



# Conduction system pacing in Heart failure

Jane Moses

25/05/2023 10:57:54 AM

ACE



78  
3:117HR

Study	Aim	Patients and randomization	QRS complex pattern	Results
Path CHF, Auricchio et al, 2002 [13]	Compare the short- and long-term clinical effects of atrial synchronous, pre-excitation of univentricular or biventricular therapy with cardiac CRT.	N = 42; randomized to biventricular CRT (24)/ univentricular CRT (17); followed for 9 months	QRS ≥ 120 ms; LBBB, 39 (93%)/ RBBB, 3 (7%)	CRT produces a long-term improvement in the clinical symptoms of patients with HF who have significant IVCD.
MIRACLE, Abraham et al, 2002 [14]	Evaluate the clinical benefit of CRT in symptomatic heart failure with IVCD.	N = 453; randomized to CRT group (228)/ control (225); followed for 6 months	QRS ≥ 130ms	Significant clinical improvement in moderate to severe heart failure with IVCD.
CONTAK CD, Higgins et al, 2003 [15]	Assess the safety and effectiveness of cardiac CRT when combined with an ICD.	N = 490; randomized to CRT (245)/control (245); followed for 6 months	QRS ≥ 120 ms; CRT group: LBBB 50%/ NSIVCD 32%/RBBB 18%; non-CRT group: LBBB 54%/NSIVCD 34%/RBBB 12%	CRT implant has improved the functional status in all patients that were indicated for ICD and have HF rEF and IVCD.
MIRACLE ICD, Young et al, 2003 [16]	Examine the efficacy and safety of combined CRT and ICD therapy in patients with NYHA class III or IV CHF despite appropriate medical management.	N = 369; randomized to CRT on (187)/ CRT off (182); followed for 6 months	QRS ≥ 130 ms; CRT group: LBBB 87%/ RBBB 13%; control group: LBBB 86%/ RBBB 14%	CRT improved quality of life, functional status, and exercise capacity in patients with moderate to severe HF, a wide QRS interval, and life-threatening arrhythmias. CRT effect on QOL score and NYHA functional class was not influenced by morphology of the BBB (R vs. L)
MIRACLE ICD II, Abraham et al, 2004 [17]	Assess the efficacy and safety of combined CRT and ICD therapy in patients with NYHA class II CHF despite appropriate medical management.	N = 186; randomized to CRT on (86)/control (101); followed for 6 months	QRS ≥ 130 ms; CRT group: LBBB 88%/ RBBB 12%; non-CRT group: LBBB 79%/RBBB 21%	Significant improvement in cardiac structure and function over 6 months. CRT did not alter exercise capacity.
CARE HF, Cleland et al, 2005 [18]	Evaluation of CRT on morbidity and mortality in patients with NYHA class III or IV.	N = 813; randomized to CRT group (409)/ control (404); followed for 18 months	QRS ≥ 120 ms	CRT improves symptoms, the QOL and reduces complications and improves mortality. The broader the QRS in general the overall better results.
REVERSE, Linde et al, 2008 [19]	Assess the effects of CRT use in patients with NYHA functional class I and II.	N = 610; randomized to CRT group (419)/ control (191); followed for 12 months	QRS ≥ 120 ms	CRT in combination with optimal medical therapy (+/-defibrillator), reduces the risk for HF hospitalization and improves ventricular structure and function in NYHA I and II.
MADIT CRT, Breithardt et al, 2009 [20]	Determine whether CRT with biventricular pacing would reduce the risk of death or HF events in patients with NYHA I or II, reduced EF of ≤ 30% and QRS duration ≥ 130 ms.	N = 1,820; randomized to CRT (CRT and ICD on) group (1,089)/control (CRT off and ICD on) (731); followed for up of 2.4 years	QRS ≥ 130 ms; CRT group: LBBB (761)/RBBB (136); control: LBBB (520)/RBBB (92)	CRT combined with ICD decreased the risk of HF events in relatively asymptomatic patients with a low ejection fraction and wide QRS complex.

# Management of HFrEF

To reduce mortality - for all patients

ACE-I/ARNI

BB

MRA

SGLT2i

lex pattern Results

ms; 93%/7%) CRT produces a long-term improvement in the clinical symptoms of patients with HF who have significant IVCD.

ms Significant clinical improvement in moderate to severe heart failure with IVCD.

ms; CRT 50%/2%/RBBB CRT group: 12%/NSIVCD CRT implant has improved the functional status in all patients that were indicated for ICD and have HFrEF and IVCD.

ms; CRT 87%/control 86%/ CRT improved quality of life, functional status, and exercise capacity in patients with moderate to severe HF, a wide QRS interval, and life-threatening arrhythmias. CRT effect on QOL score and NYHA functional class was not influenced by morphology of the BBB (R vs. L)

ms; CRT 88%/non-LBBB 21% Significant improvement in cardiac structure and function over 6 months. CRT did not alter exercise capacity.

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ms; LBBB (136); BB (92) CRT combined with ICD decreased the risk of HF events in relatively asymptomatic patients with a low ejection fraction and wide QRS complex.

To reduce HF hospitalization/mortality - for selected patients

Volume overload

Diuretics

SR with LBBB  $\geq 150$  ms

CRT-P/D

SR with LBBB 130–149 ms or non LBBB  $\geq 150$  ms

CRT-P/D

Ischaemic aetiology

ICD

Non-ischaemic aetiology

ICD

Atrial fibrillation

Anticoagulation

Atrial fibrillation

Digoxin

PVI

Coronary artery disease

CABG

Iron deficiency

Ferric carboxymaltose

Aortic stenosis

SAVR/TAVI

Mitral regurgitation

TEE MV Repair

Heart rate SR > 70 bpm

Ivabradine

Black Race

Hydralazine/ISDN

ACE-I/ARNI intolerance

ARB

# Management of HFrEF

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SGLT2i

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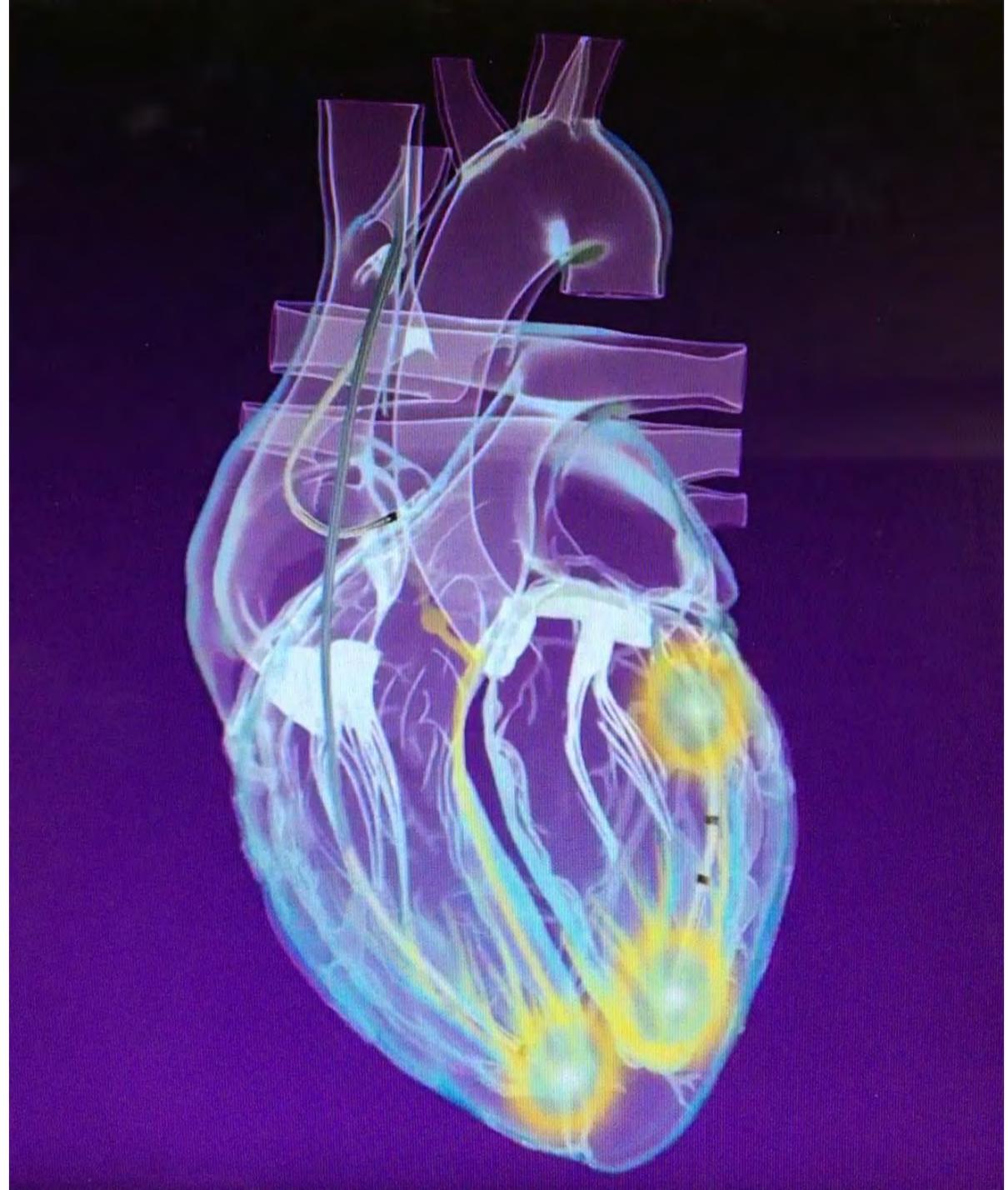
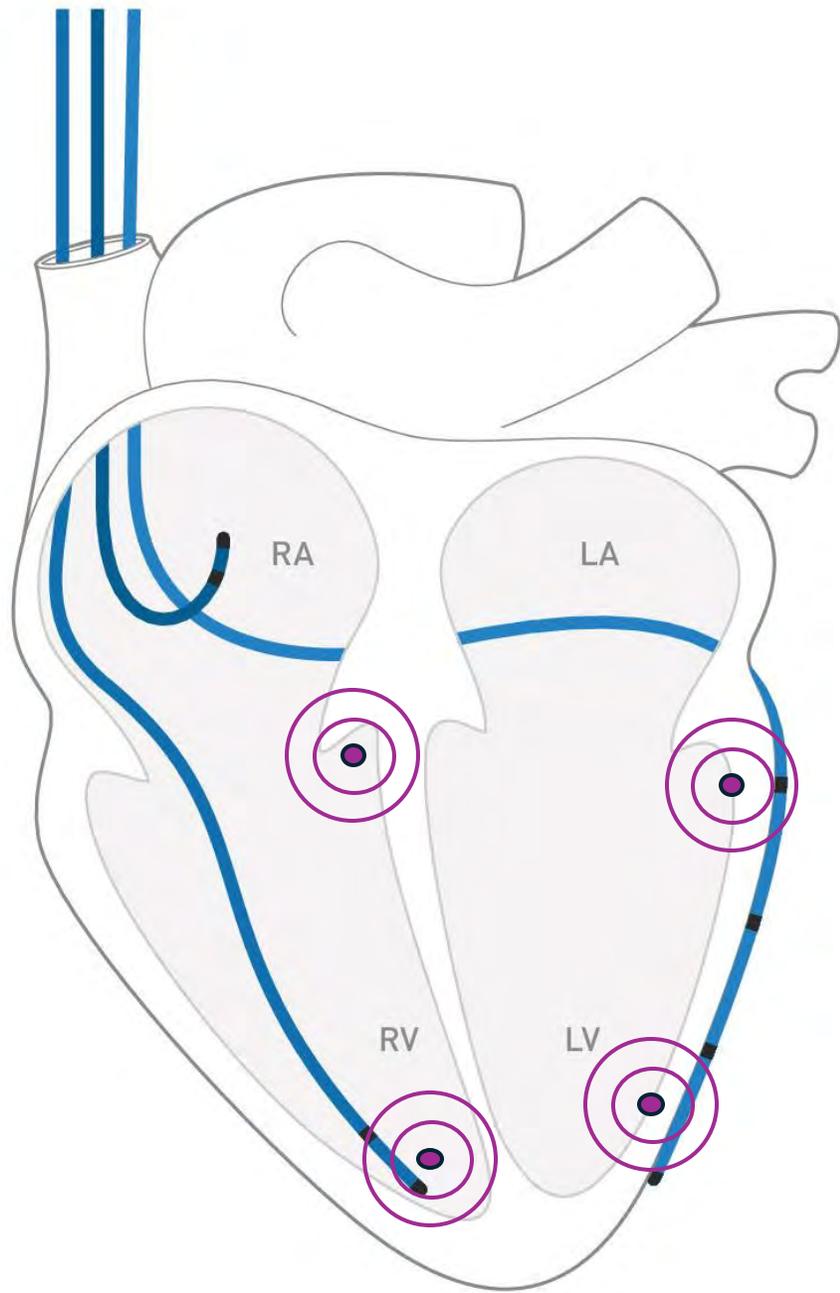
Hydralazine/ISDN

