Oxford University Hospitals NHS
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Impact of QRS duration and morphology on CRT effectiveness

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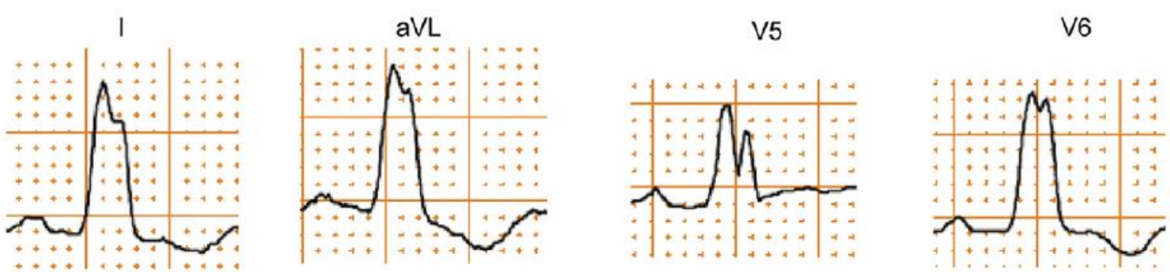
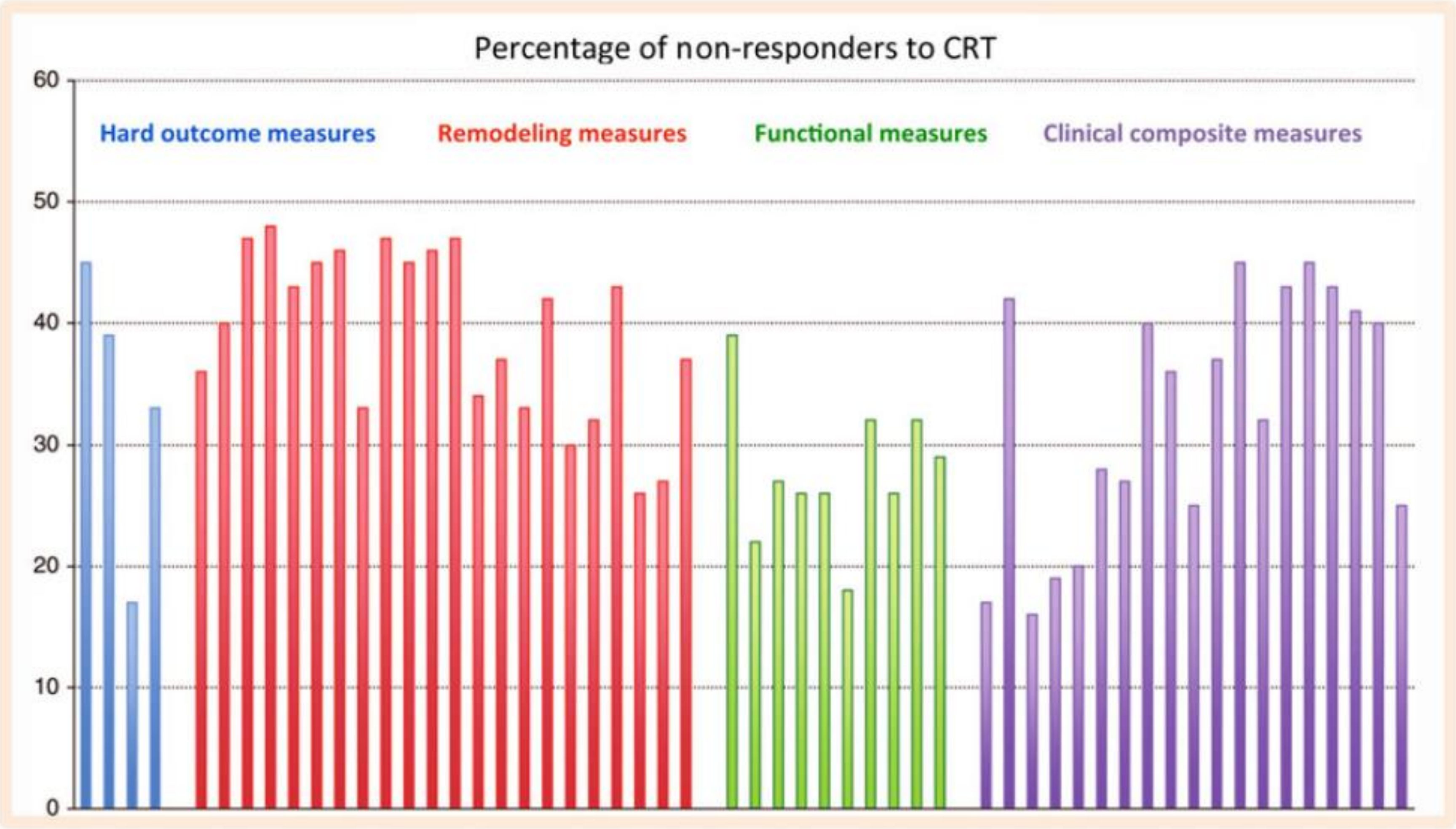


Disclosures

- None related to this talk

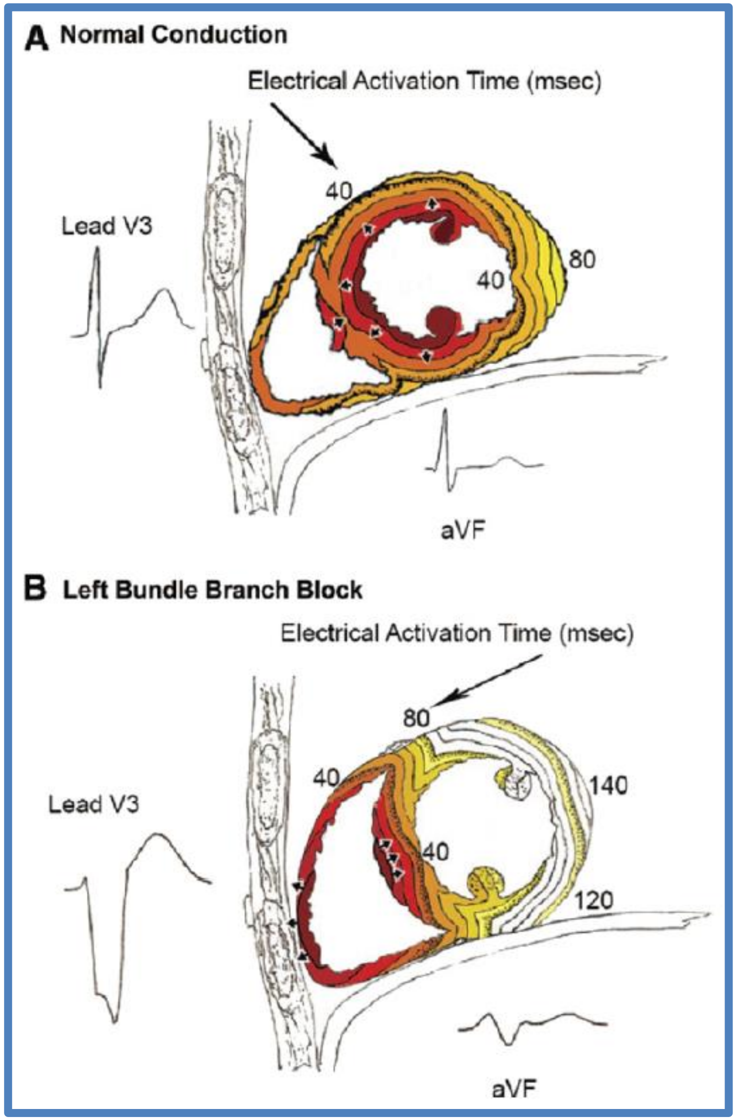
Why is QRS duration and morphology important?



