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John D. Fisher, MD

Montefiore Medical Center

Professor of Medicine,

College of Medicine, NY



Multisite pacing in CRT – does it help?

John D. Fisher, MD
Professor of Medicine
Montefiore Medical Center
Albert Einstein College of Medicine
New York, USA



Disclosures

- ♥ **Consultant: Medtronic.**
- ♥ **Investigator: many device & drug companies.**
- ♥ **Fellowship support: Boston Scientific, Medtronic, St. Jude Medical, Biotronik**

Dual-Site Pacing

♥ Atrial

- For prevention/reduction of AF
- Remains controversial

♥ For termination (ATP) of atrial and ventricular arrhythmias (Mehra and others).

♥ For atrial and ventricular CRT.

- Some early Bi-V CRT was called “multisite”.

Multisite Pacing (MSP)

What are we talking about?

- ♥ RA + LA pacing.
- ♥ RV + LV pacing.
- ♥ RA + RA pacing.
- ♥ RV + RV pacing
- ♥ RV + RV + LV pacing.
- ♥ RV + LV + LV pacing.
 - Present area of greatest interest

Pilot for dual site atrial pacing to prevent atrial fibrillation (DAPPAF)

Long-Term Outcome of Patients With Drug-Refractory Atrial Flutter and Fibrillation After Single- and Dual-Site Right Atrial Pacing for Arrhythmia Prevention

PHILIPPE DELFAUT, MD, SANJEEV SAKSENA, MD, FACC, ATUL PRAKASH, MD, MRCP, RYSZARD B. KROL, MD, PhD

Millburn, New Jersey

Objectives. An initial crossover study comparing dual- and single-site right atrial pacing was performed followed by a long-term efficacy and safety evaluation of dual-site right atrial pacing in patients with drug-refractory atrial fibrillation (AF). Also examined was the efficacy of two single-site right atrial pacing modes (high right atrium and coronary sinus ostium) and the long-term need for cardioversion, antithrombotic and antiarrhythmic drug therapies during dual-site atrial pacing.

Methods. Thirty consecutive patients with drug-refractory symptomatic AF and documented primary or drug-induced bradycardia were implanted with a dual chamber rate-responsive pacemaker and two atrial leads. Single-site atrial pacing was performed at the high right atrium or the coronary sinus ostium. Continuous atrial pacing was maintained.

Results. Mean arrhythmia-free intervals increased from 9 ± 10 days in the control period preceding implant to 143 ± 110 days ($p < 0.0001$) in single-site right atrial pacing and 195 ± 96 days in dual-site right atrial pacing ($p < 0.005$ versus single-site pacing and $p < 0.0001$ versus control). Dual-site right atrial pacing significantly increased the proportion of patients free of AF

recurrence (89%) as compared to single-site right atrial pacing (62%, $p = 0.02$). High right atrial pacing and coronary sinus ostial pacing had similar efficacy for AF prevention. Effective rhythm control was achieved in 86% of patients during dual right atrial pacing. Seventy-eight percent of patients at 1 year and 56% at 3 years remained free of symptomatic AF. The need for cardioversion was reduced after pacemaker implant ($p < 0.05$) and antithrombotic therapy was reduced ($p < 0.06$) without any thromboembolic event. Coronary sinus ostial lead dislodgement was not observed after discharge.

Conclusions. Atrial pacing in combination with antiarrhythmic drugs eliminates or markedly reduces recurrent AF. Prevention of AF is enhanced by dual-site right atrial pacing. High right atrial and coronary sinus ostial pacing do not differ in efficacy. Dual-site right atrial pacing is safe, achieves long-term rhythm control in most patients, decreases the need for cardioversion, and antithrombotic therapy can be selectively reduced.

(*J Am Coll Cardiol* 1998;32:1900-8)

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Conventional CRT (RA) + RV + LV

Multisite Pacing for End-Stage Heart Failure: Early Experience

SERGE CAZEAU, PHILIPPE RITTER, ARNAUD LAZARUS, DANIEL GRAS, HAYSSAM BACKDACH, OLIVIER MUNDLER,* and JACQUES MUGICA

From the Centre Chirurgical du Val d'Or, Saint-Cloud, and the *Service de Médecine Nucléaire, Hôpital Lariboisière, Paris, France

CAZEAU, S., ET AL.: Multisite Pacing for End-Stage Heart Failure: Early Experience. Our objective was to improve hemodynamics by synchronous right and left site ventricular pacing in patients with severe congestive heart failure (CHF). Previous studies reported a benefit of dual chamber pacing with a short AV delay in patients with severe CHF. Other works, however, show contradictory results. Deleterious effects due to a desynchronization of right (RV) and left ventricular (LV) contractions have been suggested. This study included eight subjects with widened QRS and end-stage heart failure despite maximal medical therapy, who refused, or were not eligible to undergo heart transplantation. Each patient underwent a baseline, invasive hemodynamic evaluation with insertion of three temporary leads to allow different pacing configurations, including RV apex and outflow tract pacing, and biventricular pacing between the RV outflow tract and LV and RV apex and LV. According to the results of this baseline study, the configuration of preexistent pacemakers was modified or new systems were implanted to allow biventricular pacing, which, in patients with sinus rhythm, was atrial triggered. Biventricular pacing increased the mean cardiac index (CI) by 25% (from a baseline of 1.83 ± 0.30 L/min per m^2 , $P < 0.006$), decreased the mean V wave by 26% (from a baseline of 36 ± 12 mmHg, $P < 0.004$), and decreased pulmonary capillary wedge pressure by 17% (from a baseline of 31 ± 10 mmHg, $P < 0.01$). Four patients died (1 preoperatively, 1 intraoperatively, 2 within 3 months, and 1 of a noncardiac cause). The four surviving patients have clinically improved from New York Heart Association Functional Class IV to Class II. In these survivors, CI decreased by 15% ($P < 0.007$) when multisite pacing was turned off during follow-up. In patients with end-stage heart failure, multisite pacing may be associated with a rapid and sustained hemodynamic improvement. (*PACE* 1996; 19[Pt. II]:1748-1757)

Cazeau et al 1996

- ♥ “Multisite” here = conventional CRT
 - RVA or RVOT to LV produced favorable results.

CRT may favor Reversion of AF to SR, (...which may further improve CHF?)

Clin Res Cardiol 98:189–194 (2009)
DOI 10.1007/s00392-008-0740-z

ORIGINAL PAPER

Melanie Hauck
Alexander Bauer
Frederik Voss
Hugo A. Katus
Ruediger Becker

**Effect of cardiac resynchronization therapy
on conversion of persistent atrial
fibrillation to sinus rhythm**

Dual Site RV

RV + RV

- ♥ Some reports that if an LV site cannot be achieved, then dual RV may be better than single site RV.

**Dual-site right ventricular pacing.
A rescue alternative in cardiac resynchronisation
therapy implantation failure? More efficient
stimulation for patients with borderline cardiac
resynchronisation therapy indication?
Less harmful ventricular pacing?**

Marcin Gulaj¹, Tomasz Sodolski² and Andrzej Kutarski²

¹Department of Cardiology, Ministry of Interior and Administration Hospital, Białystok, Poland

²Department of Cardiology, Medical University, Lublin, Poland



CASE REPORT

Cardiac resynchronisation therapy versus dual site right ventricular pacing in a patient with permanent pacemaker and congestive heart failure

Oruganti Sai Satish^a, Kuan-Hung Yeh^b, Ming-Shien Wen^b,
Chun-Chieh Wang^{b,*}

^a Mizam's Institute of Medical Sciences, Hyderabad, India

^b Department of Medicine, Second Section of Cardiology, Chang Gung Memorial Hospital, Chang Gung University College of Medicine, 199 Tung Hwa North Road, Sung-Shan District, Tao-Yuan, Taipei 111, Taiwan

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KEYWORDS

cardiac
resynchronisation
therapy;
heart failure;
complete heart block;
pacemaker;
atrial fibrillation

Abstract A 46-year-old male patient who had long-term right ventricular (RV) pacing for symptomatic complete heart block, initially by an epicardial, later with an endocardial pacing lead at the RV apex, developed congestive heart failure (CHF) and chronic atrial fibrillation 7 years following the pacemaker implantation and was medically treated. During follow-up, his pacemaker was upgraded to a cardiac resynchronisation therapy (CRT) device, because of uncontrolled CHF symptoms, New York Heart Association (NYHA) functional class IV, while on drugs. The patient's symptomatic status improved to NYHA functional class II with CRT. After 17 months of CRT, the battery became depleted, because of the high capture threshold of the left ventricular lead. The patient was then given dual site RV pacing (RV outflow tract + RV apex) in place of CRT, which showed similar efficacy at 12 weeks follow-up.

**Dual site RV + single-site LV.
RV + RV + LV**

Dual-site right ventricular and left ventricular pacing in a patient with left ventricular systolic dysfunction and atrial fibrillation using a standard CRT-D device



David Chase^{a,*}, Vipin Kumar^a, Amit Hooda^a

J Saudi Heart Assoc 2013

^aChristian Medical College Hospital, Vellore, Tamilnadu 632008

^{*}India

In patients undergoing cardiac resynchronization therapy with defibrillator (CRT-D) implantation for left ventricular systolic dysfunction (LVSD) accompanied by permanent atrial fibrillation (AF), generally, the unused atrial port is plugged at device implantation. We describe an alternative use for the atrial-port in this case report.

A 43 year old gentleman with LVSD due to left ventricular non-compaction (LVNC) and AF of unknown duration underwent a CRT-D implantation after optimization of cardiac failure treatment. The atrial-port which would otherwise have been plugged was connected to a high right ventricular septal (RVS) pacing-lead and the shock-lead was positioned at the right ventricular apex (RVA). This approach permitted modified cardiac resynchronization in a high RVS to left ventricular (LV) and RVA pacing sequence using the high RVS and LV pacing combined with a shock vector including the RV apex. A standard CRT-D device with a minimum programmable A-V delay of 30 ms (technically RVS to LV delay in the 'DDD' pacing mode) was used. The device was programmed to a 'DDD' pacing mode (sequential multi-site ventricular pacing with some programmability). The mode switch operation was programmed 'OFF' since atrial sensing is unavailable. Device-delivered shocks did not cardiovert the patient back to sinus rhythm suggesting that the AF was permanent (no polar cardioversion attempts were made on the presumption that the chances of maintaining sinus rhythm, given the underlying cardiac condition, were low). Subsequently, the patient required radio-frequency ablation of the atrio-ventricular node for conducted AF. Symptomatic, echocardiographic and radiological improvement preceded atrio-ventricular node ablation.

