

Pacing maneuvers in single ventricle patients

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HERZZENTRUM
LEIPZIG

I.

I have received (a) research grant(s) / in kind support

A

... from current sponsor(s)

YES

NO

B

... from any institution

YES

NO

II.

I have been a speaker or participant in accredited CME/CPD ...

A

... from current sponsor(s)

YES

NO

B

... from any institution

YES

NO

III.

I have been a consultant / strategic advisor etc. ...

A

... for current sponsor(s)

YES

NO

B

... for any institution

YES

NO

IV.

I am a holder of (a) patent / shares / stocks or ownership...

A

... related to presentation

YES

NO

B

... not related to presentation

YES

NO

SCORE: 0

???



Single ventricle

- heterogenous group of heart defects
- morphology of SV

(left ventricle)

**simple recommendation for pacing
seems to be not easy!**

- variety of conduction systems
- spontaneous/postoperative delay

....



Cardiac Pacing



- Appropriate heart rate
- Improvement of hemodynamics
 - ✓ Restoration of AV synchrony
 - ✓ Correction of intraventricular dyssynchrony
- Prevention of arrhythmias



- Pacing induced ventricular dyssynchrony
- Device/lead related complications/reoperations
 - ✓ Lead fracture
 - ✓ Thrombosis
 - ✓ Infection
 - ✓ Battery depletion
- ...

Temporary pacing

What & how to pace?

Acute Hemodynamic Benefit of Left Ventricular Apex Pacing in Children

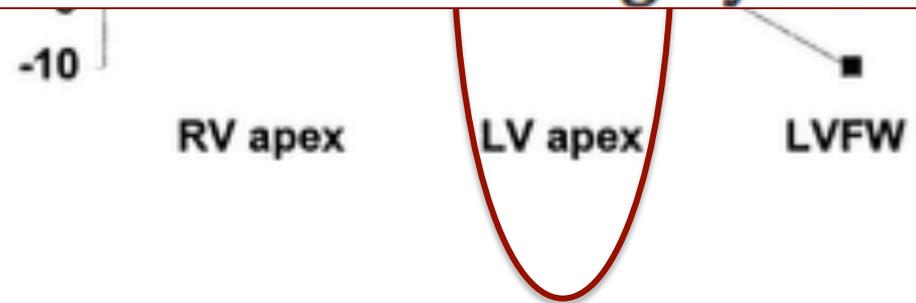
Ward Y. Vanagt, MD, Xander A. Verbeek, PhD, Tammo Delhaas, MD, PhD, Marc Gewillig, MD, PhD, Luc Mertens, MD, PhD, Patrick Wouters, MD, PhD, Bart Meyns, MD, PhD, Willem J. Daenen, MD, and Frits W. Prinzen, PhD

- 10 pts, median age 2.5y, (2m-17y)

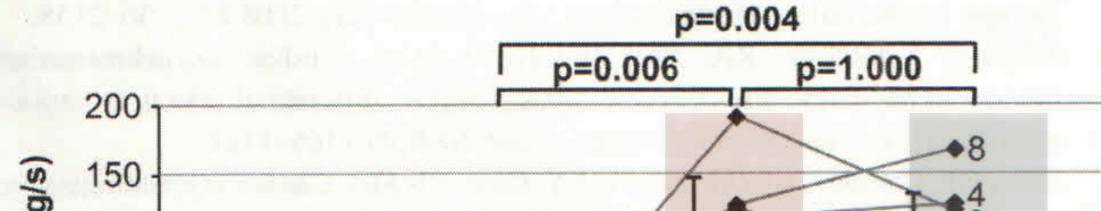
Relative changes in LVdPdtmax

Conclusions. In this short-term study left ventricular apex pacing is hemodynamically superior to right ventricular apex and left ventricular free wall pacing in children. Therefore, the left ventricular apex appears a favorable pacing site after pediatric cardiac surgery.

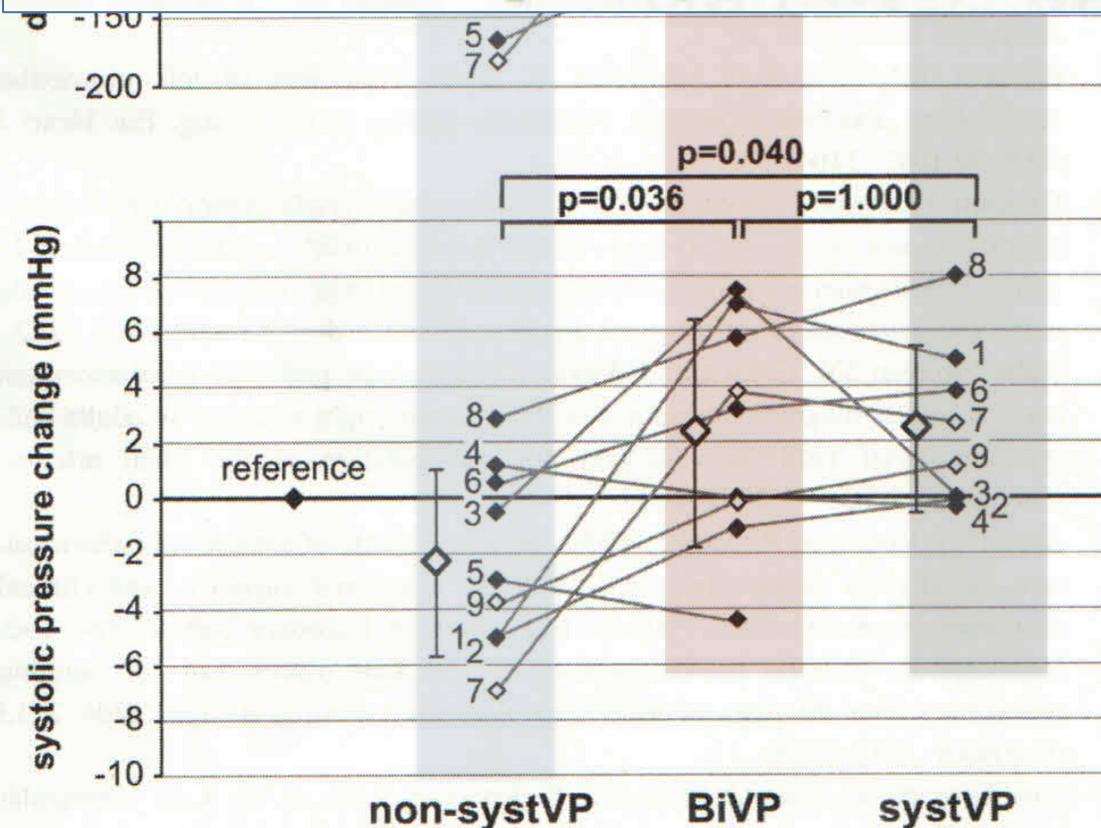
epicardial RVA/LVA/
LVFW pacing after off
bypass



Endocardial and single-site pacing in patients with a systemic right ventricle



In a population of patients with Senning/Mustard TGA, acute hemodynamic effects of endocardial systVP and BiVP were significantly and equally better than those of non-systVP (ie, conventional pacing). If, like in patients with normal



- ✓ TGA/Senn./Mus. N = 9 Pts
- ✓ temp. endocardial pacing in Cath
- ✓ dp/dt max. & RV-syst. pressure
- ✓ Non syst-VP vs syst-VP vs Bi-VP

Ventricular Resynchronization by Multisite Pacing Improves Myocardial Performance in the Postoperative Single-Ventricle Patient

Emile A. Bacha, MD, Frank J. Zimmerman, MD, Victor Mor-Avi, MD, PhD, Lynn Weinert, BS, Joanne P. Starr, MD, Lissa Sugeng, MD, and Roberto M. Lang, MD

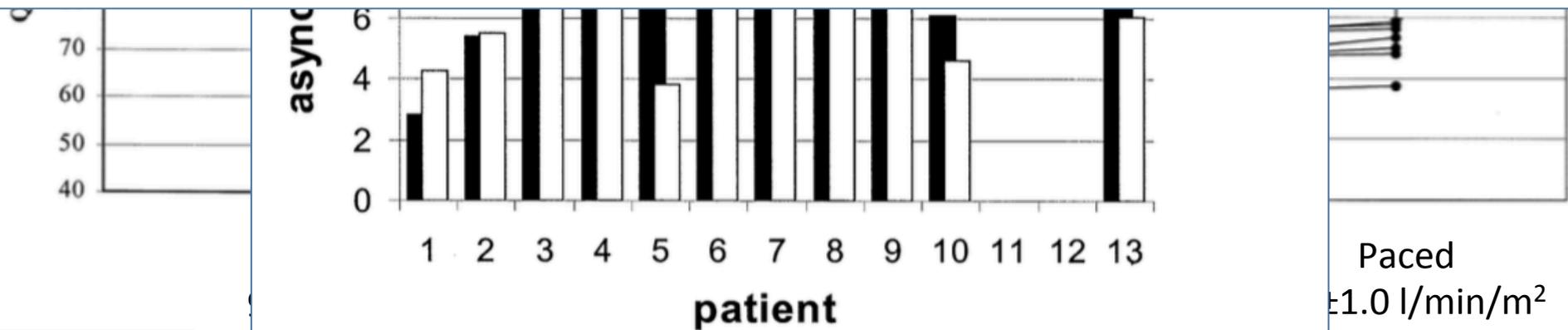
- 26 pts, mean age 28 months (7d-11yrs)
- atrial & 3 ventricular temporary wires
- at postop. day 2 (median), range 0-9d
- baseline QRS 93.9 ± 17.5 ms
- real time 3D echocardiography
 - ✓ 16 segments
 - ✓ volume changes in time

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In conclusion, multisite pacing improved cardiac performance after SV palliation. Real-time 3D echocardiography suggests that the mechanism may be caused by improved synchrony of ventricular contraction.