ACE-I/ARNI intolerance

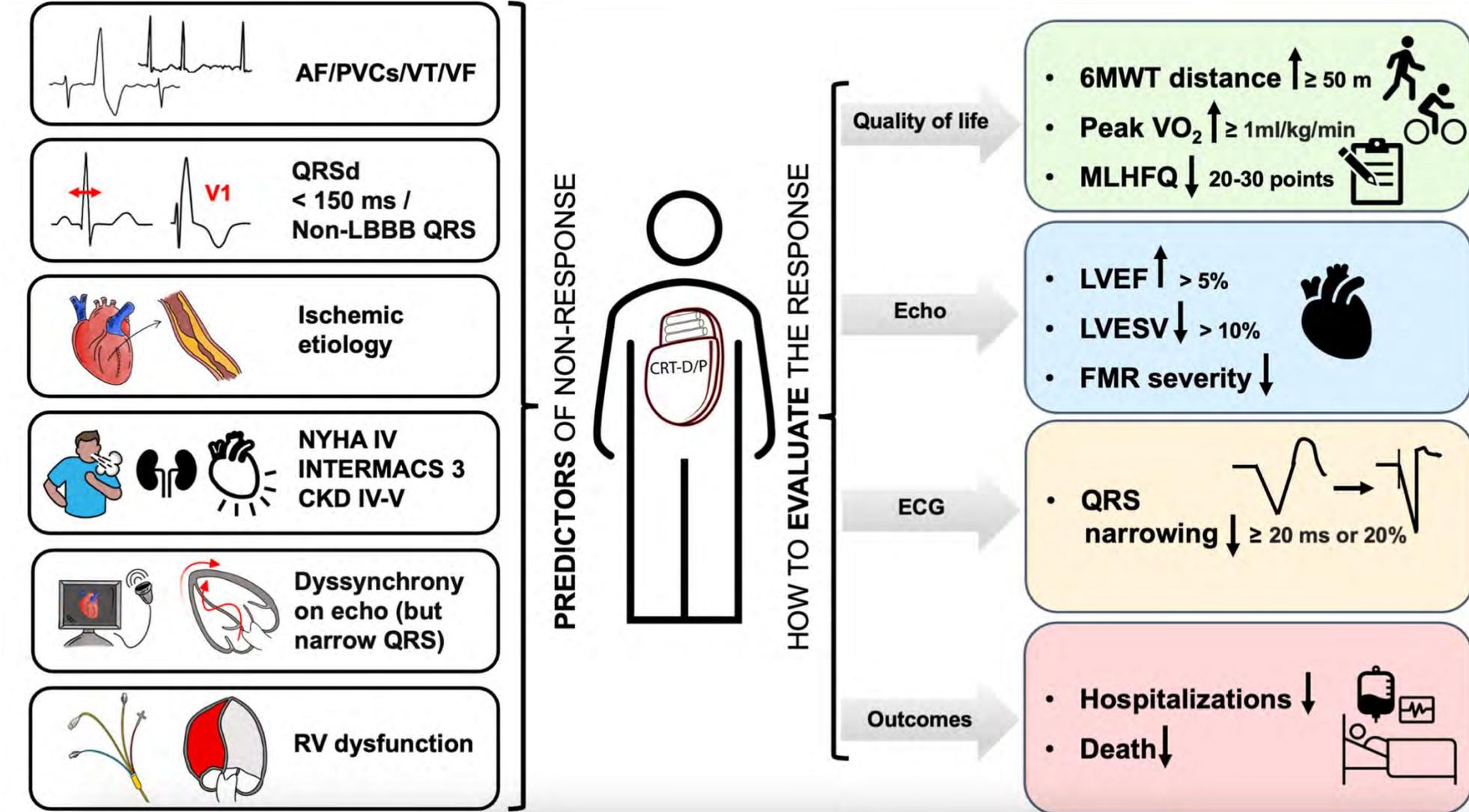
ARB

## Recommendations for cardiac resynchronization therapy in patients in sinus rhythm

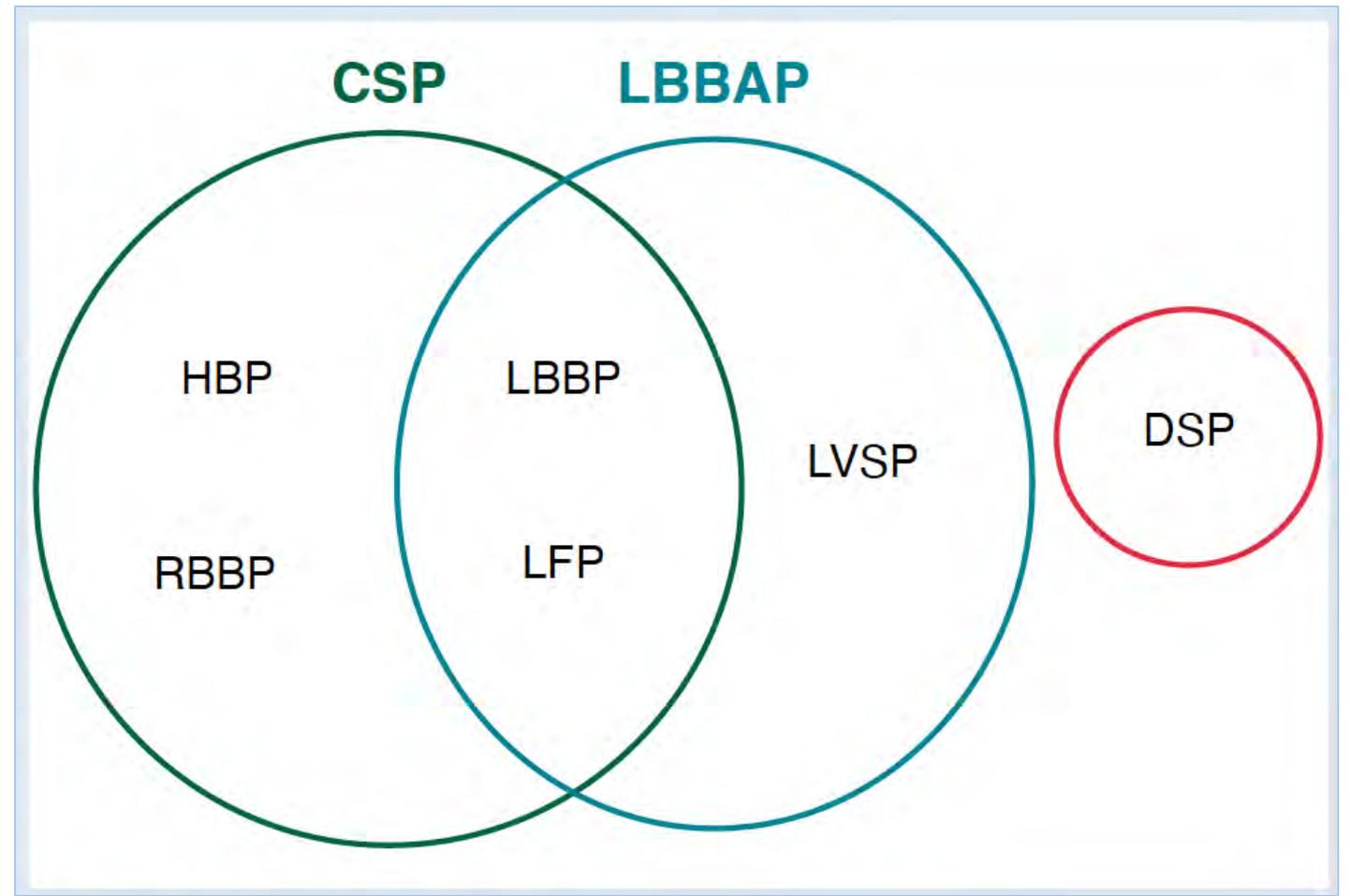
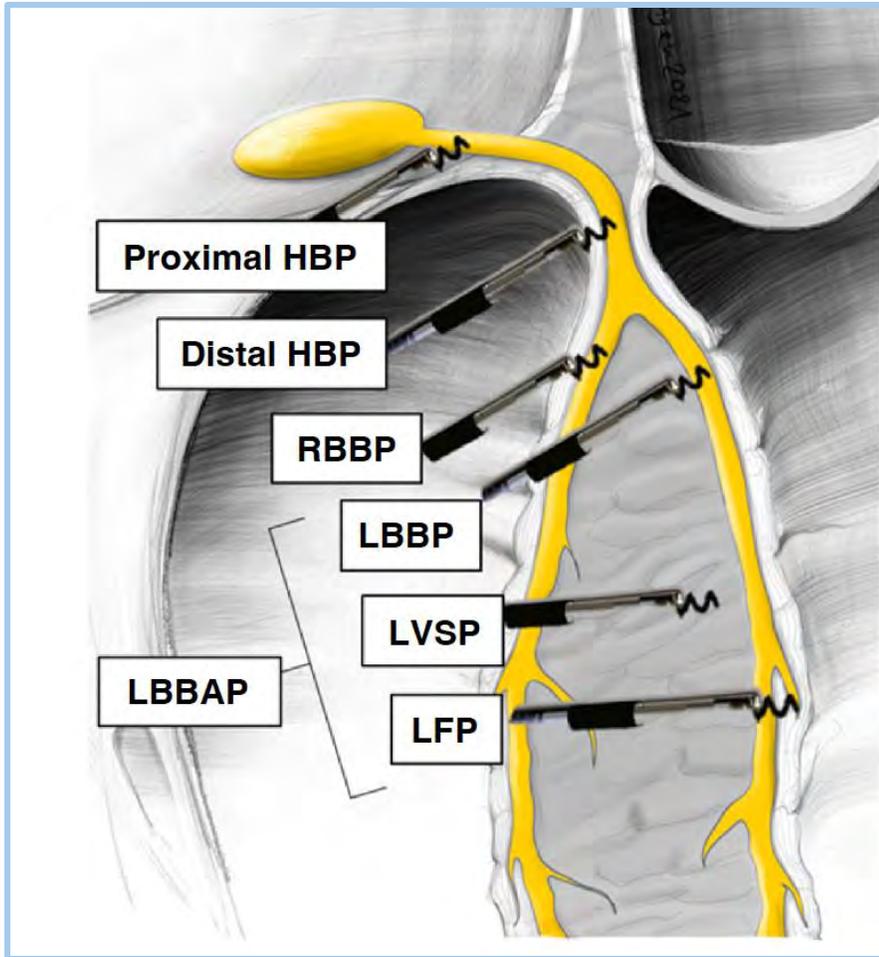
Recommendations	Class <sup>a</sup>	Level <sup>b</sup>
<b>LBBB QRS morphology</b>		
CRT is recommended for symptomatic patients with HF in SR with LVEF $\leq 35\%$ , QRS duration $\geq 150$ ms, and LBBB QRS morphology despite OMT, in order to improve symptoms and reduce morbidity and mortality. <sup>37,39,40,254–266,283,284</sup>	I	A
CRT should be considered for symptomatic patients with HF in SR with LVEF $\leq 35\%$ , QRS duration 130–149 ms, and LBBB QRS morphology despite OMT, in order to improve symptoms and reduce morbidity and mortality. <sup>37,39,40,254–266,283,284</sup>	IIa	B
<b>Non-LBBB QRS morphology</b>		
CRT should be considered for symptomatic patients with HF in SR with LVEF $\leq 35\%$ , QRS duration $\geq 150$ ms, and non-LBBB QRS morphology despite OMT, in order to improve symptoms and reduce morbidity. <sup>37,39,40,254–266,283,284</sup>	IIa	B
CRT may be considered for symptomatic patients with HF in SR with LVEF $\leq 35\%$ , QRS duration 130–149 ms, and non-LBBB QRS morphology despite OMT, in order to improve symptoms and reduce morbidity. <sup>273–278,281</sup>	IIb	B
<b>QRS duration</b>		
CRT is not indicated in patients with HF and QRS duration $< 130$ ms without an indication for RV pacing. <sup>264,282</sup>	III	A