Conclusion: Amongst AF patients with permanent AF undergoing CRT-D implantation, those patients who are likely to have the CRT-D device atrial-ports plugged could benefit from having both the options of (i) a RVA shock vector as well as (ii) a high RVS-pacing feasible, by utilizing the atrial-port of a conventional CRTD device for a RVS pacing lead, should a RVA shock-lead position be preferred. New device programming algorithms will be necessary to make patient-customized programming in this lead configuration flexible, more useful clinically and easy.

Dual site RV, + LV CRT

Chase et al 2013

- ♥ AF patient.
- ♥ A-port connected to RVS lead.
 - Near 0ms AV I.
- ♥ RV & LV ports connected normally.
- ♥ Good response.

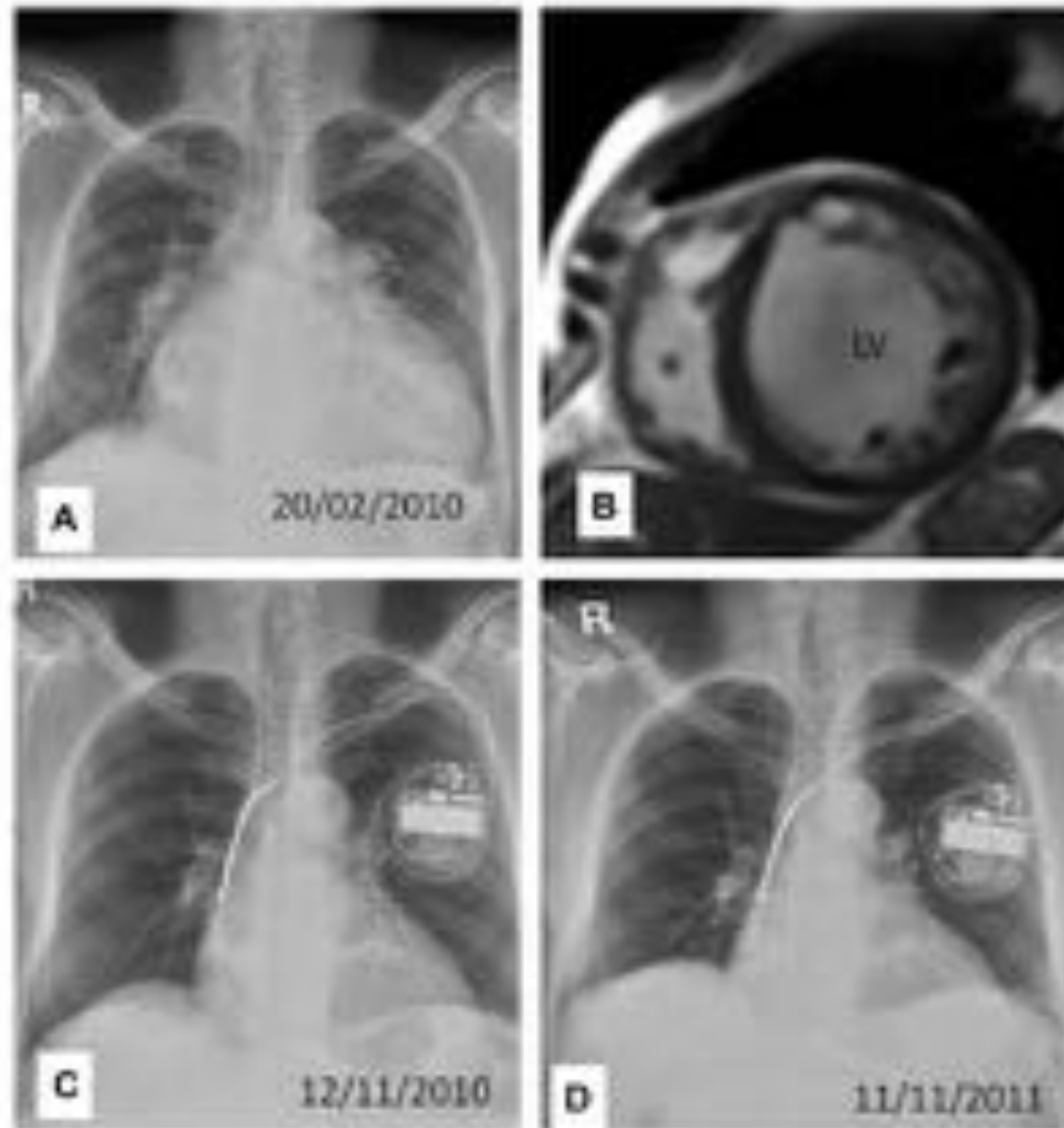


Figure 3. A & B - Baseline chest X ray and MR image; C & D - Serial follow up chest X ray images.



Effect of triangle ventricular pacing on haemodynamics and dyssynchrony in patients with advanced heart failure: a comparison study with conventional bi-ventricular pacing therapy

Kentaro Yoshida[†], Yoshihiro Seo^{*†}, Hiro Yamasaki, Kazuyuki Tanoue, Nobuyuki Murakoshi, Tomoko Ishizu, Yukio Sekiguchi, Satoru Kawano, Sadanori Otsuka, Shigeyuki Watanabe, Iwao Yamaguchi, and Kazutaka Aonuma

- ♥ RV + RV + LV
- ♥ 21 patients, over medium-term follow up.
- ♥ Dual RV, + 1LV better than standard CRT.
- ♥ No RCT yet.

However...

Right Ventricular Outflow Versus Apical Pacing in Pacemaker Patients with Congestive Heart Failure and Atrial Fibrillation

BRUCE S. STAMBLER, M.D.,* KENNETH A. ELLENBOGEN, M.D.,[†]
XIAOQING ZHANG, M.D.,[‡] THOMAS R. PORTER, M.D.,[§] FENG XIE, M.D.,^{||}
RAJESH MAJIK, M.D.,[¶] BOB SMALL, M.D.,[#] MARTIN BURKE, D.O.,**
ANDREW KAPLAN, M.D.,^{††} LAWRENCE NAIR, M.D.,^{‡‡} MICHAEL BELZ, M.D.,^{§§}
CHARLES FUENZALIDA, M.D.,^{¶¶} MICHAEL GOLD, M.D.,^{##} CHARLES LOFT, M.D.,^{***}
ARJUN SHARMA, M.D.,^{†††} RUSSELL SILVERMAN, M.D.,^{‡‡‡} FELIX SOGADÉ, M.D.,^{§§§}
BRUCE VAN NATA, M.D.,^{¶¶¶} and BRUCE L. WILKOFF, M.D.,^{###} for the SONA Investigators.

From *University Hospital of Cleveland, Case Western Reserve University, Cleveland, Ohio, USA; †Medical College of Virginia, Virginia Commonwealth University, Richmond, Virginia, USA; ‡DA Hall Medical Center, Sausalito, California, USA; ‣University of Nebraska, Omaha, Nebraska, USA; ․North Coast, Marion, Ohio, USA; ‥Lancaster General, Lancaster, Pennsylvania, USA; **University of Chicago, Chicago, Illinois, USA; ††The City Cardiology Consultants, Mesa, Arizona, USA; ‡‡Perdykian Heart Group, Albuquerque, New Mexico, USA; ‡‡‡Virginia Mason Research Center, Seattle, Washington, USA; ††††Owens Corning Associates, Aurora, Colorado, USA; †††††University of Maryland, Baltimore, Maryland, USA; ††††††Ohio State University, Columbus, Ohio, USA; †††††††Halter Health, Sacramento, California, USA; ††††††††Hartman Care Group, East Syracuse, New York, USA; †††††††††Medical Center of Central Georgia, Macon, Georgia, USA; ††††††††††Medwest Medical Group, Long Beach, California, USA; and †††††††††††Cleveland Clinic Foundation, Cleveland, Ohio, USA.

Right Ventricular Pacing Site in Heart Failure. Introduction: Prior studies suggest that right ventricular apical (RVA) pacing has deleterious effects. Whether the right ventricular outflow tract (RVOT) is a more optimal site for permanent pacing in patients with congestive heart failure (CHF) has not been established.

Methods and Results: We conducted a randomized, cross-over trial to determine whether quality of life (QOL) is better after 3 months of RVOT than RVA pacing in 105 pacemaker recipients with CHF, left ventricular (LV) systolic dysfunction (LV ejection fraction < 40%), and chronic atrial fibrillation (AF). An additional aim was to compare dual-site (RVOT + RVA, 30 ms delay) with single-site RVA and RVOT pacing. QRS duration was shorter during RVOT (267 ± 47 ms) and dual-site (249 ± 19 ms) than RVA pacing (280 ± 38 ms, $P < 0.001$). At 3 months, the RVOT group had higher ($P = 0.01$) role-emotional QOL subscale scores than the RVA group. At 9 months, there were no significant differences in QOL scores between RVOT and RVA groups. Comparing RVOT to RVA pacing within the same patient, mental health subscale scores were better ($P = 0.03$) during RVOT pacing. After 9 months of follow-up, LVEF was higher ($P = 0.04$) in those assigned to RVA rather than RVOT pacing between months 6 and 9. After 3 months of dual-site RV pacing, physical functioning was worse ($P = 0.02$) than during RVA pacing, mental health was worse ($P = 0.02$) than during RVOT pacing, and New York Heart Association (NYHA) functional class was slightly better ($P = 0.03$) than during RVOT pacing. There were no other significant differences between RVA, RVOT and dual-site RV pacing in QOL scores, NYHA class, distance walked in 6 minutes, LV ejection fraction, or mitral regurgitation.