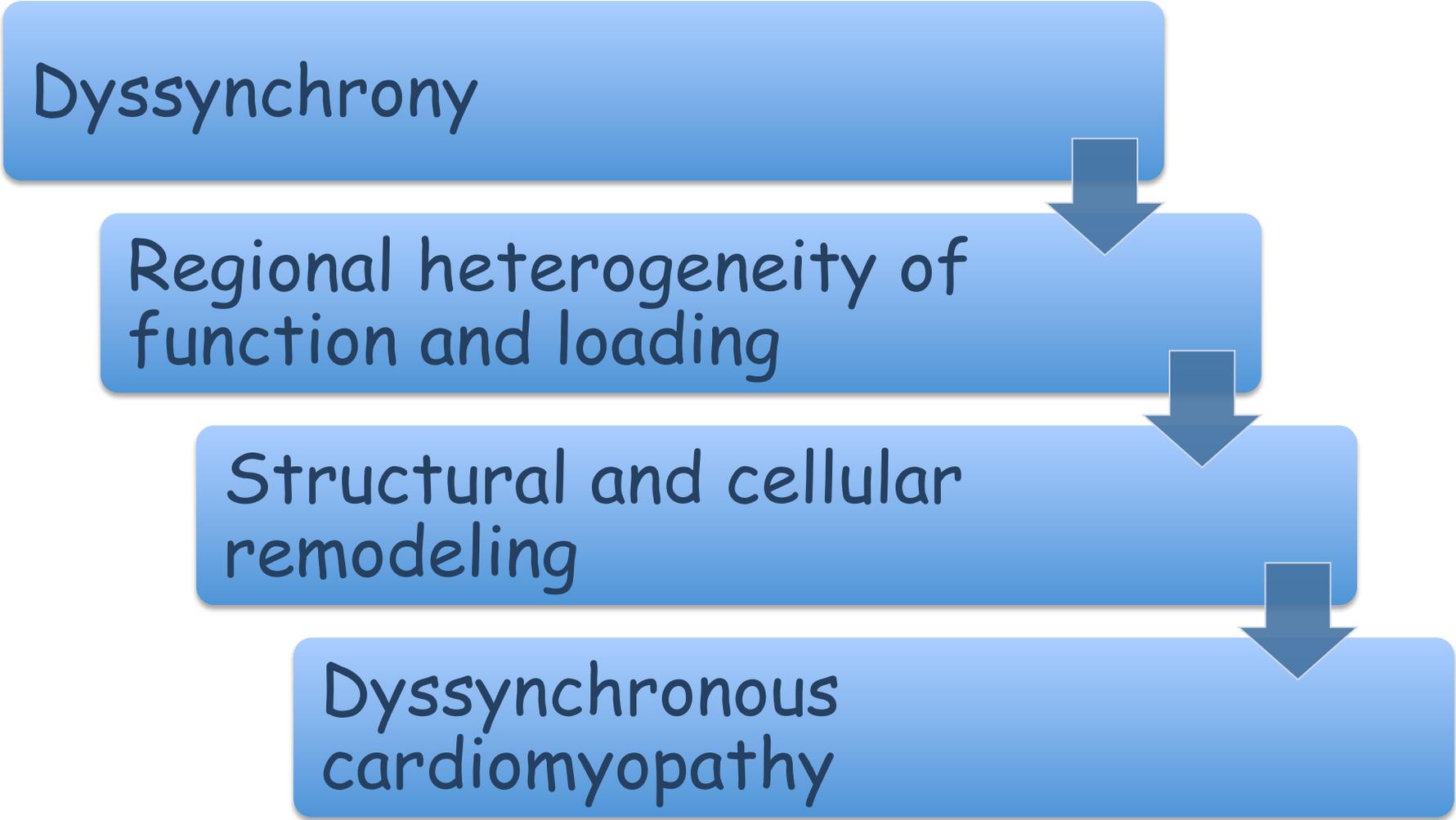


Permanent pacing

What & how to pace?

Pathophysiology of dyssynchronous cardiomyopathy

Dyssynchrony



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graph TD; A[Dyssynchrony] --> B[Regional heterogeneity of function and loading]; B --> C[Structural and cellular remodeling]; C --> D[Dyssynchronous cardiomyopathy];
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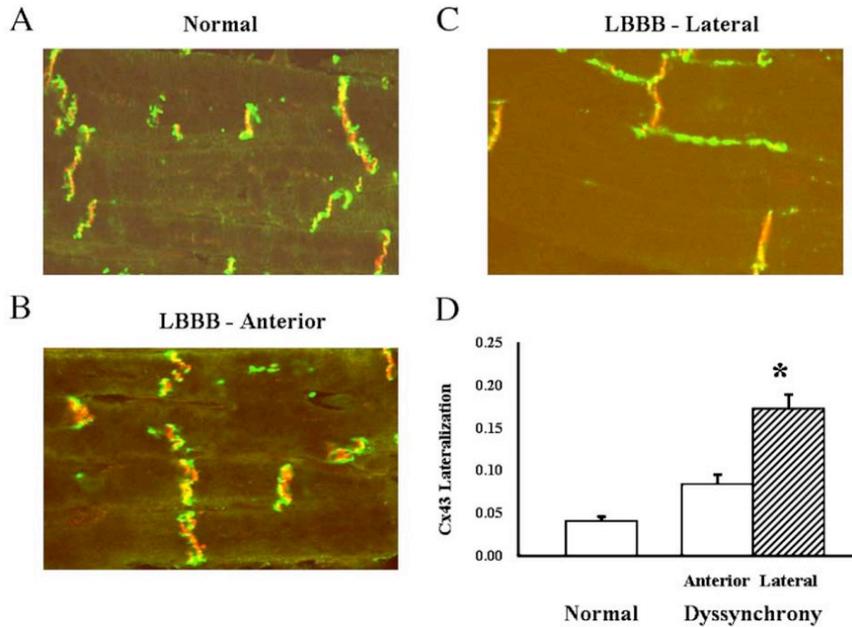
Regional heterogeneity of function and loading