# Cardiac resynchronization therapy (CRT) nonresponders in the contemporary era: A state-of-the-art review



# EHRA Consensus Statement

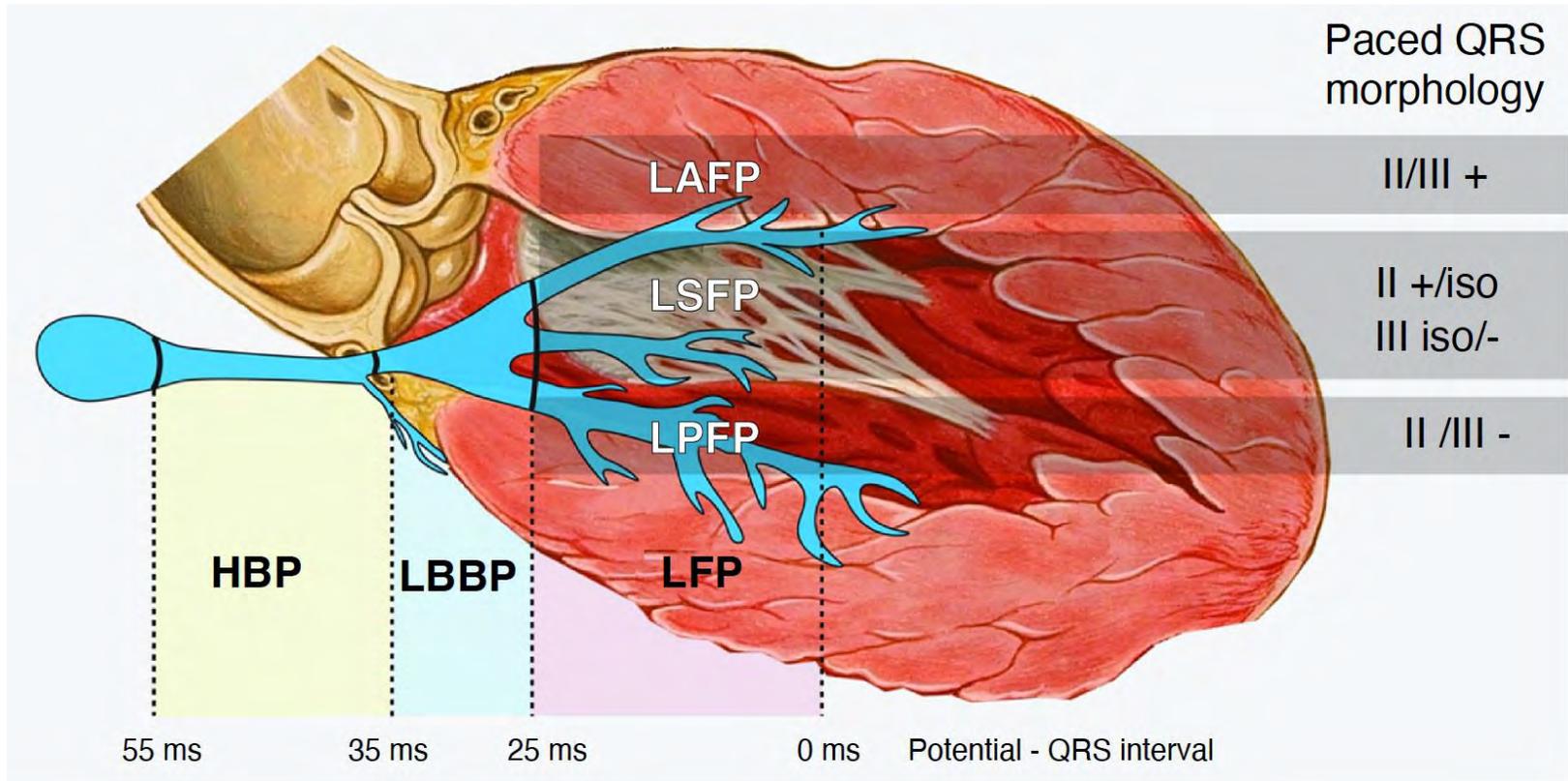


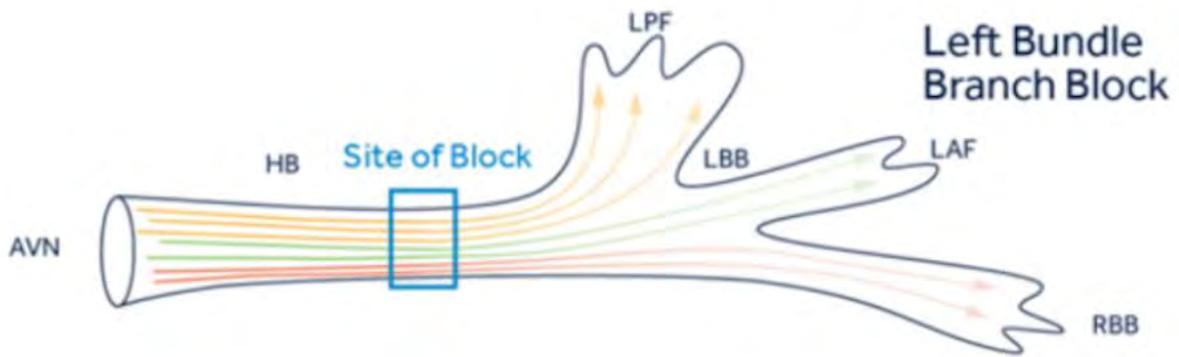
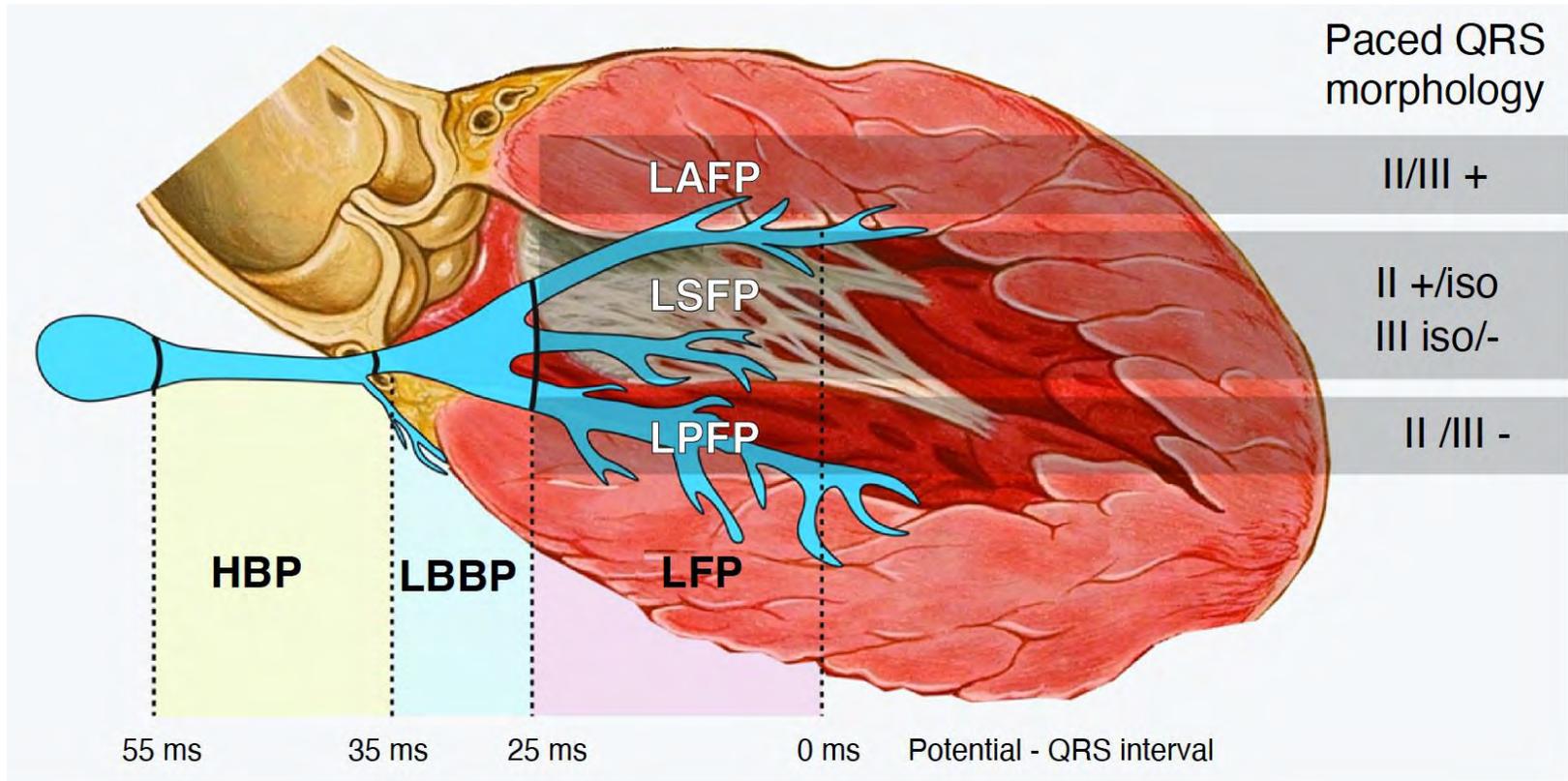
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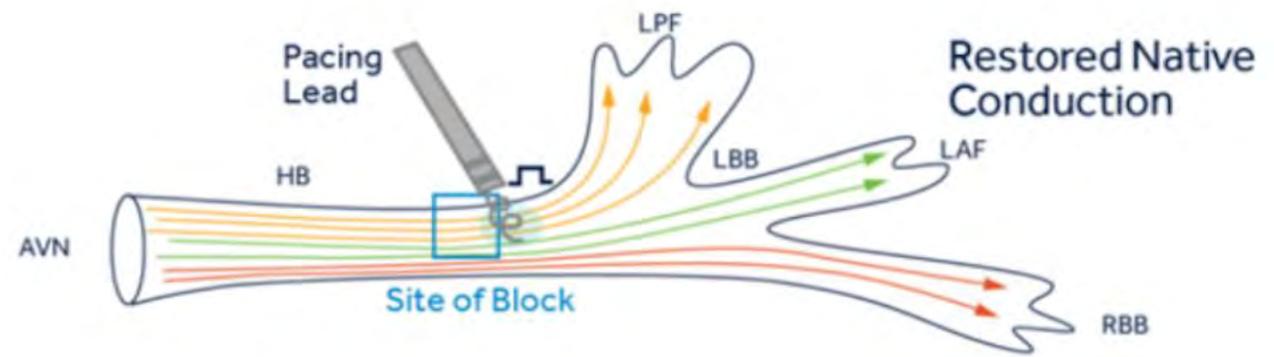
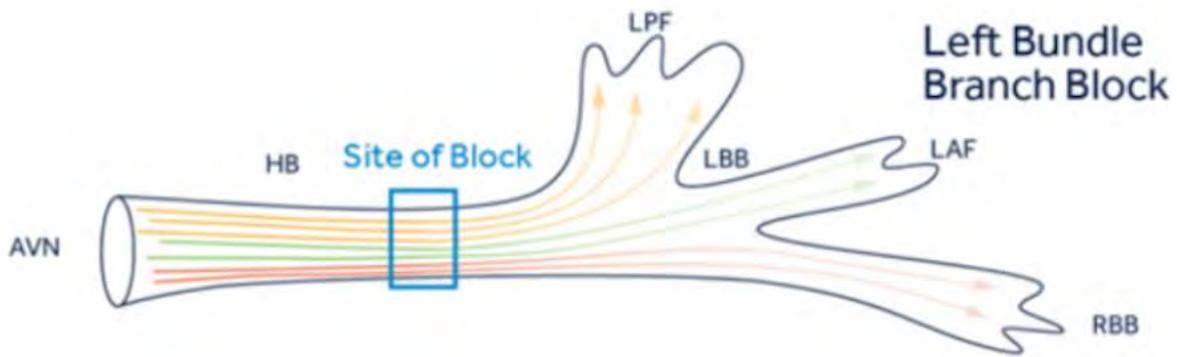
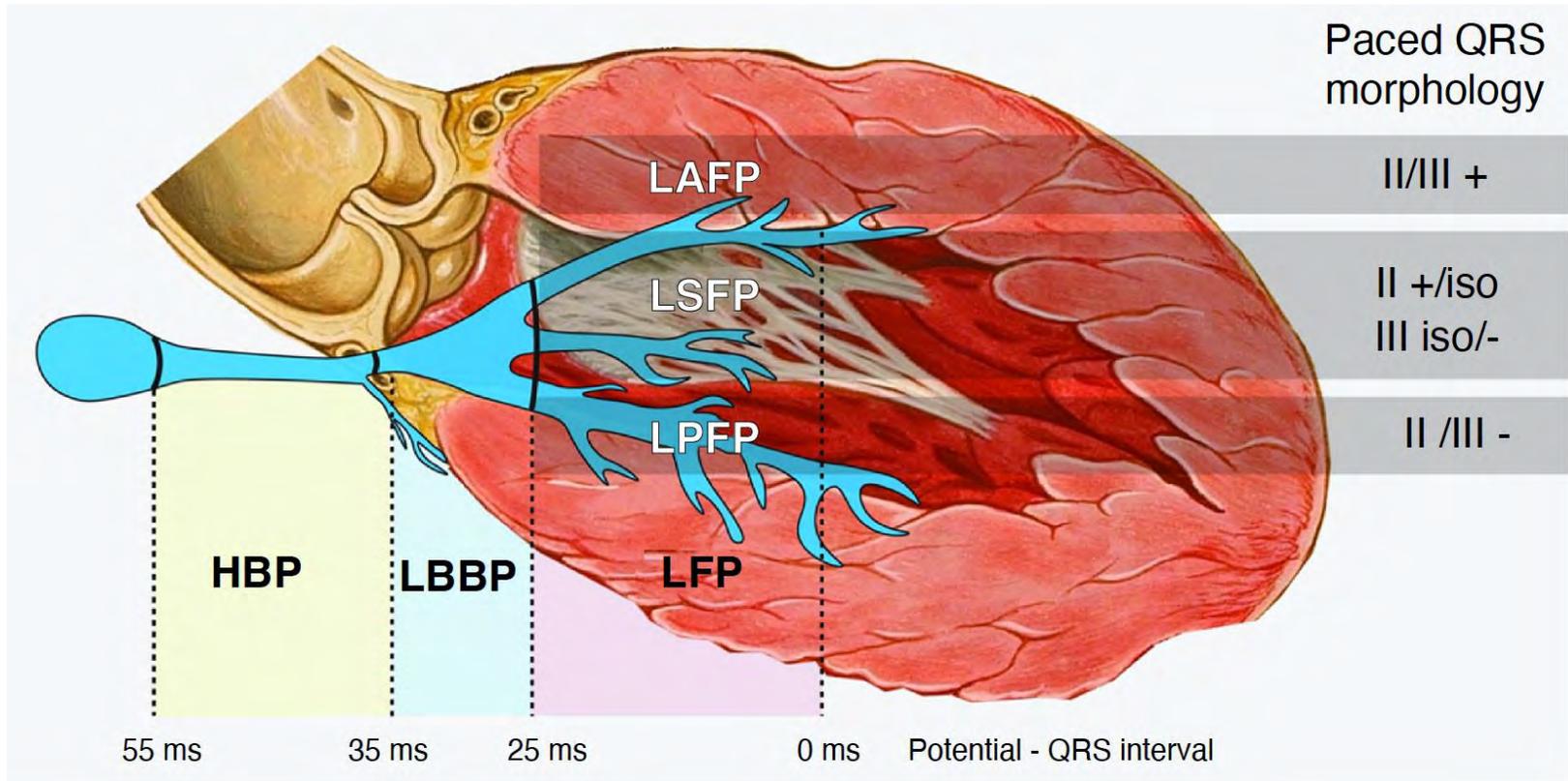
European Society  
of Cardiology

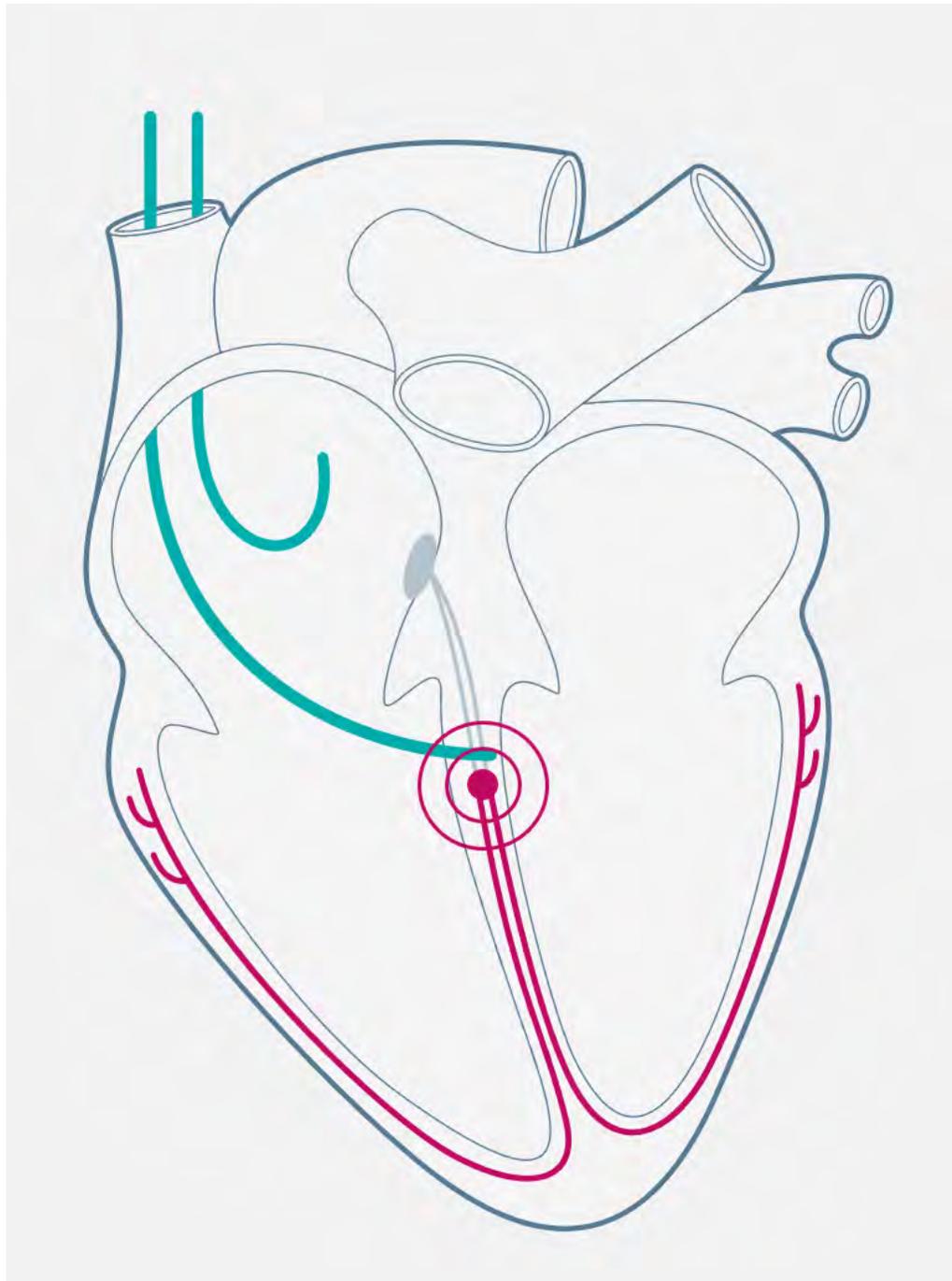
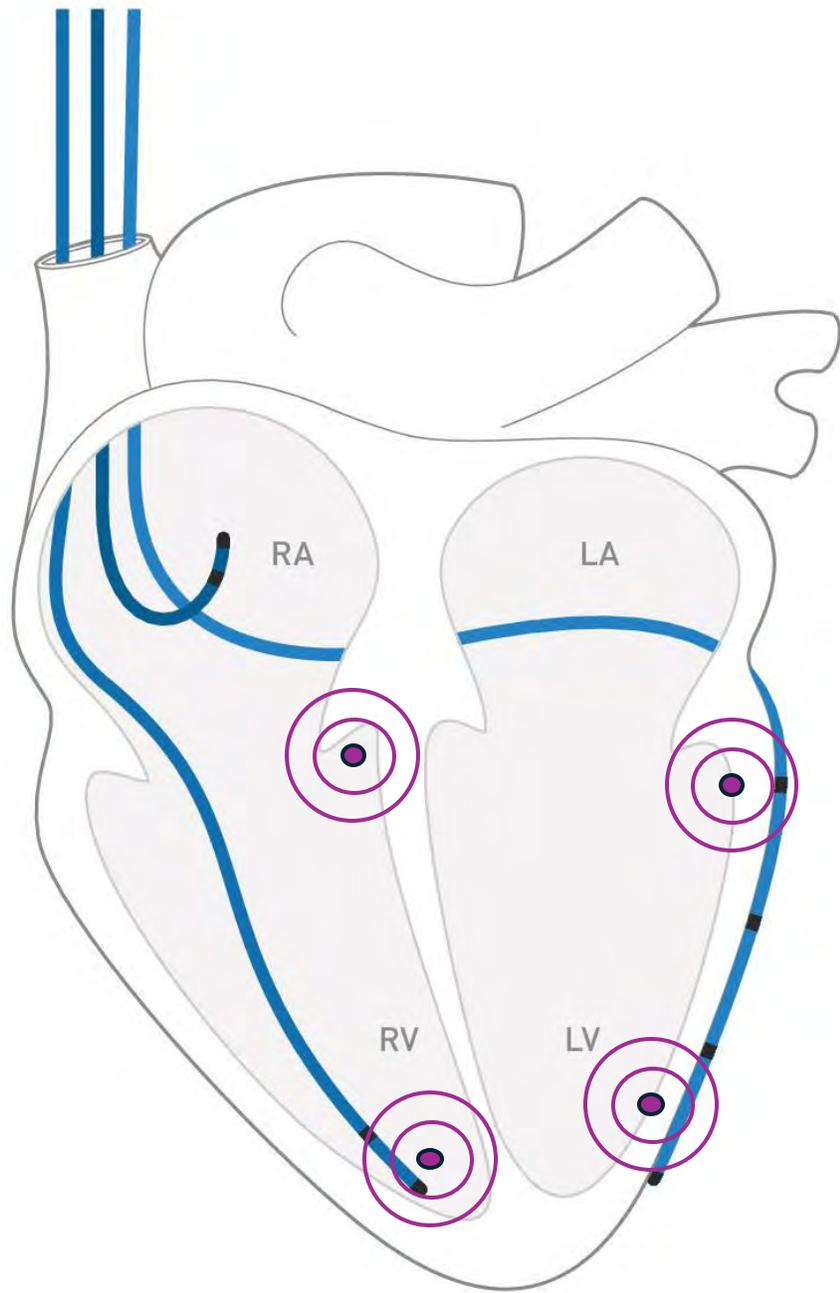
Europace (2023) 25, 1208–1236