Conclusion: In patients with CHF, LV dysfunction, and chronic AF, RVOT and dual-site RV pacing shorten QRS duration but after 3 months do not consistently improve QOL, or other clinical outcomes compared with RVA pacing. *J Cardiovasc Electrophysiol*, Vol. 44, pp. 1380-1386, November 2003.

Disappointing

Stambler et al, JCE 2003

- ♥ In pts with CHF, LV Dysfunction, CAF:
 - RVOT or dual site RV pacing shorten QRS.
 - But after 3 months, no change in QOL or other outcomes compared with RVA pacing.
 - Thus CRT with LV pacing is needed.

Multisite LV pacing



Europace

doi:10.1093/europace/euu197

REVIEW

A review of multisite pacing to achieve cardiac resynchronization therapy

Christopher Aldo Rinaldi^{1*}, Haran Burri², Bernard Thibault³, Antonio Curnis⁴, Archana Rao⁵, Daniel Gras⁶, Johannes Sperzel⁷, Jagmeet P. Singh⁸, Mauro Biffi⁹, Pierre Bordachar¹⁰, and Christophe Leclercq¹¹

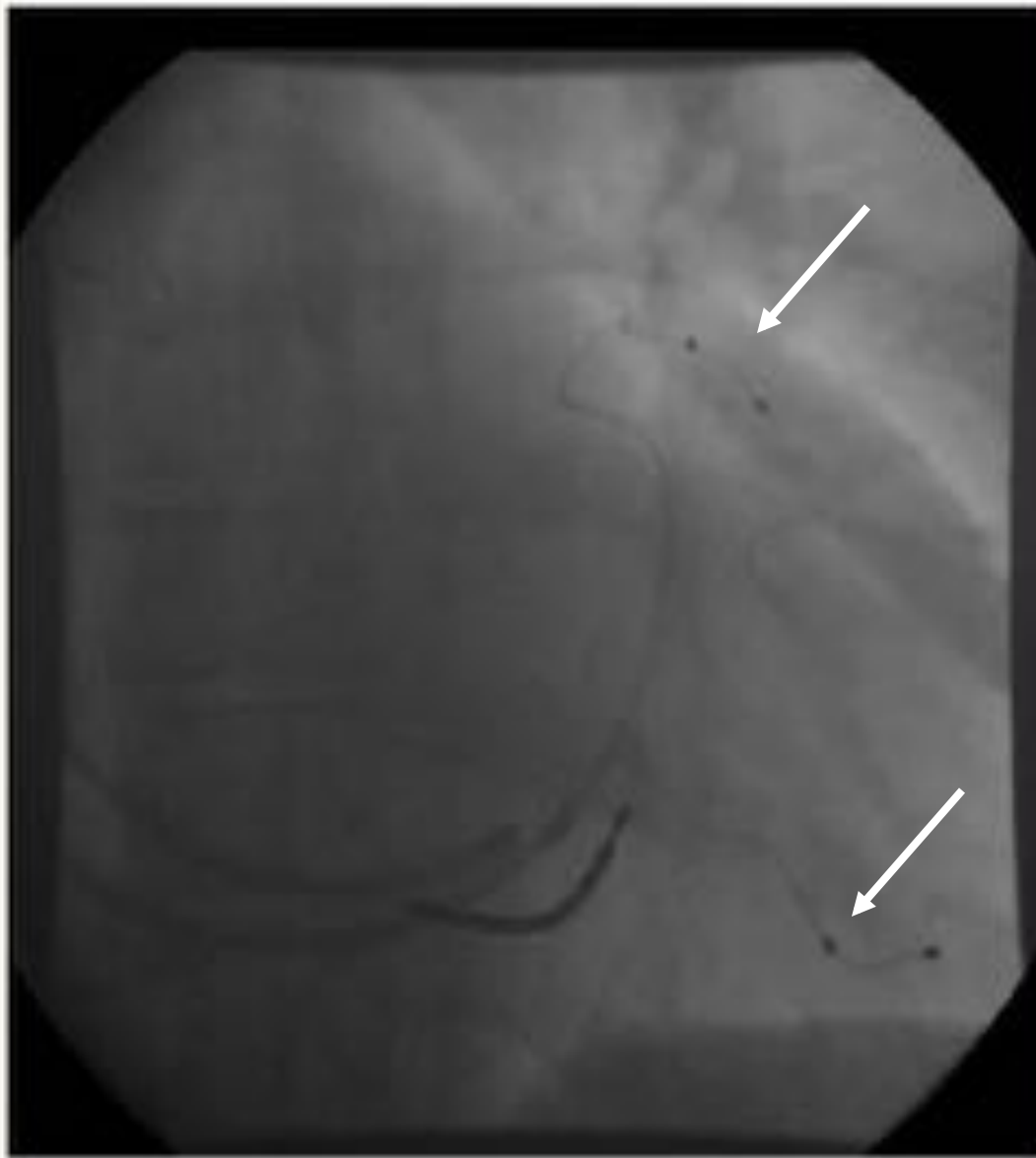


Figure 1 Anteroposterior projection of deployment of two bipolar LV pacing leads in separate branches of the CS (anterolateral and posterolateral) to achieve dual LV lead CRT.

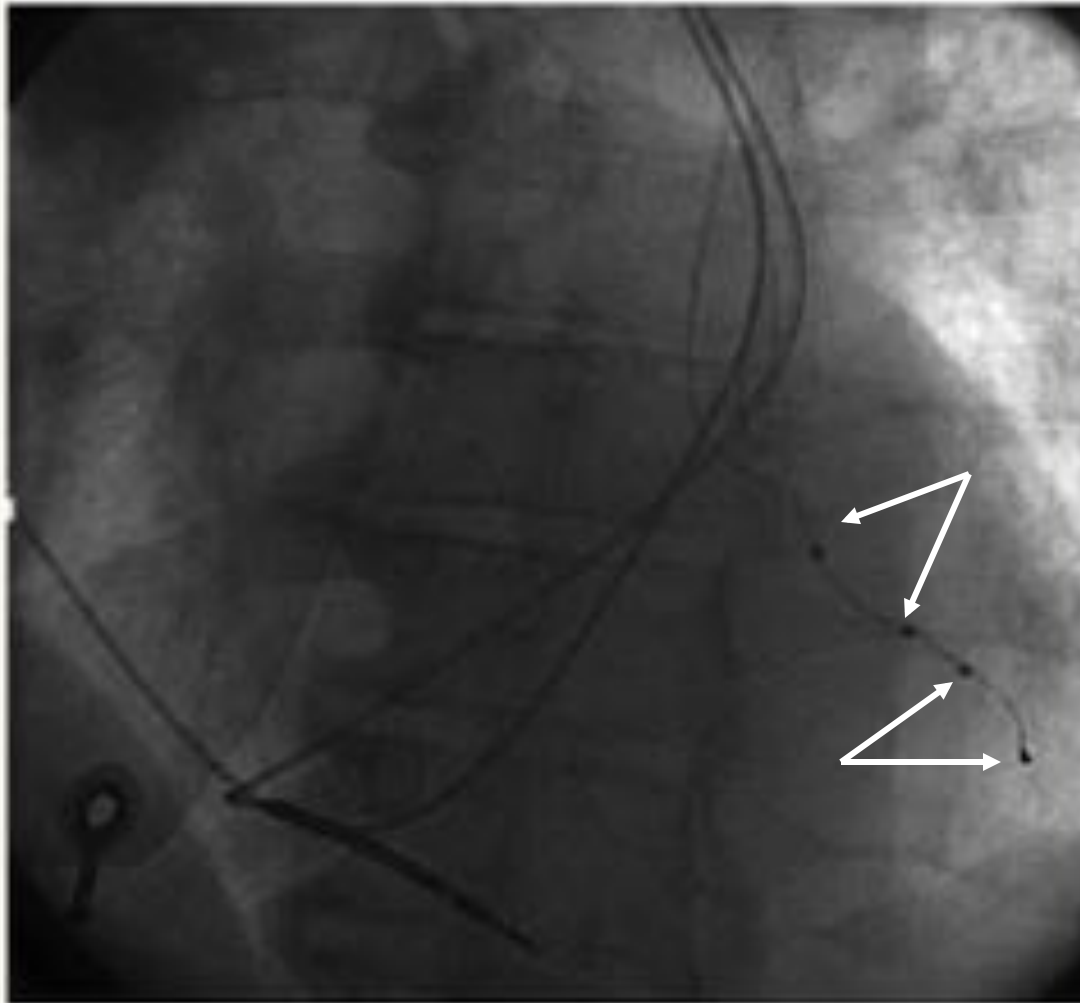


Figure 2 Top: Anteroposterior projection. Coronary sinus angiography performed with a telescopic catheter placed into a lateral cardiac vein. Bottom: LAO 30° projection. Implantation of a quadripolar LV lead using a similar approach compared with a regular bipolar LV lead. The patient has a persistent left-sided superior vena cava.