Structural and cellular remodeling

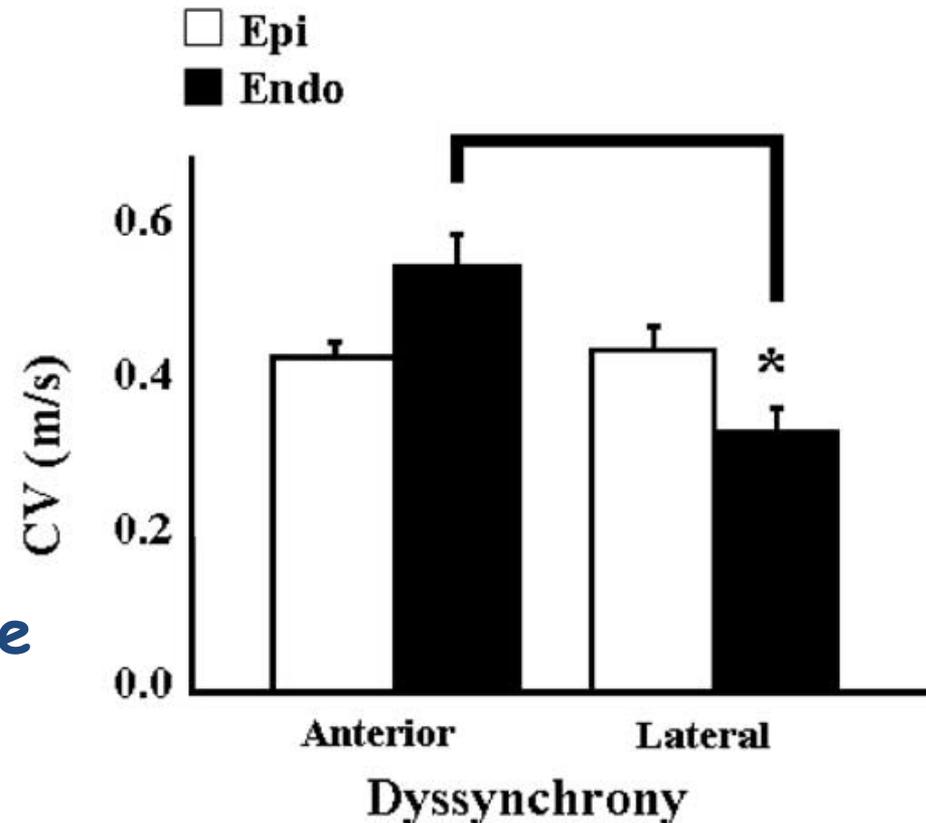
Dyssynchronous cardiomyopathy

Connexine 43 distribution and conduction velocity in dyssynchronous HF

Connexine 43 distribution



Conduction velocity

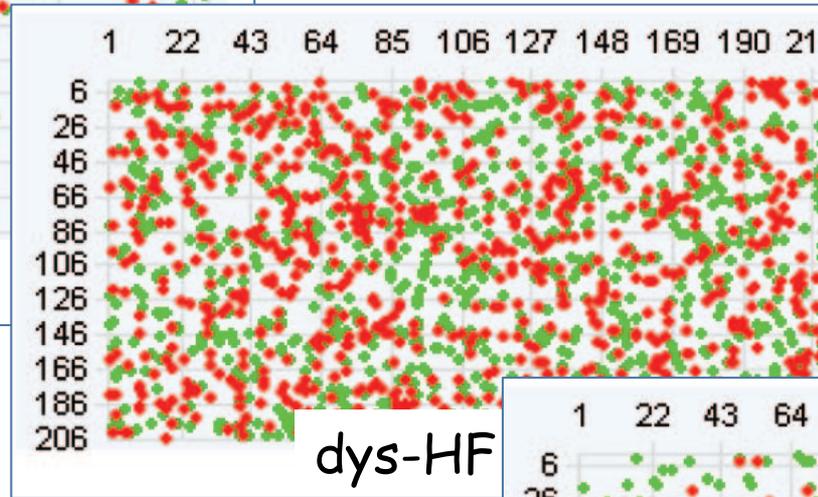
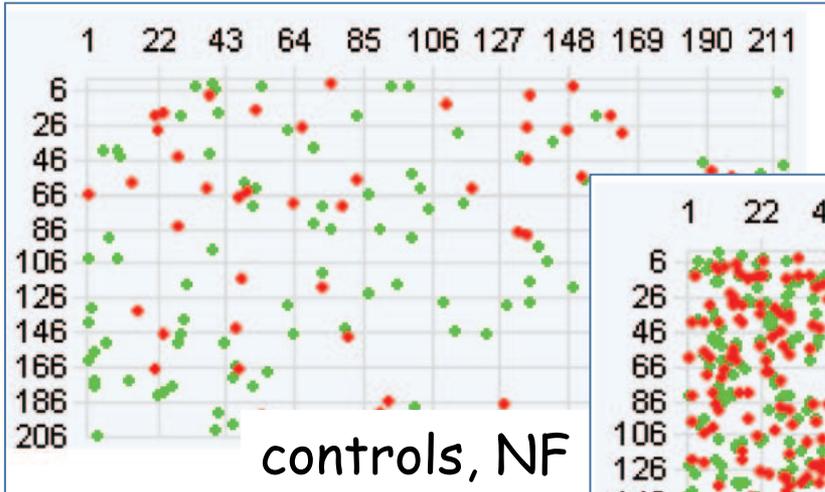


CRT restores normal connexine distribution and conduction velocity in late contracting segments

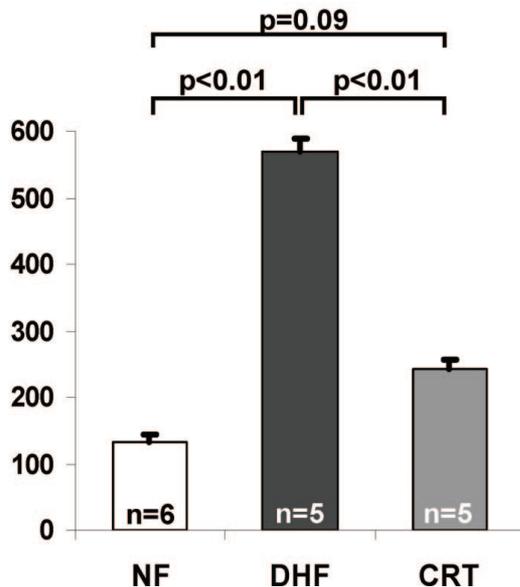
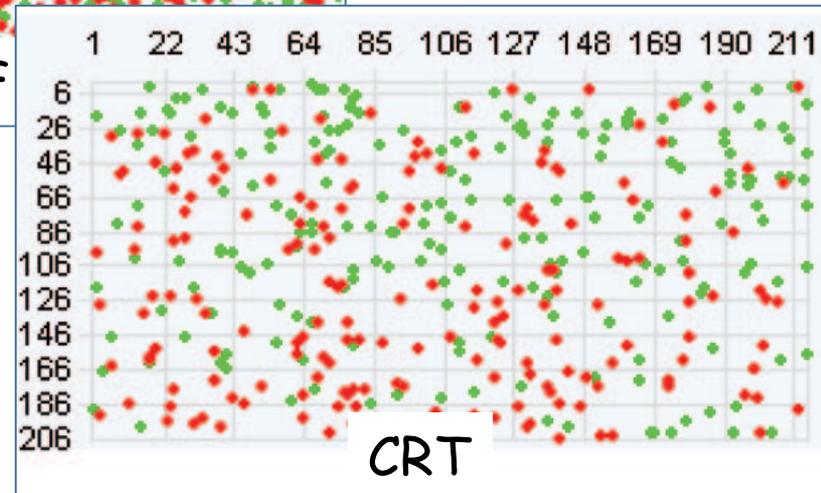
Cardiac Resynchronization Therapy Corrects Dyssynchrony-Induced Regional Gene Expression Changes on a Genomic Level

Andreas S. Barth, Takeshi Aiba, Victoria Halperin, Deborah DiSilvestre, Khalid Chakir, Carlo Colantuoni, Richard S. Tunin, Victoria Lea Dimaano, Wayne Yu, Theodore P. Abraham, David A. Kass and Gordon F. Tomaselli

Dyssynchrony leads to increased regional heterogeneity in gene expression in LV



reduced with CRT



Permanent Cardiac Pacing in Children - Choosing the Optimal Pacing Site: A Multi-Center Study

- Cross-sectional study (N=178, 21 centers)

- ✓ CAVB, structurally normal heart

- ✓ Initially normal LVEF

- ✓ Pacing sites (pts)

- ✓ RV

- RVOT (8), RV lat (44)

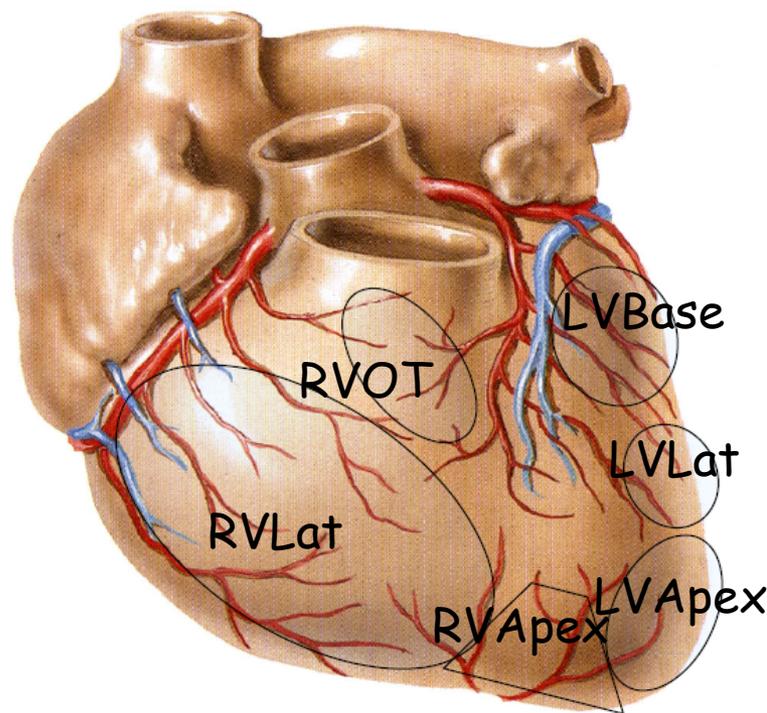
- RVA (61), RV Septum (29)

- ✓ LV

- LVA (12), LV lat (17)

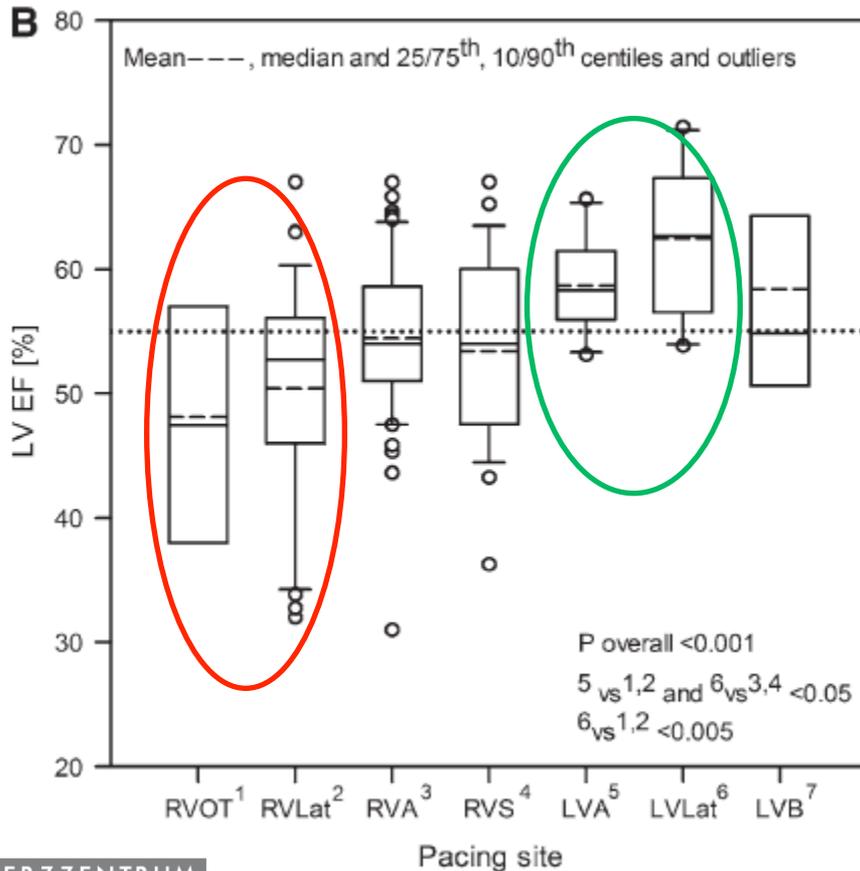
- LV Base (7)

