Imaging modalities to assess suitability for CRT

Francisco Leyva

HRC 2010

University of Birmingham

Queen Elizabeth Hospital

ESC Guidelines for CRT

HF NYHA III/IV?

EF ≤35%?

QRS≥120 ms

OPTIMALMEDICAL THERAPY

If Yes to all

Life expectancy >1 year ?

CRT-D or CRT-P indicated

Dickstein K. *Eur Heart J.* 2008; 29: 2388-2442

ESC Guidelines for CRT: a rethink

HF NYHA III/IV? ?

EF ≤35%? ?

QRS≥120 ms ?

OPTIMALMEDICAL THERAPY ?

If Yes to all

Life expectancy >1 year ?

CRT-D or CRT-P indicated

Best response to CRT within guidelines

HF NYHA III/IV?

EF ≤35%?

QRS≥120 ms

OPTIMALMEDICAL THERAPY

If Yes to all

Life expectancy >1 year ?

Best response to CRT

Successful outcomes in CRT: clinical endpoints

Definition of clinical endpoint:

A characteristic or variable that reflects how a patient feels or functions, or how long a patient survives

FDA Biomarkers Definition Working Group , 1998

CRT

Symptomatic benefit	Prognostic benefit	Combined benefit
NYHA class	All-cause mortality	NYHA class / 6-min walk
6-min walk	Cardiovascular mortality	Survival / NYHA class / 6 min walk
Quality of life		
MVO_2		
Hospitalisations		

Predictors of outcome from treatment

Desired characteristics

A true predictor of disease, not reflection of a covariable

Sensitive and specific - >90% for both

Available, reliable, easily quantifiable, reproducible

Precise cut-offs between normality and abnormality

Cut-offs derived from one population are not necessarily applicable to another

Statistical significance does not imply diagnostic utility (Bayesian statistics)

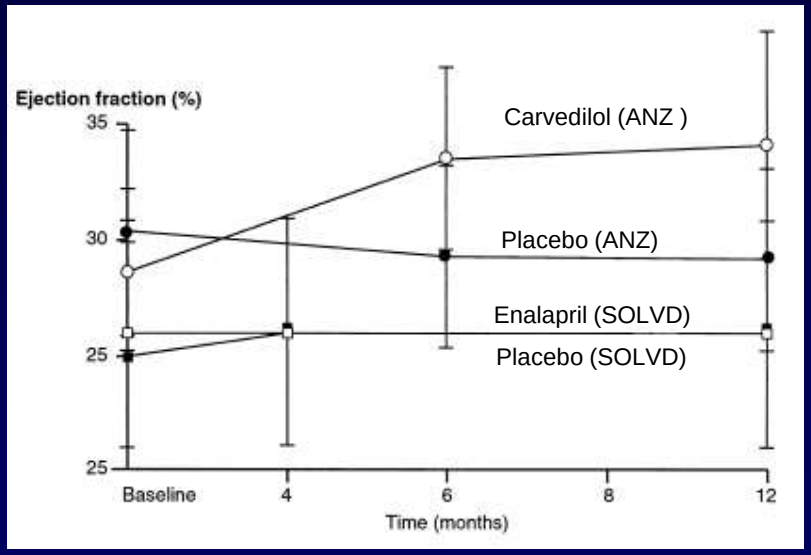
Predicting benefit from CRT: imaging modalities

Modalities

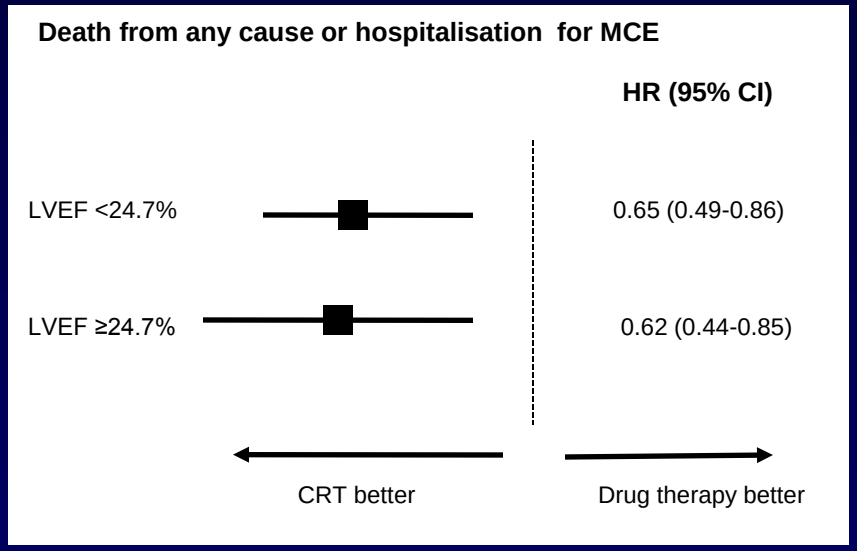
- Echocardiography
- CT
- CMR
- Electroanatomical mapping

LVEF: a predictor of outcome ?

Enalapril or carvedilol for heart failure



CRT (CARE-HF)

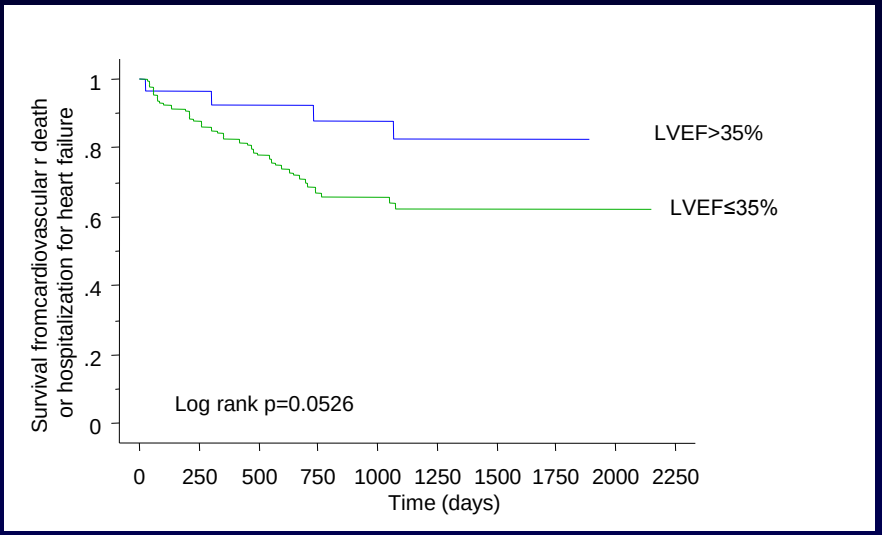


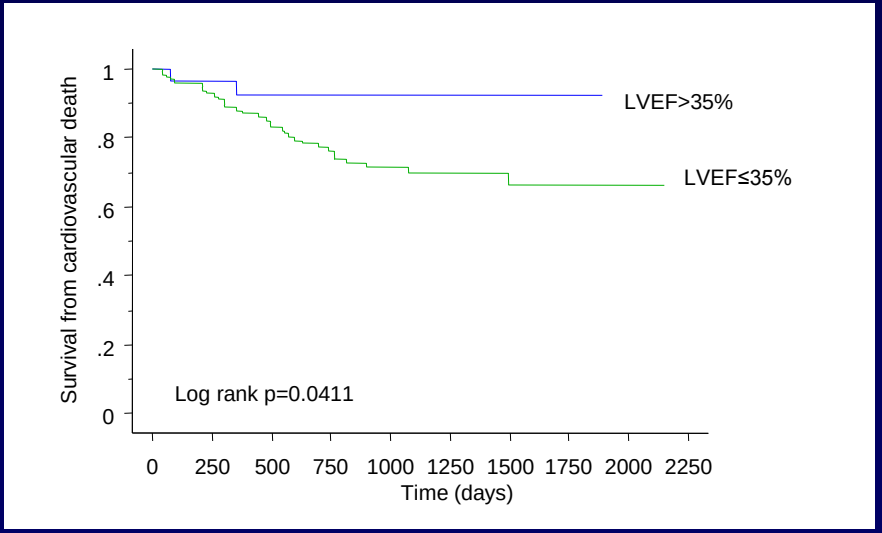
Cleland JGF, et al. N Eng J Med, 2005;352:1539-1549

CMR-LVEF: a predictor of outcome ?

	LVEF ≤35% (n=127)	LVEF >35% (n=26)
NYHA class		
Baseline	3.19 ± 0.51	3.19 ± 0.62
Follow-up	1.92 ± 0.94 **	2.0 ± 0.83 **
6-min walk m		
Baseline	242.4 ± 110.5	284.7 ± 123.2
Follow-up	306.9 ± 114.4 **	354.8 ± 133.3 *
Quality of life		
Baseline	55.6 ± 20.4	60.7 ± 23.8
Follow-up	34.0 ± 23.4 **	27.7 ± 23.9 **
Response, n (%)	99 (79)	24 (92)

*p<0.001; **p<0.0001 versus baseline within group.



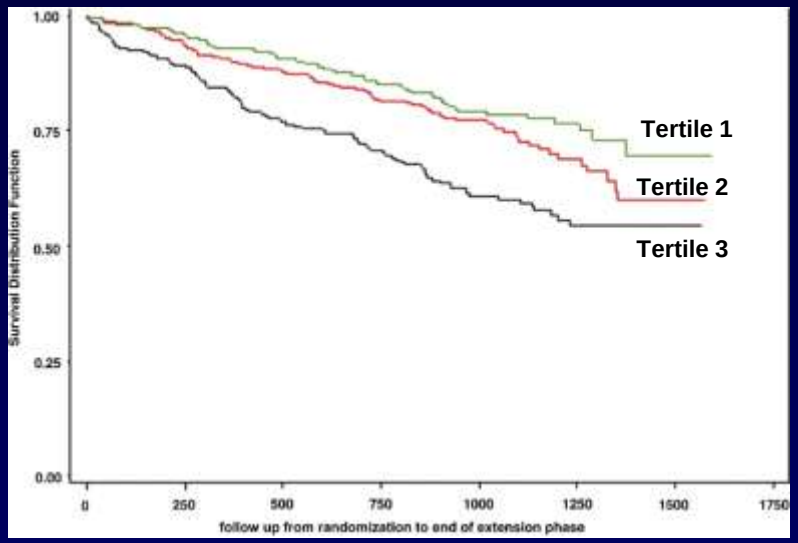


Foley PWX, et al. PACE 2009

CARE-HF study: IVMD as a predictor of mortality ?

N=813 patients randomised to CRT or optimum medical treatment only
Model for predicting all-cause mortality included 15 pre-implant variables

Baseline IVMD



Multivariate analysis:

As predictor of all-cause mortality:

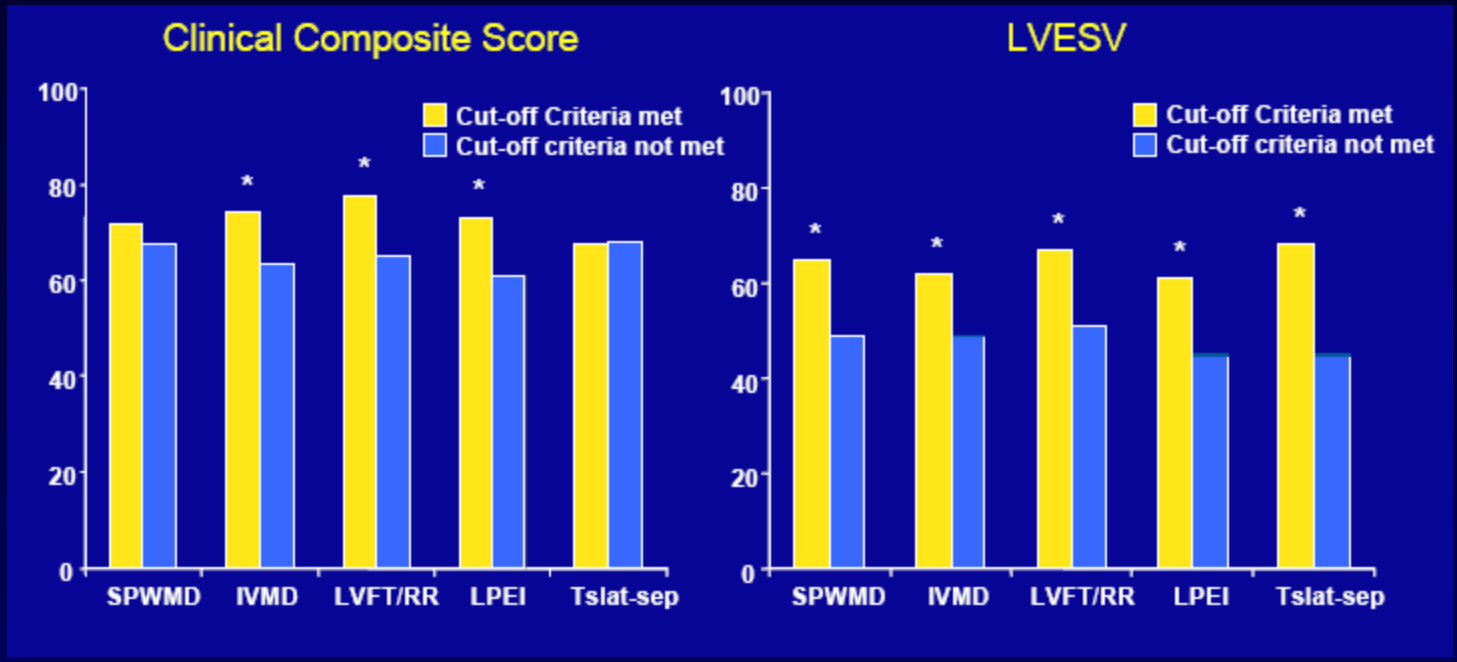
HR: 0.991 (95% CI: 0.986 -0.997)