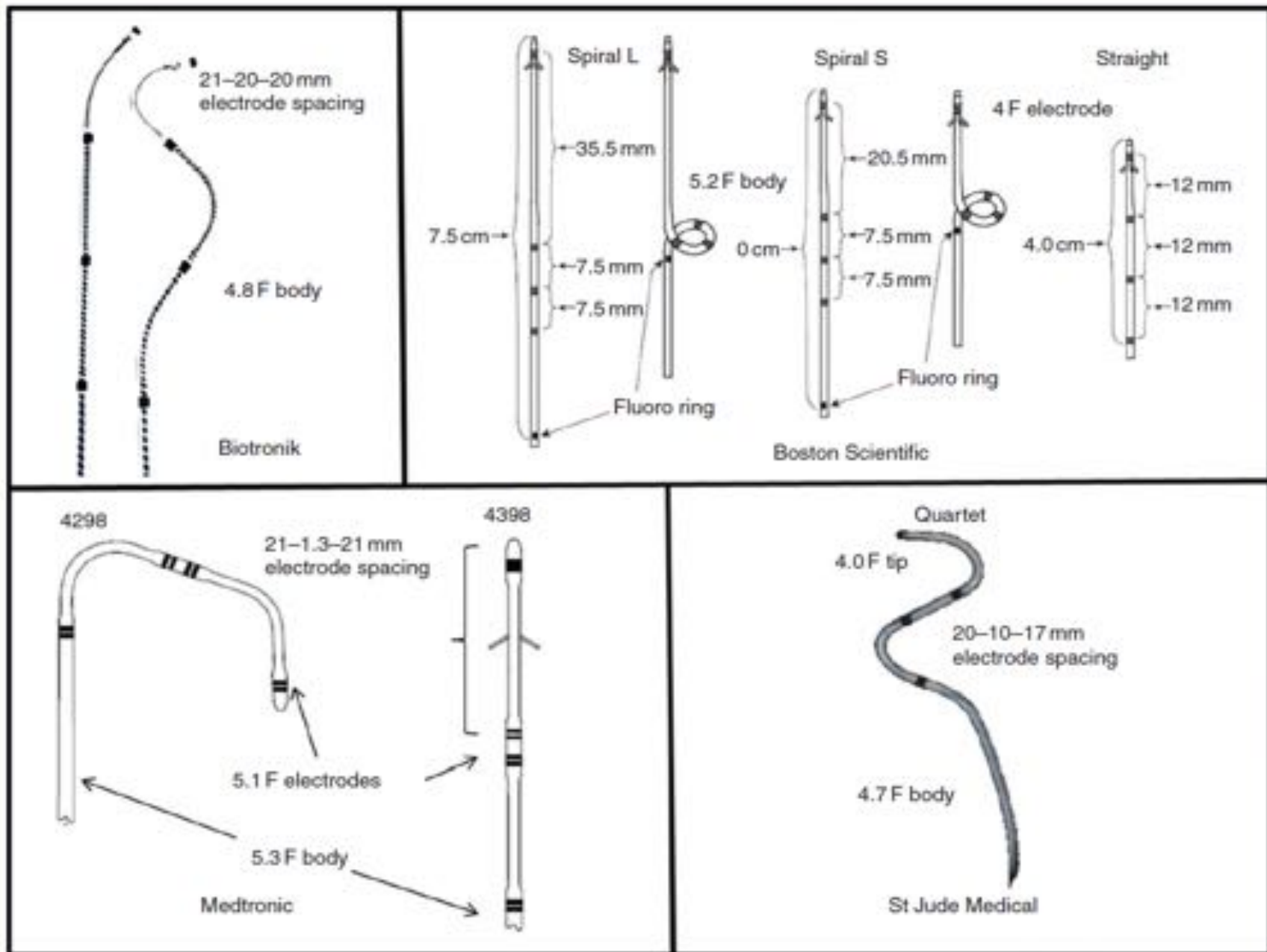


Figure 3 Currently available quadripolar LV leads, showing differences in lead design (reproduced/adapted and with permission from Boston Scientific, St Jude Medical, and Medtronic).

Features of Quadripolar LV Leads

- ♥ Need only 1 LV lead.
- ♥ Choice of poles may avoid phrenic nerve stimulation.
- ♥ May or may not provide multisite LV stimulation depending on anatomy.
- ♥ May or may not provide CRT equal to 2 separate LV leads.

Ischemic CM may benefit most from Multisite LV or Endocardial Pacing

♥ Ginks Circ A&E 2012, Europace 2012

Benefits of Endocardial and Multisite Pacing Are Dependent on the Type of Left Ventricular Electric Activation Pattern and Presence of Ischemic Heart Disease Insights from Electroanatomic Mapping

Matthew R. Ginks, MD; Anoop K. Shetty, MBBS; Pier D. Lambiase, PhD; Simon G. Duckett, MD; Julian Bostock, MSc; Janet L. Peacock, PhD; Kawal S. Rhode, PhD; Cliff Bucknall, MD; Jaswinder Gill, MD; Peter Taggart, MD; Christophe Leclercq, MD; Gerald S. Carr-White, PhD; Reza Razavi, MD; C. Aldo Rinaldi, MD



Europace (2012) 14, 373–379
doi:10.1093/europace/eur336

CLINICAL RESEARCH
Pacing and Resynchronization Therapy

Multi-site left ventricular pacing as a potential treatment for patients with postero-lateral scar: insights from cardiac magnetic resonance imaging and invasive haemodynamic assessment

Matthew R. Ginks^{1,2*}, Simon G. Duckett^{1,2}, Stamatis Kapetanakis¹, Julian Bostock¹, Shoaib Hamid¹, Anoop Shetty^{1,2}, Yingliang Ma², Kawal S. Rhode², Gerald S. Carr-White¹, Reza S. Razavi^{1,2}, and C. Aldo Rinaldi^{1,2}

LV MSP can overcome scar limitations of CRT

Biophysical Modeling to Simulate the Response to Multisite Left Ventricular Stimulation Using a Quadripolar Pacing Lead

STEVEN A. NIEDERER, PH.D.,* A.K. SHETTY, M.B.B.S.,*,† G. PLANK, PH.D.,‡ J. BOSTOCK, M.B.B.S.,† R. RAZAVI, M.D.,*,† N.P. SMITH, PH.D.,*,§ and C.A. RINALDI, M.D.,*,†

From the *Imaging Sciences & Biomedical Engineering Division, King's College London, London, United Kingdom; and †Department of Cardiology, St Thomas' Hospital, London, United Kingdom; ‡Institut für Biophysik, Medizinische Universität Graz, Graz, Austria; and §Computing Laboratory, University of Oxford, Oxford, United Kingdom

Background: Response to cardiac resynchronization therapy (CRT) is reduced in patients with posterolateral scar. Multipolar pacing leads offer the ability to select desirable pacing sites and/or stimulate from multiple pacing sites concurrently using a single lead position. Despite this potential, the clinical evaluation and identification of metrics for optimization of multisite CRT (MCRT) has not been performed.

Methods: The efficacy of MCRT via a quadripolar lead with two left ventricular (LV) pacing sites in conjunction with right ventricular pacing was compared with single-site LV pacing using a coupled electromechanical biophysical model of the human heart with no, mild, or severe scar in the LV posterolateral wall.

Result: The maximum dp/dt_{max} improvement from baseline was 21%, 23%, and 21% for standard CRT versus 22%, 24%, and 25% for MCRT for no, mild, and severe scar, respectively. In the presence of severe scar, there was an incremental benefit of multisite versus standard CRT (25% vs 21%, 19% relative improvement in response). Minimizing total activation time (analogous to QRS duration) or minimizing the activation time of short-axis slices of the heart did not correlate with CRT response. The peak electrical activation wave area in the LV corresponded with CRT response with an R^2 value between 0.42 and 0.75.

Conclusion: Biophysical modeling predicts that in the presence of posterolateral scar MCRT offers an improved response over conventional CRT. Maximizing the activation wave area in the LV had the most consistent correlation with CRT response, independent of pacing protocol, scar size, or lead location. (PACE 2012; 35:204–214)

CLINICAL RESPONSE TO MULTISITE BIVENTRICULAR PACING

Poster Contributions

Poster Sessions, Expo North

Saturday, March 09, 2013, 3:45 p.m.-4:30 p.m.

ACC 2013

Session Title: Heart Failure: Cardiac Resynchronization Therapy

Abstract Category: 17. Heart Failure: Therapy

Presentation Number: 1177-311

Authors: *Jose Cuellar-Silva, Dan Dan, Andrew Wickliffe, Thomas Deering, Serge Cazeau, Ioanna Kosmidou, Piedmont Heart Institute, Atlanta, GA, USA, Georgia Health Sciences University, Augusta, GA, USA*

Background: Lack of response to cardiac resynchronization therapy (CRT) remains a clinical challenge and is predominantly attributed to suboptimal LV lead positioning. Multisite pacing (MS-CRT) has emerged as an alternative to biventricular pacing, however clinical responses have not been thoroughly investigated.

Methods: 66 patients (45 males) with CHF (NYHA III and ambulatory III/IV) underwent initial MS-CRT (ICRT, n=49) or upgrade to MS-CRT from standard CRT after worsening of clinical status or adverse remodeling (UCRT, n=17). Major adverse clinical events (MACE) were death, heart failure (HF) hospitalization and cardiac transplantation or ventricular assist device implant at one year.

Results: Clinical characteristics and baseline LVEF, were similar between groups except for AF (64.7% vs 33.3% for the UCRT and ICRT groups, $p=0.025$) and history of ventricular arrhythmias (41.3% vs 16.7% for the UCRT and ICRT groups, $p=0.039$). Mean LVEF change after implant was not different between the ICRT and UCRT groups ($8.0\pm 8\%$ vs $4.1\pm 6.3\%$, $p=0.27$). At one year, the probability for MACE was similar between the two groups (LR=0.892). Time to first HF hospitalization was not different between groups ($222.3\pm 134d$ vs $267.2\pm 118d$ for the ICRT and UCRT groups, $p=0.818$).

Conclusions: Upgrade to MS-CRT in CRT non-responders results in clinical response similar to the observed response with initial MS-CRT implant. Multisite pacing may be useful in CRT non responders.

Acute haemodynamic comparison of multisite and biventricular pacing with a quadripolar left ventricular lead

Bernard Thibault^{1*}, Marc Dubuc¹, Paul Khairy¹, Peter G. Guerra¹, Laurent Macle¹, Lena Rivard¹, Denis Roy¹, Mario Talajic¹, Edward Karst², Kyungmoo Ryu², Patrice Paiement³, and Taraneh G. Farazi²

¹Department of Medicine and Research Center, Montreal Heart Institute and Université de Montréal, 5000 Belanger Street, Montreal, Quebec, QC H1T 1C8, Canada

²St Jude Medical, Research Department, 15900 Valley View Court, Sylmar, CA, USA; and ³St Jude Medical Canada, Clinical Research Department, 2100 Derry Road West, Suite 400, Mississauga, ON, Canada

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Aims

Pacing from multiple sites in the left ventricle (LV) may bring about further resynchronization of the diseased heart compared with biventricular (BiV) pacing. We compared acute haemodynamic response (LV dp/dt_{max}) of multisite and BiV pacing using a quadripolar LV lead.

