Imaging left ventricular dyssynchrony

February 20, 2019

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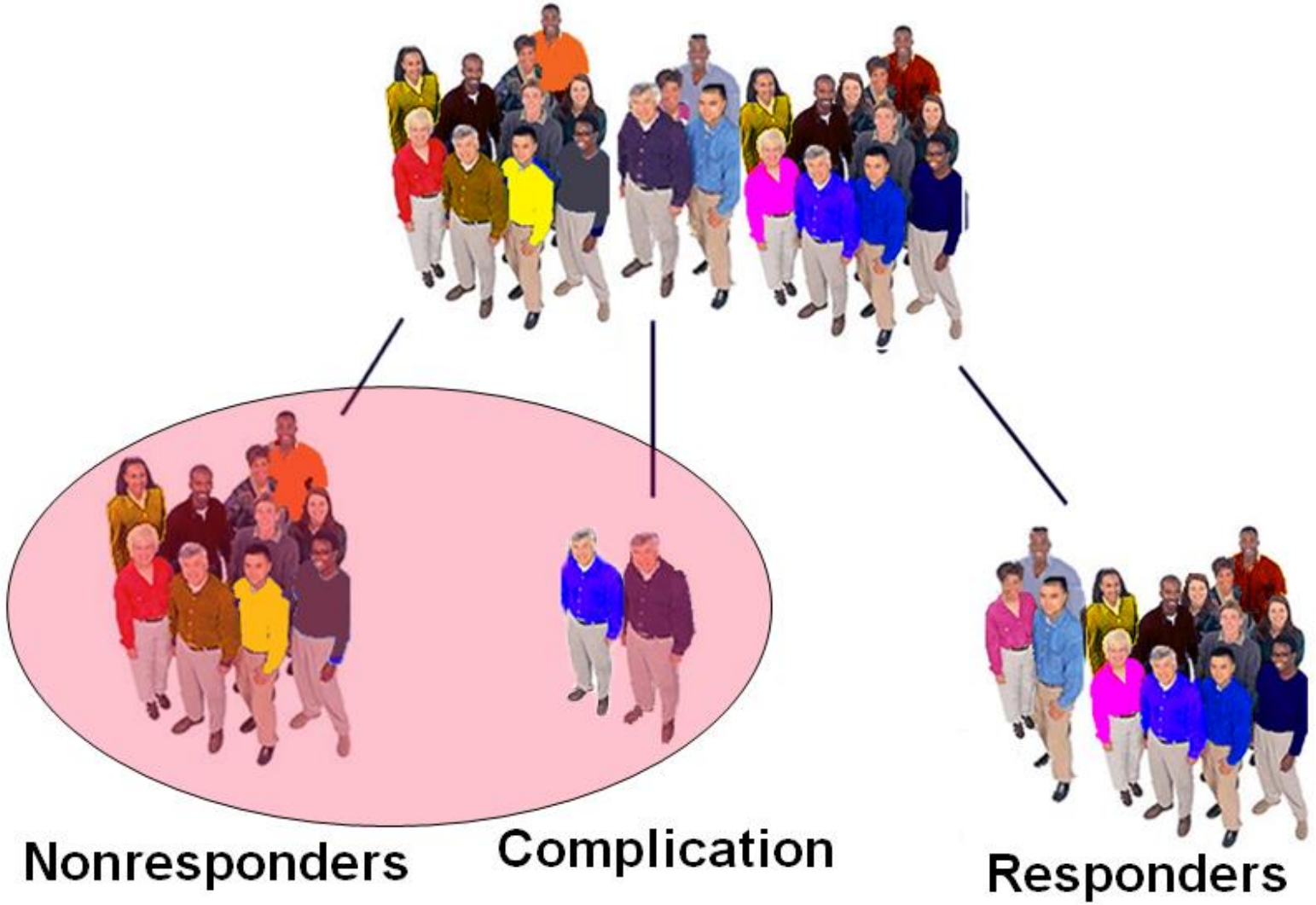
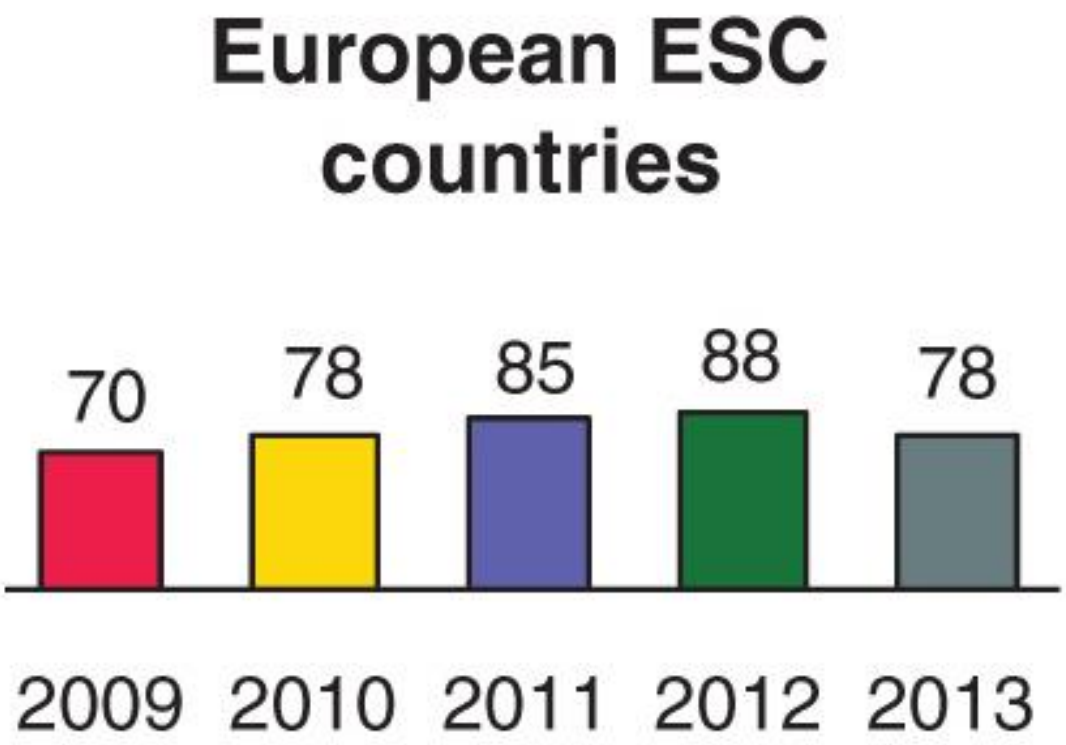
Conflicts of interest

- co-inventor of Method for Myocardial Segment Work Analysis, but no longer ownership of patent.

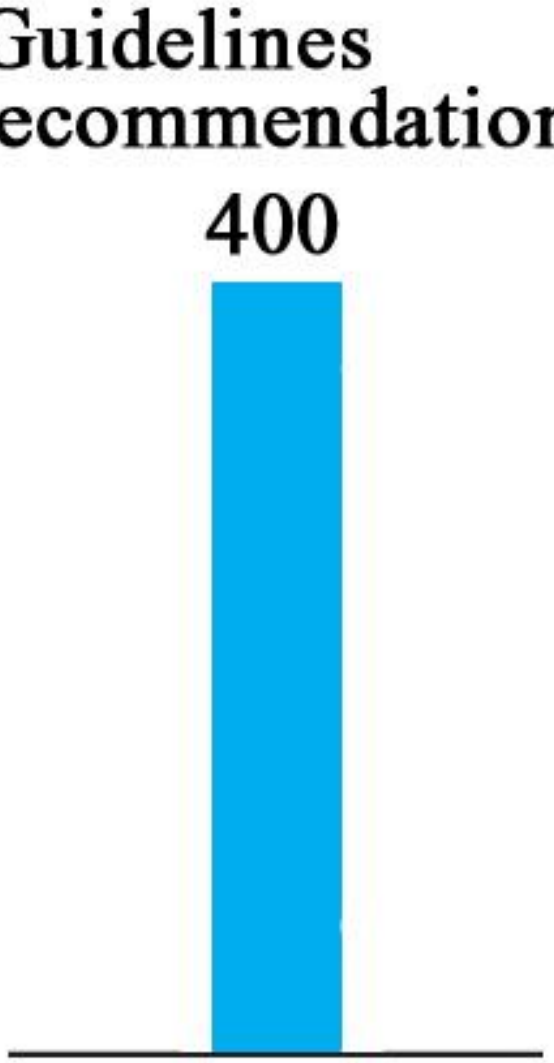
Responder rate to CRT when using only ECG and EF



Actual CRT implantation rates per million inhabitants



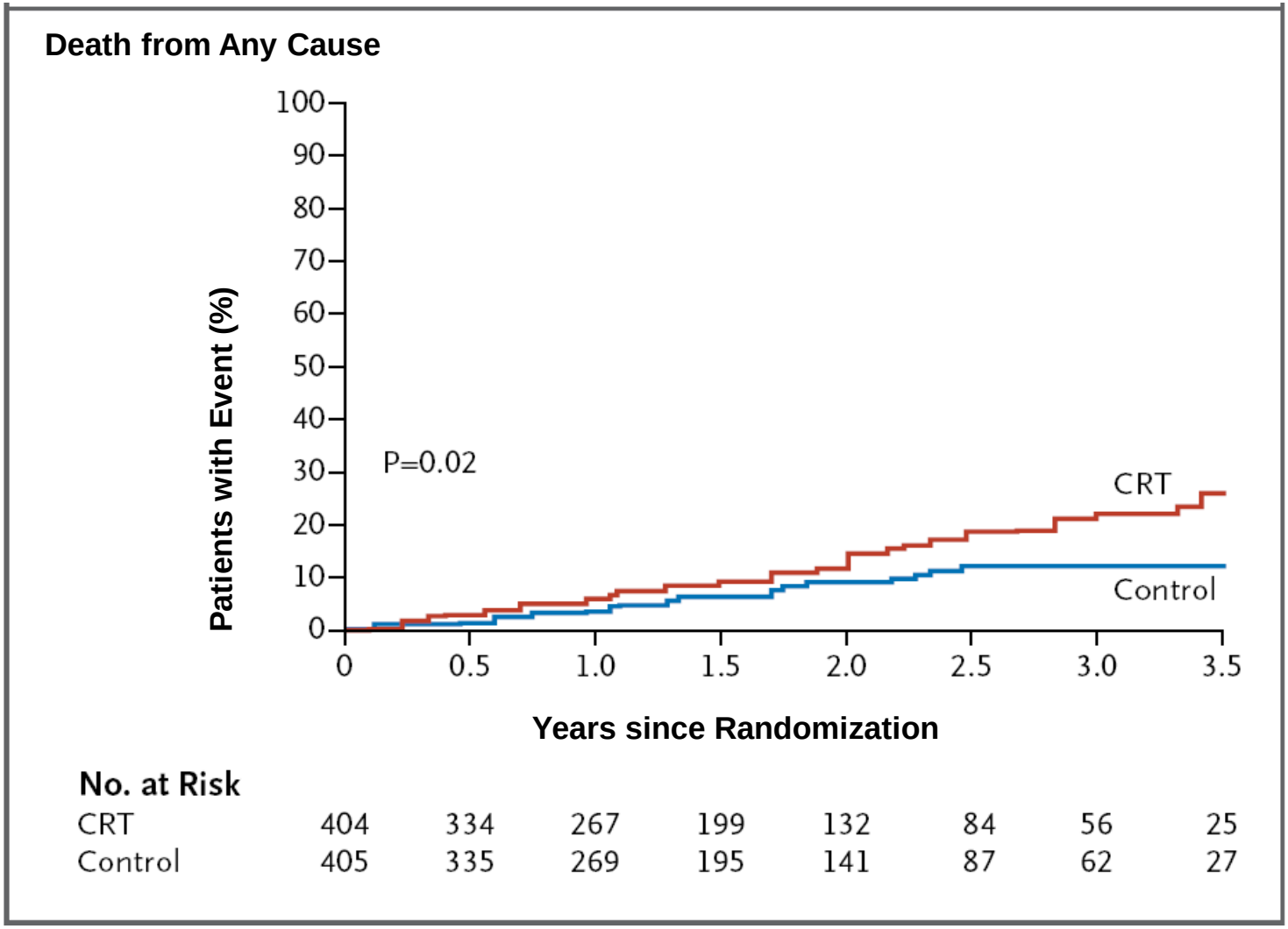
M.J. Pekka Raatikainen et al. Europace (2015) 17, i1–i75



European Heart Journal (2013) 34, 2281–2329

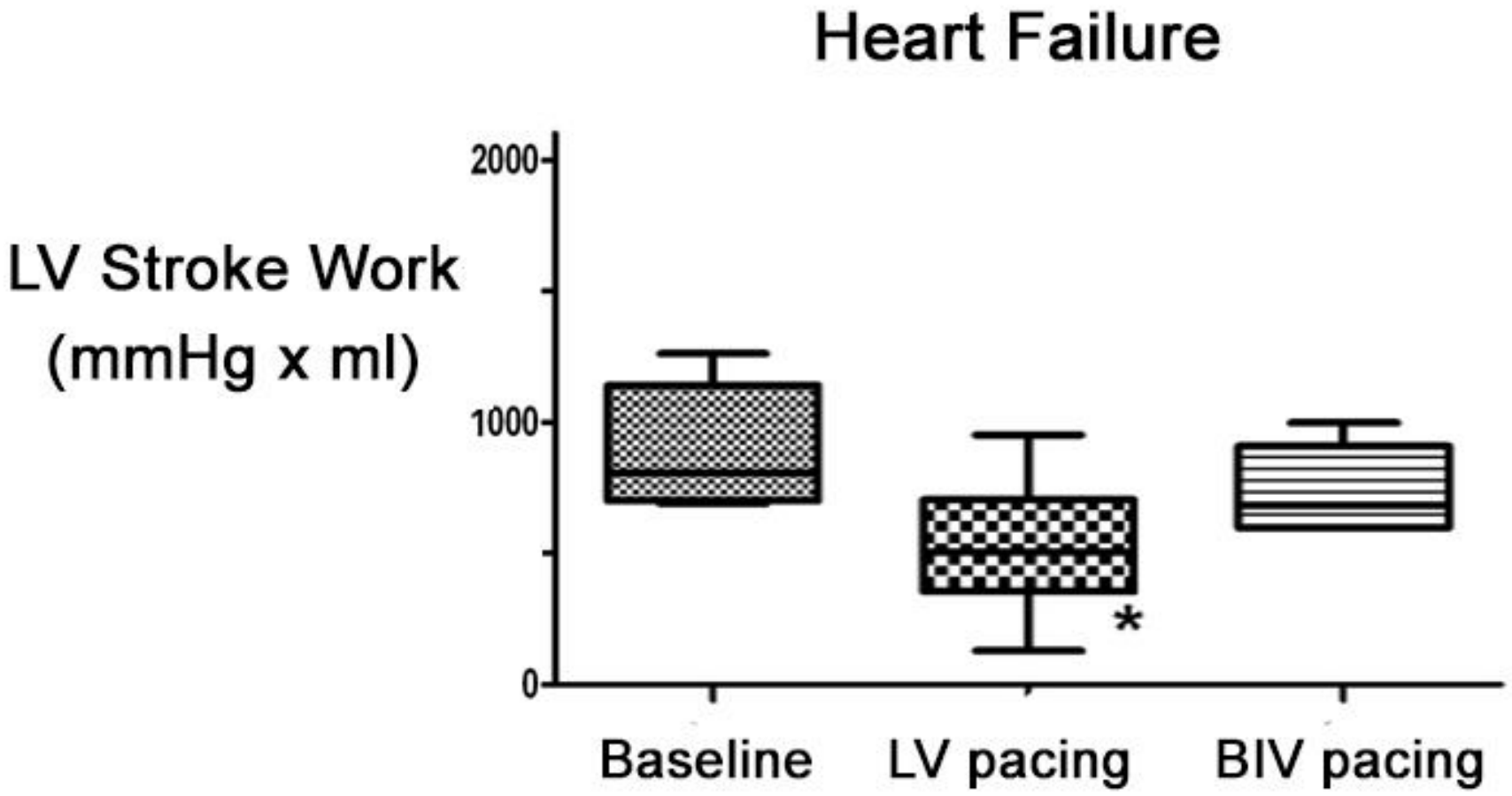
The EchoCRT study

QRS < 130 msec



Ruschitzka F et al, NEJM, 2013;396:1395-1405

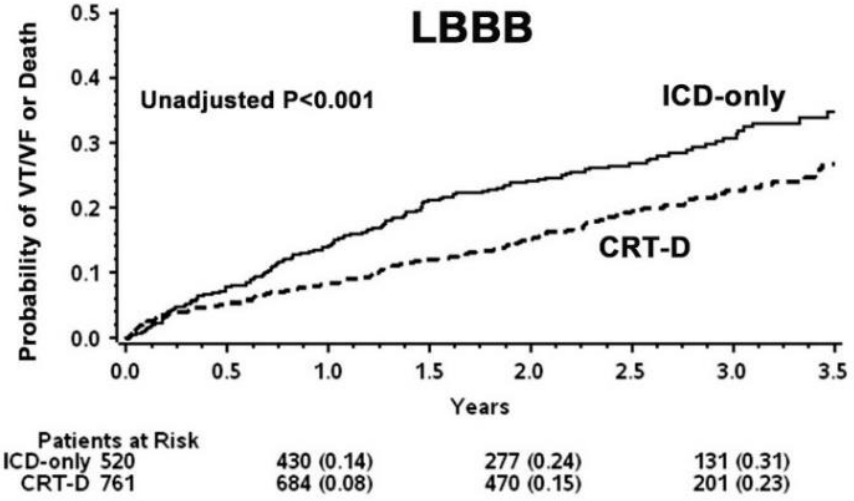
LV and BiV pacing in narrow QRS
Effect om LV Stroke Work

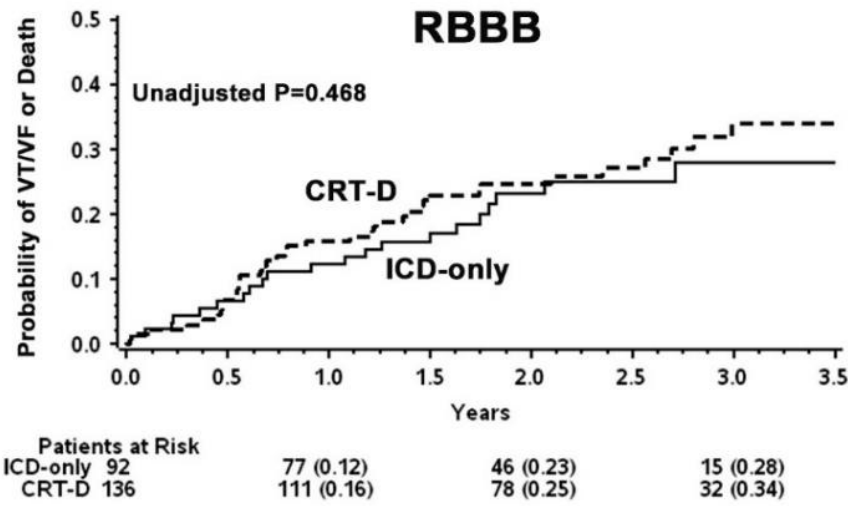


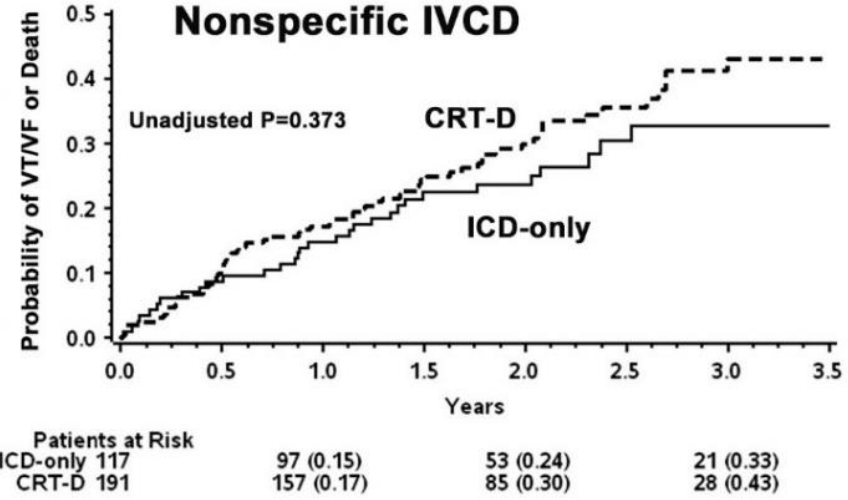
Modified from E. Bøe et al. Am J Physiol 2014; 307(3): H370-8.