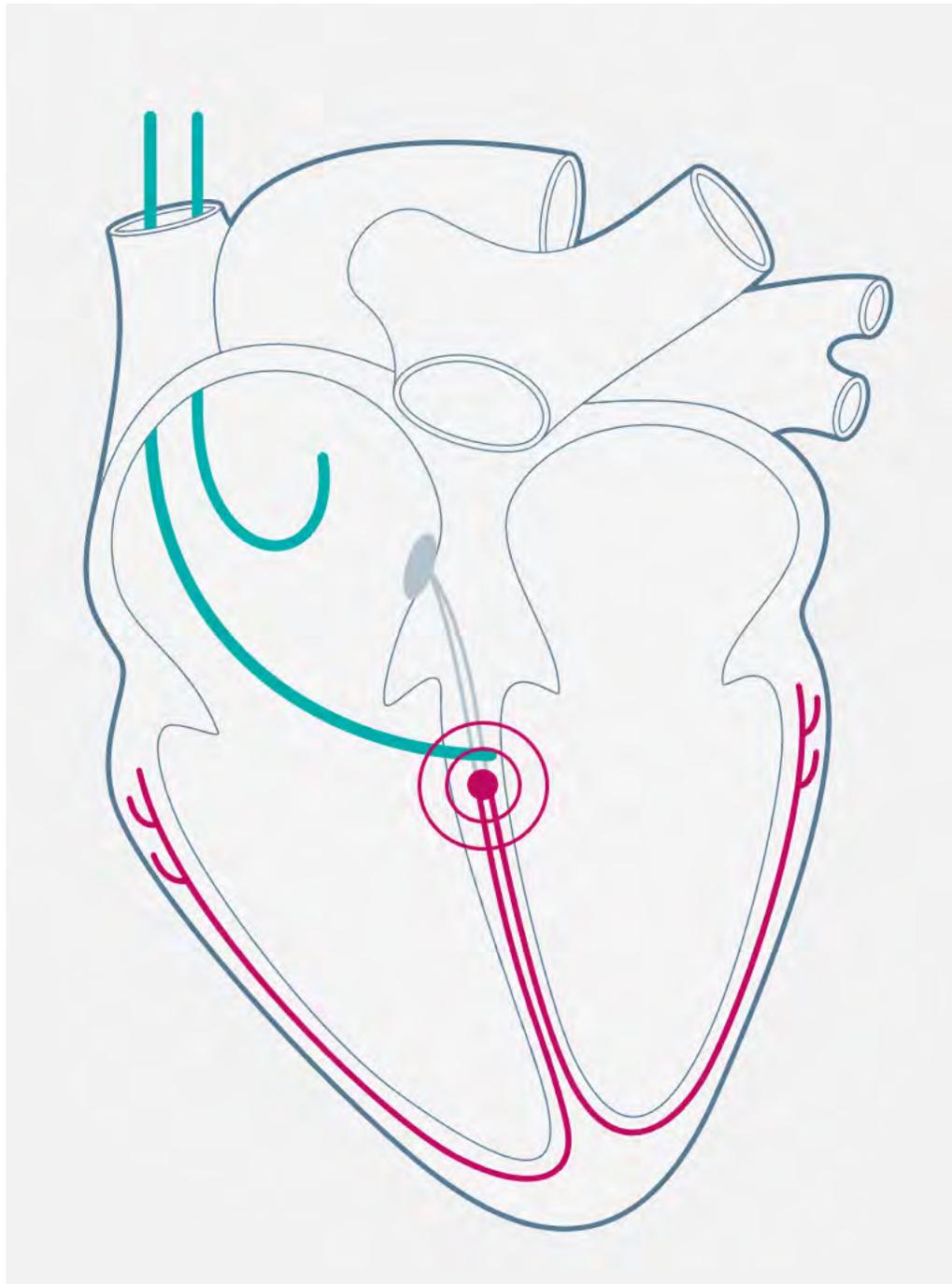
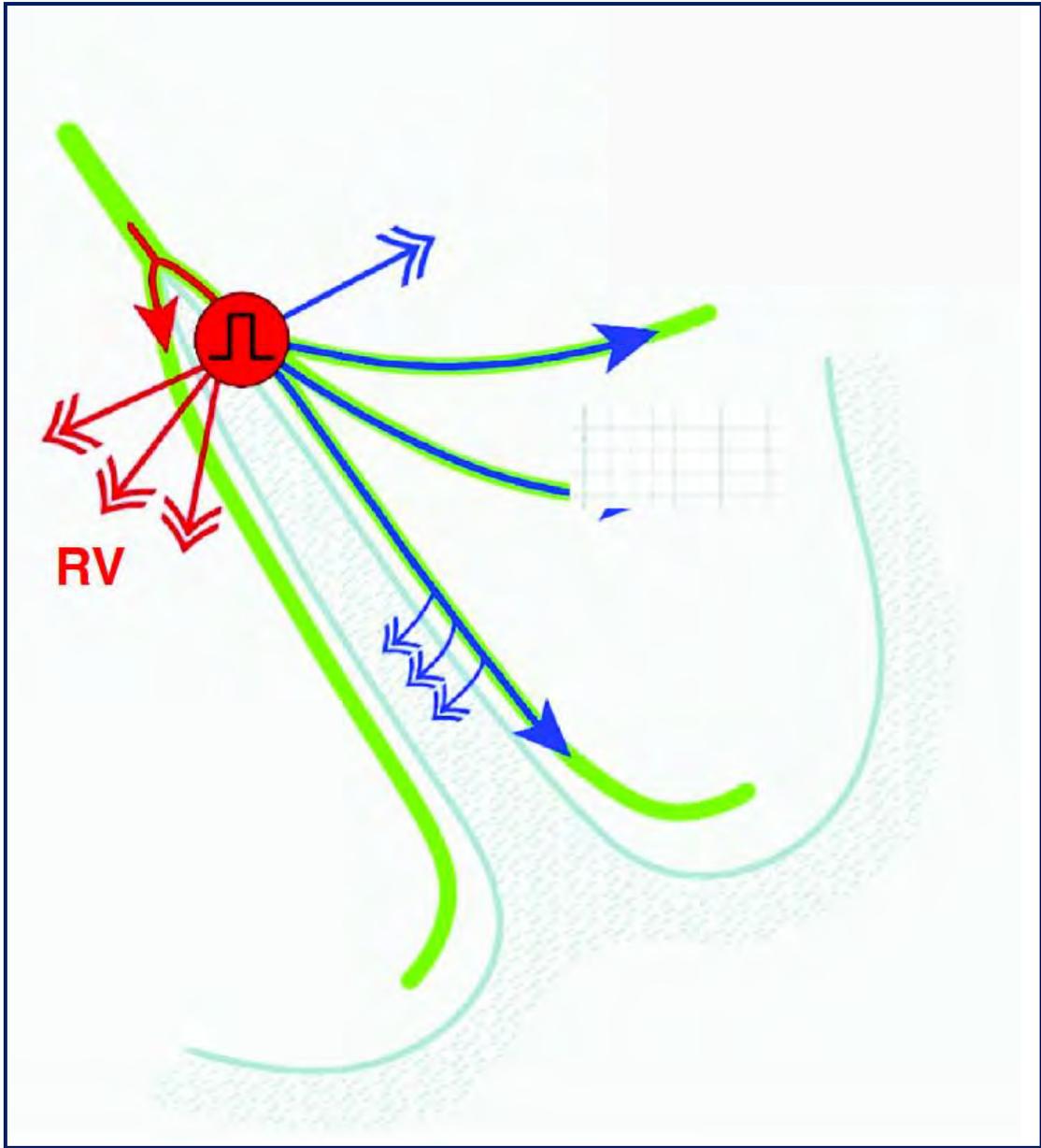
<https://doi.org/10.1093/europace/euad043>













ESC

European Society of Cardiology  
Europace (2025) 27, euaf050  
<https://doi.org/10.1093/europace/euaf050>

Activation time (ms)

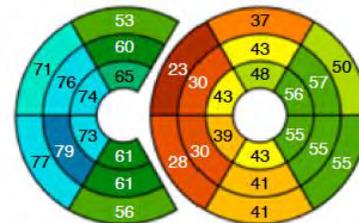
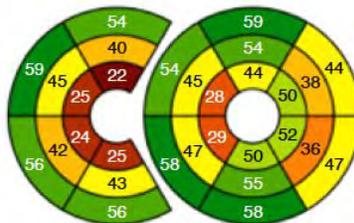
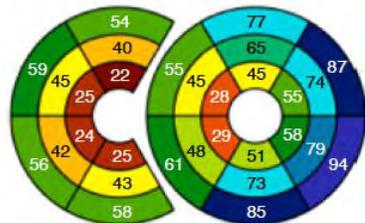
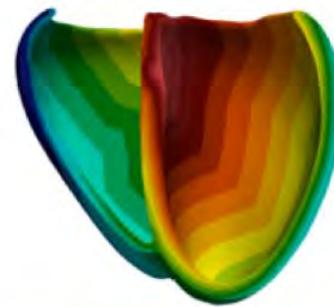
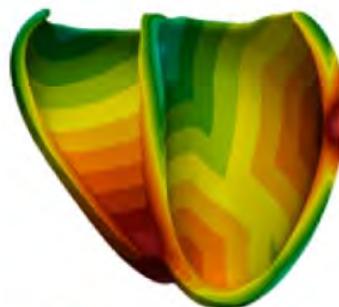
0 10 20 30 40 50 60 70 80 90 100



RVAP

BiVP

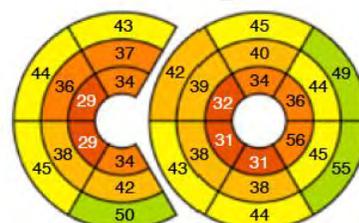
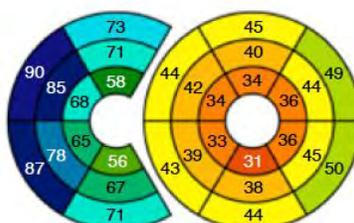
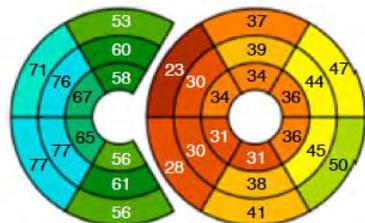
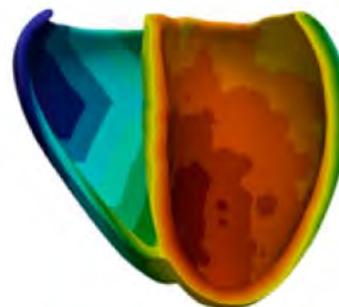
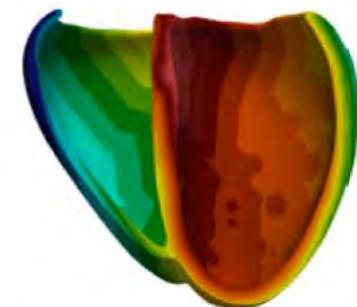
LVSP



nsLBBP

sLBBP

sHBP



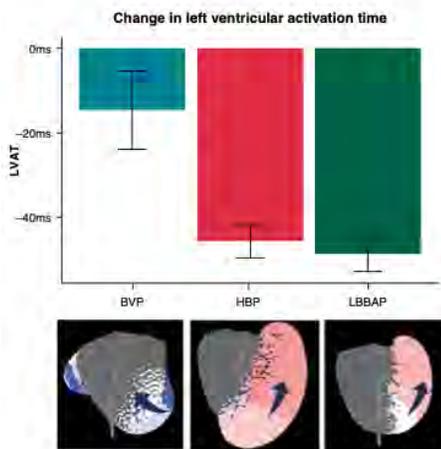
EHRA DOCUMENT



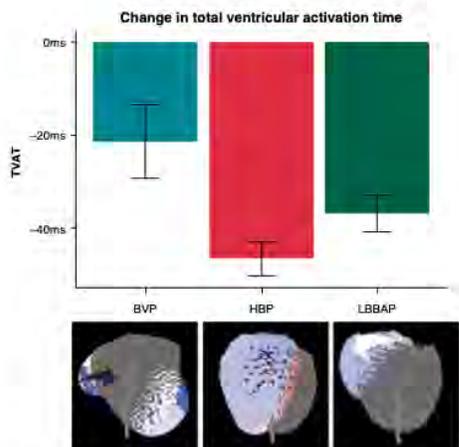
EHRA  
European Heart  
Rhythm Association

# Comparison of CRT delivery methods

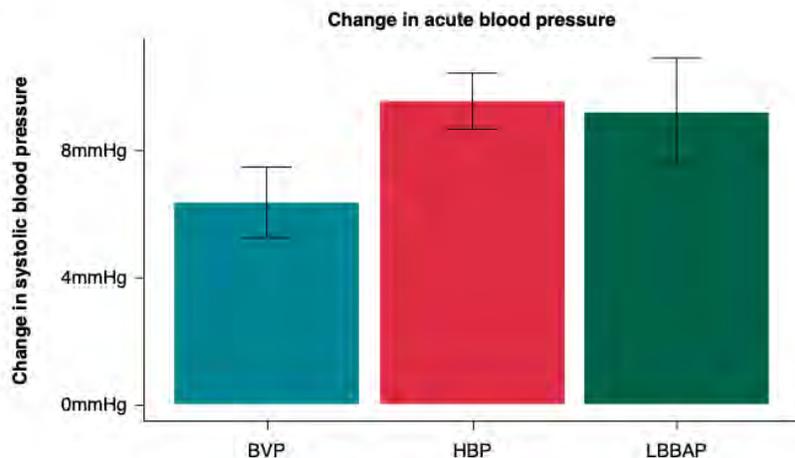
**HBP and LBBAP deliver more rapid and physiological left ventricular activation than BVP**



**HBP produces greatest reduction in total ventricular activation time. RV activation is delayed with LBBAP**



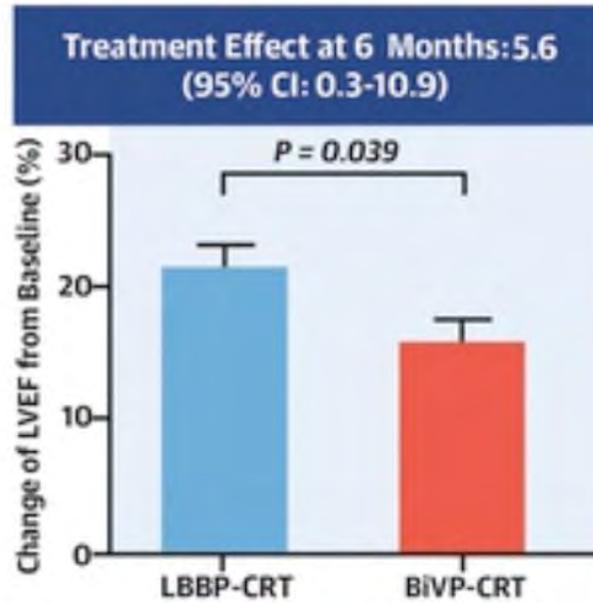
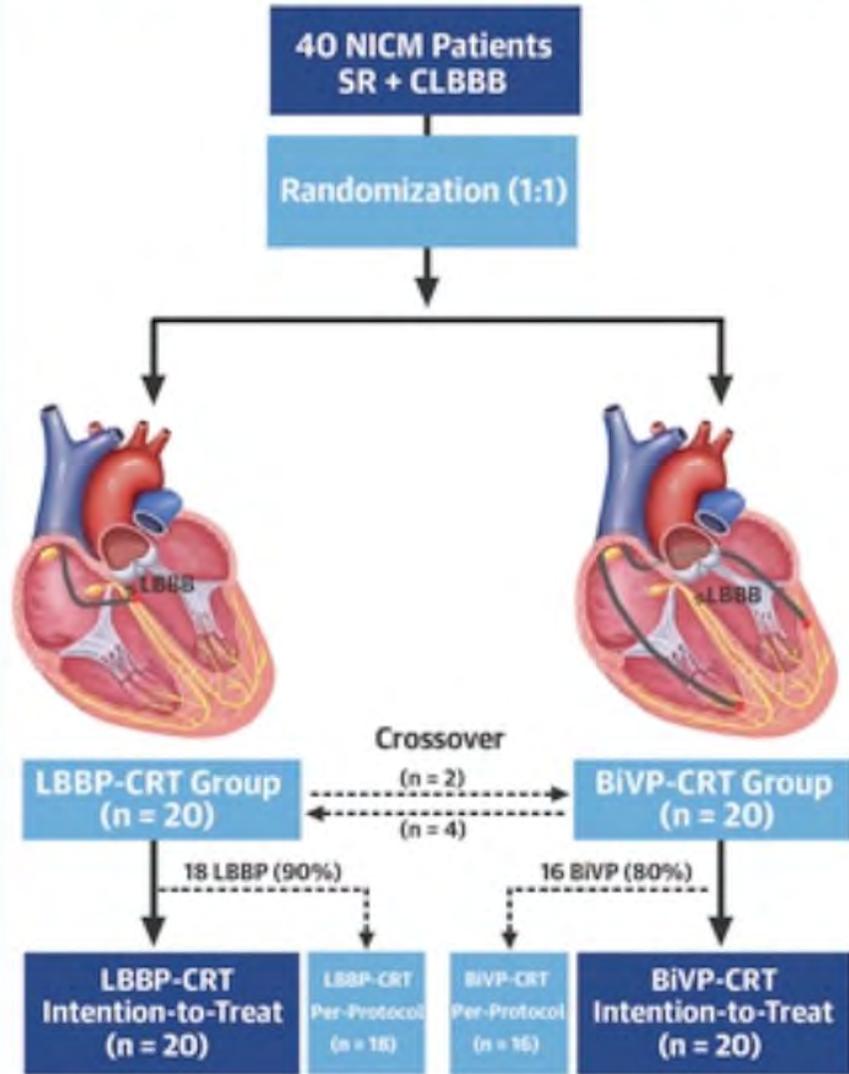
**HBP and LBBAP produces similar acute hemodynamic improvement**



