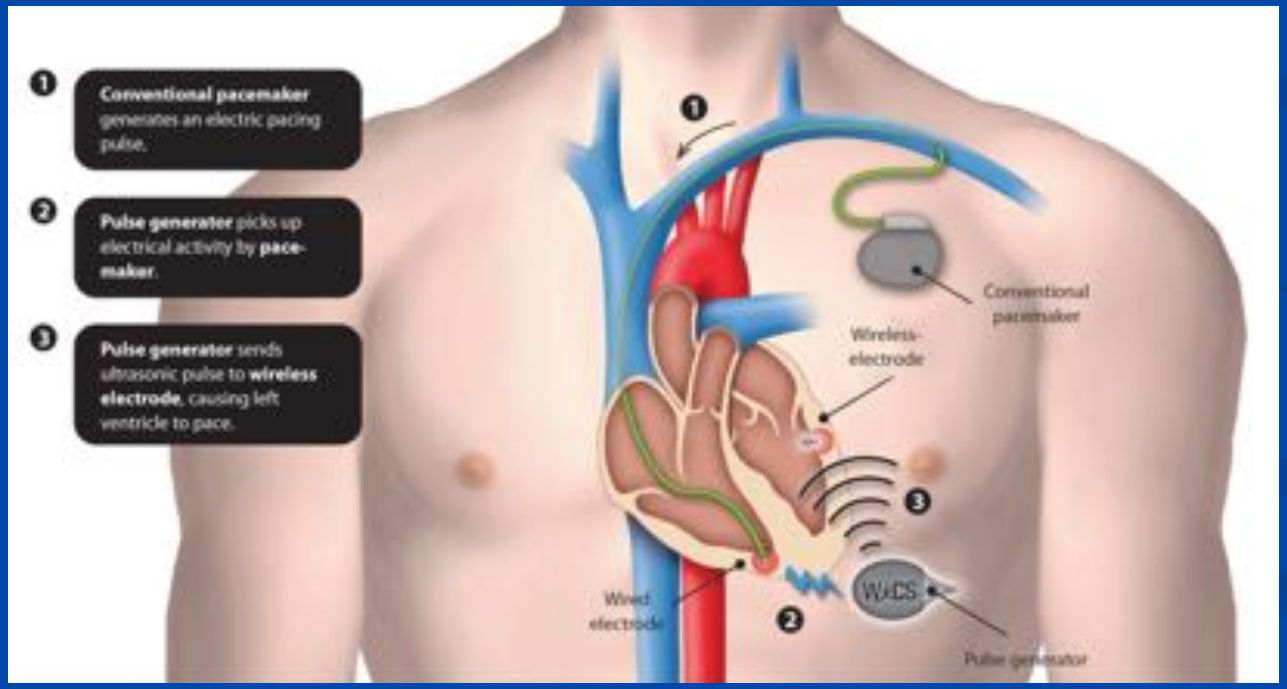
Europace (2014) 16, 681–688
doi:10.1093/europace/eut435

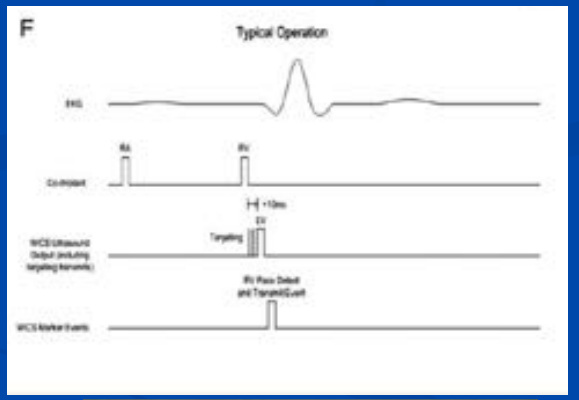
CLINICAL RESEARCH
Pacing and resynchronization therapy

Feasibility, safety, and short-term outcome of leadless ultrasound-based endocardial left ventricular resynchronization in heart failure patients: results of the Wireless Stimulation Endocardially for CRT (WiSE-CRT) study