No internal validation
No external validation
No Bayesian analysis

Conclusions: '...Patients assigned to CRT had a lower mortality even after adjusting for variables measured before and 3 months after intervention. The effect of CRT on mortality cannot be usefully predicted using such information. '

Cleland, J. et al. J Am Coll Cardiol 2008;52:438-445

PROSPECT study: predictive value of echo dyssynchrony indices

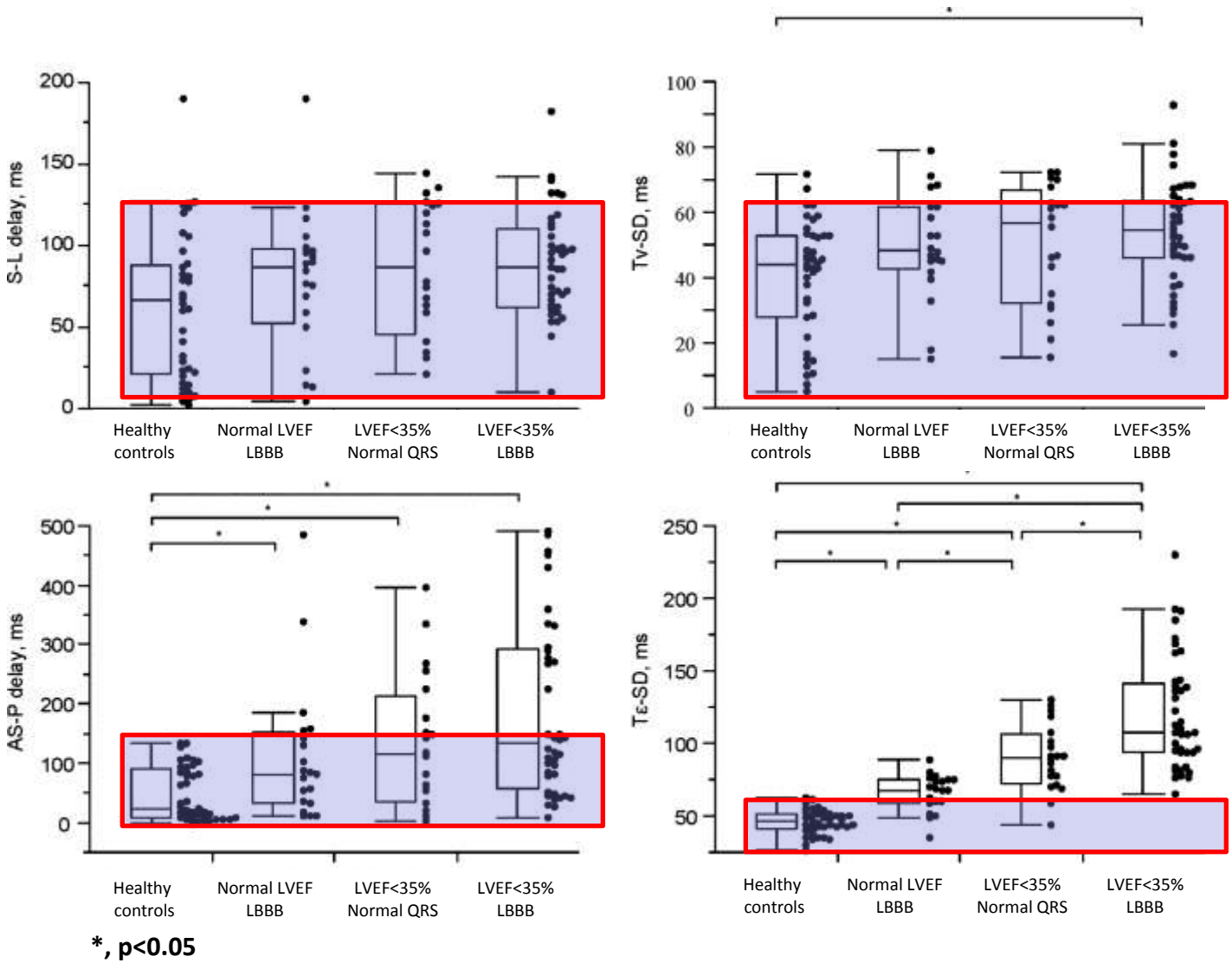


Measure	Yield (%)
SPWMD	72
IVMD	**92**
LVFT/RR	85
LPEI	95
Ts Lat-Se	67
Ts-SD	**50**

	CV (%)
Ts-SD	**33.7**
SPWMD	**72.1**

Chung E, et al. Circulation 2008;117:2608-16

Echo TDI dyssynchrony indices

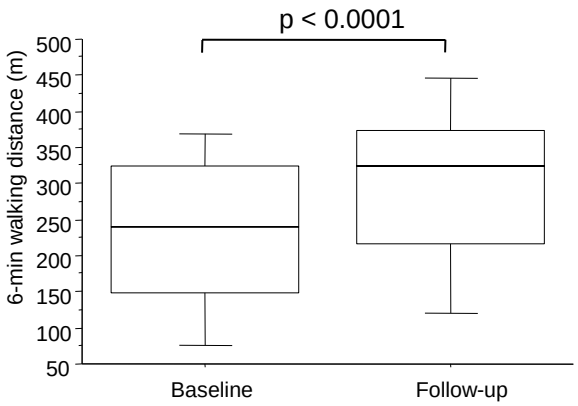


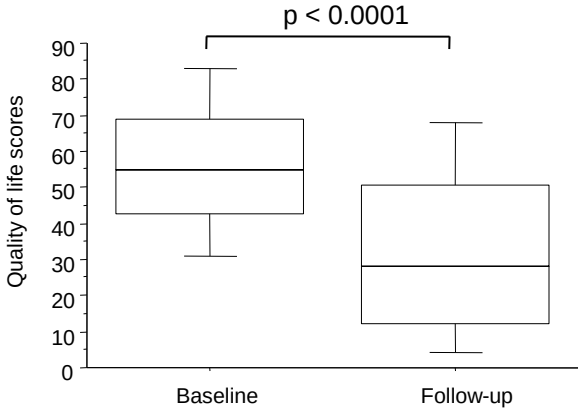
***, p<0.05**

Miyazaki, C. et al. Circulation 2008;117:2617-2625

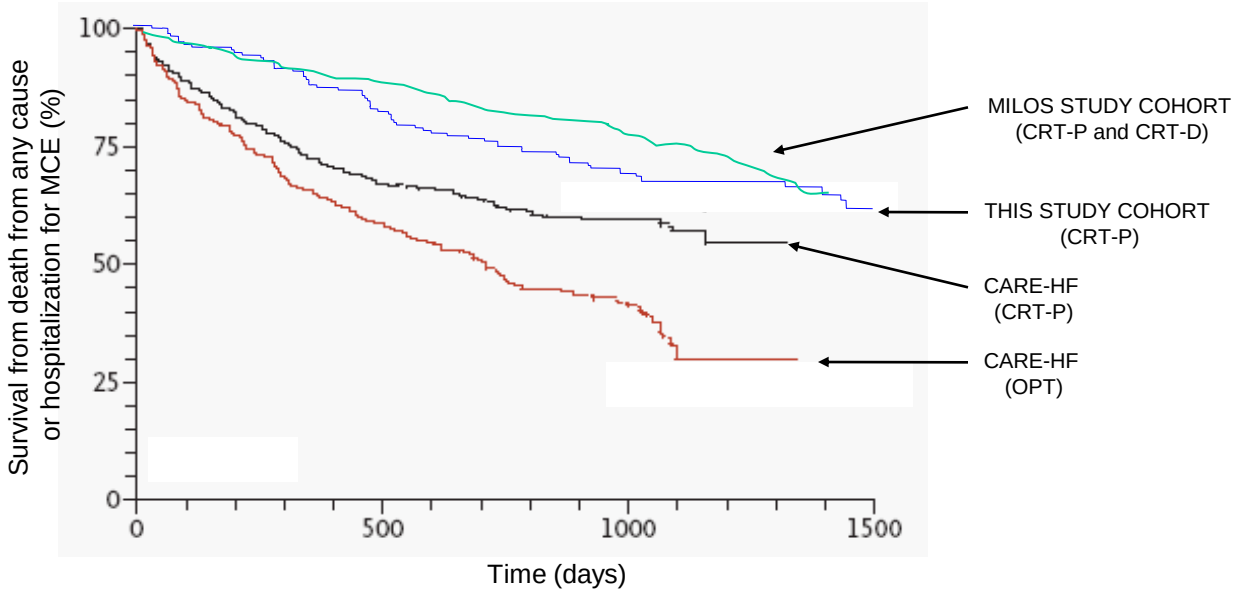
CRT in patients unselected for dyssynchrony