MADIT-CRT

LBBB in 1281 (70%), RBBB in 228 (13%), and with nonspecific IVCD in 308 (17%).

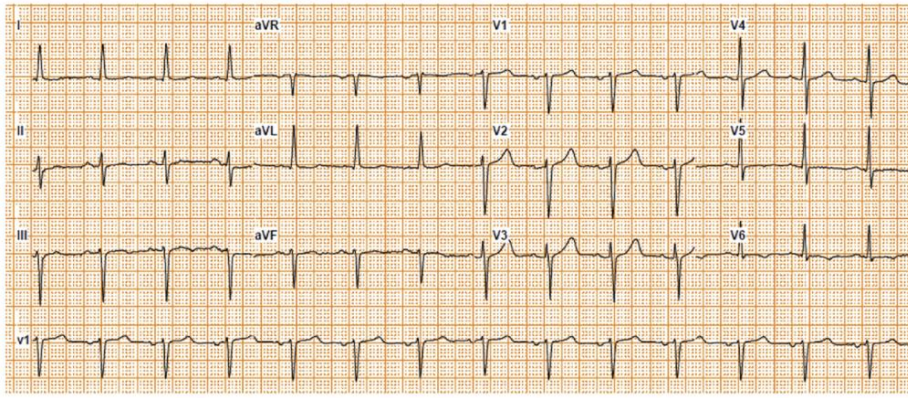




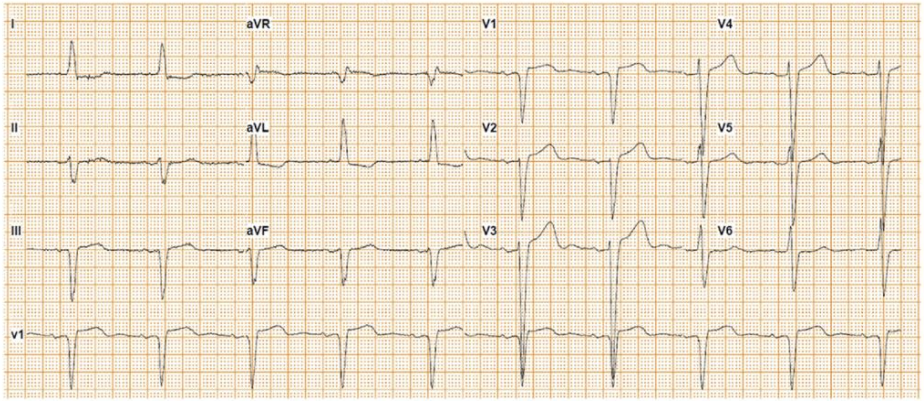


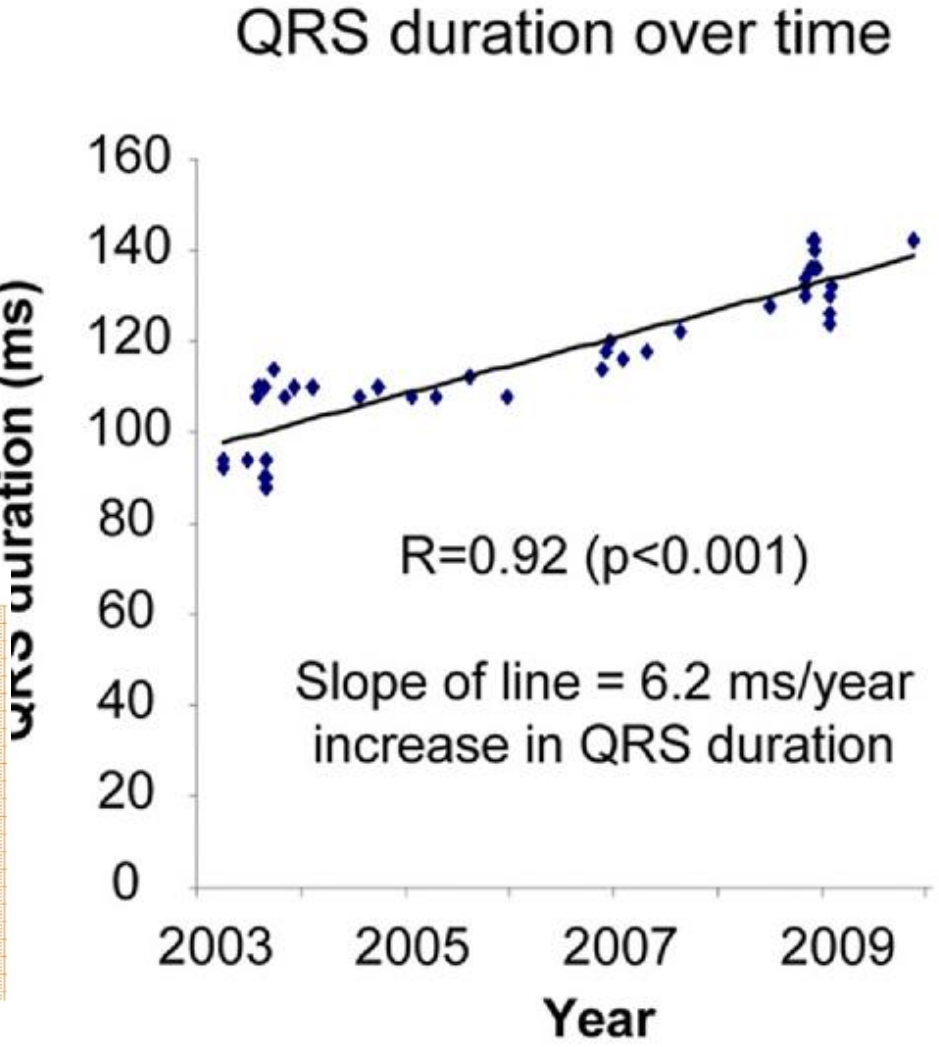
Modified from W. Zareba et al.
Circulation.2011;123:1061-1072.

B. Initial ECG: QRS duration = 92 ms



E. ECG after 6.5 years: QRS duration = 142 ms





David G. Strauss et al. Am J Cardiol 2011;107:927–934.

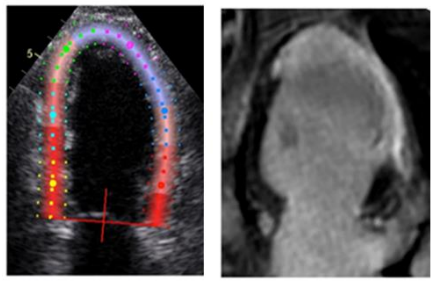
Mechanisms of LV dyssynchrony

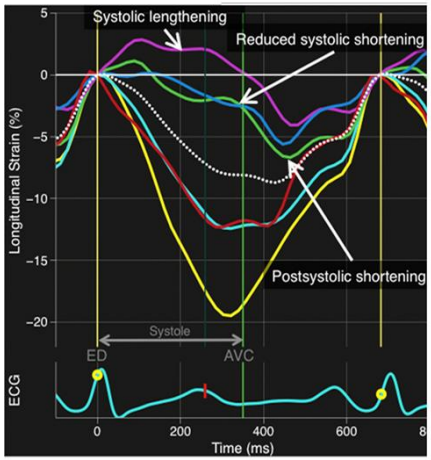
Non-electrical

Narrow QRS

Post infarct LV dysfunction

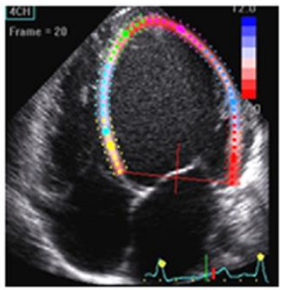
a

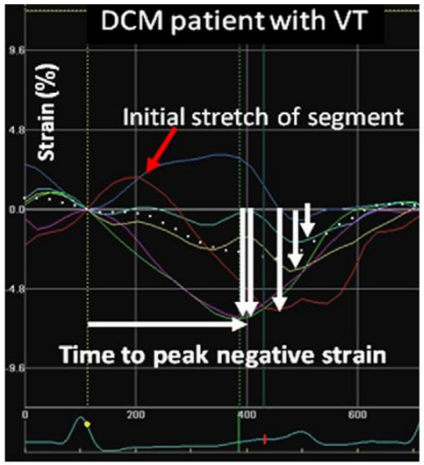




Cardiomyopathy

b



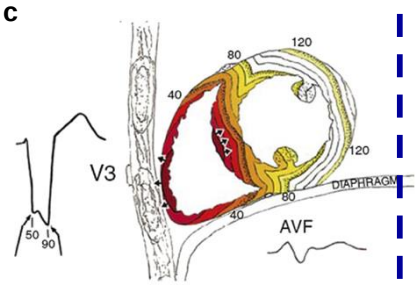


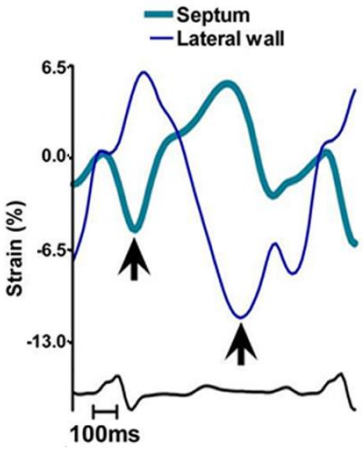
Electrical

Wide QRS

LBBB

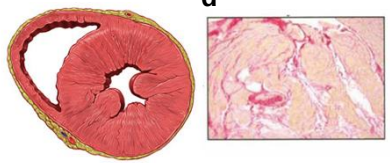
c



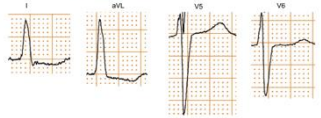


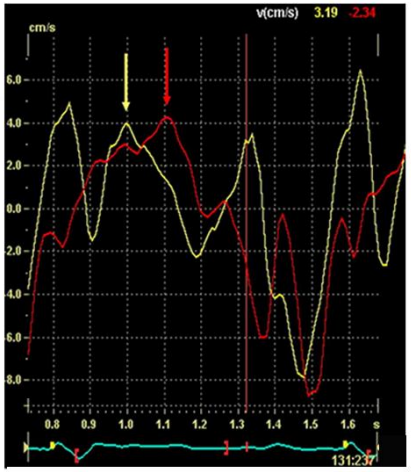
Nonspecific LV conduction delay

d



c





Modif. from Smiseth et al. EHJ 2016 (a); Haugaa et al. JASE 2012 (b); Strauss Am J Cardiol 2011 (c) and Diez Circulation 2002 (d).

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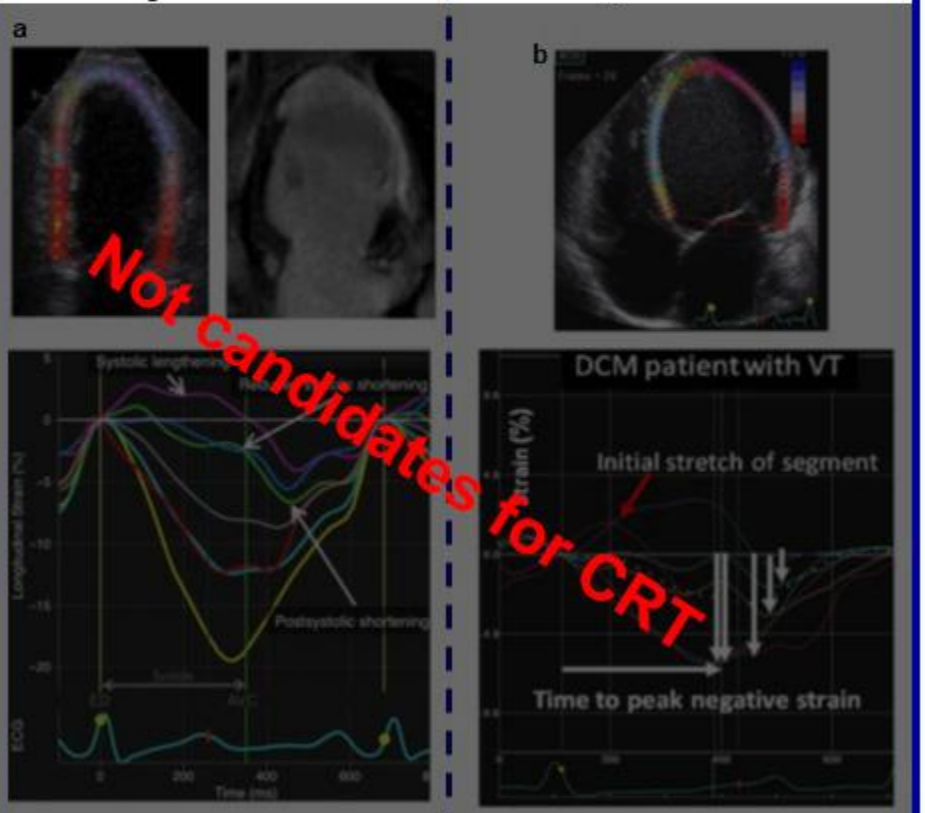
Cardiomyopathy

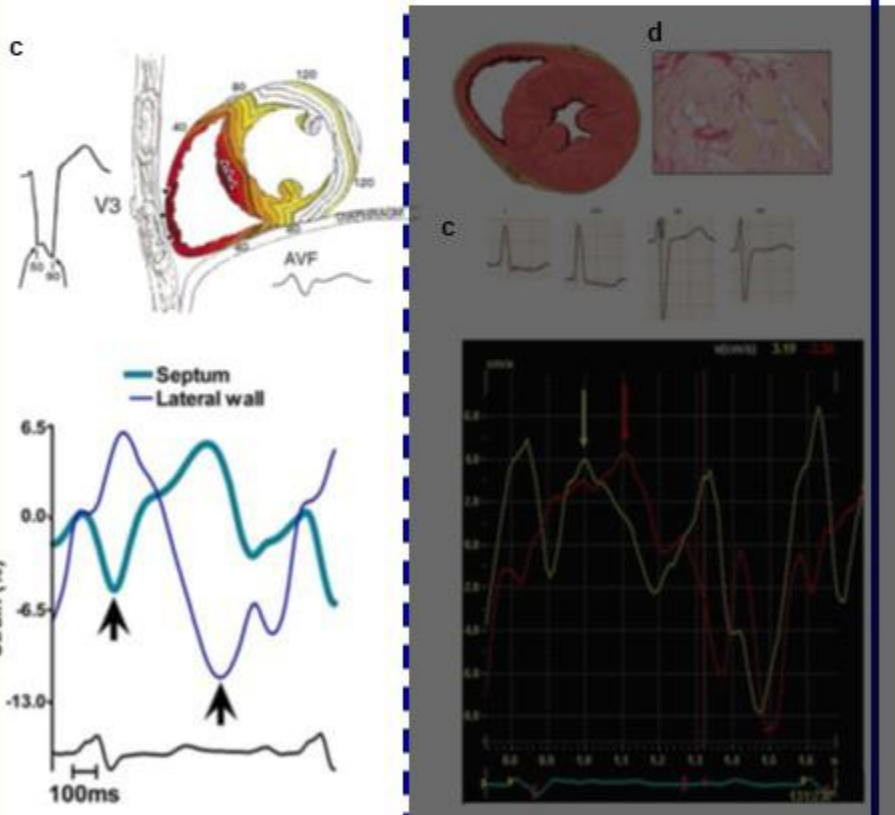


Electrical

Wide QRS

LBBB

Nonspecific LV conduction delay



Modif. from Smiseth et al. EHJ 2016 (a); Haugaa et al. JASE 2012 (b); Strauss Am J Cardiol 2011 (c) and Diez Circulation 2002 (d).