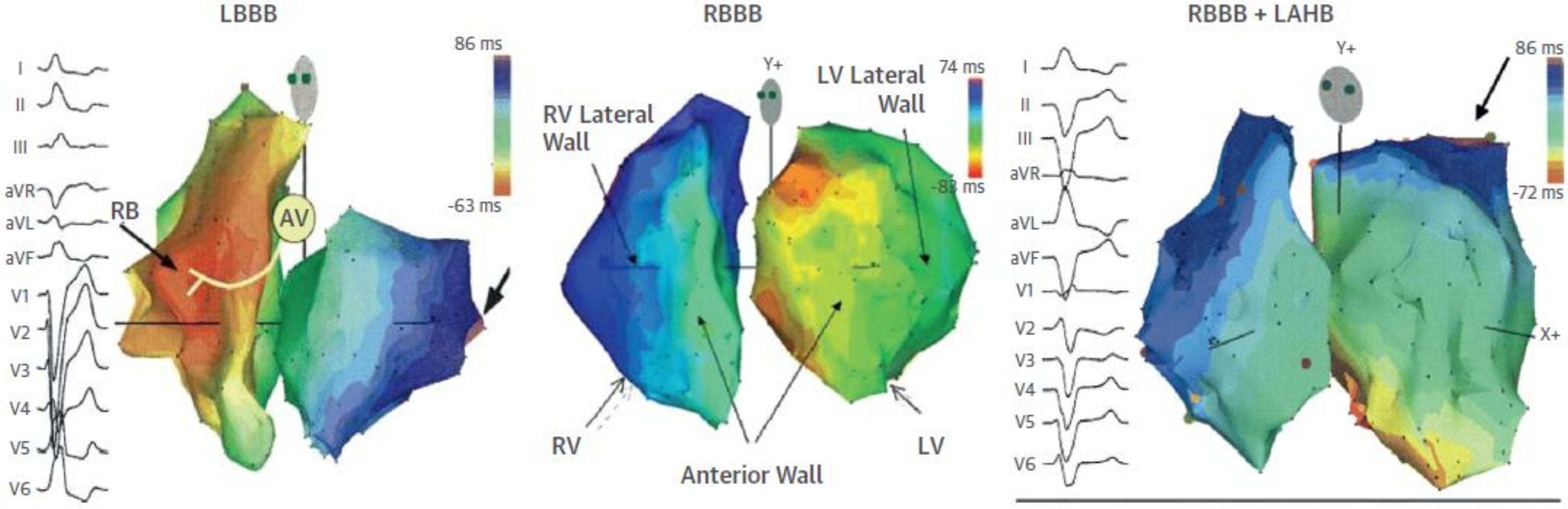
LBBB and CRT: a simple paradigm

- LBBB results in slow activation through the left ventricle and subsequent delayed lateral wall contraction

- Pacing the lateral/posterolateral LV wall via the coronary vein overcomes this delay, corrects the dyssynchrony, results in favourable remodelling and improves cardiac function and symptoms



LBBB delays LV lateral wall activation



CRT trial inclusion criteria

Trial (Ref. #)	n	Study Design	Enrollment QRS Duration, ms	Enrollment NYHA Functional Class/Etiology of HF	Enrollment LVEF, %	SR/AF Included?	% LBBB	Primary Endpoint
MUSTIC-SR (5)	58	Single-blinded, crossover CRT pacing on or off	≥150	III Ischemic and nonischemic	≤35	SR	87	6-min walk distance
MUSTIC AF (5)	43	Single-blinded crossover CRT pacing on or VVI pacing	≥200	III Ischemic and nonischemic	≤35	AF	NA*	6-min walk distance
MIRACLE (1)	453	Double-blinded, parallel control CRT pacing on or off	≥130	III, IV Ischemic and nonischemic	≤35	SR	NR	NYHA, QOL, 6-min walk distance
PATH CHF (4)	42	Single-blinded, crossover CRT pacing on or off	≥1,520	III, IV Ischemic and nonischemic (epicardial LV leads)	NA	SR	97	Peak VO_2 on CPET 6-min walk distance
MIRACLE ICD (6)	369	Double-blinded, parallel control CRT-D with CRT pacing on or off	≥130	III, IV Ischemic and nonischemic	≤35	SR	LBBB/IVCD = 94	NYHA, QOL, 6-min walk distance
CONTAK CD (8)	490	Single-blinded Phase I: crossover CRT-D with CRT pacing on or off Phase II: parallel control	≥120	II, III, IV Ischemic and nonischemic	≤35	SR	46	NYHA, QOL, 6-min walk distance
MIRACLE ICD II (7)	186	Double-blinded, parallel control CRT-D with CRT pacing on or off	≥130	II Ischemic and nonischemic	≤35	SR	LBBB/IVCD = 83.4	Peak VO_2 on CPET
COMPANION (3)	1520	Randomized CRT-D vs. OPT or CRT-D vs. OPT	≥120	III, IV Ischemic and nonischemic	≤35	SR	86	All-cause mortality or hospitalization
CARE-HF (2)	813	Randomized CRT-P vs. medical therapy	≥120	III, IV Ischemic and nonischemic	≤35	SR	95	All-cause mortality or unplanned cardiovascular hospitalization
REVERSE (9)	610	Single-blinded, parallel control CRT-D with CRT pacing on or off	≥120	I, II Ischemic and nonischemic	≤40	SR	60.5	Clinical composite score improvement
MADIT-CRT (10)	1,820	Randomized CRT-D vs. ICD (single or dual)	≥130	I, II Ischemic and nonischemic	≤30	SR	70.5	All-cause mortality or nonfatal HF event
RAFT (11)	1,798	Double-blinded, randomized CRT-D vs. ICD (single or dual)	≥120	II, III Ischemic and nonischemic	≤30	SR/AF/paced	72	All-cause mortality or HF hospitalization

Current 2013 ESC guidelines (Sinus rhythm)

Recommendations	Class [a]	Level [b]
1) LBBB with QRS duration >150 ms. CRT is recommended in chronic HF patients and LVEF ≤35% who remain in NYHA functional class II, III and ambulatory IV despite adequate medical treatment. [d]	I	A
2) LBBB with QRS duration 120–150 ms. CRT is recommended in chronic HF patients and LVEF ≤35% who remain in NYHA functional class II, III and ambulatory IV despite adequate medical treatment. [d]	I	B

Recommendations	Class [a]	Level [b]
3) Non-LBBB with QRS duration >150 ms. CRT should be considered in chronic HF patients and LVEF ≤35% who remain in NYHA functional class II, III and ambulatory IV despite adequate medical treatment. [d]	IIa	B
4) Non-LBBB with QRS duration 120–150 ms. CRT may be considered in chronic HF patients and LVEF ≤35% who remain in NYHA functional class II, III and ambulatory IV despite adequate medical treatment. [d]	IIb	B

5) CRT in patients with chronic HF with QRS duration <120 ms is not recommended.	III	B

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PRACTICE GUIDELINE

2013 ACCF/AHA Guideline for the Management of Heart Failure

A Report of the American College of Cardiology Foundation/ American Heart Association Task Force on Practice Guidelines

Developed in Collaboration With the American College of Chest Physicians, Heart Rhythm Society and International Society for Heart and Lung Transplantation

Table 2 Indications for cardiac resynchronization therapy in patients presenting with heart failure, sinus rhythm, and spontaneous conduction

Class of recommendation	Level of evidence	Baseline electrocardiographic characteristics
I	A	Left bundle branch block with >150 ms QRS duration
I	B	Left bundle branch block with QRS duration between 120 and 150 ms
IIa	B	No left bundle branch block and QRS duration > 150 ms
IIb	B	No left bundle branch block and QRS duration between 120 and 150 ms

Guidelines of European Society of Cardiology and American College of Cardiology/American Heart Association 2013.