N = 248, SR, NYHA class III (171) or IV (n=77), QRS ≥120 ms



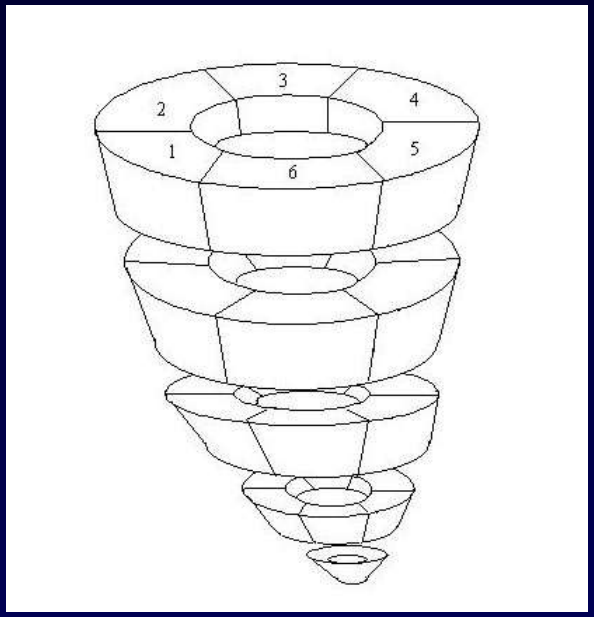


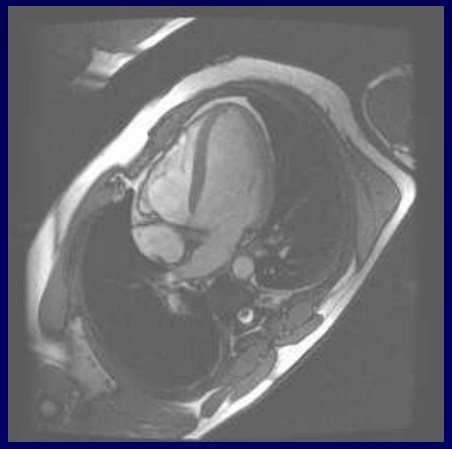
Responder rate = 81%

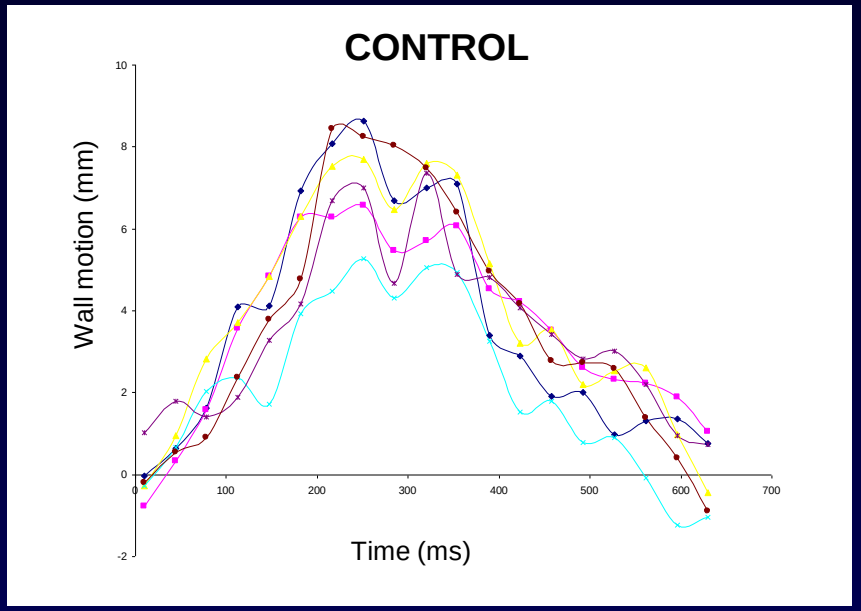


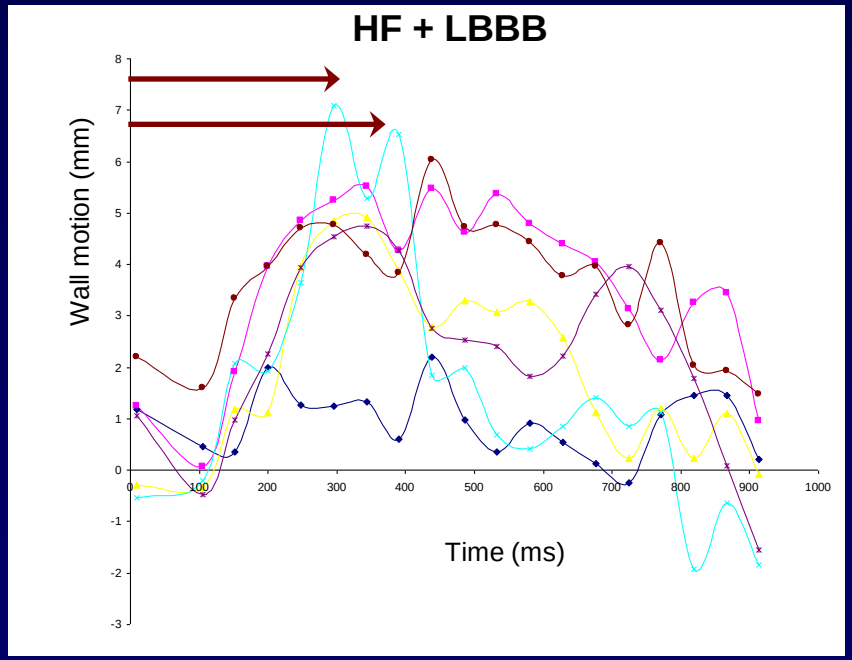
Foley PWX, et al. Int J Cardiol 2010

Assessing dyssynchrony with CMR: wall motion



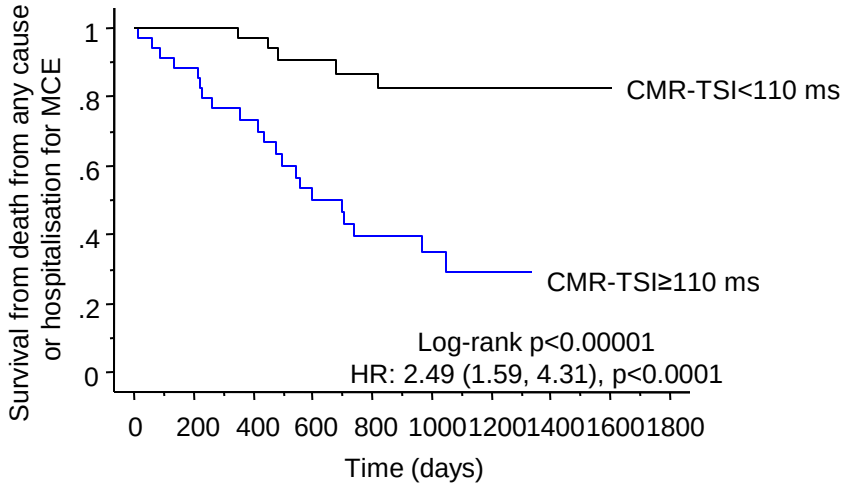


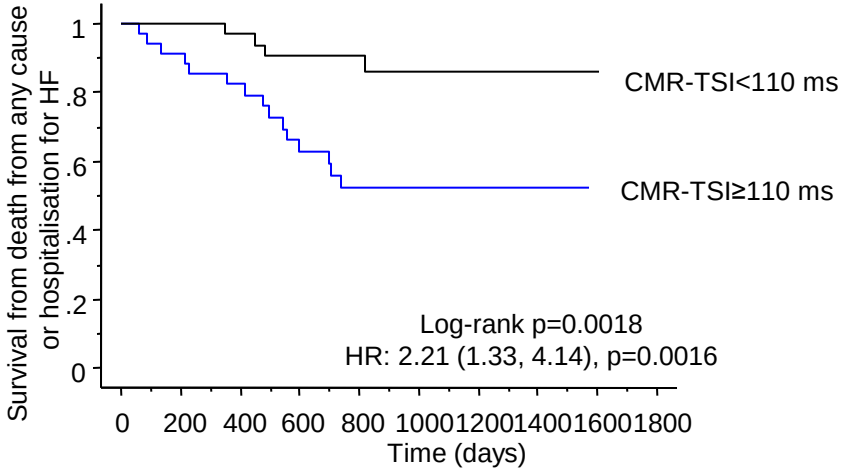


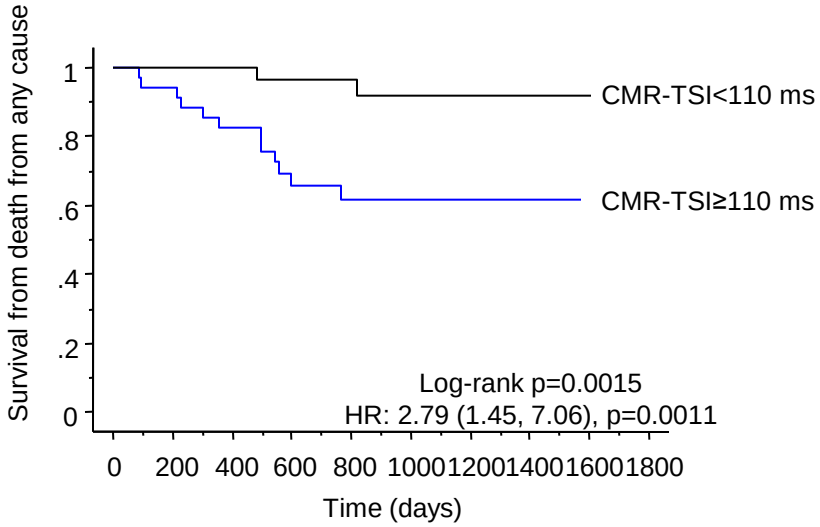


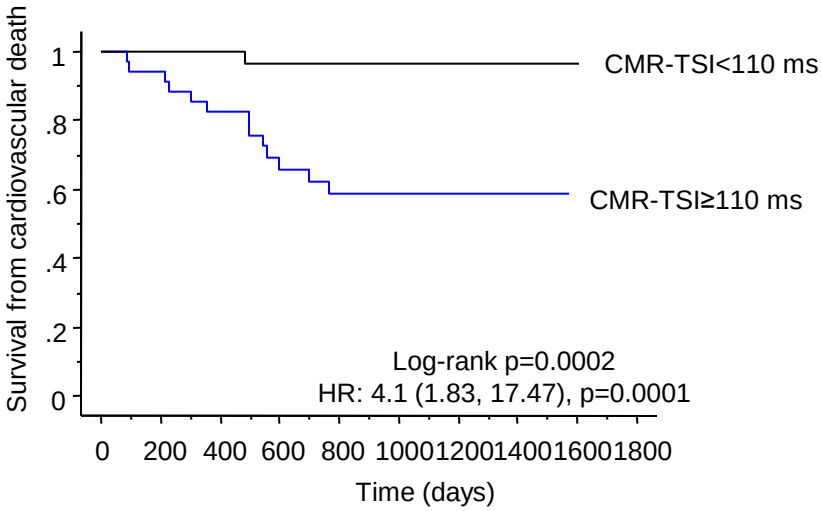
Chalil S, et al. J Am Coll Cardiol 2007

CMR-TSI and events









Chalil S, et al. J Am Coll Cardiol 2007

Guiding LV lead deployment

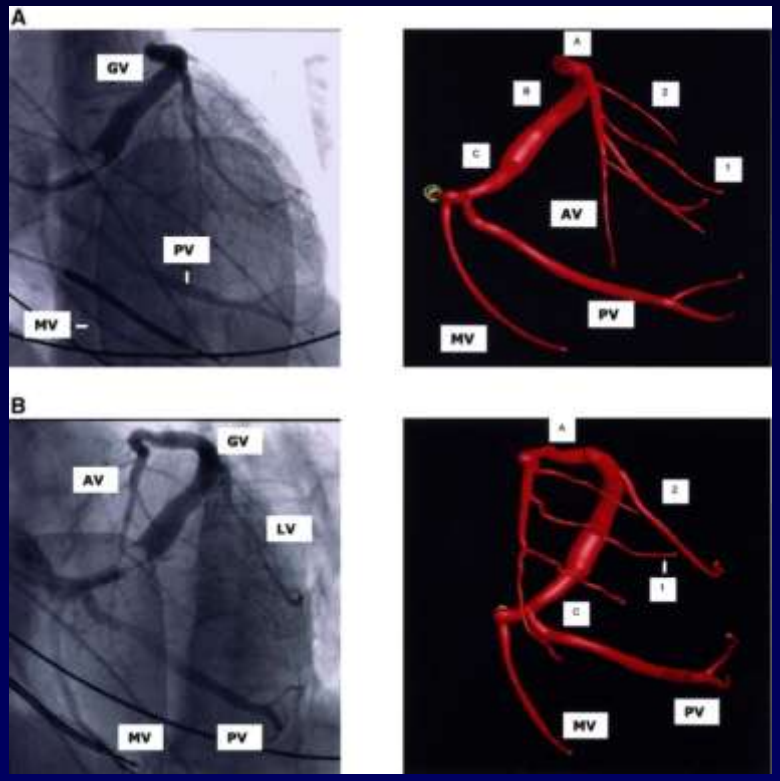
Anatomical approach

Functional approach (dyssynchrony, haemodynamics and viability)