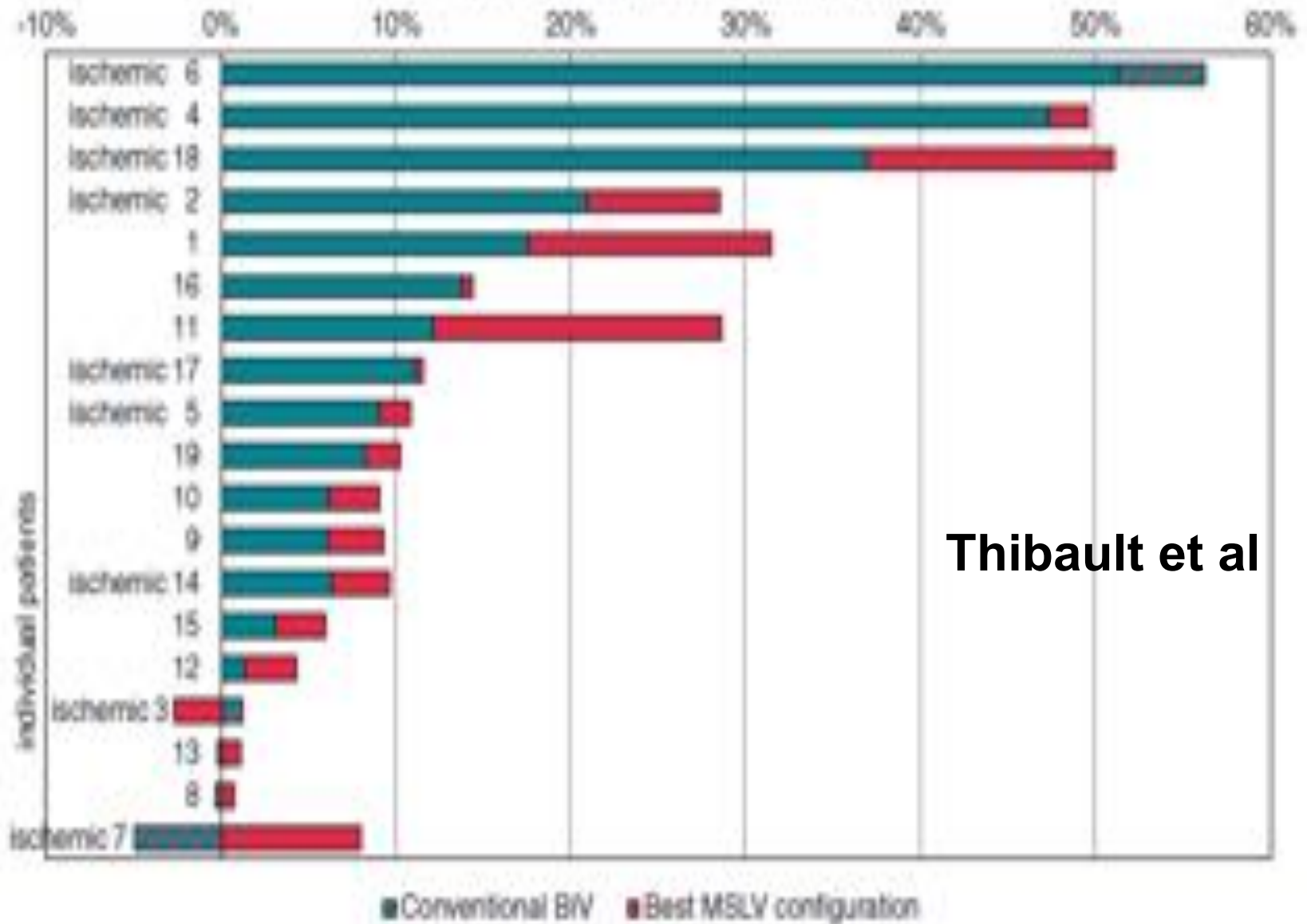
Methods and results

In 21 patients receiving cardiac resynchronization therapy, a quadripolar LV lead and conventional right atrial and ventricular leads were connected to an external pacing system. A guidewire pressure sensor was placed in the LV for continuous dp/dt measurement. Four multisite pacing configurations were tested three times each and compared with BiV pacing using the distal LV electrode. Nineteen patients had useable haemodynamic data. Median increase in LV dp/dt_{max} with BiV vs. atrial-only pacing was 8.2% (interquartile range 2.3%, 15.7%). With multisite pacing using distal and proximal LV electrodes, median increase in LV dp/dt_{max} was 10.2% compared with atrial-only pacing (interquartile range 6.1%, 25.6%). In 16 of 19 patients (84%), two or more of the four multisite pacing configurations increased LV dp/dt_{max} compared with BiV pacing. Overall, 72% of all tested configurations of multisite pacing produced greater LV dp/dt_{max} than obtained with BiV pacing. Pacing from most distal and proximal electrodes was the most common optimal configuration, superior to BiV pacing in 74% of patients.

Conclusion

In the majority of patients, multisite pacing improved acute systolic function further compared with BiV pacing. Pacing with the most distal and proximal electrodes of the quadripolar LV lead most commonly yielded greatest LV dp/dt_{max} .

Change compared to atrial-only pacing (%)



Thibault et al

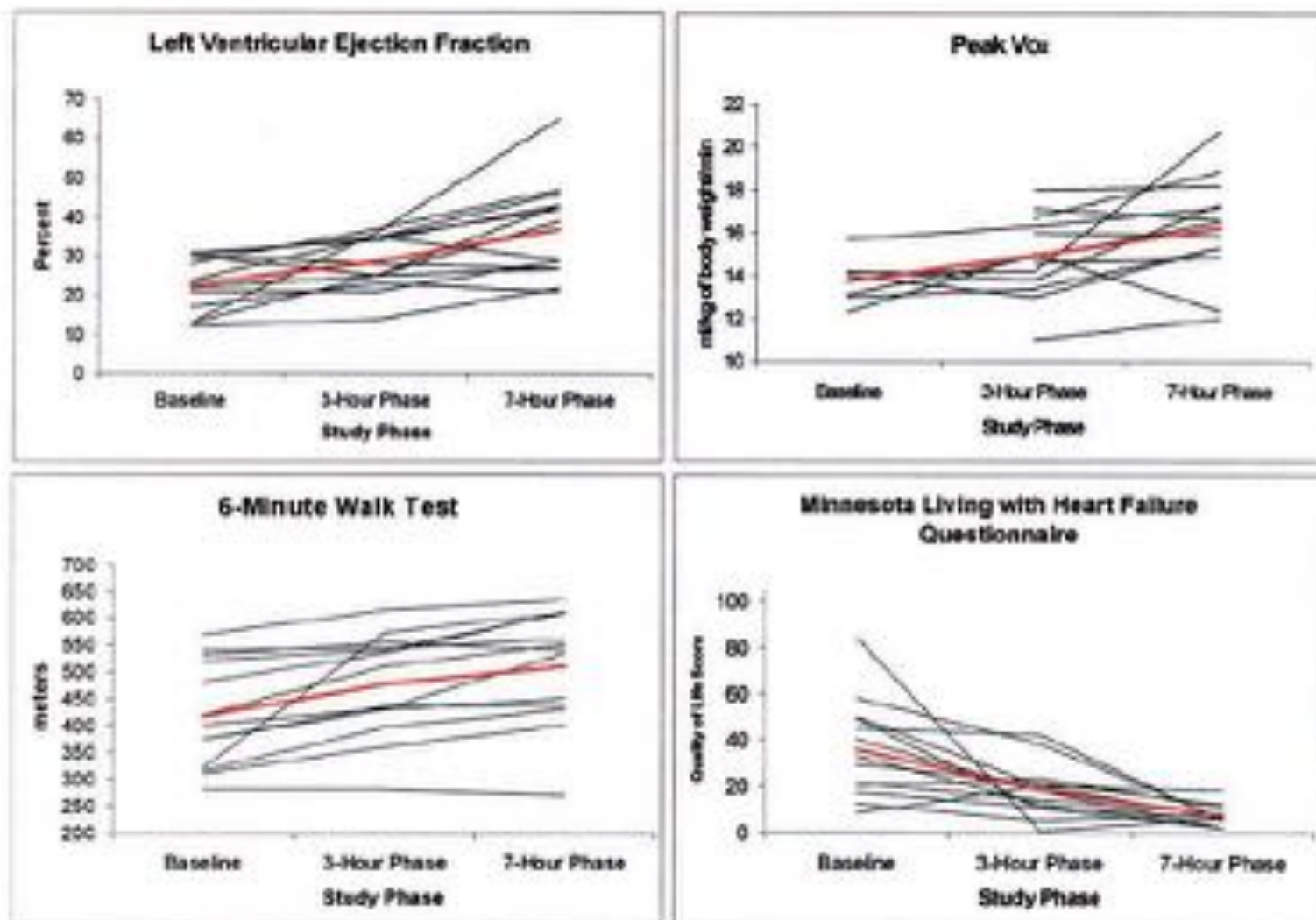


Figure 3. Changes in echocardiographic left ventricular systolic and diastolic function, maximal and submaximal exercise function, and clinical course during follow-up. A: Time course of left ventricular ejection fraction in the study phases compared with baseline in single patients (black lines) and in the overall study population (red line). B, C: Time course of the peak VO₂ (in mL/kg of body weight/min) and the distance walked in 6 minutes (in meters) in the study phases compared with baseline in single patients (black lines) and in the overall study population (red line), respectively. D: Patients' perception of the effects of heart failure on their daily lives (scores of the Minnesota Living with Heart Failure Questionnaire) in the study phases compared with baseline in single patients (black lines) and in the overall study population (red line). Subjects had mean scores that were substantially above the benchmark of 10 (e.g., reduced quality of life).

