LA SCELTA DEL MIGLIOR SITO DI STIMOLAZIONE VENTRICOLARE SINISTRA: QUALI NUOVI STRUMENTI ABBIAMO A DISPOSIZIONE?

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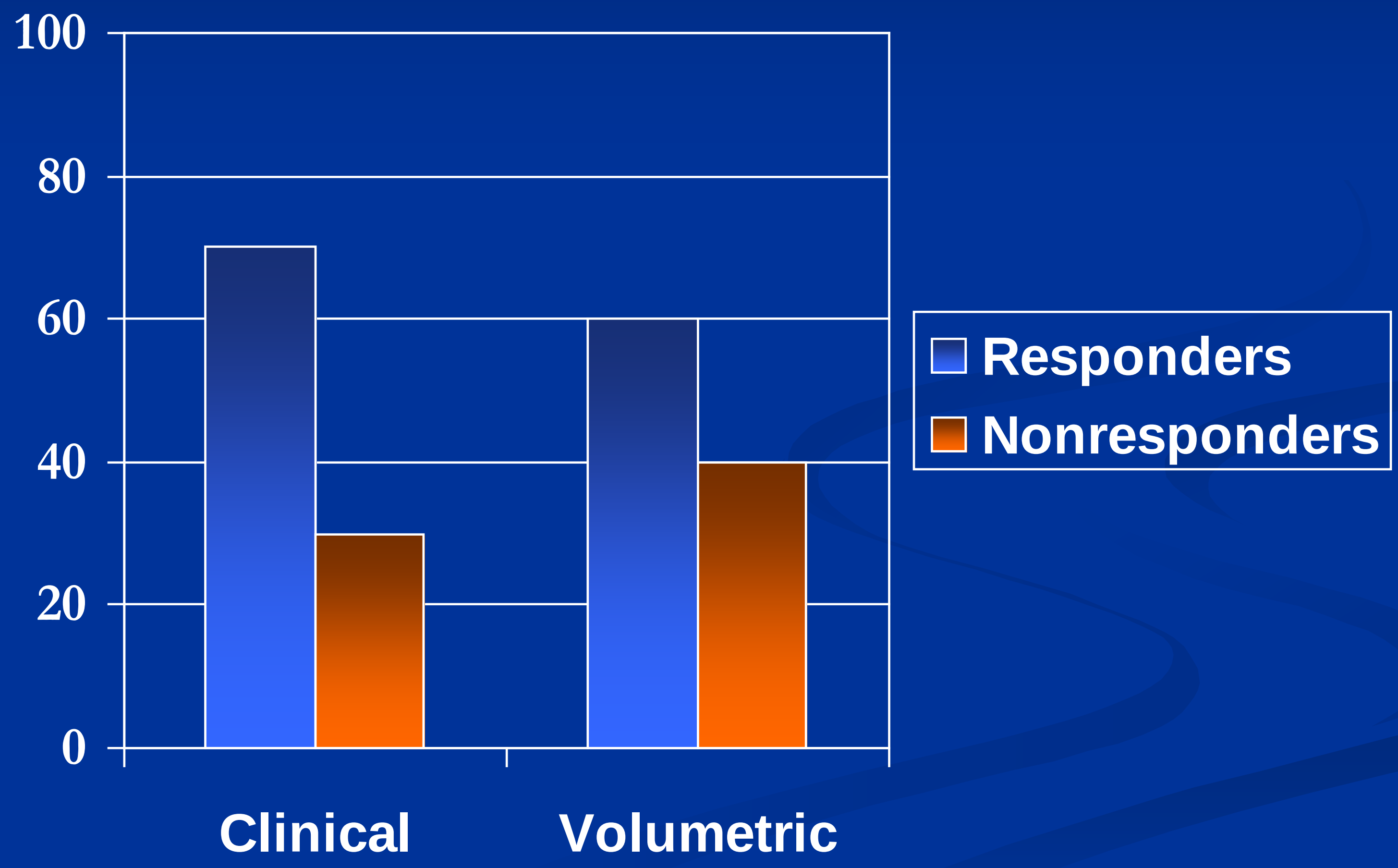
Pisa

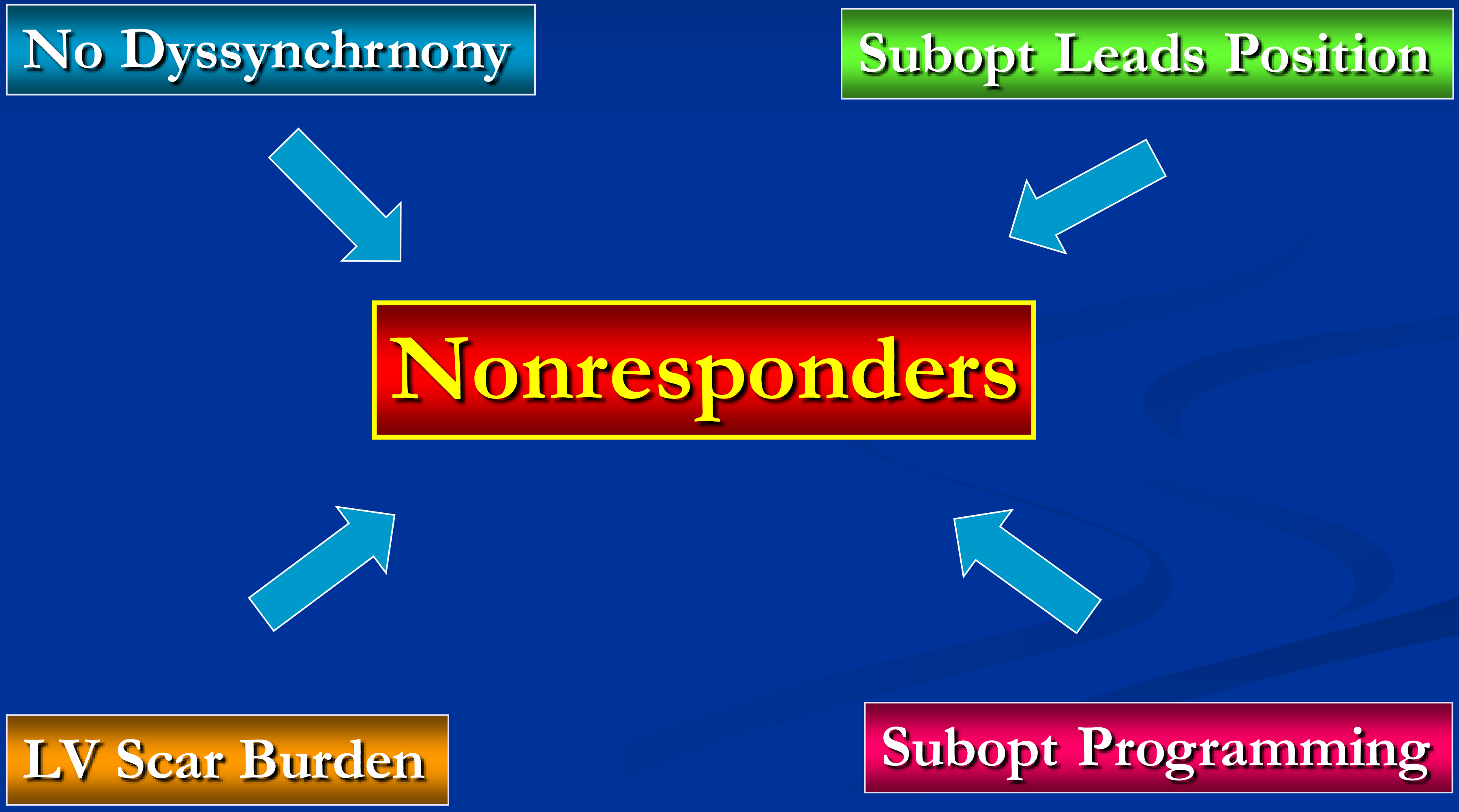
Advance in cardiac arrhythmias and great innovations in cardiology

Torino , 25-27 Ottobre 2012

CRT
Responders



CRT
Nonresponders: Causes



CRT
Nonresponders: Causes

No Dyssynchrnony

Subopt Leads Position

Nonresponders

LV Scar Burden

Subopt Programming

CRT
"Optimal" Lead Position

- Selecting the "right" patient for CRT but stimulating the "wrong" site remains an important cause of nonresponsiveness.

- Probably the notion that with CRT "one size-fits-all strategy" does not work.

CRT
"Optimal" Lead Position

- The optimal lead position may theoretically be defined by the positioning of the pacing lead that
  - *maximizes the haemodynamic benefits of CRT (?)*
  - *provides superior long-term outcome (!)*

CRT
Role of RV & LV Leads

- RV and LV pacing leads generate 2 ventricular activation wavefronts, which move in opposite directions towards each other.

- The benefit of CRT lies in effective fusion of wavefronts, synchronizing the walls of the LV.

- “Optimal” position may be identified for both RV and LV Leads?

CRT
LV pacing sites

~~Transvenous Endocardial LV pacing~~
~~Vs~~

Transvenous Epicardial LV pacing

CRT
Endocardial LV pacing??

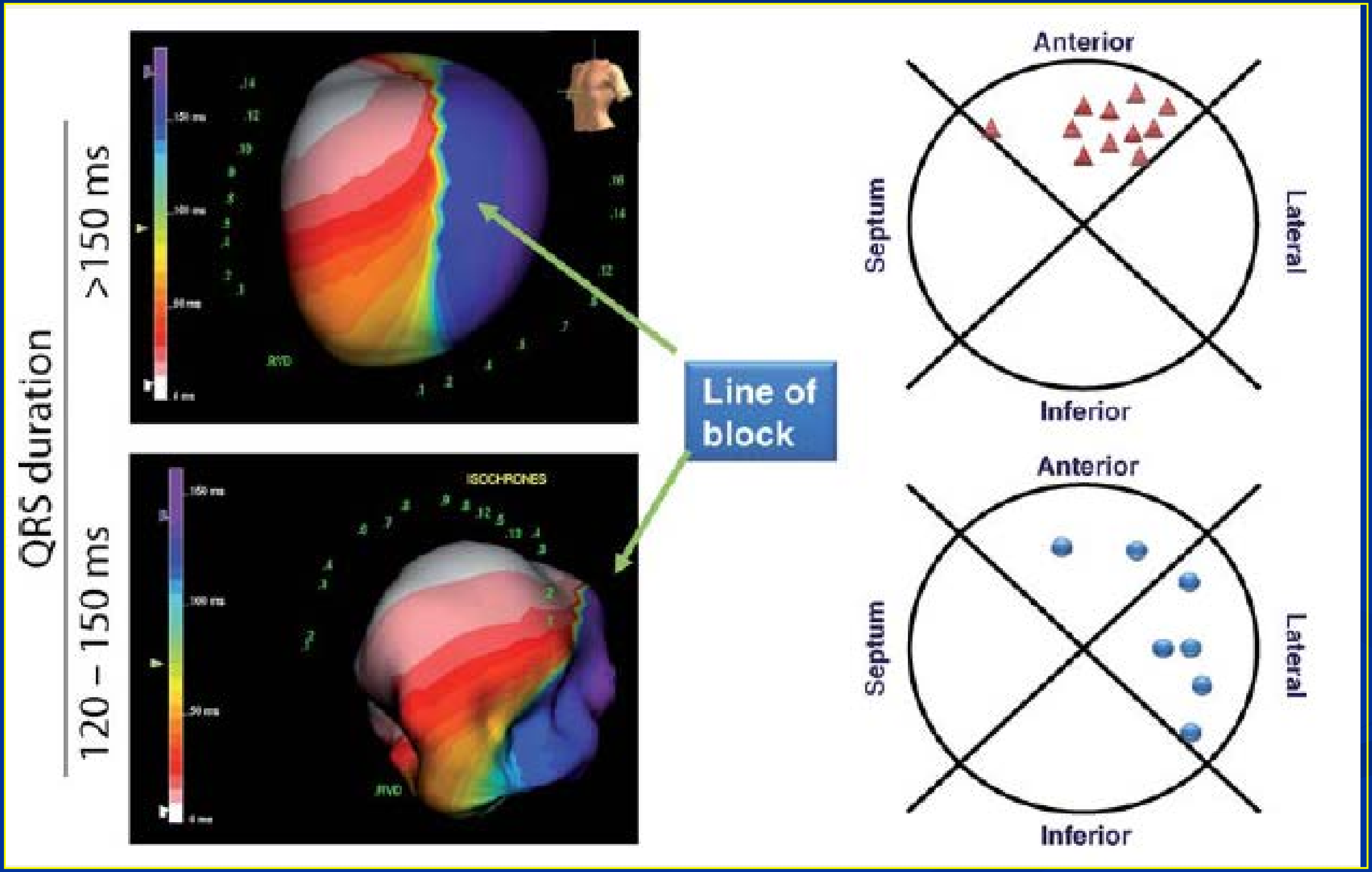
1. Less transmural dispersion of repolarization
2. Less dependent on the timing and position of LV pacing (broader activation wavefronts)
3. LV endocardial sites are more centrally located than epicardial sites
4. Subendocardial non Purkinje fibers conduct impulses faster, especially in a longitudinal direction

CRT

2. LV Lead Positions

- LV activation pattern is often unpredictable
- LBBB is associated with a U-shaped activation pattern that travels via the apex, with the lateral and posterolateral portions of the left ventricle being activated last
- This spread of electrical activity correlates well with mechanical activation and has been the main determinant of the conventional implantation approach of positioning the LV leads in a lateral location.