	<b>HBP and LBAP</b>	<b>HBP, LBBAP, and BVP</b>
	<i>n</i> = 19	<i>n</i> = 12
Male	14 (74%)	8 (67%)
Cardiomyopathy		
Ischaemic	3 (16%)	2 (17%)
Non-ischaemic	15 (79%)	10 (83%)
Dual pathology	1 (5%)	0
Left ventricular ejection fraction (%)	30 ± 6	29 ± 7
Electrocardiography		
AF	3 (16%)	3 (25%)
Pr interval	185 ± 30	182 ± 39
QRS duration	168 ± 20	167 ± 24
QRS morphology		
LBBB	16 (84%)	11 (92%)
RBBB	1 (5%)	
IVCD	1 (5%)	
Pacing-dependent	1 (5%)	1 (8%)

Ali, *Europace* (2023) **25** 1060-1067

**CENTRAL ILLUSTRATION: Left Bundle Branch Pacing vs Biventricular Pacing for cardiac Resynchronization Therapy**



Wang Y, et al. J Am Coll Cardiol. 2022;80(13):1205-1216.

## CENTRAL ILLUSTRATION: Left Bundle Branch Pacing vs Biventricular Pacing for cardiac Resynchronization Therapy

# LBBAP versus BiVP for CRT: A Systematic Review and Meta-Analysis



Heart Rhythm O2, Volume 4, Issue 11, P671-680, November 2023

## Background

Compared

Left Bundle Branch Area Pacing (LBBAP)

and

Biventricular Pacing (BiVP)

In patients with

Left Ventricular Systolic Dysfunction

## Methods

### Data Search

MEDLINE  
Embase  
Google Scholar  
Scopus  
Cochrane



Upto May 22, 2023

### Calculated

Risk Ratios  
Standardized Mean Difference



RevMan version 5.4 software

## Results

12 Studies

1242 LBBP



3004 Patients

1762 BiVP



### LBBAP Showed

#### Improved

LVEF  
NYHA Class  
Survival

#### Reduced

QRS Duration  
HF Hospitalizations  
Pacing Threshold

## Conclusion

*Compared to BiVP, LBBAP was associated with better electromechanical and clinical outcomes, including heart failure hospitalization, and all-cause mortality in patients with left ventricular systolic failure.*

LBBP-CRT  
Intention-to-Treat  
(n = 20)

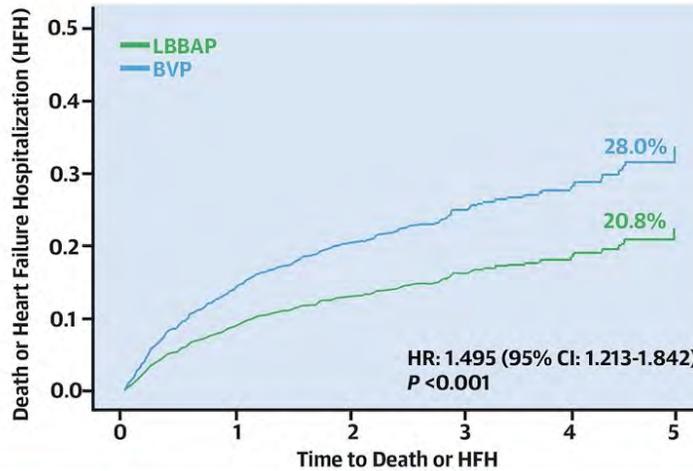
LBBP-CRT  
Per-Protocol  
(n = 18)

BiVP-CRT  
Per-Protocol  
(n = 16)

BiVP-CRT  
Intention-to-Treat  
(n = 20)

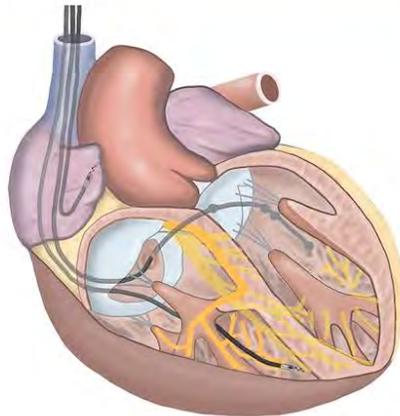
## CENTRAL ILLUSTRATION: Death or Heart Failure Hospitalization

### Time to Death or Heart Failure Hospitalization All Patients (n = 1,778)

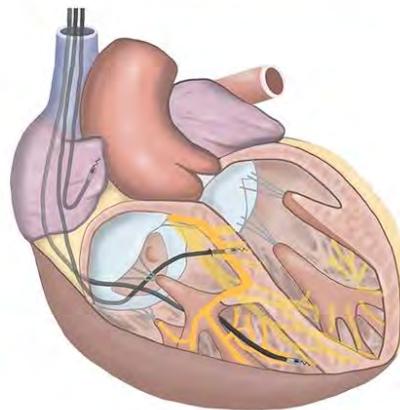


BVP	981	728	546	352	166	18
LBBAP	797	574	342	152	18	0

#### Biventricular Pacing (BVP)



#### Left Bundle Branch Area Pacing (LBBAP)



## Meta-Analysis



### Conclusion

*Compared to BiVP, LBBAP was associated with better electromechanical and clinical outcomes, including heart failure hospitalization, and all-cause mortality in patients with left ventricular systolic failure.*

3004 Patients  
1762 BiVP



Showed

Reduced

QRS Duration  
HF Hospitalizations  
Pacing Threshold

CENTRAL ILL  
Pacing for card

LBB

Heart Rh

Background

Compa

Left Bundle Br  
Pacing (LB

and

Biventricular Pa

In patient

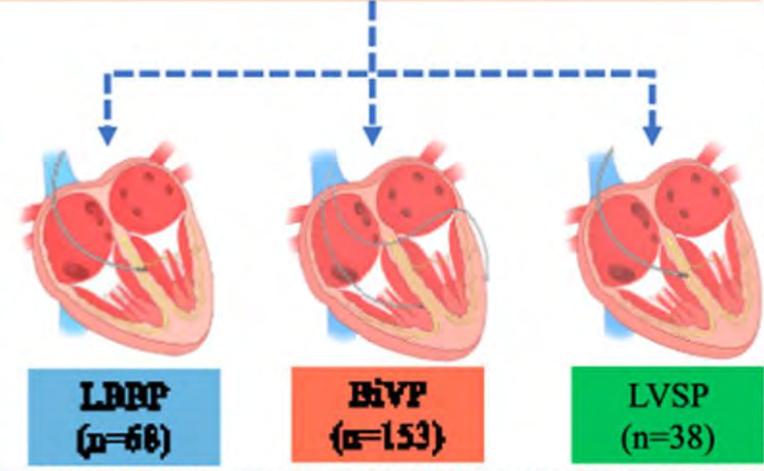
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LBBP-CRT  
Intention-to-Treat  
(n = 20)

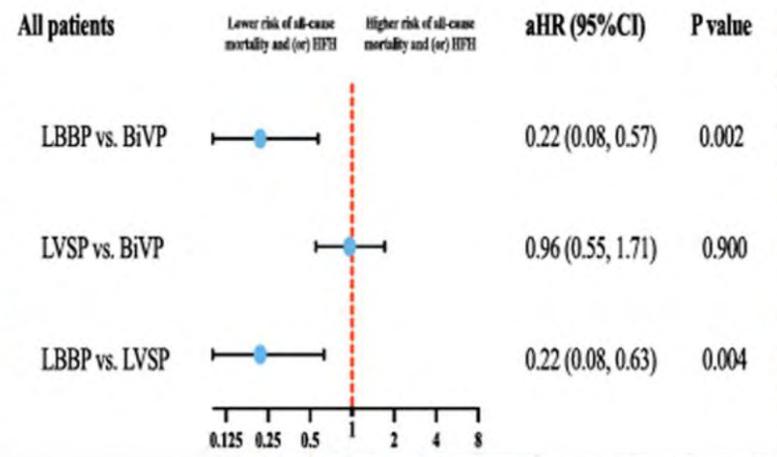
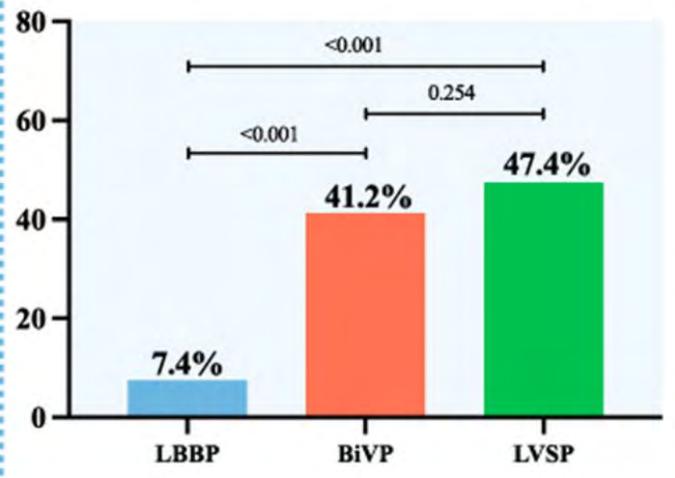
Wang Y, et al. J A

# Superior Long-term Clinical and Echocardiographic Outcomes of LBBP Compared to LVSP and BiVP

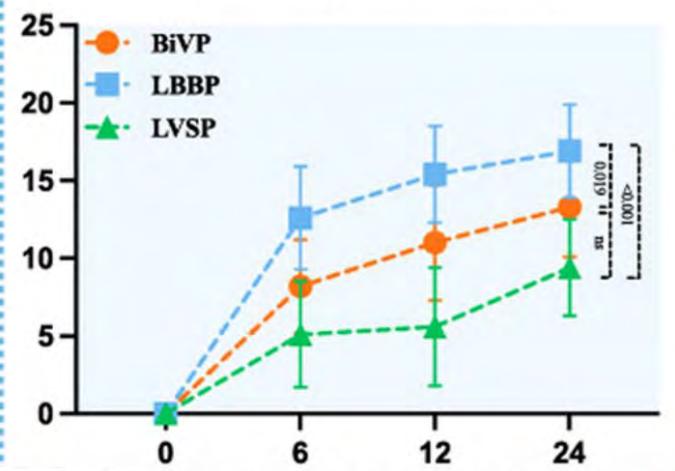
Patients with LVEF < 50% & CRT indications (n=259)



Incidence of all-cause mortality and / or heart failure hospitalization (%)



LVEF improvement (%)



CENTRAL ILL  
Pacing for card

LBBP

Heart Rhythm

Background

Comparison

Left Bundle Branch Pacing (LBBP)

and

Biventricular Pacing

In patients

Left Ventricular Dysfunction

LBBP-CRT Intention-to-Treat (n = 20)

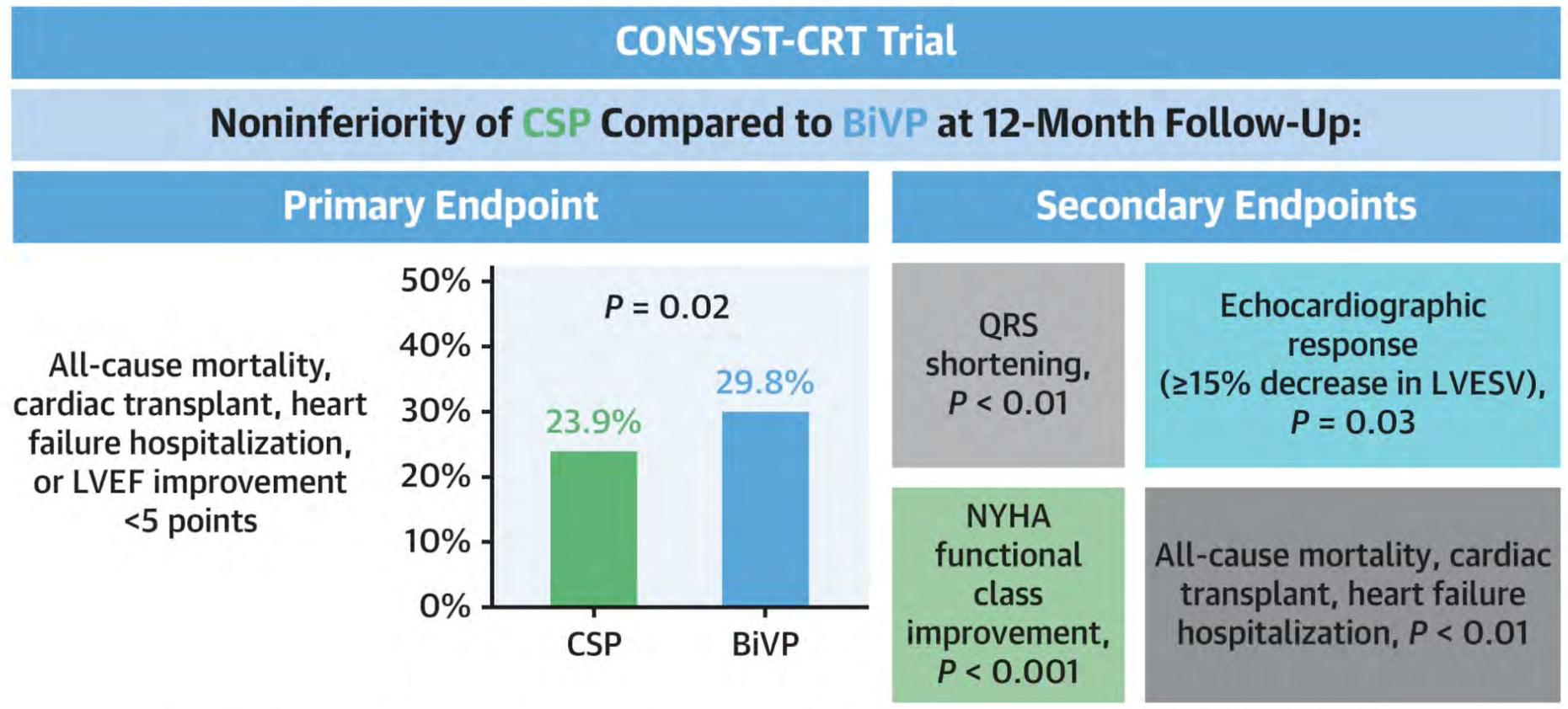
Wang Y, et al. J Am Coll Cardiol



Conclusion

Compared to BiVP, LBBP was associated with better mechanical and electrical outcomes, reduced heart failure hospitalization, and all-cause mortality in patients with left ventricular systolic failure.

