……Should I Stay or Should I go ……..

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Imaging in CRT
Current vision

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HIT
EACVI's Heart Imagers of Tomorrow

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Mechanical dyssynchrony: what is it ?

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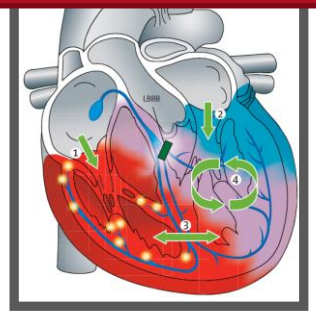
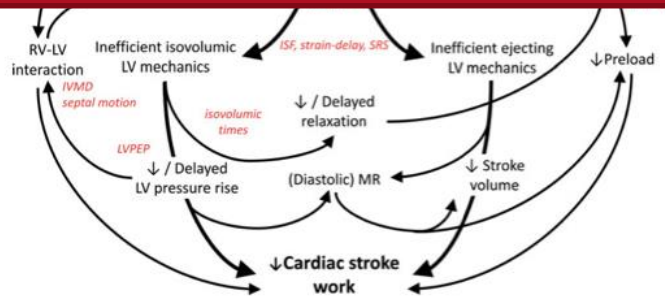
Electrical dyssynchrony:
wide QRS

Mechanical dyssynchrony:
difference of timing of LV segments

- **Should we revisite this complicated concept of mechanical Dyssynchrony,**
  Electro-mechanical coupling and impact of imaging in CRT?
- ***We have Prospect, RethinQ…and "strong" guidelines***





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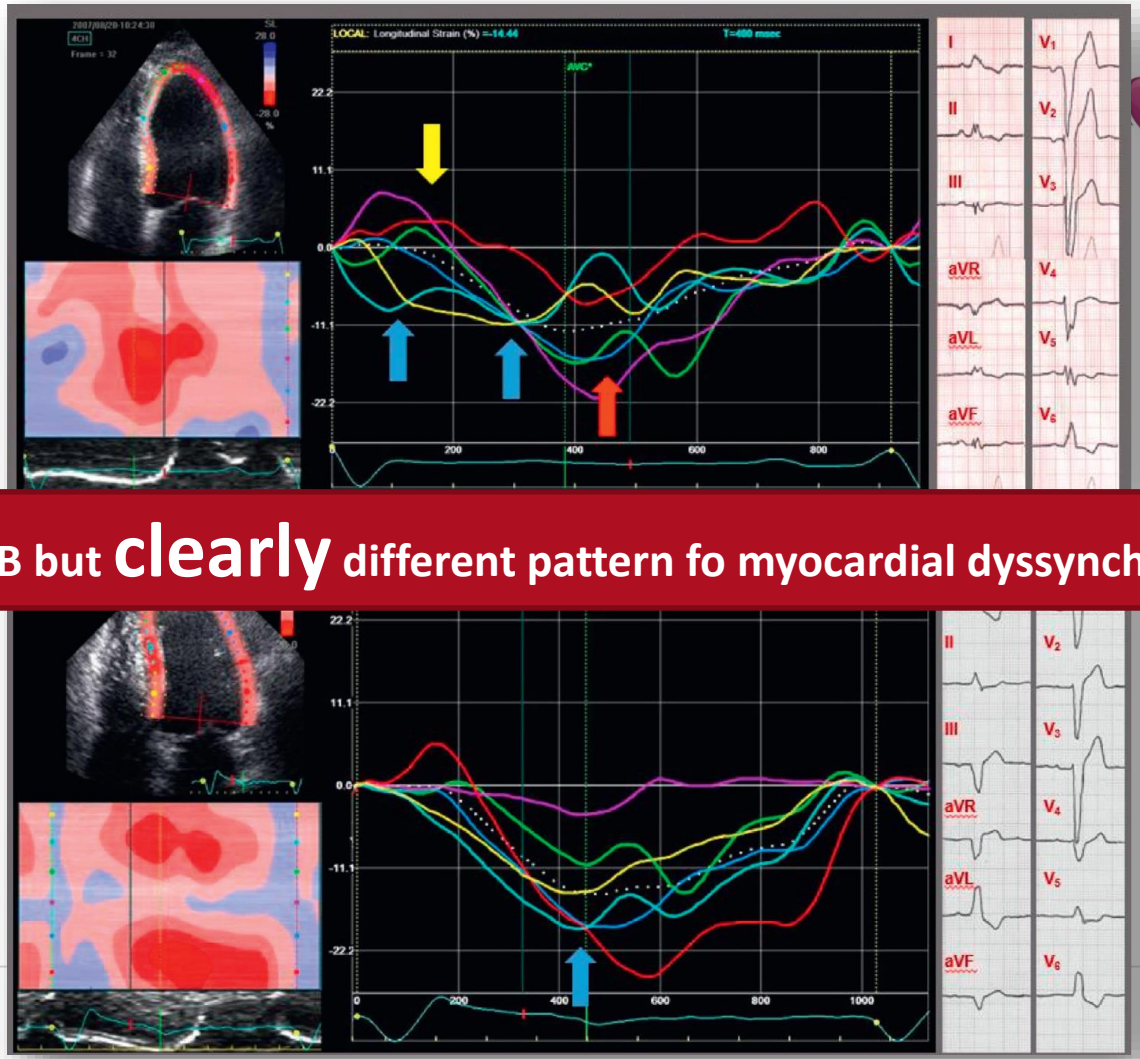
Leenders GE et al Heart Fail Rev 2011;16:235-50



Same LBBB but clearly different pattern fo myocardial dyssynchrony

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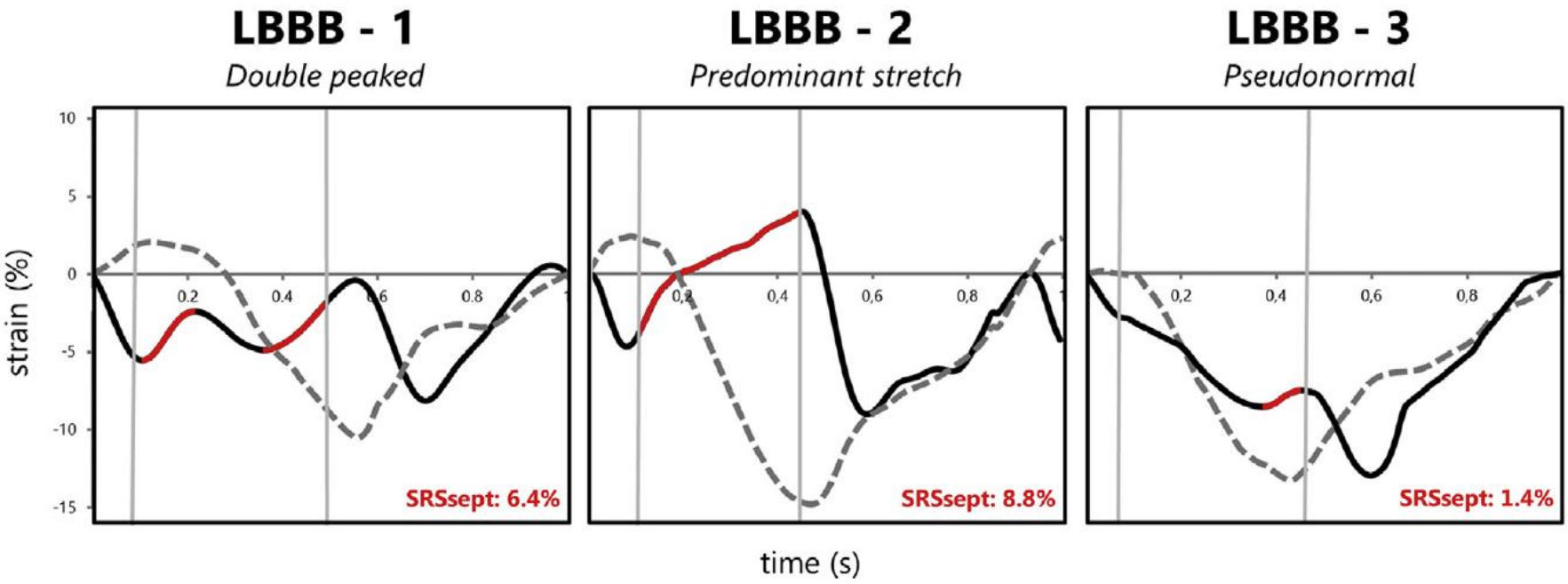


No direct and obvious relationship between **Electrical dyssynchrony** and **its mechanical consequences** …myocardial characteristics, load, geometry…might impact …

Circ Heart Fail. 2012; 5:87-96.