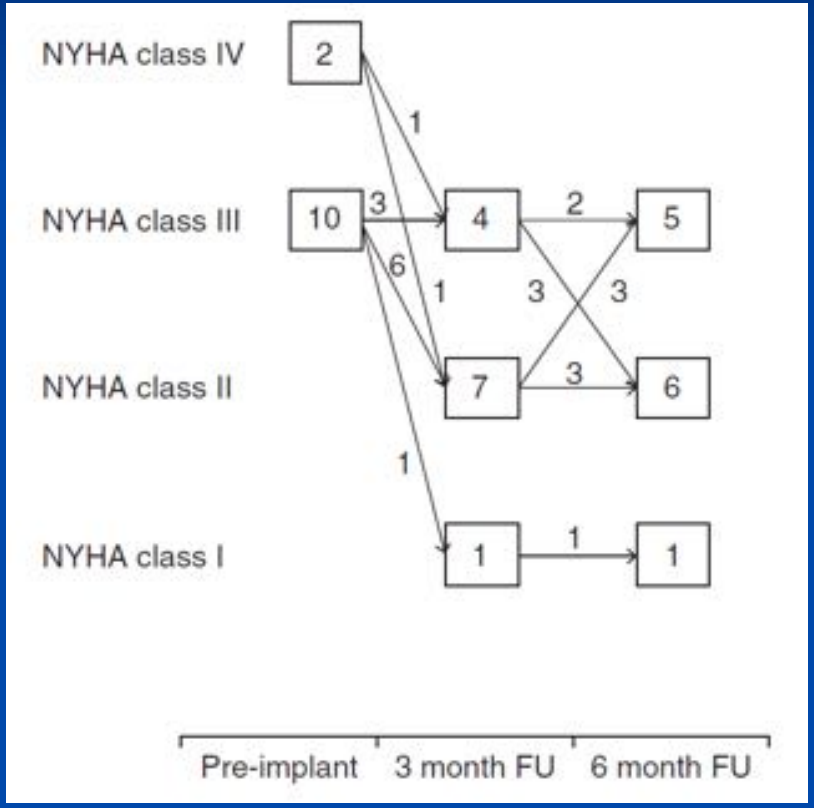
Angelo Auricchio[1]*, Peter-Paul Delnoy[2], Christian Butter[3], Johannes Brachmann[4], Lieselot Van Erven[5], Stefan Spitzer[6], Tiziano Moccetti[1], Martin Seifert[3], Thanasie Markou[2], Karolyi Laszo[6], and François Regoli[1], for the Collaborative Study Group

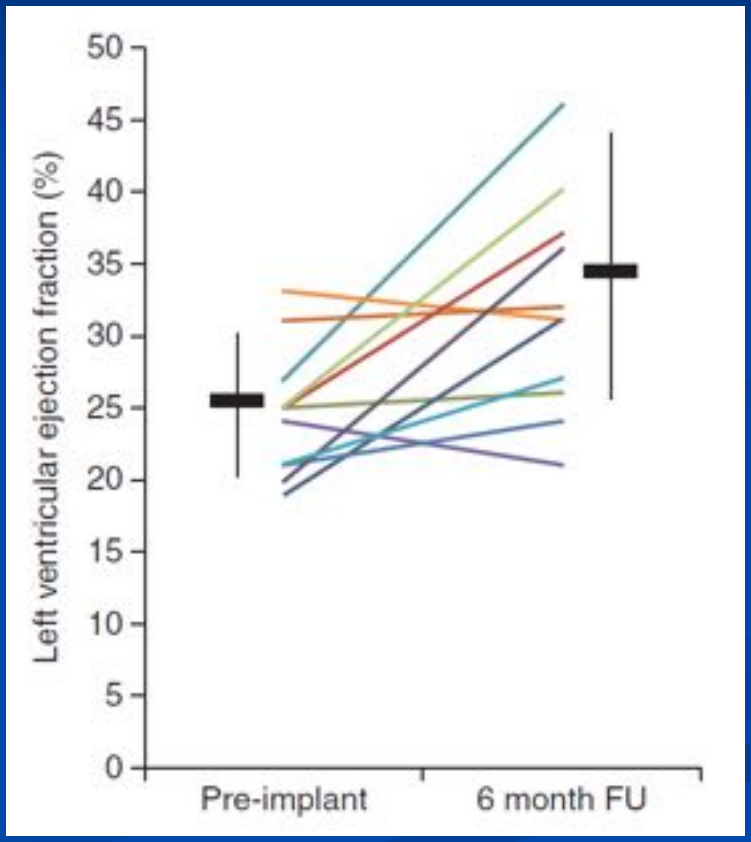
- 17 Patients
  - patients in whom attempted coronary sinus lead implantation for CRT had failed (7)
  - patients with a previously implanted CRT device, not responding to CRT (2)
  - patients with previously implanted pacemakers or implantable cardioverter-defibrillator and meeting the standard indications for CRT (8)





NYHA-class & LVEF improvement with WiSE-CRT





WiSE receives CE Mark

ebr SYSTEMS

EBR Systems Receives European CE Mark Approval for World's First Wireless Cardiac Pacing System for Heart Failure

New technology could benefit 1.5 million heart failure patients worldwide

Sunnyvale, Calif. – October 5, 2015 – EBR Systems, Inc., leading innovator in wireless heart stimulation, today announced European CE Mark (Conformité Européenne) approval for its **WiSE**™ (**Wi**reless **S**timulation **E**ndocardially) Technology.

Conclusion

Endocardial left ventricular stimulation can be considered a strategy for improving the response to CRT in a particular category of patients (unsuccessful placement through the coronary sinus; non-responders to conventional CRT; with major surgical controindications for epicardial pacing) , despite important limits. New wireless systems may extend the applicability of endocardial LV stimulation and make it safer .

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Endocardial Pacing: how to do it and when to choose it

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