# CENTRAL ILLUSTRATION: Primary and Secondary Endpoints of the CONSYST-CRT Trial (Intention-to-Treat)



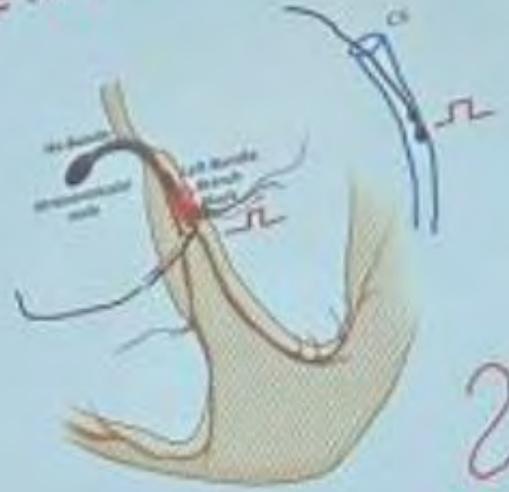
Pujol-López M, et al. JACC Clin Electrophysiol. 2025;10.1016/j.jacep.2025.03.024

My patient has an indication for resynchronisation therapy: conduction system pacing should be first line therapy in all my patients - pro



Marek Jastrzębski

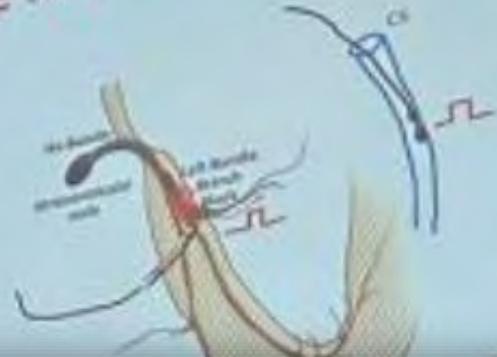
First Department of Cardiology and Interventional Electrophysiology,  
Jagiellonian University, Krakow, Poland.



EHRA 2024



My patient has an indication for resynchronisation therapy: conduction system pacing should be first line therapy in all my patients - pro



Marek Jastrzębski

First Department of Cardiology and Interventional Cardiology, Jagiellonian University, Krakow, Poland

EHRA 2024



**Synchrony is good and asynchrony is bad, and when you restore synchrony, you have good outcomes.**

Marek Jastrzębski



My patient has an indication for resynchronisation  
... conduction system pacing should be first line  
... patients - pro



**When love is in the air, you tend to neglect the evidence.**

Michael Glikson

**... and asynchrony is bad, and  
when you restore synchrony, you have good**

**outcomes.**

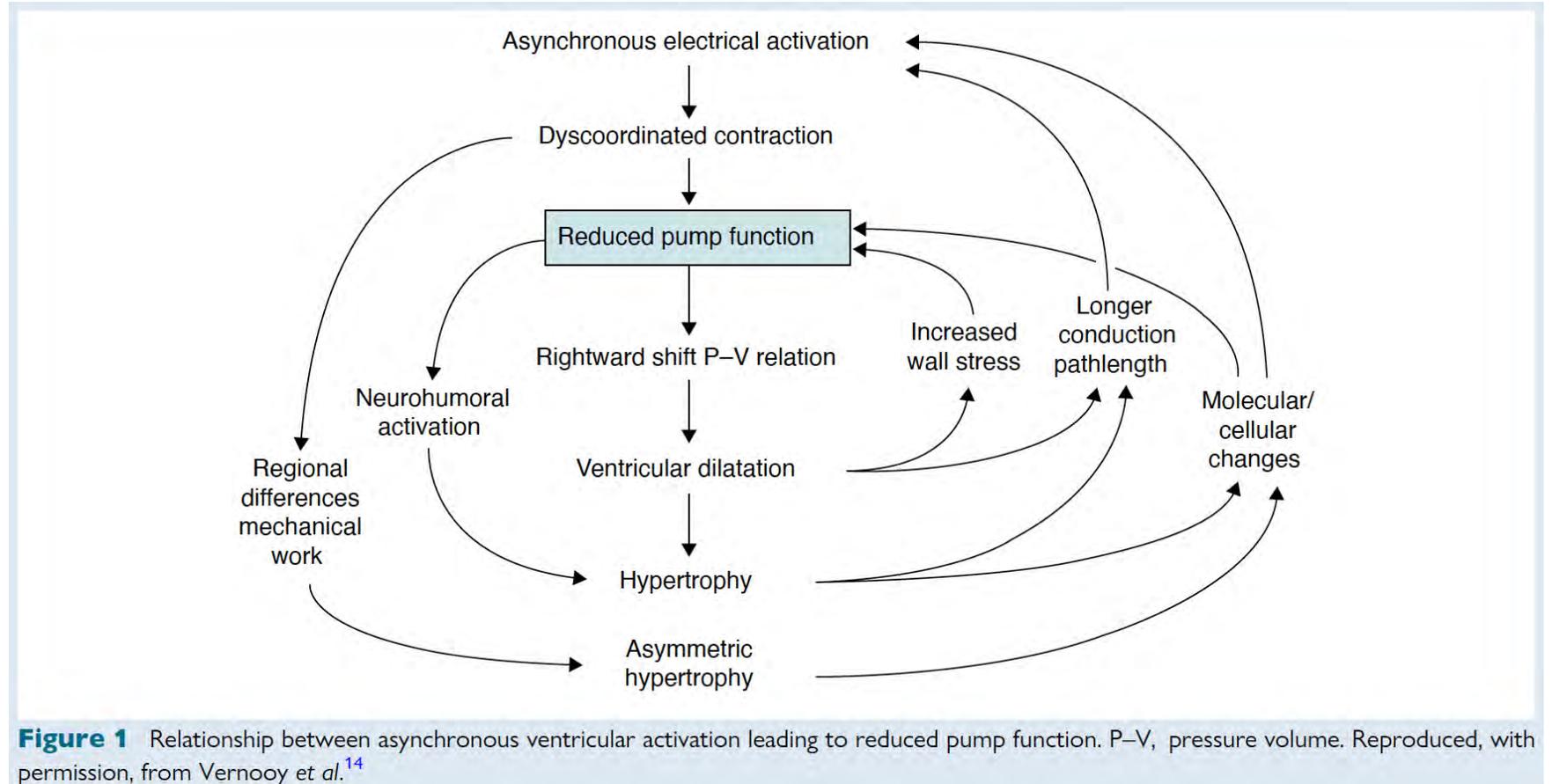
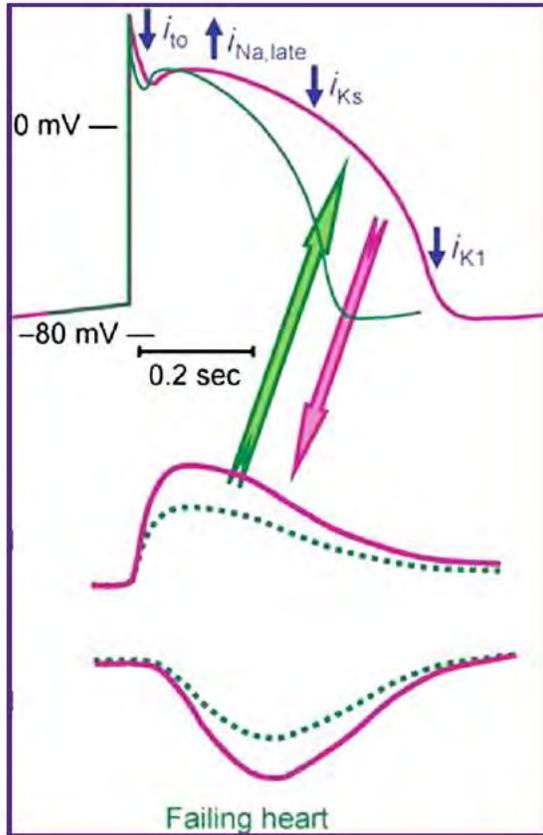
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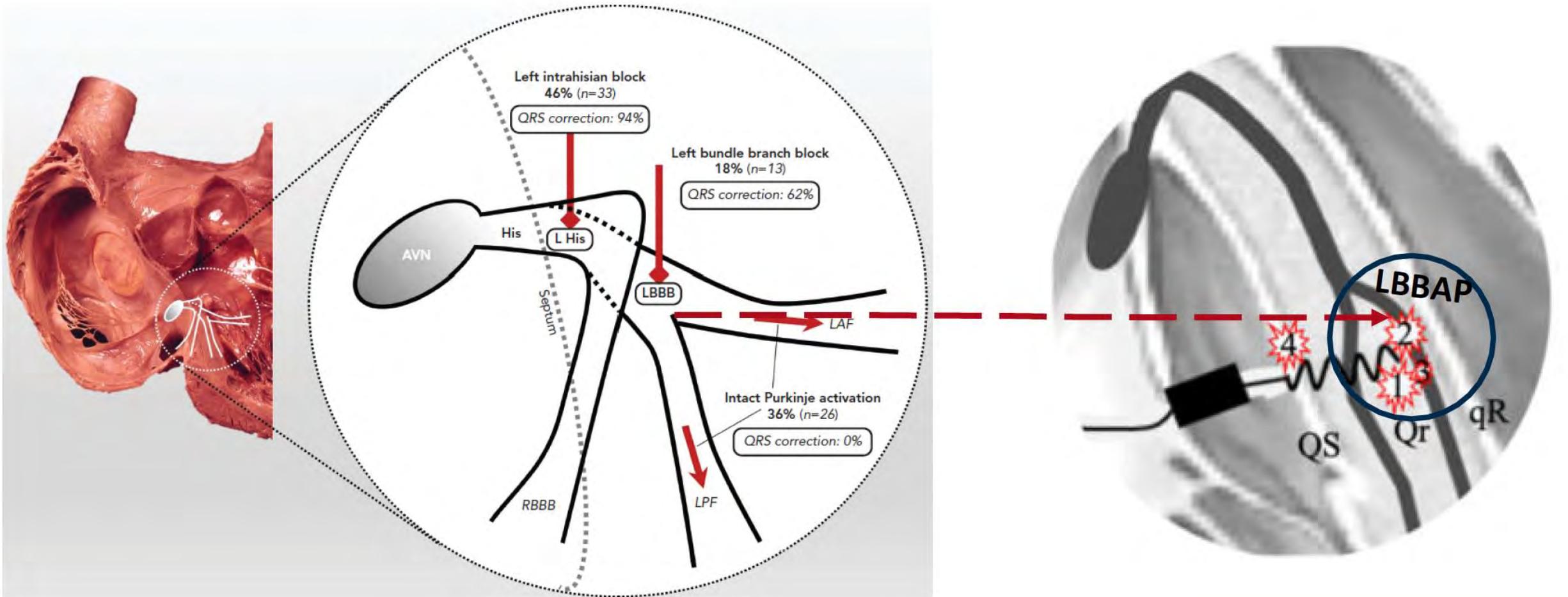


# Slowed Intraventricular Conduction is prominent in Heart Failure

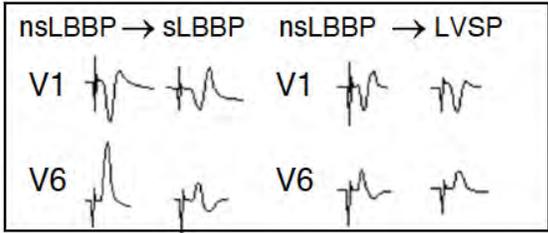


**Figure 1** Relationship between asynchronous ventricular activation leading to reduced pump function. P-V, pressure volume. Reproduced, with permission, from Vernooij et al.<sup>14</sup>

# Slowed Intraventricular Conduction is prominent in Heart Failure

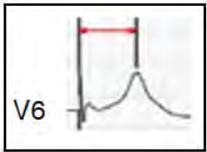


Heckman, L, et al. *J. Clin. Med.* 2021

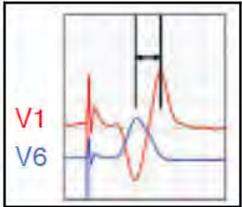


**QRS transition to LVSP or s-LBBP @ threshold test**

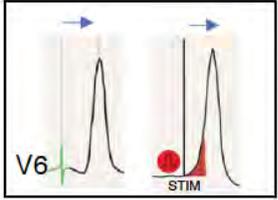
- ns-LBBP → s-LBBP : splitting of EGM and/or V1RWPT ↑ by > 10 ms.
- ns-LBBP → LVSP : V6RWPT ↑ by ≥ 15 ms



V6RWPT < 75 ms (native narrow QRS or isolated RBBB)  
 V6RWPT < 80 ms (LBBB, IVCD RBBB+ fascicular block, wide escape rhythm, asystole)



V<sub>6</sub> - V<sub>1</sub> interpeak interval > 44 ms



Potential-V6RWPT = stim-V6RWPT (+/- 10 ms)



QRS transition to s-LBBP @ programmed stimulation

- V6RWPT < 85 ms (native narrow QRS or isolated RBBB)
- V6RWPT < 100 ms (LBBB, IVCD, RBBB+ fascicular block, wide escape rhythm, asystole)
- V<sub>6</sub> - V<sub>1</sub> interpeak interval > 33 ms
- QRS transition to LVSP @ programmed stimulation
- QRS transition with V6RWPT prolongation by 10-14 ms @ threshold test