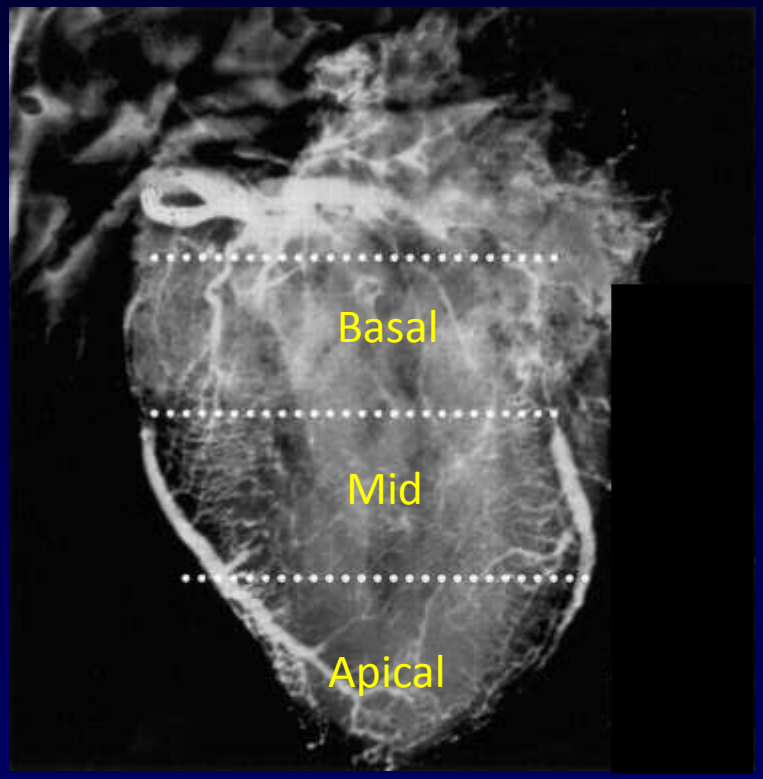
‘Practical’ approach

Combination

Anatomical approach: coronary sinus anatomy



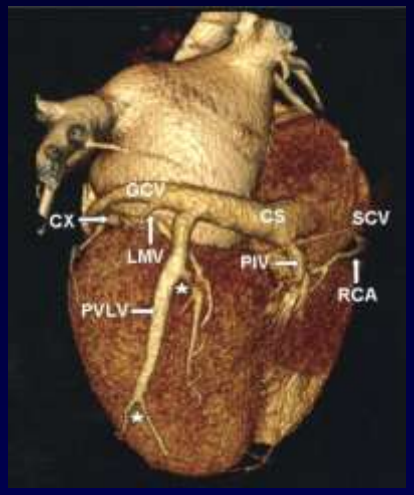
Anterolateral
Posterolateral
Lateral



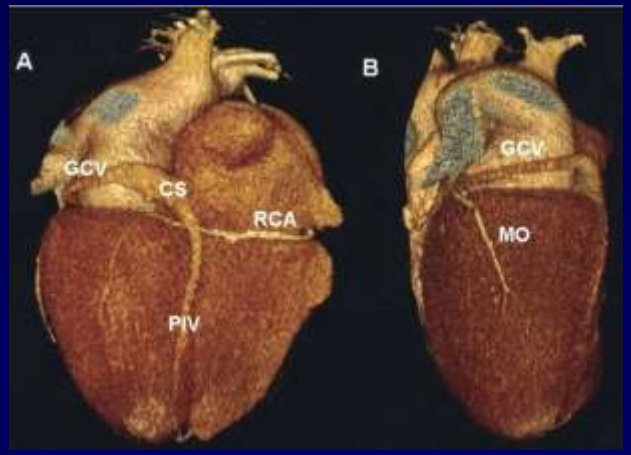
Basal
Middle
Lateral

Singh, J. P. et al. J Am Coll Cardiol 2005;46:68-74

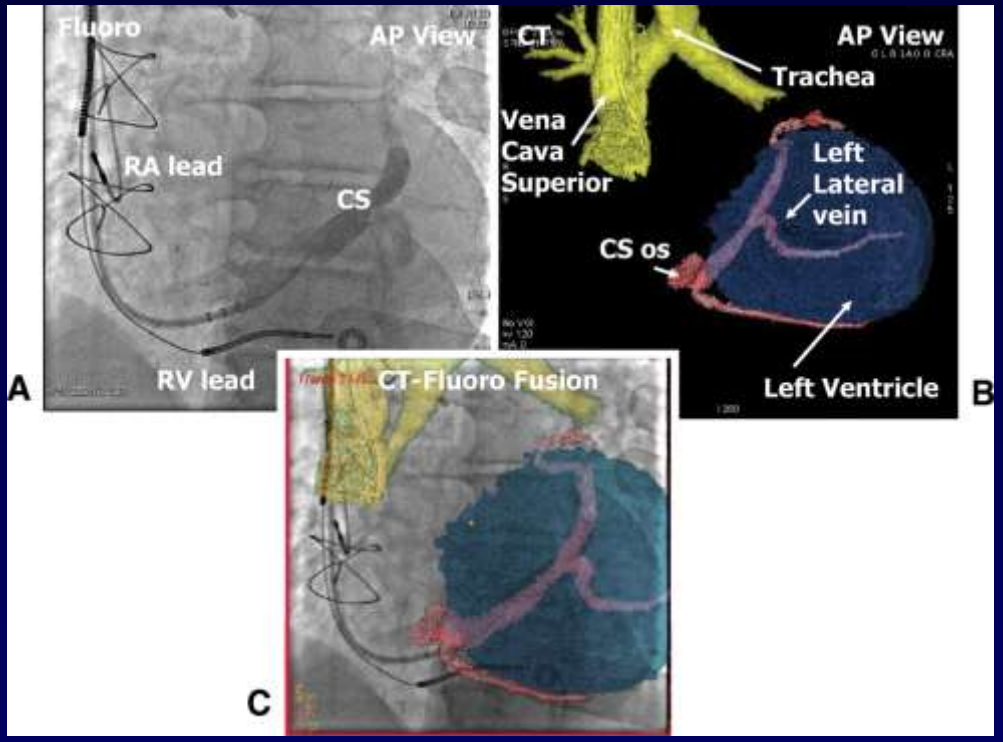
Cardiac CT venography / fluoroscopy



Healthy control



Absent PVLV and LMV in a patient with an anterolateral MI

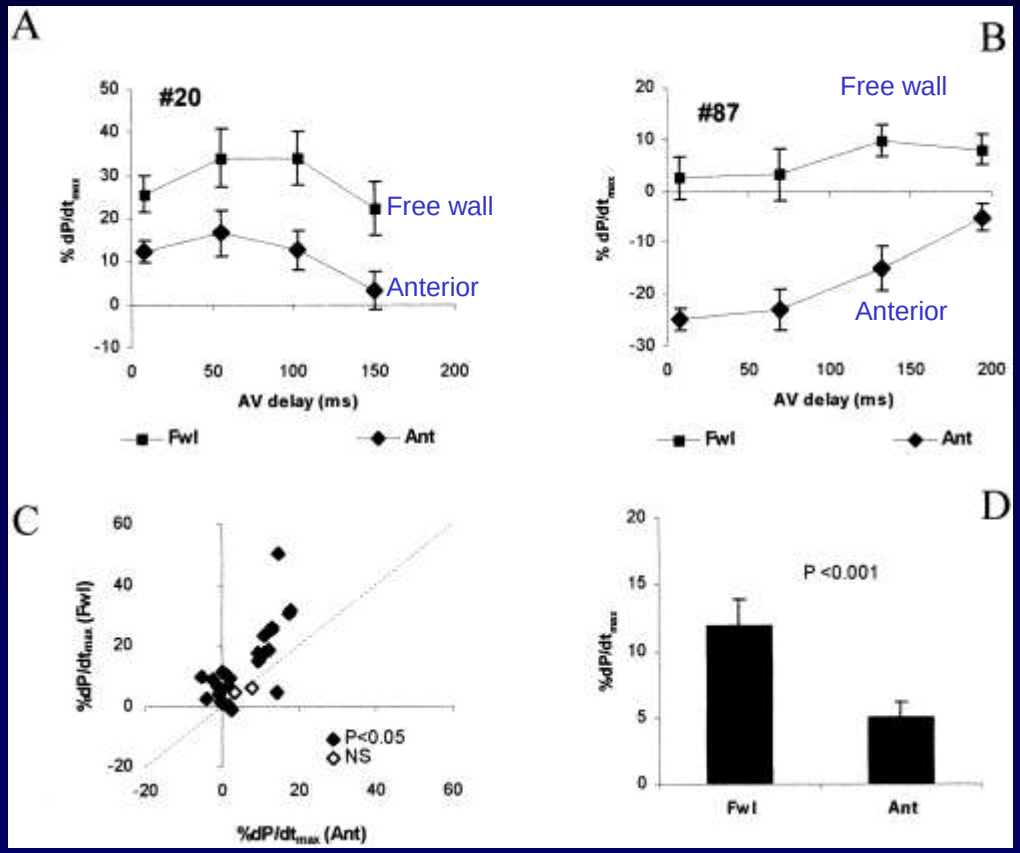


Auricchio A et al. Europace 2009;11:1483-1490

Van de Veire, N. R. et al. JACC 2006;48:1832-1838

Haemodynamics: dP/dt

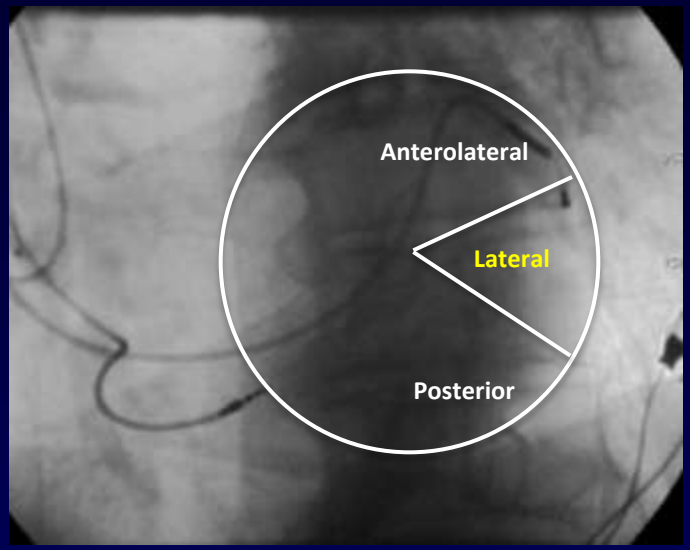
N =30 in PATH-HF trial
VDD mode at 4 AV delays
RV apex and AL or PL wall

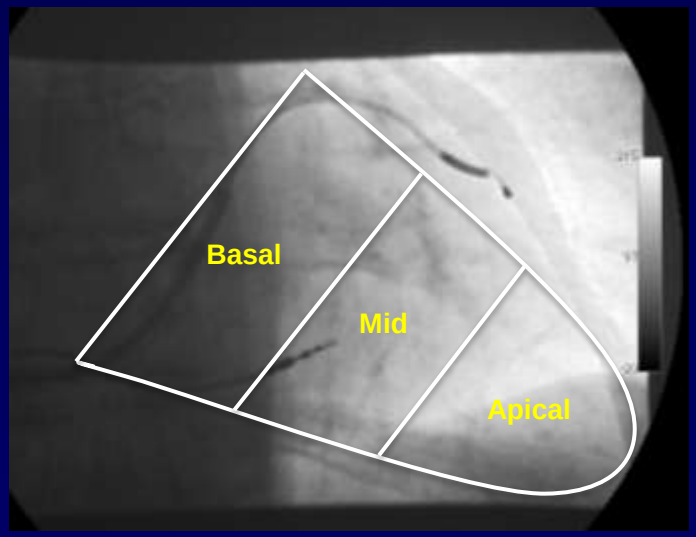


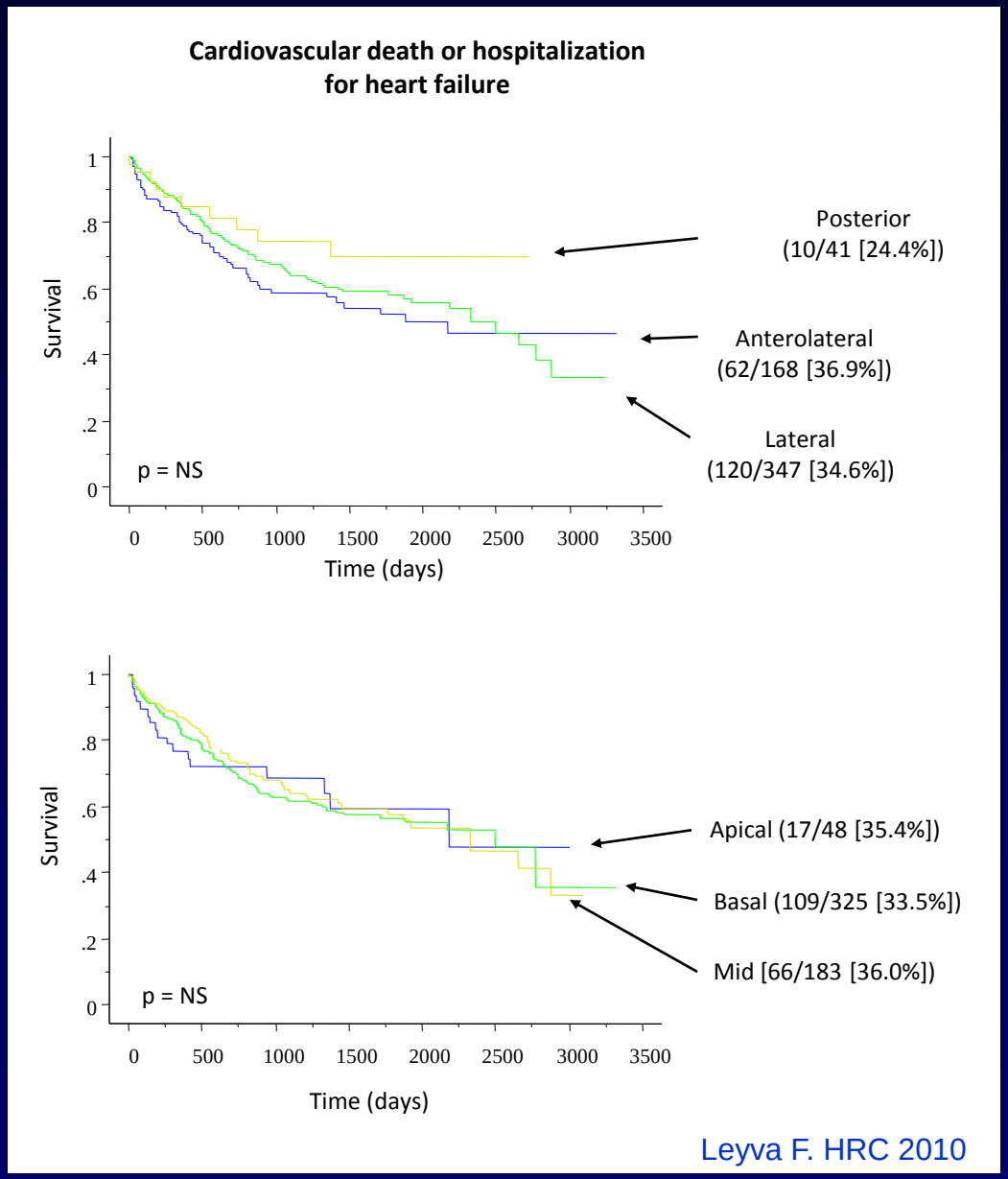
Conclusion: LV free wall pacing is superior to anterior wall pacing

Butter, C. et al. Circulation 2001;104:3026-3029

LV lead position: does it matter?