- ✓ Pacing duration 5.4 yrs

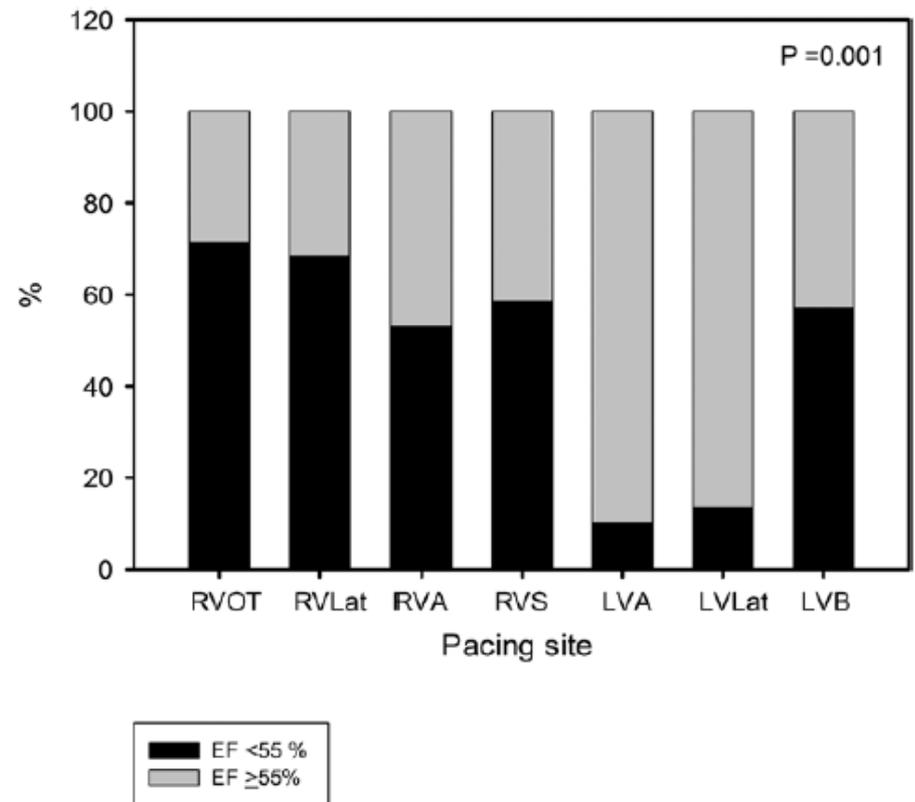


Permanent Cardiac Pacing in Children - Choosing the Optimal Pacing Site: A Multi-Center Study

LV ejection fraction at follow-up



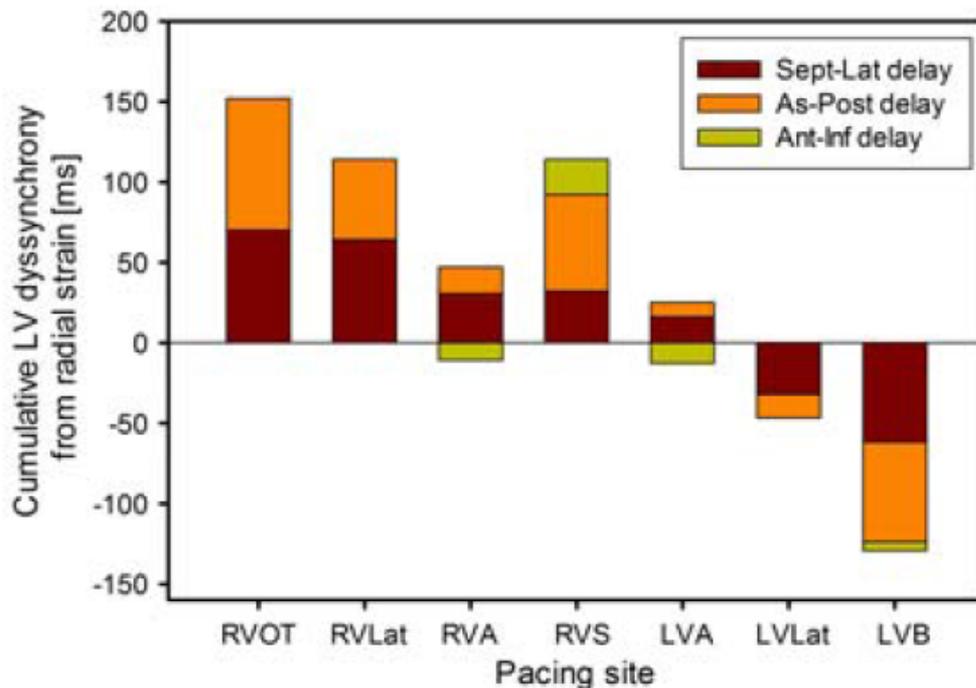
Proportion of pts with LVEF < 55 %



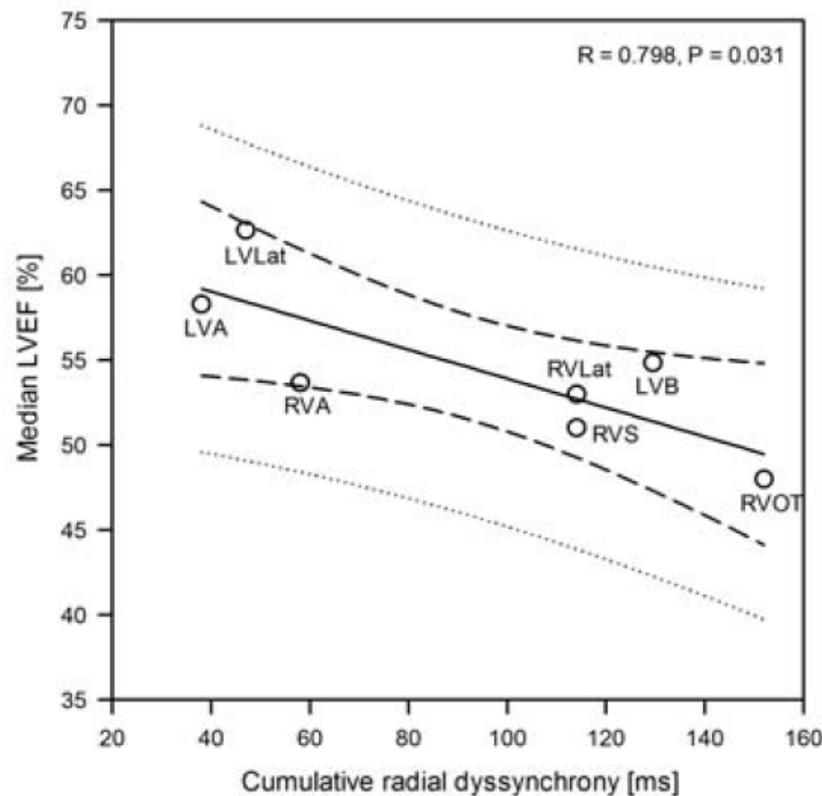
Permanent Cardiac Pacing in Children - Choosing the Optimal Pacing Site: A Multi-Center Study

Prevent conventional pacing associated cardiomyopathy by placement of the ventricular leads on LVA or LVlat wall

Cumulative LV dyssynchrony (from radial strain)



