

SRDEČNÍ RESYNCHRONIZAČNÍ LÉČBA U VSV

J. Janoušek

Dětské kardiocentrum

2. LF UK a FN v Motole

9.–11. listopadu 2025
Clarion Hotel Olomouc

XXII.

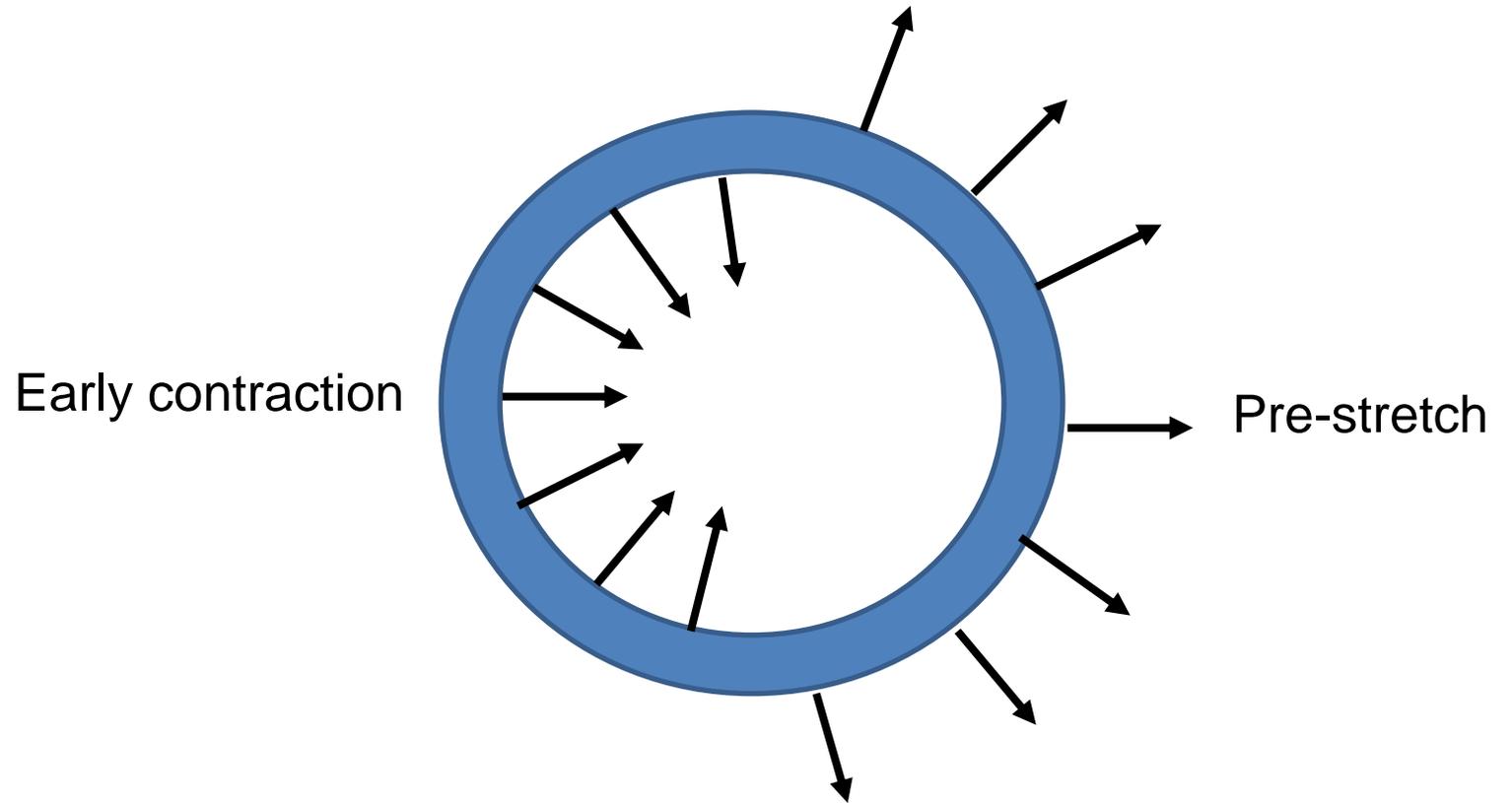
**ČESKÉ A SLOVENSKÉ
SYMPOZIUM O ARYTMIIÍCH
A KARDIOSTIMULACI**



Components of cardiac output

- Heart rate
 - Contractility
 - Preload
 - Afterload
- AND
- **Synchrony!**

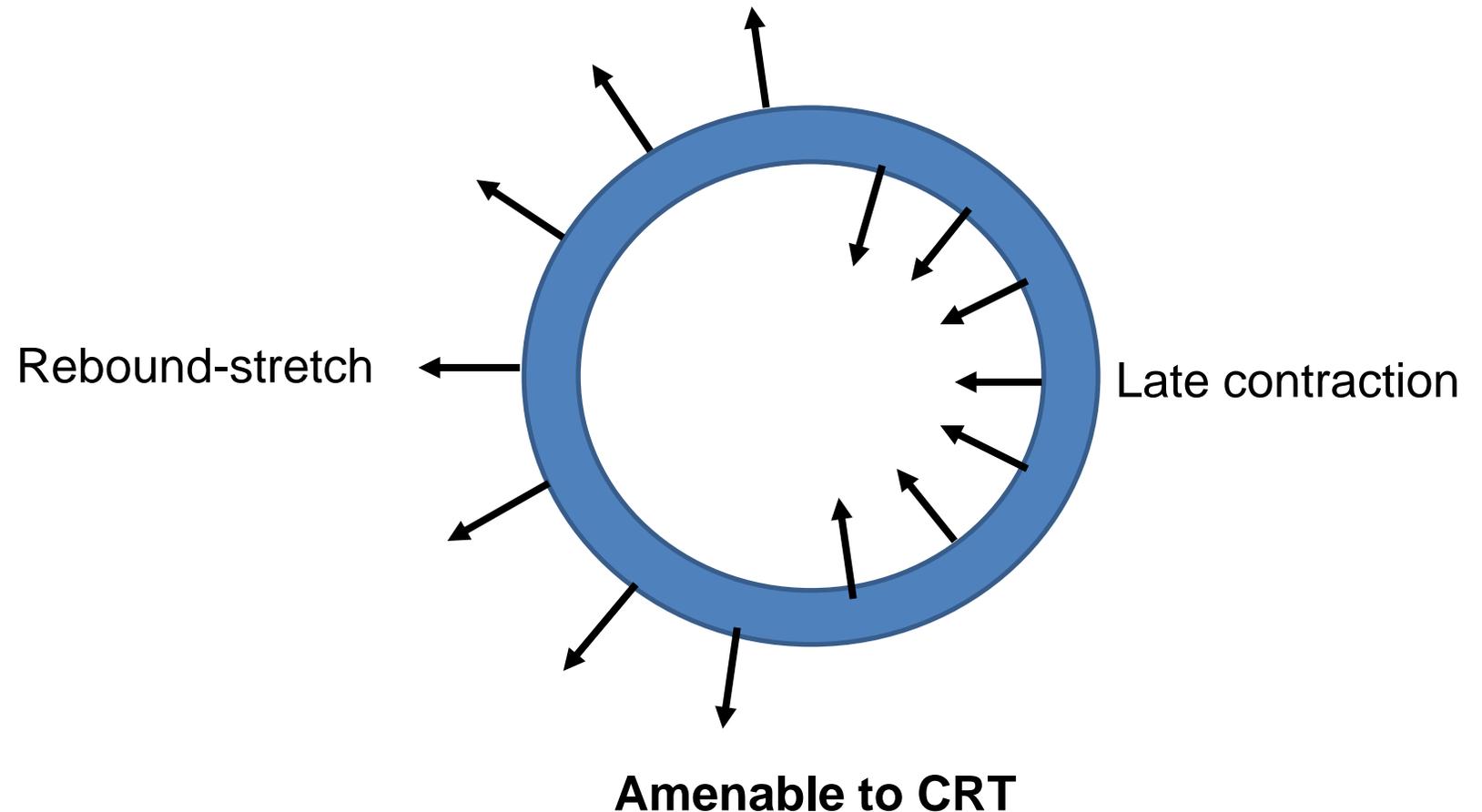
Clustered electromechanical dyssynchrony



Components of cardiac output

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- AND
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Clustered electromechanical dyssynchrony



What are the indications for CRT?

- Systemic LV failure
 - Left bundle branch block
 - RV paced
- Systemic RV failure
 - Right bundle branch block
 - LV paced
- Single-ventricular failure
 - Any bundle branch block
 - Single site pacing
- Pulmonary RV failure
 - Right bundle branch block

Specific for CHD

Much more structural and functional diversity!

What are the indications for CRT?

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 - Right bundle branch
 - LV paced
- Single-ventricular failure
 - Any bundle branch
 - Single site pacing
- Pulmonary RV failure
 - Right bundle branch

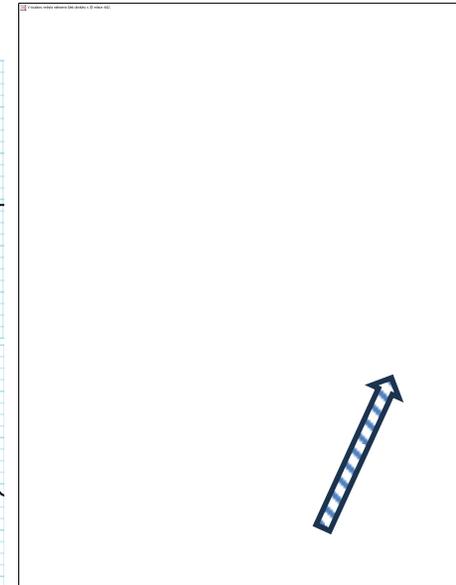
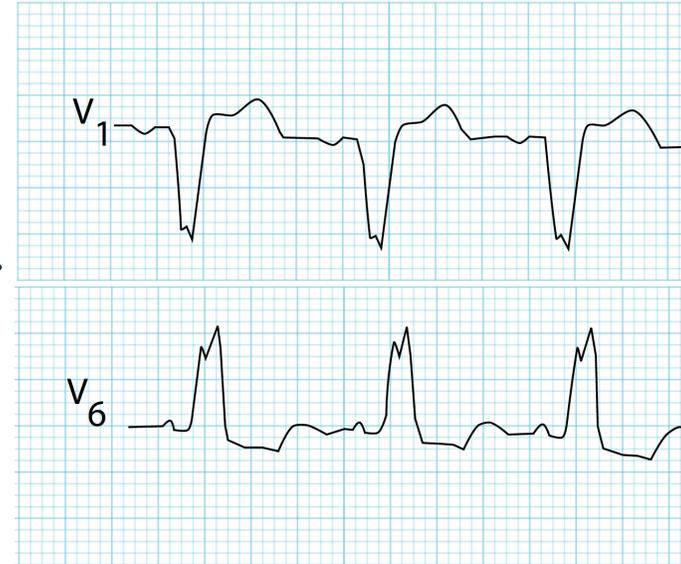
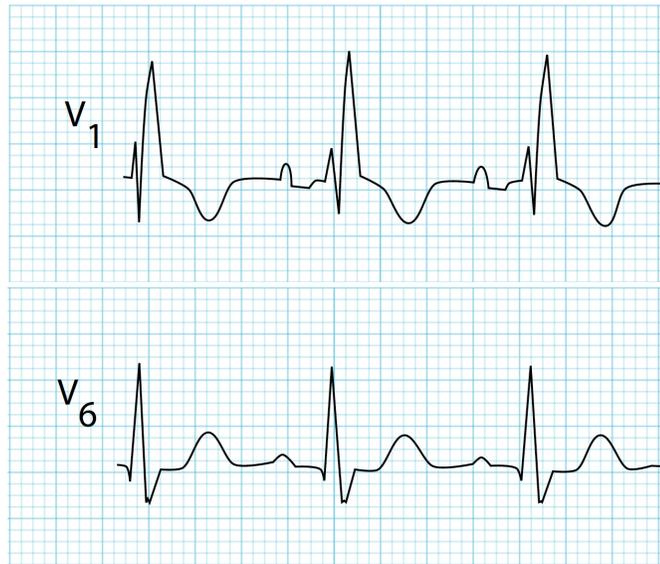
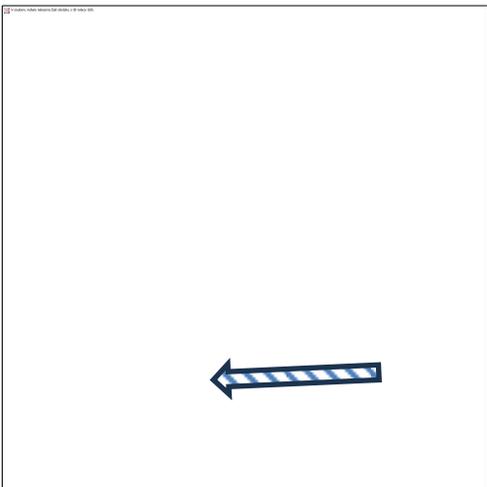
2023 HRS/APHRS/LAHRS guideline on cardiac physiologic pacing for the avoidance and mitigation of heart failure ^e EF <45 %