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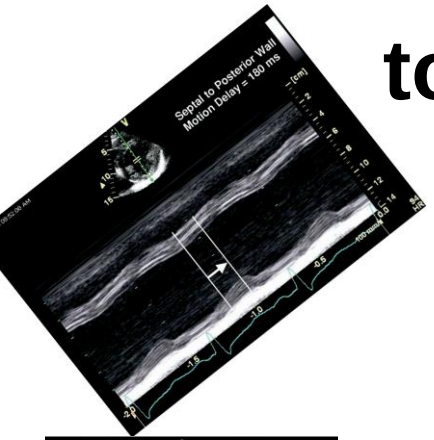
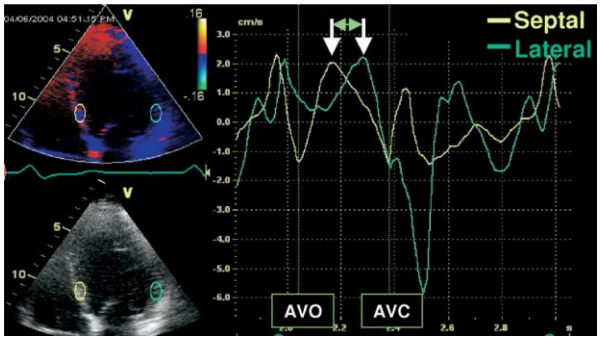
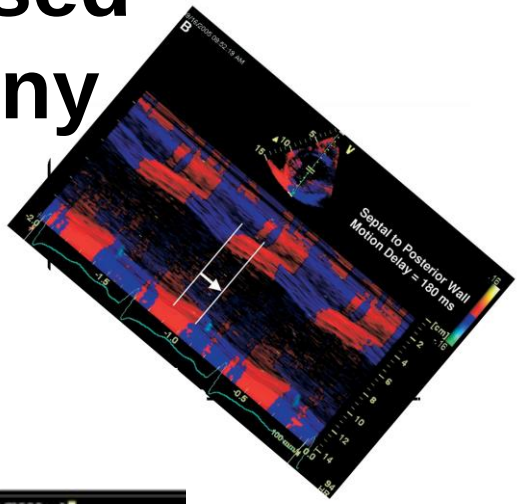
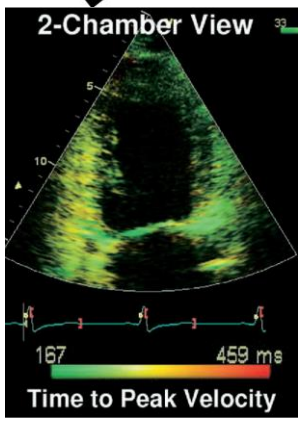
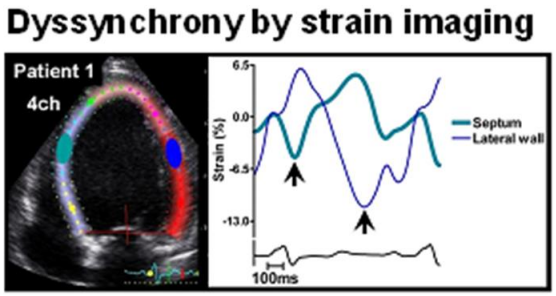
Multiple indices may be used to assess LV dyssynchrony

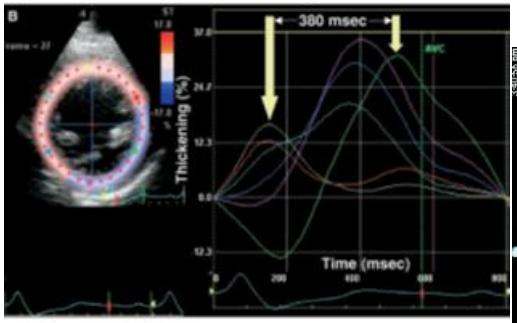


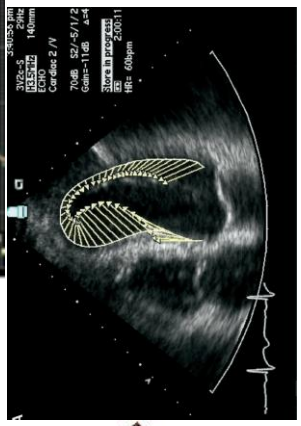


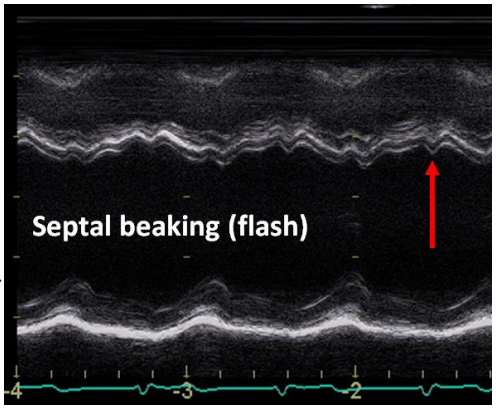


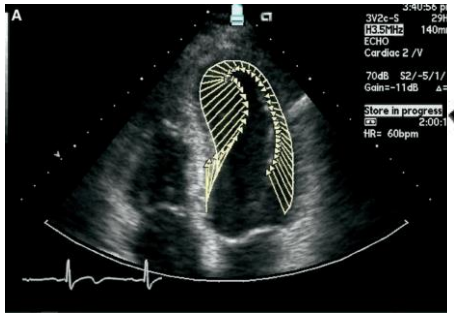


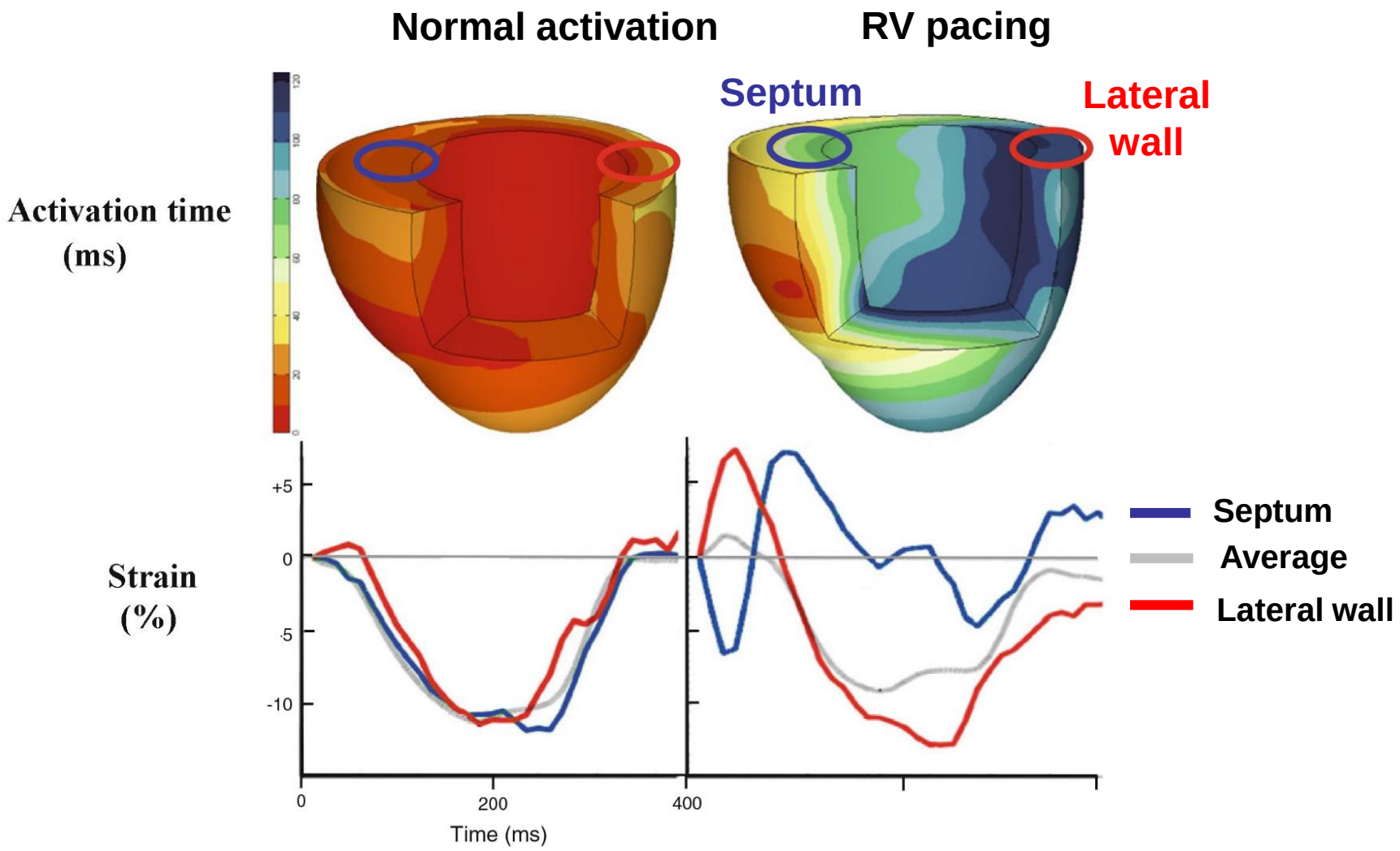






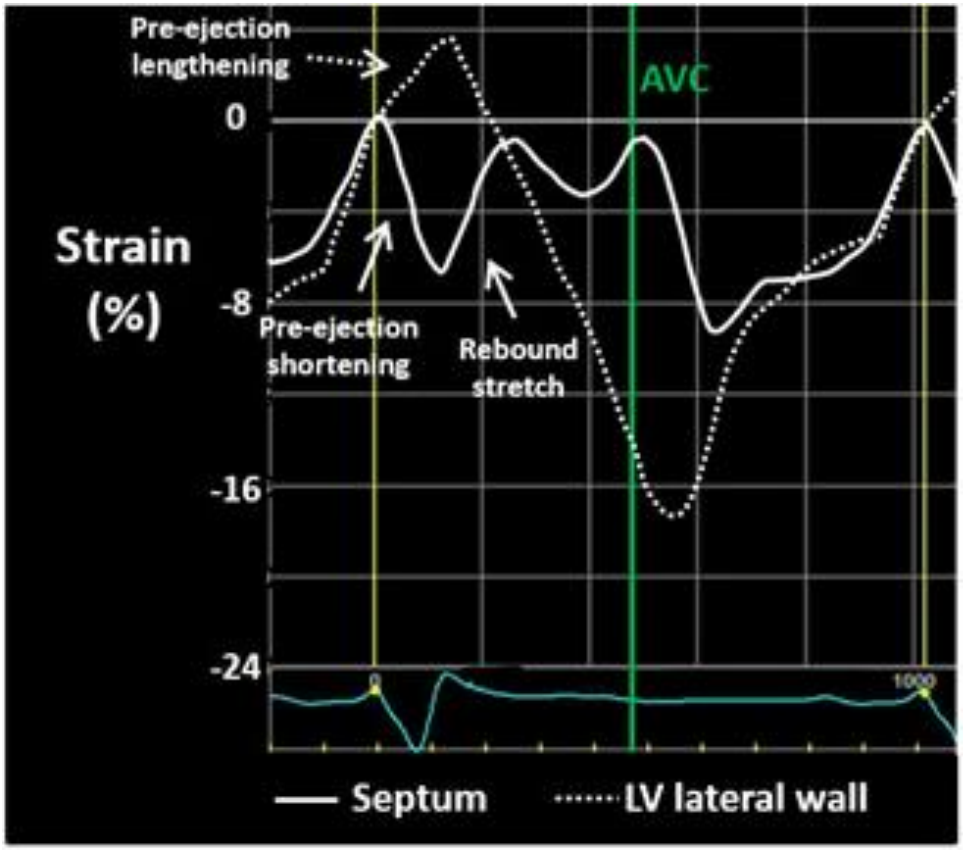


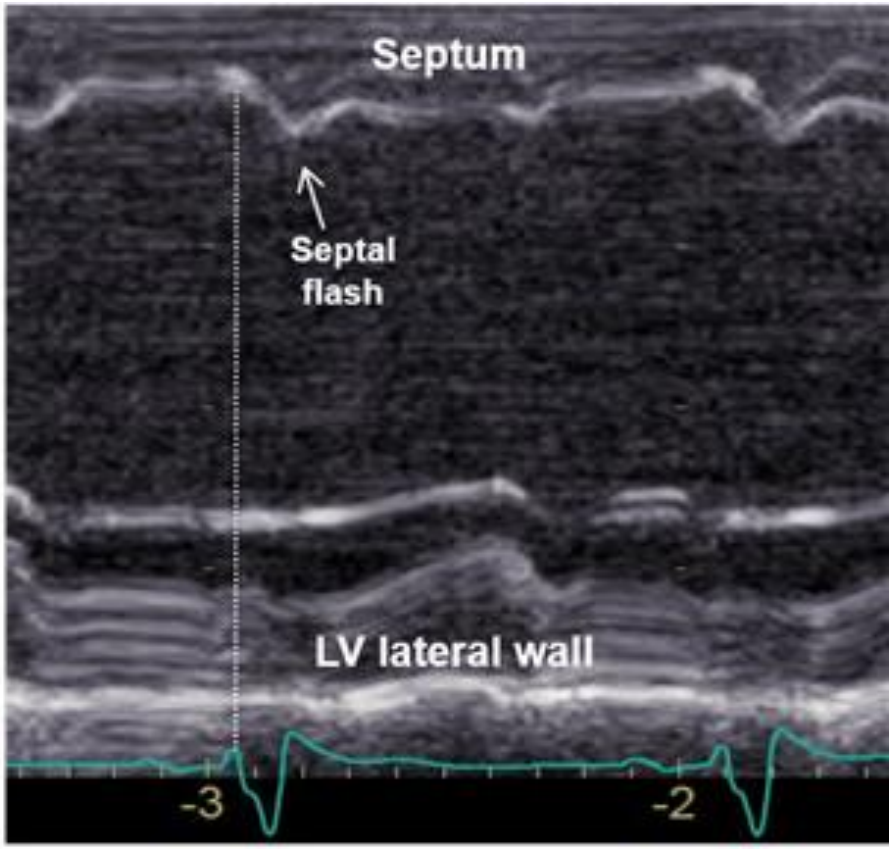




FW Prinzen et al. Heart Fail Rev (2011) 16:215–224

Contraction pattern in patients with «typical» LBBB





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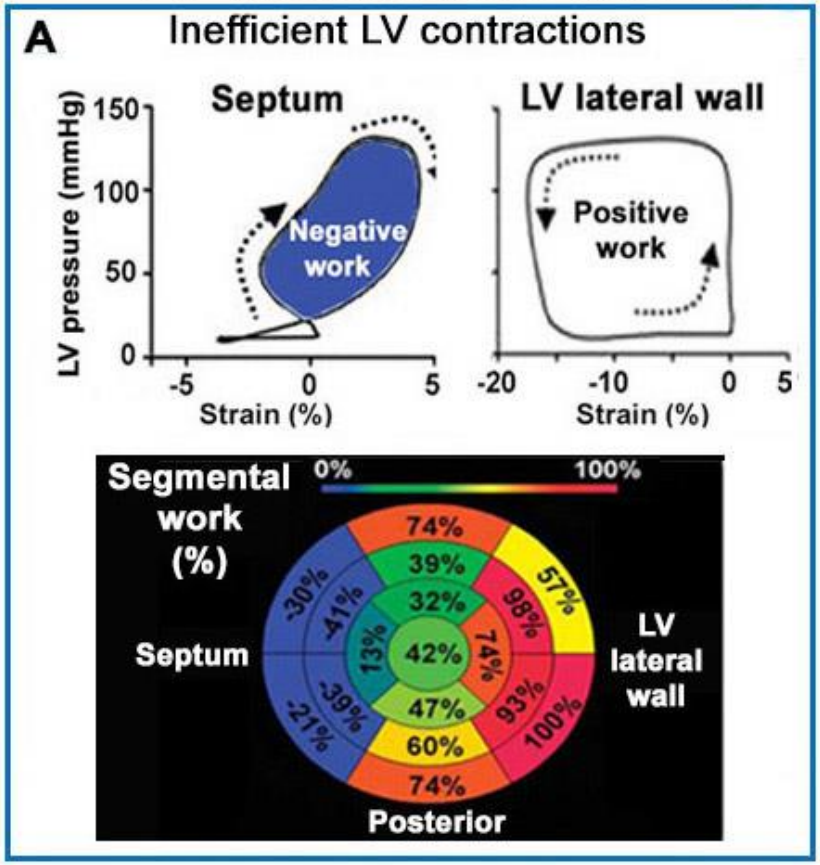
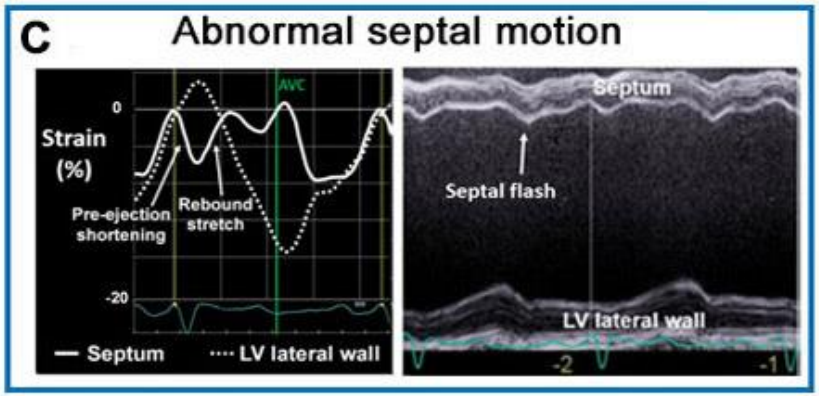
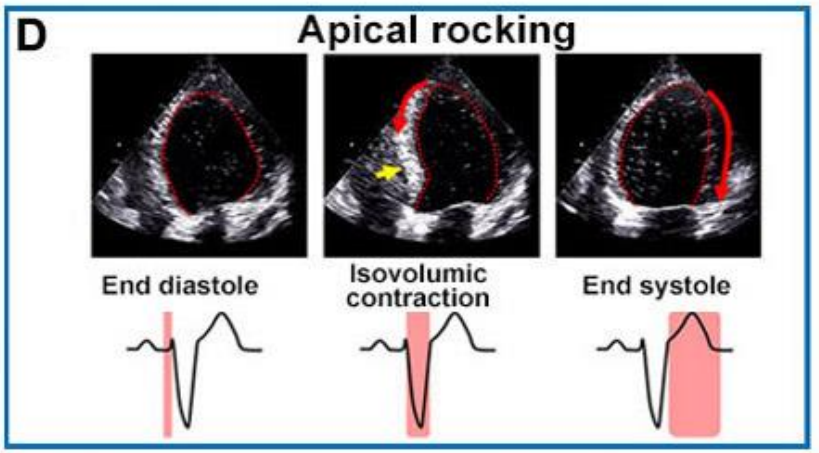
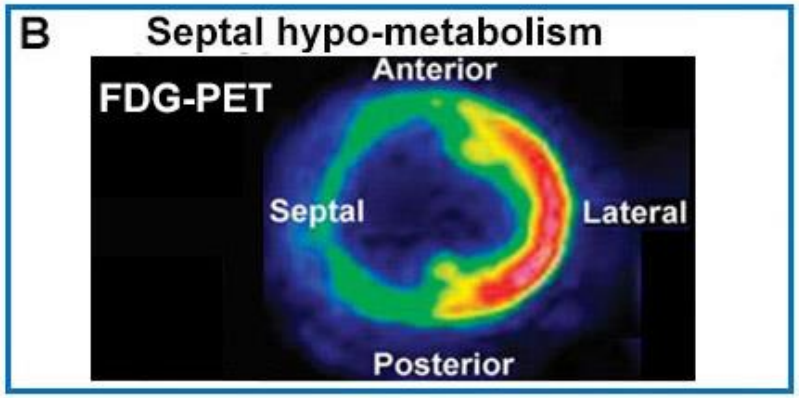
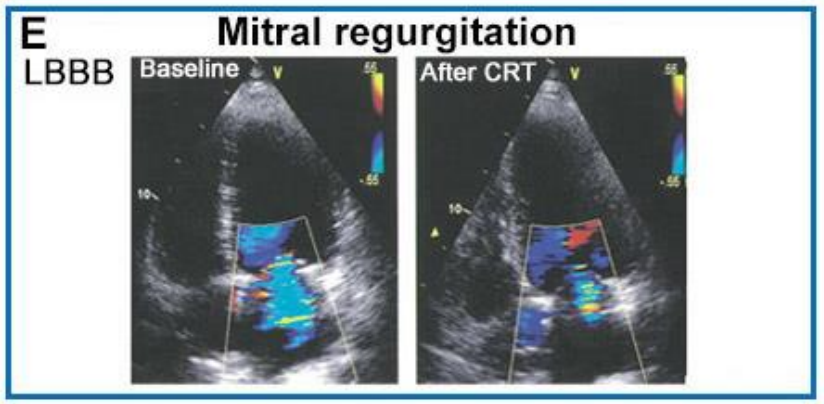
LV mechanical and metabolic features of LBBB