LVEF vs LV dyssynchrony



Studies on CRT in CHD patients

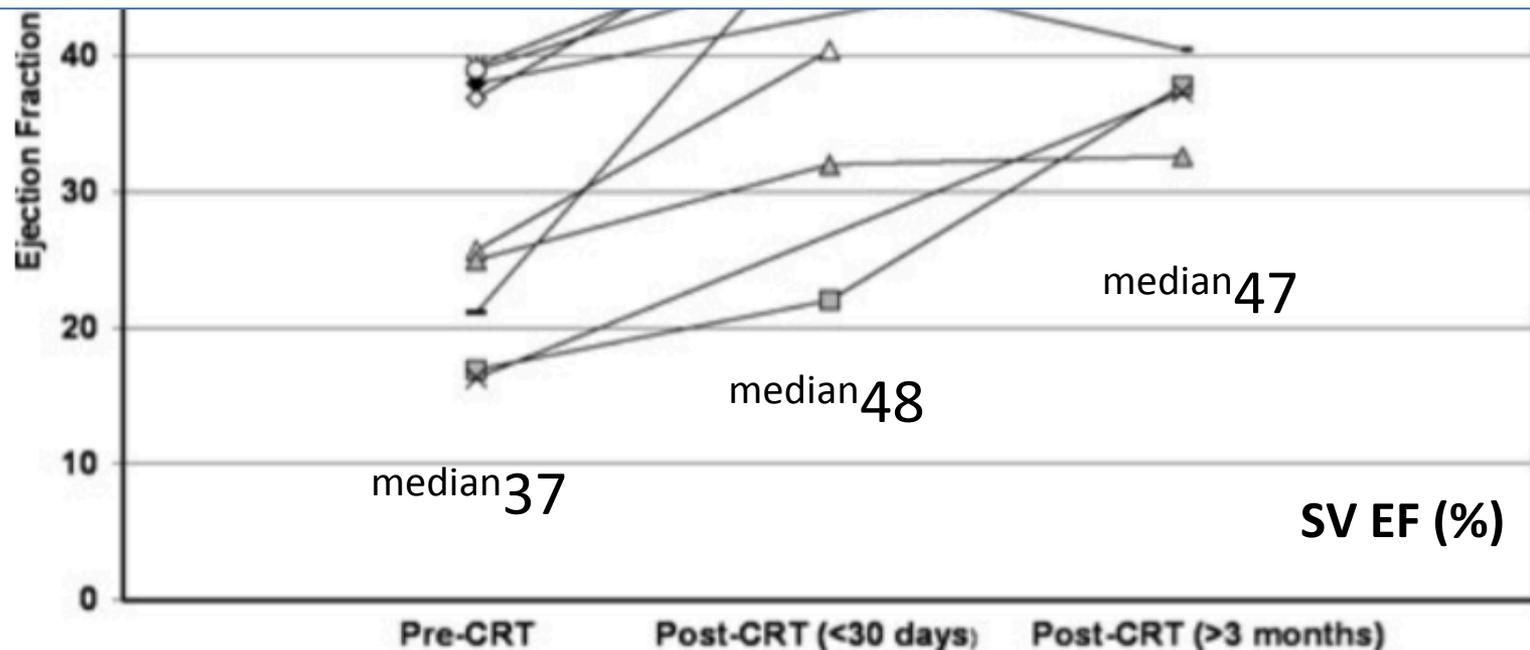
Author	Year	No. Pts.	CHD %	Systemic RV %	Single Ventricle %	Conv. Pacing %	Non-resp. %
Janoušek et al	2004	8	100	100	0	75	-
Dubin et al	2005	103	70.9	16.5	6.8	44.7	10.7
Khairy et al	2006	13	100	30.8	0	100	11.1
Moak et al	2006	6	33.3	0	0	100	0
Jauvert et al	2009	7	100	100	0	71.4	-
Cecchin et al	2009	60	76.7	15.0	21.7	68.3	10.0
Janoušek et al	2009	109	79.8	33.0	3.7	77.1	13.7
Thambo et al	2013	9	100	0	0	0	-

Adapted from PACES/HRS expert consensus statement on the recognition and management of arrhythmias in adult CHD; 2014

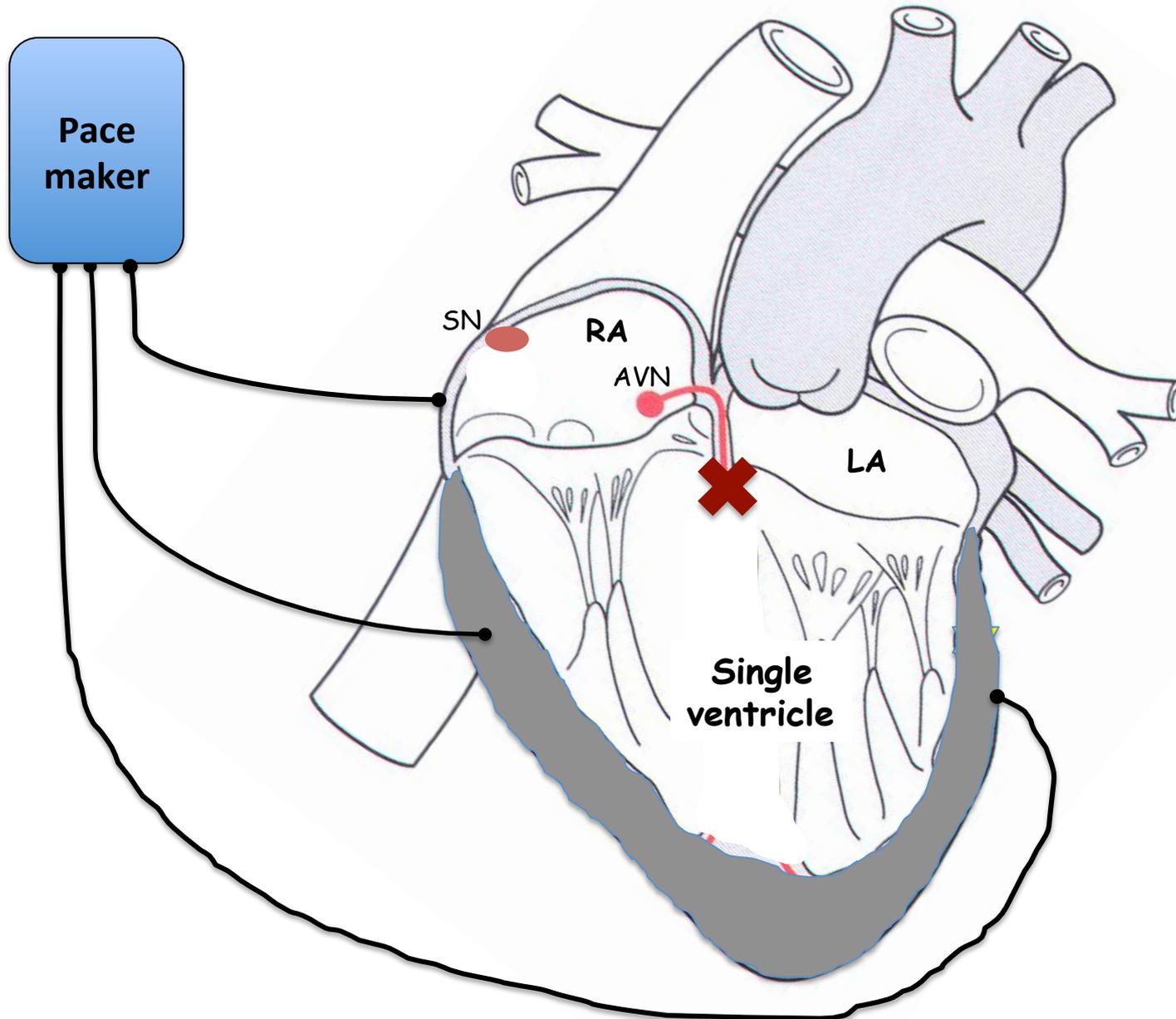
Single ventricle

N=13 pts., pre-CRT paced 8/13

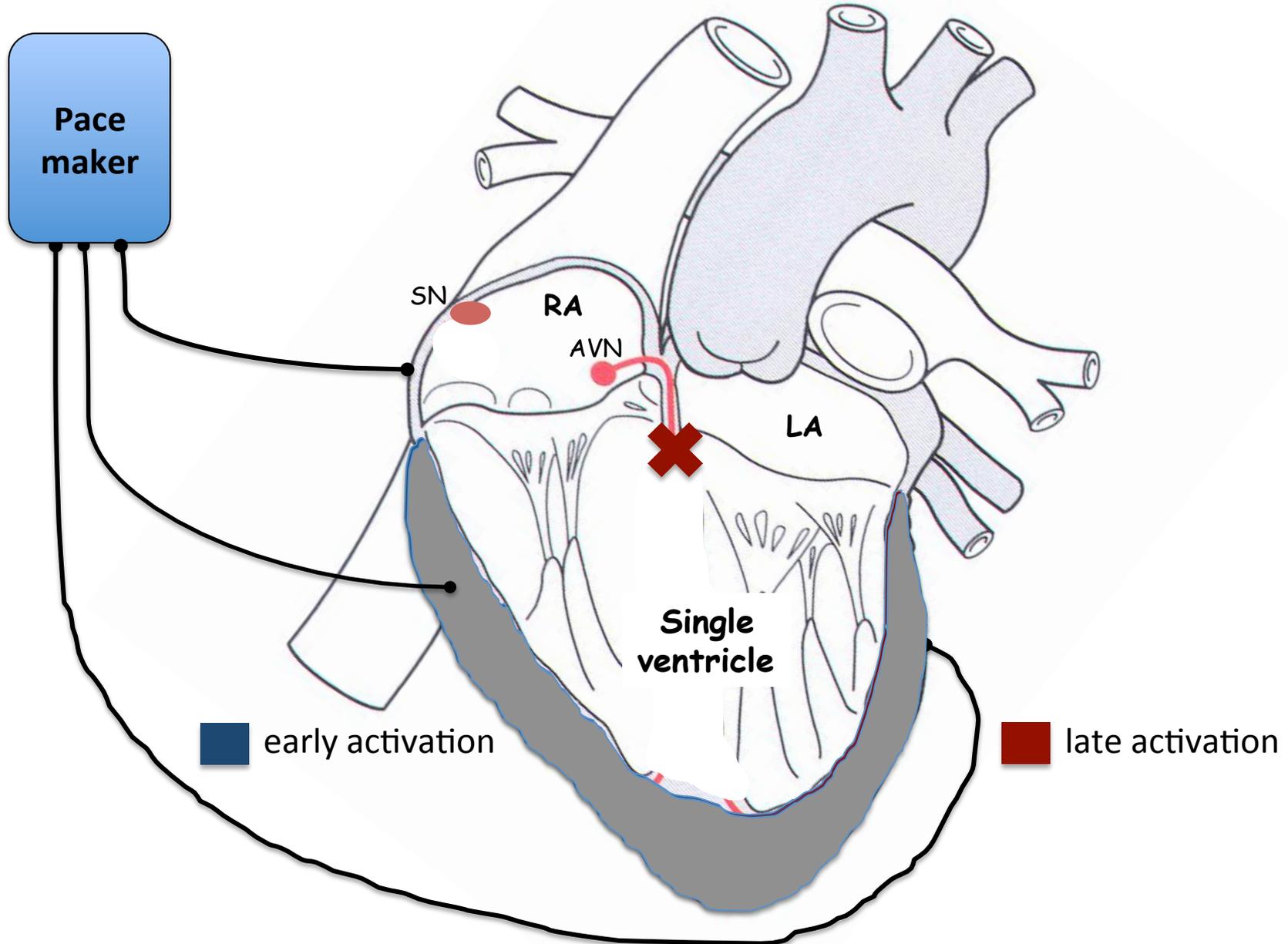
Our approach to this group has evolved over time, but a high importance was placed on obtaining maximal distance between the two leads and aiming for the midventricular regions rather than the base.