Recommendations for CHD			
COR	LOE	Recommendations	References
2a	C-LD	1. In patients with CHD on GDMT with a systemic LV, LVEF <45%, and ventricular dyssynchrony (as defined by a QRS duration z score of ≥3 or ventricular pacing ≥40%), CRT with BiV pacing is reasonable to reduce the risk of mortality or need for transplant.	400–408
2a	C-LD	2. In patients with CHD and a systemic single ventricle who require pacing, apical pacing is reasonable in preference to nonapical pacing.	409
2b	C-LD	3. In patients with CHD and a systemic single ventricle with symptomatic HF on GDMT, CRT with multisite ventricular pacing may be considered to maintain functional class or ventricular function.	400,402,410,411
2b	C-LD	4. In patients with CHD and a systemic RV with symptomatic HF on GDMT associated with ventricular electrical delay or requiring substantial ventricular pacing, CRT with BiV pacing may be considered to improve or maintain functional class or ventricular function.	400–408,412–415
2b	C-LD	5. In patients with CHD and a subpulmonary RV with RV dysfunction and RBBB, CRT with fusion-based pacing may be considered to improve RV function.	416–418
2b	C-LD	6. In patients with CCTGA and AV block in whom anatomic repair has not been performed, CSP with HBP or LBBAP may be considered to improve functional status.	419,420

Electrical imaging in dyssynchrony

- Keep things simple while looking for a CRT candidate
 - 12-lead ECG
 - Is there a conduction delay within the failing ventricle?
 - If so, think about CRT!

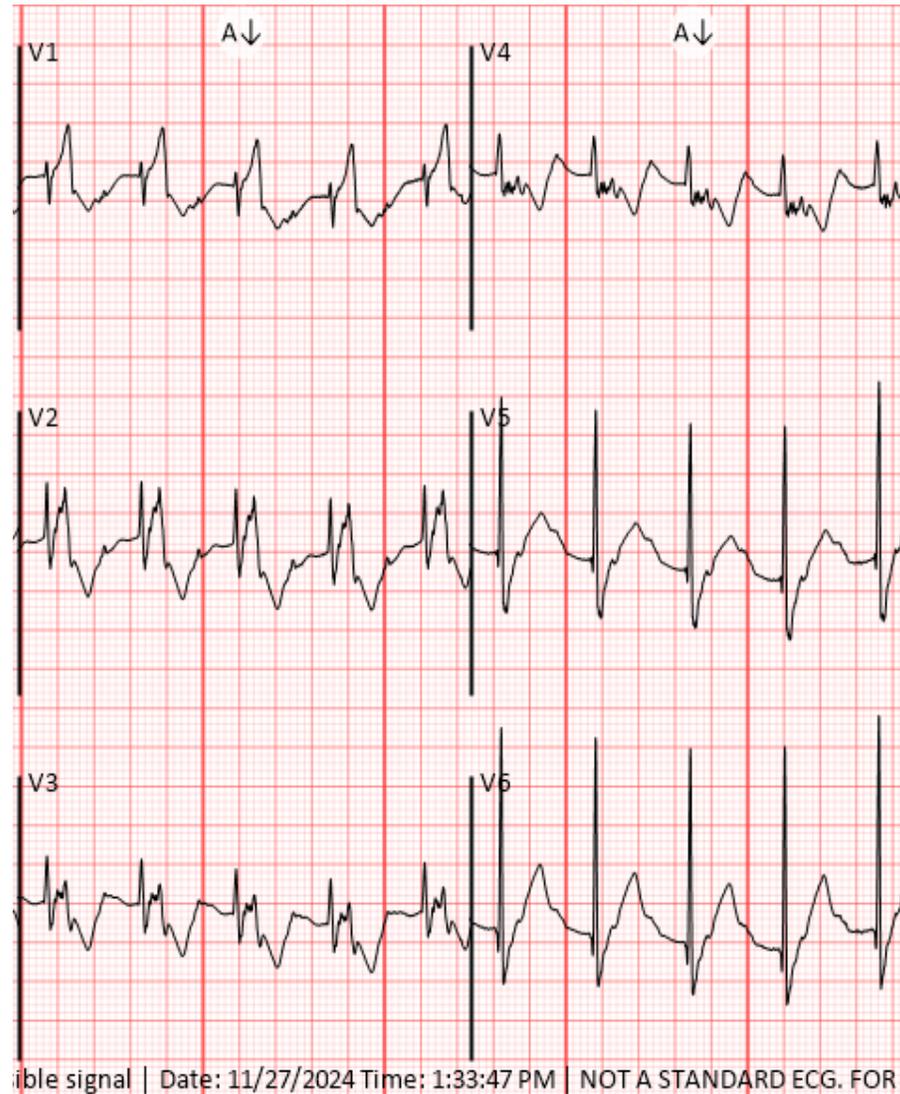
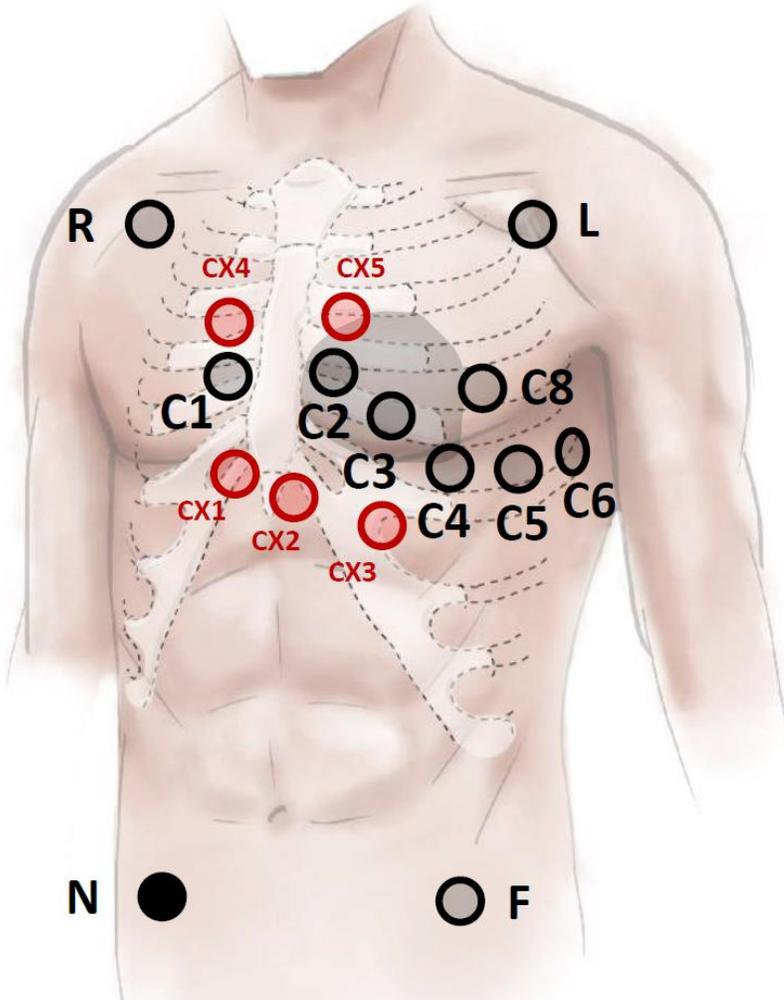
Right bundle
branch block



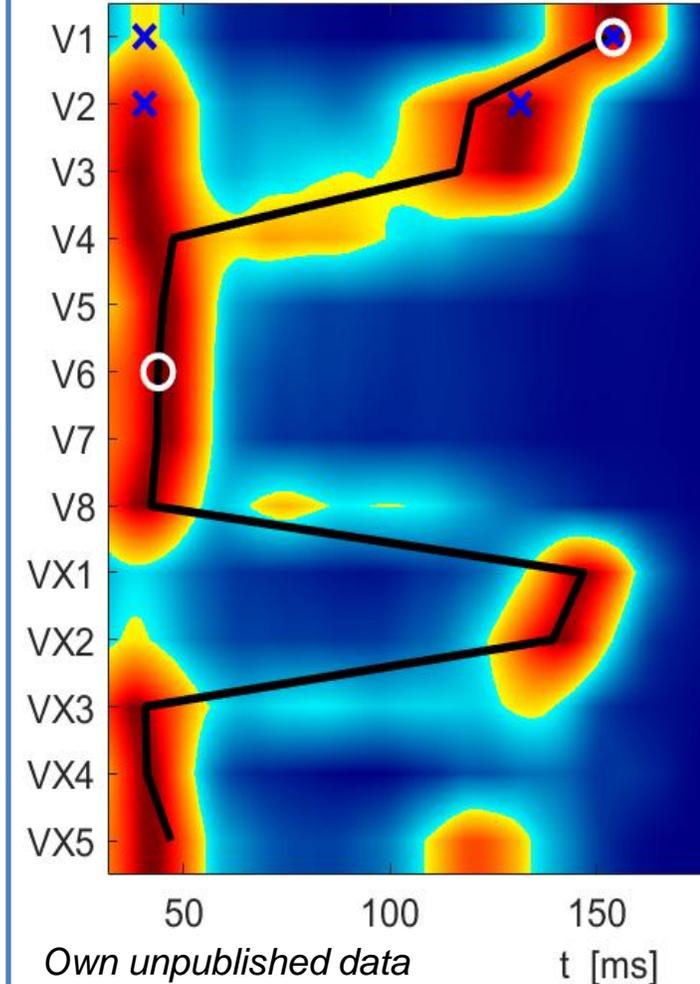
Electrical imaging in dyssynchrony

Ultra-high frequency ECG

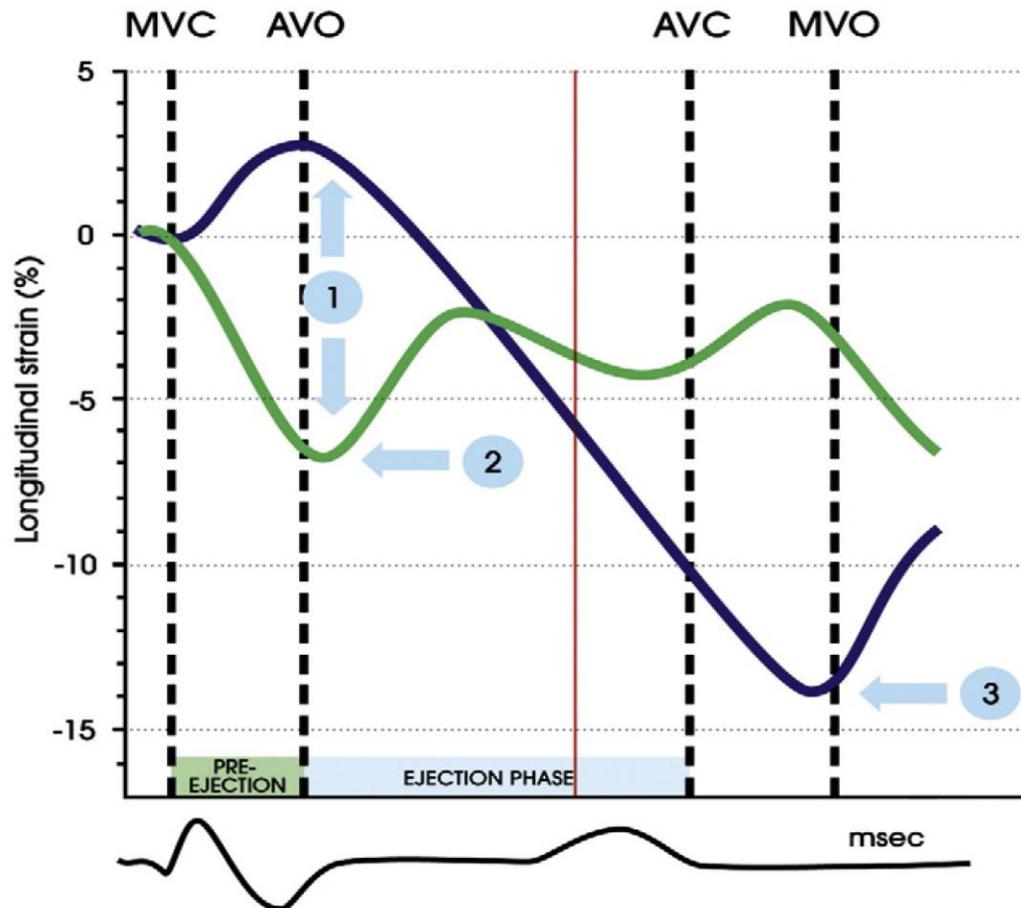
UHF-ECG lead positions



UHF ECG map



Mechanical imaging in dyssynchrony



Classic-pattern dyssynchrony

1. Early septal contraction and *early lateral wall stretching*
2. Peak septal contraction <70 % of ejection phase followed by *rebound stretch*
3. Peak lateral wall contraction after AVC