Table 1 Studies of MPS delivered by a quadripolar

Author, year	Number of patients	Study type	Findings
Thibault et al (2013)	19 (21)	Acute comparative study Measurement: invasive haemodynamic evaluation (dP/dt)	72% of patients, MPP improved acute systolic function vs. conventional CRT. Pacing most distal and proximal electrodes most commonly yielded greatest $LVdP/dt_{max}$
Rinaldi et al (2013)	41(52)	Comparative study after implant Measurement: echocardiographic dyssynchrony (TDI)	64% of patients MPP resulted in significant reduction in dyssynchrony vs. conventional CRT
Pappone et al (2013)	44	Randomized comparative study at the time of implant Measurement: invasive haemodynamic evaluation (pressure-volume loops)	Main finding: CRT with MPP can significantly improve acute LV haemodynamic parameters assessed with PV loop measurements as compared with conventional CRT

**But remember RV + RV + LV
Also produced favorable early results
That lessened over time.**

**How many sites are needed to optimize
MSP?**

**Studied in canines with chronic
LBBB**

Acute electrical and hemodynamic effects of multisite left ventricular pacing for cardiac resynchronization therapy in the dyssynchronous canine heart

Sylvain Ploux, MD,^{1,†} Marc Strik, MD,² Arne van Hunnik, BSc,² Lars van Middendorp, MD,² Marion Kuiper, BSc,² Frits W. Prinzen, PhD²

From the ¹Department of Physiology, Cardiovascular Research Institute Maastricht, Maastricht University, Maastricht, The Netherlands, ²Hôpital de Haut-Lévêque, CHU de Bordeaux, Pessac, France, and ³L'Institut de Rythmologie et modélisation Cardiaque, Université de Bordeaux Segalen, Bordeaux, France.

BACKGROUND Multisite left ventricular (multi-LV) epicardial pacing has been proposed as an alternative to conventional single-site LV (single-LV) pacing to increase the efficacy of cardiac resynchronization therapy.

OBJECTIVE To compare the effects of multi-LV versus single-LV pacing in dogs with left bundle branch block (LBBB).

METHODS Studies were performed in 9 anaesthetized dogs with chronic LBBB using 7 LV epicardial electrodes. Each electrode was tested alone and in combination with 1, 2, 3, and 6 other electrodes, the sequence of which was chosen on the basis of practical real-time electrical mapping to determine the site of the latest activation. LV total activation time (LVTAT) and dispersion of repolarization (DRep) were measured by using approximately 100 electrodes around the ventricles. LV contractility was assessed as the maximum derivative of left ventricular pressure (LVdP/dt_{max}).

RESULTS Single-LV pacing provided, on average, a $-4.0\% \pm 9.3\%$ change in LVTAT and $0.2\% \pm 13.7\%$ change in DRep. Multi-LV pacing markedly decreased both LVTAT and DRep in a stepwise fashion to reach $-41.3\% \pm 5\%$ ($P < .001$ for overall comparison) and $-14.2\% \pm 19.5\%$ ($P < .02$ for overall comparison) in the septuple-LV pacing configuration, respectively. Single-LV pacing provided a mean increase of $10.7\% \pm 7.7\%$ in LVdP/dt_{max}.

LVdP/dt_{max} incrementally increased by the addition of pacing electrodes to $16.4\% \pm 8.7\%$ ($P < .001$ for overall comparison). High response to single-LV pacing could not be improved further during multi-LV pacing.

CONCLUSIONS Compared with single-LV pacing, multi-LV pacing can considerably reduce both LVTAT and DRep in dogs with LBBB, but the improvement in contractility is limited to conditions where single-LV pacing provides suboptimal improvement. Further studies are warranted to determine whether these acute effects translate in antiarrhythmic properties and better long-term outcomes.

KEYWORDS Cardiac resynchronization therapy; Multisite left ventricular pacing; Heart failure; Left bundle branch block; Cardiac mapping; Biventricular pacing

ABBREVIATIONS CRT = cardiac resynchronization therapy; DRep = dispersion of repolarization; LBBB = left bundle branch block; LV = left ventricular; LVdP/dt_{max} = maximum derivative of left ventricular pressure; LVTAT = left ventricular total activation time; multi-LV = multisite left ventricular; RV = right ventricular; single-LV = single-site left ventricular

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LBBB

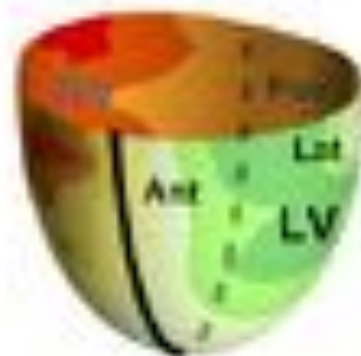
1 LV Pacing Site

LV dP/dt_{max}: +10%

2 LV Pacing Sites

LV dP/dt_{max}: +15%

120 ms



3 LV Pacing Sites

LV dP/dt_{max}: +19%

4 LV Pacing Sites

LV dP/dt_{max}: +19%

7 LV Pacing Sites

LV dP/dt_{max}: +25%



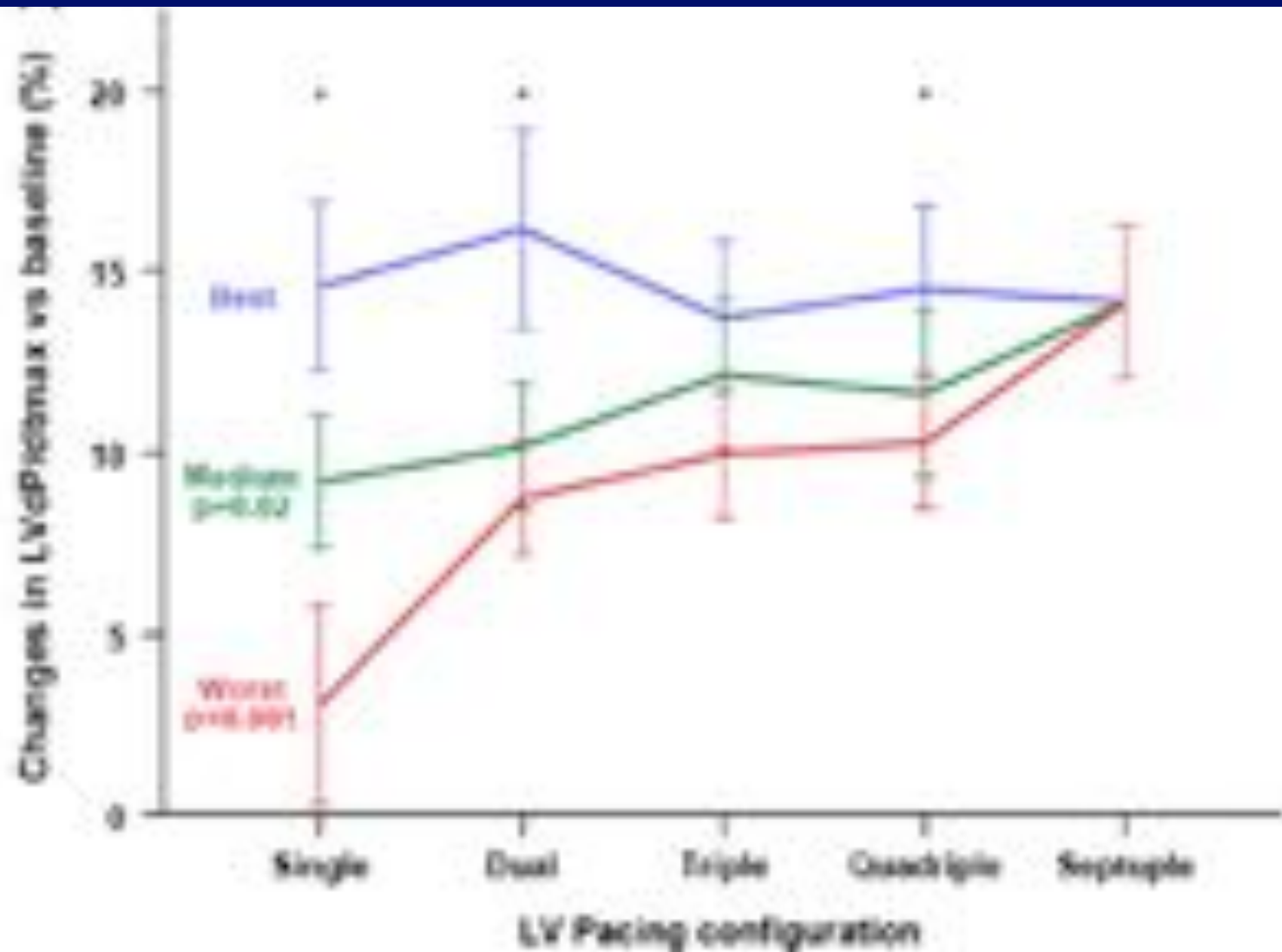
0 ms



Pacing Site



Latest Activated Region



MultiPoint Pacing Trial

ClinTrials.gov NCT02066467

♥ BSC-Guidant European trial.

♥ 2014-2016

♥ Randomize:

- Conventional CRT.
- CRT-MSP with Quad LV lead.

MORE-CRT

ClinTrials.gov NCT02006069

- ♥ SJM European trial.
- ♥ 2014-2017.
- ♥ All get quad LV lead but programmed to conventional CRT.
- ♥ After 6 months:
 - responders continued as CRT.
 - Non-responders randomized to conventional or MSP-CRT.

Hierarchy?

- ♥ Sometimes a good LV position cannot be achieved through the coronary sinus.
- ♥ A “hierarchy” has been suggested:
 - RV + LV
 - Maybe RV + LV + LV.
 - Or RV + RV + LV
 - Dual site RV (RV + RV).
 - RVOT.
 - RVA. Known to be bad with poor LV function.