J Am Soc Echocardiogr 2017;30:1012-20

EHJim 2017

Bicentric study Lille – Rennes

284 CRT Candidates, QRS > 120 ms

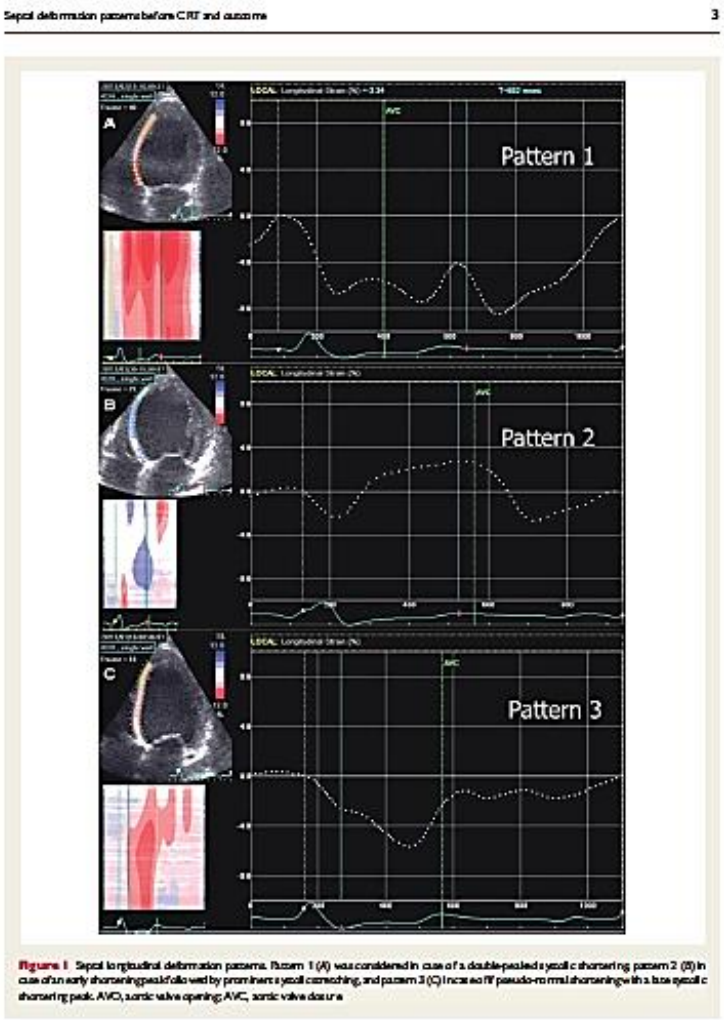
Mean QRS width 165 ms

LBBB 75%

3 patterns of septal deformation

Clinical outcomes

- ✓ death,
- ✓ cardiovascular death,
- ✓ HF hospitalization



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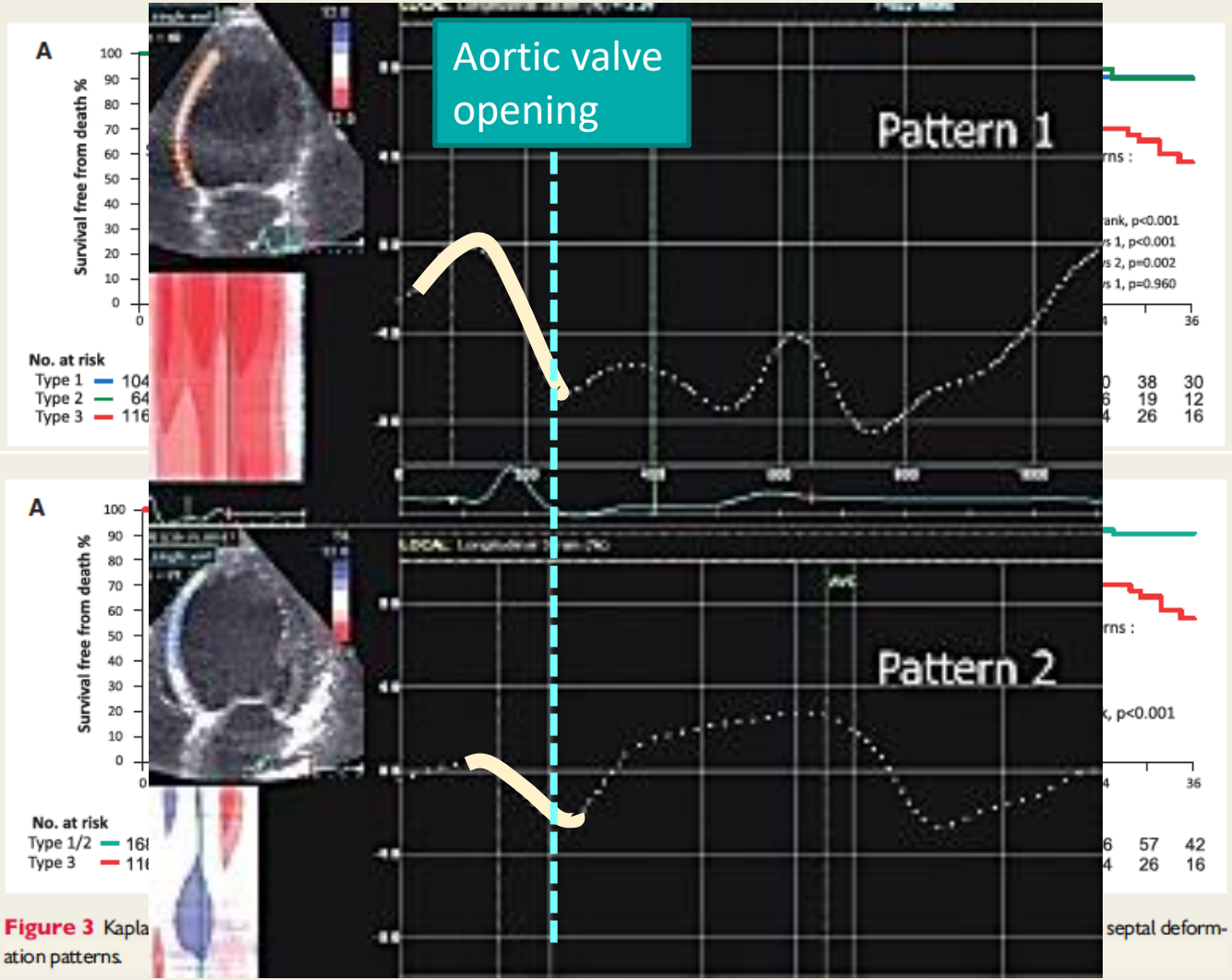

Figure 3 Kapla septal deform-ation patterns.

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Prognostic importance of septal deformation patterns in patients with intermediate QRS duration (QRS width 120 to 150 ms)

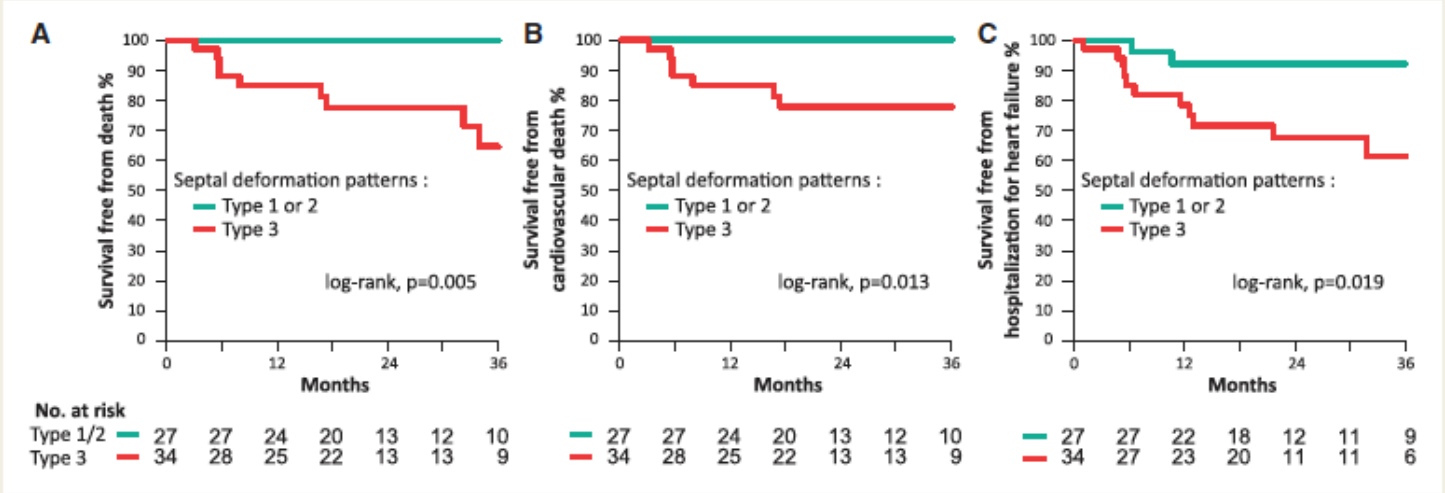

Figure 4 Kaplan–Meier event-free survival for mortality (*A*) cardiovascular mortality (*B*) and hospitalization for HF (*C*) according to septal deformation patterns in the patients with a QRS duration between 120 and 150 ms.

True LBBB if all 3 of the following echocardiographic characteristics were present:

1) "early" shortening of at least 1 basal or midventricular segment in the septal wall

2) Too early septal peak shortening (within the first 70% of ejection phase)

3) Lateral wall peak shortening after aortic valve closure.

Before CRT implantation in a symptomatic patient with a typical LBBB and QRS > 150ms

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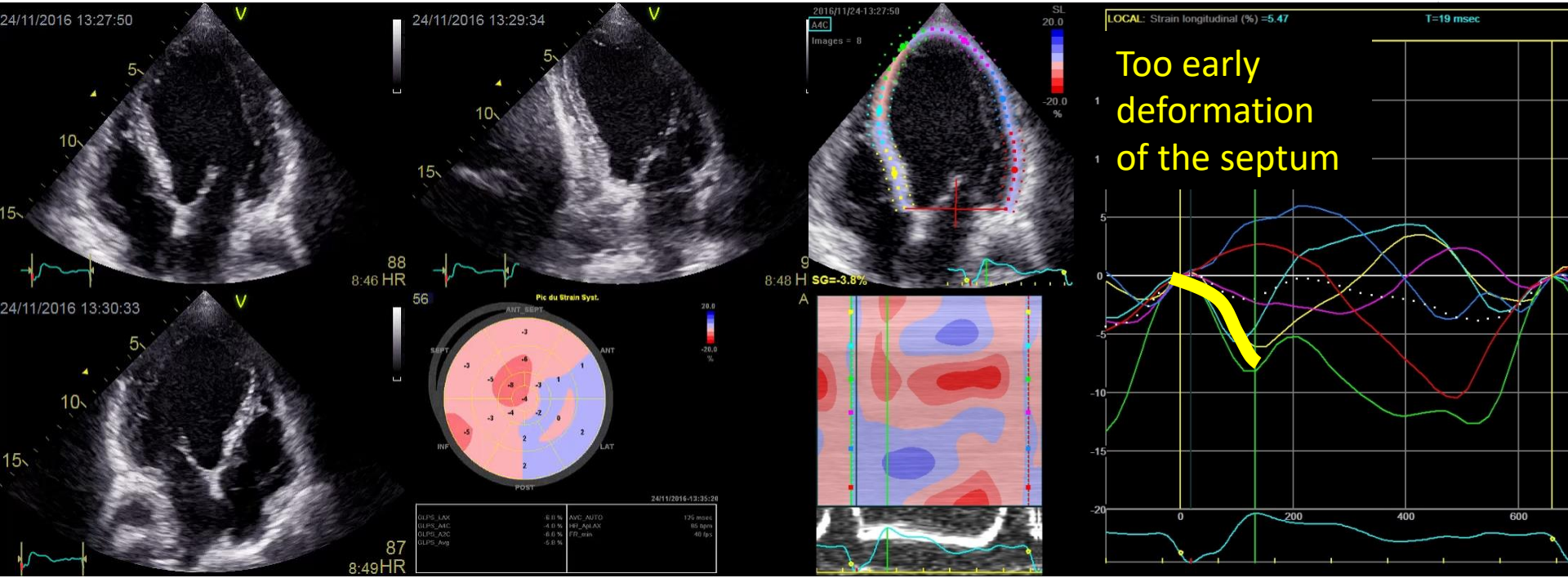

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12month later, CRT implantation & asymptomatic patient

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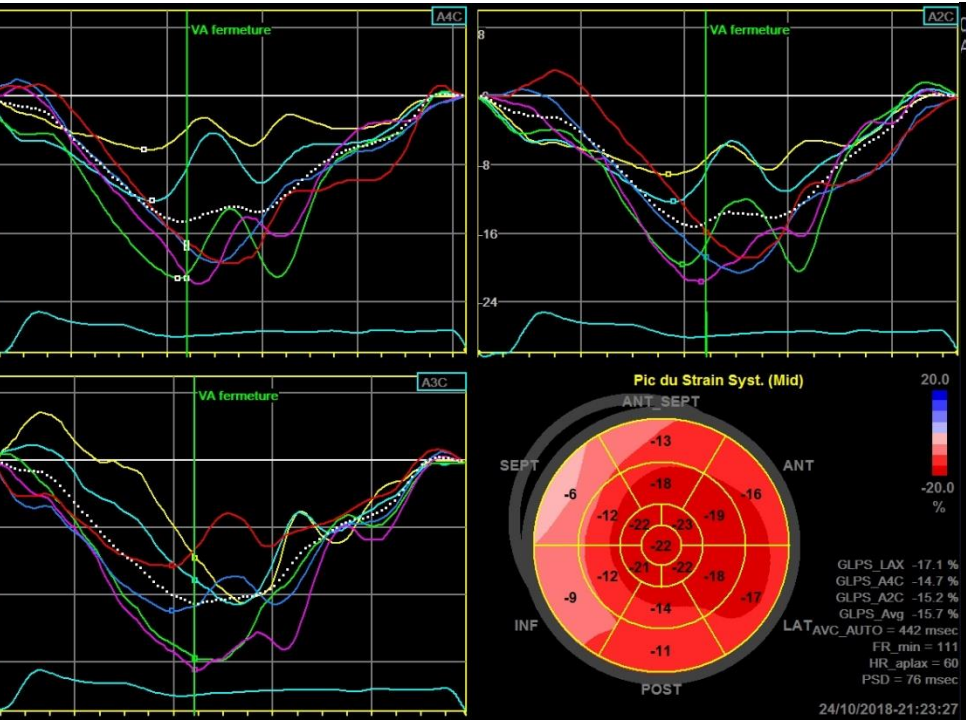