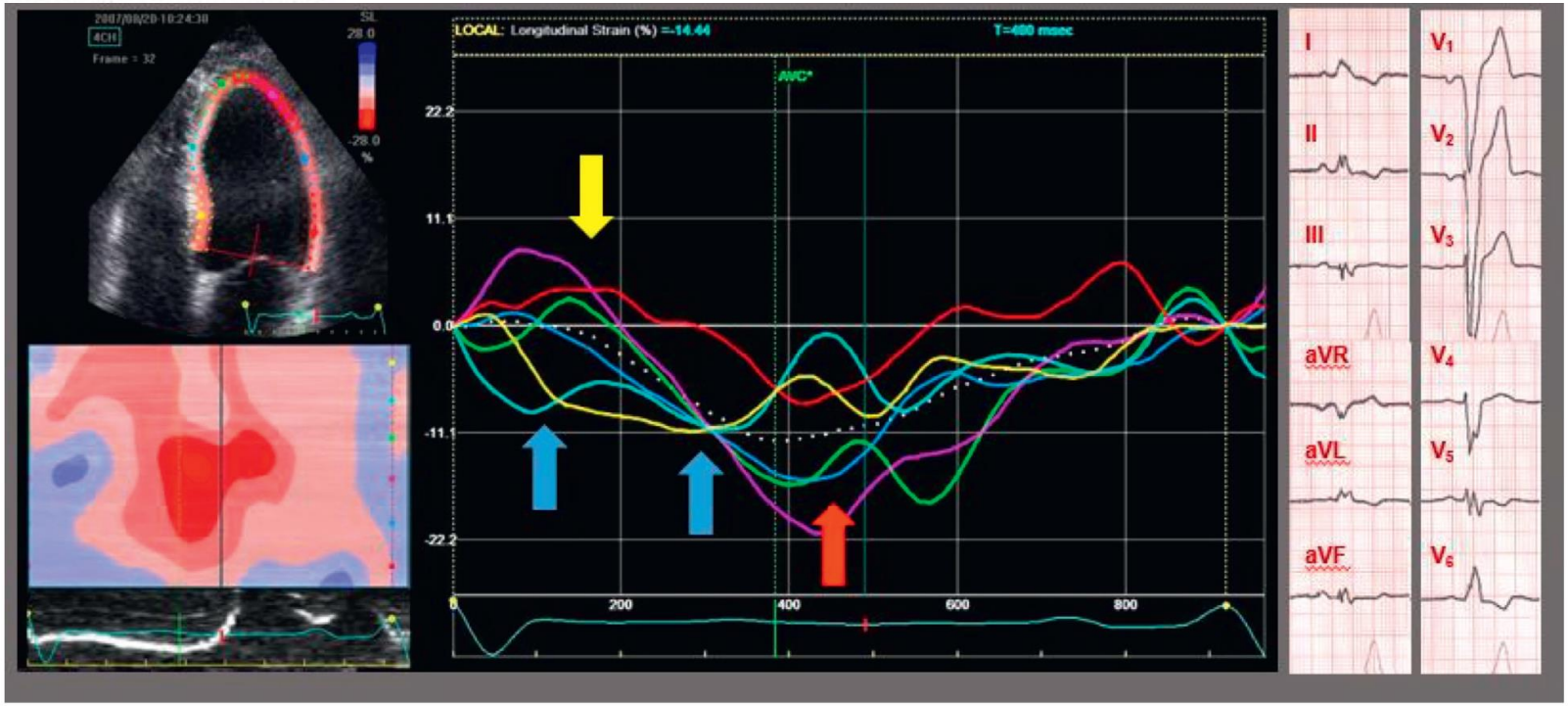


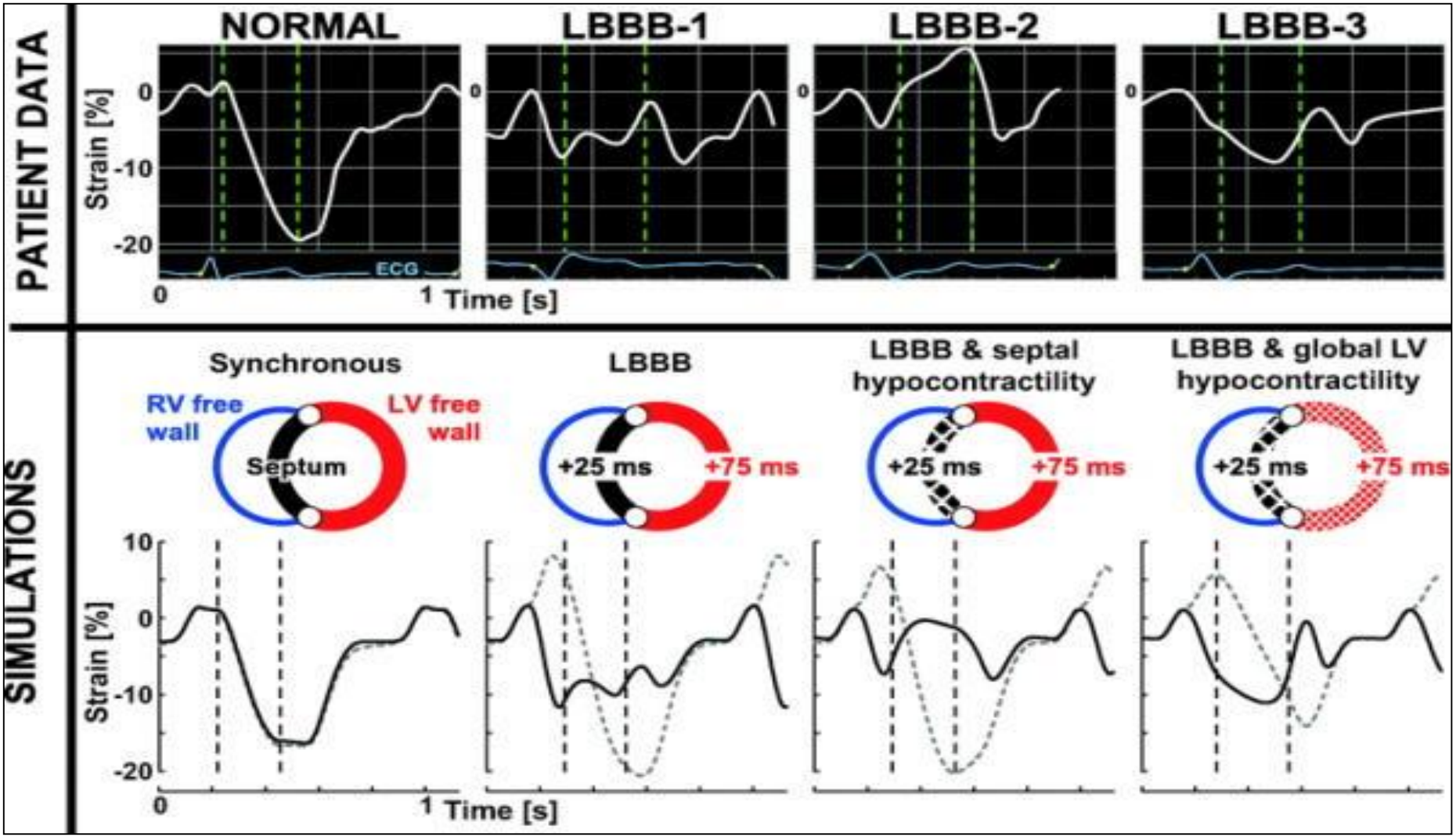
OA Smiseth and J Aalen. Trends Cardiovasc Med. 2018, Oct 25. Free access.

JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY VOL. 66, NO. 6, 2015

Identification of Typical Left Bundle Branch Block Contraction by Strain Echocardiography Is Additive to Electrocardiography in Prediction of Long-Term Outcome After Cardiac Resynchronization Therapy

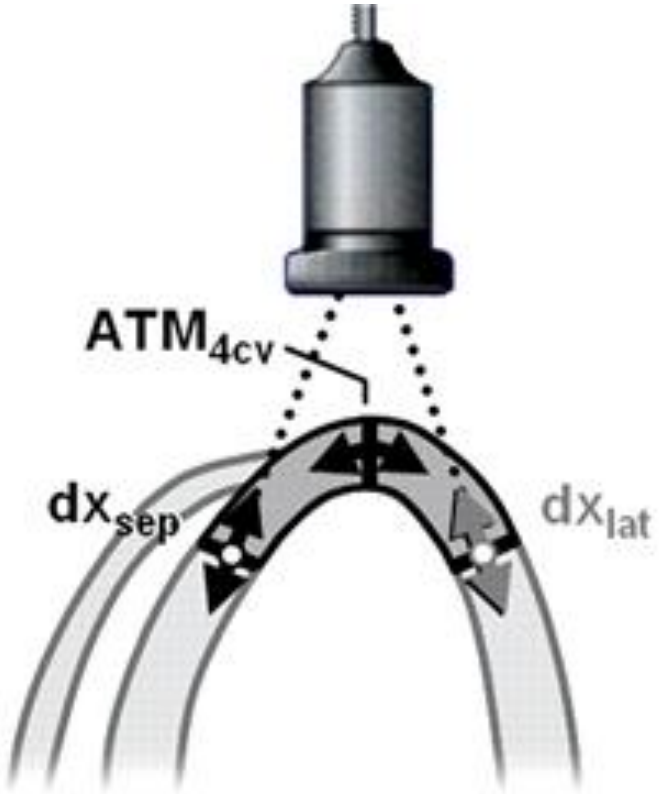
Niels Risum, MD, PhD,* Bhupendar Tayal, MD,†‡ Thomas F. Hansen, MD,§ Niels E. Bruun, MD, DMSc,†§ Magnus T. Jensen, MD, PhD,‖ Trine K. Lauridsen, MD,§ Samir Saba, MD,† Joseph Kisslo, MD,¶ John Gorcsan III, MD,† Peter Sogaard, MD, DMSc‡

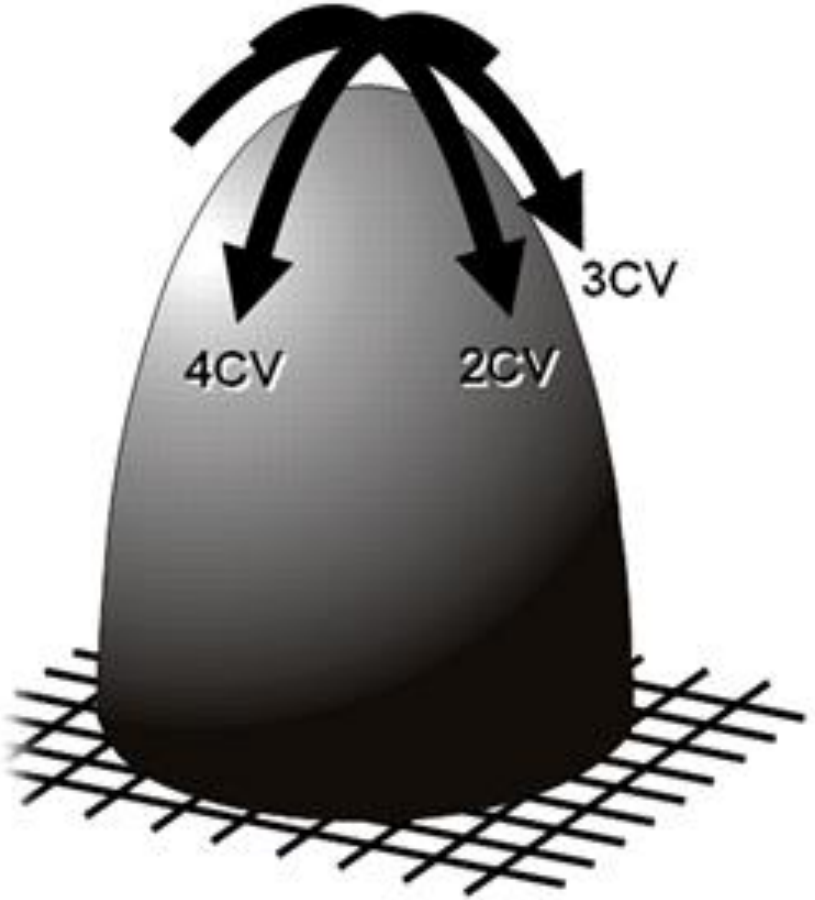




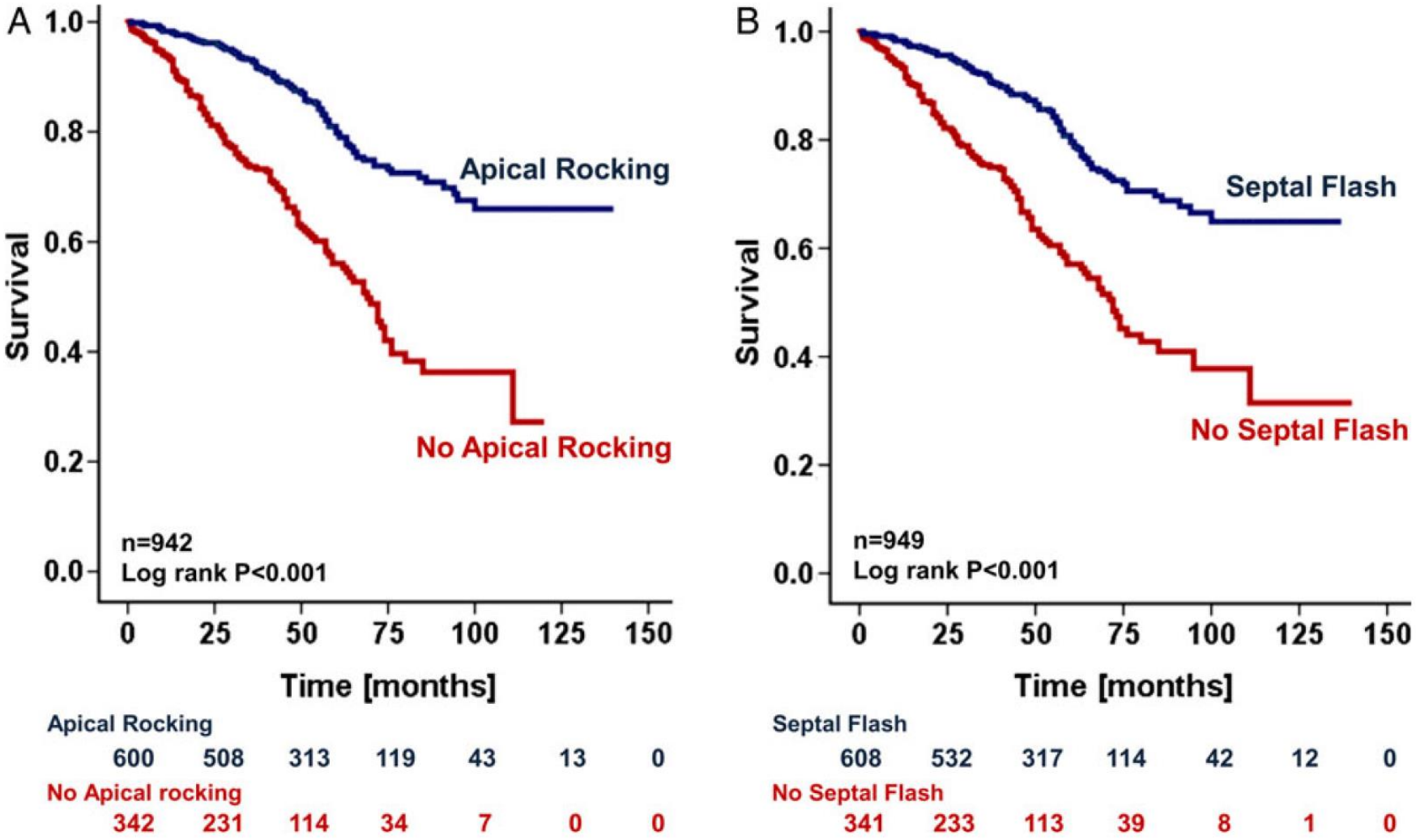
Leenders/Prinzen et al. Circulation: Heart Failure January 2012.