CRT
2. LV Lead Positions



Regoli, Auricchio, Europace 2009

CRT

2. LV Lead Positions

- A high level of heterogeneity in the depolarization wave front of the LV and a wide variance in the area of latest LV activation.
  - *The presence of a scar may shift the region of latest activation*
  - *Even in the nonischemic heart, LV activation can be influenced by the spatial conductive properties of the substrate*

CRT
2. LV Lead Position: Strategy

- Radiological/Anatomical
- Mechanical
- Electrophysiological

CRT
2. LV Lead Position: Strategy

- Radiological/Anatomical

CRT
2. LV Lead: R/A Strategy

- Fluoroscopy is the principal imaging modalitity used by CRT implanters in clinical practice.
- In acute studies, the lateral LV free wall appears to be the optimal pacing site in terms of the rate of rise of LV pressure (dP/dt).*
- Clinical studies, however, have failed to show a consistent effect of LV lead position on symptomatic response or mortality. **

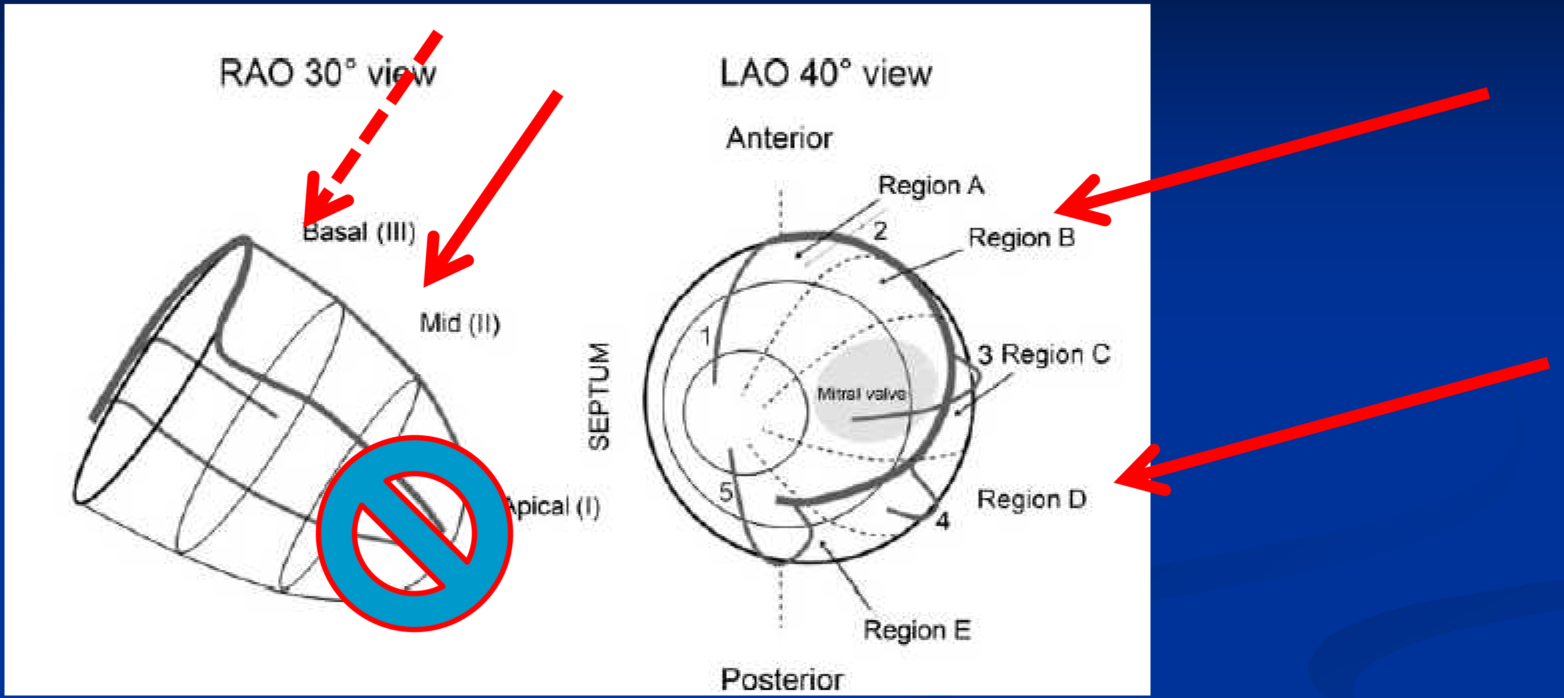
* Butter et al, Circulation 2001
** Gasparini et al, PACE 2003
** Kronborg et al, Europace 2009

CRT

2. LV Lead Position: CRT Trials

Trial	RV Lead Position	LV Position
MUSTIC 2001	"RV lead was positioned as far as possible from the LV lead."	"The target site was preferably the lateral wall, midway between base and apex, but other lateral or posterior sites were also acceptable. The great cardiac vein or the middle cardiac vein was used only when other sites were not accessible."
MIRACLE 2002	"…a standard right ventricular lead."	"LV lead which was placed into a distal cardiac vein"
COMPANION 2004	"…use of commercially available leads for …. RV pacing or for pacing with defibrillation."	"A distal branch of the coronary sinus vein chosen by the physician for LV stimulation. Correct placement of the coronary venous or left ventricular lead was subsequently verified radiographically"
CARE HF 2005	"…the use of standard RV lead."	"Investigators were asked to position the LV lead to pace the lateral or posterolateral left ventricular wall transvenously and provide radiographic documentation."
MADIT CRT 2009	"Standard techniques were used to implant the CRT–ICD."	"Standard techniques were used to implant the CRT–ICD"

CRT
LV Lead Position: Guidelines 2007



Preference for the implantation site is usually given to the lateral and the postero-lateral regions of the LV,[373] corresponding to regions B–D of the proposed schema (*Figure B.1*). Even more important is placing the LV lead in a basal or median section of these three regions, avoiding the apical section, which is too close to the right ventricular lead.

Guidelines for cardiac pacing and cardiac resynchronization therapy

The Task Force for Cardiac Pacing and Cardiac Resynchronization Therapy of the European Society of Cardiology. Developed in Collaboration with the European Heart Rhythm Association

CRT

LV Lead Position: Guidelines 2010-2012

2010 Focused Update of ESC guidelines on device therapy in heart failure

An update of the 2008 ESC guidelines for the diagnosis and treatment of acute and chronic heart failure and the 2007 ESC guidelines for cardiac and resynchronization therapy

NO

INDICATIONS

ON LEAD POSITION

ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure 2012

The Task Force for the Diagnosis and Treatment of Acute and Chronic Heart Failure 2012 of the European Society of Cardiology. Developed in collaboration with the Heart Failure Association (HFA) of the ESC

CRT

LV Lead Position: Consensus CRT 2012

The final position of the LV pacing lead depends on the anatomy of the cardiac venous system, the performance and stability of the pacing lead, and the absence of PNS.

CRT

LV Lead Position: No vessel

Zucchelli G. In: Transvenous lead extraction. Bongiorni ed. Springer 2011

CRT

LV Lead Position: Branch stenosis

Zucchelli G. In: Transvenous lead extraction. Bongiorni ed. Springer 2011

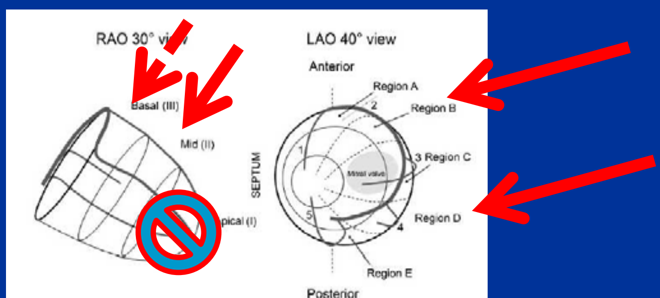
CRT

LV Lead Position: CS subocclusion

Zucchelli G. In: Transvenous lead extraction. Bongiorni ed. Springer 2011

CRT
LV Lead Position: Consensus CRT 2012

Recent reports, including those from the MADIT-CRT* and REVERSE-HF† study, have shown that an apically positioned LV lead location is associated with a worse clinical outcome.

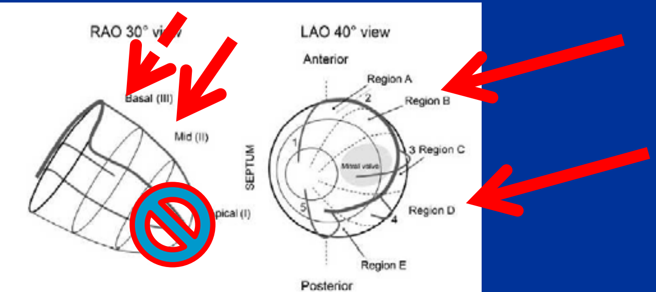


*Singh et al. Circulation 2011
† Thebault C et al. Eur Heart J 2012

CRT
LV Lead Position: Consensus CRT 2012

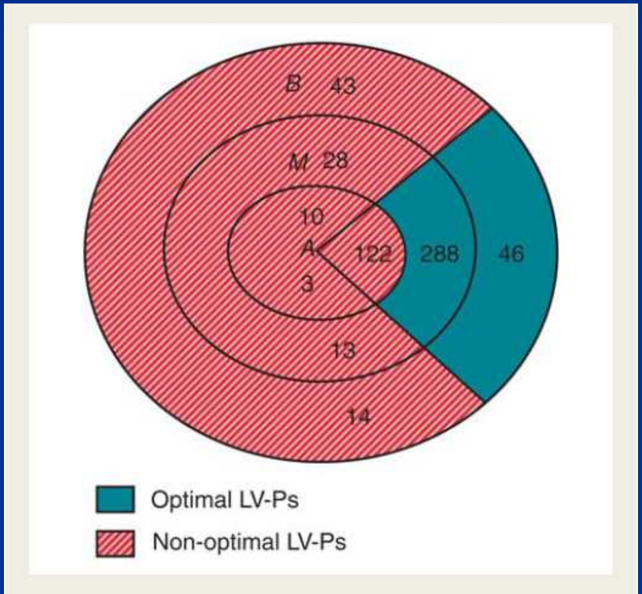
The COMPANION and MADIT-CRT studies recently showed a comparable response between lateral, anterior, or posterior LV lead locations.

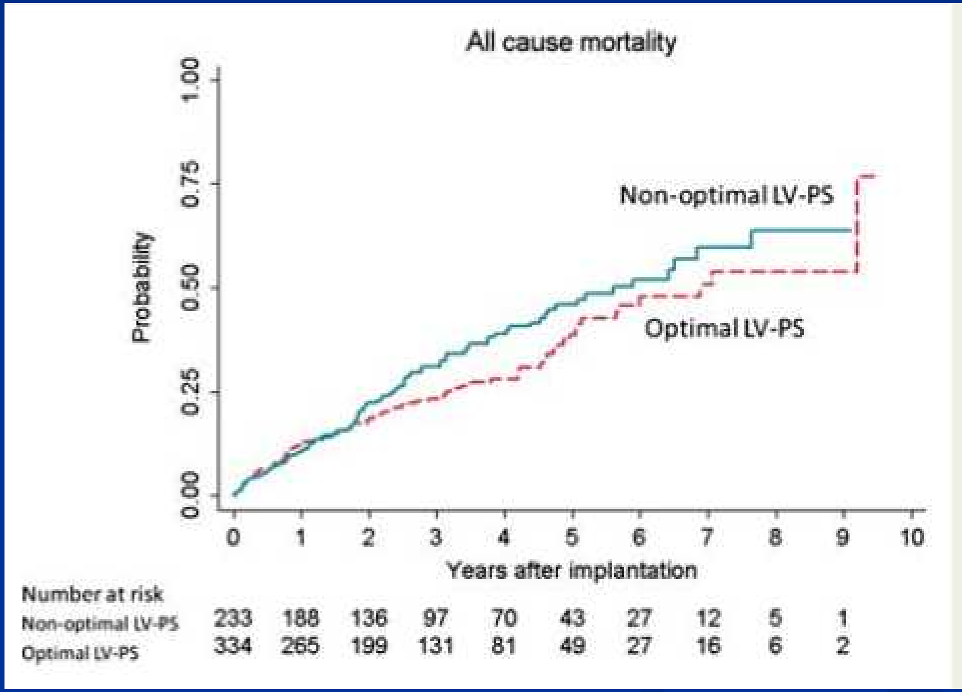
Recent data from the REVERSE-HF maintain the potential benefit of a lateral lead location.