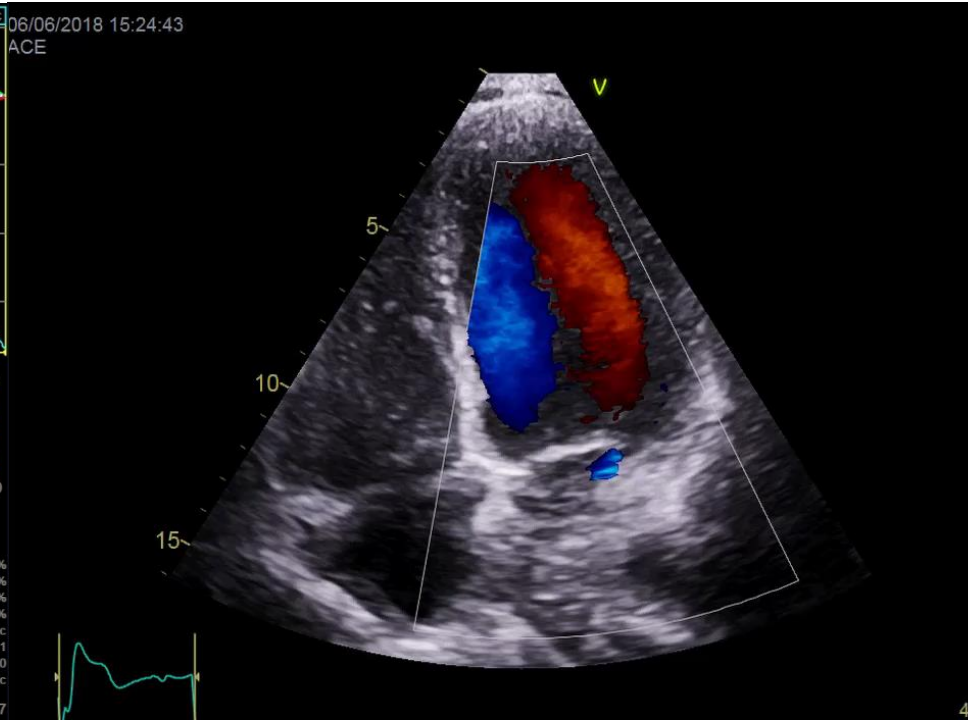

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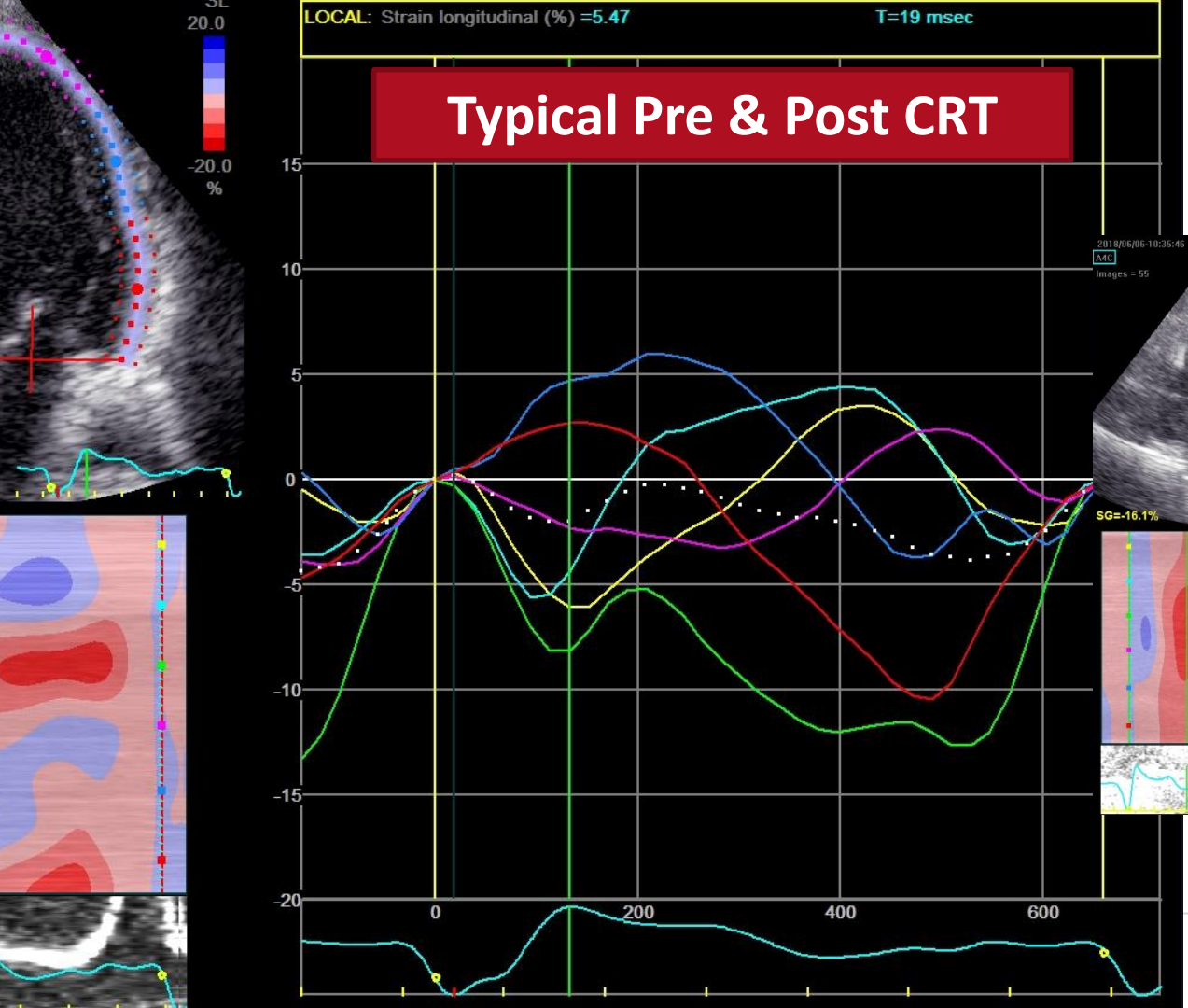
Typical Pre & Post CRT



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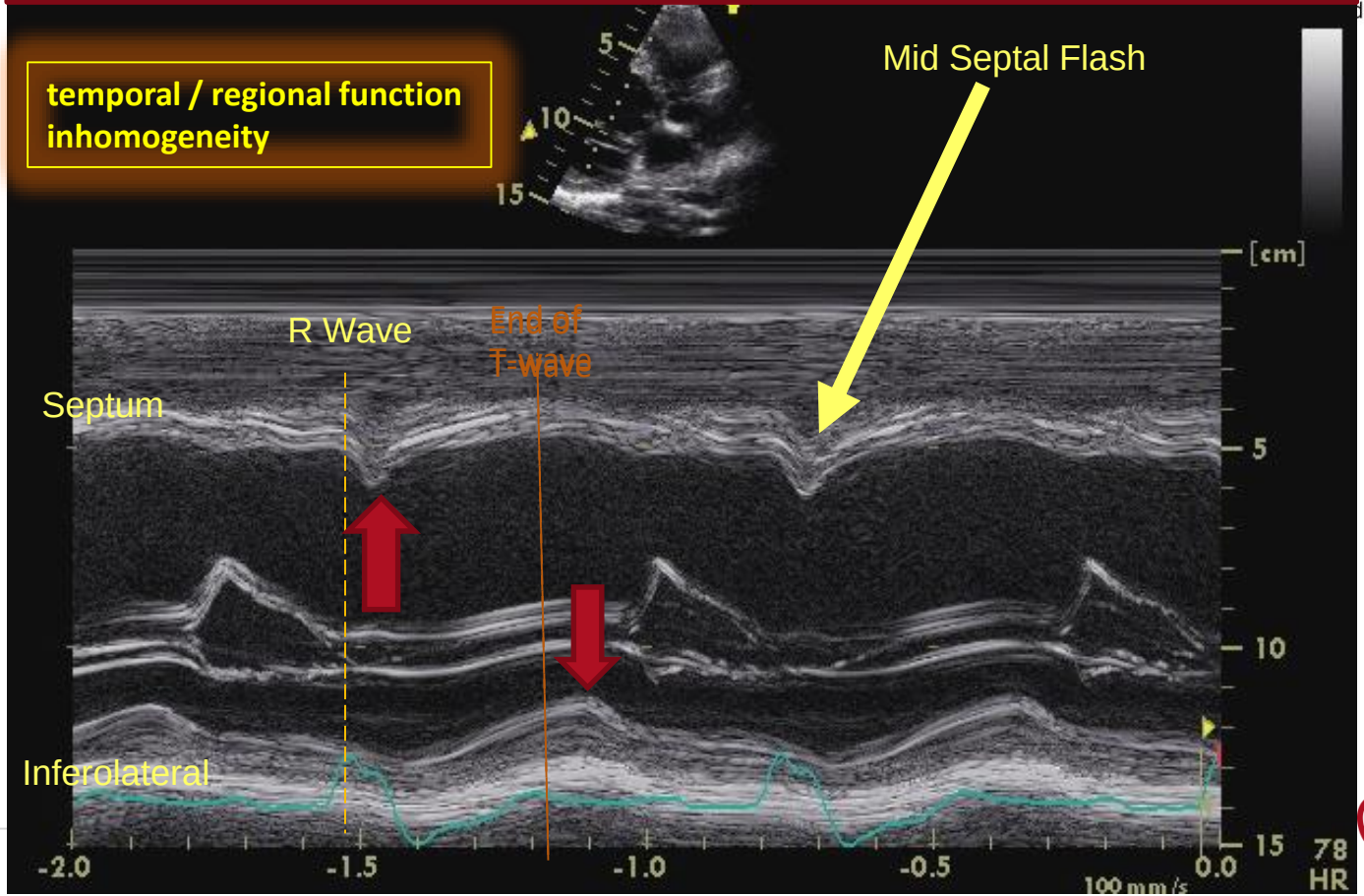
Intra LV dyssynchrony : Septal Flash



Apical Rocking

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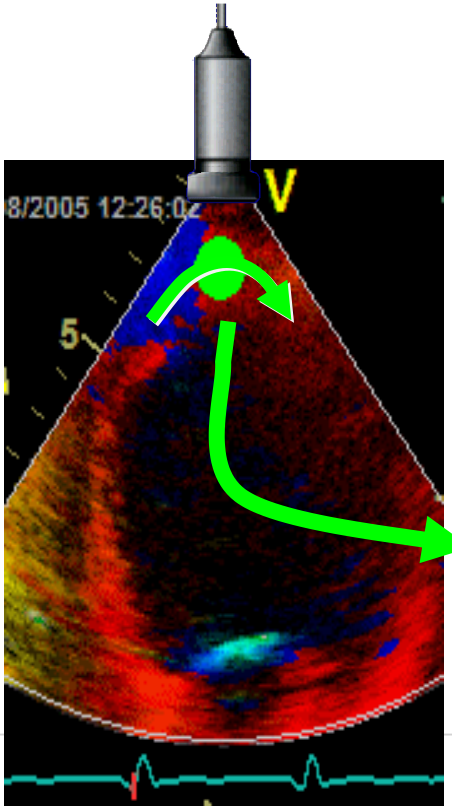
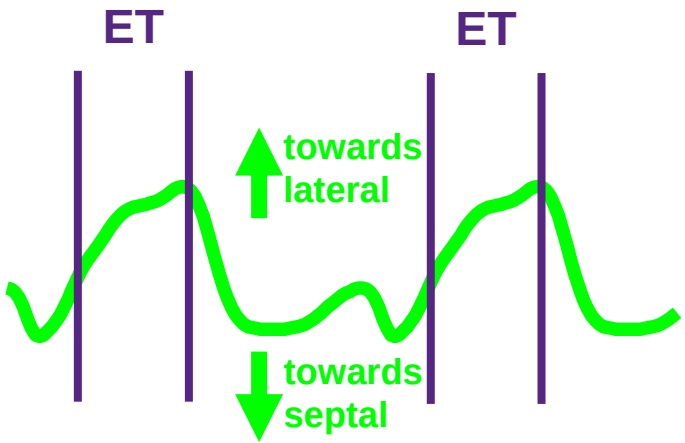


4 chamber view:
septal - lateral motion



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Stankovic et al. European Heart Journal – Cardiovascular Imaging (2016) 17, 262–269

New automatic tools to select candidates for Cardiac Resynchronization Therapy

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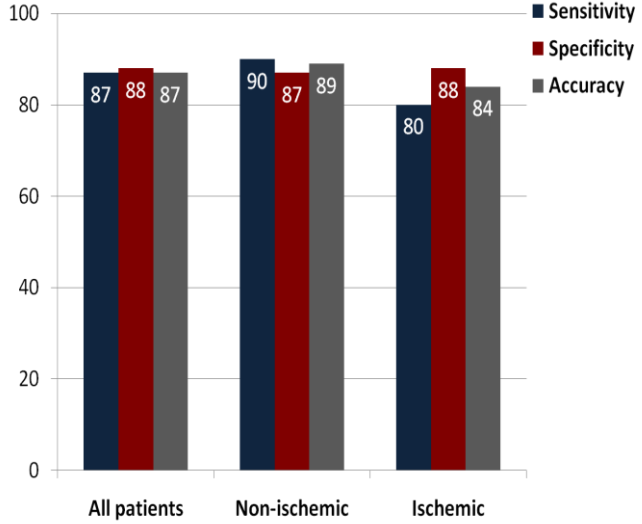
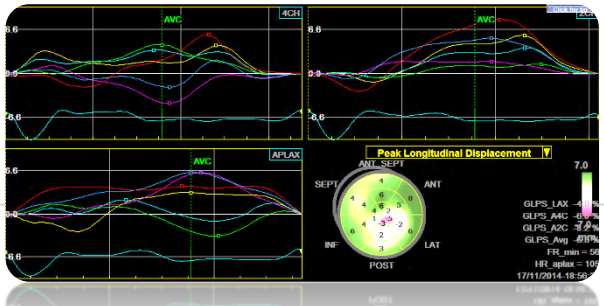
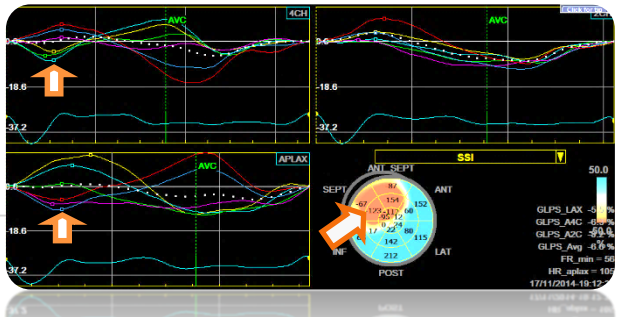
Apical Rocking