Apical rocking

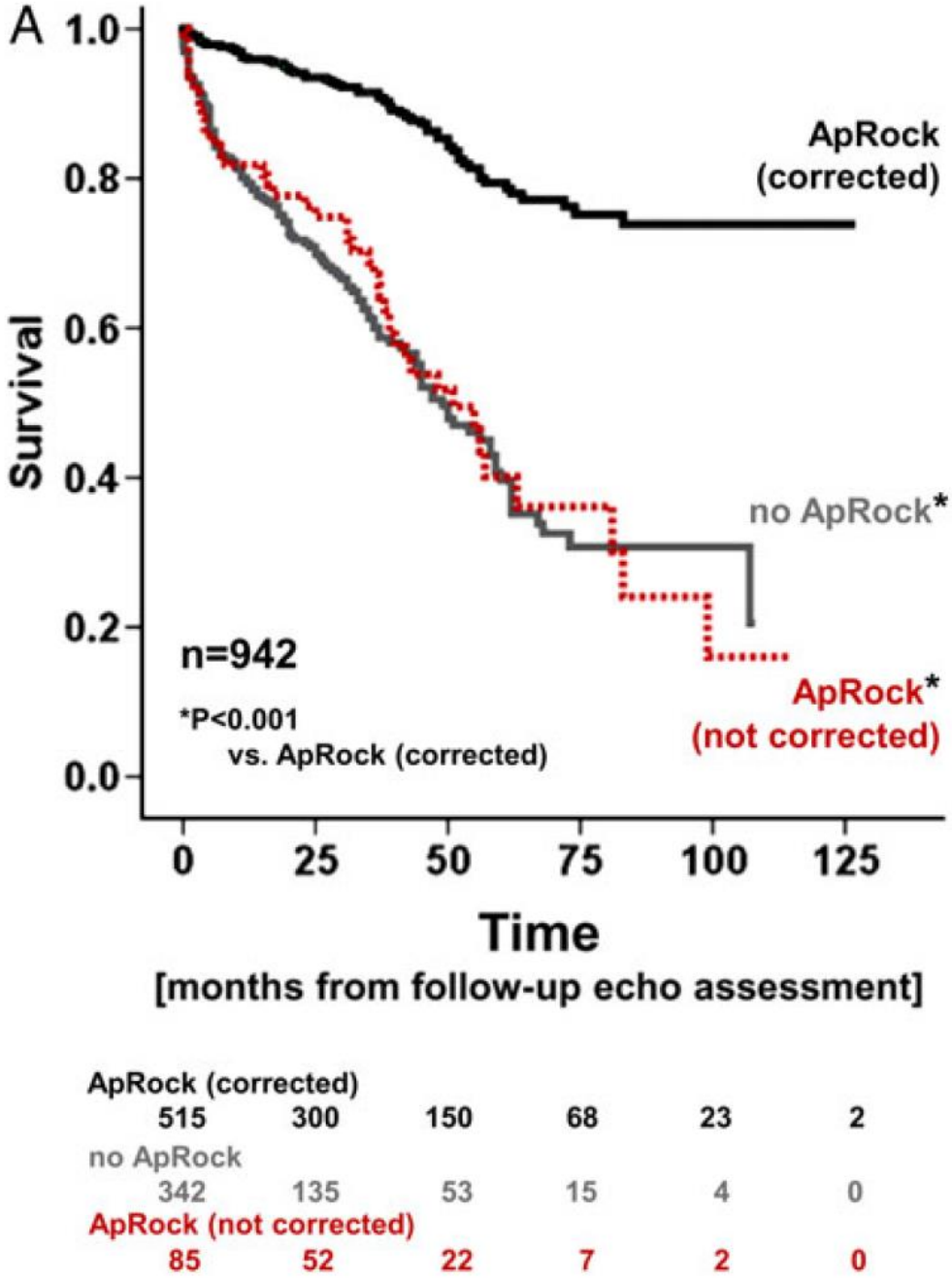




Modified from Szulik M et al. Eur J Echocardiogr 2010;11:863-869



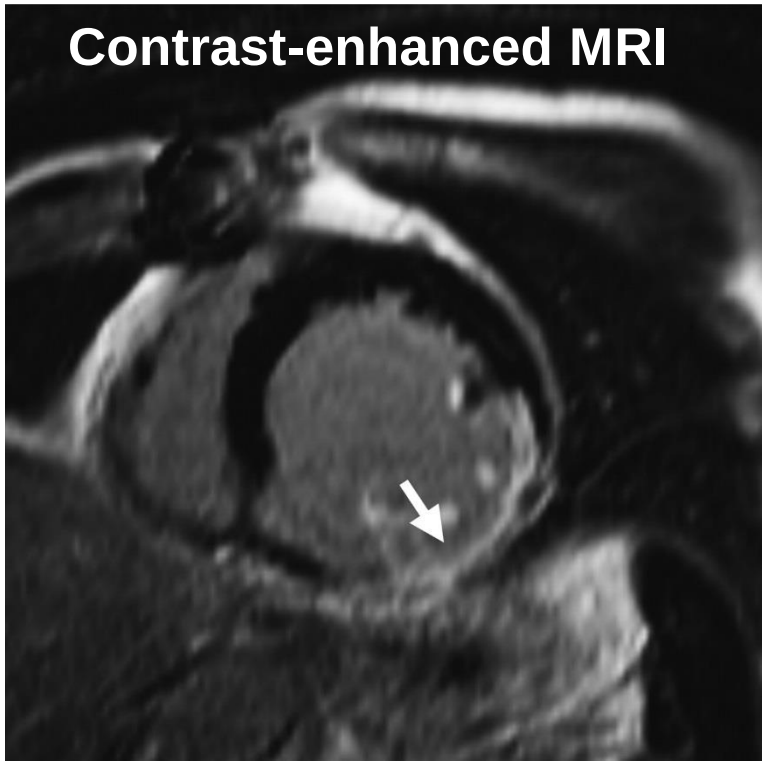
I Stankovic et al., European Heart Journal – Cardiovascular Imaging (2016) 17, 262–269



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

Scar matters

For long term (6 months) response

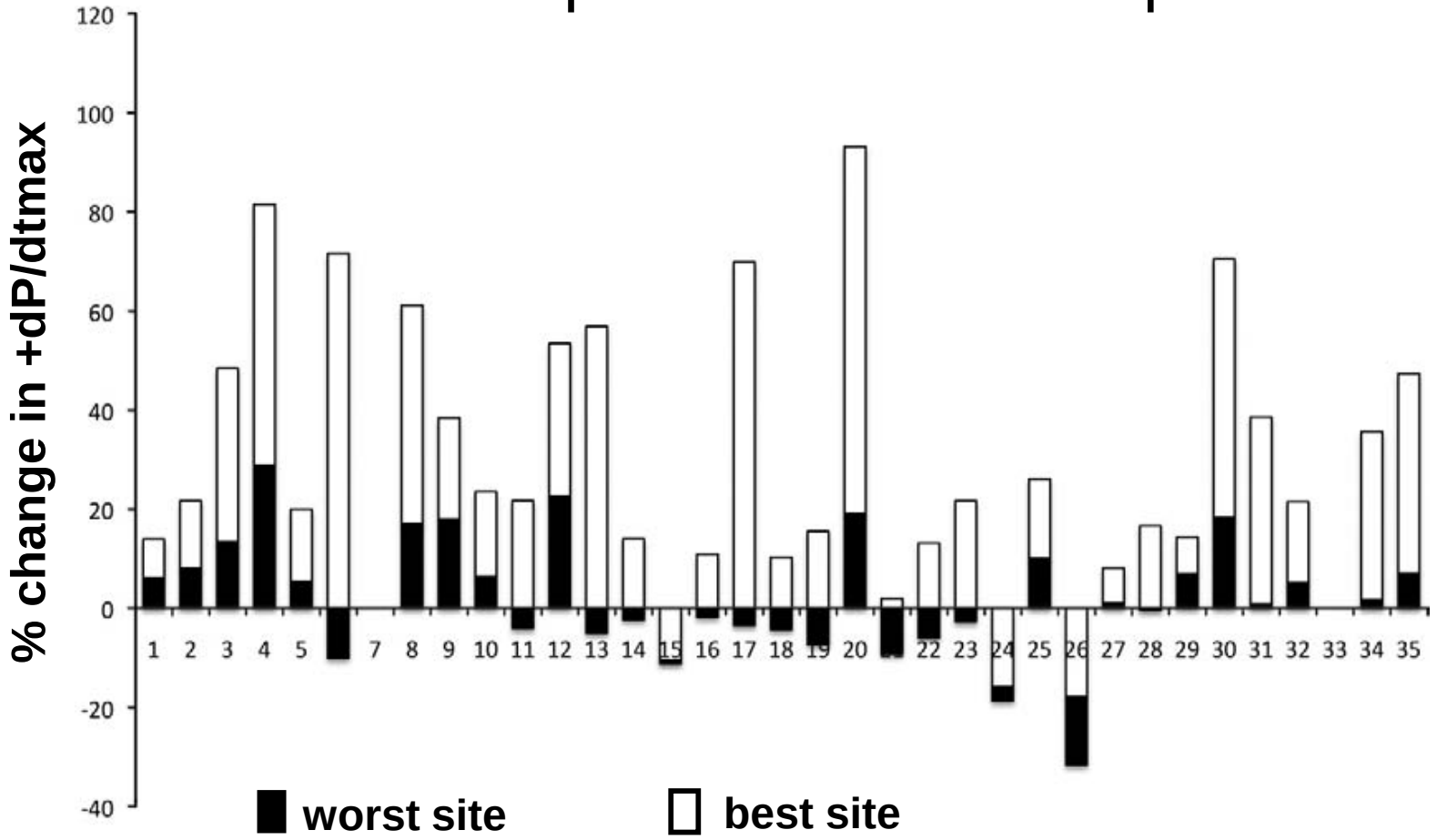


"CRT does not reduce LV dyssynchrony in patients with transmural scar tissue in the posterolateral LV segments, resulting in clinical and echocardio-graphic nonresponse to CRT."

Modif. From GB Bleeker et al. *Circulation*. 2006;113:969-976.

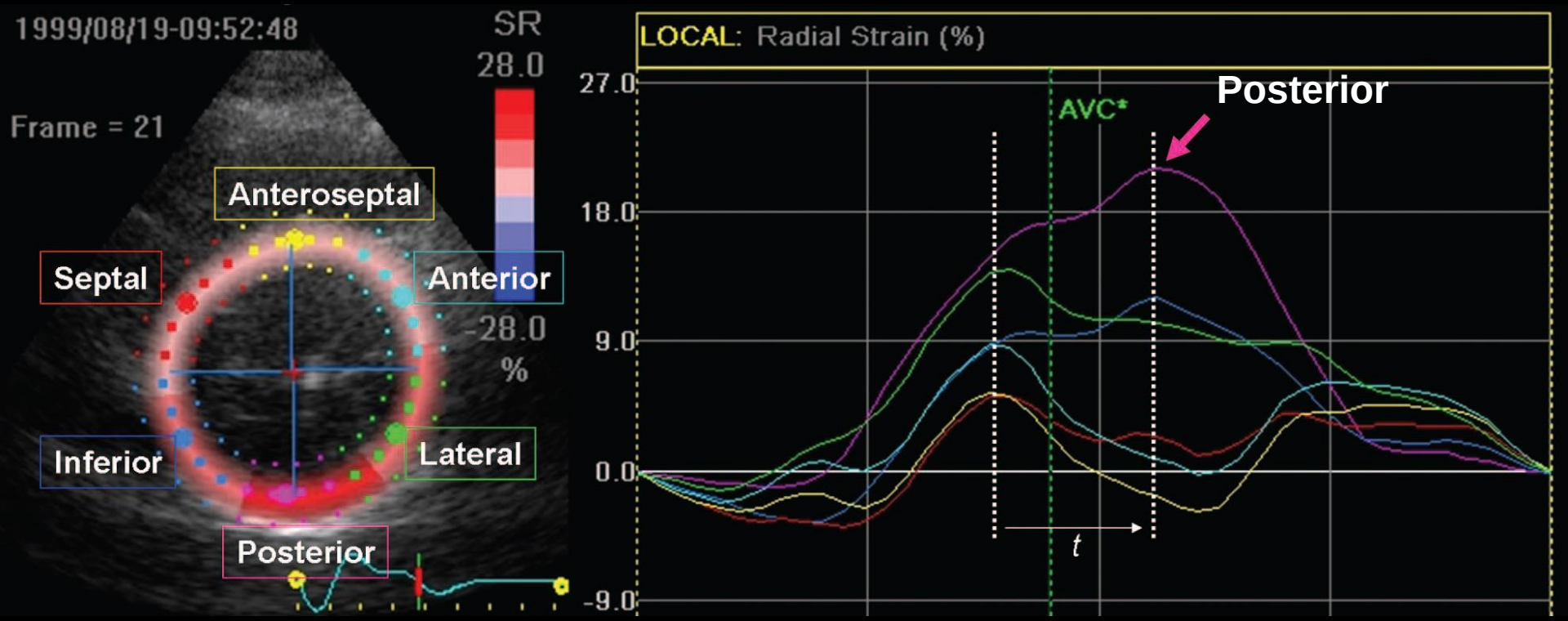
Pacing site matters

Acute response in individual patients



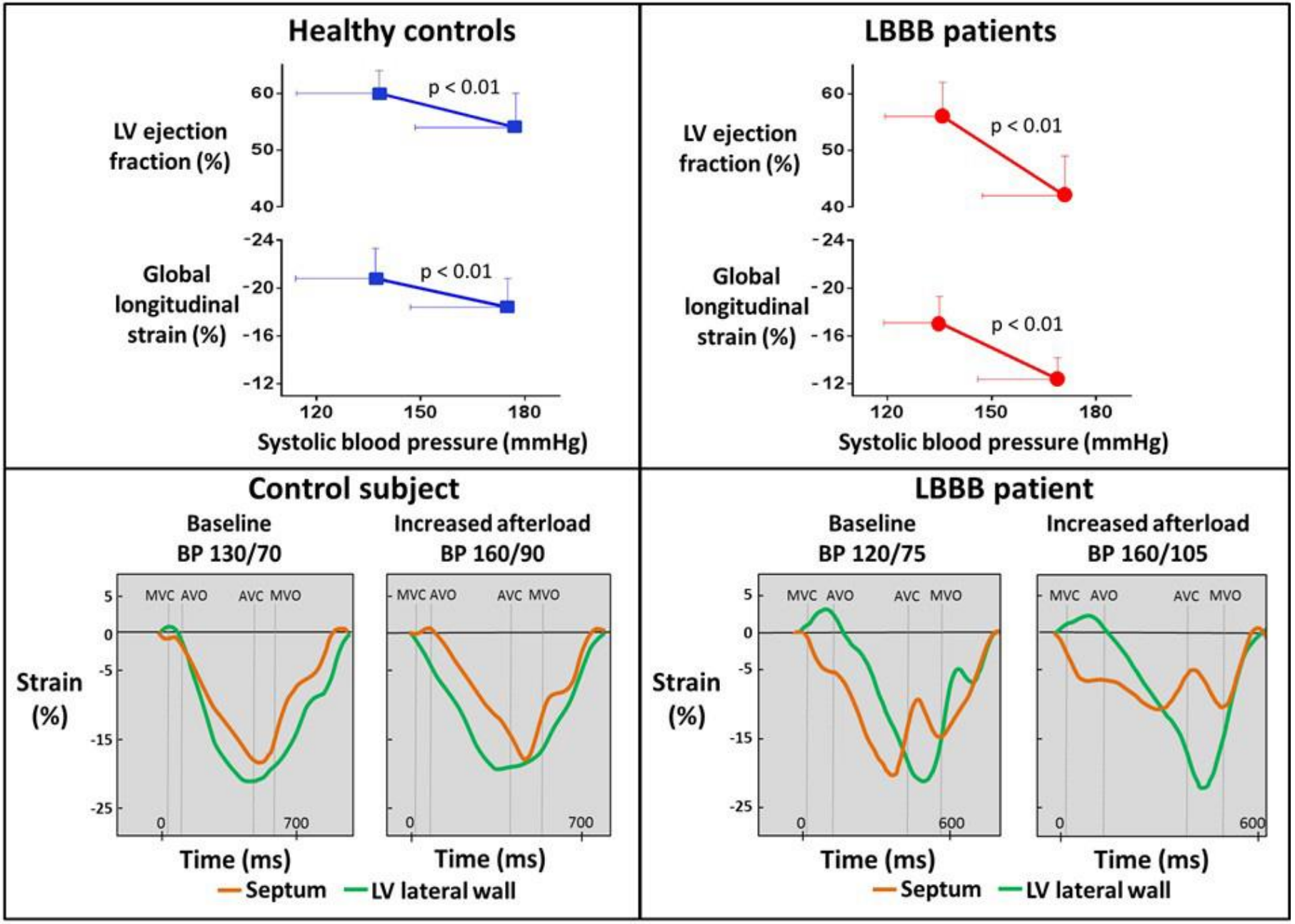
N. Derval et al. J Am Coll Cardiol. 2010;55:566-575.