NHS England NICE guidelines 2014

	LVEF ≤ 35%			
	NYHA functional class			
	I	II	III	IV
QRS <120ms	ICD if there is a high risk of sudden cardiac death			ICD and CRT not clinically indicated
QRS 120-149ms without LBBB	ICD	ICD	ICD	CRT-P
QRS 120-149ms with LBBB	ICD	CRT-D	CRT-P or CRT-D	CRT-P
QRS ≥150ms	CRT-D	CRT-D	CRT-P or CRT-D	CRT-P

Implantable cardioverter defibrillators and cardiac resynchronisation therapy for arrhythmias and heart failure

Technology appraisal guidance
Published: 25 June 2014
nice.org.uk/guidance/ta314

NHS
National Institute for Health and Clinical Excellence

Europace Advance Access published August 29, 2015

Europace
doi:10.1093/europace/euv319

ESC GUIDELINES

2015 ESC Guidelines for the management of patients with ventricular arrhythmias and the prevention of sudden cardiac death

The Task Force for the Management of Patients with Ventricular Arrhythmias and the Prevention of Sudden Cardiac Death of the European Society of Cardiology (ESC)

Table A. Cardiac resynchronization therapy in the primary prevention of sudden death in patients in sinus rhythm and New York Heart Association functional class III/ambulatory class IV

Recommendations	Class[a]	Level
CRT is recommended to reduce all-cause mortality in patients with an LVEF ≤35% and LBBB despite at least 3 months of optimal pharmacological therapy who are expected to survive at least 1 year with good functional status:		
– With a QRS duration >150 ms	I	A
– With a QRS duration of 120–150 ms	I	B
CRT should or may be considered to reduce all-cause mortality in patients with an LVEF ≤35% without LBBB despite at least 3 months of optimal pharmacological therapy who are expected to survive at least 1 year with good functional status:		
– With a QRS duration >150 ms	IIa	B
– With a QRS duration of 120–150 ms	IIb	B

Table B. Cardiac resynchronization therapy in the primary prevention of sudden death in patients with permanent atrial fibrillation in New York Heart Association functional class III/ambulatory class IV

Recommendations	Class[a]	Leve
CRT should be considered to reduce all-cause mortality in patients with chronic HF, QRS ≥120 ms and LVEF ≤35% who remain in NYHA functional class III/ambulatory class IV despite at least 3 months of optimal pharmacological therapy who are expected to survive at least 1 year with good functional status, provided that biventricular pacing as close as possible to 100% can be achieved.	IIa	B
AV junction ablation should be considered in case of incomplete biventricular pacing.	IIa	B

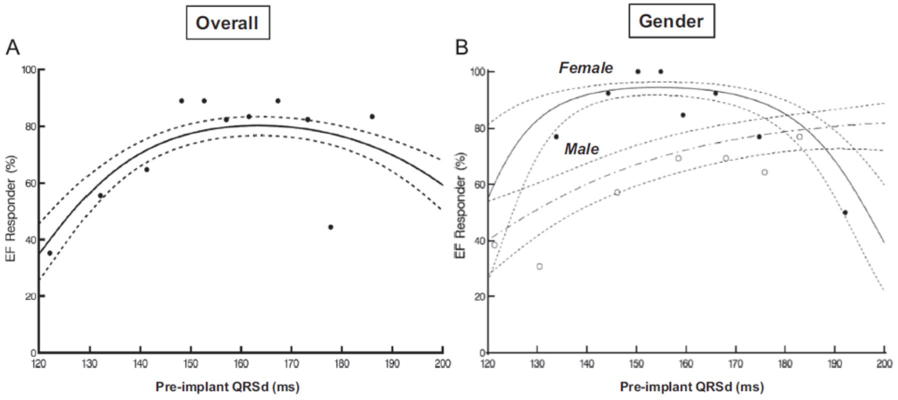
Table C. Cardiac resynchronization therapy defibrillator[a] in the primary prevention of sudden death in patients in sinus rhythm with mild (New York Heart Association class II) heart failure

Recommendations	Class[b]	Level[c]
CRT-D is recommended to reduce all-cause mortality in patients with a QRS duration ≥130 ms, with an LVEF ≤30% and with LBBB despite at least 3 months of optimal pharmacological therapy who are expected to survive at least 1 year with good functional status.	I	A
CRT-D may be considered to prevent hospitalization for HF in patients with a QRS duration ≥150 ms, irrespective of QRS morphology, and an LVEF ≤35% despite at least 3 months of optimal pharmacological therapy who are expected to survive at least 1 year with good functional status.	IIb	A