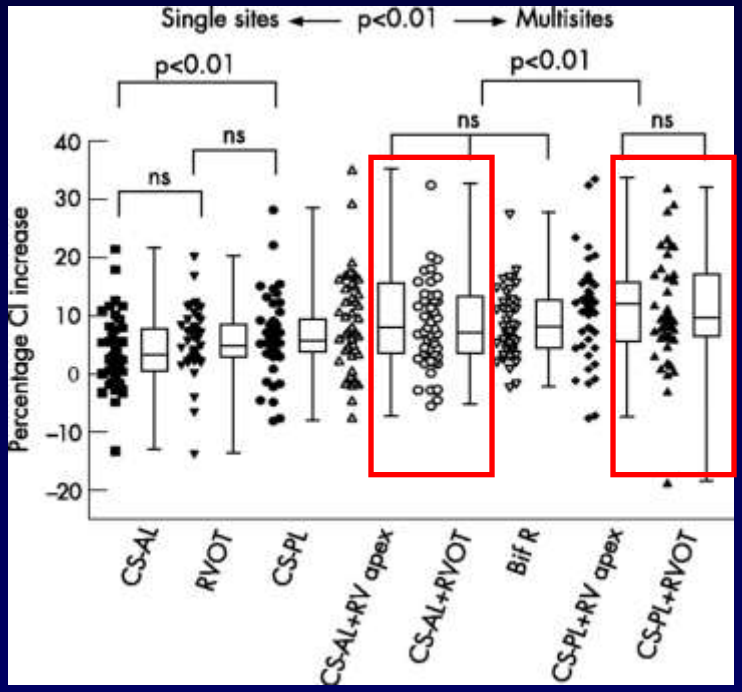






Haemodynamics: aortic VTI

Acute echocardiographic study
N = 48
Femoral approach: unipolar pacing wires to LV, bipolar pacing catheters to RV
Cardiac index (CI) assessed by aortic VTI
Response = 10% increase in CI



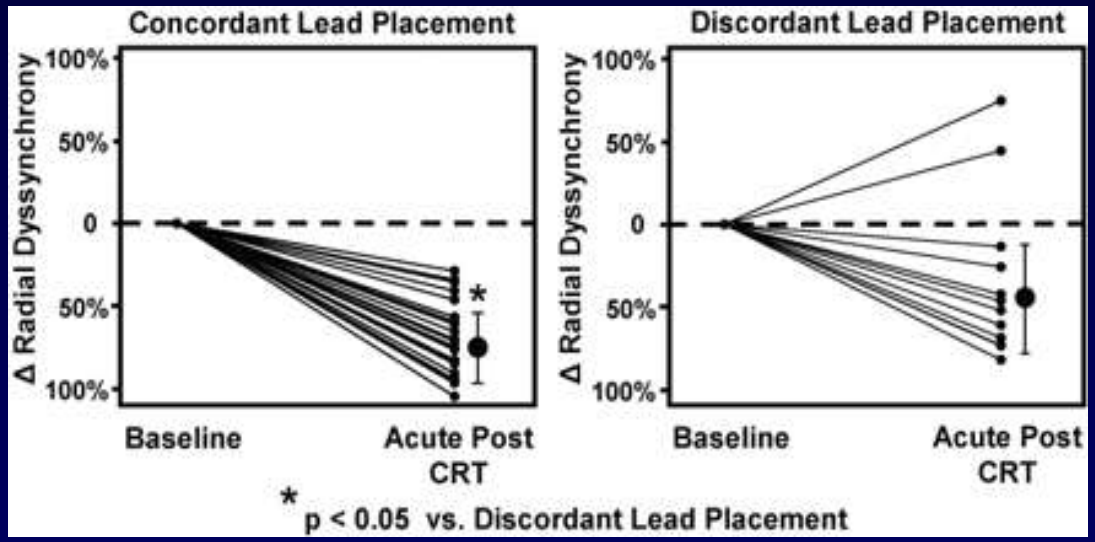
Multisite: % increase in CI greater with CS-PL than CS-AL
% increase in CI greatest with CS-PL and RV apex

van Campen, C M C et al. Heart 2006;92:1795-1800

Radial dyssynchrony

Concordance: proximity of lead position to latest mechanical activation site

N = 42 patients with heart failure



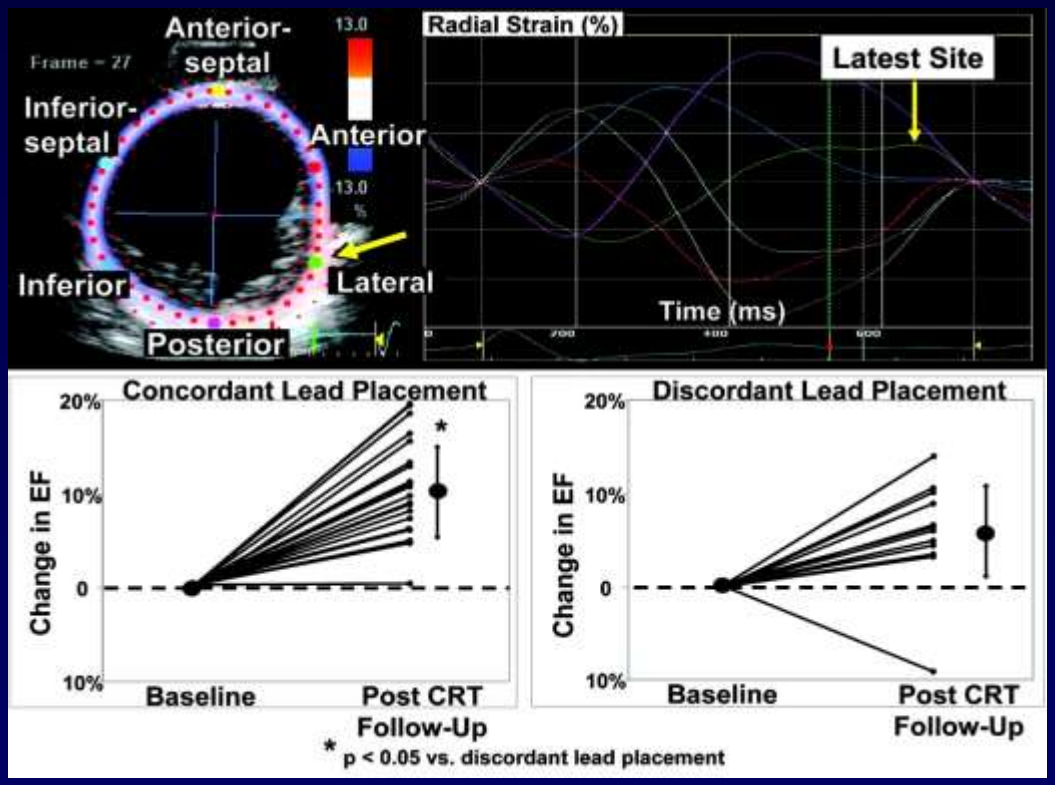
Speckle tracking radial strain used to map mechanical activation time from 12 radial sites (6 basal, 6 mid-LV). LV lead tip localized using fluoroscopy.

Concordance was defined as LV lead tip matching the same site as the latest mechanical activation from the 12 radial sites.

Miske G, et al. Circulation. 2007;116:II-739

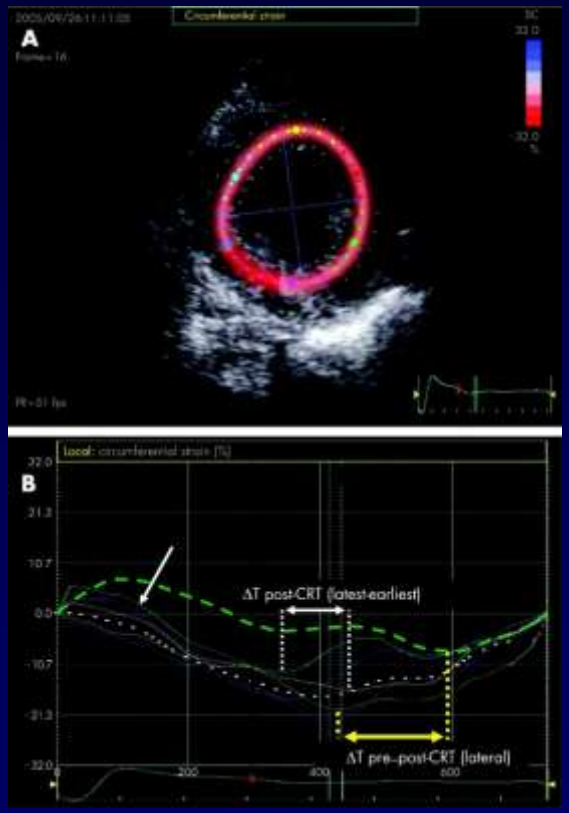
Radial strain

N = 64 patients undergoing CRT
Identification of site of latest mechanical activation by speckle-tracking, radial strain and EF response based on LV lead placement site

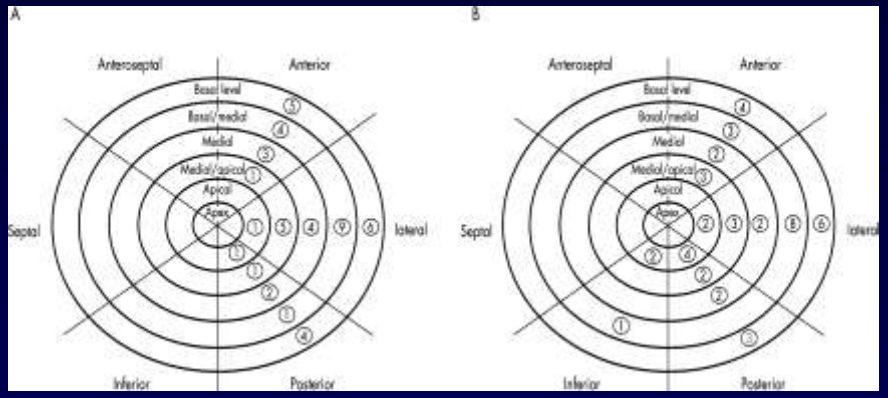


Suffoletto, M. S. et al. Circulation 2006;113:960-968

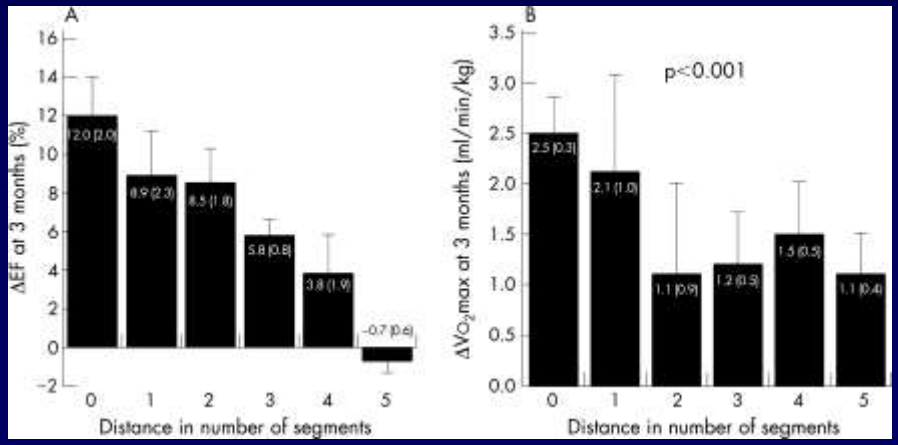
Comparing sites: circumferential strain



Distribution of segments with the latest peak systolic strain before CRT (A) and the assumed LV (B)



After 3 months of CRT-P:

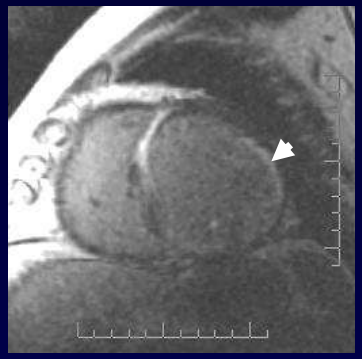


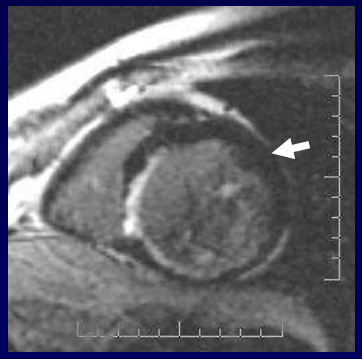
Distance (counted in segments in the 36-segment model) from the segment with the latest peak systolic strain before CRT to the segment with the assumed LV lead position.