CRT

2. LV Lead Position: optimal position??





Europace (2009) 11, 1177–1182
doi:10.1093/europace/eup202
CLINICAL RESEARCH
Pacing and CRT

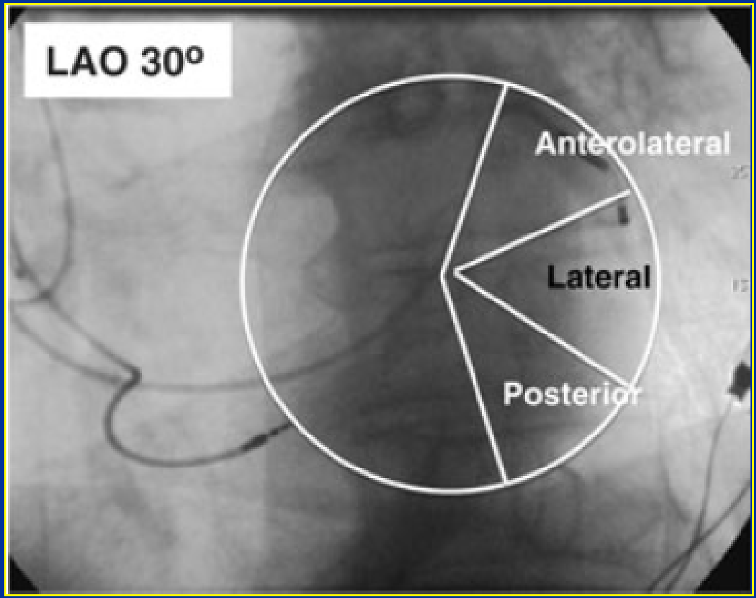
Long-term clinical outcome and left ventricular lead position in cardiac resynchronization therapy

Mads Brix Kronborg[1*], Andi Eie Albertsen[2], Jens Cosedis Nielsen[1], and Peter Thomas Mortensen[1]

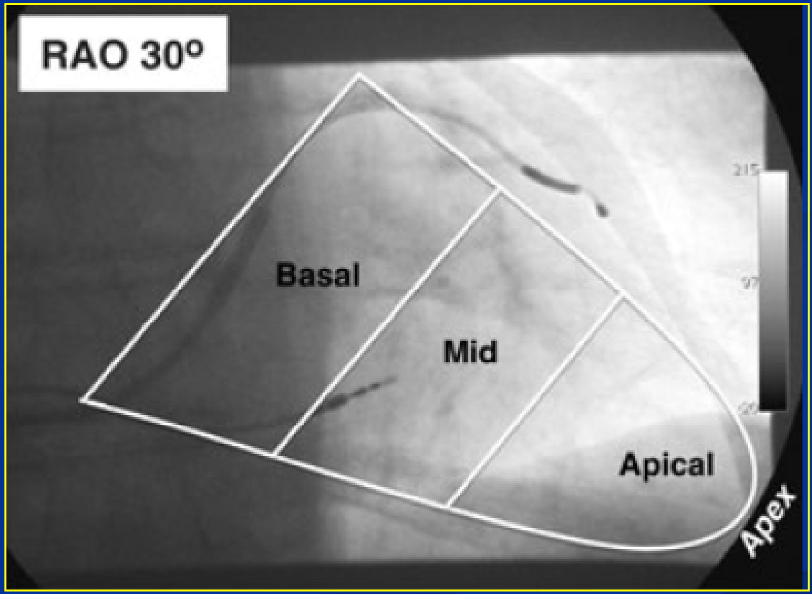
CRT

2. LV Lead: R/A Strategy

Circumferential



Longitudinal

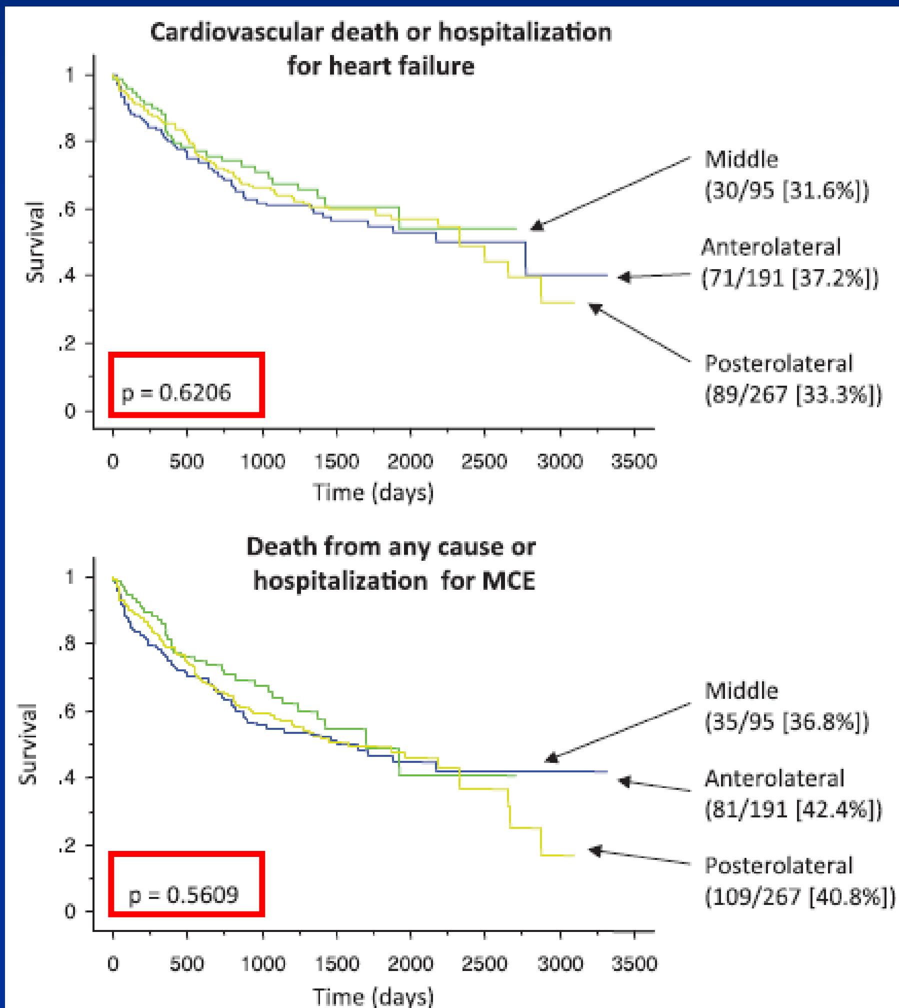


Foley et al, PACE 2011

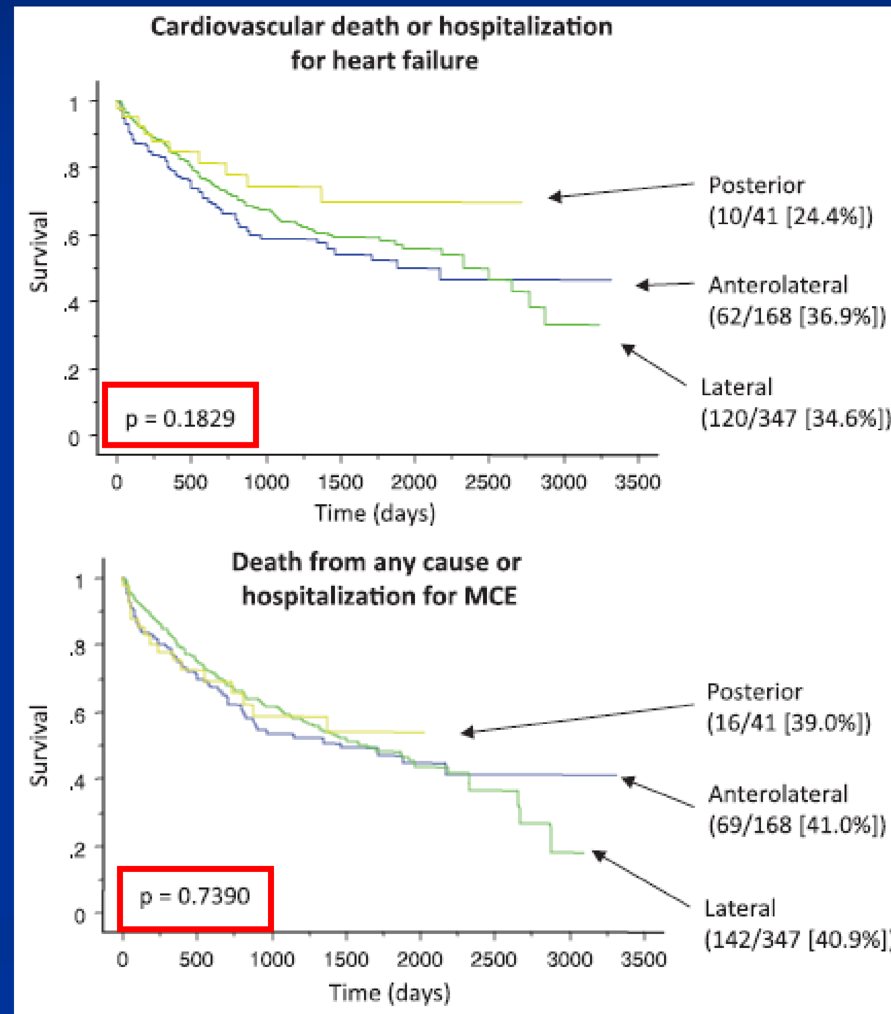
CRT

2. LV Lead: R/A Strategy

Circumferential



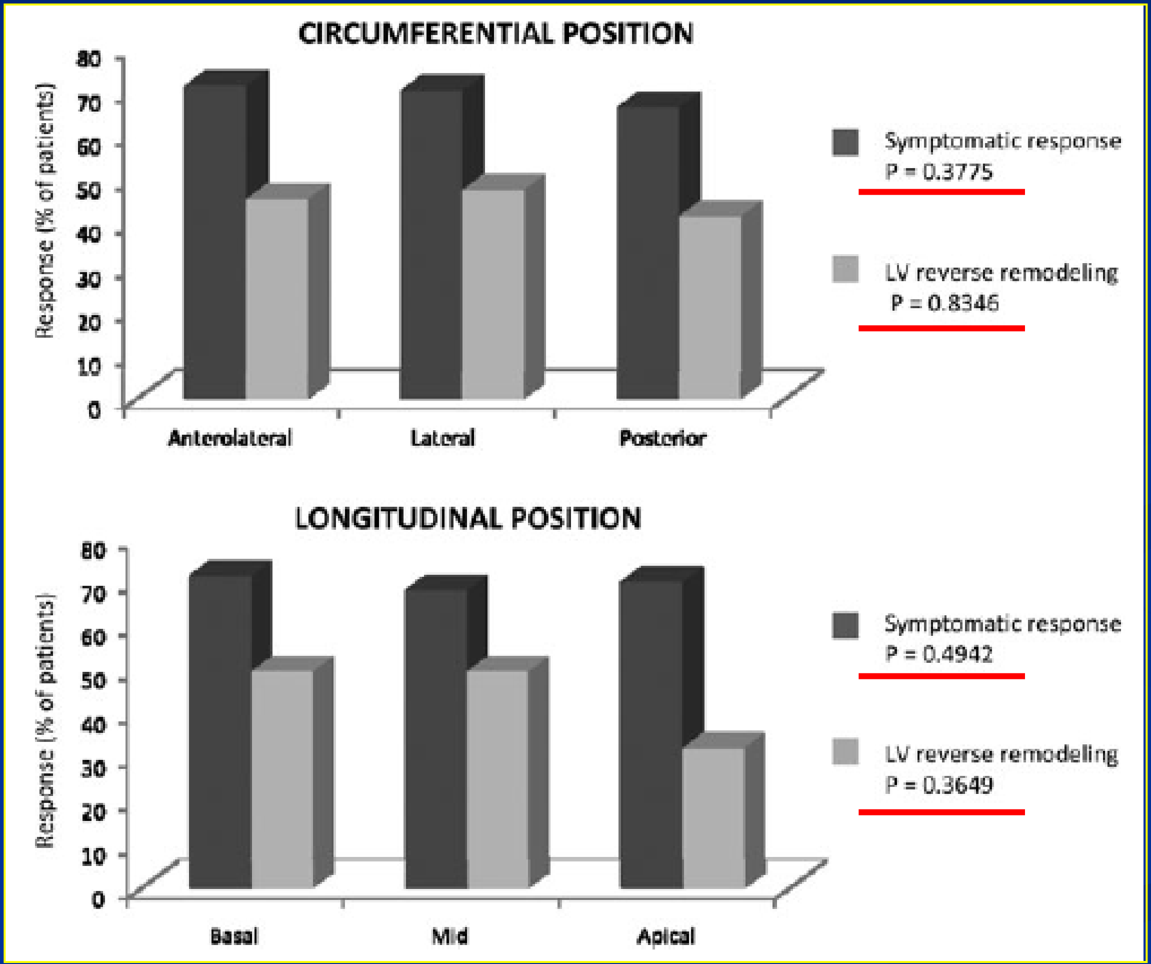
Longitudinal



Foley et al, PACE 2011

CRT

2. LV Lead: R/A Strategy



Foley et al, PACE 2011

CRT
2. LV Lead Position: Strategy

- Radiological/Anatomical
- Mechanical
-

CRT

2. LV Lead Position: Mech Strategy

- Mechanical strategy is based on the identification of the latest (viable) mechanical LV contraction and on the lead/segment concordance.