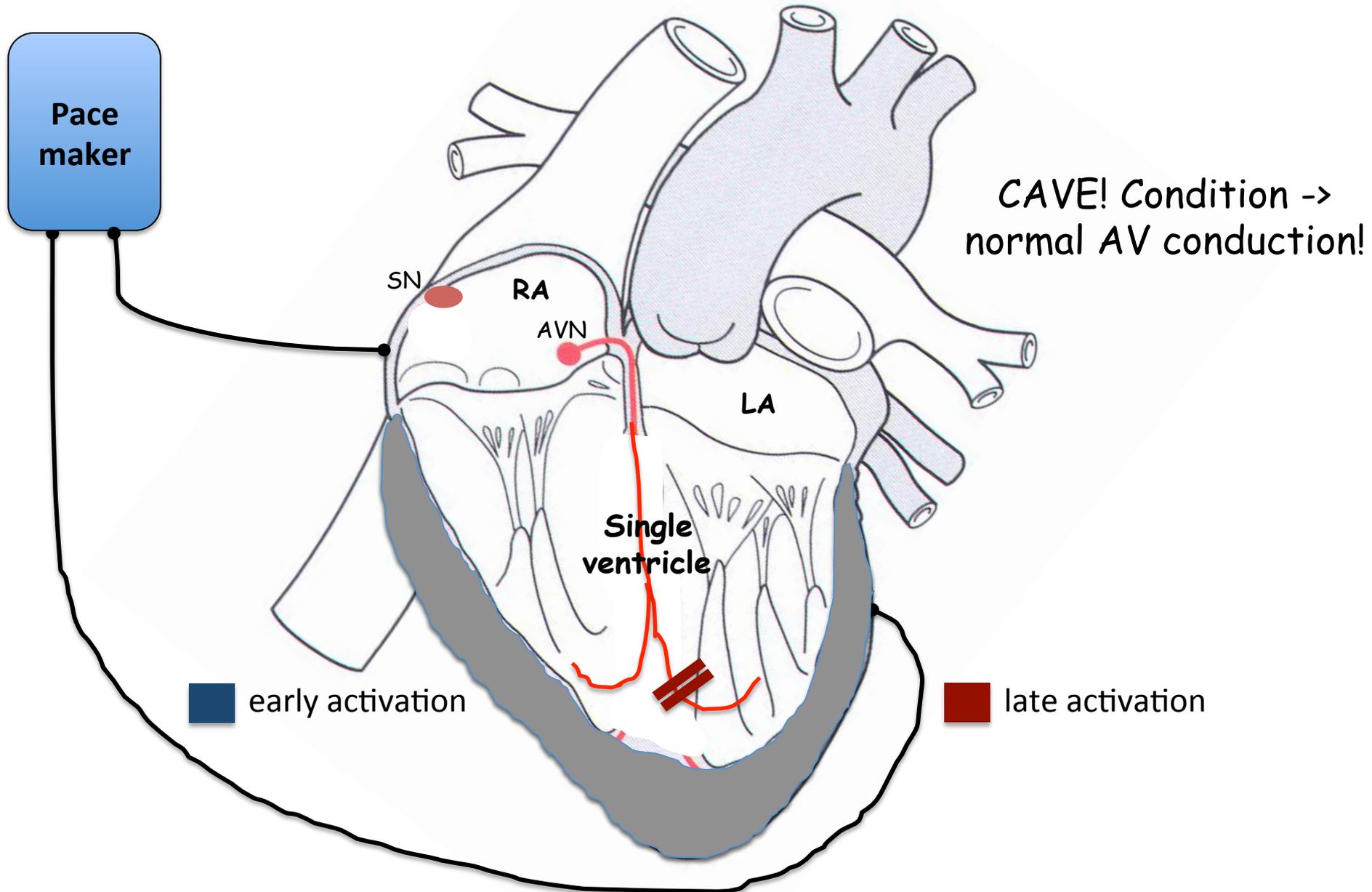
Primary bifocal pacing of single ventricle



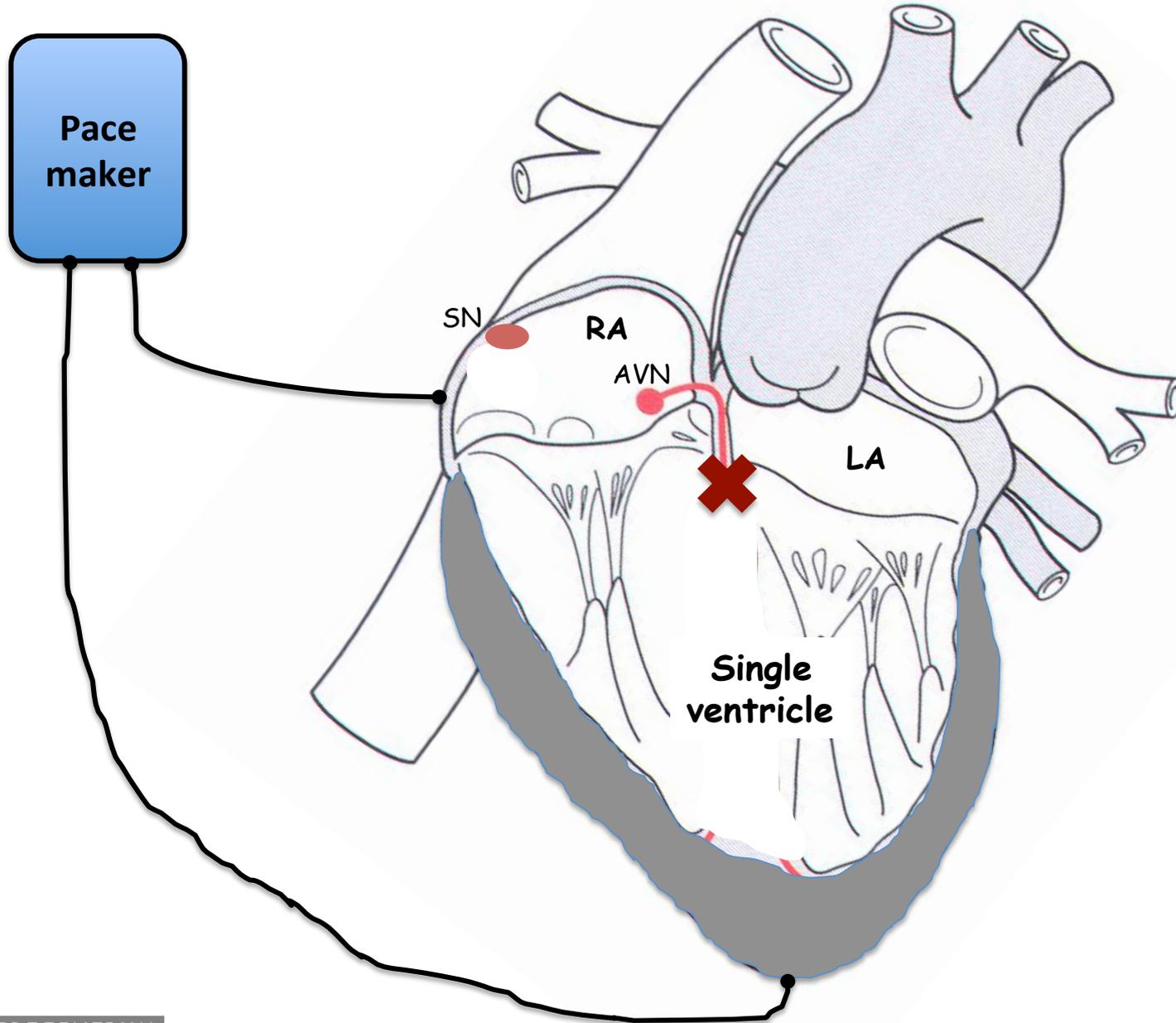
Upgrade of single site pacing of single ventricle



Fusion of spontaneous depolarisation and single site pacing of SV



single site apical pacing of single ventricle



PACES/HRS Expert Consensus Statement on the Recognition and Management of Arrhythmias in Adult Congenital Heart Disease

CRT INDICATIONS: CLASS I/IIa

COR	LOE	Recommendation
I	B	CRT is indicated in adults with CHD, a systemic LVEF\leq35% , sinus rhythm, complete LBBB with a QRS complex \geq150 ms (spontaneous or paced), and NYHA class II to IV symptoms
IIa	B	CRT can be useful for adults with CHD, a systemic LVEF\leq35% , sinus rhythm, complete LBBB with a QRS complex 120-149 ms (spontaneous or paced), and NYHA class II to IV symptoms
IIa	C	CRT can be useful for adults with a systemic RVEF\leq35% , right ventricular dilation, NYHA class II to IV symptoms, and complete RBBB with a QRS complex \geq150 ms (spontaneous or paced)
IIa	C	CRT can be useful in adults with CHD, a systemic ventricular ejection fraction \leq35% , an intrinsically narrow QRS complex, and NYHA class I to IV symptoms who are undergoing new or replacement device implantation with anticipated requirement for significant (>40%) ventricular pacing .