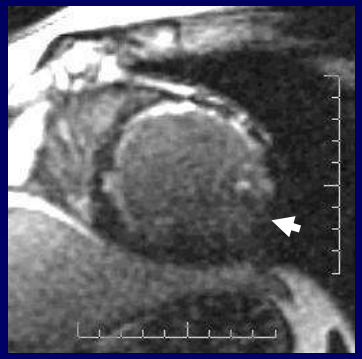
Becker, M. et al. Heart 2007;93:1197-1203

Posterolateral scar and response to CRT

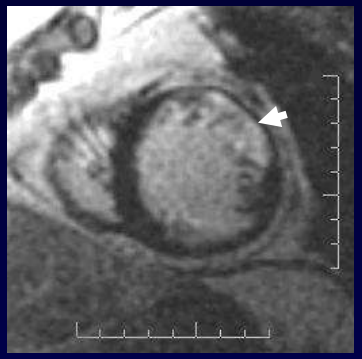
RESPONDERS

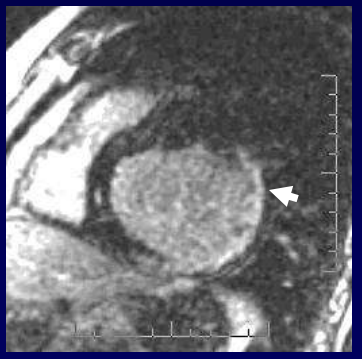


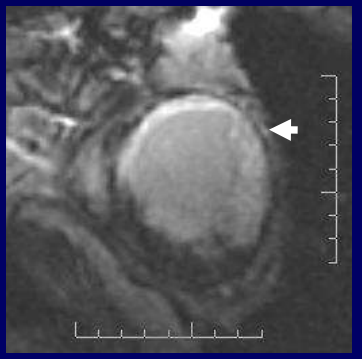




NON-RESPONDERS

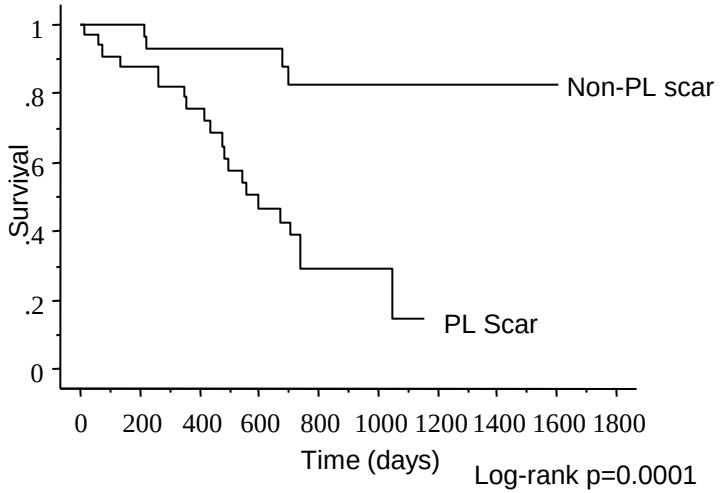




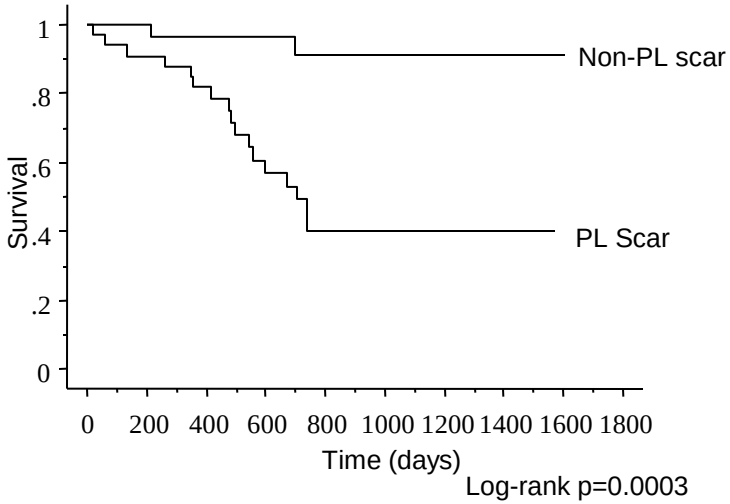


Posterolateral scar and response to CRT

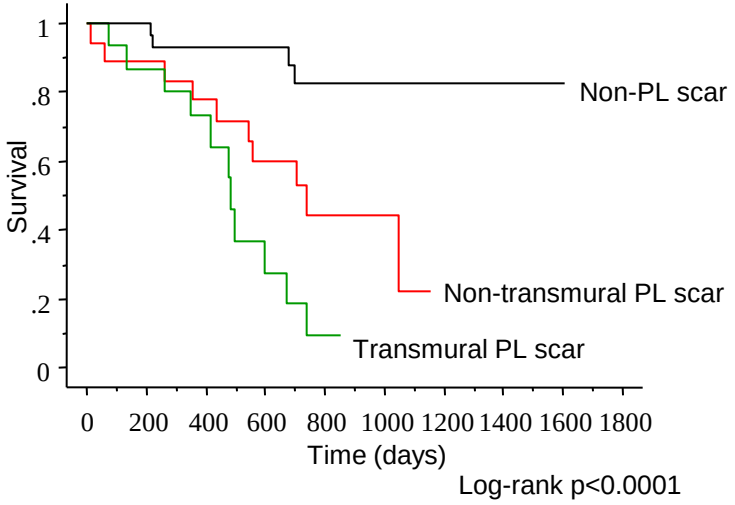
Cardiovascular death or hospitalisation for MCE



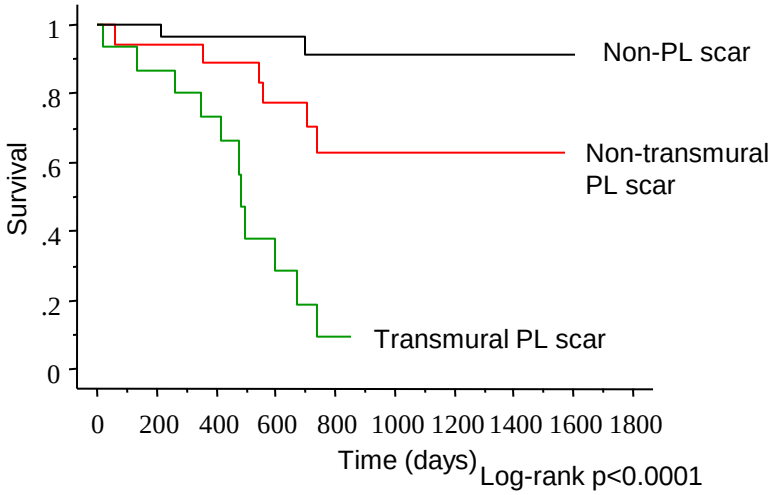
Cardiovascular death or hospitalisation for heart failure



Cardiovascular death or hospitalisation for MCE



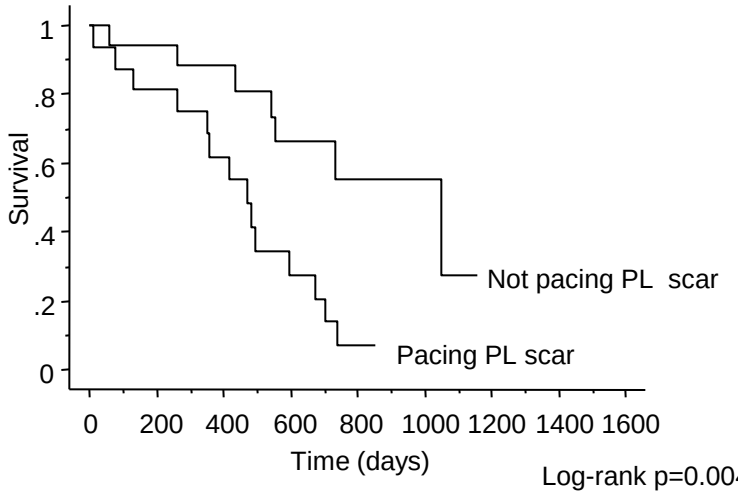
Cardiovascular death or hospitalisation for heart failure



Chalil S, et al. J Am Coll Cardiol, 2007.

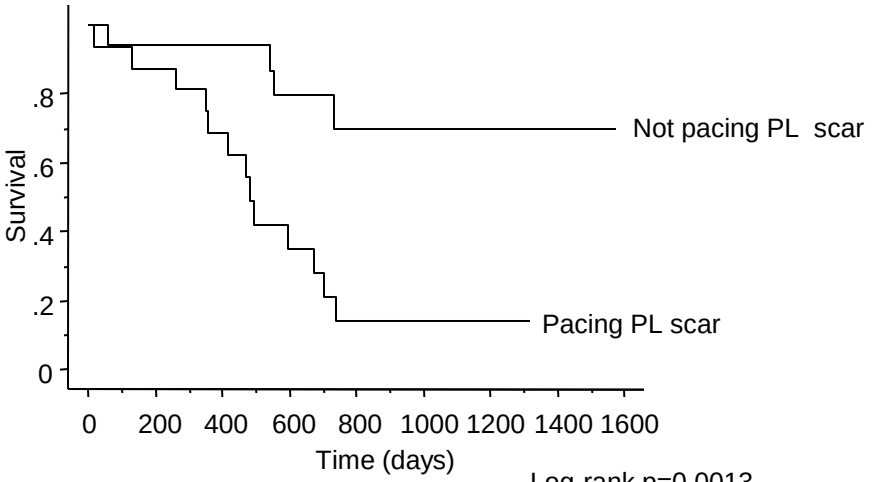
Effects of pacing posterolateral scar

Cardiovascular death or hospitalisation for MCE



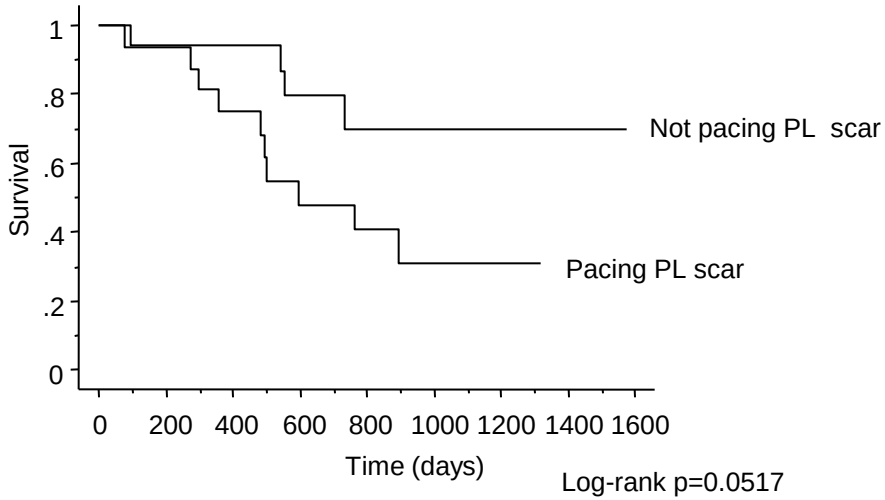
Log-rank p=0.0041
HR: 1.94 (1.22, 3.27), p=0.0046