Qr / QR / qR in V<sub>1</sub>

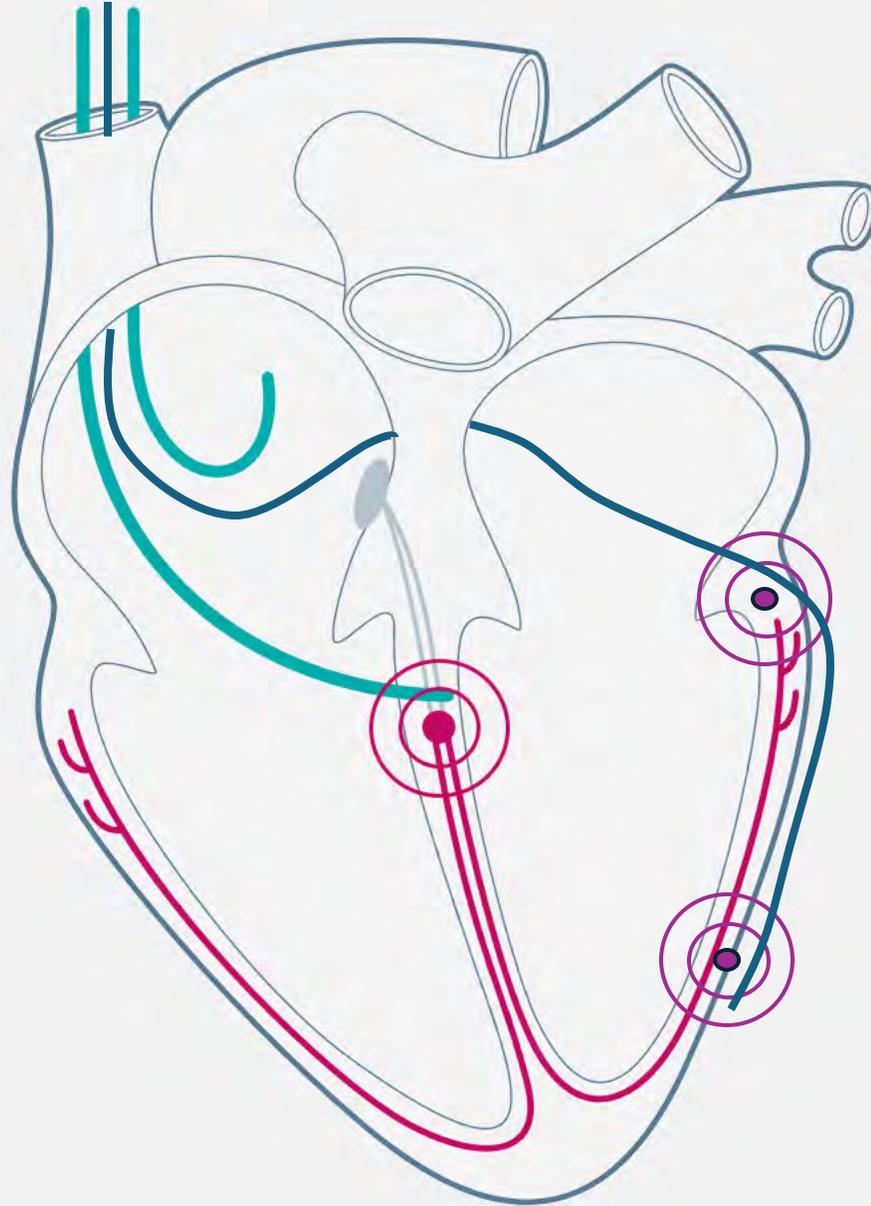
DSP

LBBP

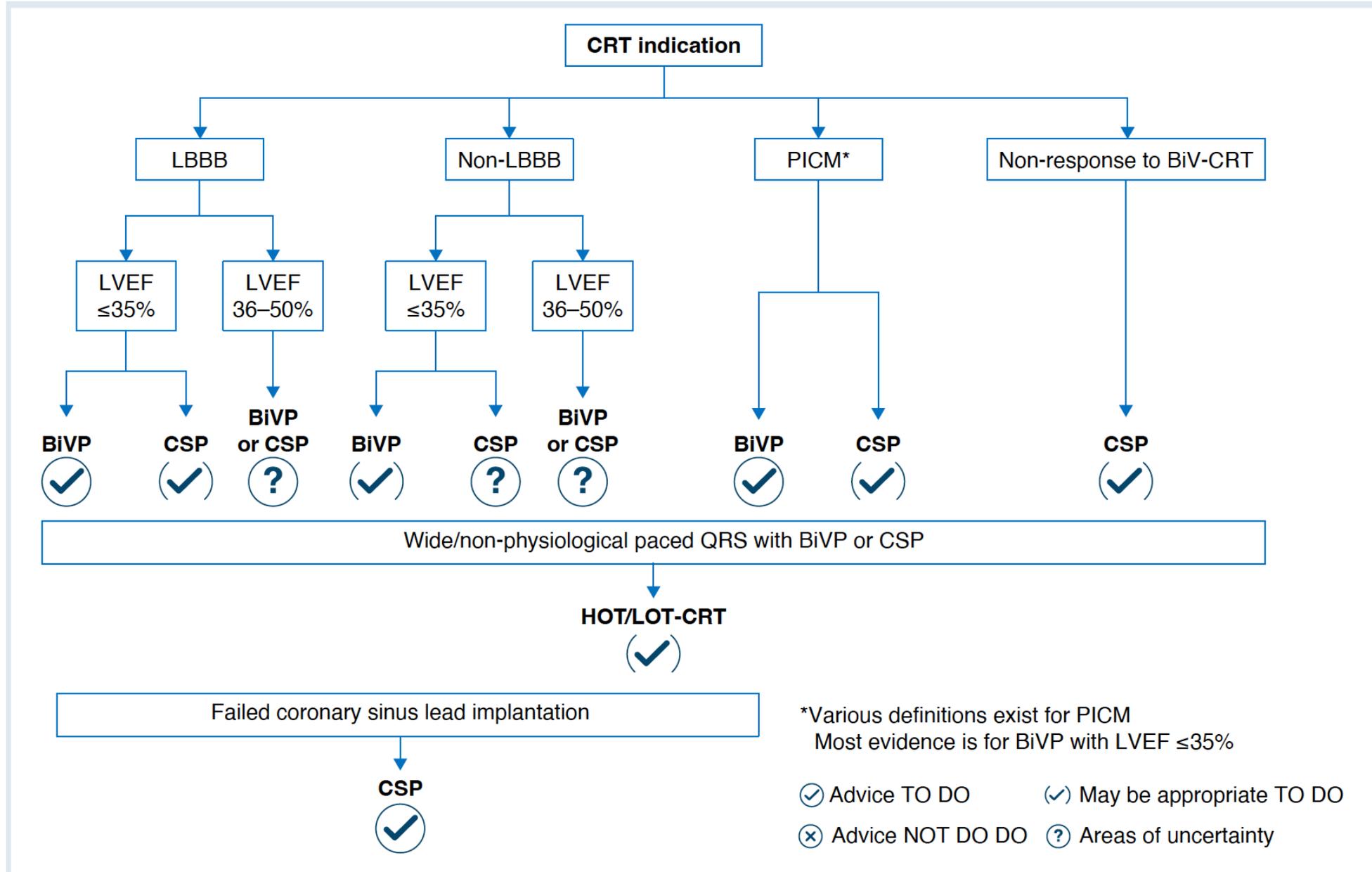
Likely LBBP

LVSP

# HOT/LOT CRT



# EHRA Consensus Statement



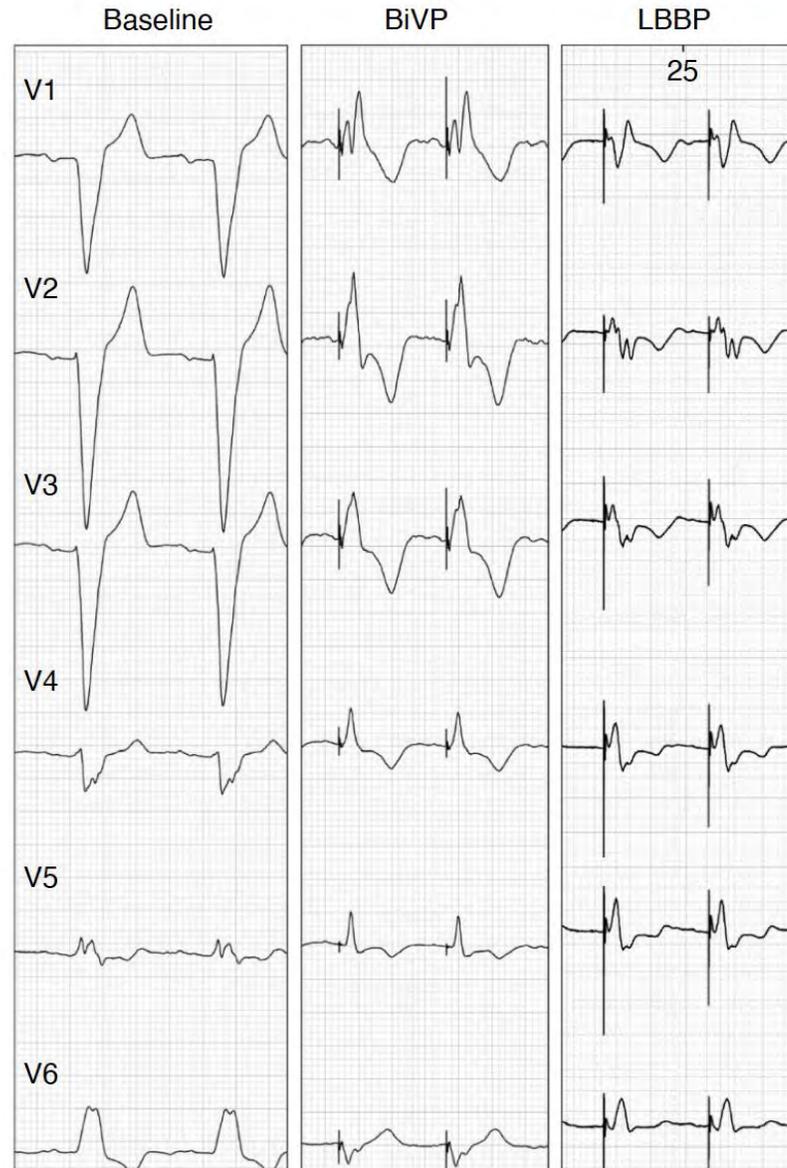
# EHRA Consensus Statement



# EHRA Consensus Statement



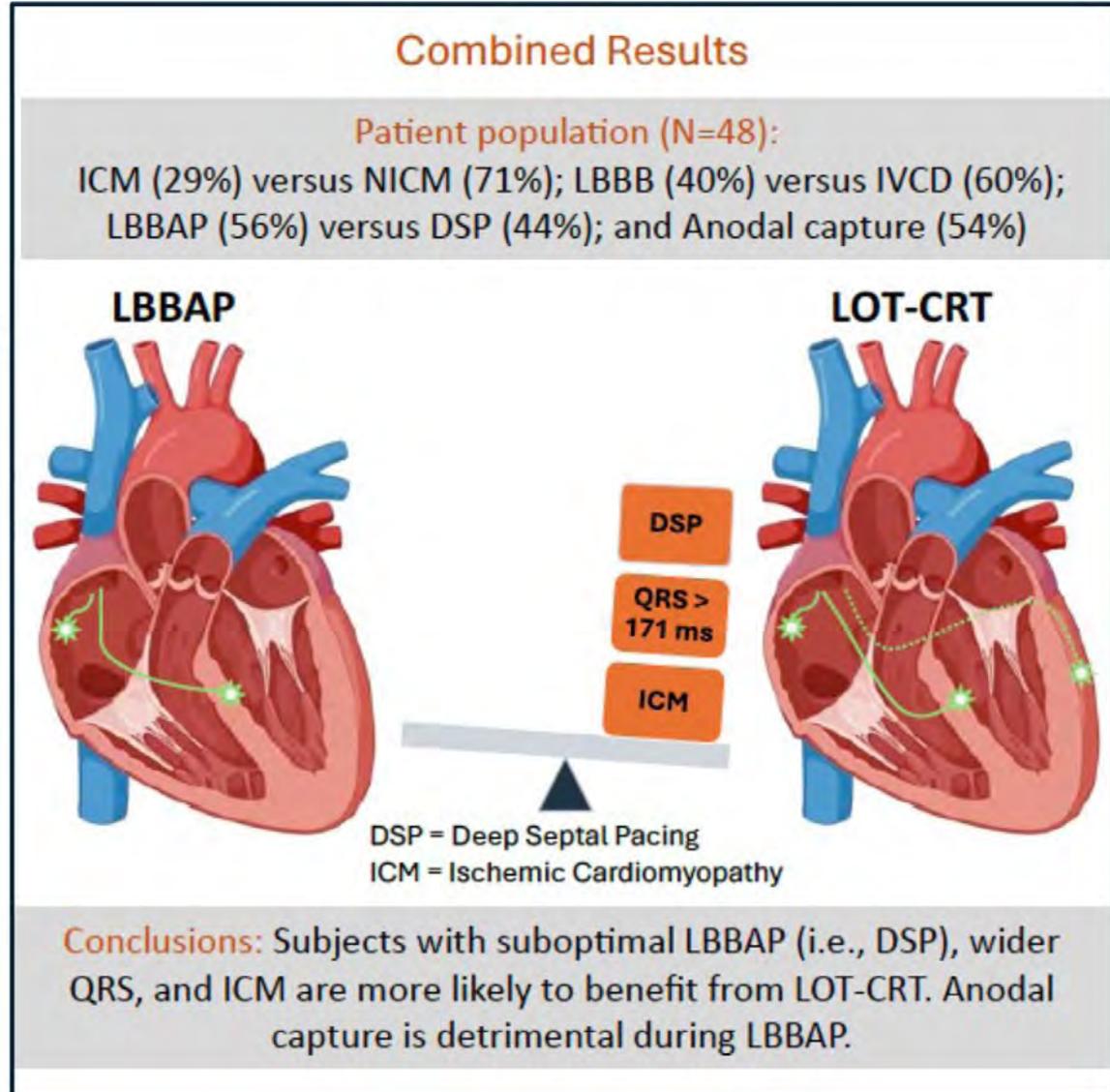
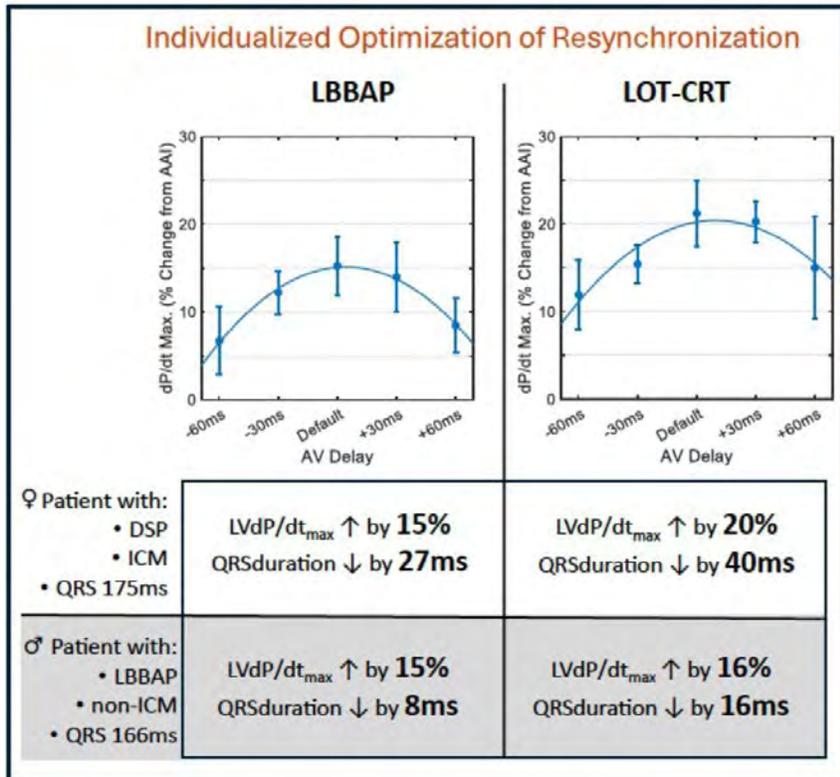
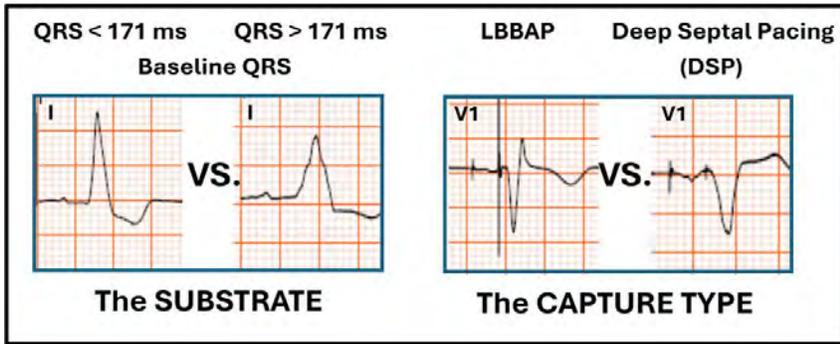
# EHRA Consensus Statement