CRT can be useful for adults with a **single ventricle ejection fraction \leq 35%**, ventricular dilatation, **NYHA class II to IV** symptoms, and a **QRS complex \geq 150 ms** due to intraventricular conduction delay that produces a complete RBBB or LBBB morphology (spontaneous or paced)



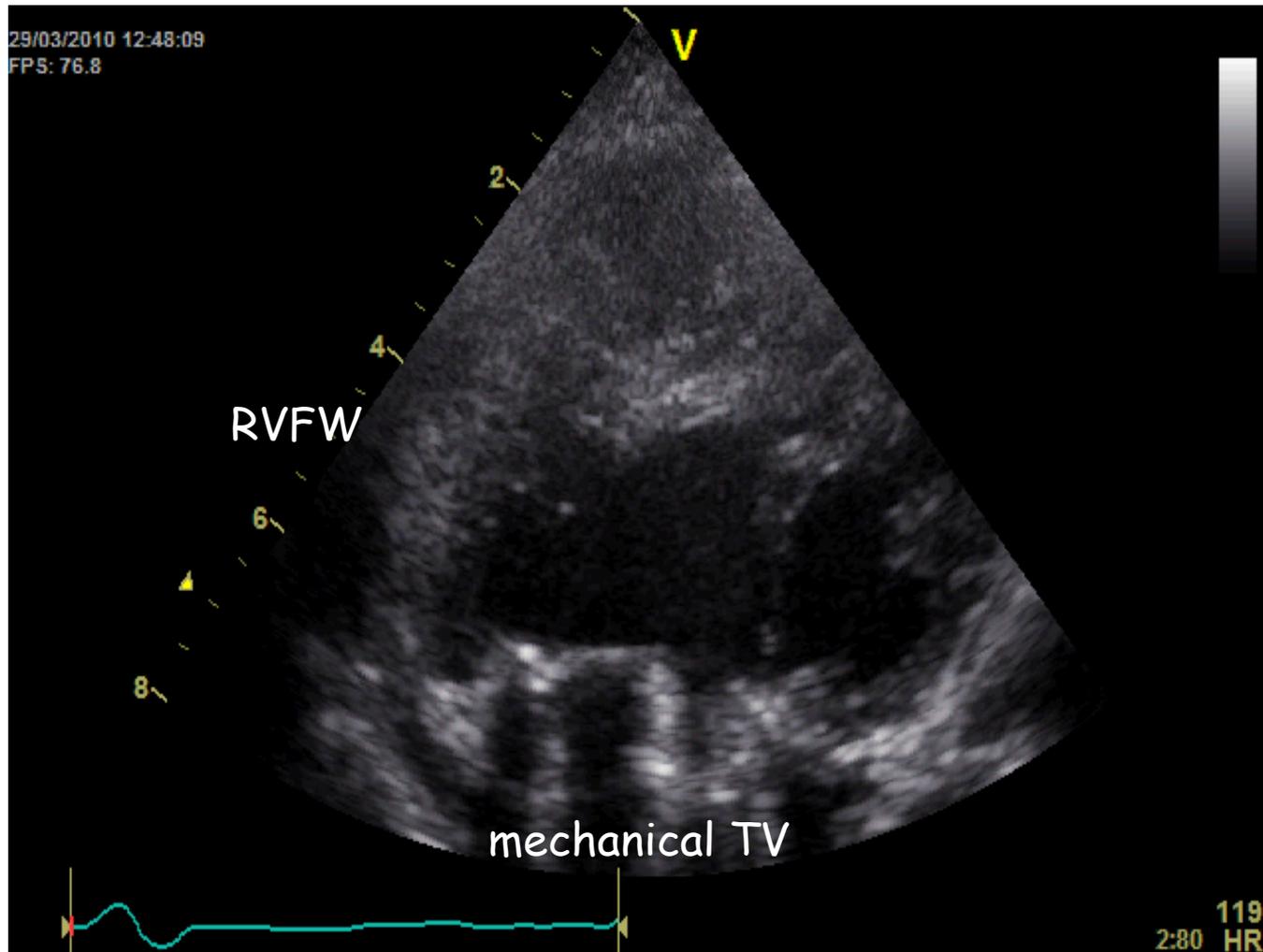
Summary

- "to be paced" can be dangerous
- Look at site with minimal "dyssynchrony potential"
- Use less hardware as you can -> reduce number of complications
- Screen your SV patients with wide QRS and dysfunction of SV for indication to elimination of dyssynchrony

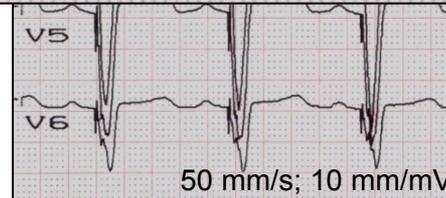
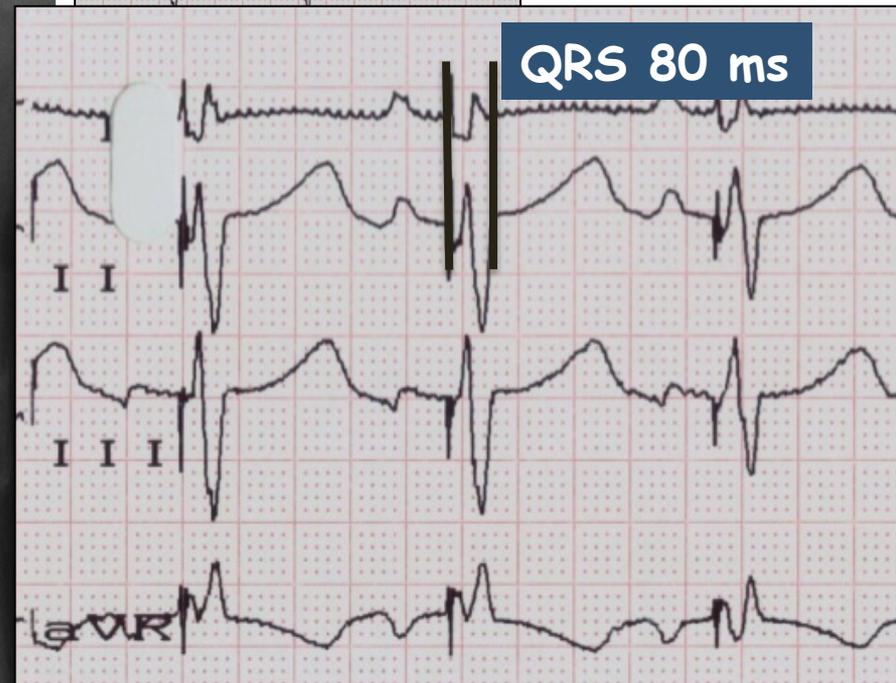
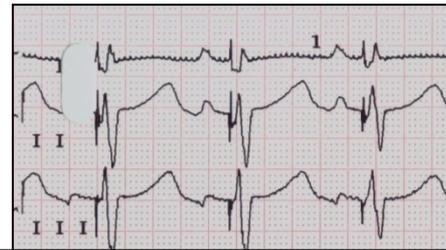
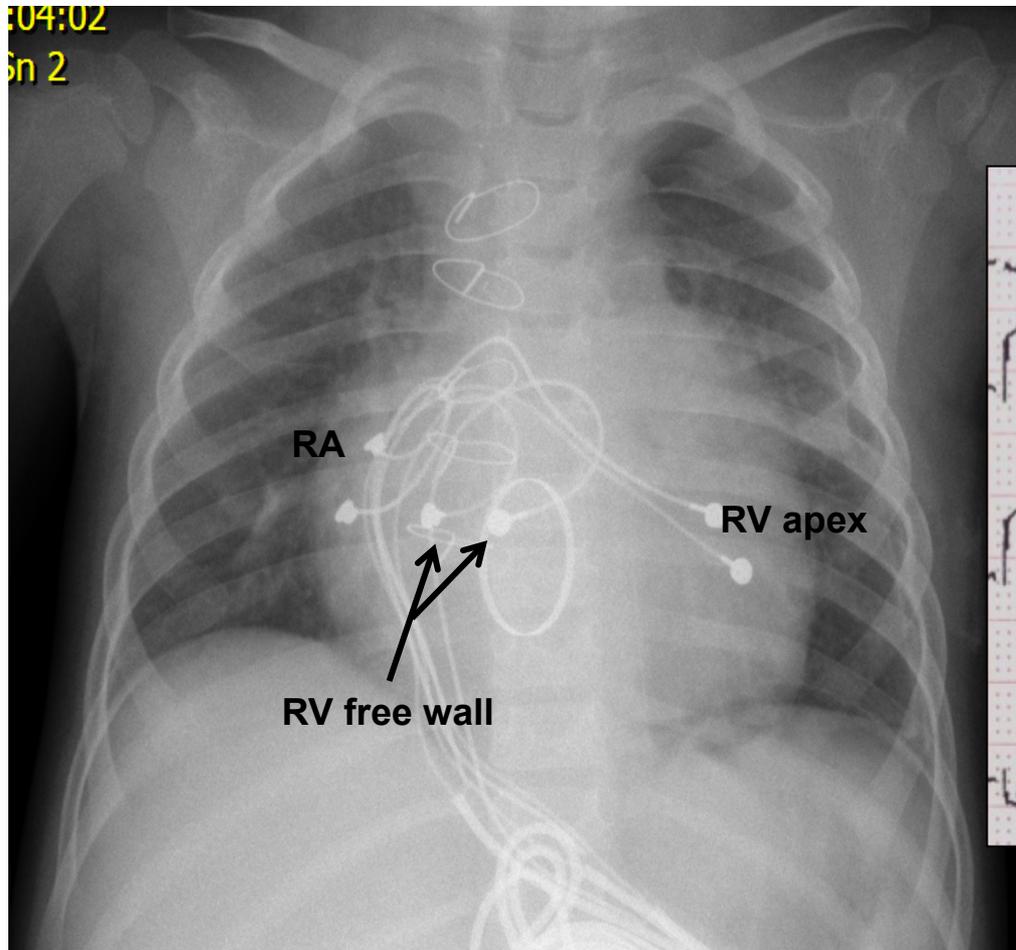
Thank you for attention!