Cardiovascular death or hospitalisation for heart failure



Log-rank p=0.0013
HR: 2.30 (1.36, 4.34), p=0.0014

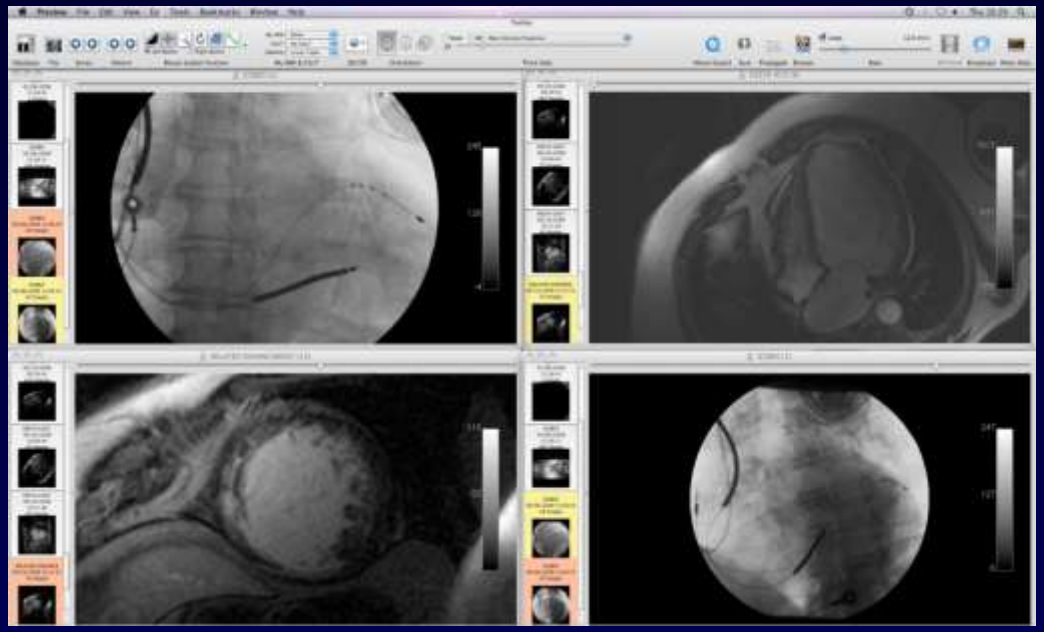
Cardiovascular death

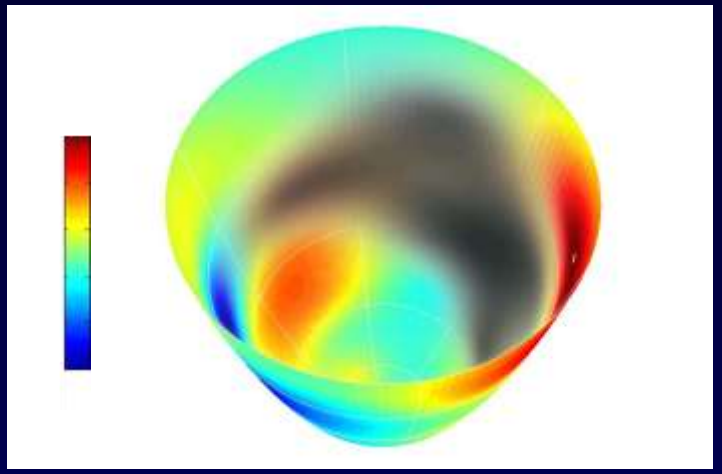


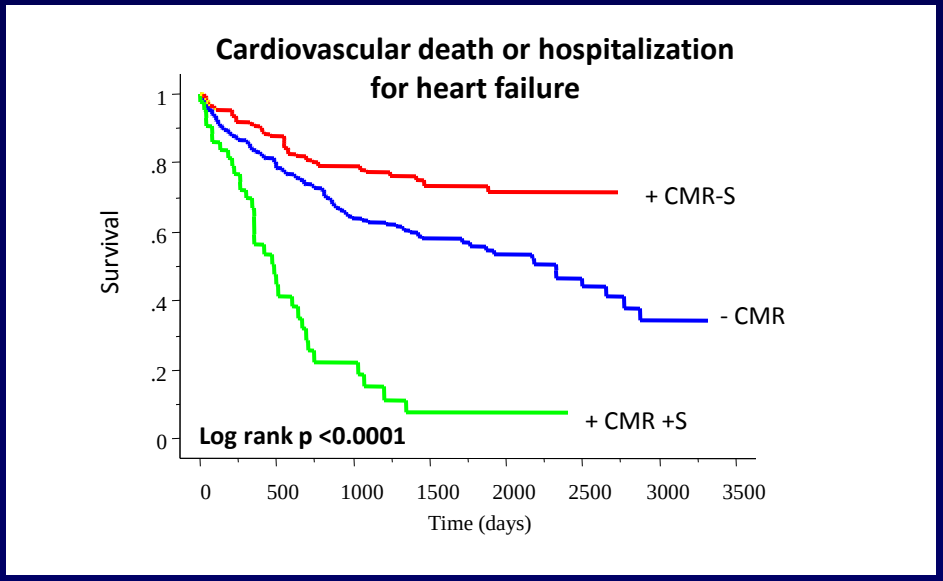
Log-rank p=0.0517
HR: 1.73 (1.00, 3.31), p=0.0499

Chalil S, et al. J Am Coll Cardiol, 2007.

Role of CMR in LV lead deployment







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Predictors of outcome after CRT

Univariate Cox analysis

Parameter	HR (95% CI)	LR-X^2	p
Posterolateral scar location	16.8 (6.94 to 40.5)	58.6	<0.0001
CMR-TSI, ms*	1.01 (1.01 to 1.02)	22.5	<0.0001
Scar burden, %	1.03 (1.01 to 1.04)	13.3	0.0001
CMR-LVEF, %	0.94 (0.90 to 0.98)	11.1	0.0032
Sodium, mmol/L	0.88 (0.81 to 0.96)	8.2	0.0031
Creatinine, µmol/L	1.01 (1.00 to 1.02)	7.92	0.0049
Transmurality (transmural)	2.51 (1.29 to 4.84)	7.64	0.0057
Male gender	2.59 (0.92 to 7.32)	4.15	0.0417
Uric acid, µmol/L	1.00 (1.00 to 1.00)	2.33	0.1265
NYHA class	1.73 (0.84 to 3.37)	2.24	0.1343
CABG	0.75 (0.53 to 1.08)	2.42	0.1196
QRS duration, ms	1.01 (1.00 to 1.02)	1.01	0.2202
Age, yrs	1.01 (0.98 to 1.05)	0.78	0.3765
Atrial fibrillation	1.16 (0.80 to 1.63)	0.64	0.4220
Diabetes mellitus	-0.84 (0.57 to 1.33)	0.61	0.4324
Haemoglobin, g/dL	0.98 (0.83 to 1.02)	0.51	0.4763

Predictors of outcome after CRT

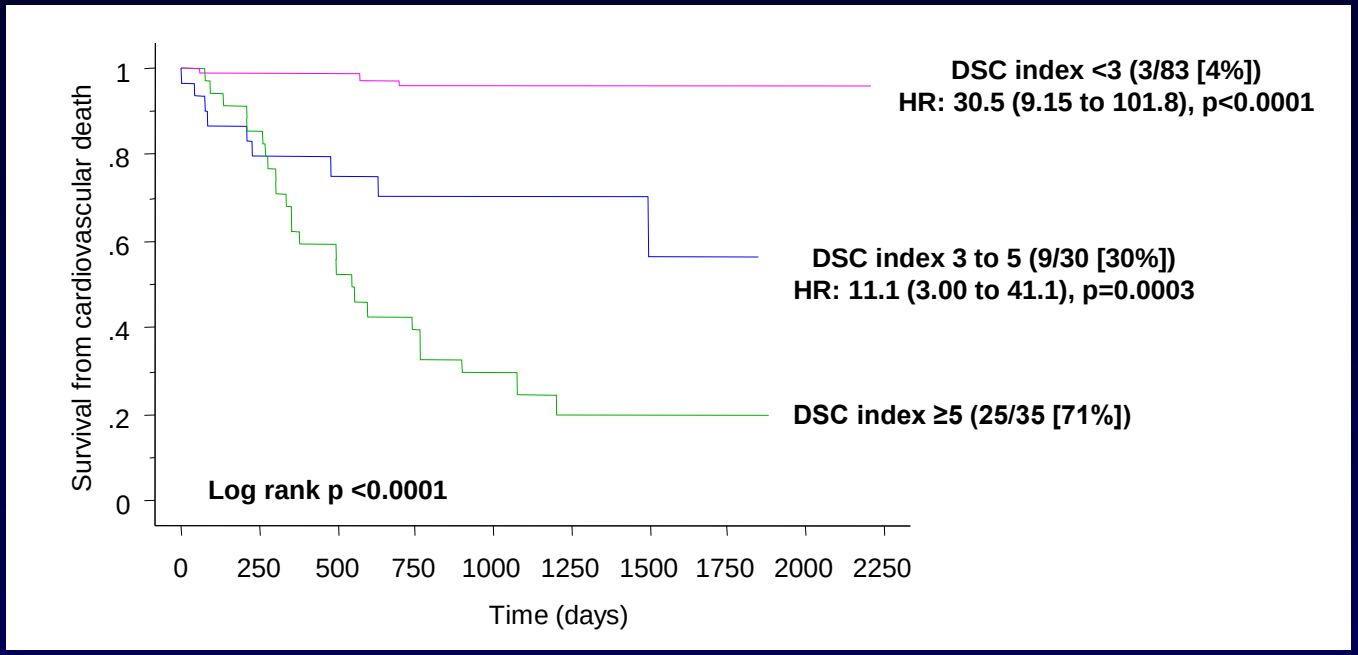
Multivariate Cox analysis with bootstrapping

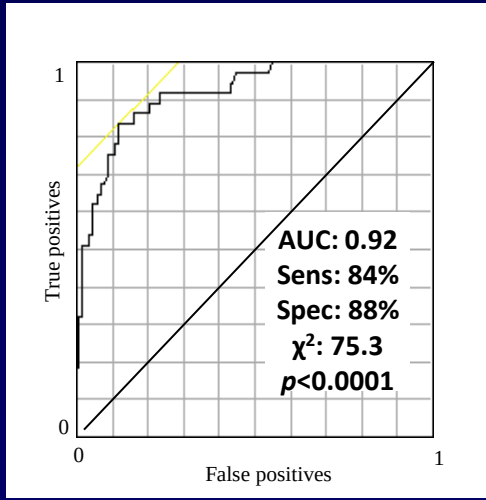
Parameter	HR (95% CI)	Z-score	p
Posterolateral scar location	12.2 (4.97 to 30.1)	5.46	<0.0001
CMR-TSI, ms*	1.01 (1.00 to 1.02)	3.26	0.0011
Creatinine, µmol/L	1.01 (1.00 to 1.02)	2.83	0.0046

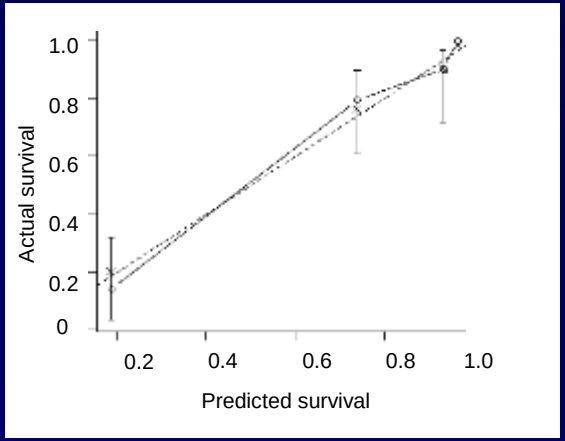
Dyssynchrony **S**car **C**reatinine

DSC index = (2.5039 if posterolateral scar; 0 if absent) + 0.0107 . CMR-TSI) + (0.0132 . Creatinine)