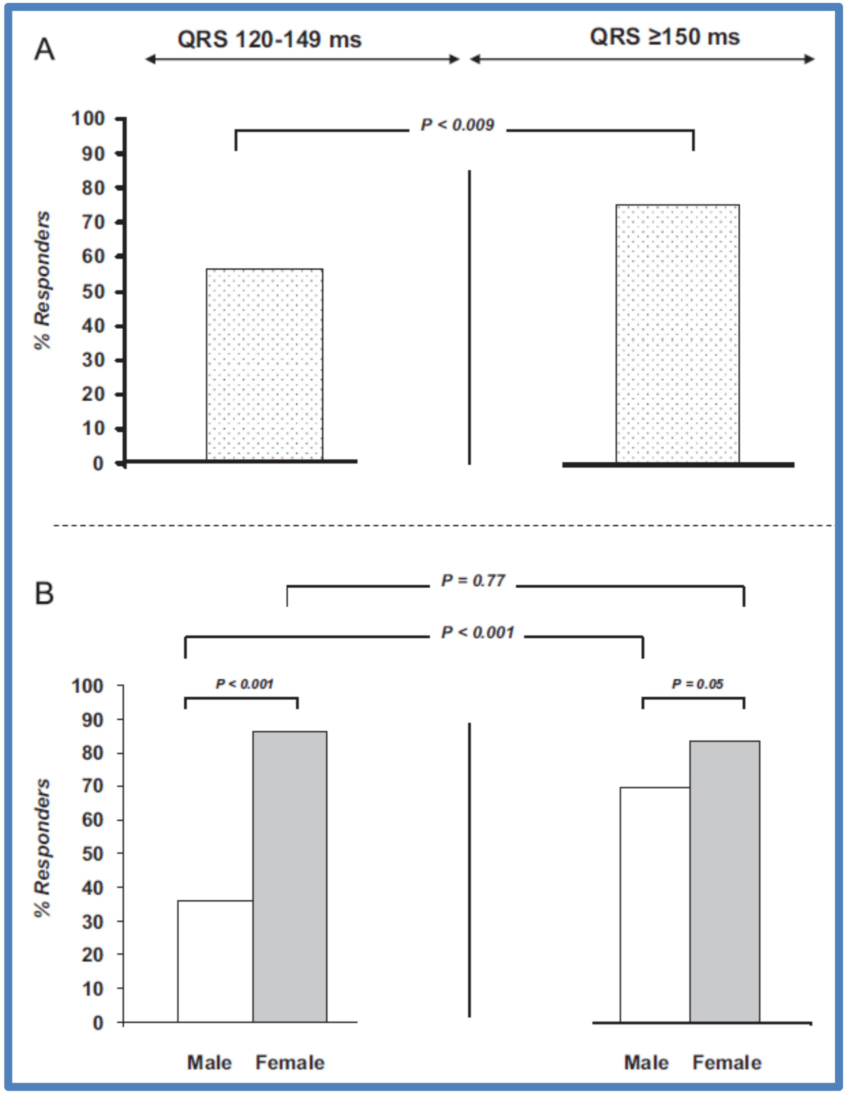
QRS duration: 150ms cutoff

N Varma *Heart Rhythm* 2014

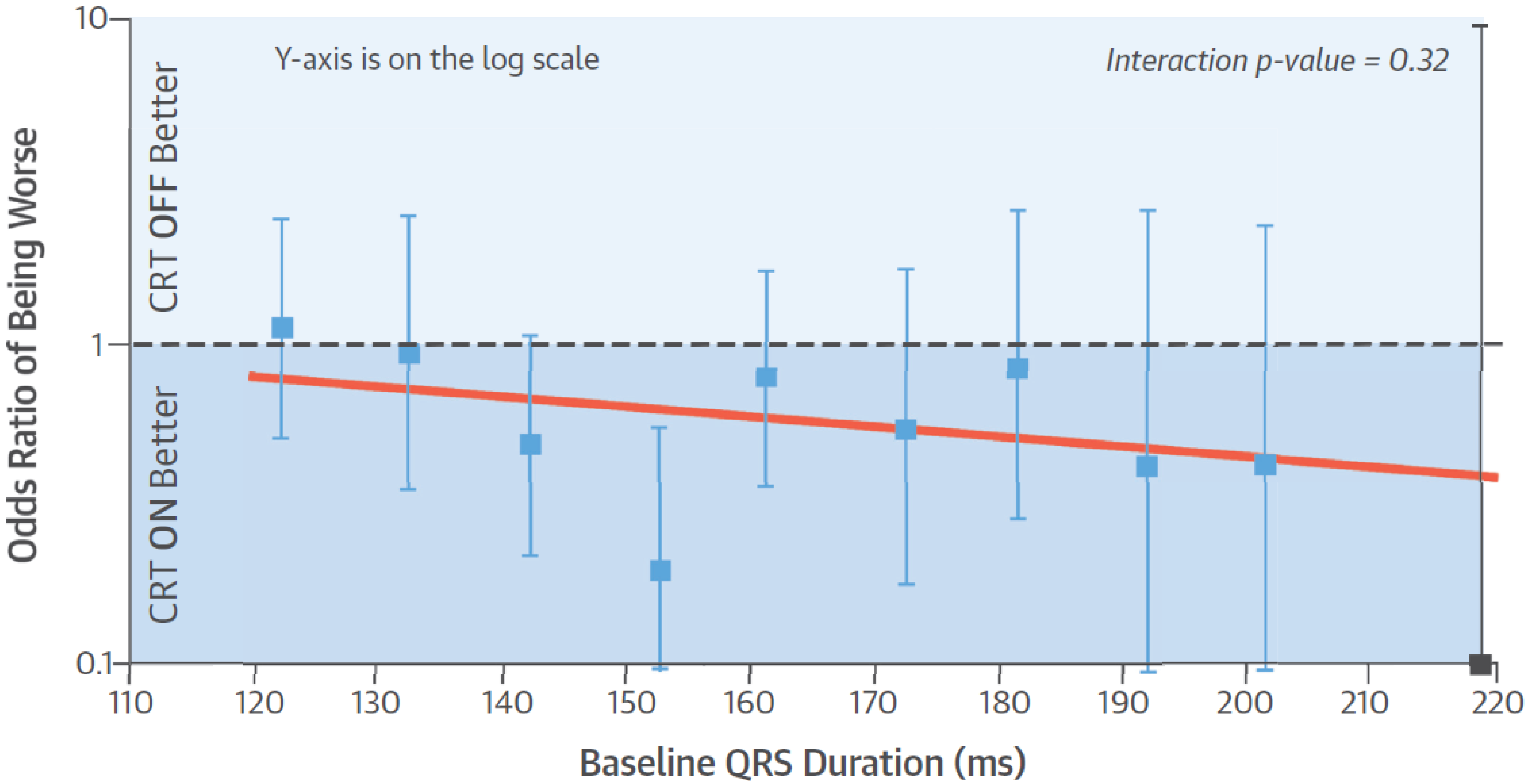
Cleveland Clinic: 212 patients with LBBB and non-ischaemic cardiomyopathy



Dichotomising at 150ms may exclude a large number of women with potential to respond to CRT



Relation between QRS duration and response: REVERSE Trial



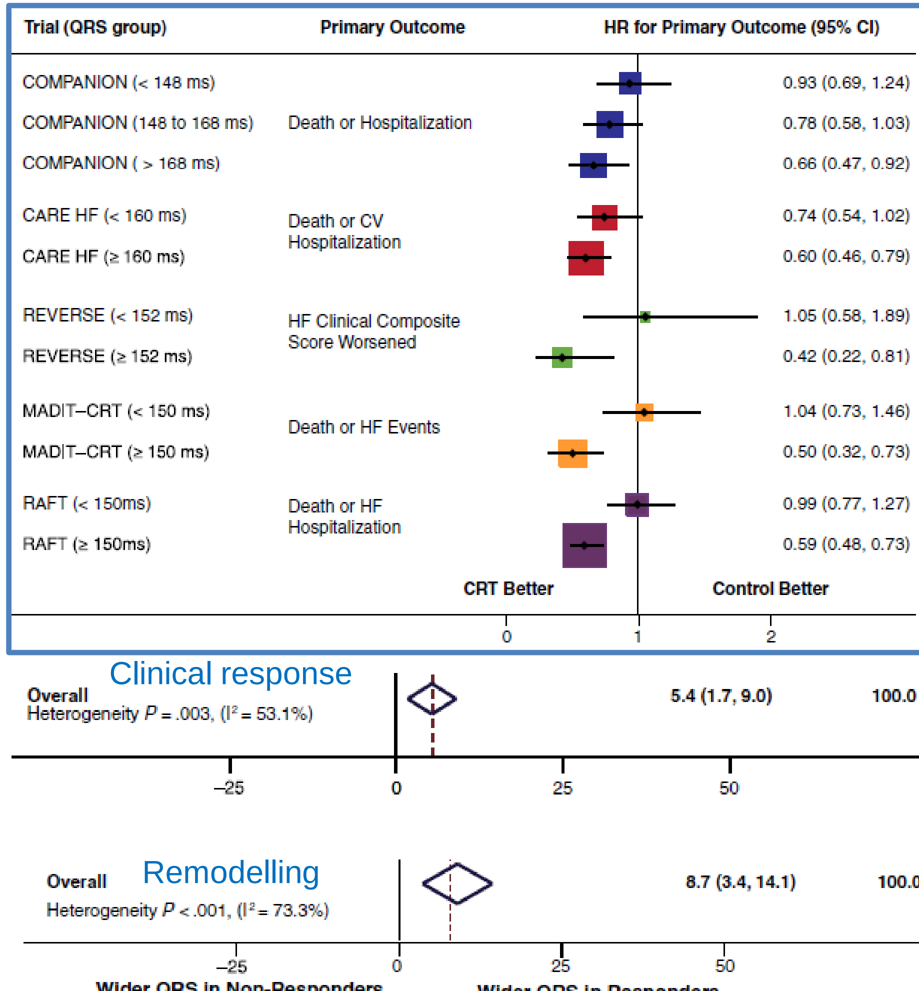
Poole, J.E. et al. J Am Coll Cardiol. 2016; 67(9):1104–17.