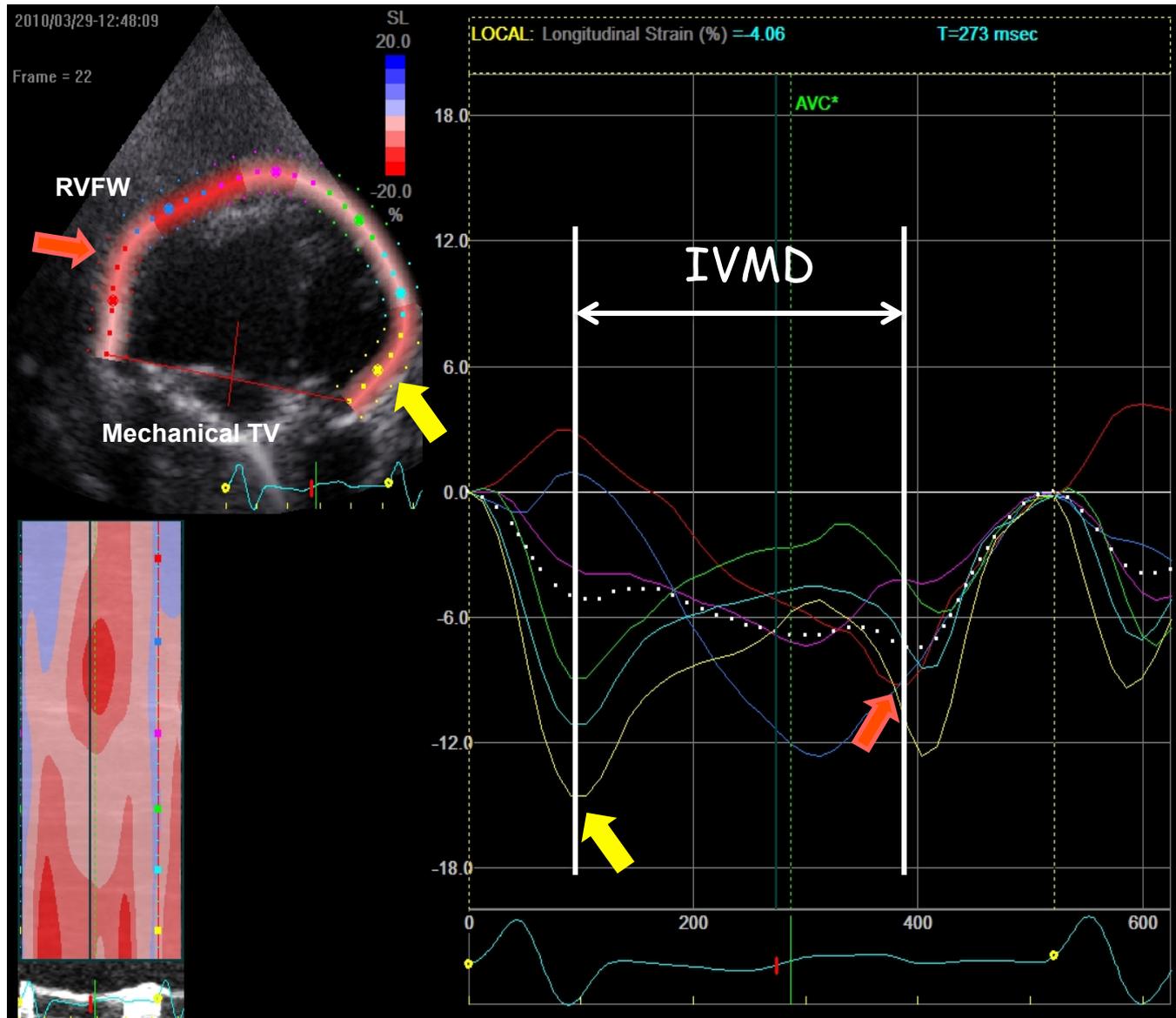
HLHS, St.p. BCPA & TVR; 2,5 y/o, RV failure



Results - Lead placement

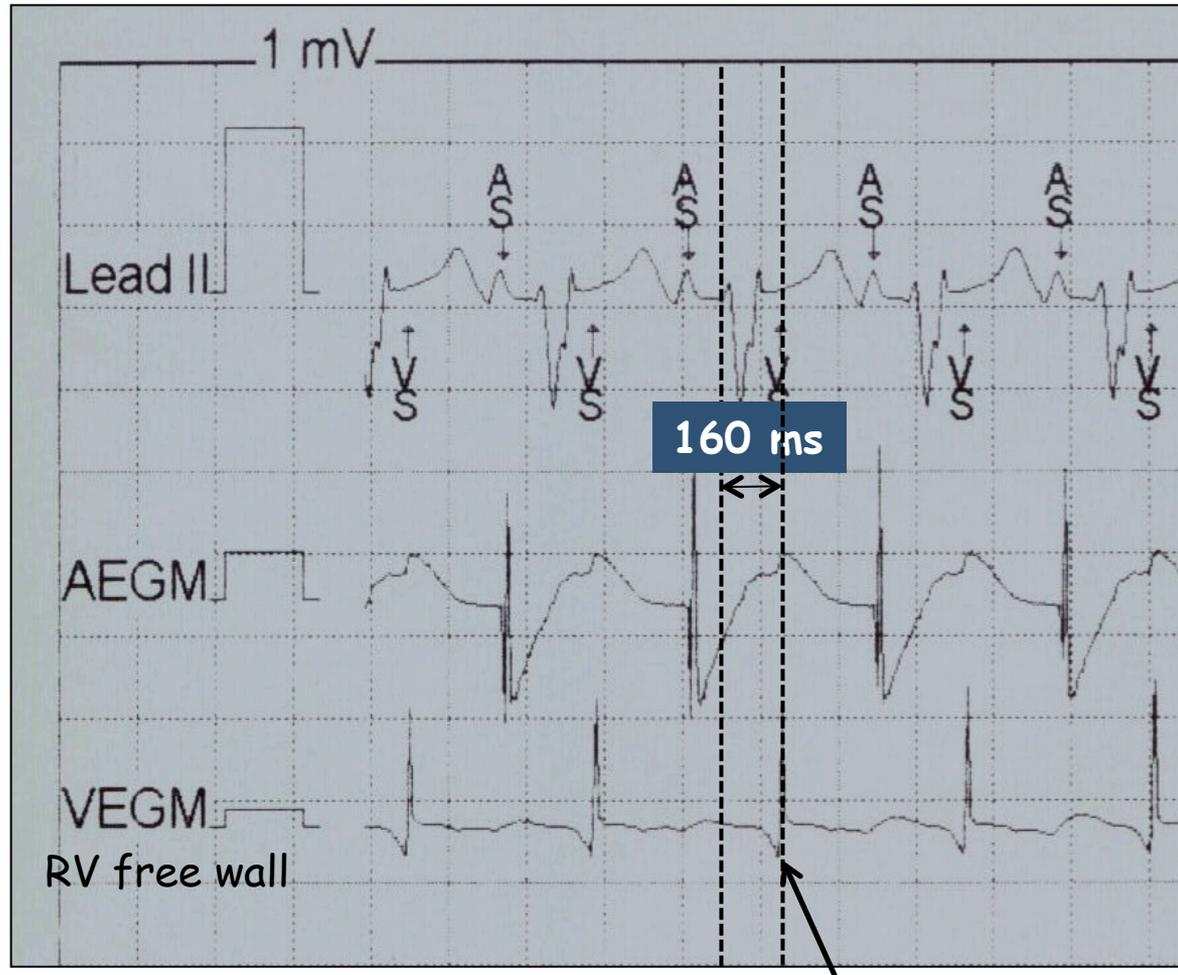


Pre-procedural mechanical mapping - 2DS



Peri-procedural electrical activation mapping

Search for latest local electrical activation during baseline rhythm



Local activation at the site of the systemic ventricular lead

HLHS, St.p. BCPA & TVR; 2,5 y/o, RV failure