CRT

2. LV Lead Position: Mech Strategy

- Echocardiography
  - TDI (PW, Colour, Colour 3D)
  - TDI Derived Strain
  - 2D Derived Strain
  - TSI
  - TT
  - Real Time 3D

→ Location
Timing

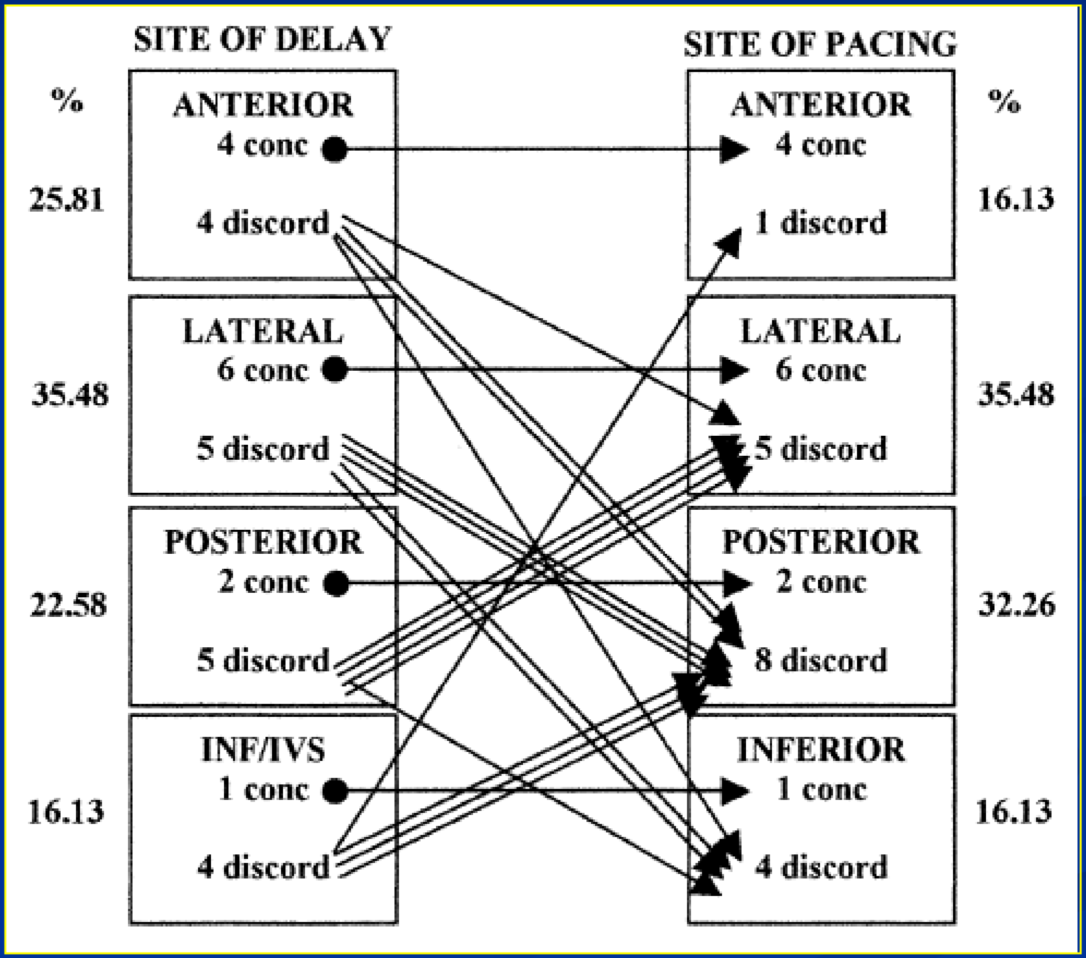
- Nuclear Imaging
  - SPECT
  - CT
  - MRI

→ Substrate

Ypenburg et al, *Non invasive imaging in CRT*, PACE 2008

CRT

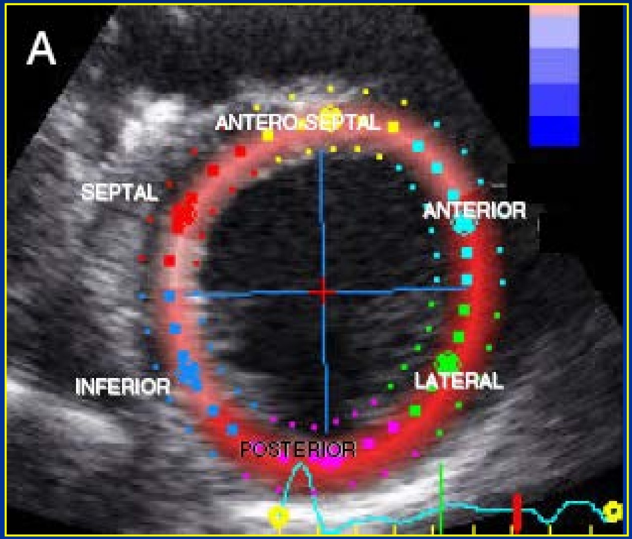
2. LV Lead Position: Mech Strategy

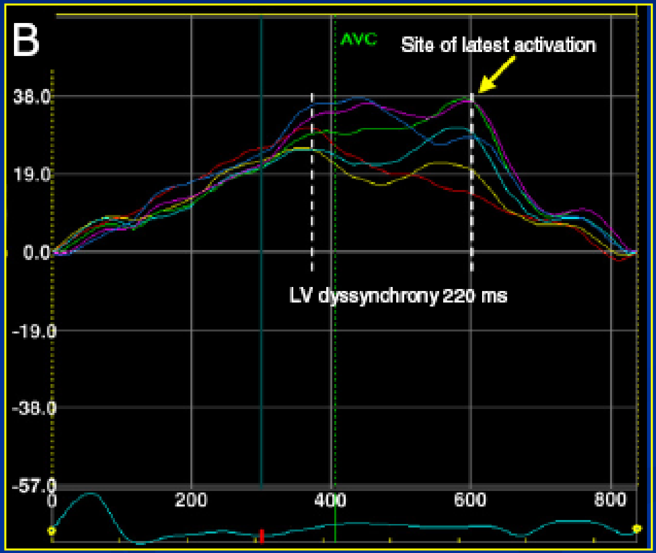


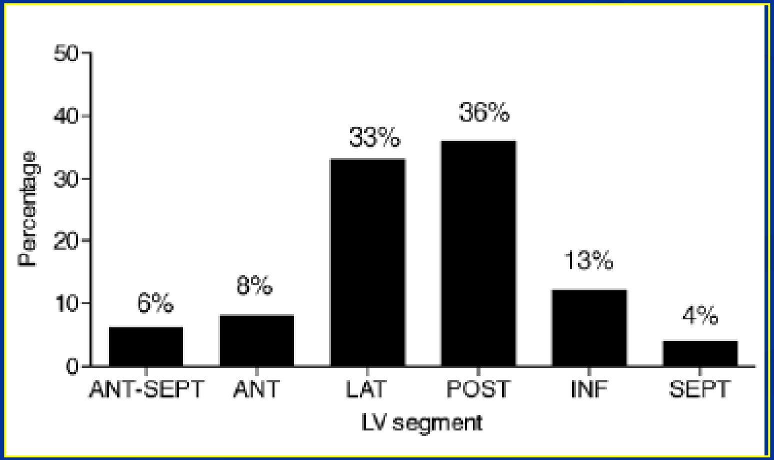
Ansalone et al, *JACC* 2002

CRT

2. LV Lead Position: Mech Strategy



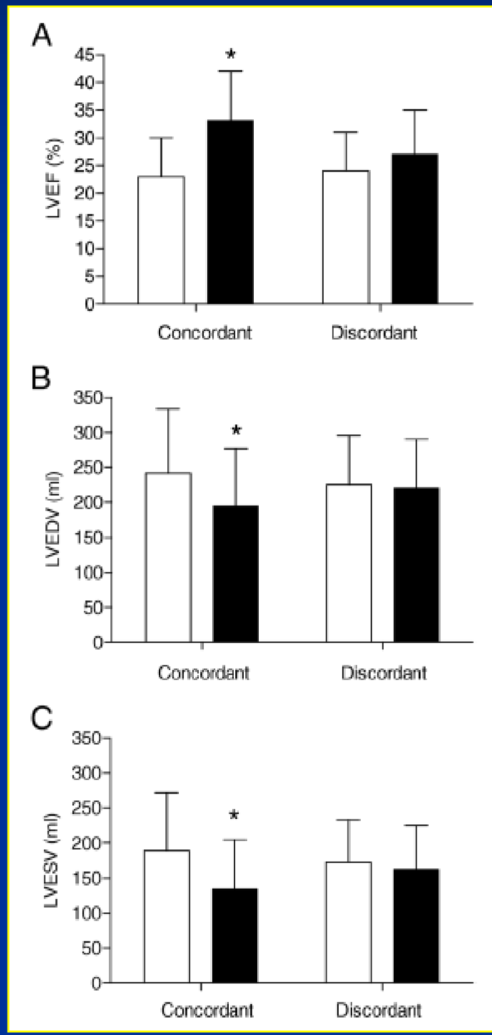


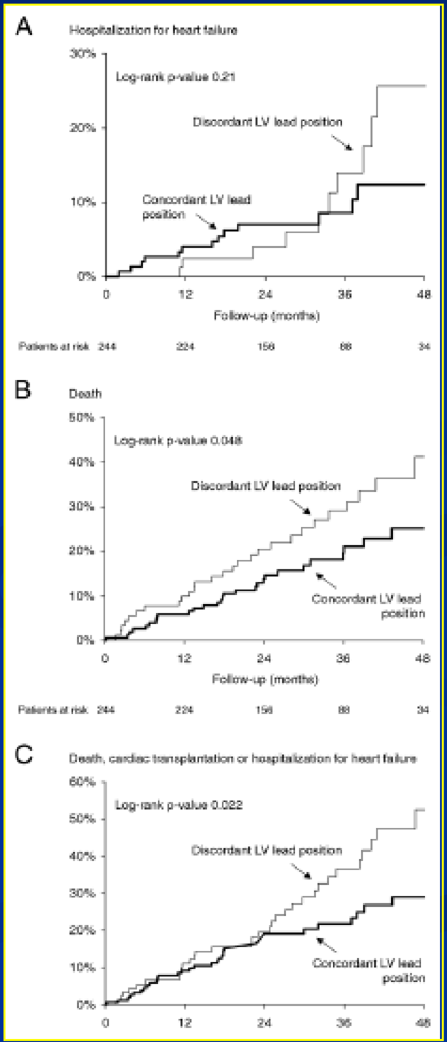


Ypenburg et al, *JACC 2008*

CRT

2. LV Lead Position: Mech Strategy



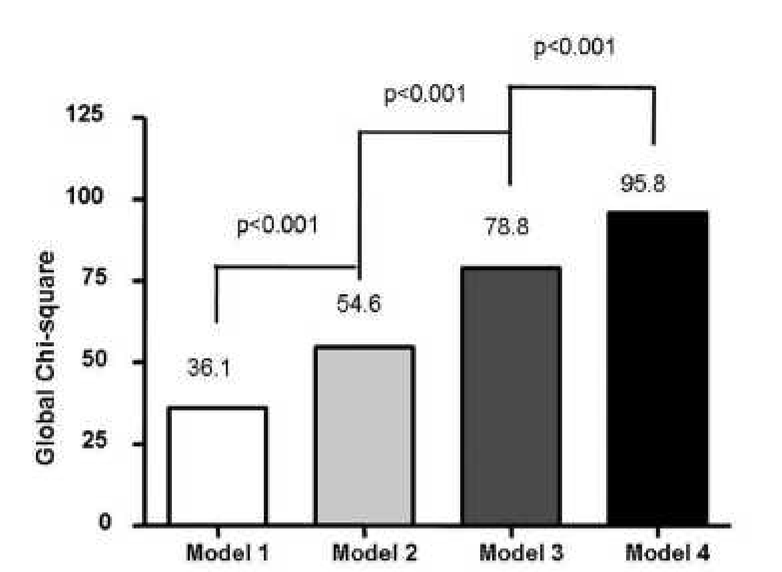


Ypenburg et al, *JACC 2008*

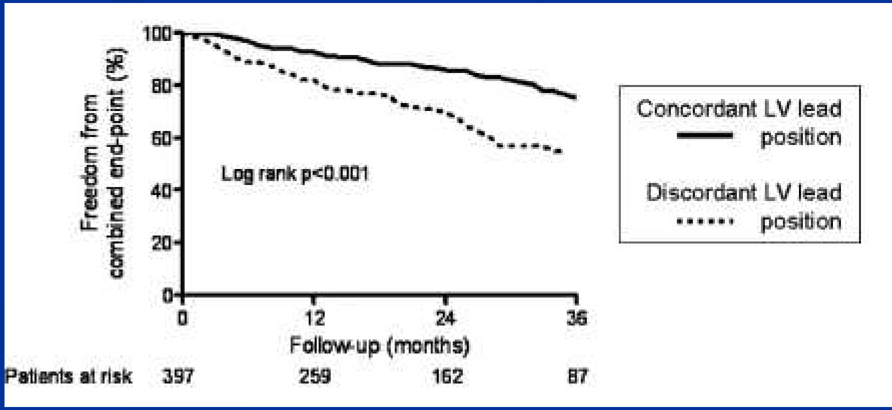
CRT

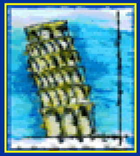
2. LV Lead Position: Mech Strategy

Model		Harrell C-Concordance Statistic Index
1	Clinical parameters	0.659
2	Clinical parameters+LV dyssynchrony	0.703
3	Clinical parameters+LV dyssynchrony+ discordant LV lead position	0.732
4	Clinical parameters+LV dyssynchrony+ discordant LV lead position+Myocardial scar	0.751



Larger baseline LV dyssynchrony predicted superior long-term survival, whereas discordant LV lead position and myocardial scar predicted worse outcome.





Department of Cardiovascular Diseases 2 - University Hospital of Pisa

Delgado et al, *Circulation 2011*

CRT
2. LV Lead Position: Strategy

- Radiological/Anatomical
- Mechanical
- Electrophysiological

CRT

2. LV Lead Position: EP Strategy

- Since CRT is a form of electrical therapy for disorderly electrical activation of the heart, it makes sense to attempt to target the region with the maximal electrical delay.