Predictors of outcome after CRT

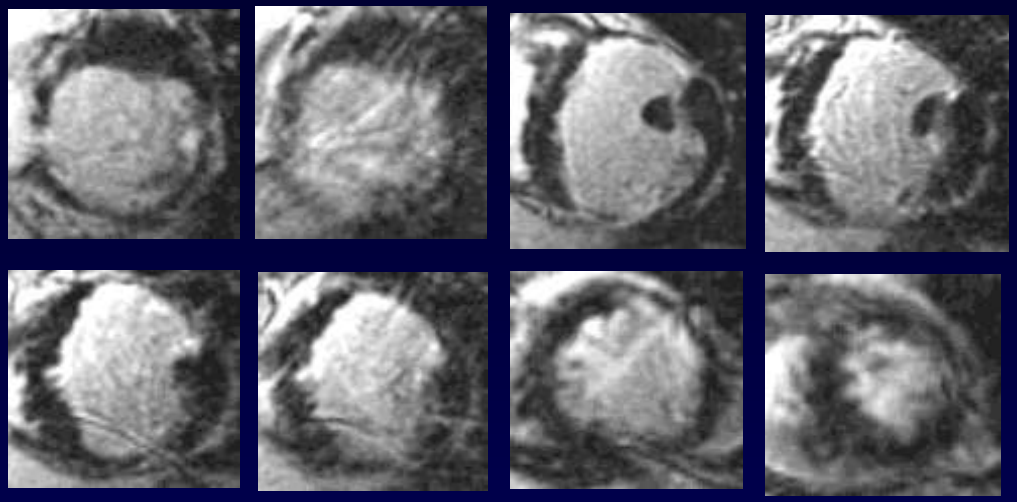


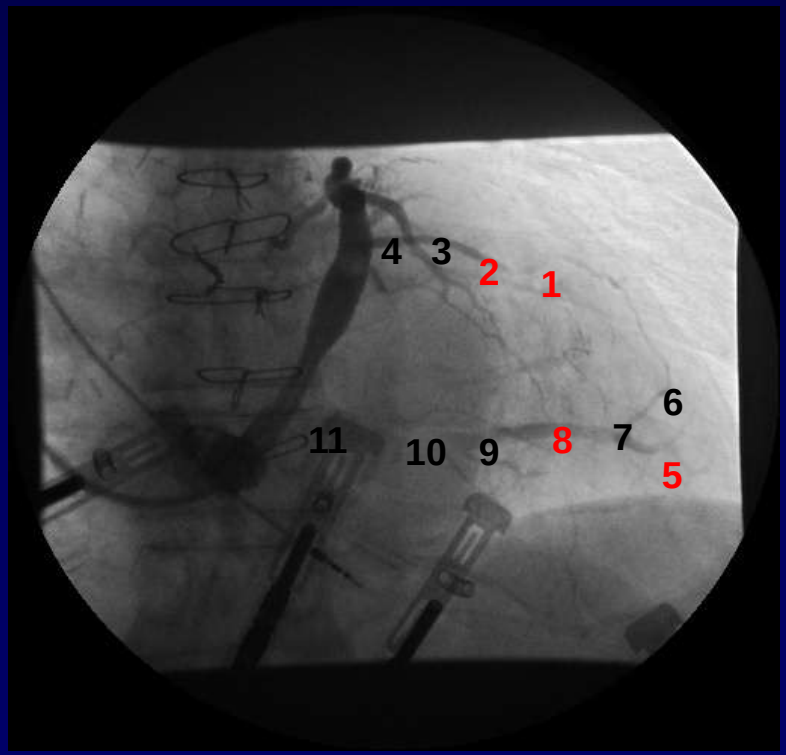




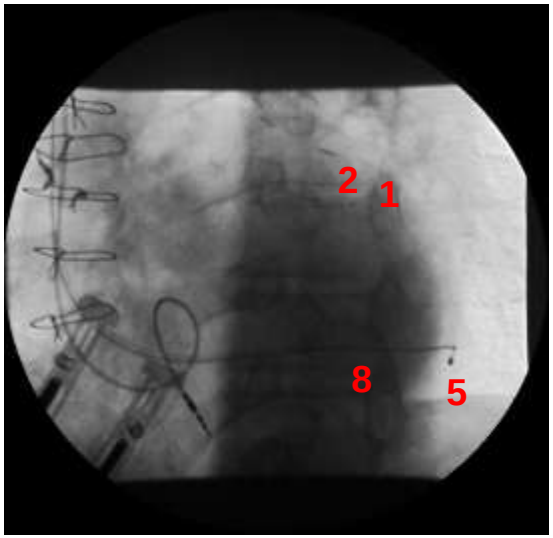
Foley PWX et al. Heart 2009

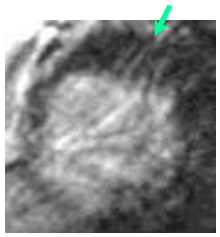
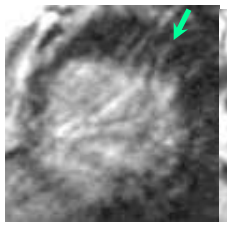
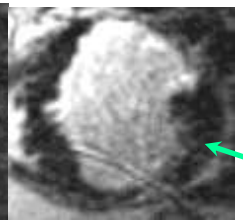
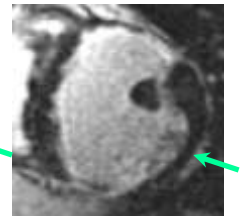
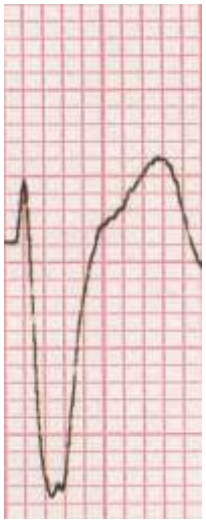
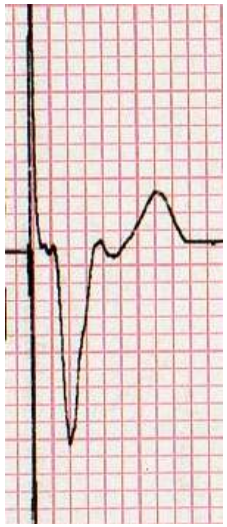
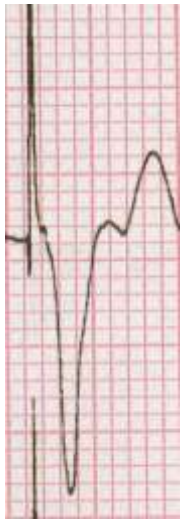
Issues in deploying an LV lead: scar mapping with CMR





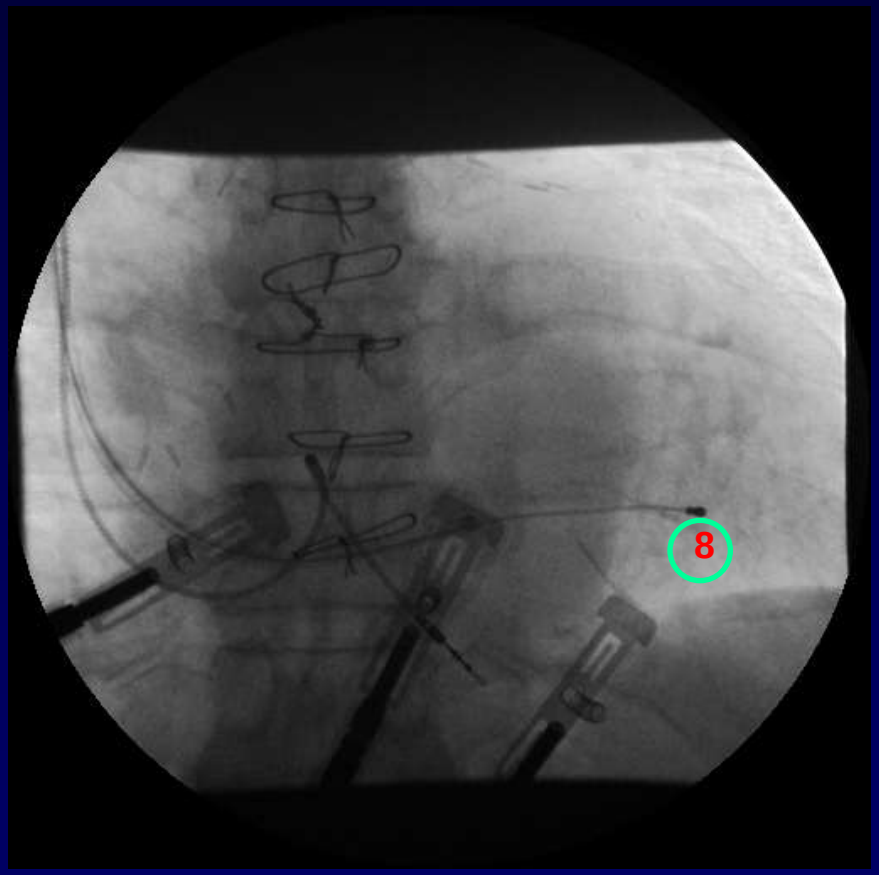
Leyva F. HRC 2010



	Intrinsic	2	1	8	5
					
					
QRS (ms)	169	91	85	118	198
Threshold (V)		0.6	1.0	0.3	9.0
R wave (mV)		3.9	13.1	12.0	8.7

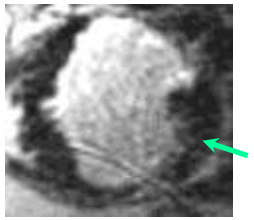
Leyva F. HRC 2010

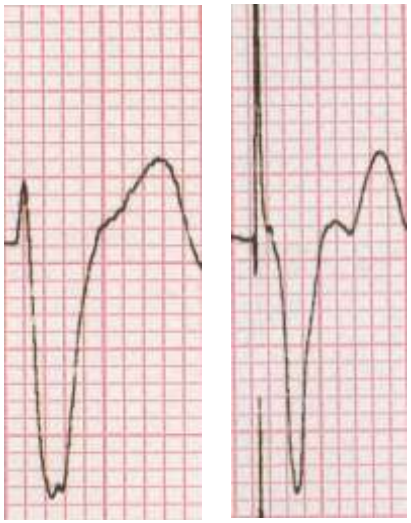
Position 8: accepted



8

Intrinsic





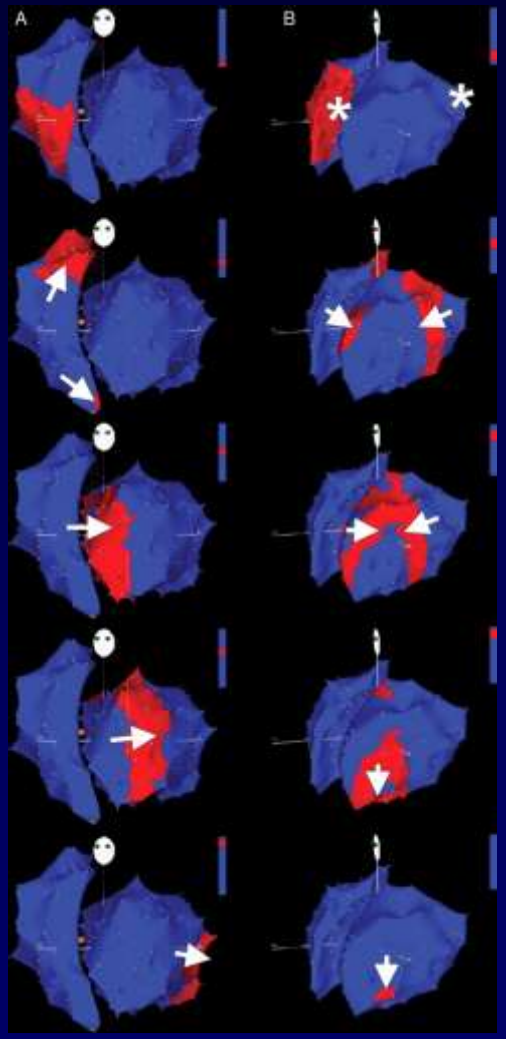
QRS (ms)	169	118
Threshold (V)		0.3
R wave (mV)		12.0

Leyva F. HRC 2010

Electroanatomical mapping in CRT

LBBB

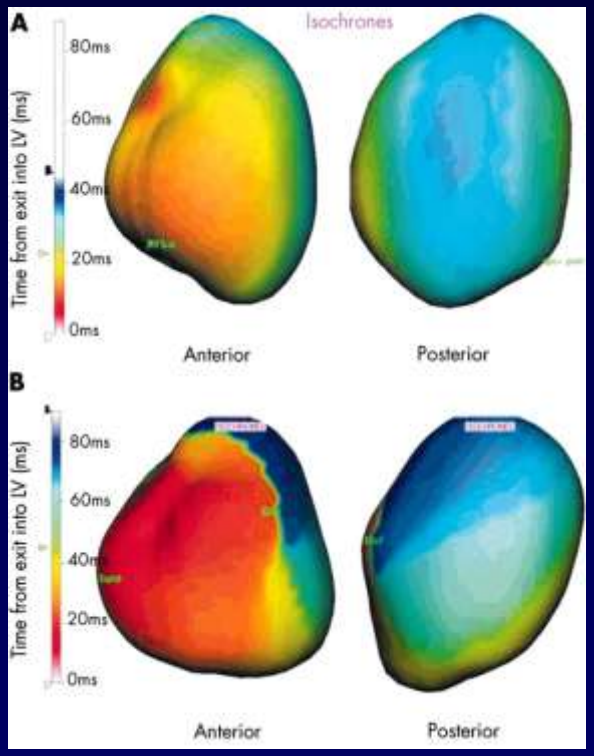
Intrinsic **CRT**

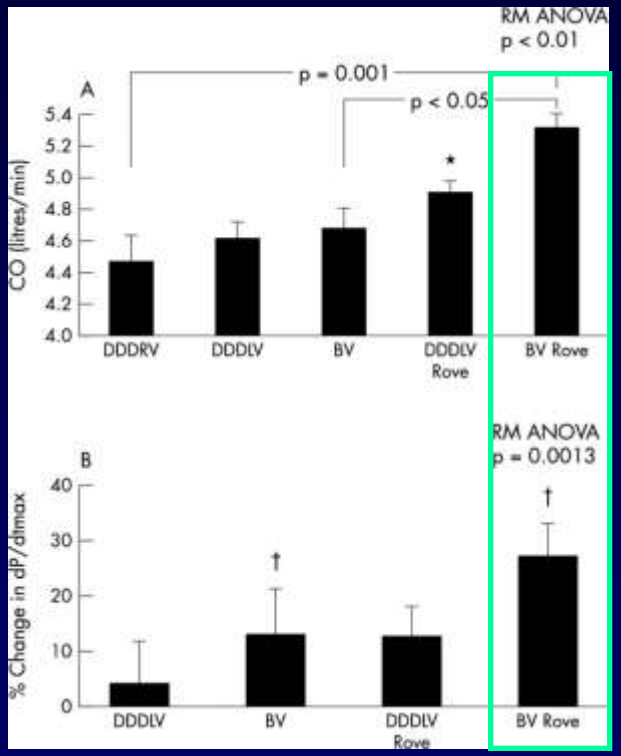


Kautzner J , Peichl P Europace 2008;10:iii106-iii109

Comparing sites: local conduction with non-contact mapping

N = 10 undergoing CRT
Non-contact mapping 5-14 days later
Ensite system; steerable ablation catheter used as a roving catheter to pace region of interest





Isochronal maps of LV activation in IDCM
without (A) and with (B) a region of slow conduction

Lambiase, P D et al. Heart 2004;90:44-51

Conclusions

Patient selection for CRT

Apart from quantification of LV function, no role of imaging in selecting patients for CRT

No role for dyssynchrony measures in patient selection

Guiding LV lead deployment:

Use CMR to guide LV pacing away from scarred myocardium

Targeting to area of electrical/mechanical activation not ready for clinical practice