The latest activated segment identifies the best pacing site



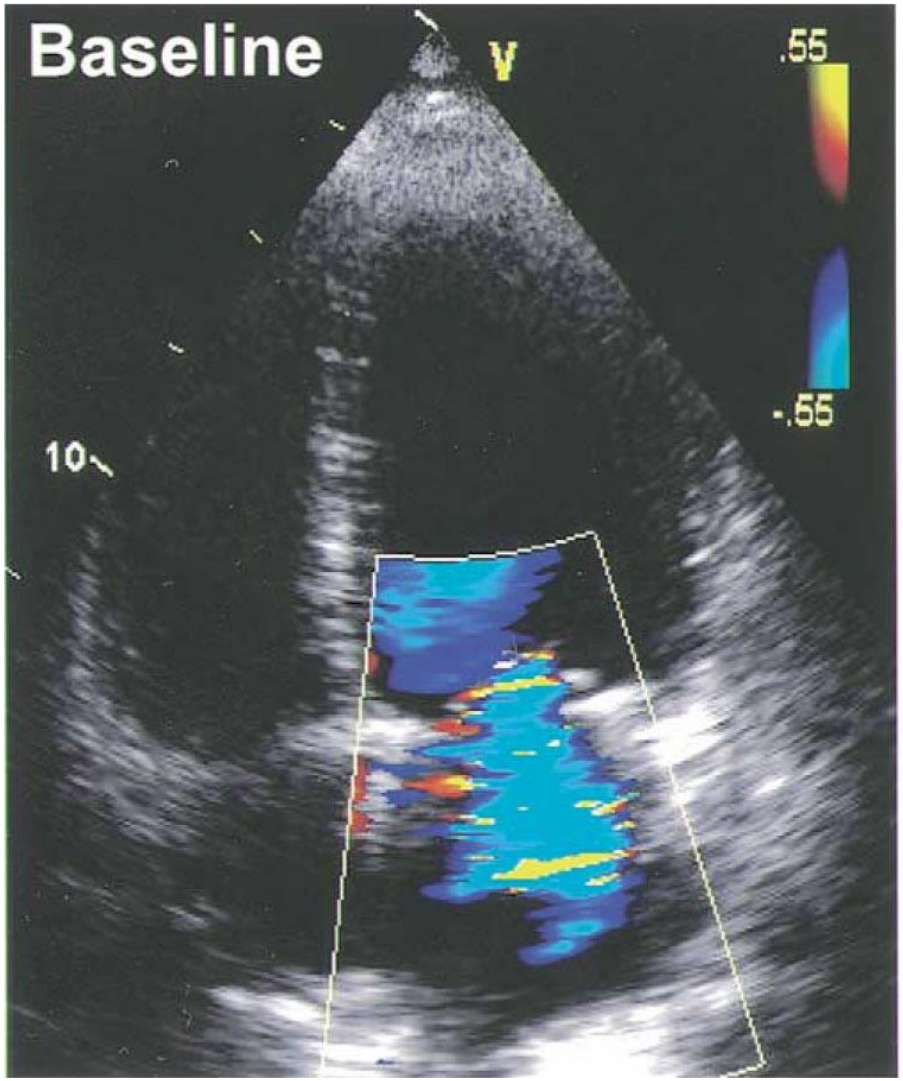
Modif. from V. Delgado et al. Circulation. 2011;123:70-78

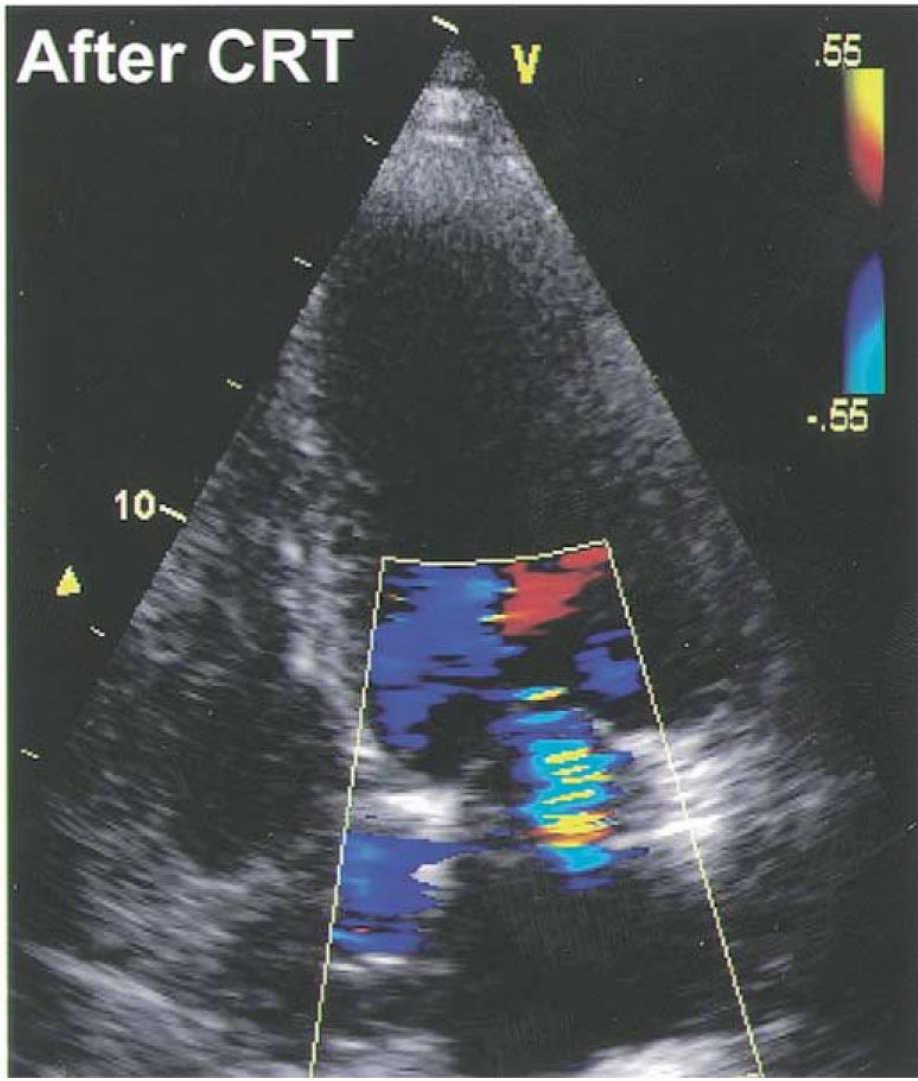
Dyssynchrony in apparently healthy individuals



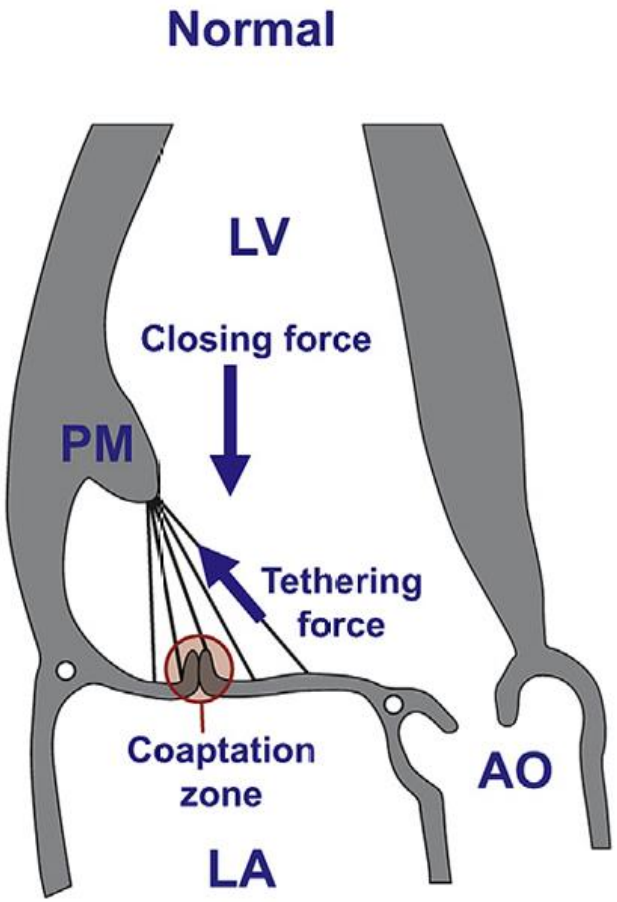
Aalen/ Smiseth et al. .JACC Cardiovasc Imaging. 2018 Jan 12

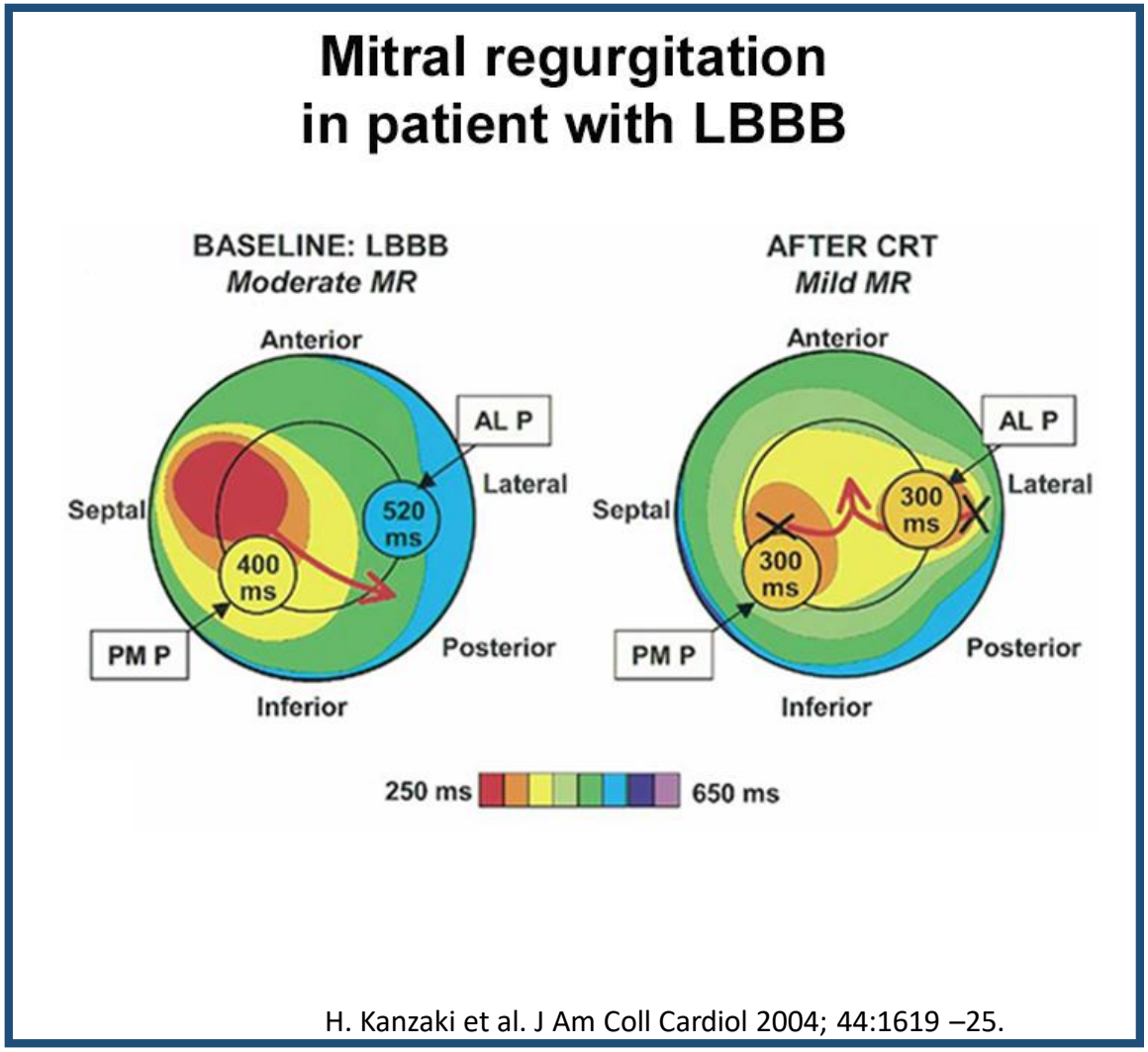
Mitral regurgitation in LBBB





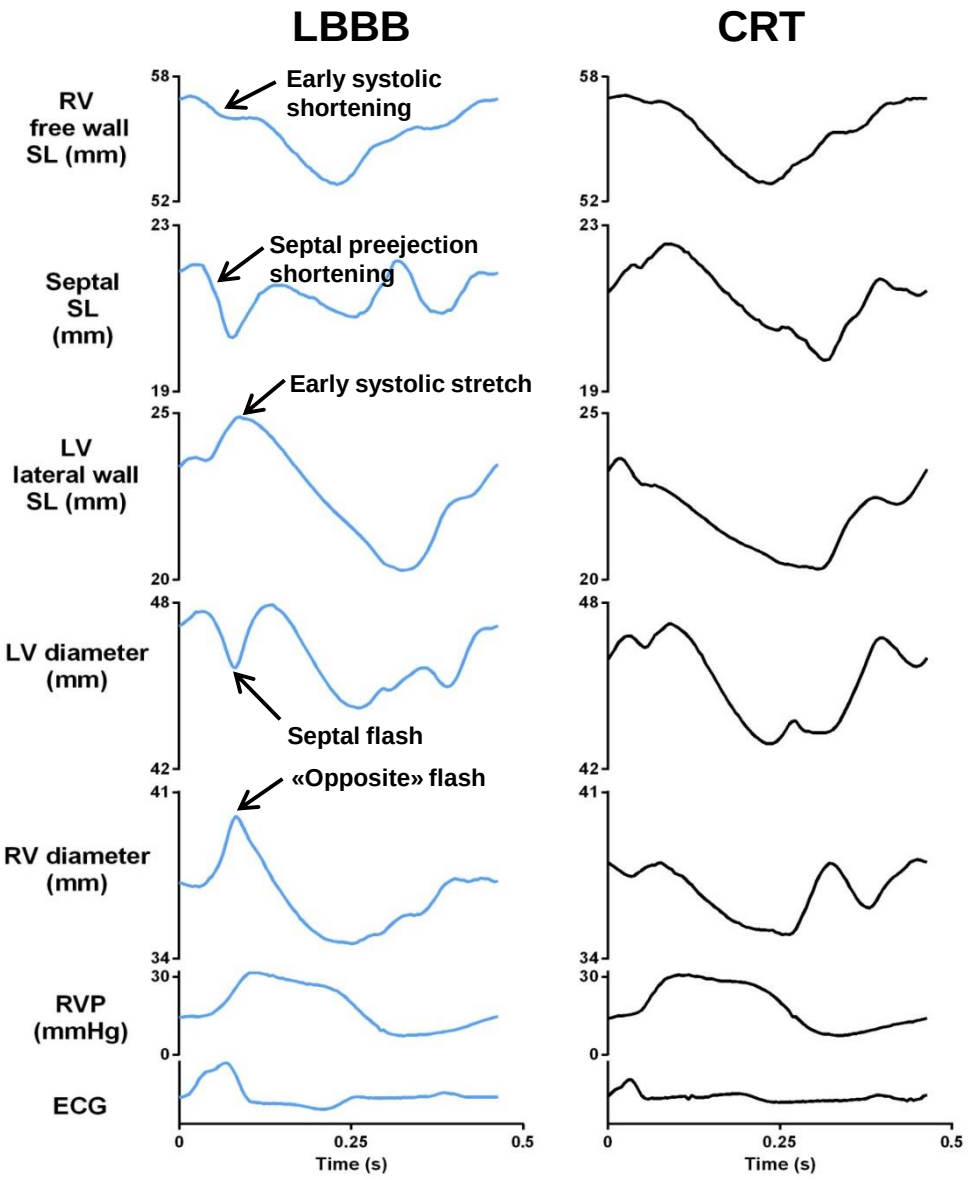
H. Kanzaki et al. J Am Coll Cardiol 2004; 44:1619 –25.





J.J. Silbiger. J Am Soc Echocardiogr 2013;26:1107-17.

What about the Right Ventricle?



SL= segment length

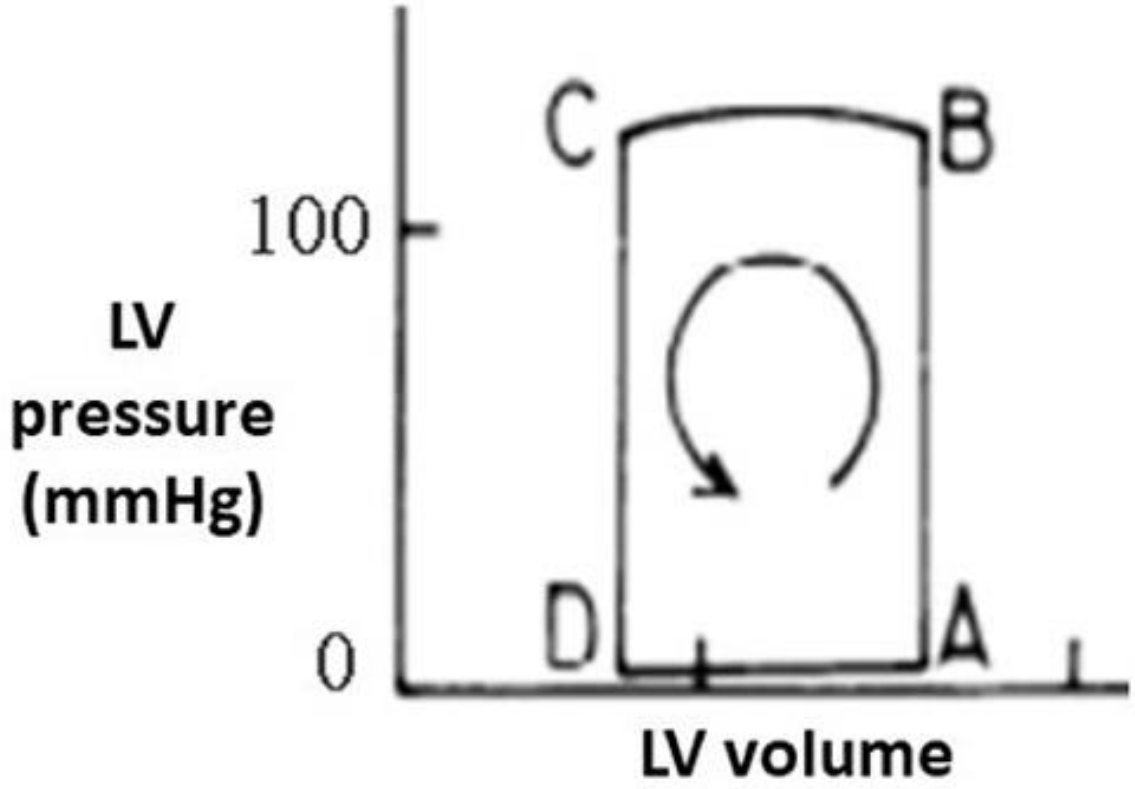
P. Storsten/H. Skulstad et al. 2018

ACCF/HRS/AHA/ASE/HFSA/SCAI/SCCT/SCMR Appropriate Use Criteria for ICD/CRT.