CRT

2. LV Lead Position: EP Strategy

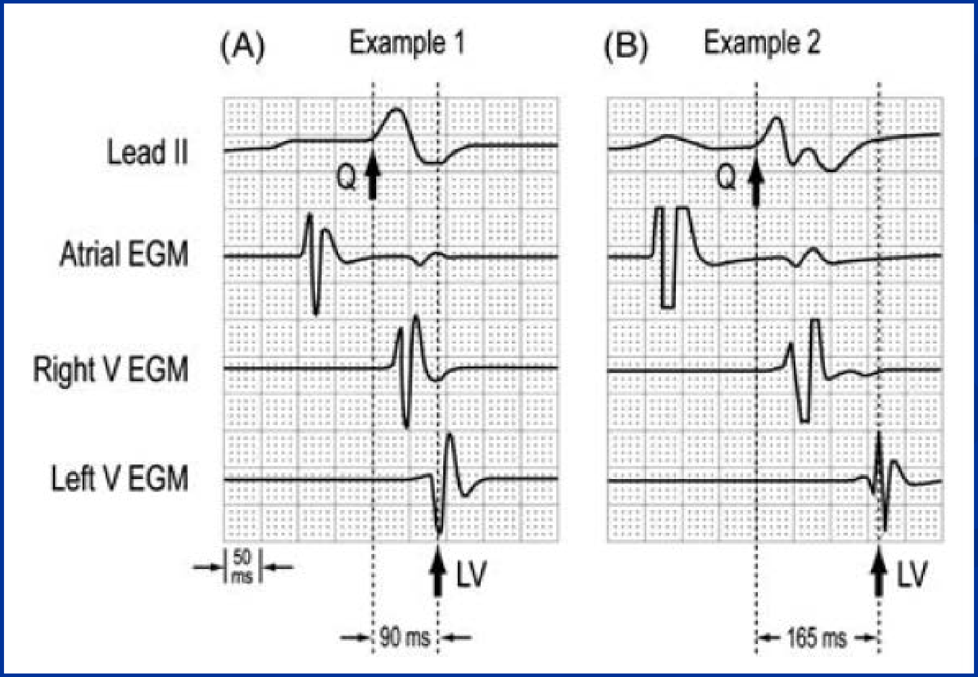
- Singh et al. reported that LV delay:
  - correlates directly with acute haemodynamic response LV dP/dtmax.
  - the percentage of LV delay as a function of QRS duration predicted also chronic clinical outcomes after 1 y.
- Data recently confirmed by a randomized multicenter trial.

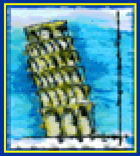
CRT

2. LV Lead Position: EP Strategy

- A practical strategy is the intra-procedural use of intracardiac electrograms to measure the LV lead electrical delay (LVLED) to help individualize lead placement.

- This delay is corrected for the baseline QRS (recorded simultaneously) by expressing it as a percentage of the baseline QRS duration.





Gold et al, *EHJ 2011*

CRT

2. LV Lead Position: EP Strategy

Table 3 The left ventricular end-systolic volume and QOL response rates for the QLV quartiles

QLV	*n*	LVESV response rate (%)	QOL response rate (%)
0–70 ms	124	38.7	50.0
70–95 ms	98	39.8	54.6
95–120 ms	109	57.8	65.1
120–195 ms	95	68.4	72.0
Pearson χ^2		<0.001	0.004

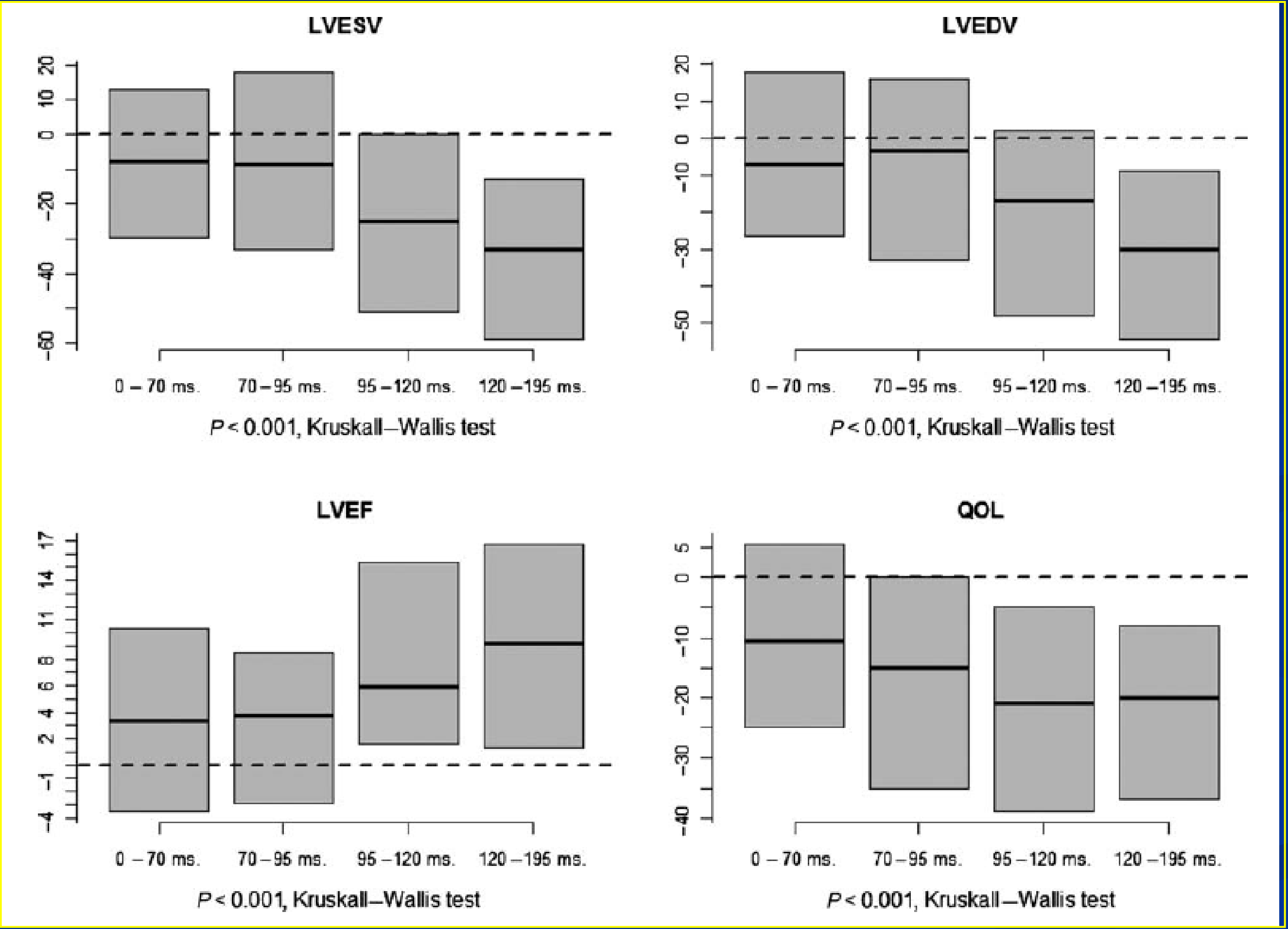
Table 4 Multivariate logistic regression model results[a]

Covariate	Odds ratio (95% CI), *P*-value	
	LVESV response	QOL response
QLV 2nd quartile vs. 1st quartile	1.10 (0.62–1.95), 0.743	1.30 (0.75–2.26), 0.355
QLV 3rd quartile vs. 1st quartile	1.86 (1.04–3.31), 0.036	1.86 (1.05–3.31), 0.033
QLV 4th quartile vs. 1st quartile	3.21 (1.58–6.50), 0.001	2.73 (1.35–5.54), 0.005
Age (per 1 year increase)	1.00 (0.98–1.02), 0.801	0.99 (0.97–1.01), 0.209
LVEF (per 1% increase)	0.98 (0.94–1.01), 0.186	1.00 (0.96–1.03), 0.83
Ischaemic vs. non-ischaemic	0.58 (0.37–0.91), 0.019	1.05 (0.67–1.64), 0.846
QRS (>150 ms vs. ≤150 ms)	0.86 (0.53–1.40), 0.543	0.88 (0.55–1.43), 0.611
LBBB vs. non-LBBB	1.20 (0.72–2.01), 0.48	1.17 (0.71–1.93), 0.526
Male vs. Female	0.53 (0.33–0.85), 0.008	0.56 (0.34–0.91), 0.018
NYHA class IV vs. I–III	1.67 (0.44–6.29), 0.45	3.41 (0.69–16.92), 0.133
LVESV	1.00 (0.99–1.01), 0.98	1.00 (0.99–1.00), 0.682

Gold et al, *EHJ 2011*

CRT

2. LV Lead Position: EP Strategy



Gold et al, *EHJ 2011*

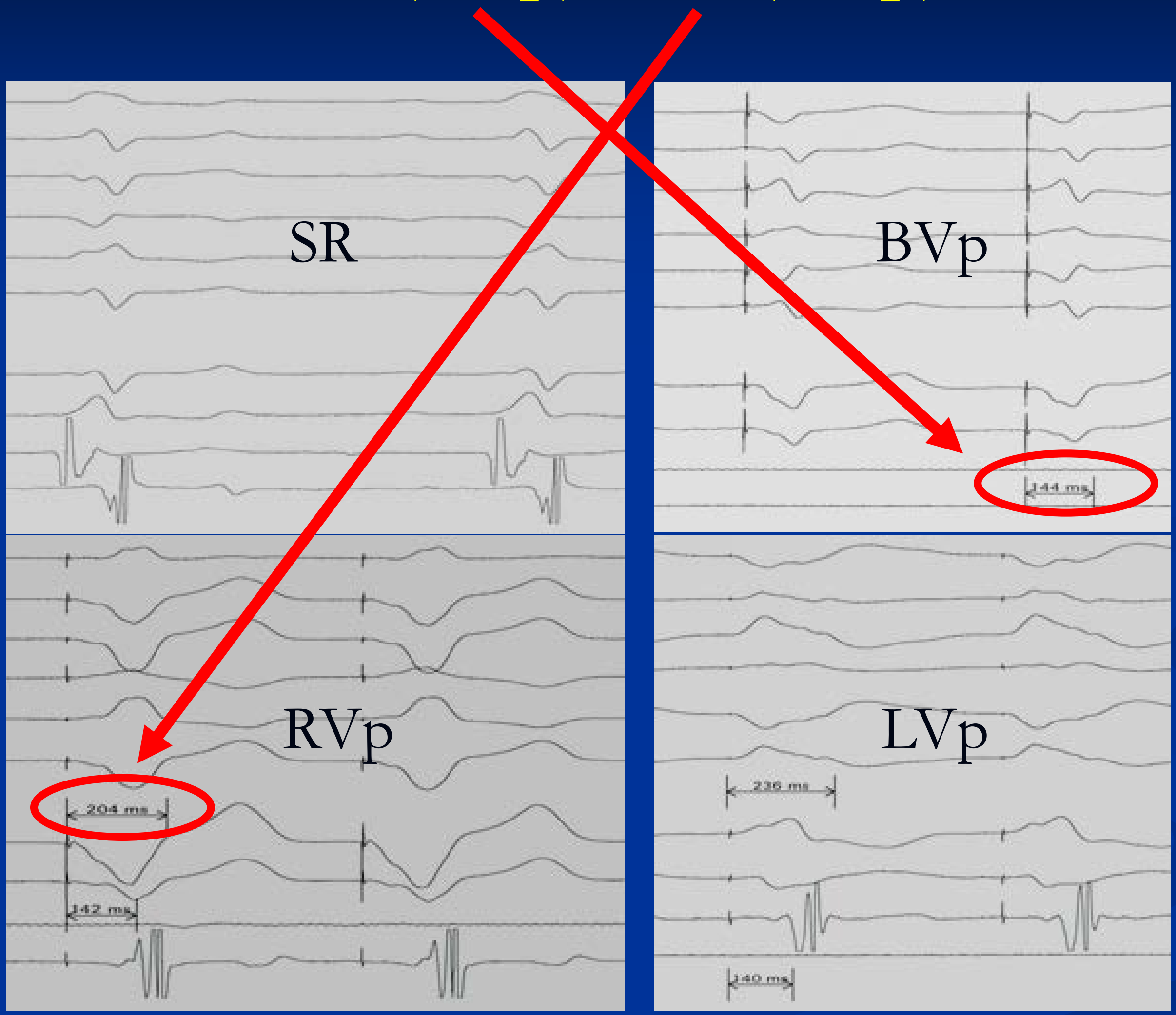
QRS(BVp)/QRS(RVp)

Electrocardiographic and electrophysiological parameters (acronyms)	
Right ventricular pacing (RVp)	
S(RVp)-LVegm, ms	The interval between the onset of the RVp and the onset of the LV lead electrogram
QRS(RVp), ms	QRS duration during RVp
S(RVp)-LVegm$_i$	The ratio of S(RVp)-LVegm with QRS(RVp)
Left ventricular pacing (LVp)	
S(LVp)-RVegm, ms	The interval between the onset of the LVp and the onset of the RV lead electrogram
QRS(LVp), ms	QRS duration during LVp
S(LVp)-RVegm$_i$	The ratio of S(LVp)-RVegm with QRS(LVp)
Biventricular pacing (BVp)	
QRS(BVp), ms	QRS duration during BVp
QRS(BVp)/QRS(basal)	The ratio of QRS(BVp) with QRS(basal)
QRS(BVp)/QRS(RVp)	**The ratio of QRS(BVp) with QRS(RVp)**
QRS(BVp)/QRS(LVp)	The ratio of QRS(BVp) with QRS(LVp)
QRS(BVp)/QRS(RVp-LVp)$_{mean}$	The ratio of QRS(BVp) with QRS mean duration during LVp and RVp

RV indicates right ventricular, LV left ventricular, RVp indicates right ventricular pacing, LVp left ventricular pacing, BVp indicates biventricular pacing.