- **Simple qualitative tool analyzed in systole**
- **But Also measurable:**
- ***new speckle tracking based analysis tools to detect responders to CRT***







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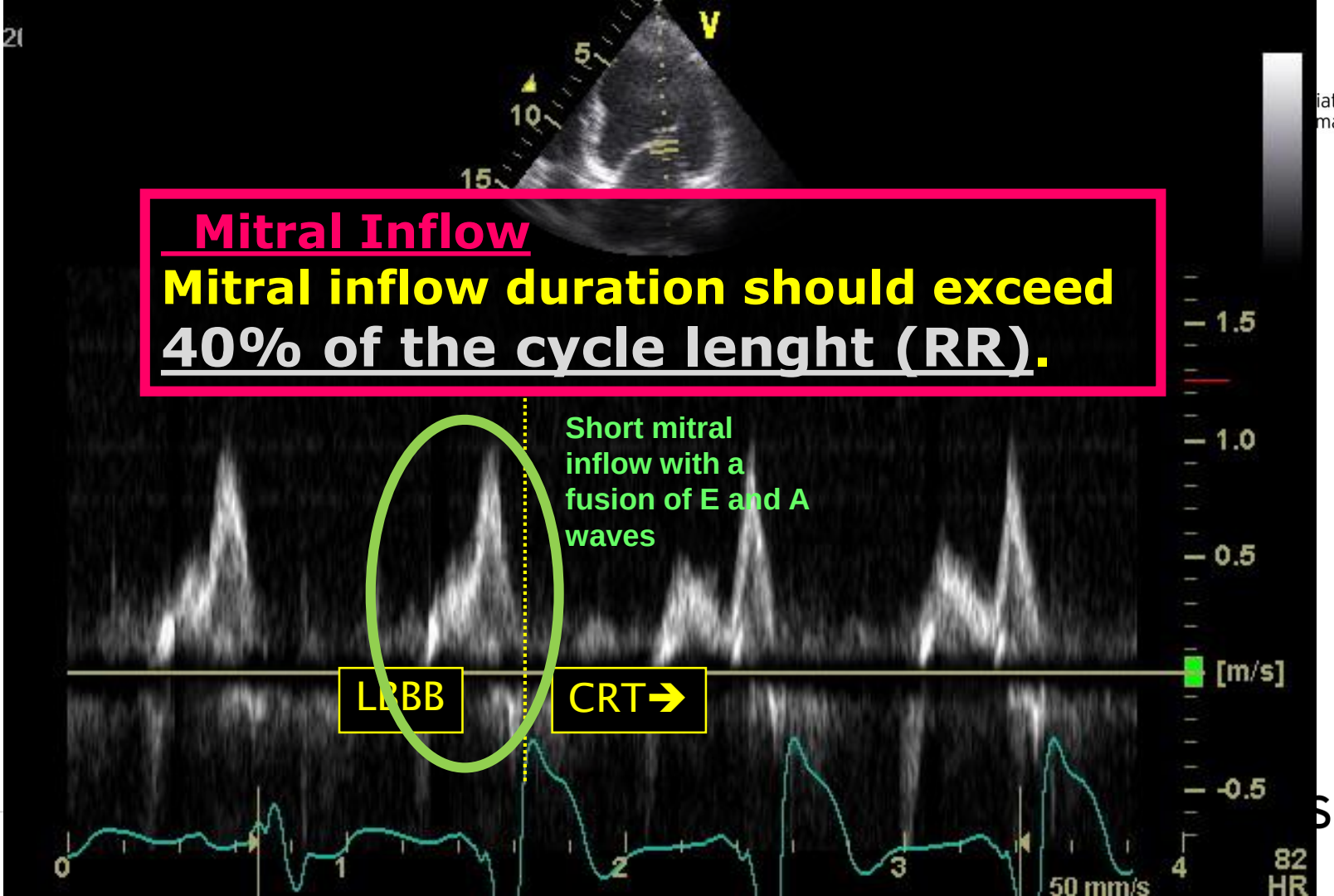
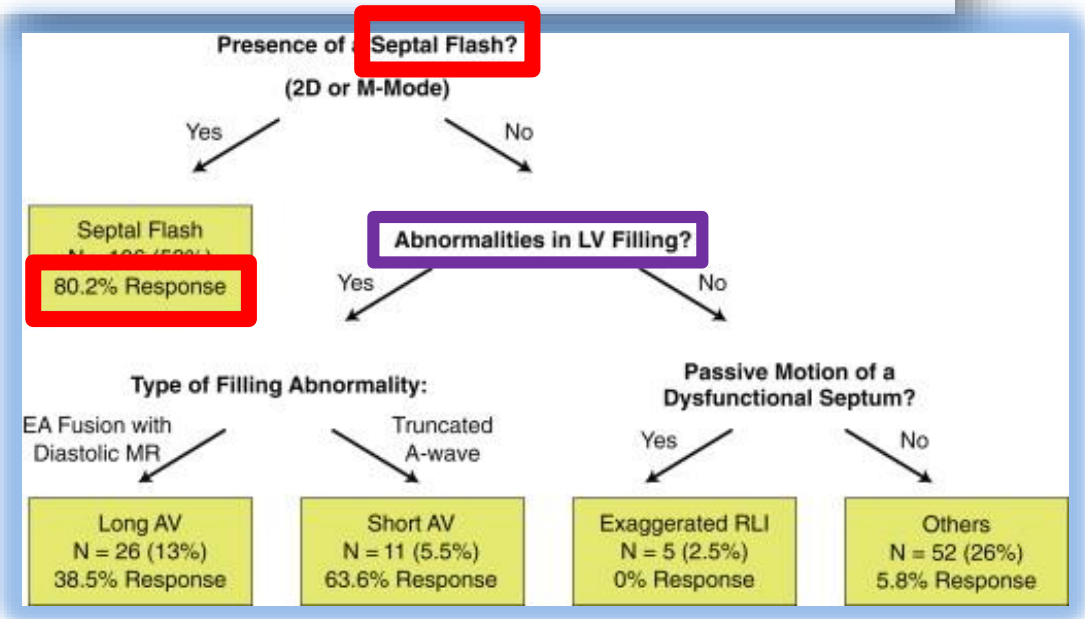

Mitral Inflow
Mitral inflow duration should exceed 40% of the cycle lenght (RR).
Short mitral inflow with a fusion of E and A waves
LBBB
CRT➔
1.5
1.0
0.5
[m/s]
-0.5
50 mm/s
82
HR

ORIGINAL RESEARCH

Mechanical Abnormalities Detected With Conventional Echocardiography Are Associated With Response and Midterm Survival in CRT



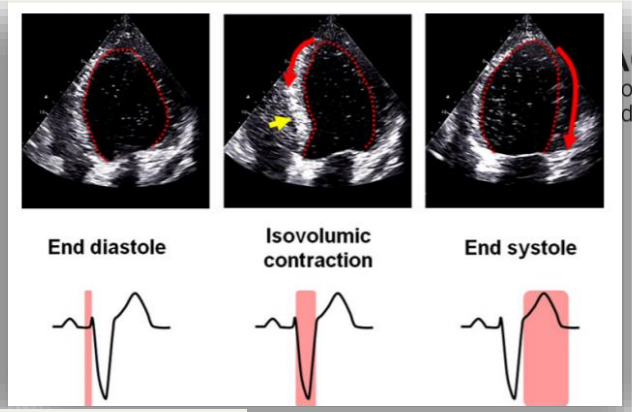
CONCLUSIONS The presence of a correctable abnormality evaluated by conventional echocardiography is associated with LV reverse remodeling and better survival at midterm follow-up. Clinical characteristics and myocardial viability also have an influence. (J Am Coll Cardiol Img 2014;7:969-79) © 2014 by the American College of Cardiology Foundation.

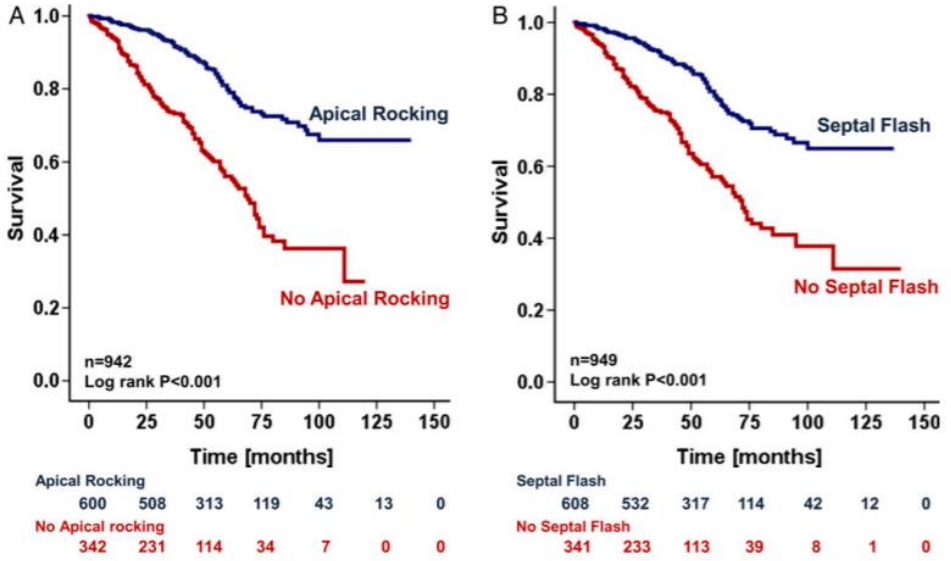
JACC: Cardiovascular Imaging, Volume 7, Issue 10, 2014, 969 - 979

European Heart Journal – Cardiovascular Imaging (2016) **17**, 262–269
doi:10.1093/ehjci/jev288

Relationship of visually assessed apical rocking and septal flash to response and long-term survival following cardiac resynchronization therapy (PREDICT-CRT)

Ivan Stankovic[1,2†], Christian Prinz[3†], Agnieszka Ciarka[1], Ana Maria Daraban[1,9], Martin Kotrc[4,10], Marit Aarones[5], Mariola Szulik[6], Stefan Winter[7], Ann Belmans[8], Aleksandar N. Neskovic[2], Tomasz Kukulski[6], Svend Aakhus[5], Rik Willems[1], Wolfgang Fehske[7], Martin Penicka[4], Lothar Faber[3], and Jens-Uwe Voigt[1*]



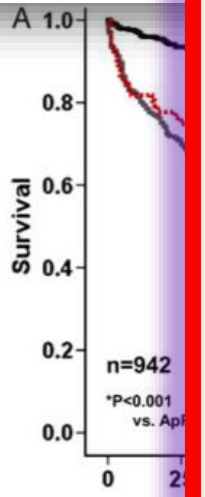


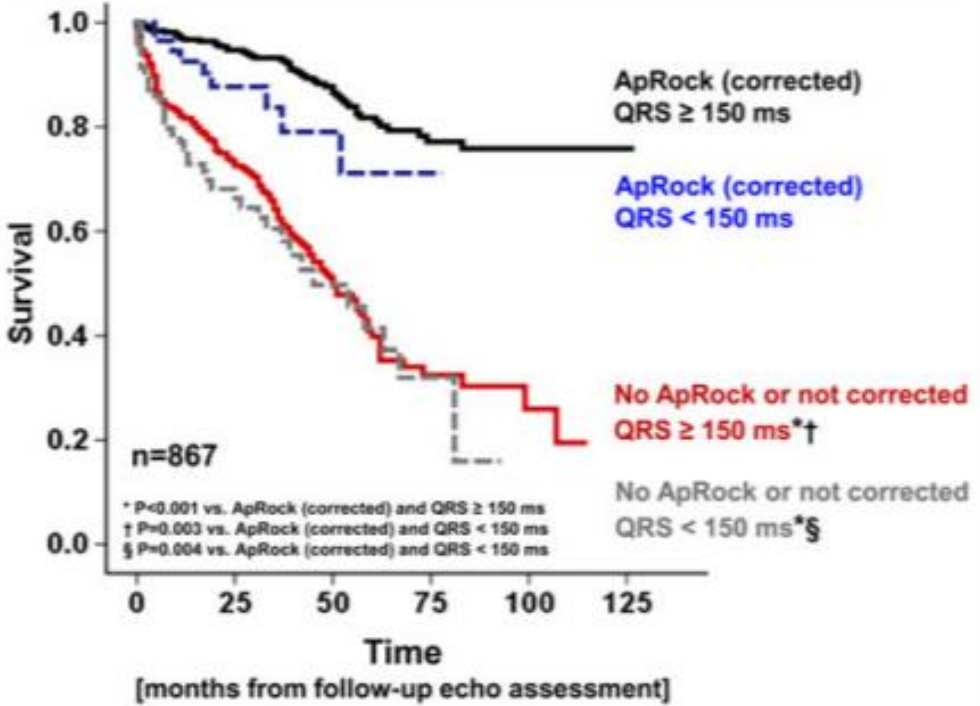
1060 patients eligible for CRT underwent echocardiographic examinations before and 12+6 months after device implantation