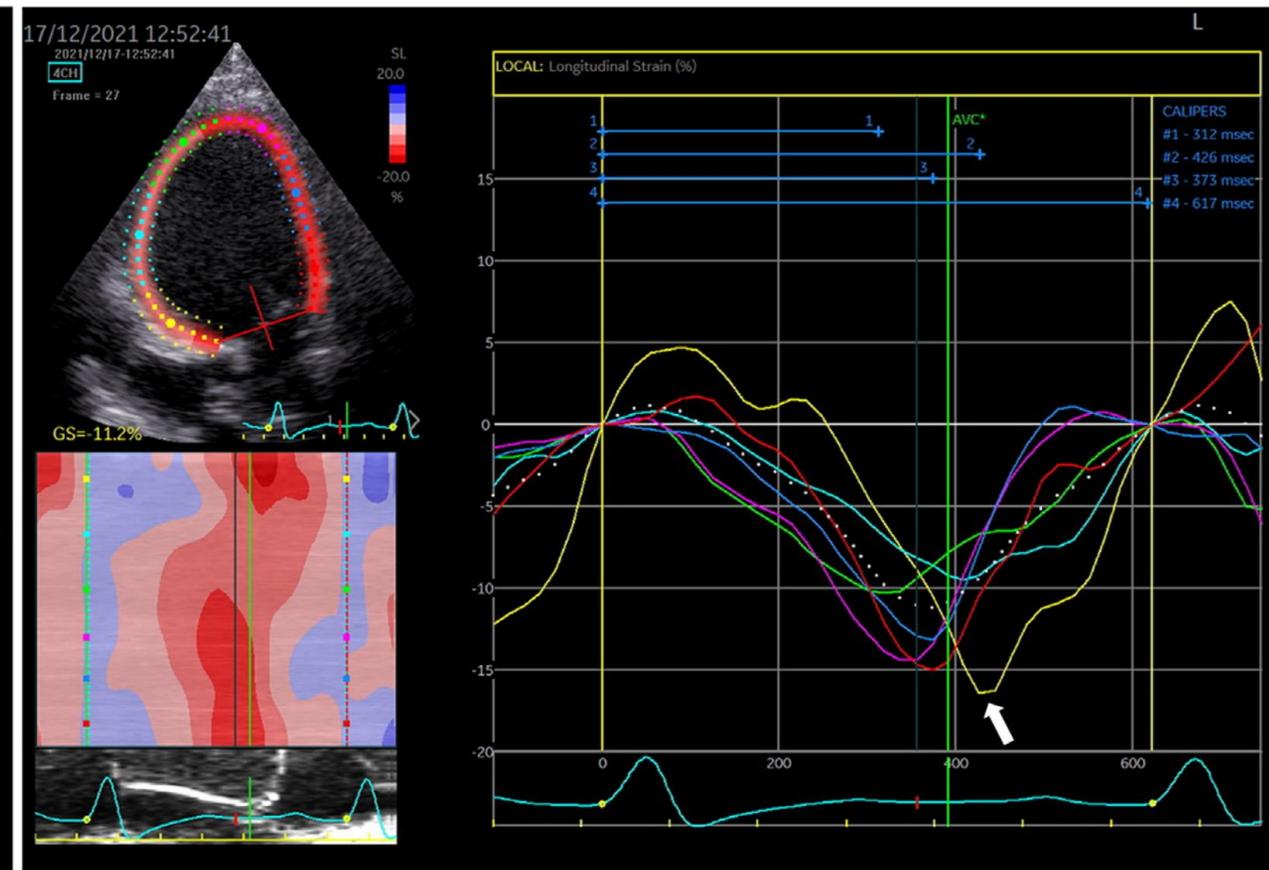
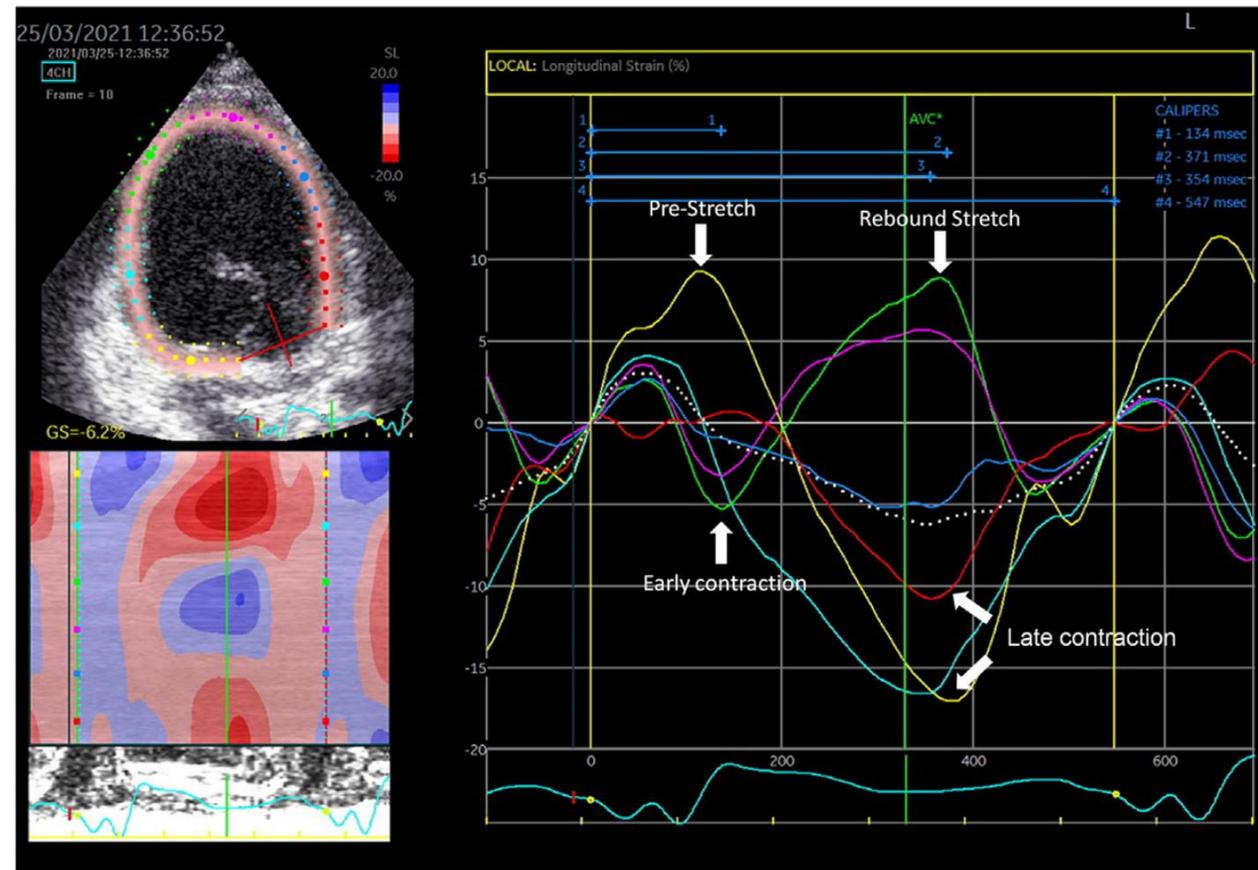
Correlates with CRT efficacy