"There is current controversy on the role of dyssynchrony in assessing the likelihood of response to CRT, and this argues that dyssynchrony assessments should not be included in consideration for CRT implantation."

JACC Vol. 61, No. 12, 2013

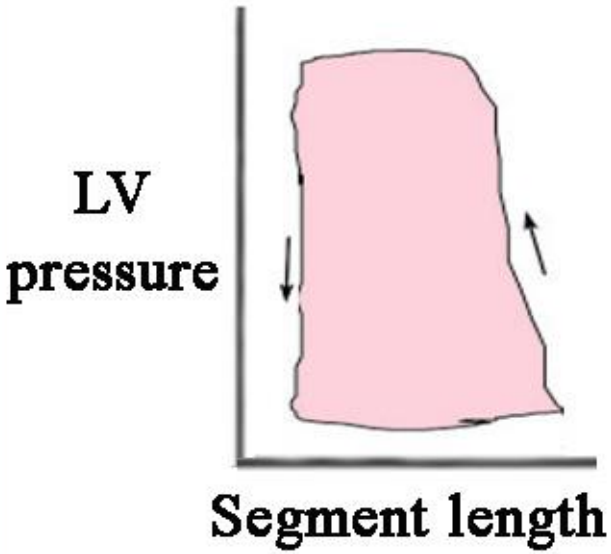
Area of the LV pressure-volume loop reflects myocardial work and oxygen consumption



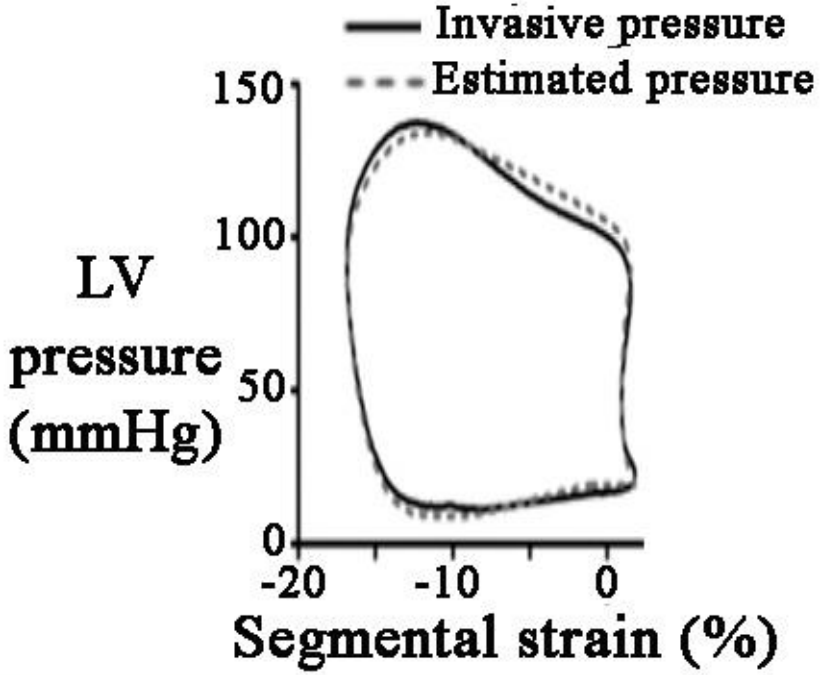
Suga H. Am J Physiol,1979

Area of the loop reflects segmental work

Animal experiment

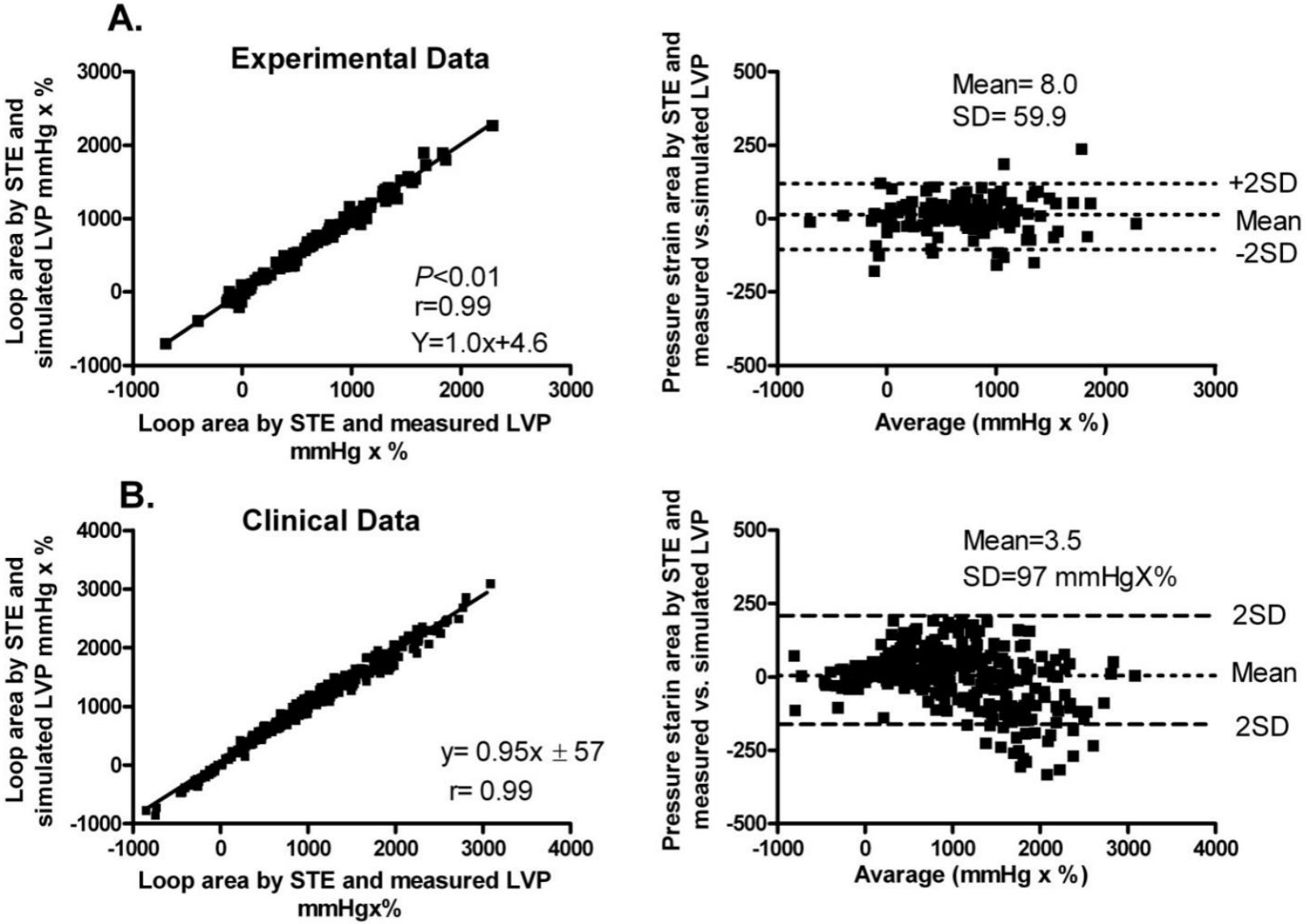


Patient with heart failure



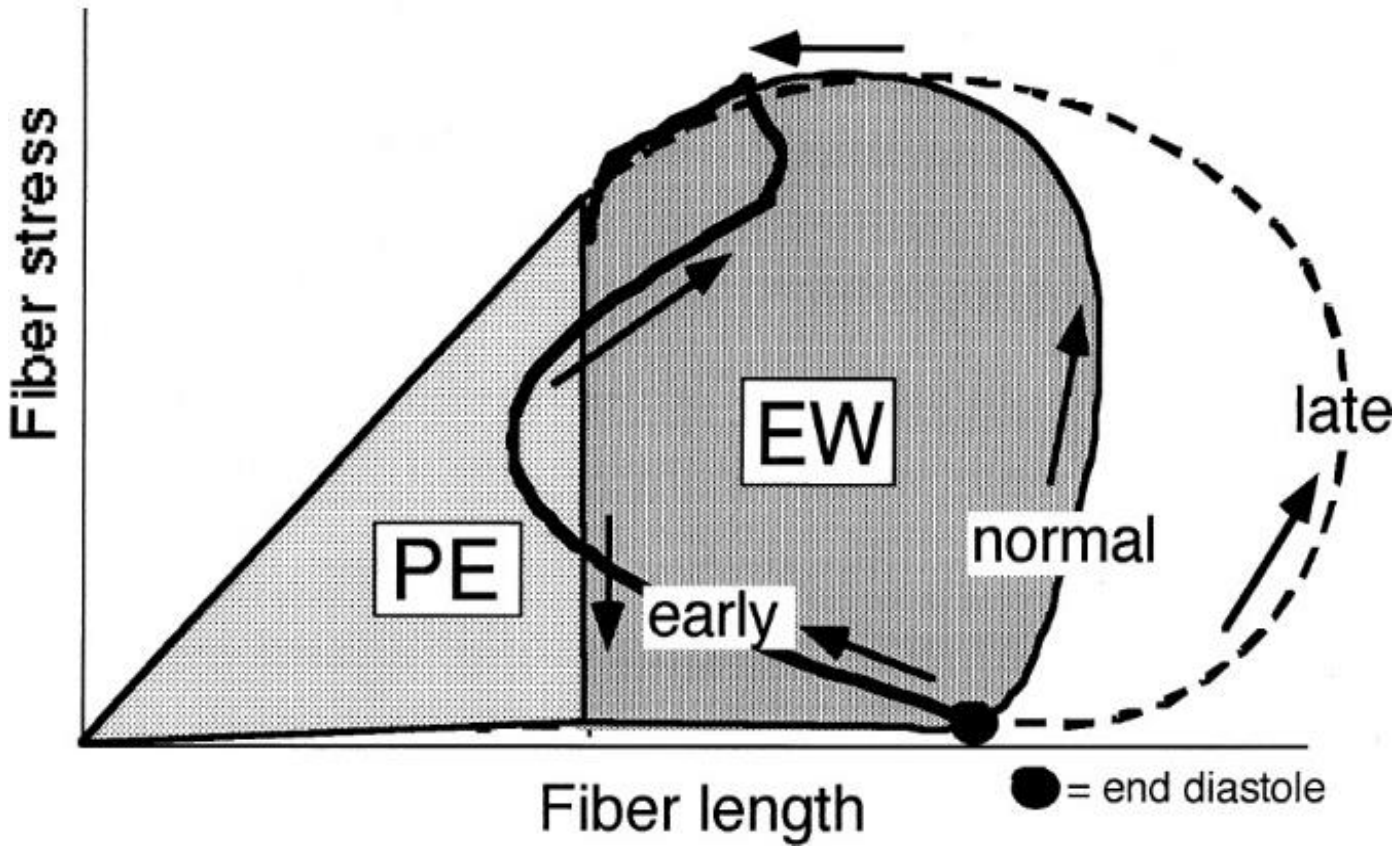
Modified from Russell/Smiseth et al. Eur Heart J 2012; 33 (6): 724-733.

Area of pressure strain loops measured vs simulated pressure



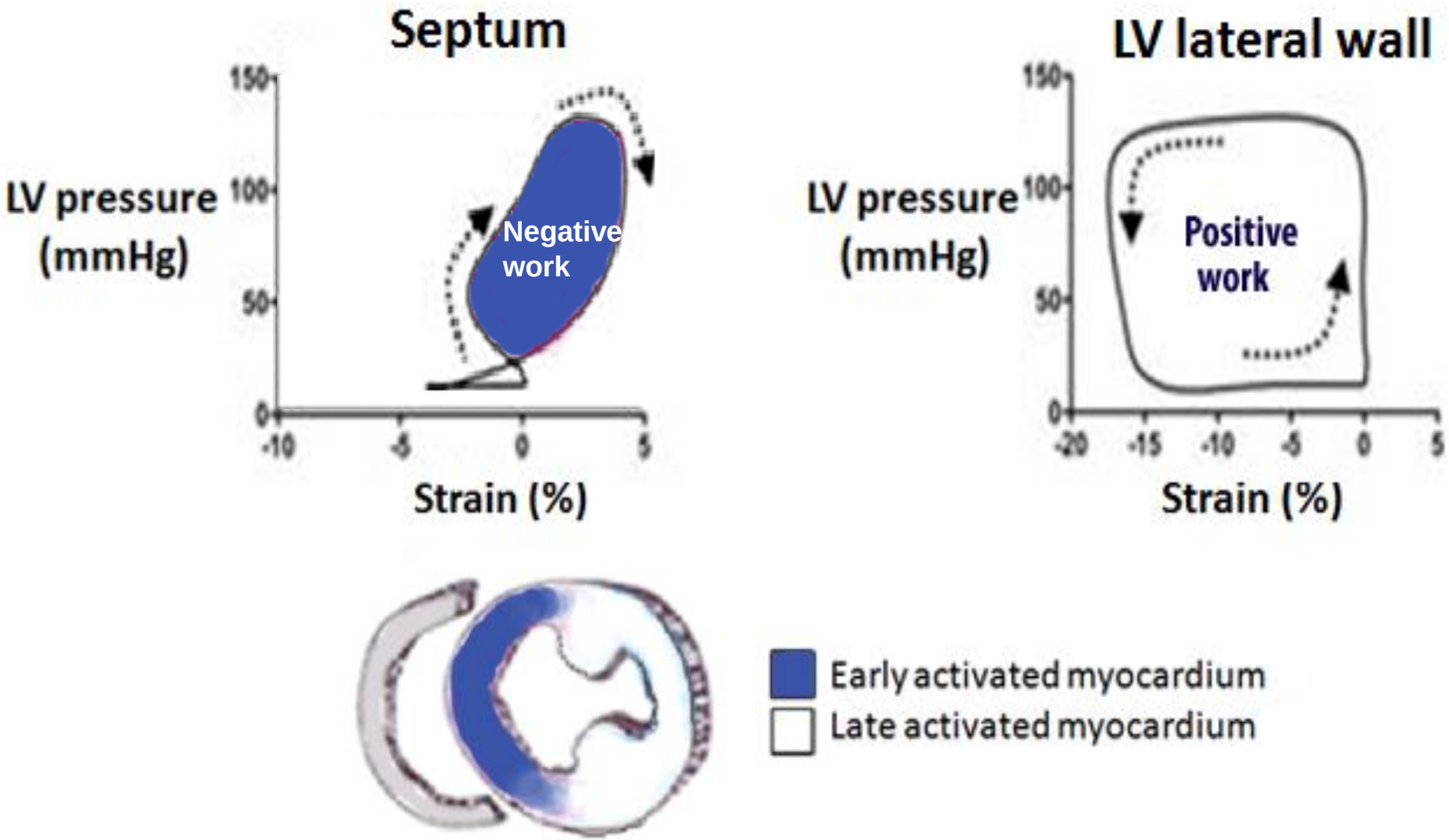
Russell/Smiseth et al. Eur Heart J 2012; 33 (6): 724-733.

MRI Tagging During Ventricular Pacing

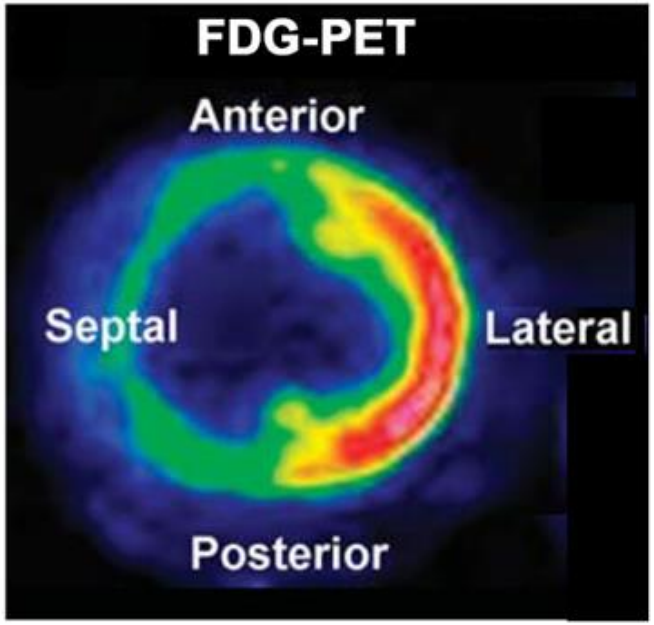


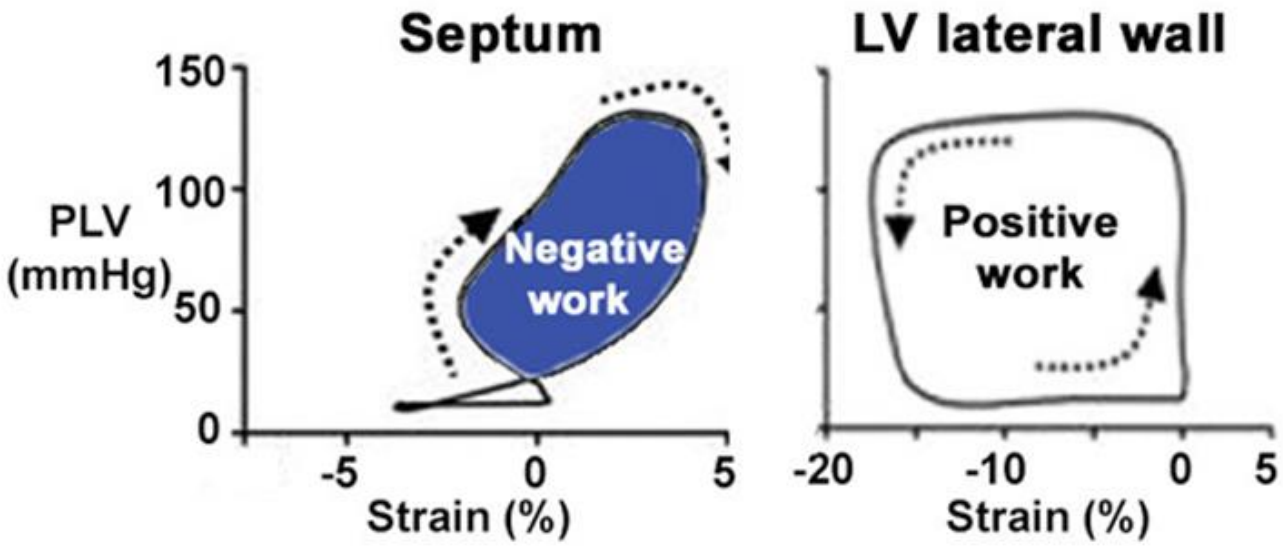
FW Prinzen et al, J Am Coll Cardiol 1999;33:1735– 42.