European Heart Journal – Cardiovascular Imaging (2016) 17, 262–269
doi:10.1093/ehjci/jev288

Relationship of visually assessed ap septal flash to response and long- following cardiac resynchronizati (PREDICT-CRT)

Ivan Stankovic[1,2†], Christian Prinz[2†], Agnieszka Ciarka[1], Martin Kotrc[4,10], Marit Aarones[5], Mariola Szulik[6], Stefan Aleksandar N. Neskovic[2], Tomasz Kukulski[4], Svend Aakh Wolfgang Fehske[7], Martin Penicka[4], Lothar Faber[3], and





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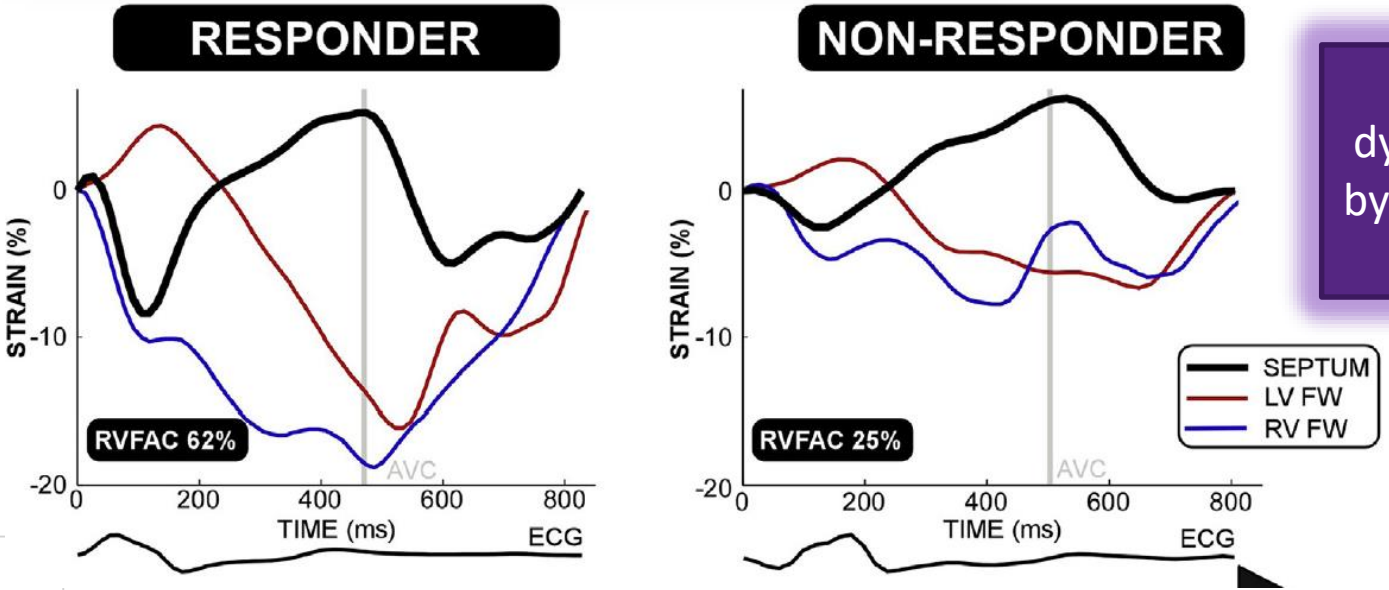
Echocardiographic Prediction of Cardiac Resynchronization Therapy Response Requires Analysis of Both Mechanical Dyssynchrony and Right Ventricular Function: A Combined Analysis of Patient Data and Computer Simulations

Wouter M. van Everdingen, MD, John Walmsley, PhD, Maarten J. Cramer, MD, PhD, Iris van Hagen, MD, Bart W. L. De Boeck, MD, PhD, Mathias Meine, MD, PhD, Tammo Delhaas, MD, PhD, Pieter A. Doevendans, MD, PhD, Frits W. Prinzen, PhD, Joost Lumens, PhD, and Geert E. Leenders, MD, PhD, *Utrecht and Maastricht, The Netherlands; Luzern, Switzerland; and Pessac, France*

Mechanical dyssynchrony parameters do not reflect the negative impact of reduced RV contractility on CRT-response.
Echo prediction of CRT-response should include parameters of mechanical dyssynchrony & RV function

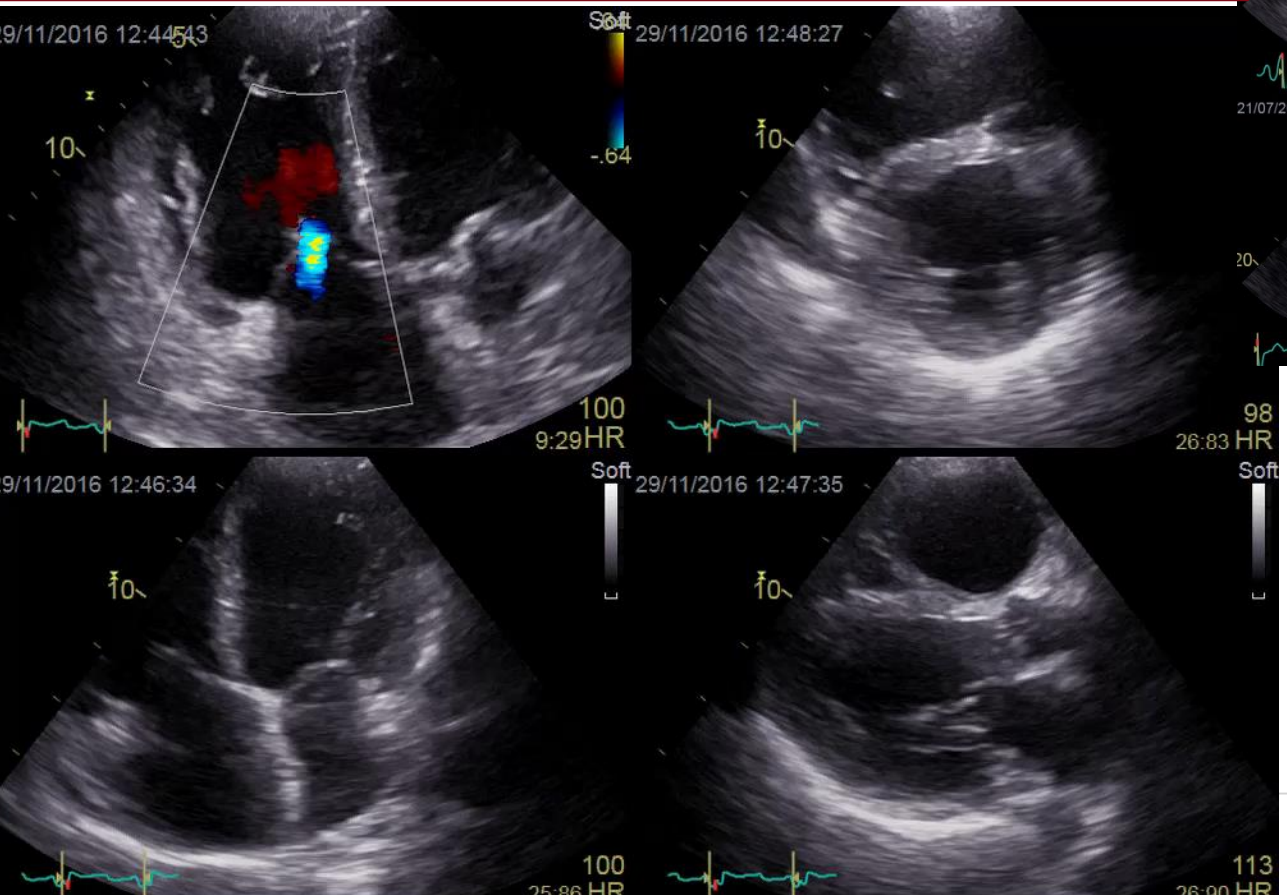


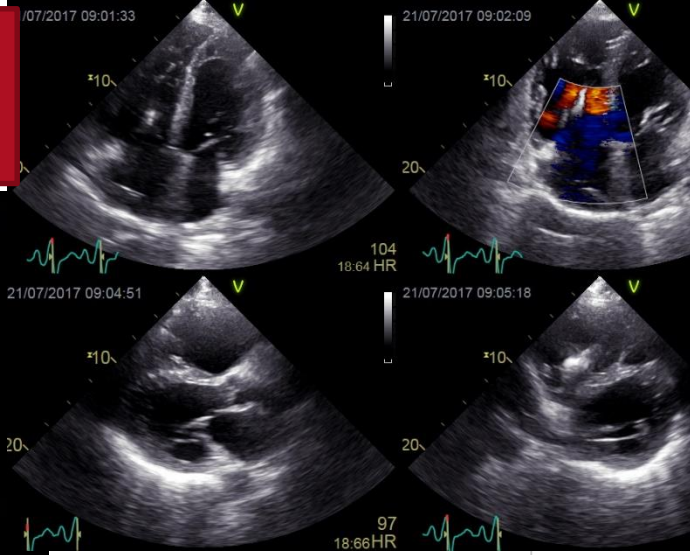
LV mechanical dyssynchro assessed by Longitudinal strain + RV function

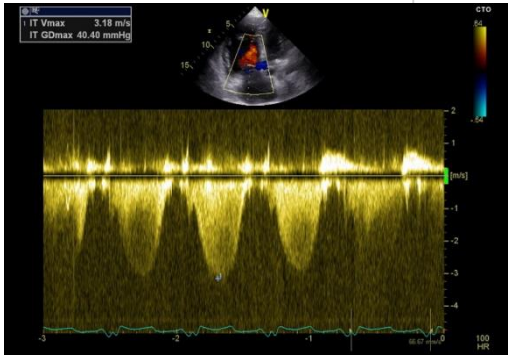
Circ Heart Fail. 2012; 5:87-96.

J Am Soc Echocardiogr 2017;30:1012-20

Before CRT implantation in a symptomatic patient with a typical LBBB and QRS > 150ms







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LBBB : mechanical dyssynchrony according to conduction & function….don't forget

No myocyte = no dyssynchrony

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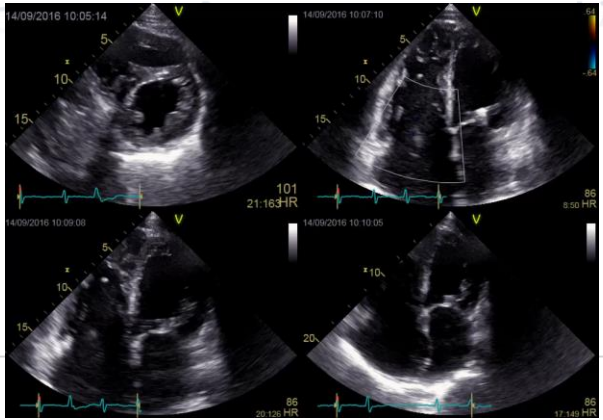
In addition to the LV markers used in this study, a neglected association of reverse remodeling is the status of the right ventricle (12). Both RV size (end-diastolic area index >10.0 cm^2/m^2) and RV dysfunction (fractional area change ≥35%) are important independent predictors of failure of reverse remodeling. Additionally, LV function (measured as global longitudinal strain, cutoff <−7%), and left atrial size area <26 cm^2 are important determinants of response. The site of the implanted pacemaker lead is an important determinant of response (13)—mal-located leads have been documented as a source, not of only nonresponse, but also of deterioration. Targeting the lead to the site of maximum dyssynchrony has been known for several years to maximize the chances of success (14). All of these considerations reinforce the need to consider, not only dyssynchrony, but also a variety of other imaging parameters.