Classic-pattern dyssynchrony in congenital heart disease

Single ventricle, LV type

Apical pacing

CRT

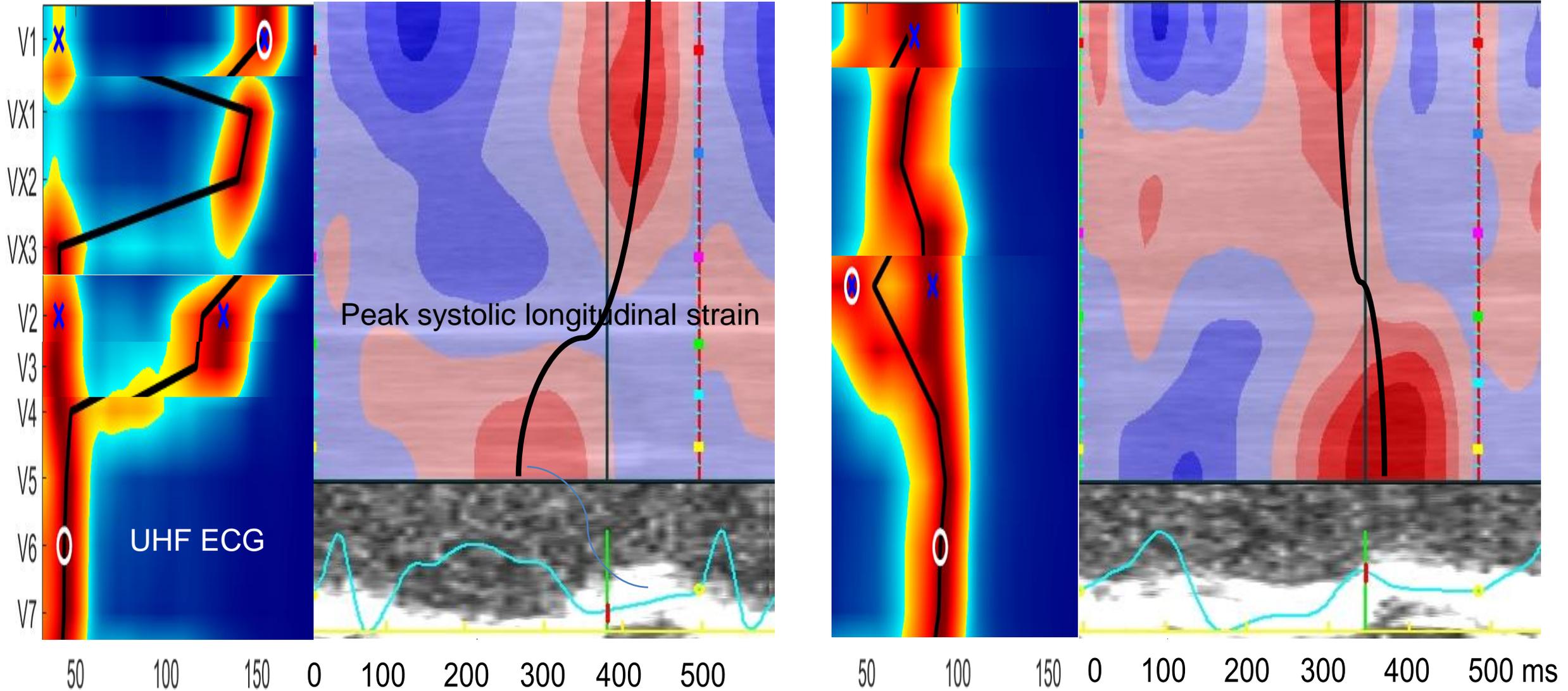


Electromechanical interaction

Before CRT

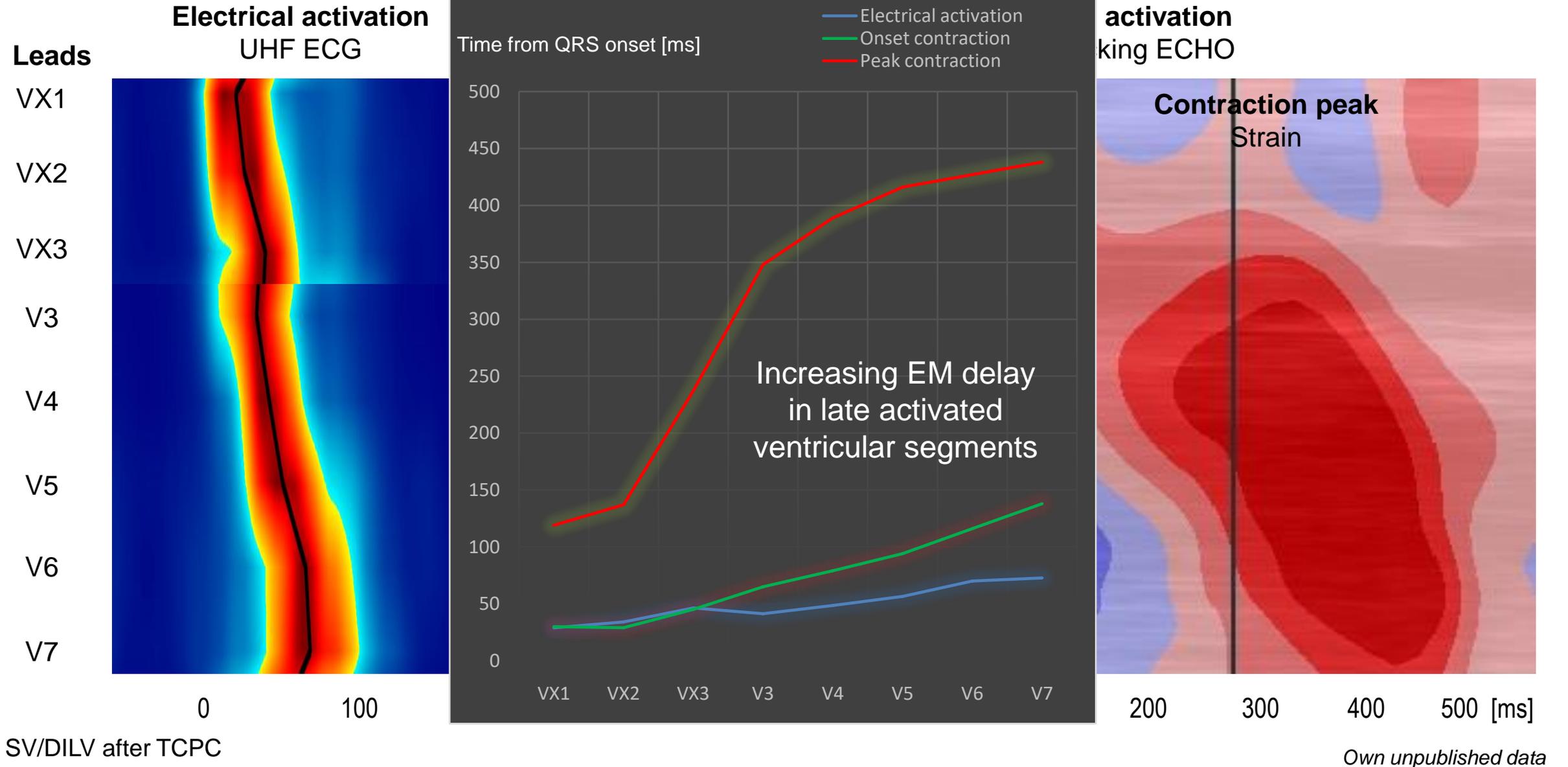
Ebstein after Cone repair

After RV-CRT



Own unpublished data

Electromechanical interaction

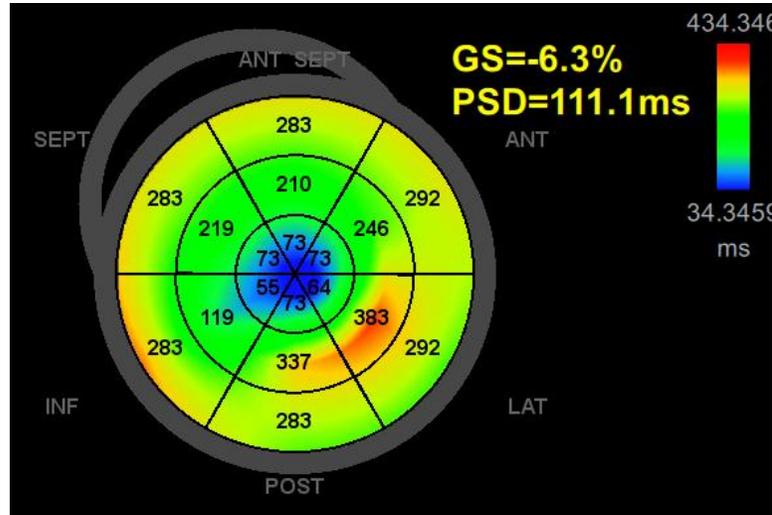


Myocardial work

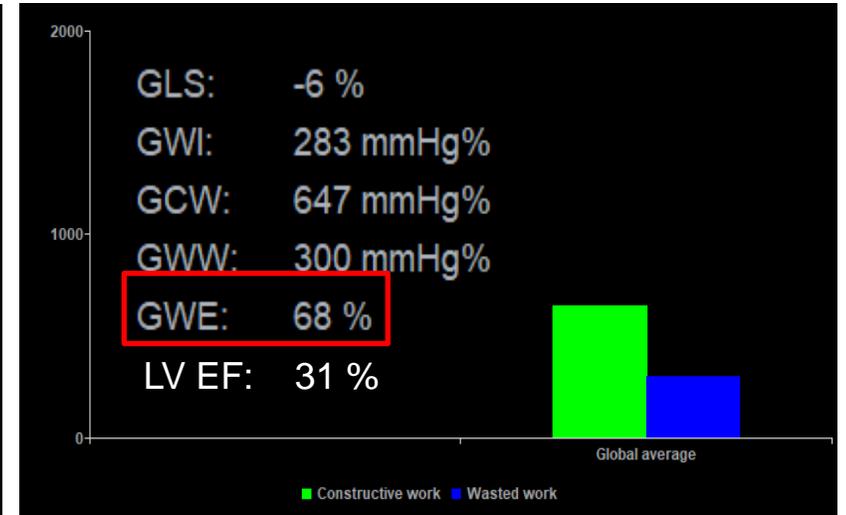
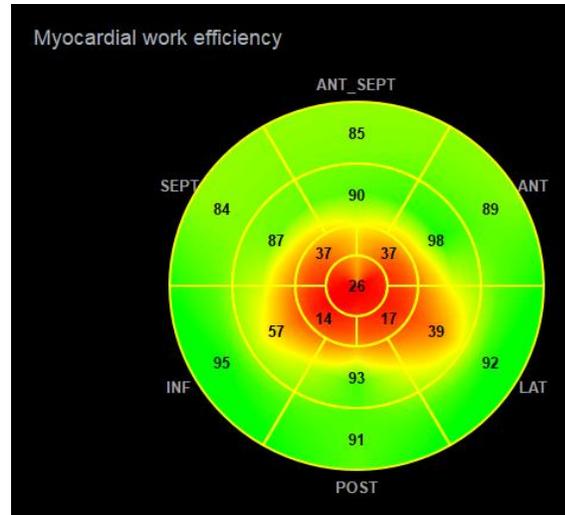
Single ventricle, LV type

Apical
pacing

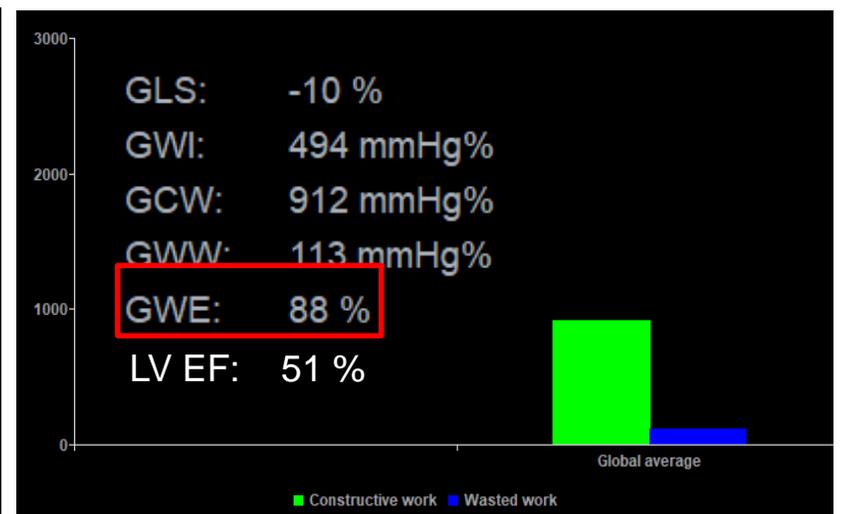
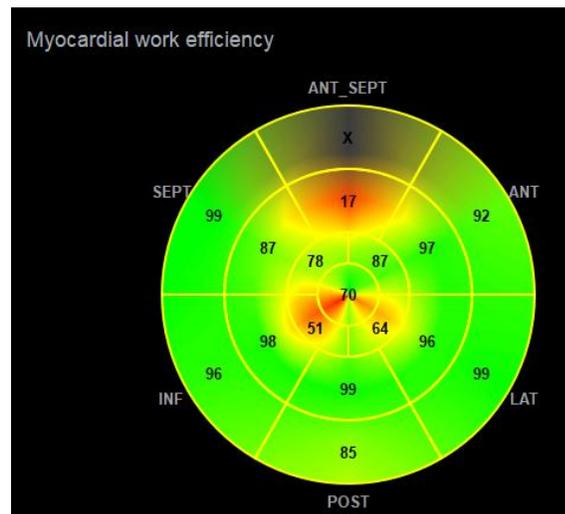
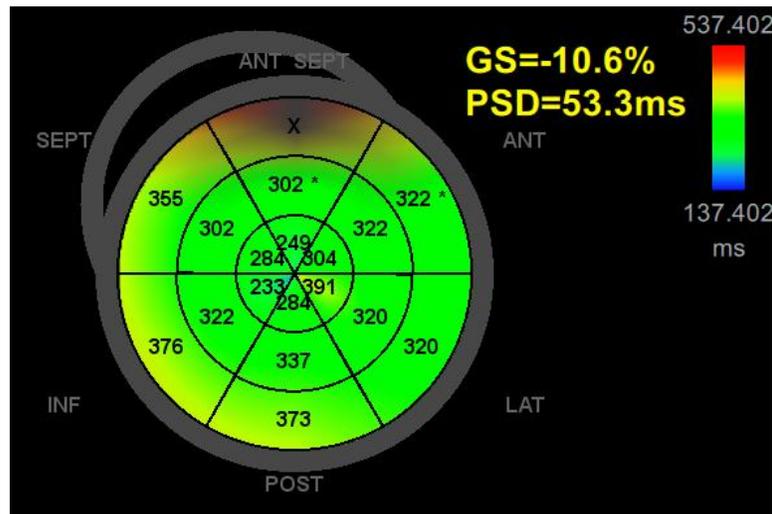
Time to peak strain



Myocardial work efficiency



CRT

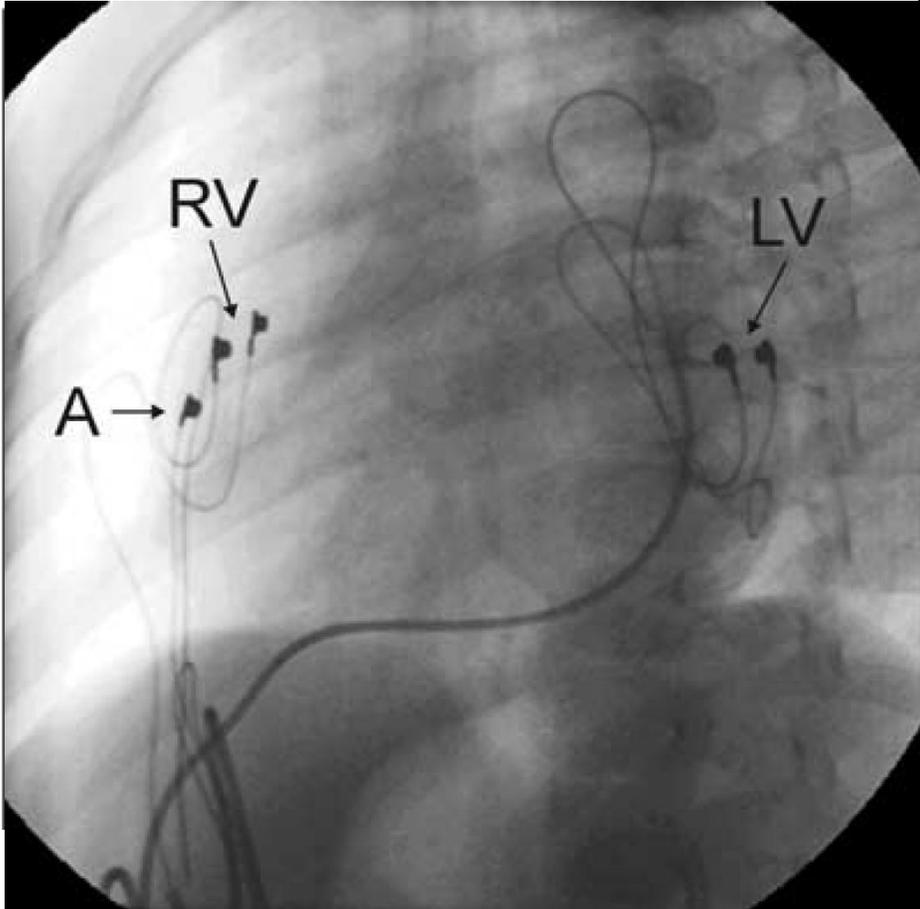


How to apply CRT in pediatric patients?