“Thinking out of the Box”

Impulse Dynamics™ Multisite RV Cardiac Contractility Modulation (CCM) delivered during RP at multiple RV sites

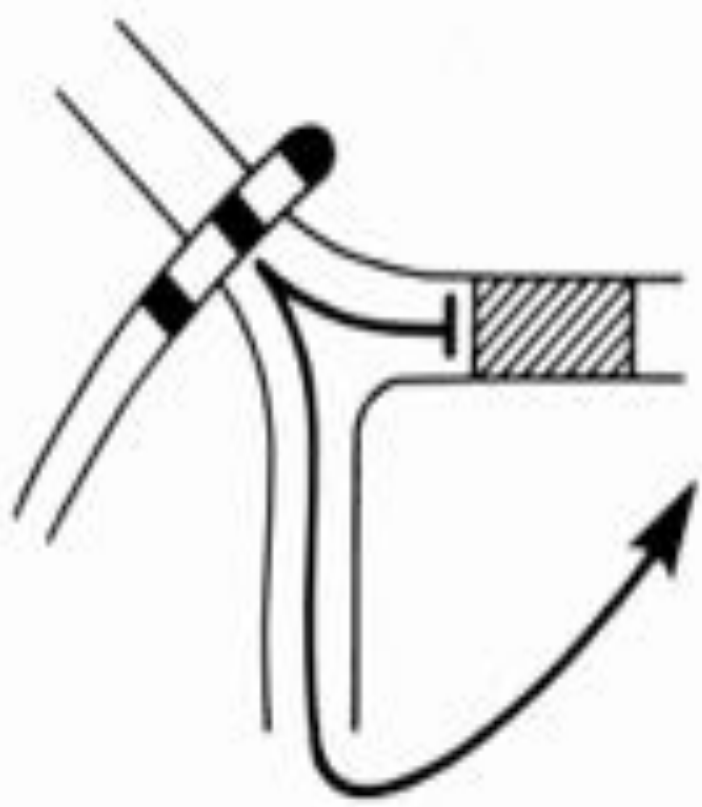
First Human Chronic Experience with Cardiac Contractility Modulation by Nonexcitatory Electrical Currents for Treating Systolic Heart Failure: Mid-Term Safety and Efficacy Results from a Multicenter Study

CARLO PAPPONE, M.D., Ph.D., GIUSEPPE AUGELLO, M.D.,
SALVATORE ROSANIO, M.D., Ph.D., GABRIELE VICEDOMINI, M.D.,
VINCENZO SANTINELLI, M.D., MASSIMO ROMANO, M.D., EUSTACHIO AGRICOLA, M.D.,
FRANCESCO MAGGI, D.Sc., GERHARD BUCHMAYR, D.Sc.,† GIOVANNI MORETTI,‡
YUVAL MIKA, D.Sc.,* SHLOMO A. BEN-HAIM, M.D., Ph.D.,‡ MICHAEL WOLZT, M.D.,‡
GUENTER STIX, M.D.,‡ and HERWIG SCHMIDINGER, M.D.‡

Conclusion: CCM therapy appears to be safe and feasible. Proarrhythmic effects of this novel therapy seem unlikely. Preliminary data indicate that CCM gradually and significantly improves systolic performance, symptoms, and functional status. CCM therapy for 7 hours per day is associated with greater dispersion near the mean, emphasizing the need to individually tailor CCM delivery duration. The technique appears to be attractive as an additive treatment for severe HF. Controlled randomized studies are needed to validate this novel concept. (*J Cardiovasc Electrophysiol*, Vol. 15, pp. 418-427, April 2004)

His Bundle Pacing for CRT

- ♥ Early studies (Rosen, Narula) indicated that some LBBB originated proximally in fibers in the HB that were destined to become the LBB.
- ♥ Early attempts at chronic HB pacing (Furman, Karpawich) foiled by development of fibrosis.
- ♥ Small modern steroid-eluting screws have re-opened interest in HB pacing.



QRS:

NSR:	LBBB
H-Paced:	LBBB

LBBB
Normal



Fig. 6.
Diagrammatic sketches of the left-sided conduction system as observed in 49 hearts (from Démoulin, J. C., Thesis, in preparation).

Cardiac Resynchronization Through Selective His Bundle Pacing in a Patient with the So-Called InfraHis Atrioventricular Block

PABLO MORIÑA-VÁZQUEZ, RAFAEL BARBA-PICHARDO, JOSÉ VENEGAS-GAMERO, and MANUEL HERRERA-CARRANZA

From the Arrhythmia and Pacing Unit, Critical Care Department, "Juan Ramón Jiménez" Hospital, Huelva, Spain

MORIÑA-VÁZQUEZ, P., ET AL.: Cardiac Resynchronization Through Selective His Bundle Pacing in a Patient with the So-Called InfraHis Atrioventricular Block. We present a case of InfraHis AV block in which selective His bundle pacing with His-ventricular conduction through the conduction system was accomplished. While further investigations are developed, this approach may be an alternative for cardiac resynchronization in cases of difficult coronary sinus access. (*PACE* 2005; 28:726-729)

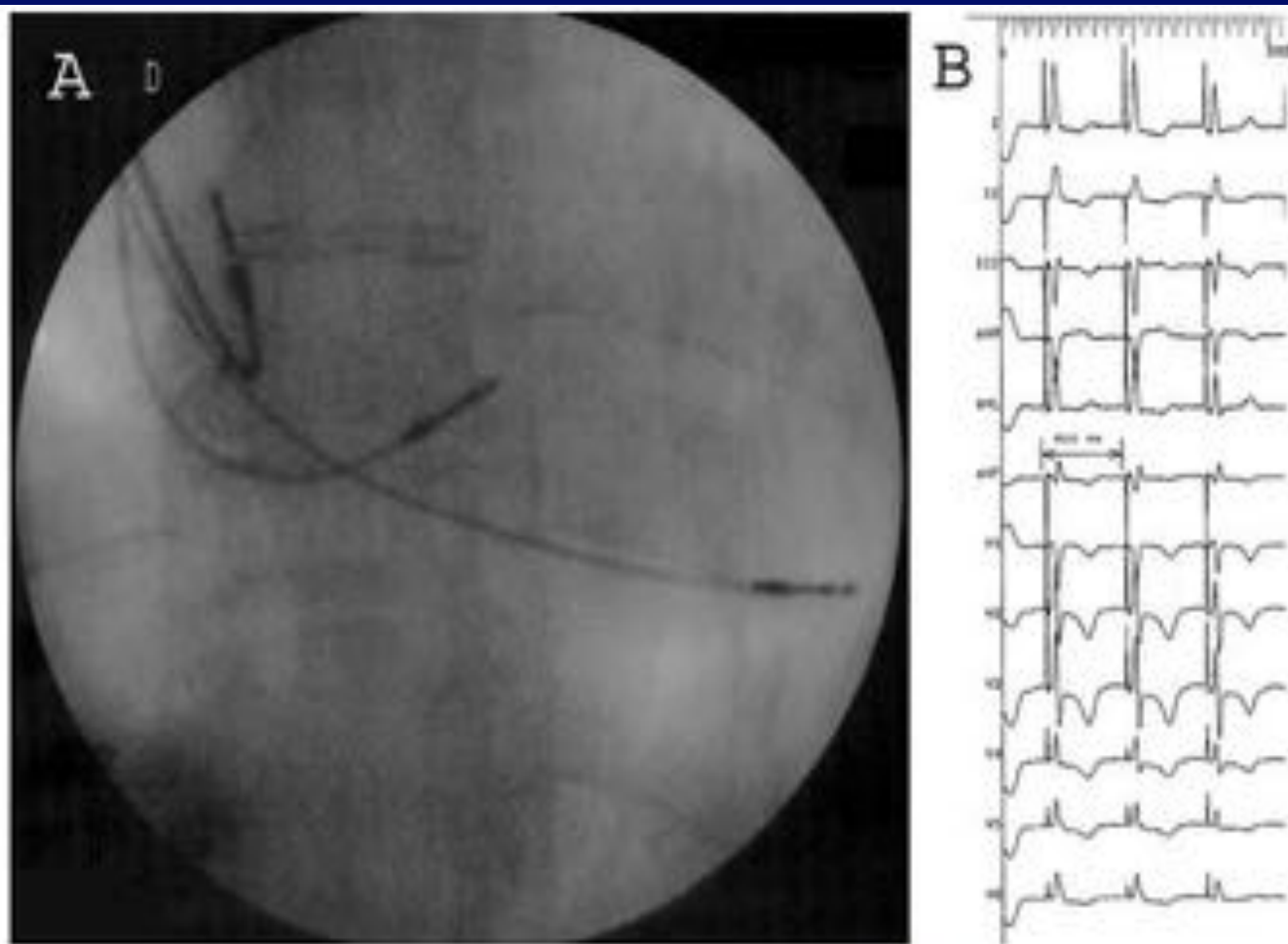


Figure 2. Panel A: PA x-ray showing the final position of the right atrial, right ventricular, and His bundle leads. Panel B: Continuous pacing at the final position of the His bundle lead catheter beside the reference temporary catheter, the third complex is a pure His bundle capture, while the other two QRS complex are minimally fused.

Permanent His-bundle pacing is feasible, safe, and superior to right ventricular pacing in routine clinical practice



Parikshit S. Sharma, MD, MPH,^{*} Gopi Dandamudi, MD, FHRS,^{*} Angela Naperkowski, RN, FHRS, CCDS, CEPS,^{*} Jess W. Oren, MD,[†] Randle H. Storm, MD, FHRS,[‡] Kenneth A. Ellenbogen, MD, FHRS,[‡] Pugazhendhi Vijayaraman, MD, FHRS^{*}

From the ^{*}Geisinger Wyoming Valley Medical Center, Wilkes Barre, Pennsylvania, [†]Geisinger Medical Center, Danville, Pennsylvania, and [‡]Virginia Commonwealth University Medical Center, Richmond, Virginia.

BACKGROUND Right ventricular pacing (RVP) has been associated with heart failure and increased mortality. His-bundle pacing (HBP) is more physiological but requires a mapping catheter or a backup right ventricular lead and is technically challenging.

OBJECTIVE We sought to assess the feasibility, safety, and clinical outcomes of permanent HBP in an unselected population as compared to RVP.