EDITORIAL COMMENT

Selection for Cardiac Resynchronization Therapy

All in a Flash?*

Thomas H. Marwick, MBBS, PhD, MPH



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JACC: CARDIOVASCULAR IMAGING
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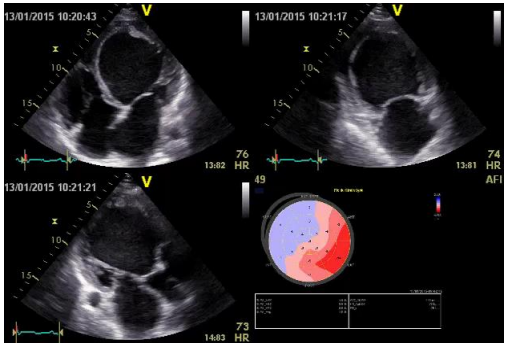
VO
ISSN
DOI:10.1016/

Presence of Extensive LV Remodeling Limits the Benefits of CRT in Patients With Intraventricular Dyssynchrony

Erberto Carluccio, MD, Paolo Biagioli, MD, Gianfranco Alunni, MD, Adriano Murrone, MD, Paola Pantano, MD, Emilia Biscottini, MD, Cinzia Zuchi, MD, Gianluca Zingarini, MD, Claudio Cavallini, MD, Giuseppe Ambrosio, MD, PHD



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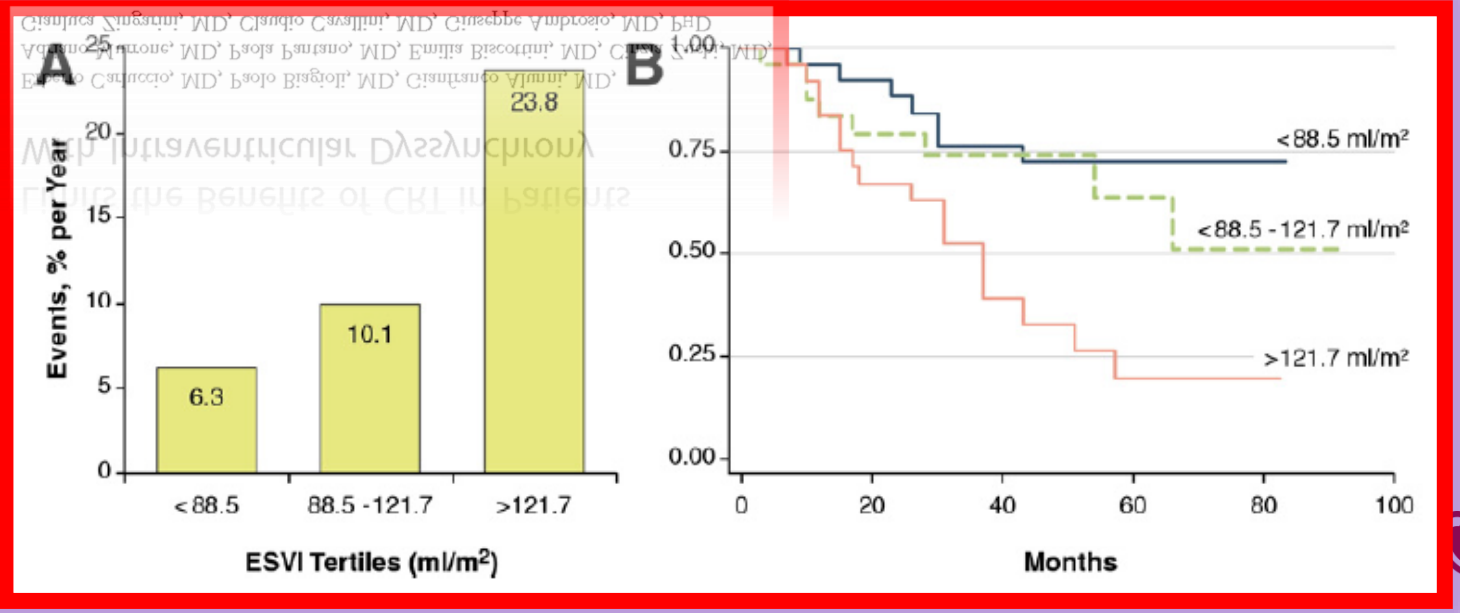

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Two questions have to be answered during a dyssynchrony assessment:

(1)- 'Is there a temporal inhomogeneity in regional myocardial contraction?'

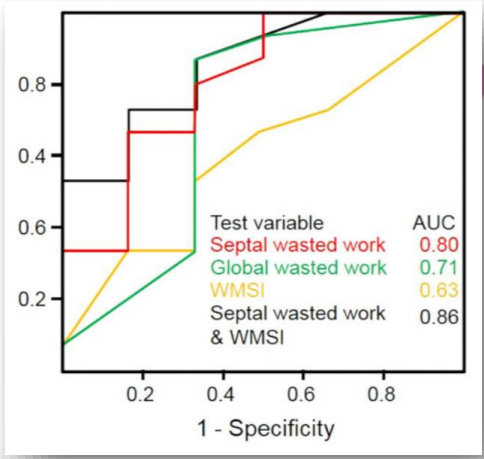
(2)- 'Is there a regional inhomogeneity in the residual myocardial function?'

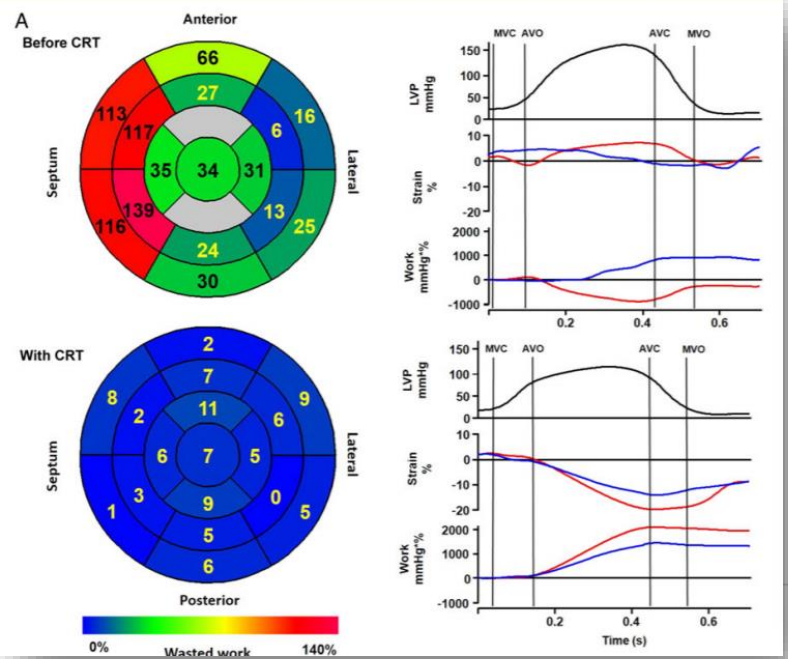
Szulik et al. European Journal of Echocardiography (2010) 11, 863–869

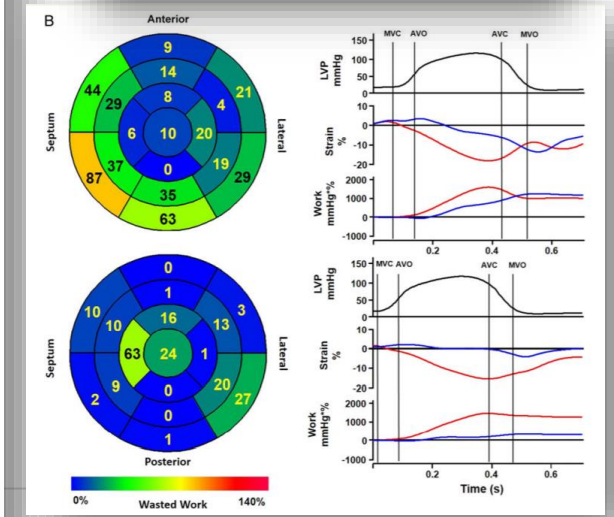
European Heart Journal – Cardiovascular Imaging (2016) **17**, 624–632
doi:10.1093/ehjci/jew019

Wasted septal work in left ventricular dyssynchrony: a novel principle to predict response to cardiac resynchronization therapy

J. Vecera[1,2], M. Penicka[2], M. Eriksen[1], K. Russell[1], J. Bartunek[2], M. Vanderheyden[2], and O.A. Smiseth[1]*







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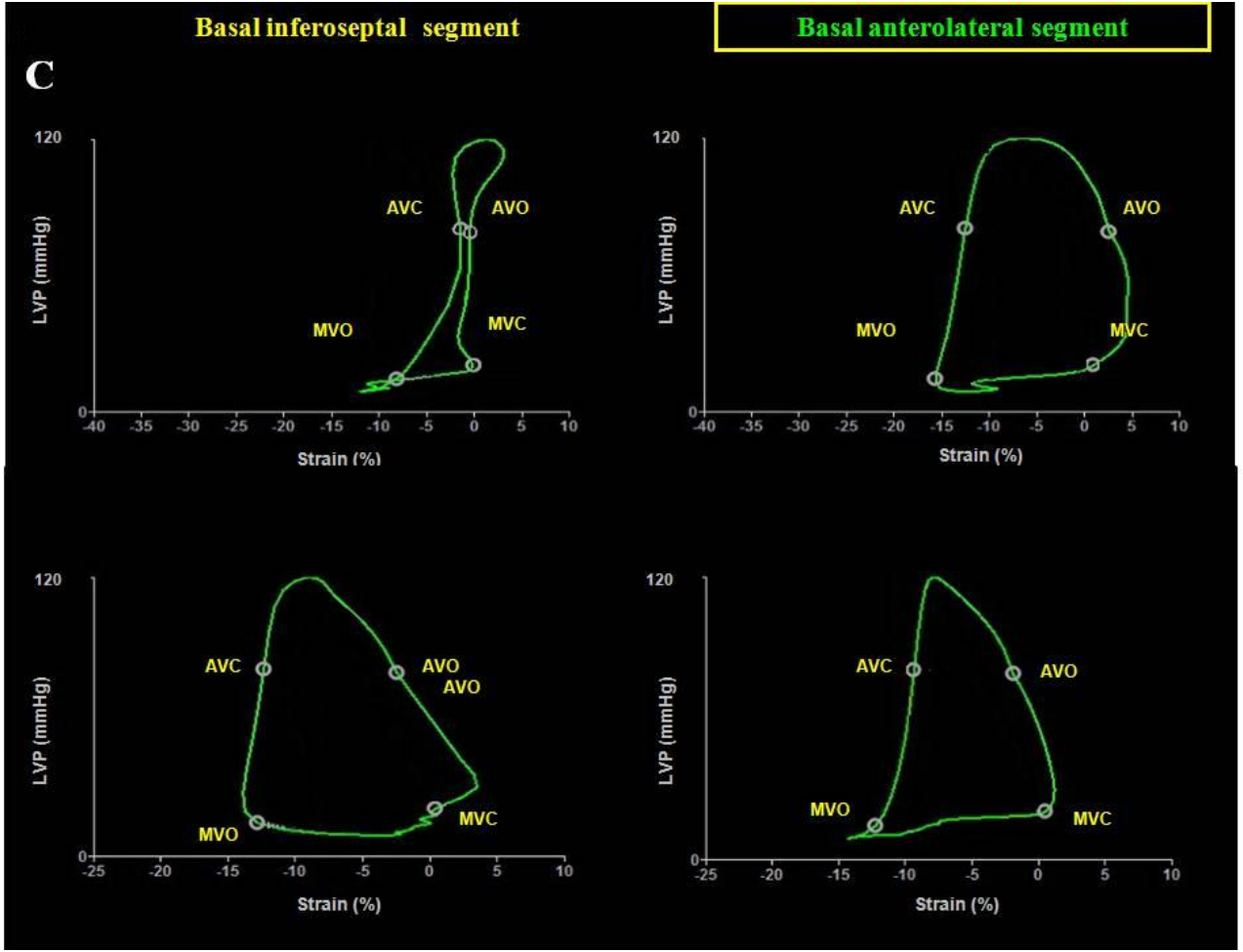

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Prediction of Response to Cardiac Resynchronization Therapy: value of cardiac work when compared to other dyssynchrony parameters.

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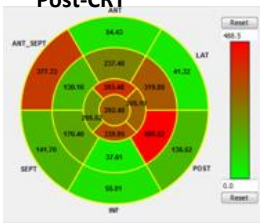
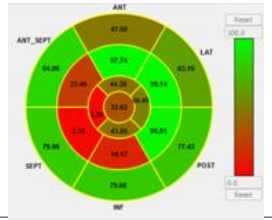
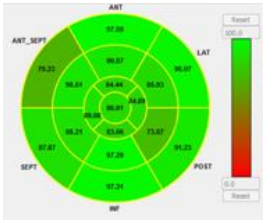
Pre-CRT

Post-CRT







Negative Work

Work Efficiency

	AUC	Sensibility	Specificity	PPV	NPV	Accuracy
AV	0.56	0.32	0.79	0.37	0.75	0.66
IV	0.65	0.68	0.62	0.71	0.59	0.66
SF	0.72	0.81	0.35	0.69	0.51	0.64
PosW>1057	0.70	0.55	0.85	0.72	0.73	0.73
NegW> | -338 |	0.70	0.40	0.94	0.72	0.80	0.79
SF+ PosW>1057+ NegW> | -384 |	0.75	0.98	0.52	0.87	0.89	0.89

AV, atrio-ventricular dyssynchrony; IV, interventricular dyssynchrony; NPV, negative predictive value; PosW, Positive Work; PPV, positive predictive value; SF, septal flash.