At least one lead must be placed at the site of late ventricular activation!

Dilated Cardiomyopathy Associated with Dual-Chamber Pacing in Infants: Improvement Through Either Left Ventricular Cardiac Resynchronization or Programming the Pacemaker Off Allowing Intrinsic Normal Conduction *JCE 2004*

JAN JANOUŠEK, M.D., VIKTOR TOMEK, M.D., VÁCLAV CHALOUPECKÝ, M.D., PH.D., and ROMAN ANTONÍN GEBAUER, M.D.

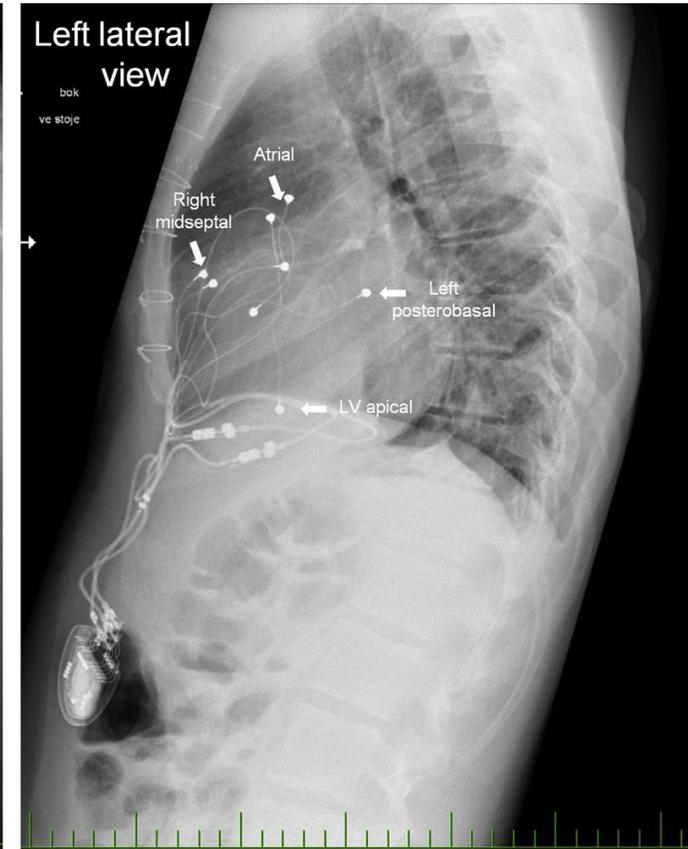
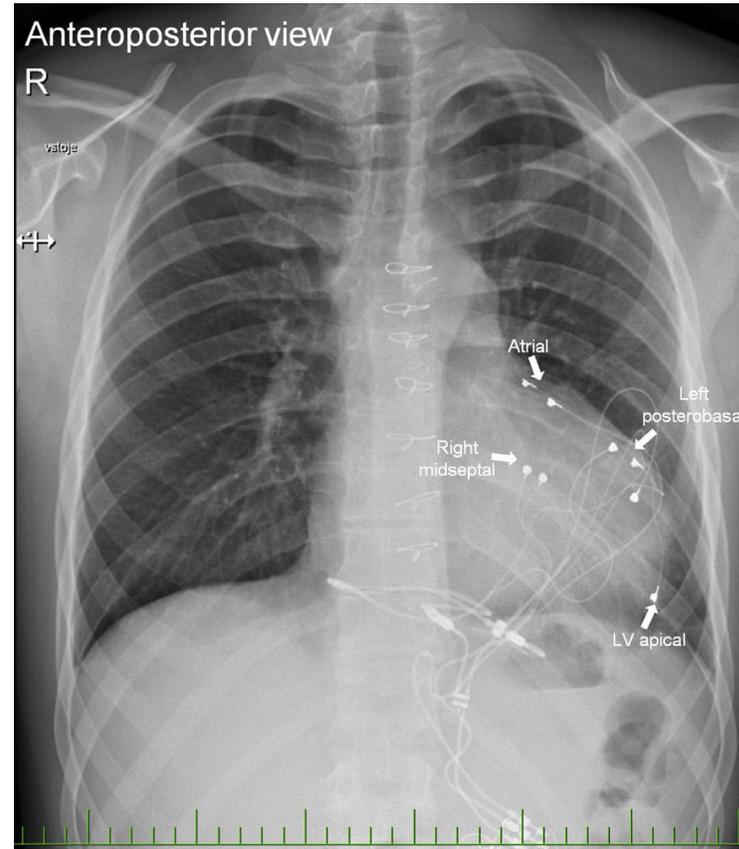


Multisite Pacing for Heart Failure Associated With Left Ventricular Apical Pacing in Congenital Heart Disease



JACC CE 2022

Karel Koubský, MD, PhD,^a Jan Kovanda, MD,^a Miroslav Ložek, MSc,^{a,b} Viktor Tomek, MD, PhD,^a Michal Jičínský, MD,^a Roman Gebauer, MD,^a Peter Kubuš, MD, PhD,^a Jan Janoušek, MD, PhD^a

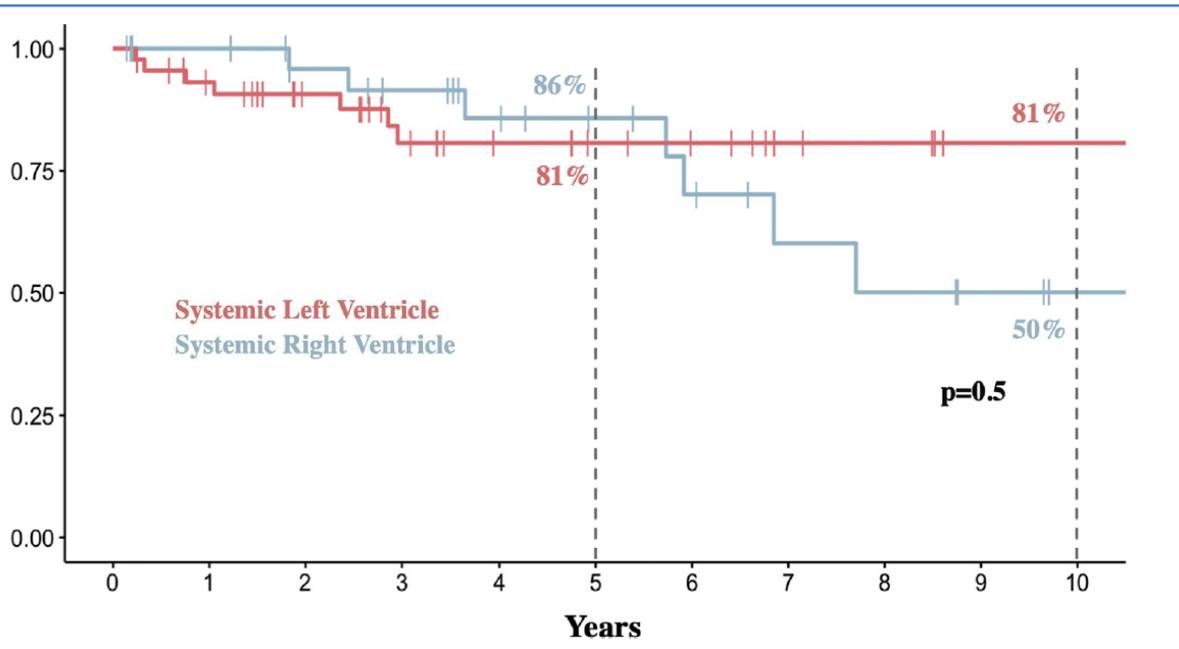


Cardiac resynchronization therapy in patients with congenital heart disease and systemic right ventricle ^e

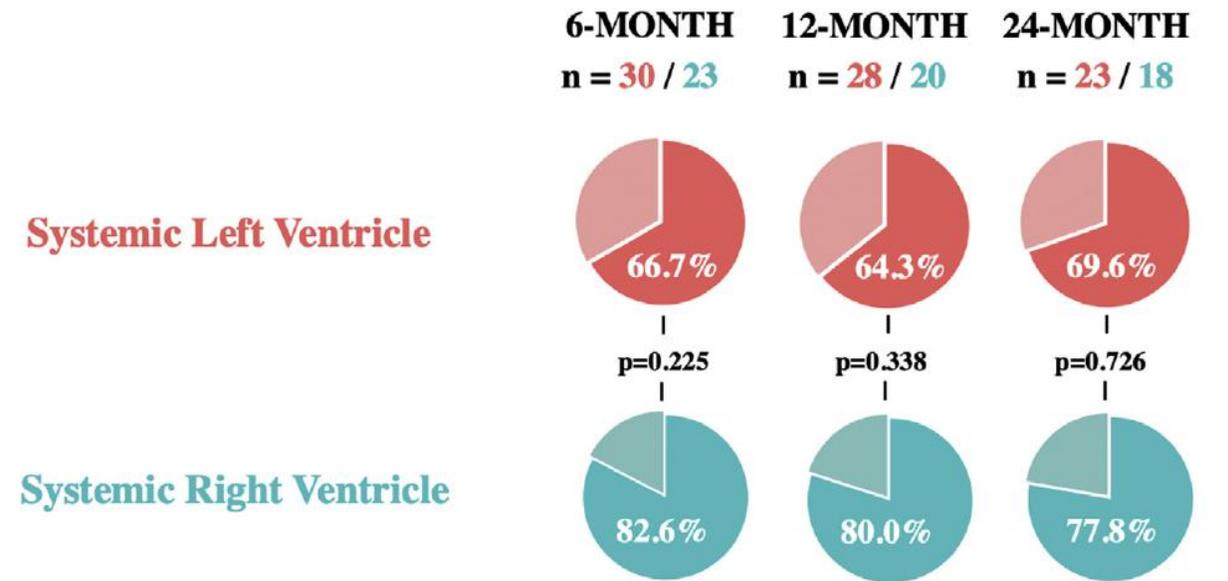
- N = 85 with CHD, mainly adults,
- Systemic RV = 36.5 %

Response to CRT was defined as an increase in systemic ventricular ejection fraction of $\geq 10\%$ and/or an improvement in New York Heart Association functional class by at least 1 grade.