Zucchelli et al. EUROPACE 2010

QRS(BVp)/QRS(RVp) = 0.71



Zucchelli et al. EUROPACE 2010

CRT

2. LV Lead Position: EP Strategy

Table 3 Electrocardiographic parameters of responders and non-responders group

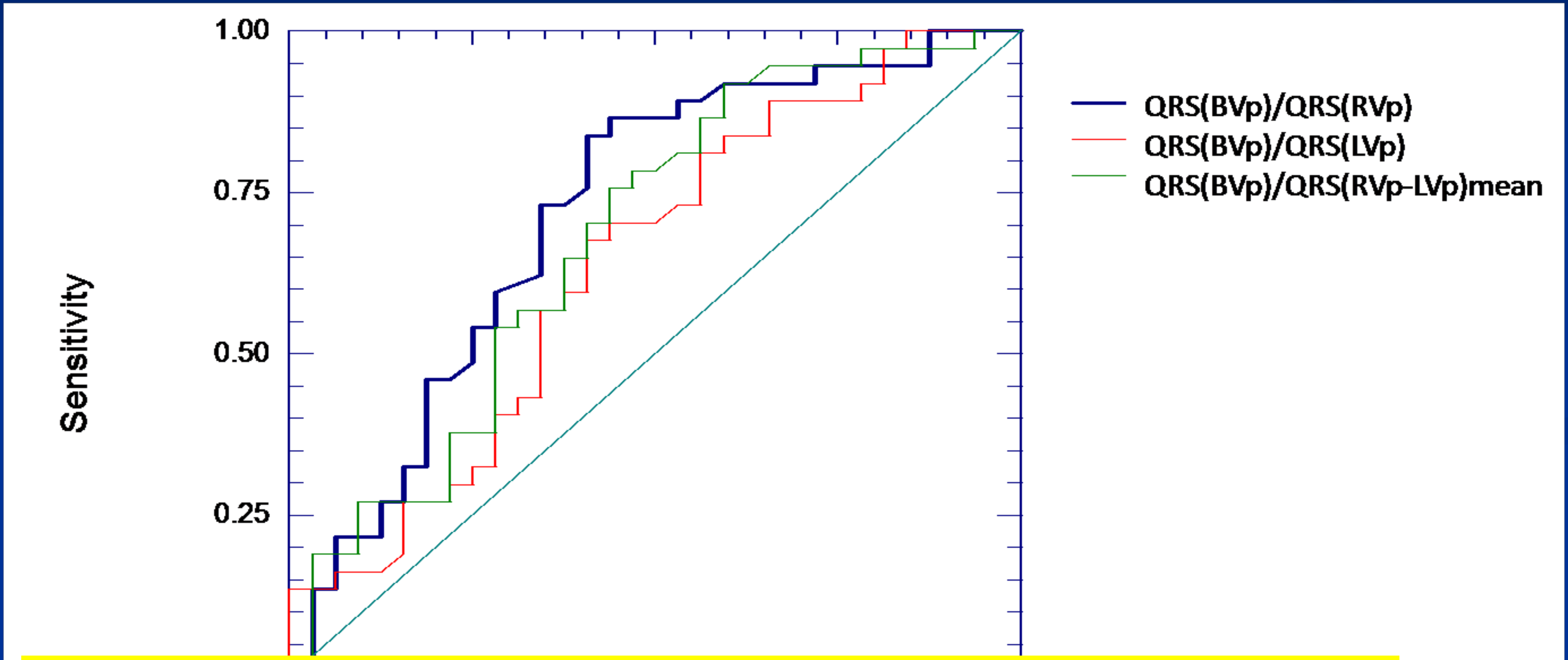
	Responders ($n = 45$)	Non-responders ($n = 34$)
QRS(RVp), ms	209.9 ± 22.3	209.4 ± 23.5
QRS(LVp), ms	215.7 ± 30	214.6 ± 31.4
QRS(BVp), ms	154.2 ± 16.9*	167.6 ± 26.6
QRS(BVp)/QRS(RVp)	0.74 ± 0.05†	0.8 ± 0.1
QRS(BVp)/QRS(LVp)	0.72 ± 0.08*	0.79 ± 0.13
$QRS(BVp)/QRS(RVp-LVp)_{mean}$	0.73 ± 0.05§	0.79 ± 0.1
QRS(BVp)/QRS(basal)	0.95 ± 0.17	1.02 ± 0.2

See Methods for the acronyms.
*$P < 0.05$, †$P < 0.005$, §$P < 0.01$ for responders vs. non-responders.

Zucchelli et al. EUROPACE 2010

CRT

2. LV Lead Position: EP Strategy

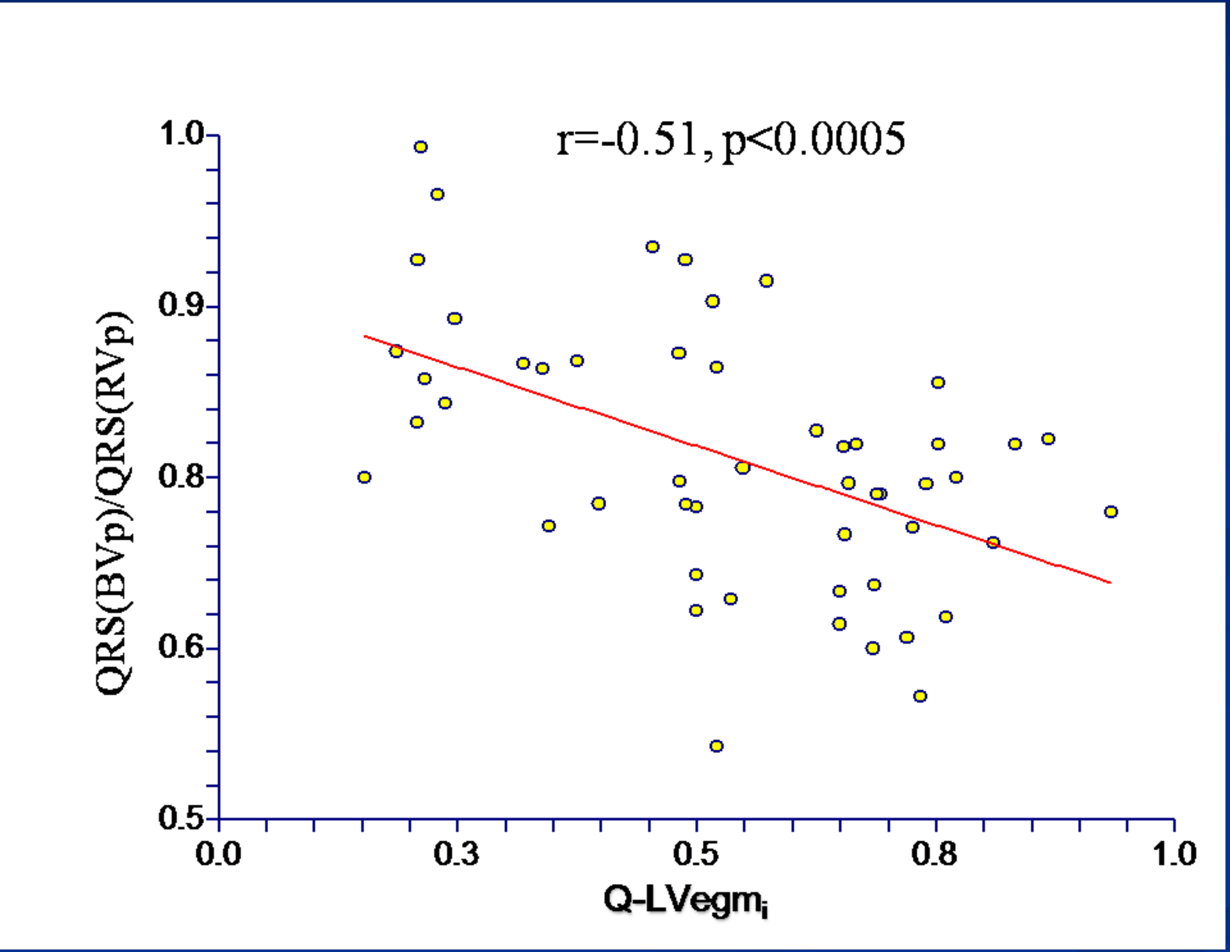


The value with the optimal predictive accuracy was 0.78.
with positive and negative predictive of 70% and 76% respectively.

Zucchelli et al. EUROPACE 2010

CRT

2. LV Lead Position: EP Strategy

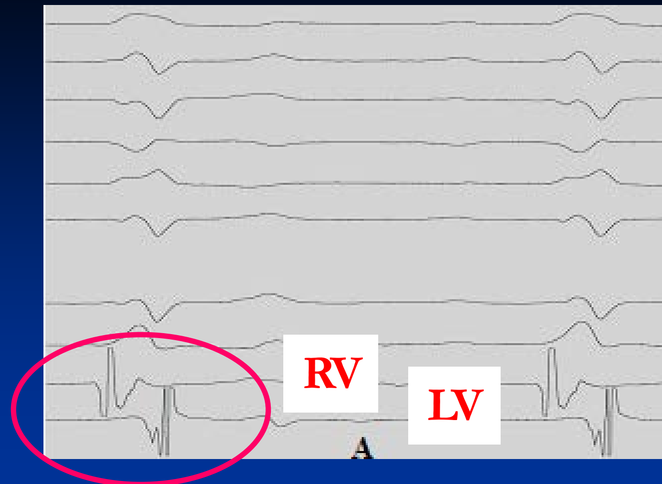


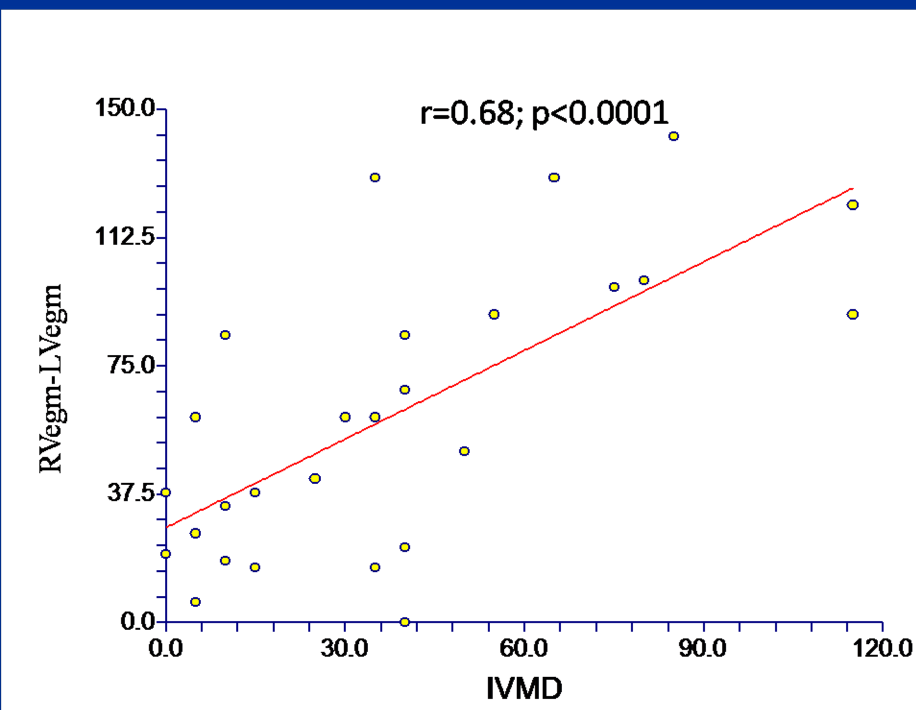
Zucchelli et al. EUROPACE 2010

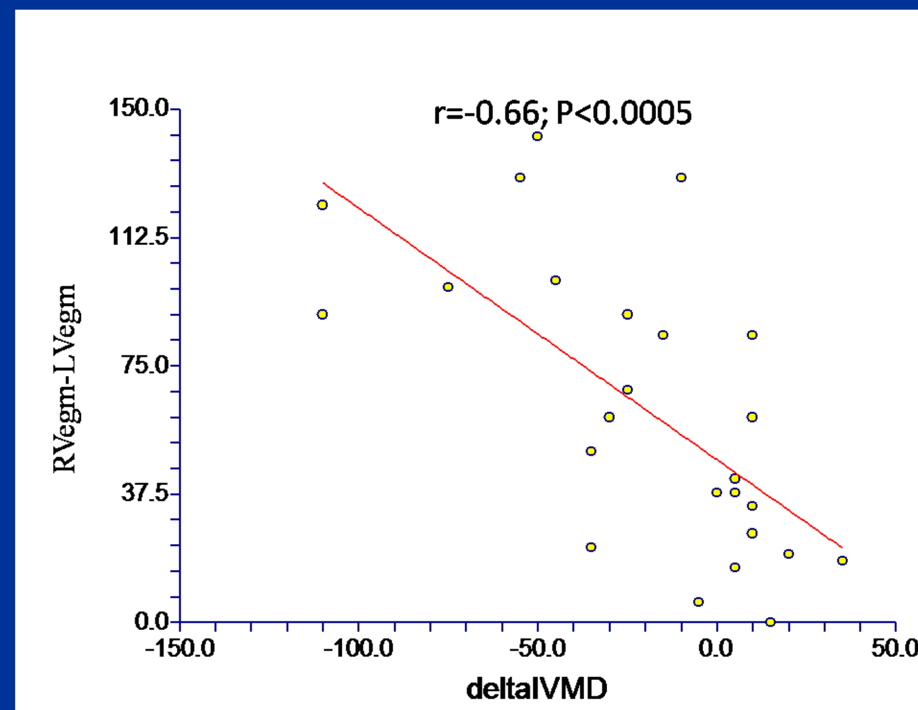

Europace
doi:10.1093/europace/euq267
CLINICAL RESEARCH

Role of intraoperative electrical parameters in predicting reverse remodelling after cardiac resynchronization therapy and correlation with interventricular mechanical dyssynchrony