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Galli…Donal. EHJim 2017

Value of Myocardial Work Estimation in the Prediction of Response to Cardiac Resynchronization Therapy

Elena Galli, MD, PhD, Christophe Leclercq, MD, PhD, Maxime Fournet, MD, Arnaud Hubert, MD, Anne Bernard, MD, PhD, Otto A. Smiseth, MD, PhD, Philippe Mabo, MD, Eigil Samset, PhD, Alfredo Hernandez, PhD, and Erwan Donal, MD, PhD, *Rennes and Tours, France; and Oslo, Norway*

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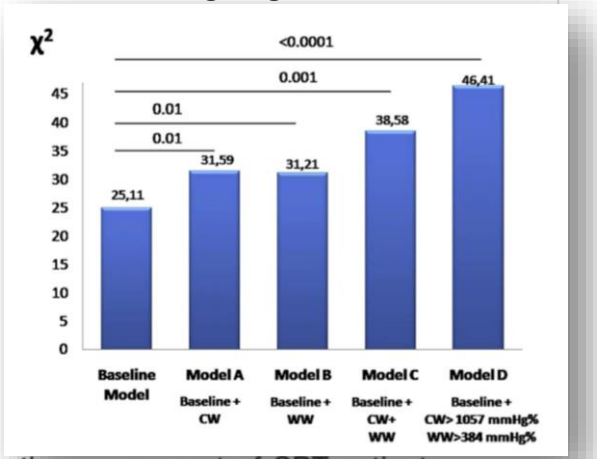
Table 4 Se, Sp, PPV, and NPV, in monoparametric and multiparametric approach to predict CRT positive response

	Se	Sp	PPV	NPV	Accuracy
AVD	32	79	74	39	48
IVD	68	62	77	51	66
SF	81	62	81	63	75
CW > 1,057 mm Hg%	56	85	88	51	66
WW > 338 mm Hg%	40	94	93	46	59
AVD + IVD + SF + CW > 1,057 mm Hg% + WW > 384 mm Hg%	6	100	100	37	39
CW > 1,057 mm Hg% + WW > 384 mm Hg%	22	100	100	41	49

AVD, Atrioventricular dyssynchrony; *IVD*, interventricular-dyssynchrony. Data are percentages.

Ninety-seven patients undergoing CRT



Conclusions: The estimation of CW and WW by PSLs is a novel tool for the assessment of CRT patients. Although these parameters cannot be used by their own to select CRT candidates, they can provide further insights into the comprehension of dyssynchrony mechanisms and contribute to improving the identification of CRT responders. (J Am Soc Echocardiogr 2018;31:220-30.)

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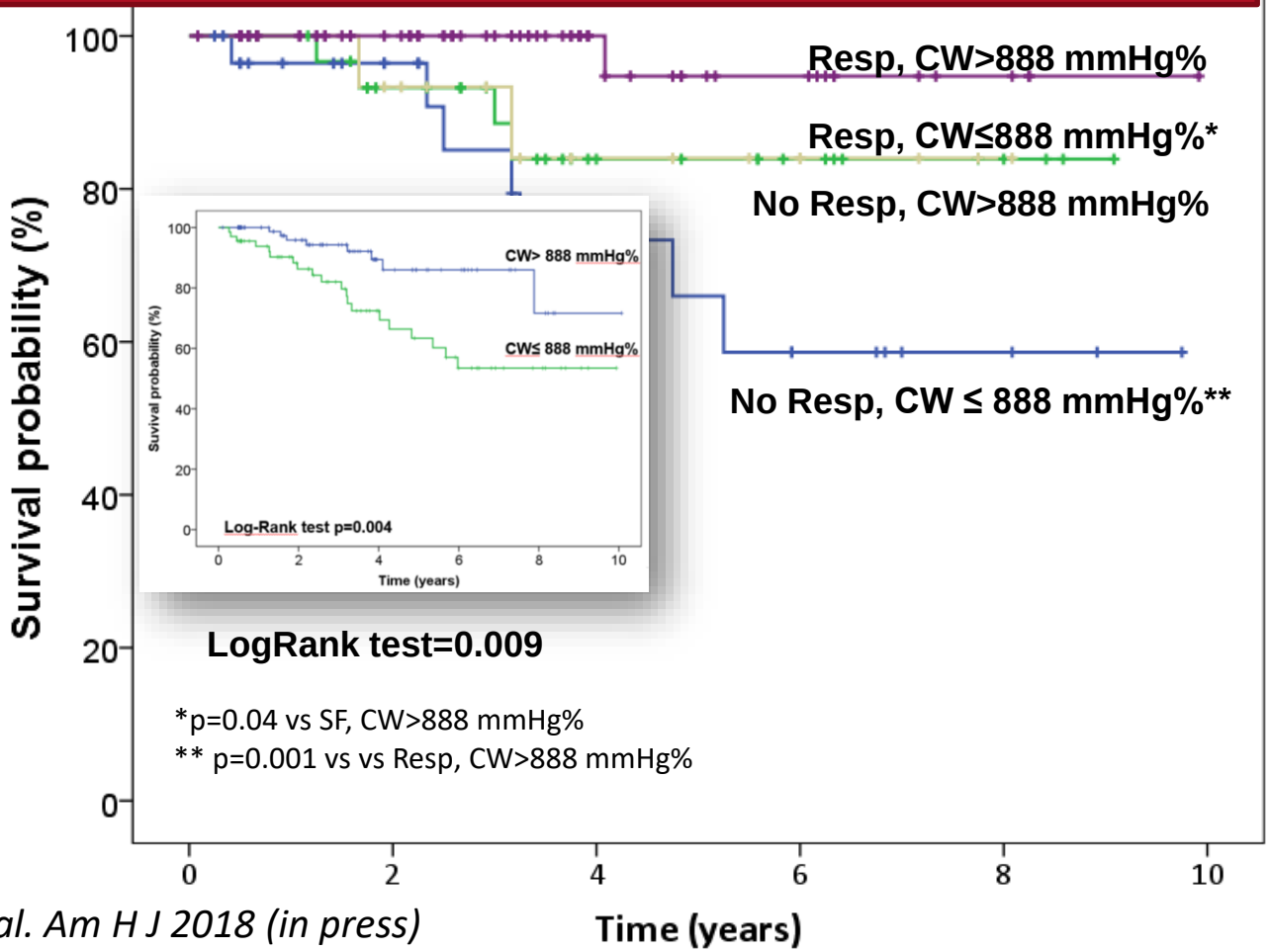
Freedom from cardiac death according to CW and CRT response



*p=0.04 vs SF, CW>888 mmHg%

** p=0.001 vs vs Resp, CW>888 mmHg%

Galli/Donal. Am H J 2018 (in press)

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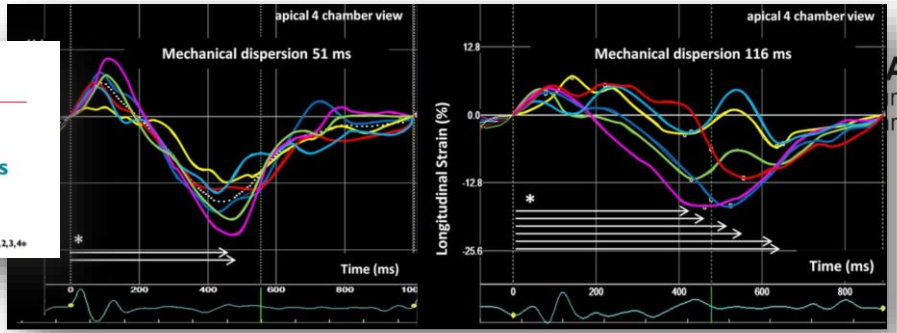
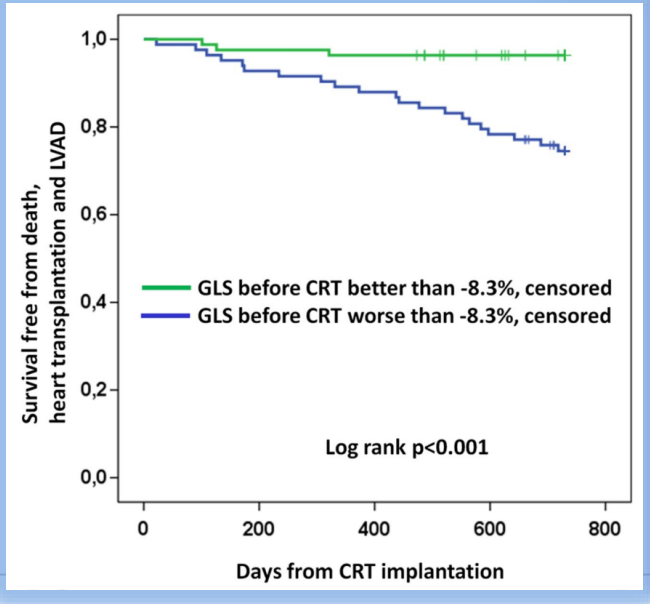
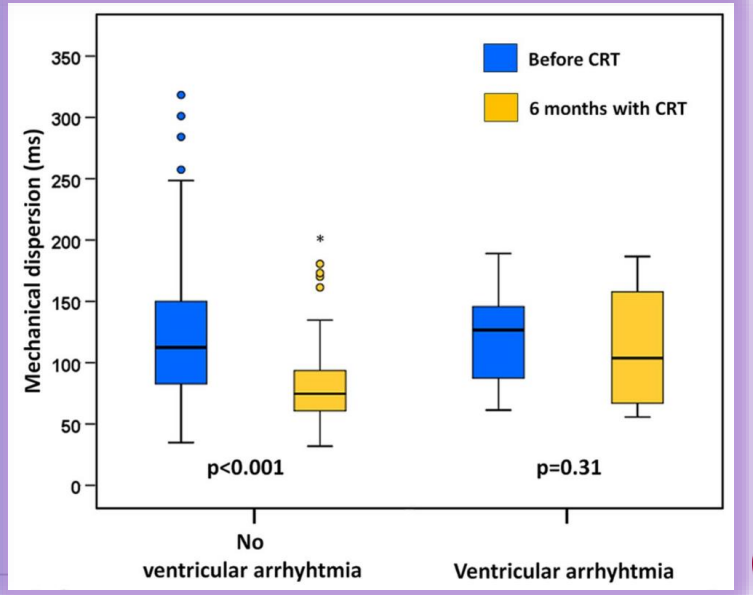
European Heart Journal – Cardiovascular Imaging (2016) 17, 343–350
doi:10.1093/ehjci/jev173

Left ventricular markers of mortality and ventricular arrhythmias in heart failure patients with cardiac resynchronization therapy

Nina E. Hasselberg[1,2,3,4], Kristina H. Haugaa[1,2,3,4], Anne Bernard[5], Margareth P. Ribe[1,2,4], Erik Kongsgaard[1,2,3,4], Erwan Donal[5], and Thor Edvardsen[1,2,3,4]*







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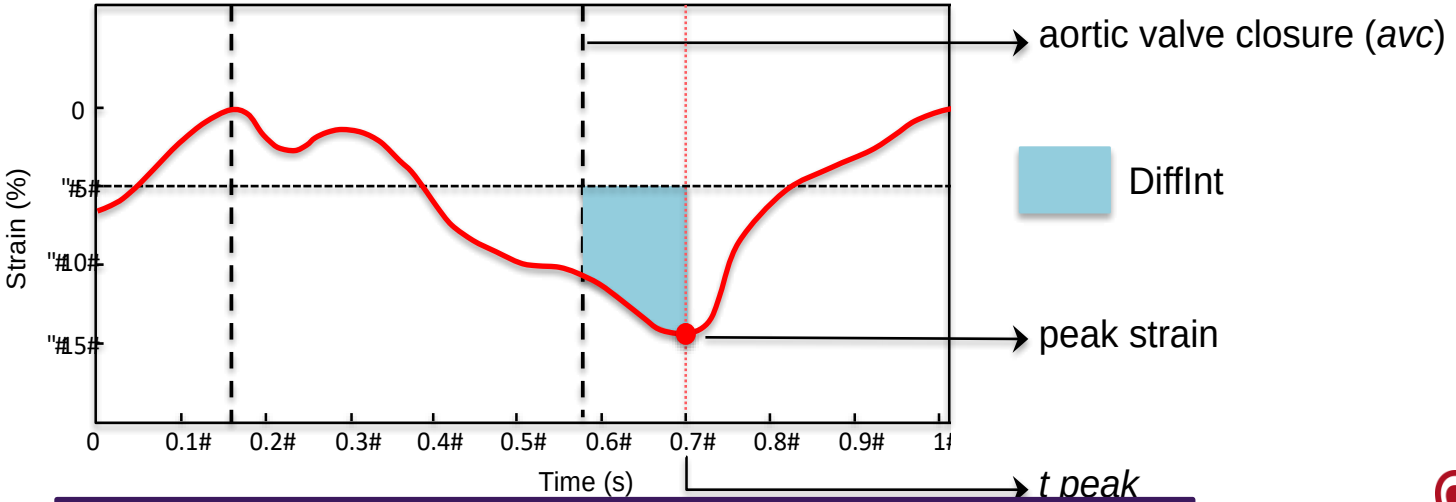
Analysis of the longitudinal strain and the area under the curves at the peak vs at the end of systole