METHODS All patients requiring pacemaker implantation routinely underwent attempt at permanent HBP using the Select Secure (model 3830) pacing lead in the year 2011 delivered through a fixed-shaped catheter (C315 HIS) at one hospital and RVP at the second hospital. Patients were followed from implantation, 2 weeks, 2 months, 1 year, and 2 years. Fluoroscopy time (FT), pacing threshold (PTH), complications, heart failure hospitalization, and mortality were compared.

RESULTS HBP was attempted in 94 consecutive patients, while 98 patients underwent RVP. HBP was successful in 75 patients (80%). FT was similar (12.7 ± 8 minutes vs 10 ± 14 minutes; median 9.1 vs 6.4 minutes; $P = .14$) and PTH was higher in the HBP group than in the RVP group (3.35 ± 0.9 V vs 0.6 ± 0.5 V at 0.5 ms; $P < .001$) and remained stable over a 2-year follow-up period. In patients with $>40\%$ ventricular pacing ($>60\%$ of patients), heart failure

hospitalization was significantly reduced in the HBP group than in the RVP group (2% vs 15%; $P = .02$). There was no difference in mortality between the 2 groups (13% in the HBP group vs 18% in the RVP group; $P = .45$).

CONCLUSION Permanent HBP without a mapping catheter or a backup right ventricular lead was successfully achieved in 80% of patients. PTH was higher and FT was comparable to those of the RVP group. Clinical outcomes were better in the HBP group than in the RVP group.

KEYWORDS His-bundle pacing; Para-Hisian pacing; Right ventricular pacing; Heart failure; Clinical outcomes; Safety; Feasibility

ABBREVIATIONS AF = atrial fibrillation; AV = atrioventricular; DMBP = direct His-bundle pacing; ECG = electrocardiogram/electrocardiographic; FT = fluoroscopy time; HB = His-bundle; HBP = His-bundle pacing; HF = heart failure; HFH = heart failure hospitalization; LV = left ventricular; LVEF = left ventricular ejection fraction; PHP = para-Hisian pacing; PTH = pacing threshold; RBBB = right bundle branch block; RVP = right ventricular pacing

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HB pacing may give results similar to conventional CRT

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Heart Rhythm, Vol 12, No 2, February 2015

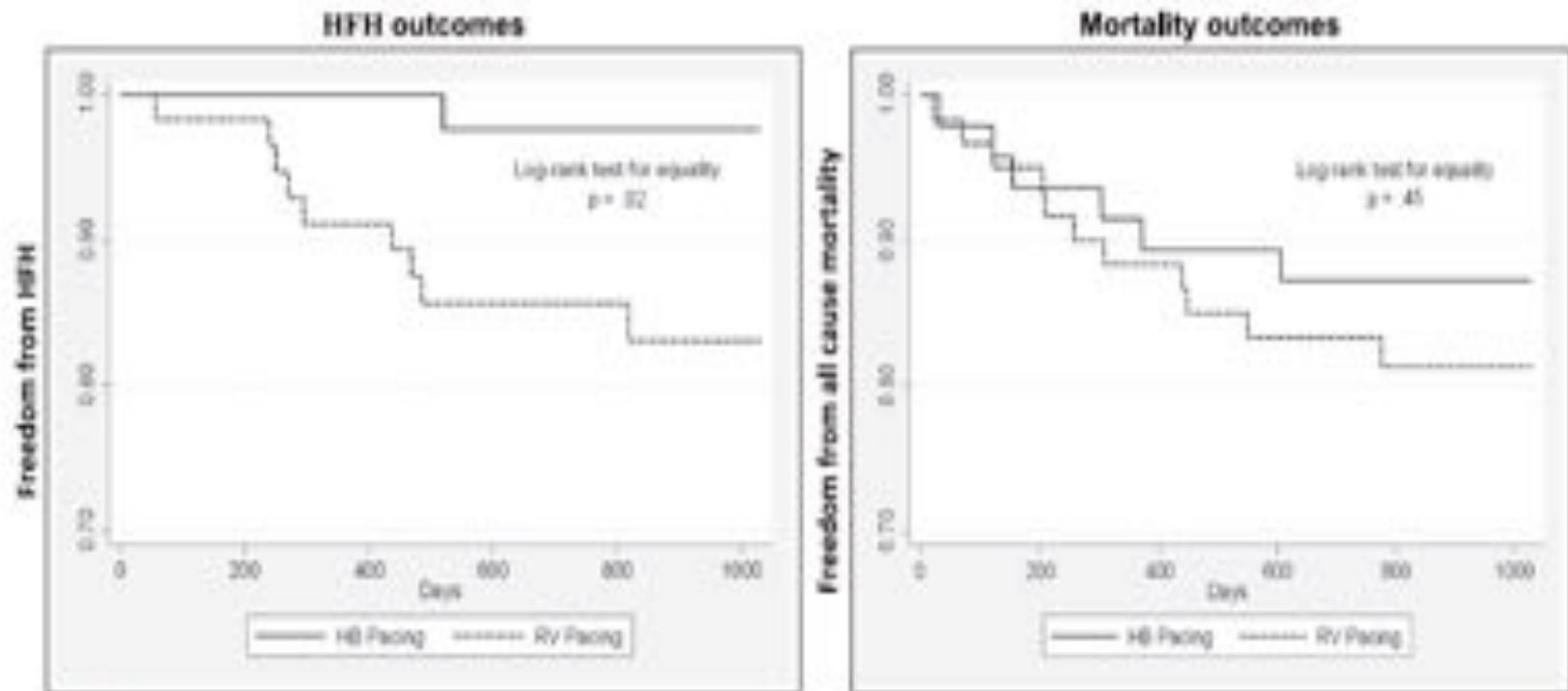
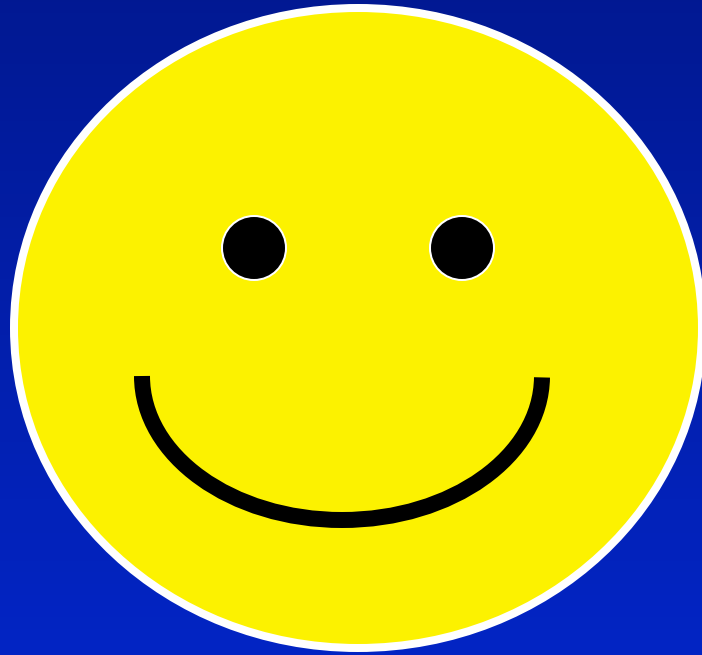


Figure 5 Kaplan-Meier survival curves depicting heart failure hospitalization (HFH) and all-cause mortality outcome differences in patients with >40% ventricular pacing, comparing His-bundle (HB) pacing with right ventricular (RV) pacing.

Conclusions

- ♥ CRT is important for heart failure patients especially with LBBB.
- ♥ Conventional CRT (RV + LV) is sufficient for most.
- ♥ For others, quadripolar LV leads give option of LV MSP.
- ♥ Other entities also should be considered:
 - Endocardial and surgically placed LV leads, unconventional stimulation, His Bundle pacing.

All Done!



AF + CHF: AVJ ablation + CRT, or PVI?

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Four-Year Efficacy of Cardiac Resynchronization Therapy on Exercise Tolerance and Disease Progression The Importance of Performing Atrioventricular Junction Ablation in Patients With Atrial Fibrillation

Maurizio Gasparini, MD,* Angelo Auricchio, MD, PhD,‡§ François Regoli, MD,* Cecilia Fantoni, MD,‡
Mihoko Kawabata, MD,‡ Paola Galimberti, MD,* Daniela Pini, MD,* Carlo Ceriotti, MD,*
Edoardo Gronda, MD,* Catherine Klersy, MD, MSc,† Simona Fratini, MD,‡ Helmut H. Klein, MD‡
Milan and Pavia, Italy; Magdeburg, Germany; and Lugano, Switzerland

AF + CHF: AVJ ablation + CRT, or PVI?

Pulmonary-Vein Isolation for Atrial Fibrillation in Patients with Heart Failure

Mohammed N. Khan, M.D., Pierre Jais, M.D., Jennifer Cummings, M.D., Luigi Di Biase, M.D., Prashanthan Sanders, M.D., David O. Martin, M.D., Josef Kautzner, M.D., Steven Hao, M.D., Sakis Themistoclakis, M.D., Raffaele Fanelli, M.D., Domenico Potenza, M.D., Raimondo Massaro, M.D., Oussama Wazni, M.D., Robert Schweikert, M.D., Walid Saliba, M.D., Paul Wang, M.D., Amin Al-Ahmad, M.D., Selwa Beheiry, M.D., Pietro Santarelli, M.D., Randall C. Starling, M.D., Antonio Dello Russo, M.D., Gemma Pelargonio, M.D., Johannes Brachmann, M.D., Volker Schibgilla, M.D., Aldo Bonso, M.D., Michela Casella, M.D., Antonio Raviele, M.D., Michel Haïssaguerre, M.D., and Andrea Natale, M.D.,
for the PABA-CHF Investigators*

CONCLUSIONS

Pulmonary-vein isolation was superior to atrioventricular-node ablation with biven-tricular pacing in patients with heart failure who had drug-refractory atrial fibril-lation. (ClinicalTrials.gov number, NCT00599976.)

AV Node Ablation in AF + CRT: Choose patients carefully: There's no turning back!