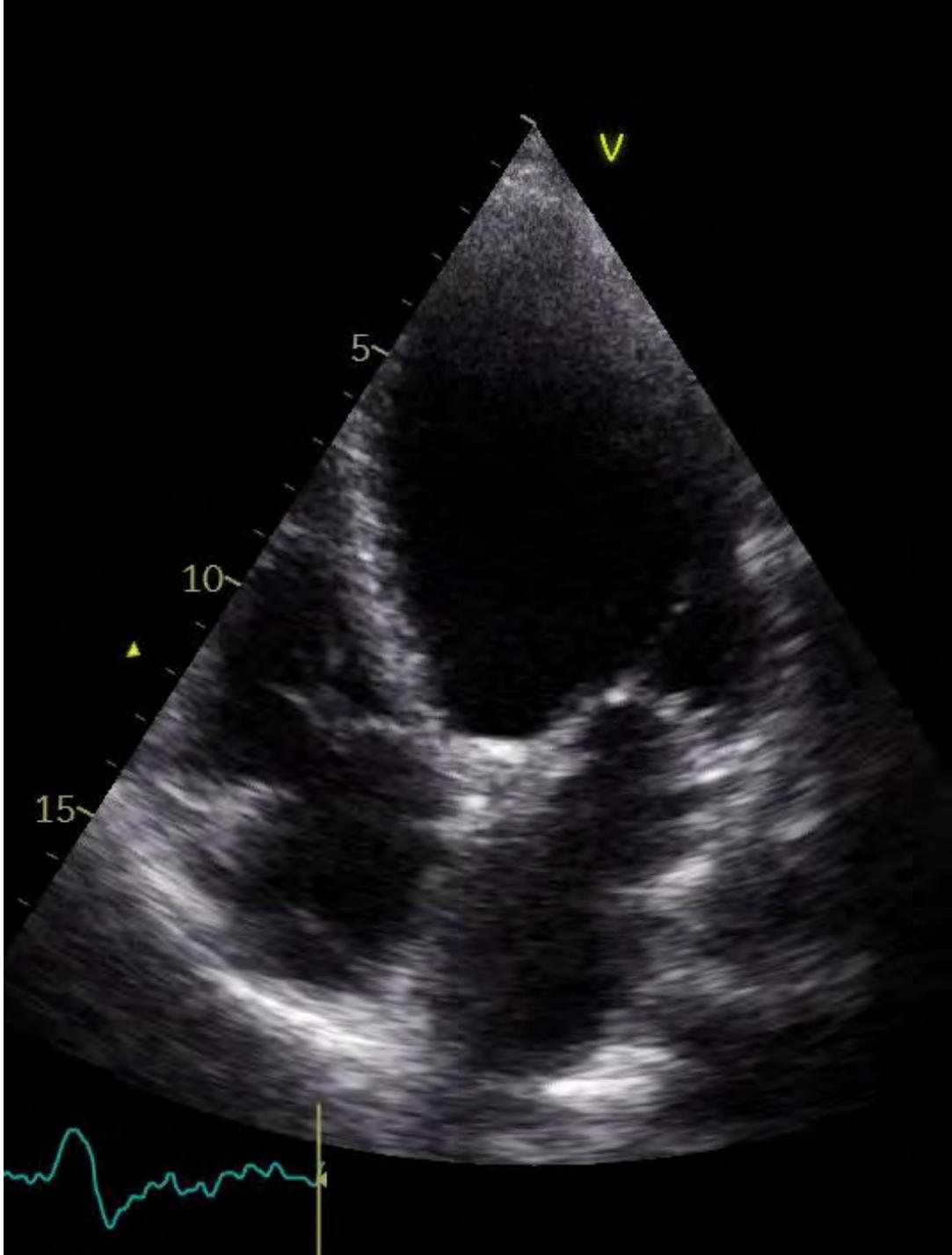


# EHRA Consensus Statement



# Multicenter Hemodynamic Assessment of the LOT-CRT Strategy: When Does Combining Left Bundle Branch Pacing and Coronary Venous Pacing Enhance Resynchronization?: Primary Results of the CSPOT Study





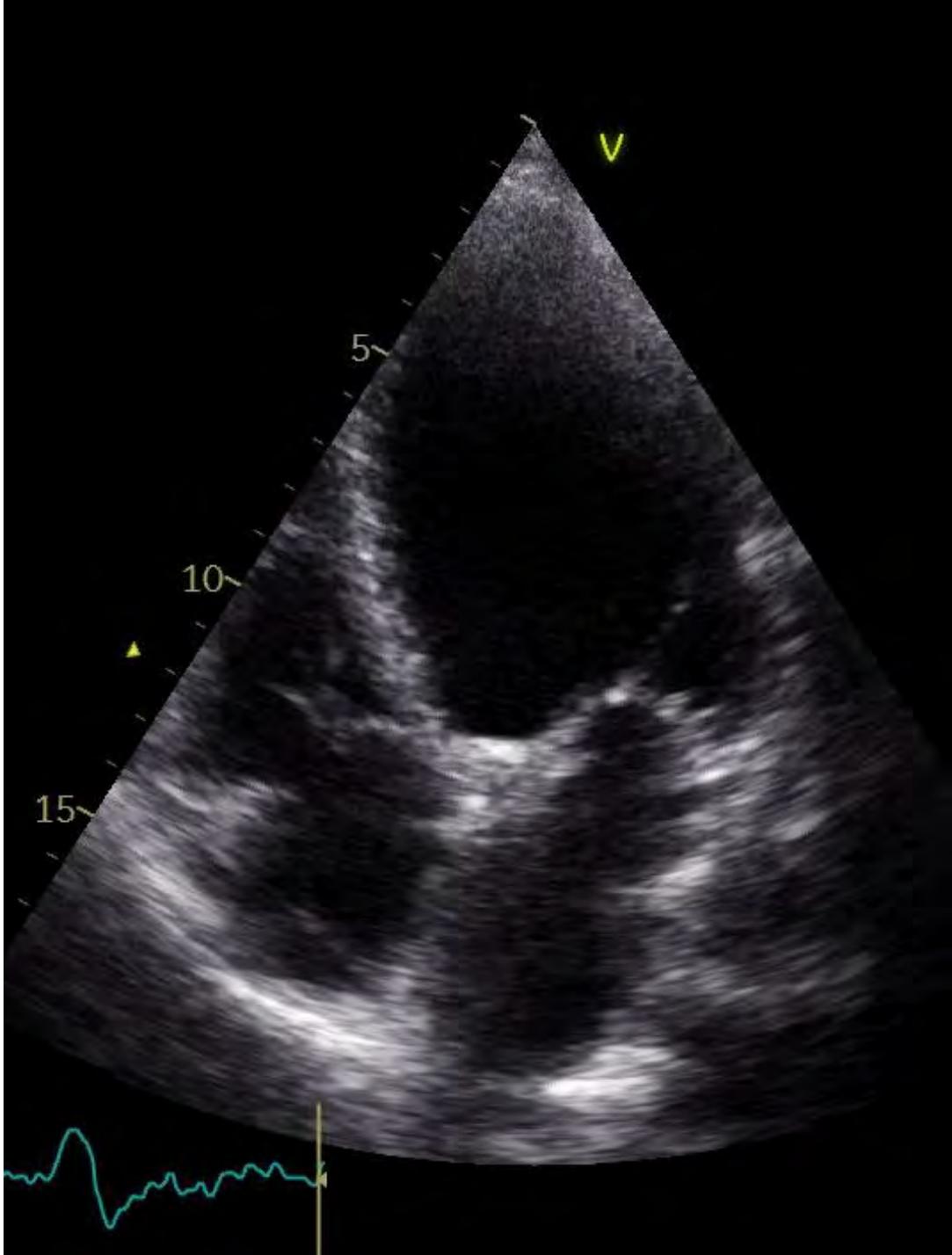
68 year old male

- Hypertension
- Dyslipidaemia

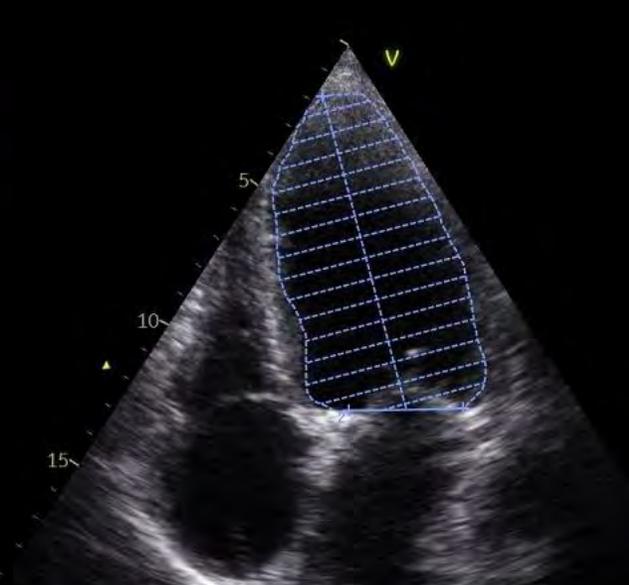
Now:

- CHB with poor EF (LVEF 20%)
- Ideopathic DCMO
- Unobstructed coronaries

BiV-CRT



LVEF MOD A4C	25 %
SV MOD A4C	52 ml
2 LVLs A4C	9.7 cm
LVESV MOD A4C	156 ml
1 LVLd A4C	9.8 cm
LVEDV MOD A4C	207 ml



EF Biplane	25 %
LVEDV MOD BP	188 ml
LVESV MOD BP	141 ml
LVEF MOD A2C	23 %
SV MOD A2C	37 ml
2 LVLs A2C	9.3 cm
LVESV MOD A2C	123 ml
1 LVLd A2C	9.1 cm
LVEDV MOD A2C	159 ml

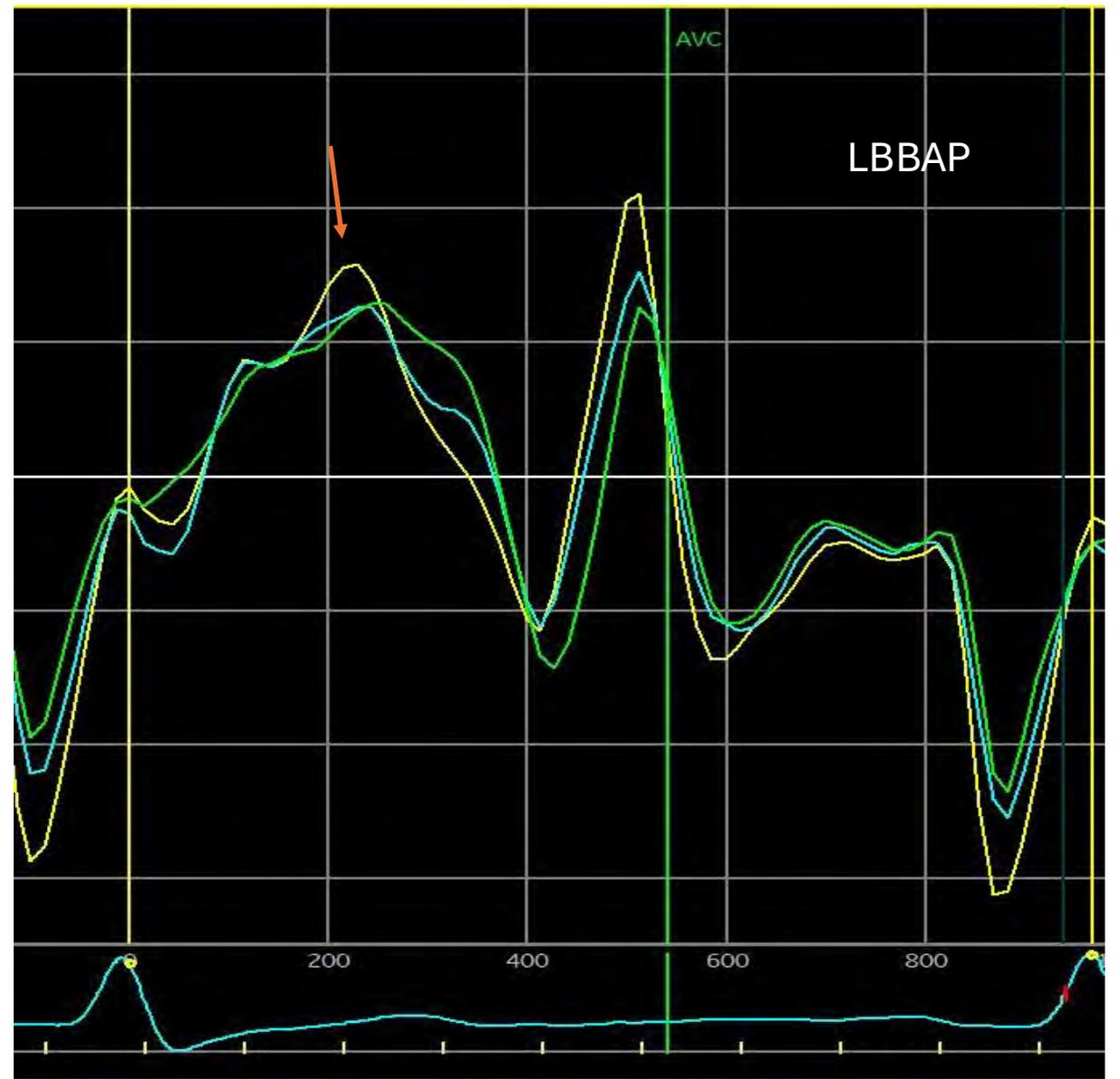
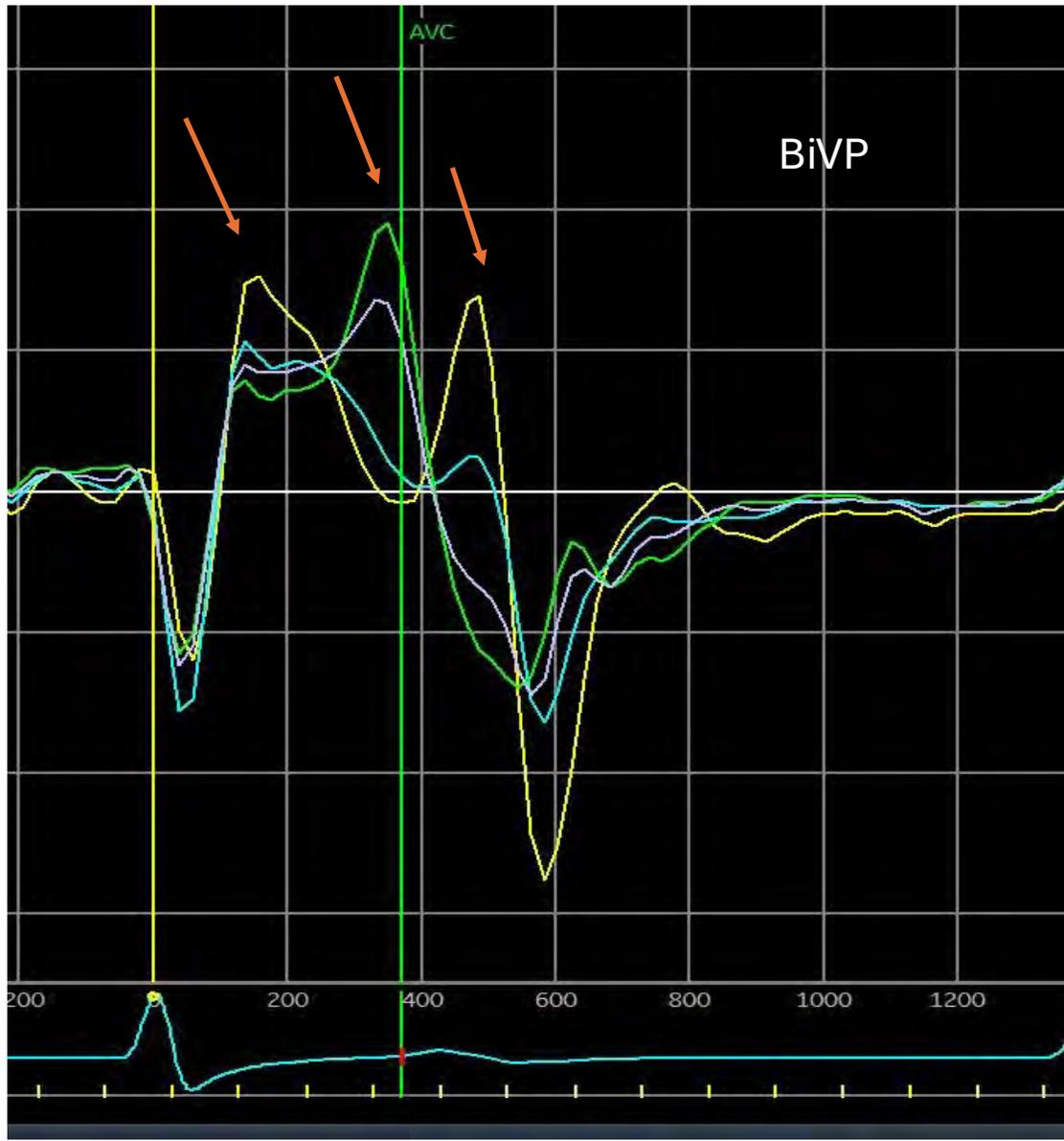


LVEF MOD A4C	49 %
SV MOD A4C	91 ml
2 LVLs A4C	7.9 cm
LVESV MOD A4C	95 ml
1 LVLd A4C	9.5 cm
LVEDV MOD A4C	185 ml



LVESV MOD BP	82 ml
LVESVInd MOD BP	48.42 ml/m2
LVEF MOD A2C	48 %
SV MOD A2C	64 ml
2 LVLs A2C	7.8 cm
LVESV MOD A2C	70 ml
1 LVLd A2C	9.3 cm
LVEDV MOD A2C	134 ml









# Conduction system pacing in Heart failure

Jane Moses