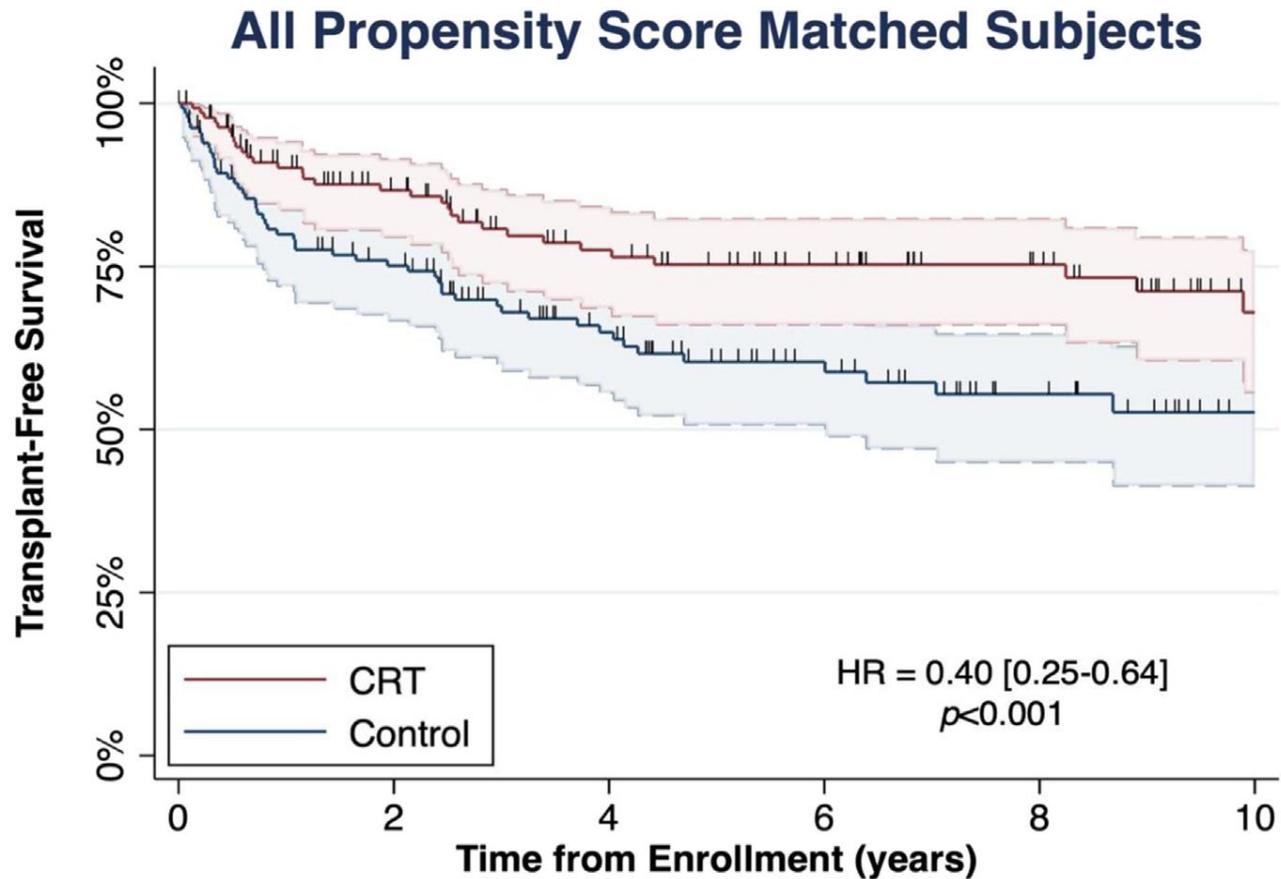
Overall mortality and heart transplantation



Rate of CRT responders



What is the impact of CRT on survival?



Number at risk		0	2	4	6	8	10
CRT	139	94	70	53	40	21	
Control	139	91	61	39	24	10	

- 139 patients
 - age 12.8 (4.9-20.0) yrs
- 139 propensity score matched controls
 - age 14.9 (6.9-22.5) yrs

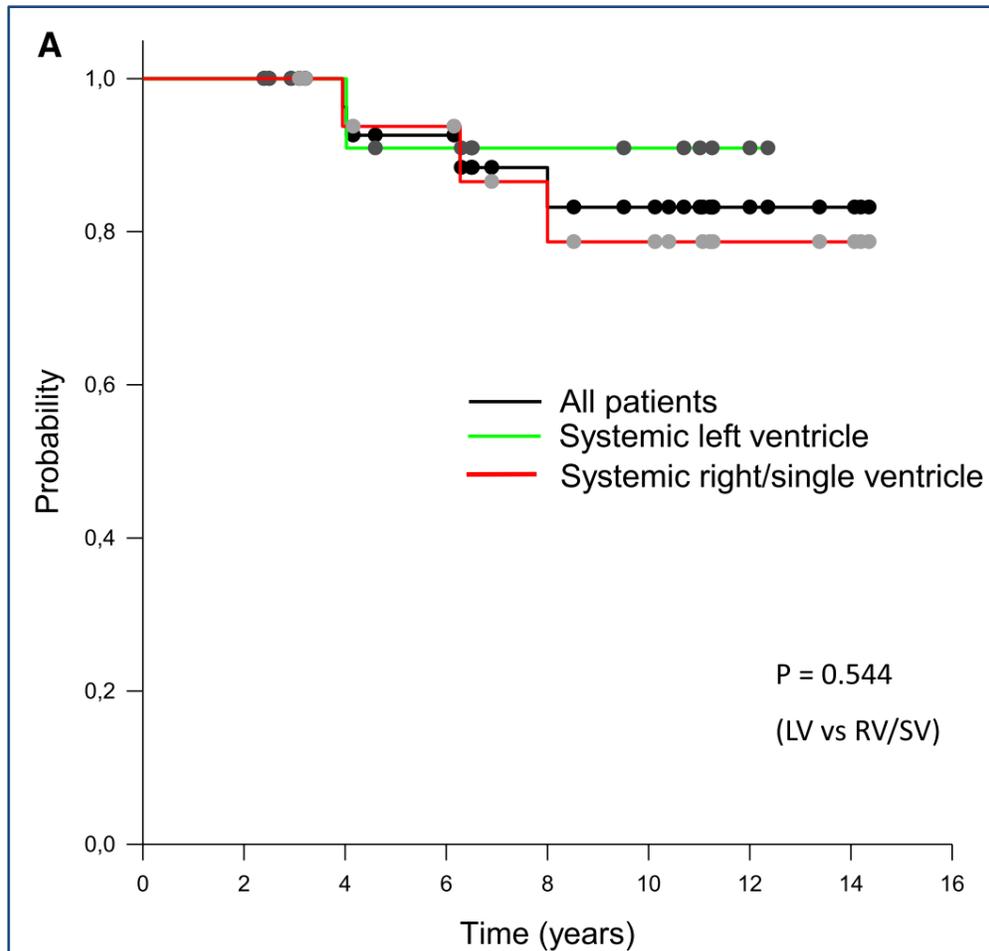
Multicenter Study of Survival Benefit of Cardiac Resynchronization Therapy in Pediatric and Congenital Heart Disease

Henry Chubb, MA, MBBS, PhD,^{a,b} Douglas Y. Mah, MD,^{c,d} Maully Shah, MD,^e Kimberly Y. Lin, MD,^e

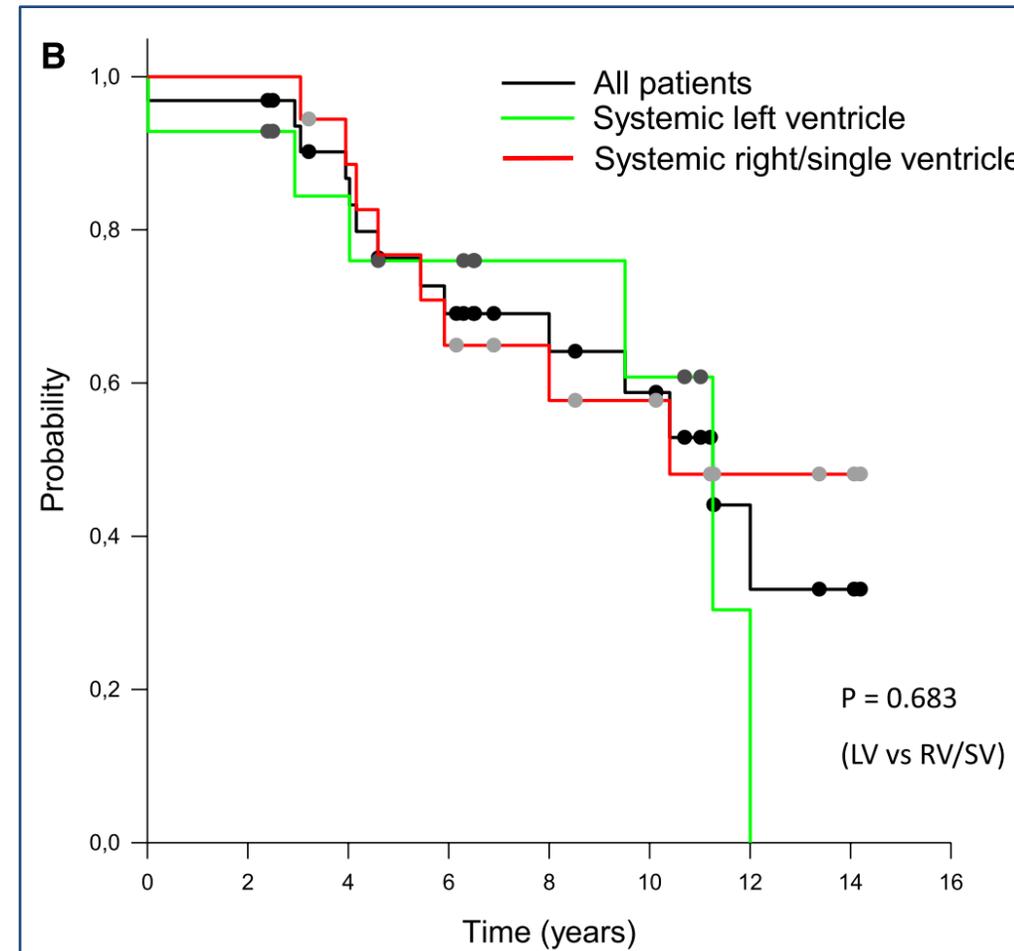
JACC: CLINICAL ELECTROPHYSIOLOGY VOL. ■, NO. ■, 2023

What is the probability of CRT complications?

Freedom from cardiovascular death, heart failure hospitalization and new transplant listing



Freedom from A + CRT termination, or surgical revision of the pacing system other than elective battery replacement



Outcome of Patients With Heart Disease Undergoing Synchronization Therapy

Popelová, MD; Jan Kovanda, MD; Kamil Sedláček, MD;

JAMA 2021

Conclusions

- CRT is a powerful tool for
 - Treatment of chronic dyssynchronous heart failure in CHD
- Basic principles similar to CRT in adults with idiopathic/ischemic heart disease
 - Structural heterogeneity and patient size requires specific approaches
- ECG and ECHO in conjunction are able to identify CRT correctable substrate
 - And individualize the implantation strategy
- Pulmonary RV resynchronization evolves to an additional option for treatment of chronic RV dysfunction

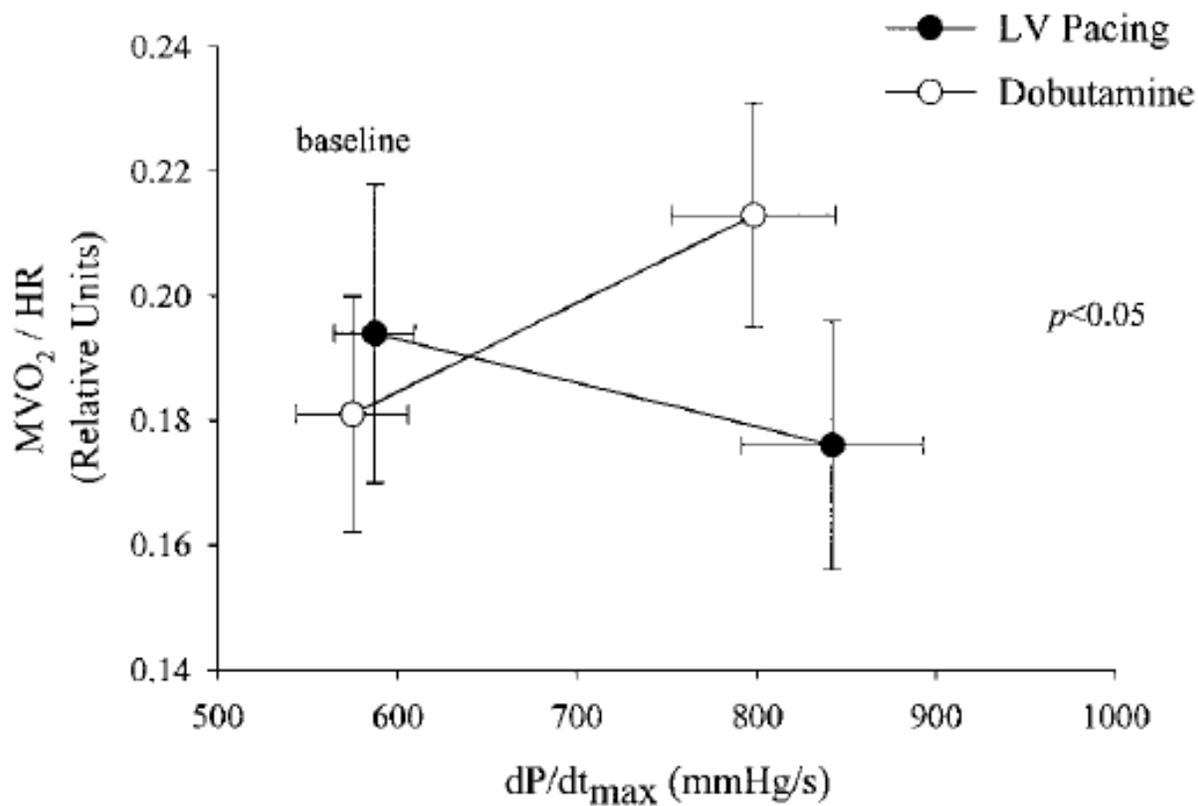
Thank you for your attention

Stay synchronized!