Importance of QRS duration: meta-analysis

AR Bryant *Journal Electrocardiology* 2013

	N	QRSd inclusion	Mean QRS	Mean age (years)	Female	ICM	Mean LVEF	NYHA 2	NYHA 3	NYHA 4	Mean 6MWD	ACE or ARB	Beta-blocker	Diuretic
Randomized trials														
PATH-CHF II	86	≥120 ms	155 ms	60	34%	38%	0.23	–	–	67%	407 m	–	73%	–
COMPANION	1520	≥120 ms	160 ms	67	33%	55%	0.21	0%	86%	14%	262 m	89%	68%	95%
CARE-HF	813	≥120 ms	160 ms	67	27%	38%	0.25	0%	94%	6%	–	95%	72%	43%
REVERSE	610	≥120 ms	153 ms	63	21%	55%	0.27	82%	18%	0%	389 m	97%	95%	80%
RAFT	1798	≥120 ms	158 ms	66	17%	67%	0.23	80%	20%	0%	353 m	97%	90%	84%
MADIT-CRT	1820	≥130 ms		65	25%		0.24	85%	0%	0%	361 m	98%	93%	75%
Observational studies														
Van Bommel et al.[49]	123	≤120 ms	105 ms	61	21%	61%	0.27	0%	100%	0%	310 m	90%	93%	94%
Achilli et al.[51]	52	Any	153 ms	70	40%	40%	0.23	–	–	–	262 m	–	–	–
Gasparini et al.[53]	376	Any	167 ms	66	20%	54%	0.29	0%	87%	13%	315 m	87%	79%	87%
Yu et al.[52]	102	Any	133 ms	65	25%	46%	0.14	0%	88%	12%	316 m	93%	69%	97%
Oyenuga et al.[54]	221	≥100 ms	147 ms	62	30%	57%	0.24	–	–		–	–	–	–
Cazeau et al.[39]	60	≤150 ms	121 ms	65	15%	43%	0.27	3%	90%	7%	313 m	85%	72%	97%
Agosti et al.[43]	47	≥120 ms	149 ms	74	19%	36%	0.25	15%	34%	49%	254 m	–	–	–
Akyol et al.[31]	35	≥120 ms	166 ms	60	32%	80%	0.22	–	–	–	–	94%	91%	100%
Alonso et al.[19]	26	≥120 ms	178 ms	66	8%	35%	0.22	–	–	–	–	–	–	–
Antonio et al.[44]	87	≥120 ms	145 ms	62	37%	72%	0.24	10%	68%	22%	–	–	–	–
Ariga et al.[45]	86	≥120 ms	160 ms	71	26%	71%	0.22	0%	81%	19%	–	84%	60%	50%
Bax et al.[23]	85	≥120 ms	173 ms	65	25%	55%	0.23	–	–	–	288 m	95%	84%	98%
Garcia-Seara et al.[40]	78	≥120 ms	172 ms	70	27%	40%	0.27	0%	86%	14%	–	92%	74%	95%
Jaussaud et al.[46]	30	≥120 ms	153 ms	60	23%	45%	0.25	–	–	7%	–	89%	93%	83%
Lim et al.[41]	100	≥120 ms	154 ms	63	30%	35%	0.26	–	94%	–	–	90%	85%	47%
Molhoek et al.[28]	125	≥120 ms	165 ms	61	23%	51%	0.21	–	–	–	254 m	83%	56%	84%
Mollema et al.[35]	242	≥120 ms	165 ms	66	19%	64%	0.23	–	–	–	288 m	89%	66%	89%
Yeim et al.[37]	96	≥120	158 ms	66	13%	46%	0.27	–	–	–	–	–	–	–
Ypenburg et al.[38]	51	≥120 ms	161 ms	68	22%		0.22	4%	84%	12%	310 m	84%	57%	94%
Ypenburg et al.[42]	286	≥120 ms	156 ms	66	17%	57%	0.25	0%	95%	5%	–	–	–	–
Diaz-Infante et al.[26]	143	≥130 ms	165 ms	68	21%	34%	0.27	17%	80%	3%	273 m	–	–	–
Lellouche et al.[34]	164	≥130 ms	158 ms	60	24%	47%	0.22	0%	77%	23%	–	87%	79%	74%
Penicka et al.[24]	49	≥130 ms	181 ms	71	–	47%	0.25	–	–	–	–	88%	84%	–
Pires et al[32]	538	≥130 ms	167 ms	66	27%	57%	0.21	–	–	–	269 m	92%	63%	95%
Davis et al.[25]	85	≥140 ms	168 ms	66	12%	71%	0.21	4%	85%	11%		–	22%	–
Yu et al.[22]	30	≥140 ms	159 ms	64	33%	37%	0.25	–	–	–	317 m	–	–	–
Achilli et al.[30]	133	≥150 ms	157 ms	72	25%	47%	0.26	14%	61%	25%	–	–	–	–
Chan et al.[21]	63	≥150 ms	182 ms	69	44%	95%	0.23	–	–	–	307 m	–	–	–
Lecoq et al.[27]	138	≥150 ms	189 ms	68	39%	35%	0.20	0%	70%	30%	306 m	–	–	–
Iler et al.[10]	337	–	128 ms	65	24%	–	0.22	–	–	–	–	–	–	–
Kamireddy et al.[9]	113	–	155 ms	69	30%	73%	0.24	–	–	–	–	–	–	–
Laurenzi et al.[33]	38	–	179 ms	73	16%	45%	0.26	0%	89%	11%	–	95%	68%	100%
Lipoldova et al.[47]	194	–	163 ms	62	25%	31%	0.21	–	–	–	–	–	–	–
Lunati et al.[20]	52	–	195 ms	61	12%	35%	0.26	4%	73%	23%	–	–	–	–
Pitzalis et al.[29]	60	–	171 ms	63	47%	22%	0.25	0%	100%	0%	–	80%	77%	100%
Rickard et al.[48]	233	–	160 ms	65	27%	53%	0.23	–	–	–	–	80%	76%	82%
Samesima et al.[36]	56	–	184 ms	60	39%		0.31	–	68%	16%	–	–	–	–
Zucchelli et al.[50]	86	–	165 ms	68	29%	51%	0.24	–	–	–	–	94%	89%	91%

6 RCTs, 38 observational studies



What about narrow QRS and echo evidence of mechanical dyssynchrony?

Trial (Ref. #)	n	Study Design	Enrollment QRS Duration, ms	Enrollment NYHA Functional Class/HF Etiology	Enrollment LVEF, %	SR/AF Included?	Primary Endpoint
RethinQ (34)	172	Parallel control CRT-D with CRT pacing on or off	<130	NYHA III Ischemic and nonischemic	≤35	SR	Peak VO_2 on CPET
NARROW CRT (35)	120	CRT-D vs. DDD-ICD	<120	II/III Ischemic only	≤35	SR	HF clinical composite response
EchoCRT (33)	809	Parallel control CRT-D with CRT pacing on or off	<130	III/IV Ischemic and nonischemic	≤35	SR	All-cause or first hospitalization for worsening HF
LESSER EARTH (32)	85	Parallel control CRT-D with CRT pacing on or off	<120	Symptoms of HF and a 6-min walk ≤400 m ischemic and nonischemic	≤35	SR	Exercise capacity and LV reverse remodeling

No benefit in peak VO_2

Significant benefit in clinical composite score

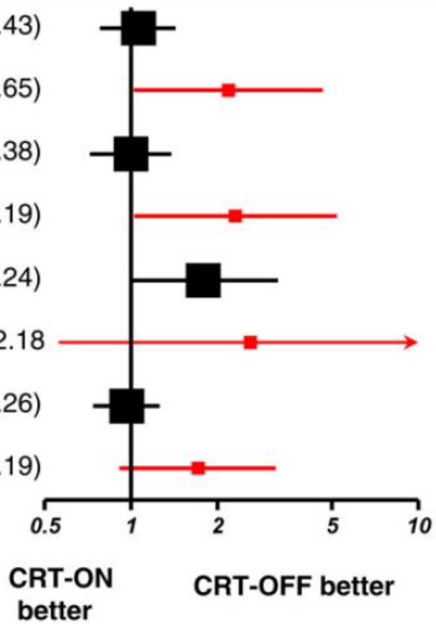
Stopped due to futility and trend to cause harm

Stopped due to futility and safety concerns

What about narrow QRS and echo evidence of mechanical dyssynchrony?