Giulio Zucchelli[1*], Ezio Soldati[1], Andrea Di Cori[1], Raffaele De Lucia[1], Luca Segreti[1], Gianluca Solarino[1], Gabriele Borelli[2], Vitantonio Di Bello[2], and Maria Grazia Bongiorni[1]





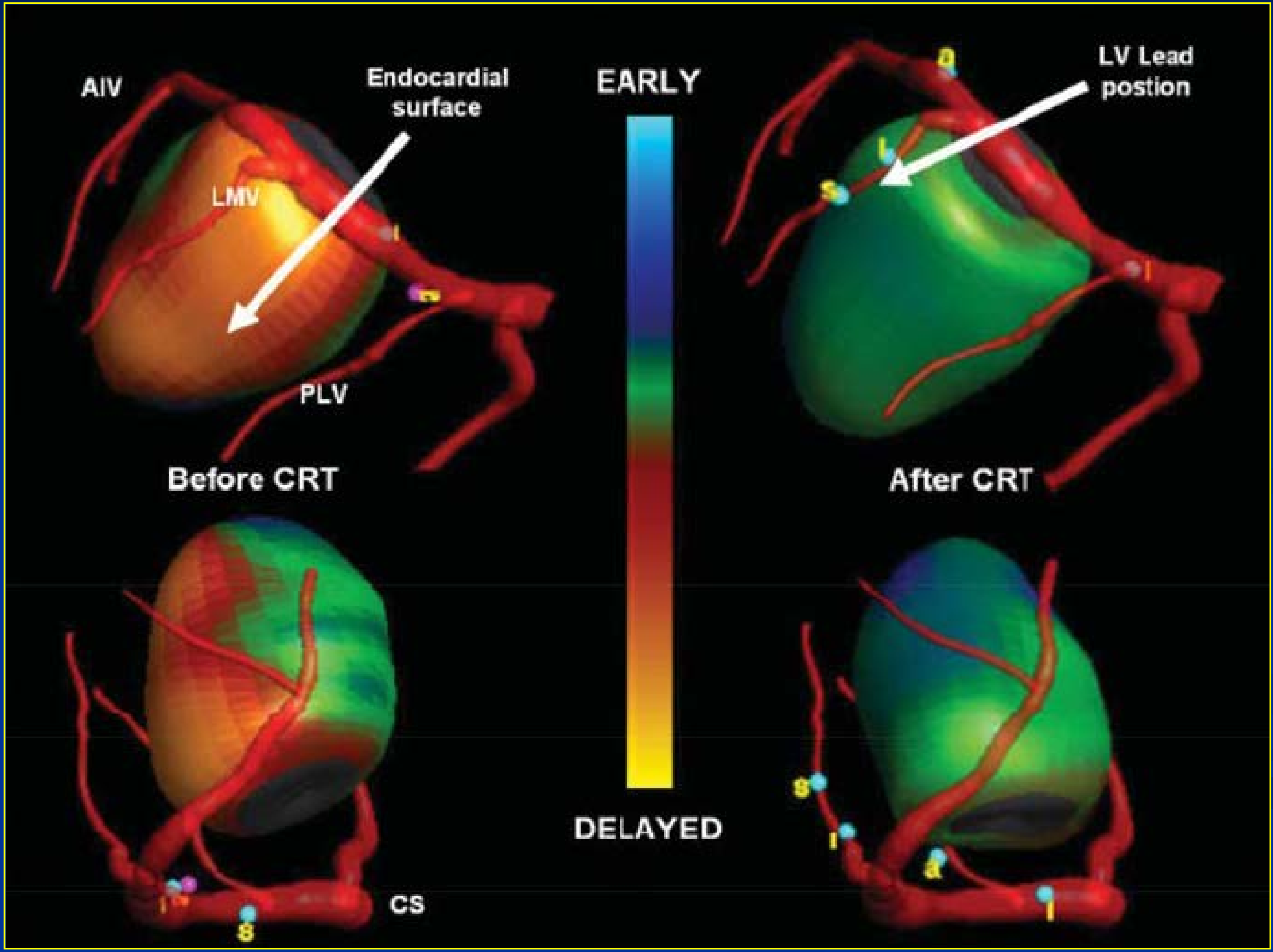


Correlation between RVegm-LVegm and IVMD/delta IVMD

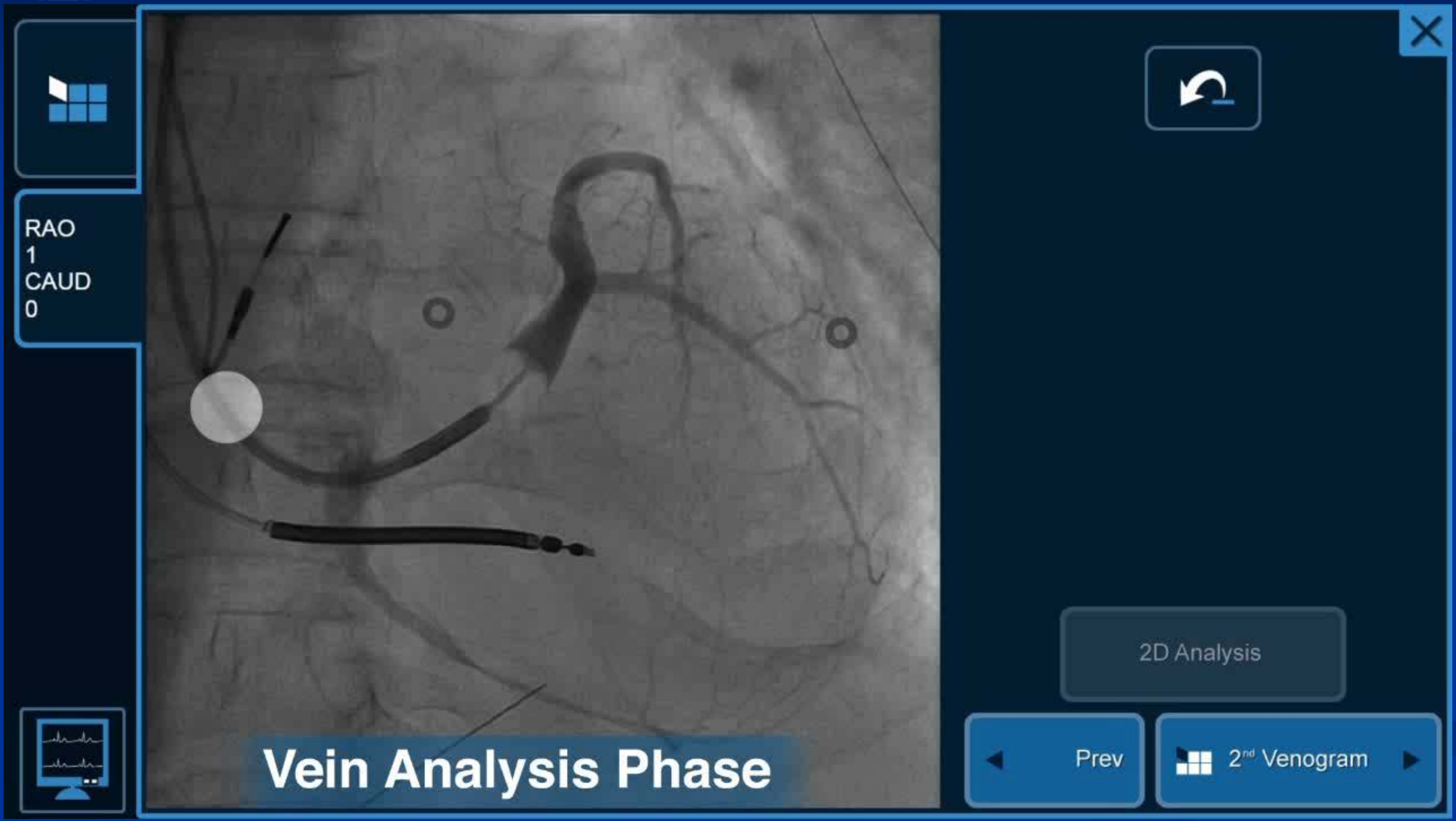
CRT
RV/LV Lead Position

	RVL	LVL
Radiological/Anatomical	+/-	+
Mechanical	-	+ +
Electrophysiological	+/-	+ +

New technology



CARDIOGUIDE



Medtronic

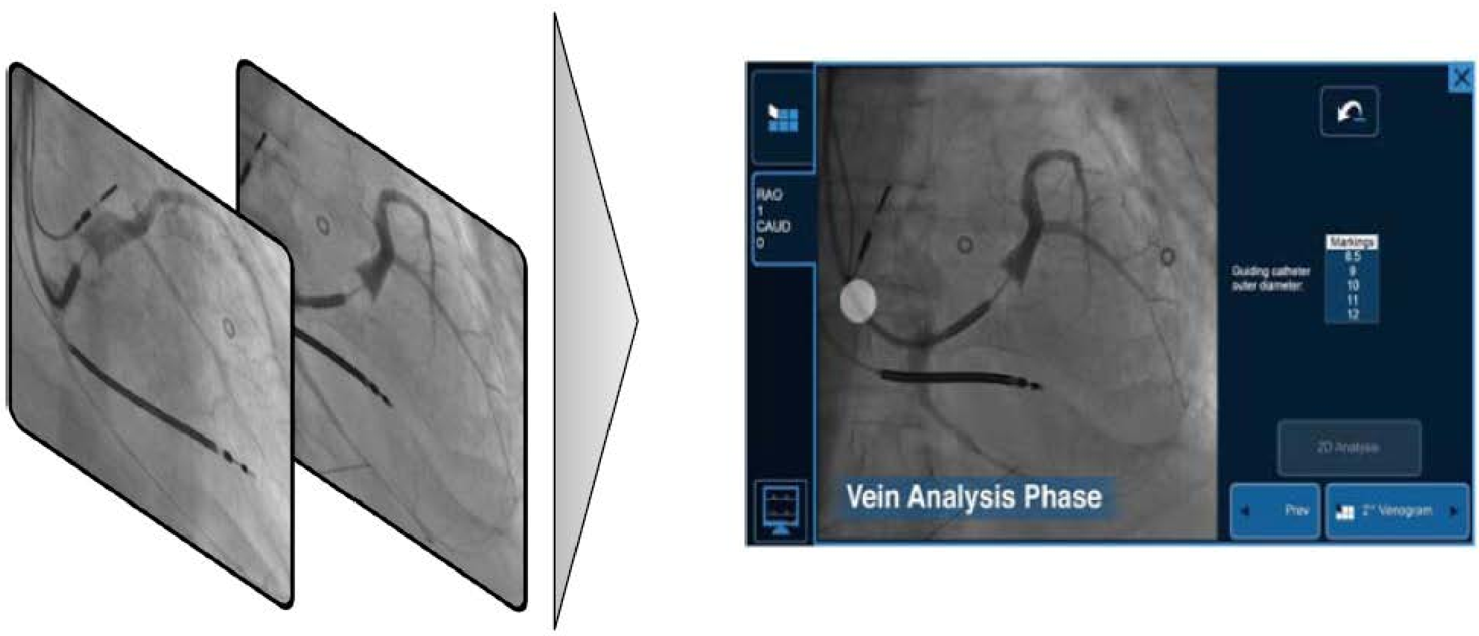
All patient and clinic data displayed are fictitious and for demonstration purposes only.