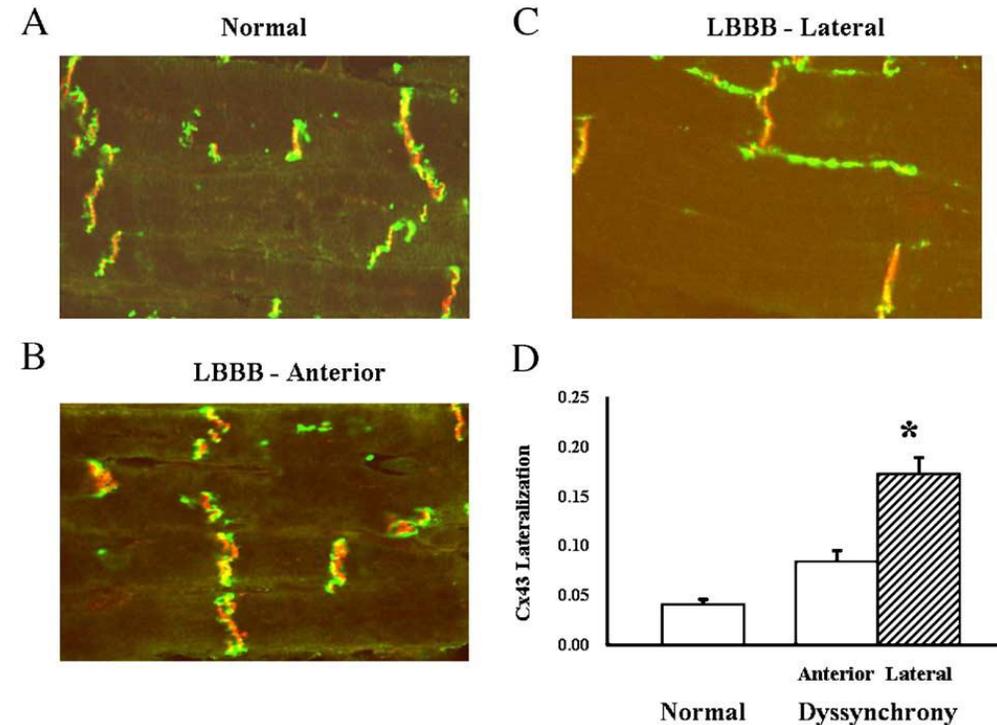


What are the effects of CRT?

Improved cardiac function at diminished energy cost



Reverse cellular remodeling



CRT restores normal connexine distribution and conduction velocity in late contracting segments

Mechanical imaging in dyssynchrony

Role of echocardiography



Conventional

2D and blood Doppler

Global picture of filling and ejection timing
in a failing heart



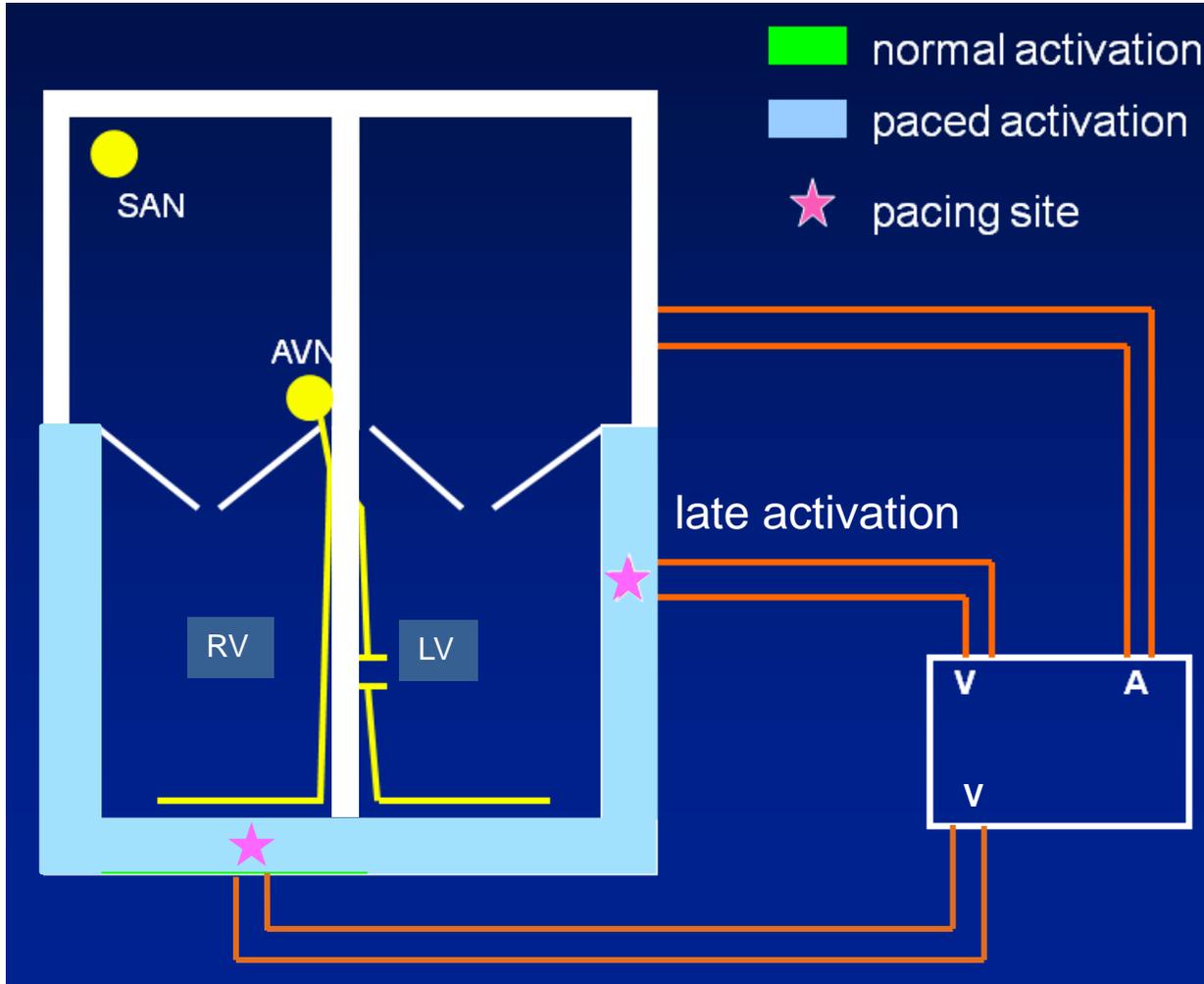
Advanced

Speckle tracking imaging

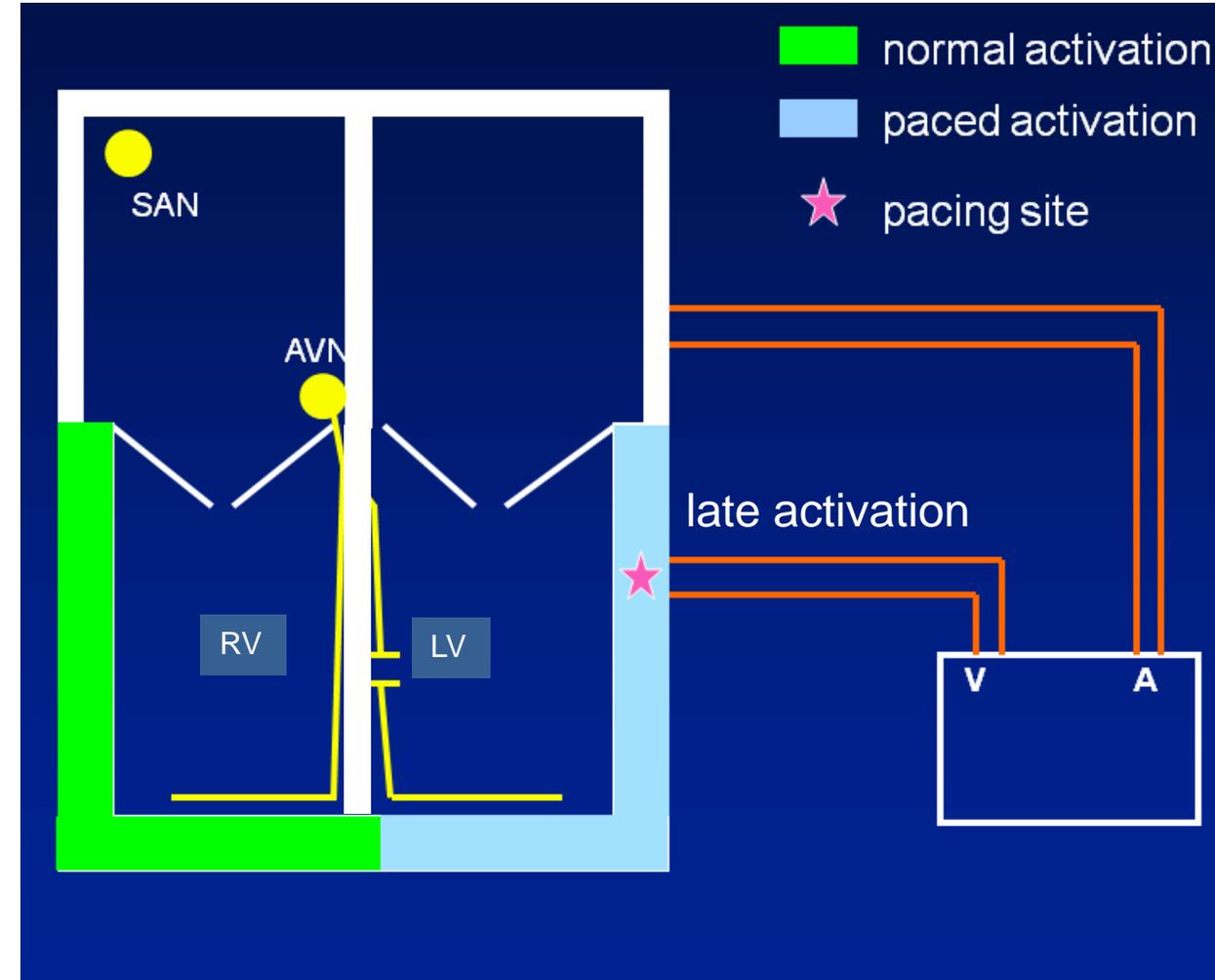
Classic-pattern dyssynchrony
Segmental motion timing
Relation to filling and ejection

How to apply CRT in pediatric patients?