Patient with LBBB



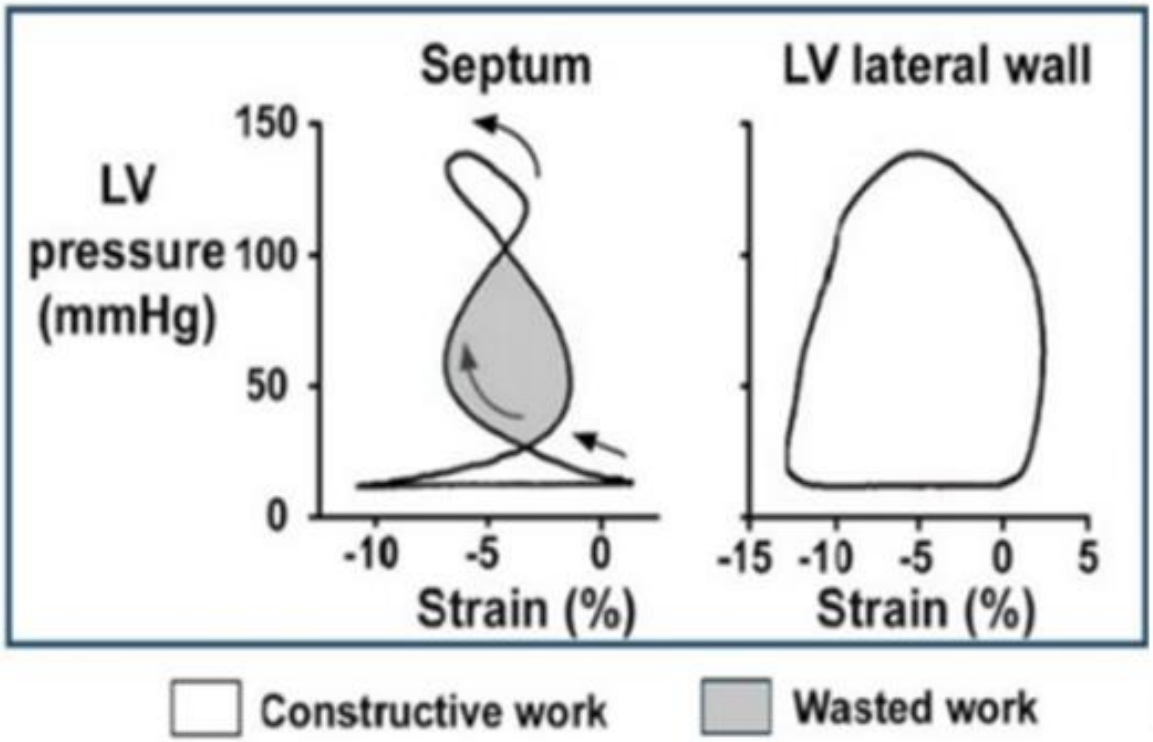
OA Smiseth, 2018

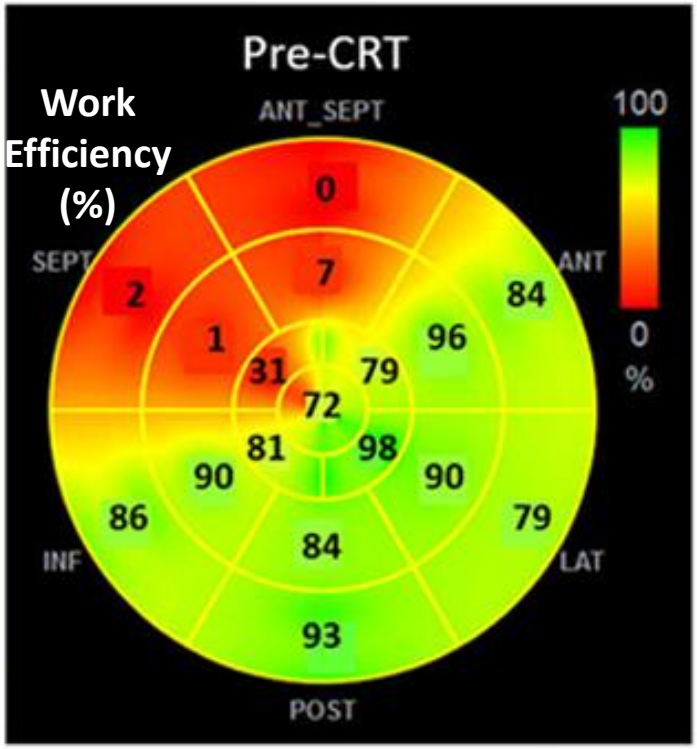




Modified from Russell/Smiseth et al. Eur Heart J 2012; 33: 724-733.

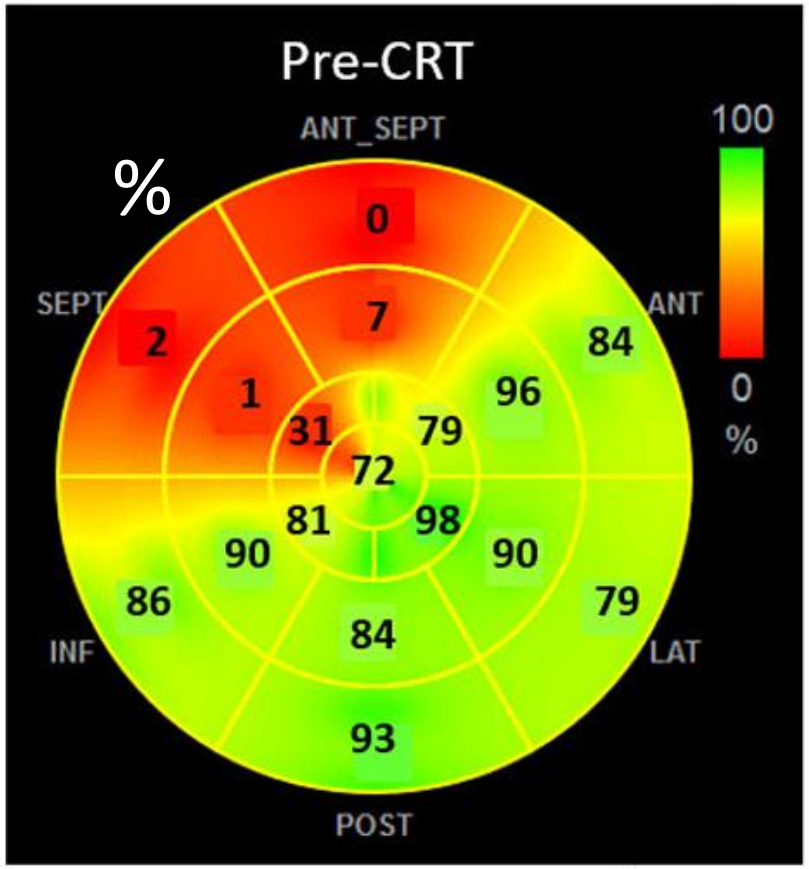
$$\text{Myocardial work efficiency}\,(\%) = \frac{\text{Constructive work}}{\text{Wasted work + Constructive work}}$$

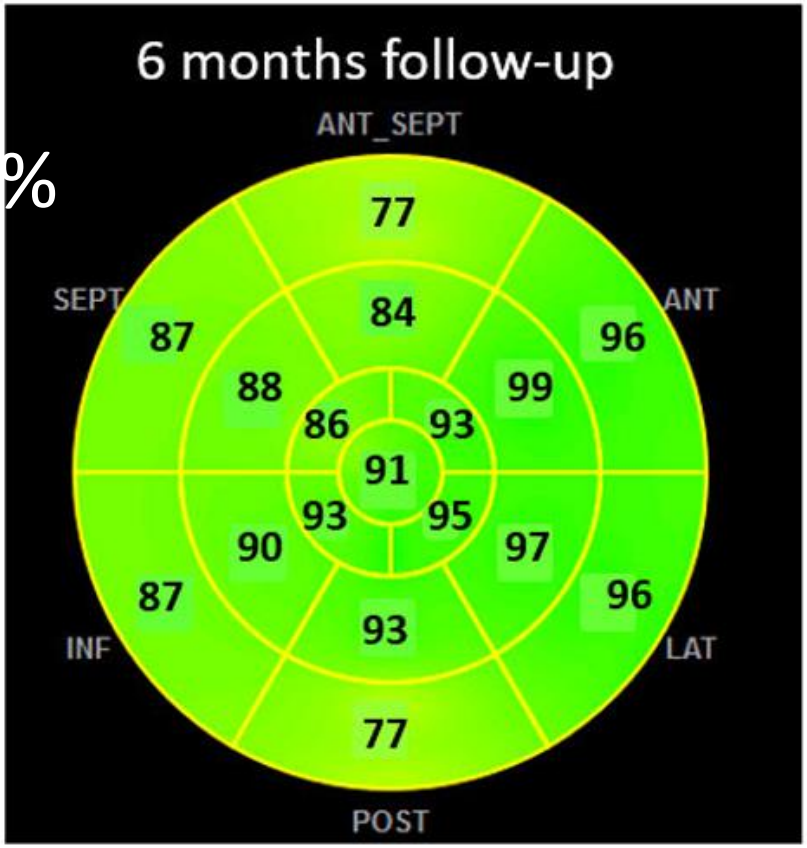




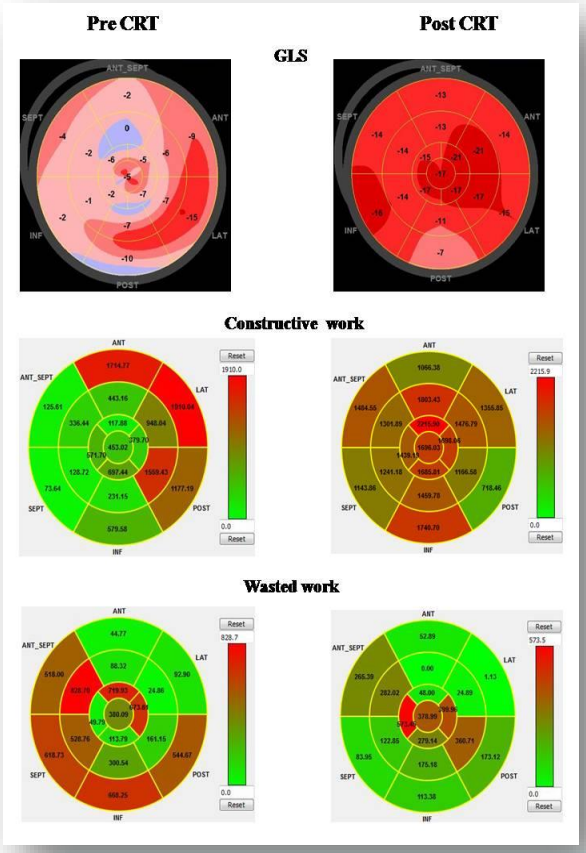
OA Smiseth and J Aalen. Trends Cardiovasc Med. 2018, Oct 25. Free access.

Effect of CRT on Myocardial Work Efficiency

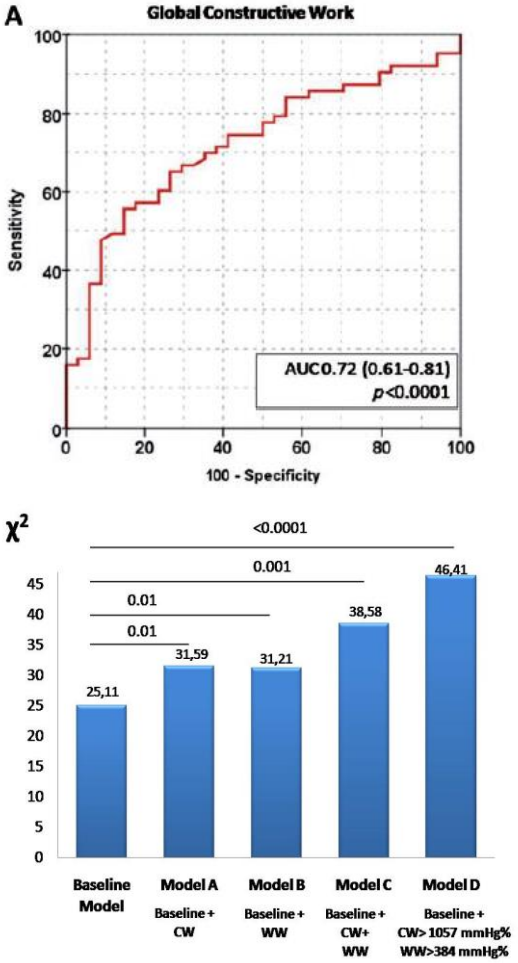




OA Smiseth and J Aalen. Trends Cardiovasc Med. 2018, Oct 25. Free access.



CW> 1057 mmHg is a predictor of CRT response with a OR of 8.05 (p<0.001)



Galli E, Donal E et al. Eur J CV Imaging 2017
Galli E, Donal E et al JASE 2018

The CRID study

Contractile Reserve In Dyssynchrony: A novel principle to identify candidates for Cardiac Resynchronisation Therapy

Oslo, Leuven, Rennes, Aalst, Karolinsk
To be published 2020.

Machine Learning Algorithm Predicts Cardiac Resynchronization Therapy Outcomes

Lessons From the COMPANION Trial

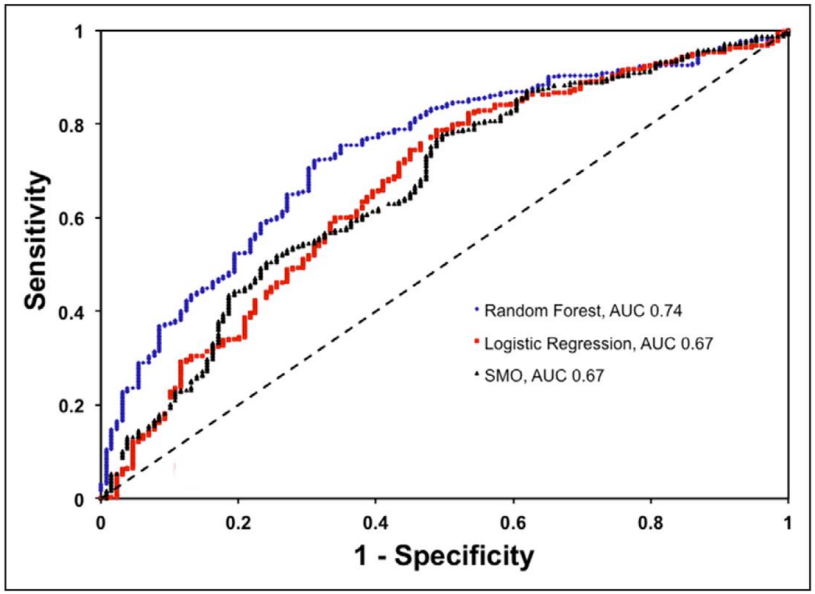
Kalscheur MM et al., Circ Arrhythm Electrophysiol. 2018 Jan;11(1):e005499.

Table. Forty-Five Features Used in Final Model Development

Domain	Individual Features
Demographics	Sex, age
Physical characteristics	Body mass index, heart rate, systolic blood pressure, diastolic blood pressure, pulse pressure
Heart failure	Cause, duration of heart failure, NYHA class, 6-minute walk distance
LV assessment	LV ejection fraction, method of LV assessment, LV end-diastolic diameter
ECG	QRS duration, PR interval, QRS morphology
Comorbid conditions	Intermittent atrial arrhythmia, diabetes mellitus, hepatic disease, cerebrovascular disease, peripheral vascular disease, carotid artery disease, pulmonary hypertension, renal disease, hypertension, hyperlipidemia, other, no comorbid conditions
Surgical interventions	CABG, valve replacement, angioplasty, coronary stent, no cardiac surgeries
Medications classes	ACE inhibitor, angiotensin-receptor blocker, anticoagulant, lipid lowering, antiplatelet, β-blocker, calcium channel blocker, digoxin, nitrate, aldosterone antagonist, class III antiarrhythmic

ACE indicates angiotensin-converting enzyme; CABG, coronary artery bypass grafting; LV, left ventricular; and NYHA, New York Heart Association.

LV ejection fraction, method of LV assessment, LV end-diastolic diameter



Kalscheur MM et al., Circ Arrhythm Electrophysiol. 2018 Jan;11(1):e005499.

How can we do better?

Proposed algorithm: Selecting pts for CRT

Rule in

1. Heart failure and low EF
2. QRS > 120 ms
3. Dominantly wasted work
   In the septum.

Rule out

1. Scar in LV lateral wall
2. Scar in septum
3. Preterminal HF, «point of no return»

OA Smiseth, 2018

Conclusions

1. Follow the guidelines

2. With patients in the «grey zone», including wide QRS with atypical morphology, atrial fibrillation and QRS 120-150ms, do imaging of septal motion. In these cases septal motion patterns consistent with LBBB type activation pattern, favours CRT.

3. Define scar distribution to optimize positioning of pacing leads.