QRS < 120 ms — QRS 120–130 ms

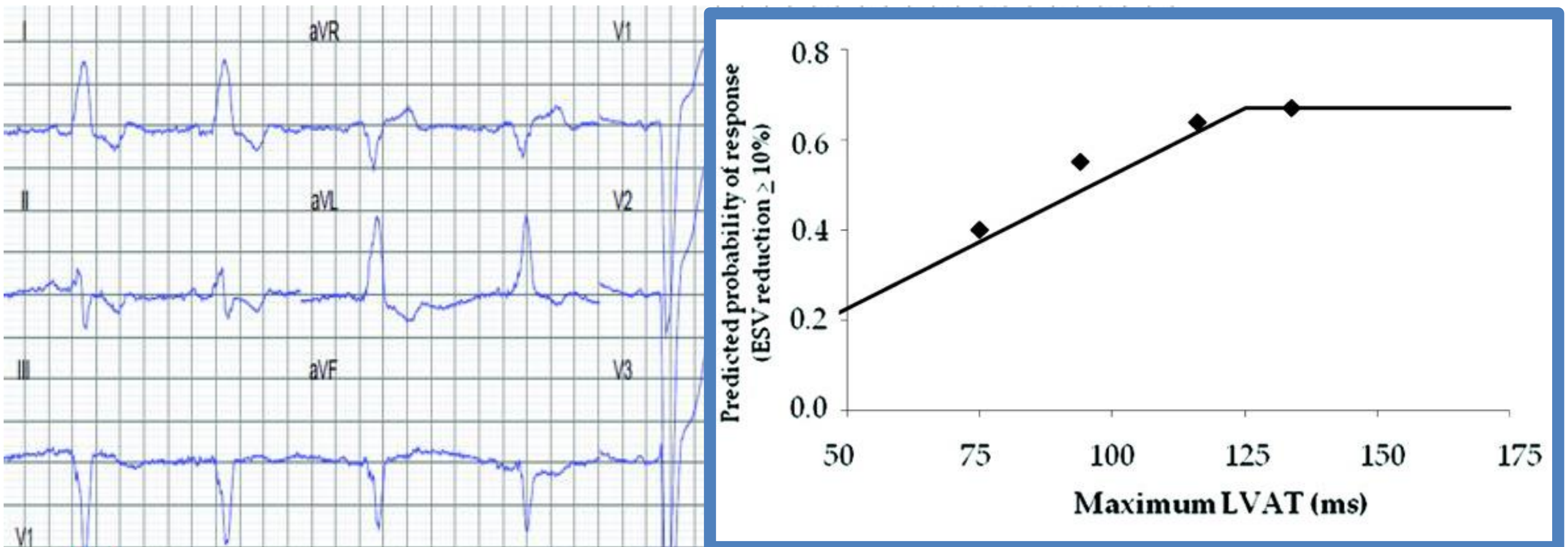
Endpoint	CRT=OFF	CRT=ON	Adjusted HR (95% CI)	*P*	*P* int.
Death or CHF hosp.	85 (25.91%)	92 (27.63%)	1.06 (0.78–1.43)	0.725	0.160
	17 (22.97%)	23 (35.38%)	2.18 (1.02–4.65)	**0.044**	
CHF hospitalization	75 (22.87%)	78 (23.42%)	1.00 (0.72–1.38)	0.991	0.162
	15 (20.27%)	20 (30.77%)	2.31 (1.03–5.19)	**0.043**	
All cause mortality	17 (5.18%)	35 (10.51%)	1.79 (0.99–3.24)	0.056	0.711
	9 (12.16%)	9 (13.85%)	2.60 (0.56–12.18	0.225	
CV hospitalization	111 (33.84%)	114 (34.23%)	0.97 (0.74–1.26)	0.808	0.154
	26 (35.14%)	31 (47.69%)	1.71 (0.91–3.19)	0.093	



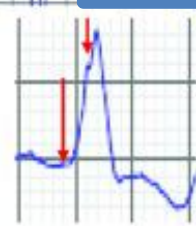
EchoCRT Trial: comparison of <120 with 120-130 ms