❑ meter of

n = 130		Response	Non response	p
Energy Lost	*I*L,avc – *I*L,peak	-59 ± 103 %	+21 ± 113 %	0.009



Quantification of the wasted energy, wasted regional deformation

Lim, Donal et al. Eur J Heart Fail 2011;13:984-991

Bernard / Donal. *J Am Soc Echocardiogr* 2015;28:700-8

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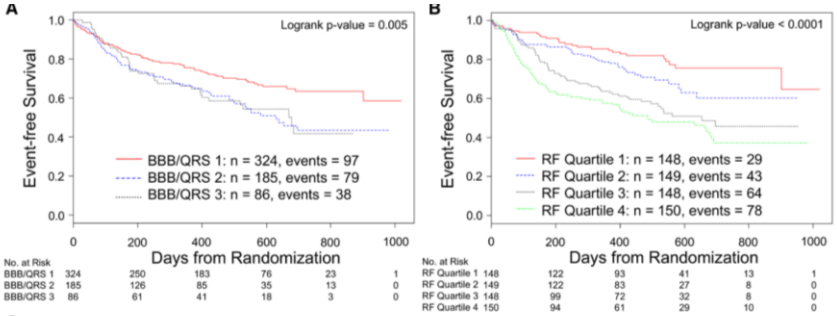
Computer Modeling

The Future of Cardiac Resynchronization Therapy Patient Selection?

Machine Learning Algorithm Predicts Cardiac Resynchronization Therapy Outcomes

Lessons From the COMPANION Trial

In the COMPANION trial, a machine learning algorithm produced a **model that predicted clinical outcomes after CRT**.
Applied before device implant, this model may better differentiate outcomes over current clinical discriminators and **improve shared decision-making with patients**.



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All-Cause Mortality or HF Hospitalization by Subgroup

Subgroup	HR	95% Confidence Interval	P-Value
BBB / QRS 2*	1.56	1.16 - 2.10	0.003
BBB / QRS 3*	1.57	1.07 - 2.28	0.02
RF Quartile 2†	1.60	1.00 - 2.57	0.05
RF Quartile 3†	2.60	1.67 - 4.03	<0.0001
RF Quartile 4†	3.26	2.13 - 5.00	<0.0001

*Reference is BBB / QRS 1
†Reference is RF Quartile 1
HF = Heart Failure, HR = Hazard Ratio

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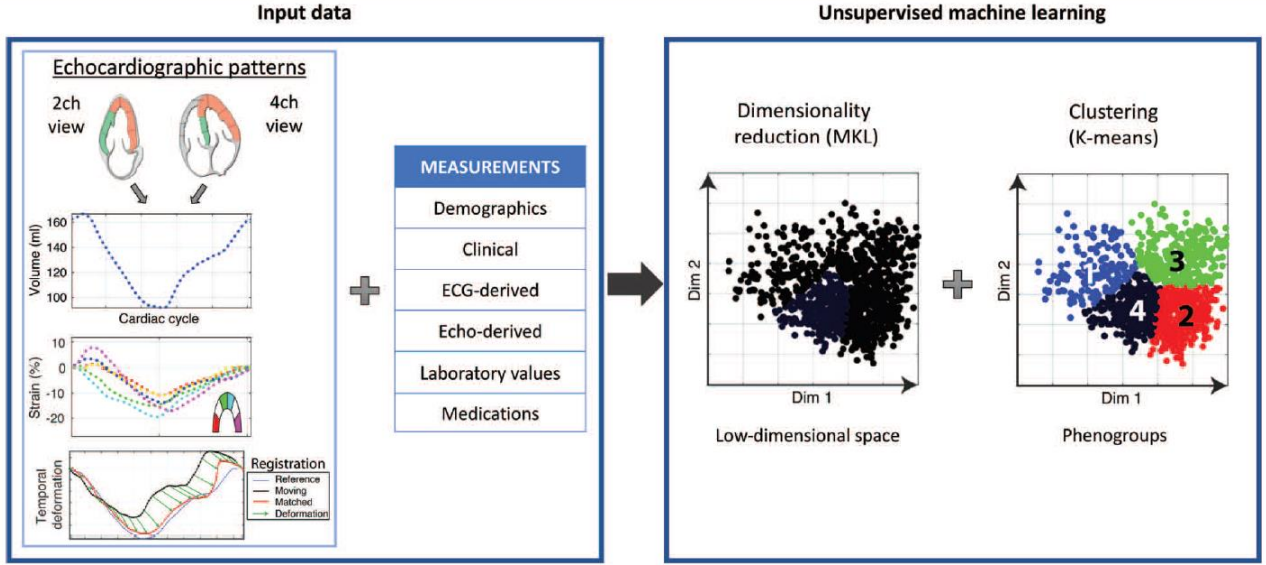
Circ Arrhythm Electrophysiol. 2018;11:e005499. DOI: 10.1161/CIRCEP.117.005499

ESC European Society of Cardiology
European Journal of Heart Failure (2018)
doi:10.1002/ejhf.1333

RESEARCH ARTICLE

EACVI European Association of Cardiovascular Imaging

Machine learning-based phenogrouping in heart failure to identify responders to cardiac resynchronization therapy



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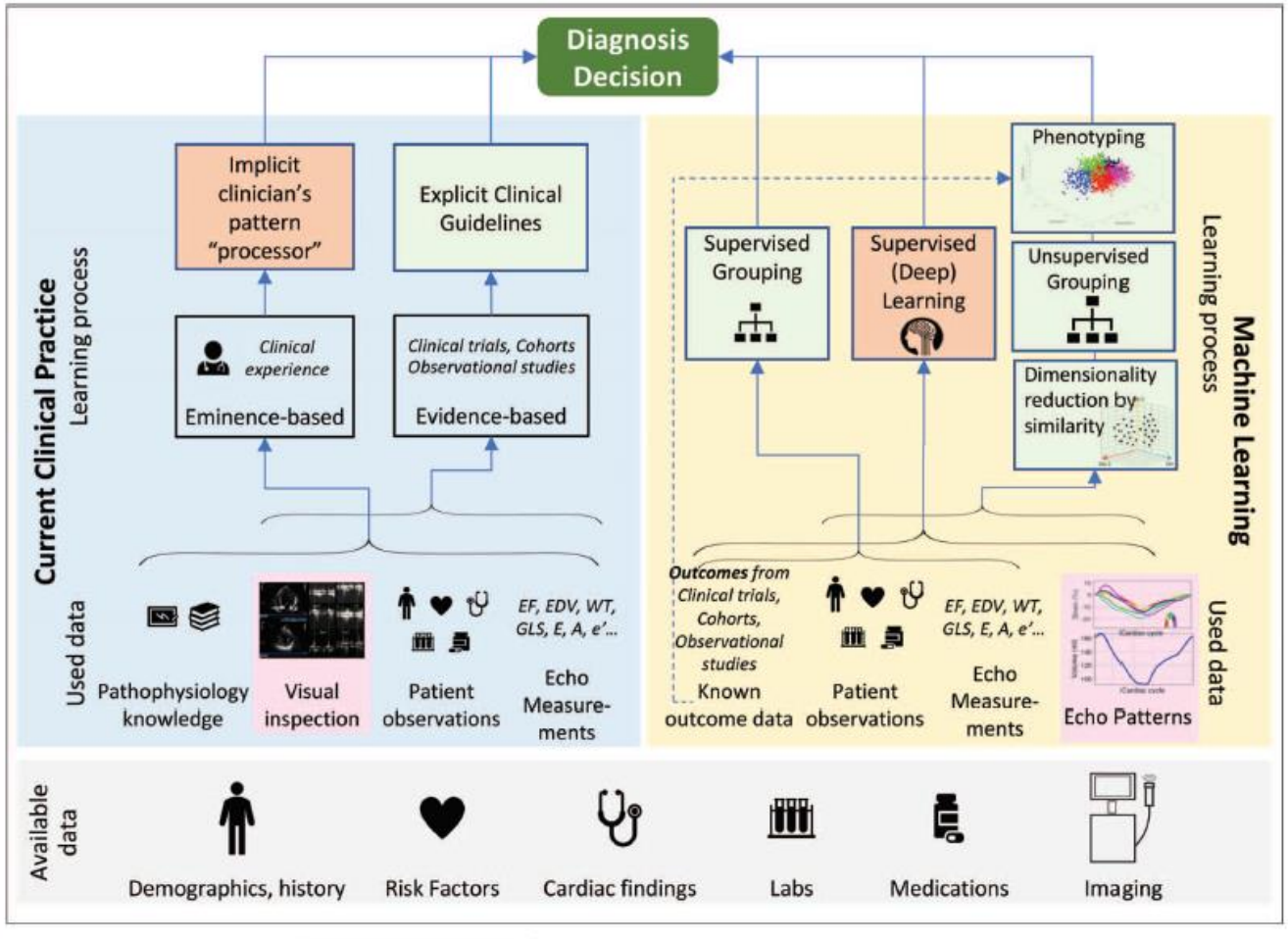

Imaging in CRT
Difficult to convince after Prospect
…
Artifitial intelligence and all the data that are acquired through the echo recording?

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Towards Personalized Cardiology: Multi-Scale Modeling of the Failing Heart

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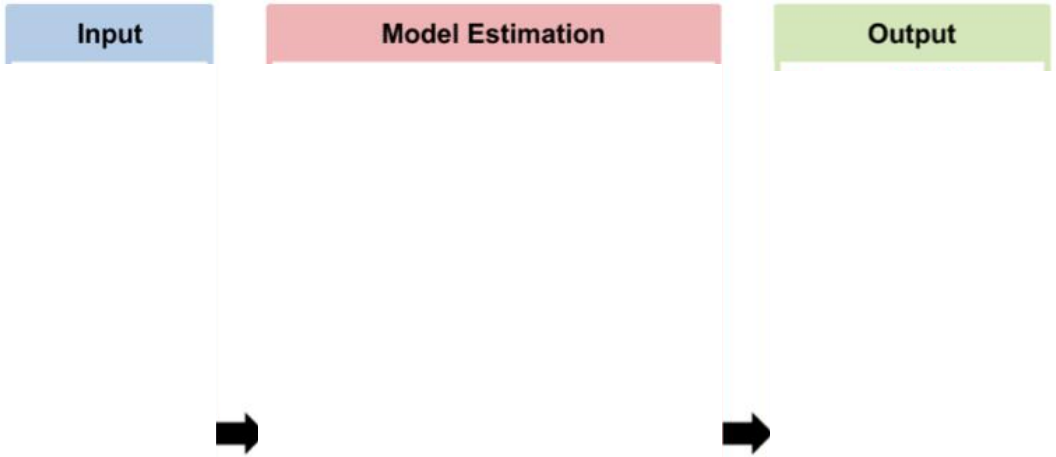

Kayvanpour E. *Plos One* 2015;10:e0134869.

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HIT
EACVI's Heart Imagers of Tomorrow

Echo in CRT

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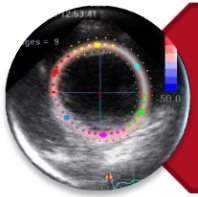
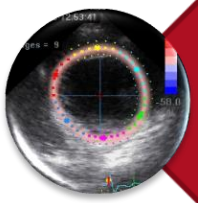
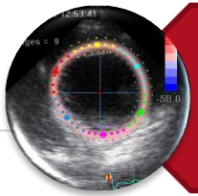


ELECTRICAL DYSSYNCHRONY ≠ MECHANICAL



Still matter of research BUT better than in the past we understand the determinant of RESPONSE to CRT



New STRAIN computations MAKE IT EASIERto understand and to predict

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SAVE THE DATE!

4 - 7 December 2019
Vienna, Austria

Main themes

Cardiomyopathies and
Imaging in Acute Cardiac Care

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