Classical biventricular pacing



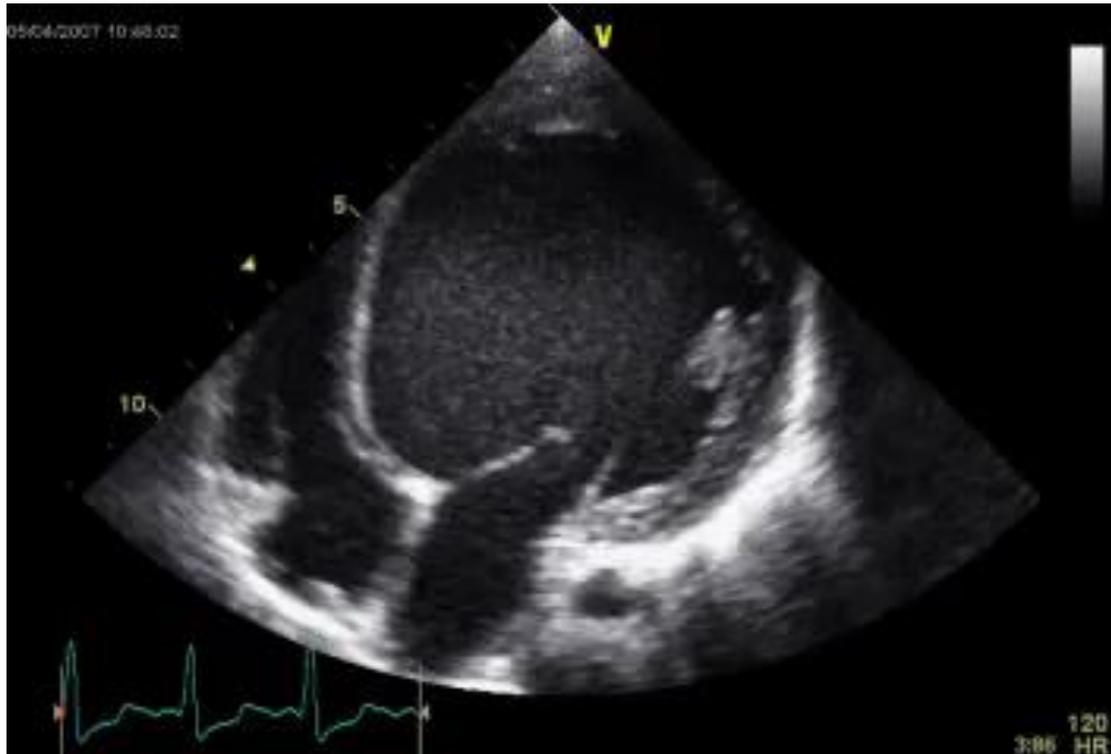
Single site pacing in fusion



What do we get clinically from CRT: ventricular function

Reverse ventricular remodeling and up to normalization of ventricular function in super-responders

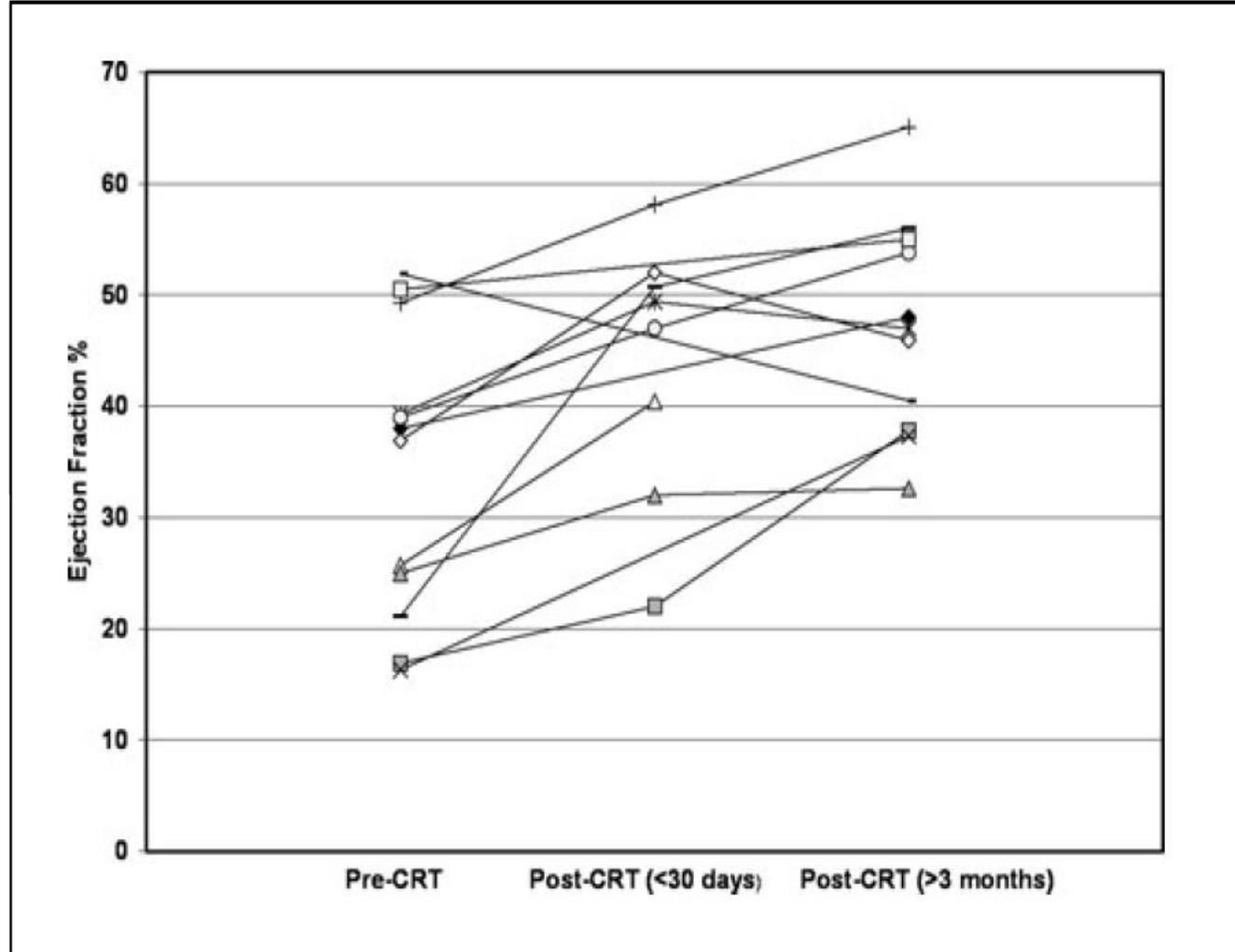
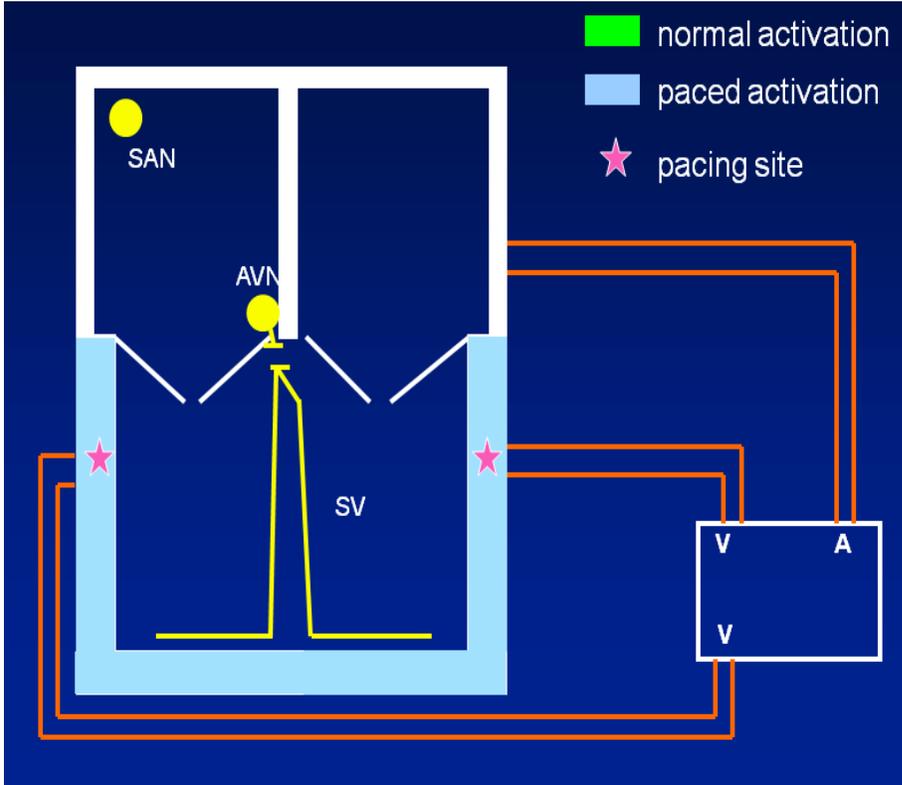
Before CRT, EF = 14%



After 3 weeks of CRT, EF = 28 %



Resynchronizing the single ventricle



Our high im-
between
ns rather
midline
adequate

Topics

- Characteristics of dyssynchronous heart failure
- Electrical/mechanical imaging in dyssynchrony
- CRT in systemic/single/pulmonary ventricular failure
- Not covered:
 - Conduction system pacing

Electrical imaging in dyssynchrony

Ultra-high-frequency ECG

UHF-ECG principle

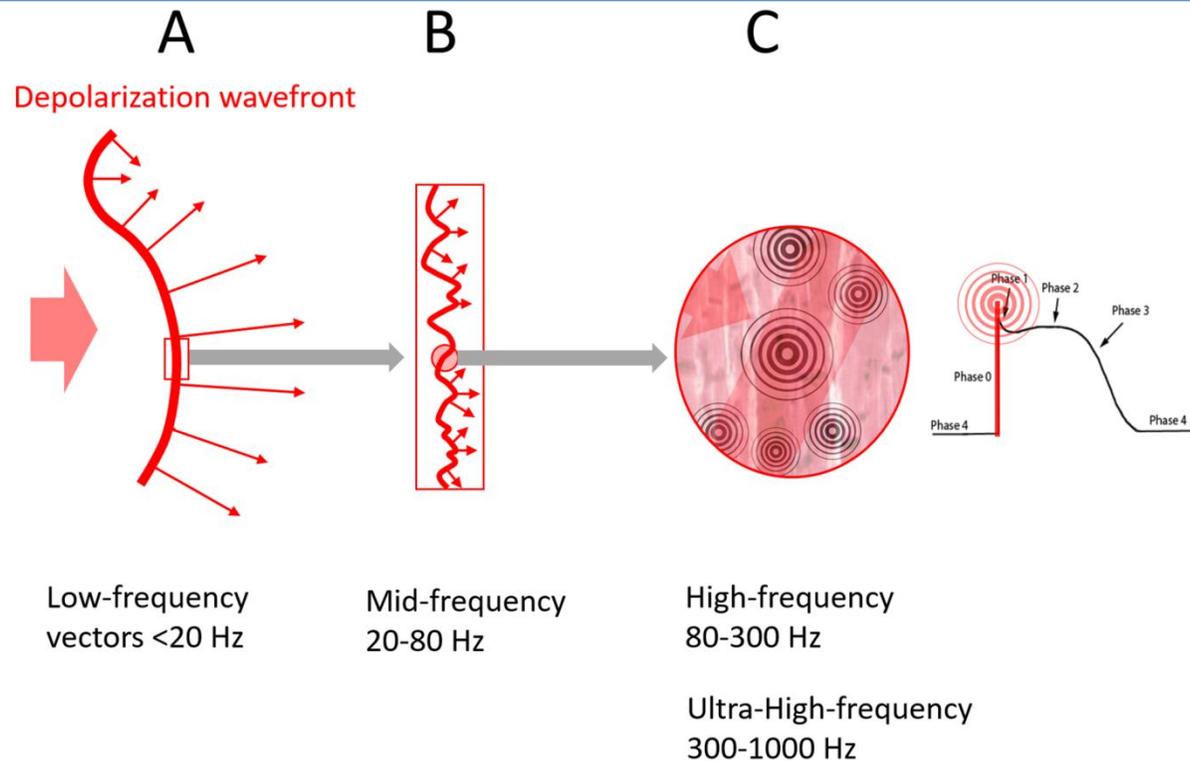


Figure 1. Different frequency characteristics of the depolarization wave. **A:** Low-frequency vectors 0.2-20 Hz. **B:** The mid-frequency 20-80 Hz. **C:** High-frequency 80-300 Hz and ultra-high-frequency 300-1000 Hz.

<https://www.vdimaging.com/>

Journal of Cardiovascular
Electrophysiology

THE OFFICIAL JOURNAL OF THE WORLD SOCIETY OF ARRHYTHMIAS



INNOVATIVE TECHNIQUES

Novel ultra-high-frequency electrocardiogram tool for the description of the ventricular depolarization pattern before and during cardiac resynchronization

Pavel Jurak PhD, Karol Curila MD, PhD, Pavel Leinveber MS, Frits W. Prinzen PhD, Ivo Viscor PhD, Filip Plesinger PhD, Radovan Smisek MS, Radka Prochazkova MS ... See all authors

- Detects only near-field ECG signals
- Visualizes ventricular activation sequence as projected to body surface