$LVAT_{max}$

M O Sweeney *Circulation* 2010



Lead II. RVAT=45.3 ms

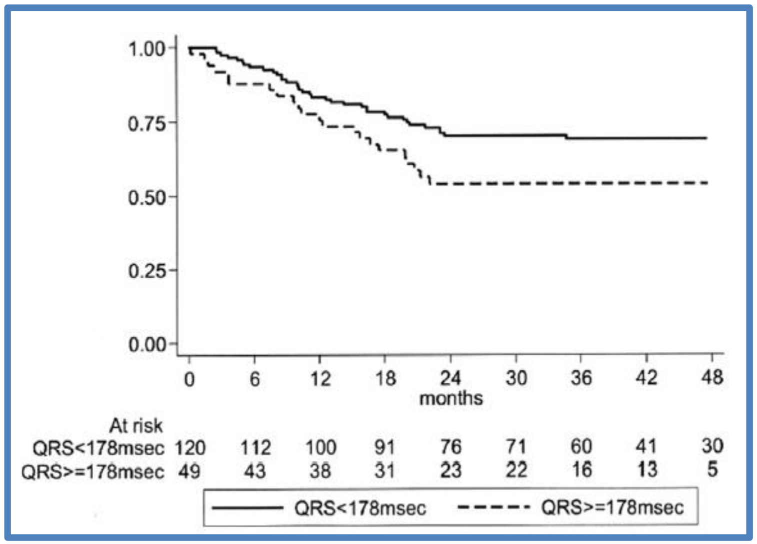


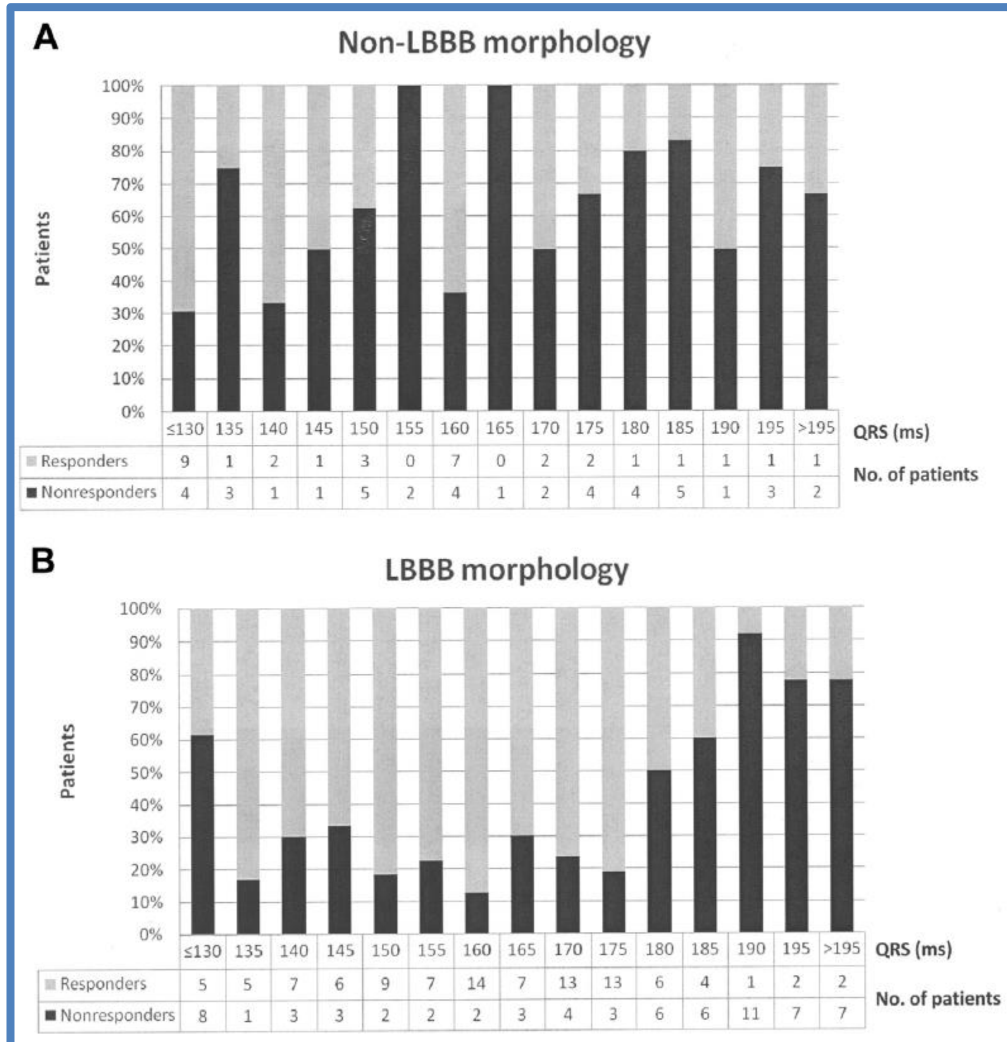
Lead V6. RVAT=52.8 ms

LVATmax = QRSd – shortest RVAT = 142.7ms

Can the QRS be too wide?

B Sassone *Am J Cardiol* 2015





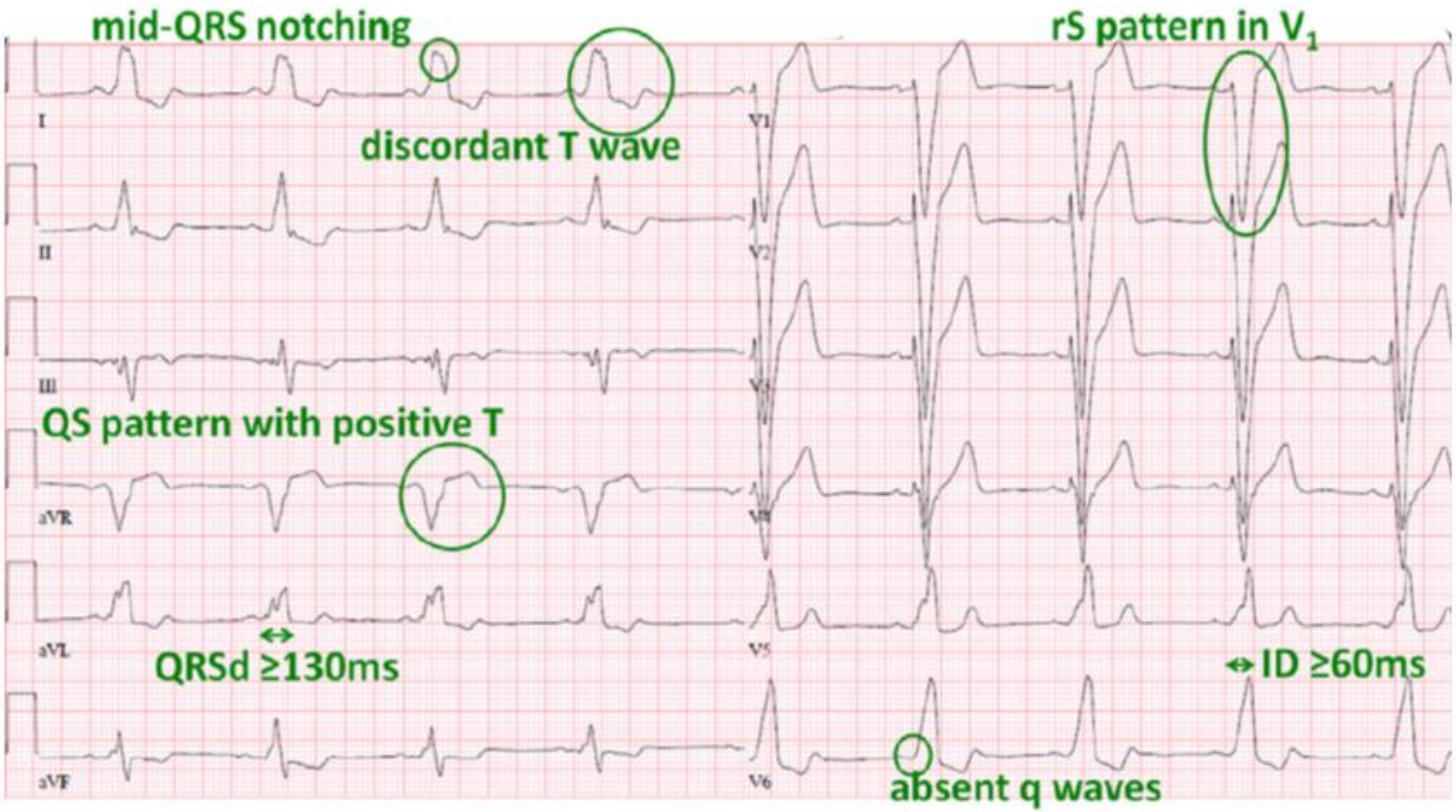
What is the definition of LBBB?

ECG parameters for complete LBBB according to guidelines of European Society of Cardiology (ESC) [11], American Heart Association (AHA)/American College of Cardiology Foundation (ACCF)/Heart Rhythm Society (HRS) [12], Strauss et al. [13], MADIT-CRT [14] and REVERSE [15] clinical CRT trials.

ECG parameter for complete LBBB	ESC	AHA	Strauss	MADIT	REVERSE
QRS duration (ms) ≥	120	120	♀130 ♂140	130	120
QS or rS in V_1	Yes	Yes	Yes	Yes	Yes
Positive T in V_1	Yes	No	No	No	No
Normal ID R in V_1–V_3	No	Yes	No	No	No
ID R in $V_5 \geq 60$ ms	No	Yes	No	No	No
ID R in $V_6 \geq 60$ ms	Yes	Yes	No	No	No
ID R in I ≥ 60 ms	Yes	No	No	No	No
Notch-/slurred R in I, aVL and V_5–V_6	No	Yes	No	No	No
Mid-QRS notch/slurring in ≥ 2 leads of V_1–V_2, V_5–V_6, I, aVL	No	No	Yes	No	No
RS pattern allowed in V_5–V_6	No	Yes	Yes	Yes	Yes
Absent q in V_5–V_6	No	Yes	No	Yes	Yes
Absent q in I	No	Yes	No	No	No
QS with positive T in aVR	Yes	No	No	No	No
Usually discordant T	Yes	Yes	No	No	No