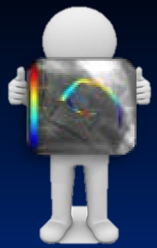
CardioGuide™ IMPLANT SYSTEM

CARDIOGUIDE

1. Take two venograms

2. Trace coronary vasculature





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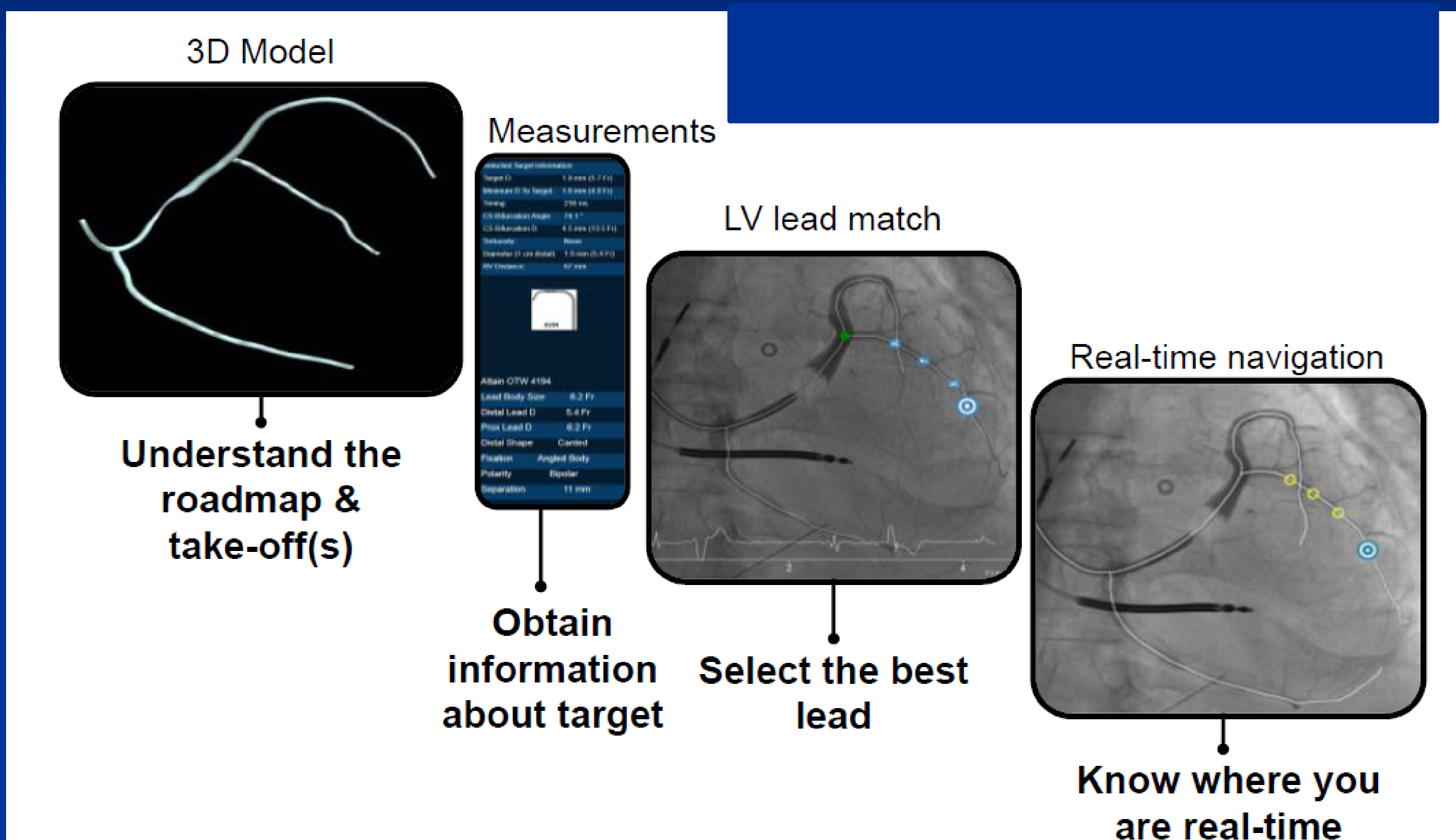
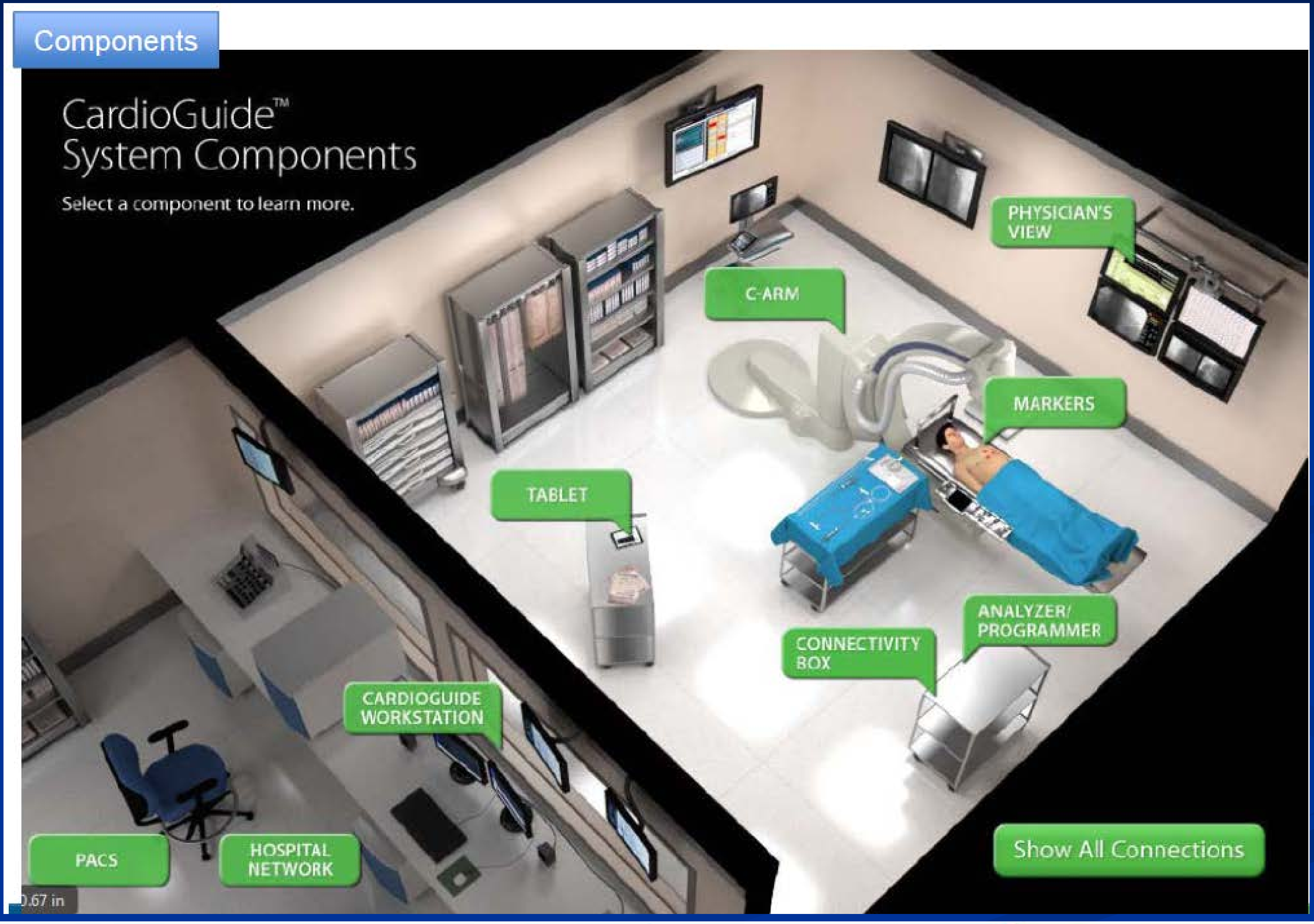
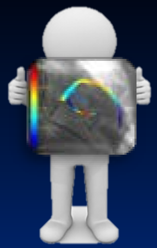


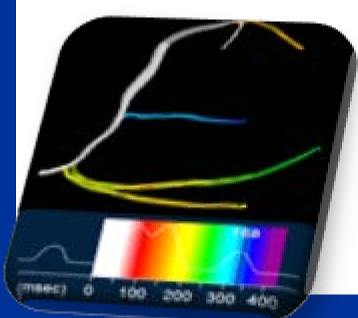
CARDIOGUIDE

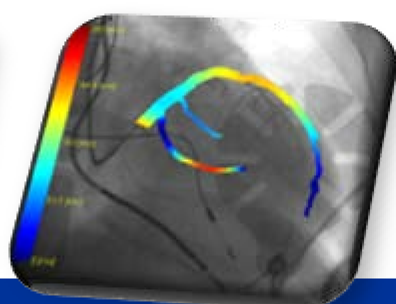




CARDIOGUIDE

1. **CardioGuide 3D**
   - Create a three-dimensional model of the coronary vasculature.
   - Show how Medtronic LV leads match patients anatomy.
   - Support LV lead navigation to the target site.
2. **CardioGuide *m*-Map (future release)**
   - Identify areas of late mechanical activation.
   - Provide recommendations for LV leads and delivery tools
3. **CardioGuide e-Map (future release)**
   - Identify areas of late electrical activation and non-viable tissue





SonR @ impianto per ottimizzare impianto LV lead

Obiettivo:

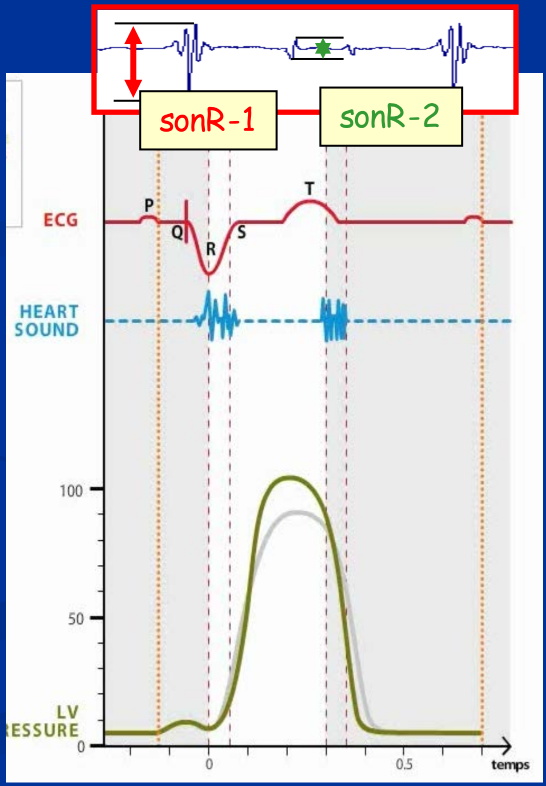
Utilizzando il catetere atriale SonR (senza cioè dover aggiungere strumenti invasivi), identificare la miglior configurazione di pacing (fra le diverse disponibili) su base emodinamica (stima LVdP/dt)

Razionale:

• *SonR è un marker di tipo emodinamico (correla con LVdP/dt)*
• *⇓ ritardi EM, ⇑ contratt., ⇑ DFT ottimizzano la perform. emodin.*

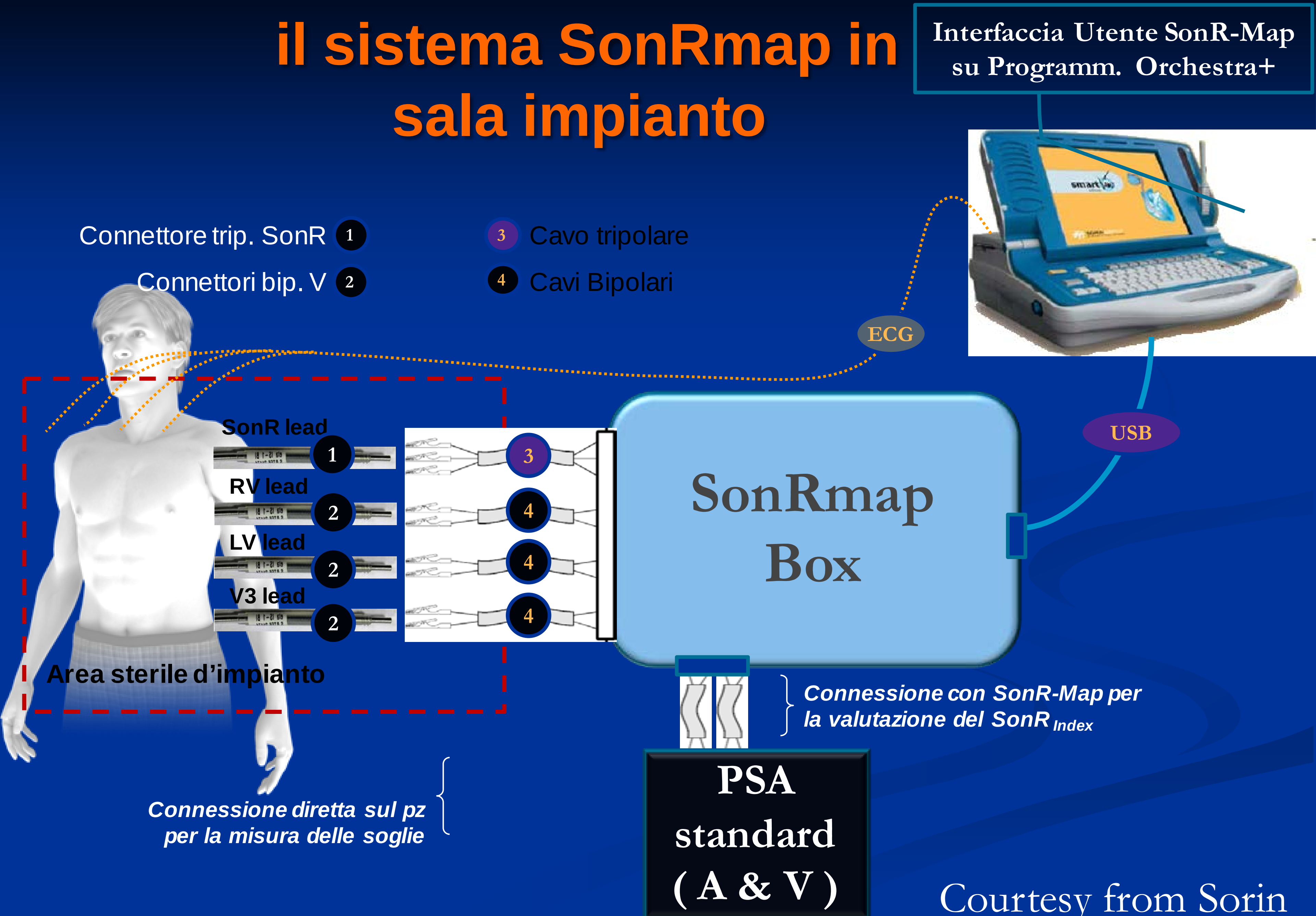
Stato dell'arte:

Fase di studi clinici pilota



Courtesy from Sorin

il sistema SonRmap in sala impianto



Courtesy from Sorin

Conclusions

- Pacing the "right" segments in the "right" patient is desirable.
- A purely anatomic approach may be of limited value.
- New technology (Cardio-Guide) could integrate all strategies (radiological, mechanical and EP), and improve results without wasting time.