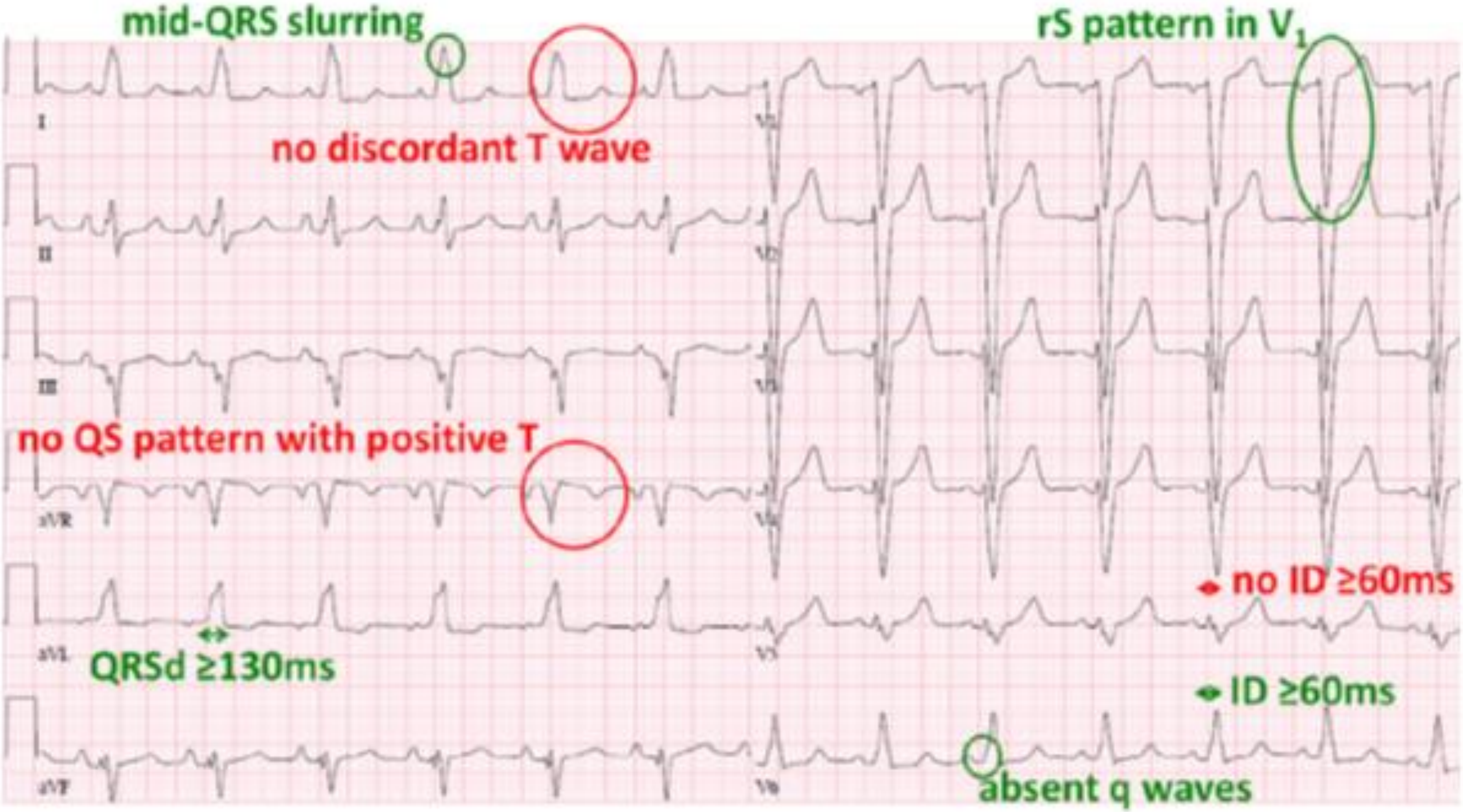
van Deursen et al, *J Electrocardiol* 2014;47:202-211

LBBB: “perfect example”



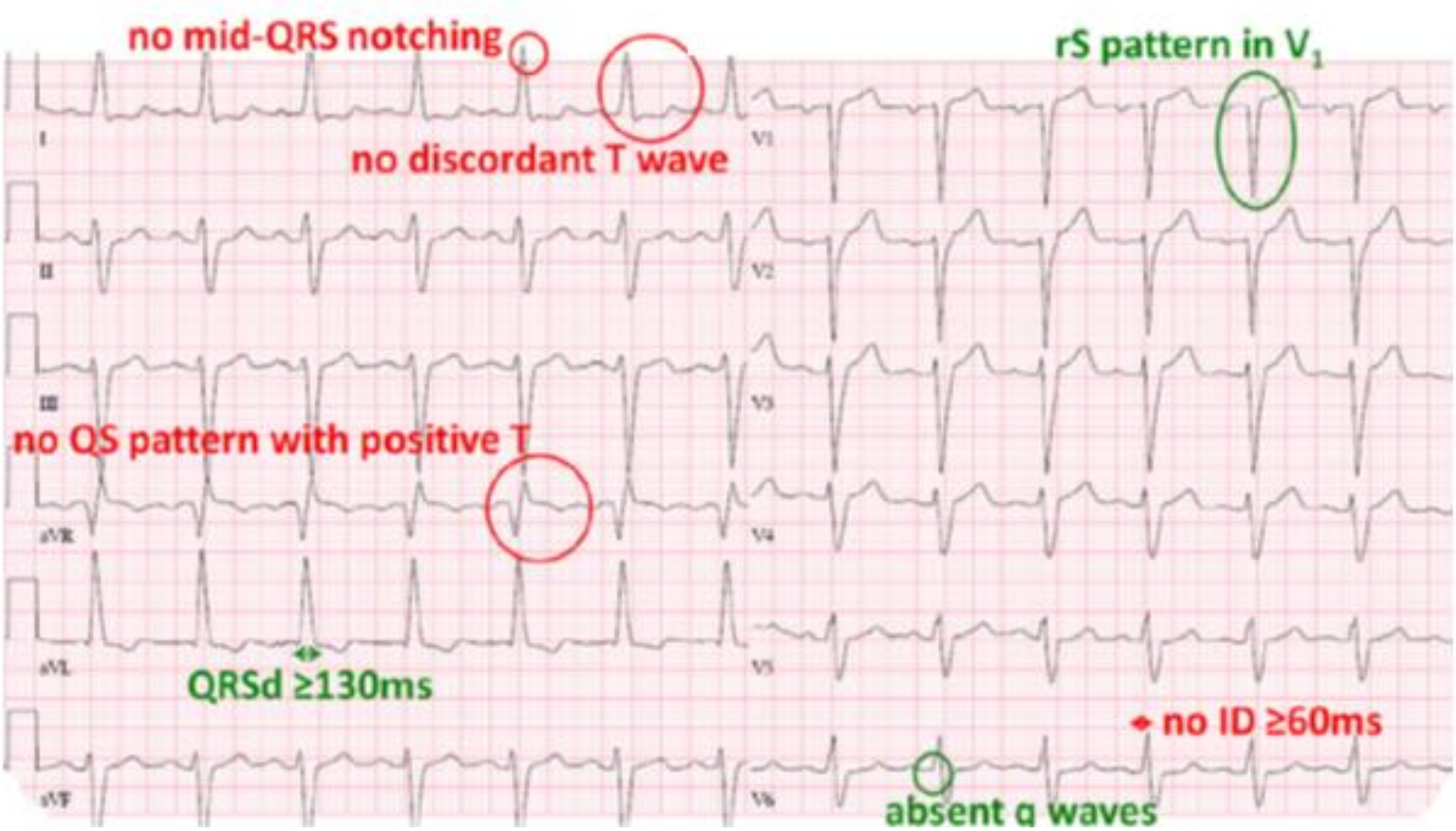
van Deursen et al, *J Electrocardiol* 2014;47:202-211

LBBB: ? "suboptimal" for CRT



van Deursen et al, *J Electrocardiol* 2014;47:202-211

LBBB: ? ”suboptimal” for CRT

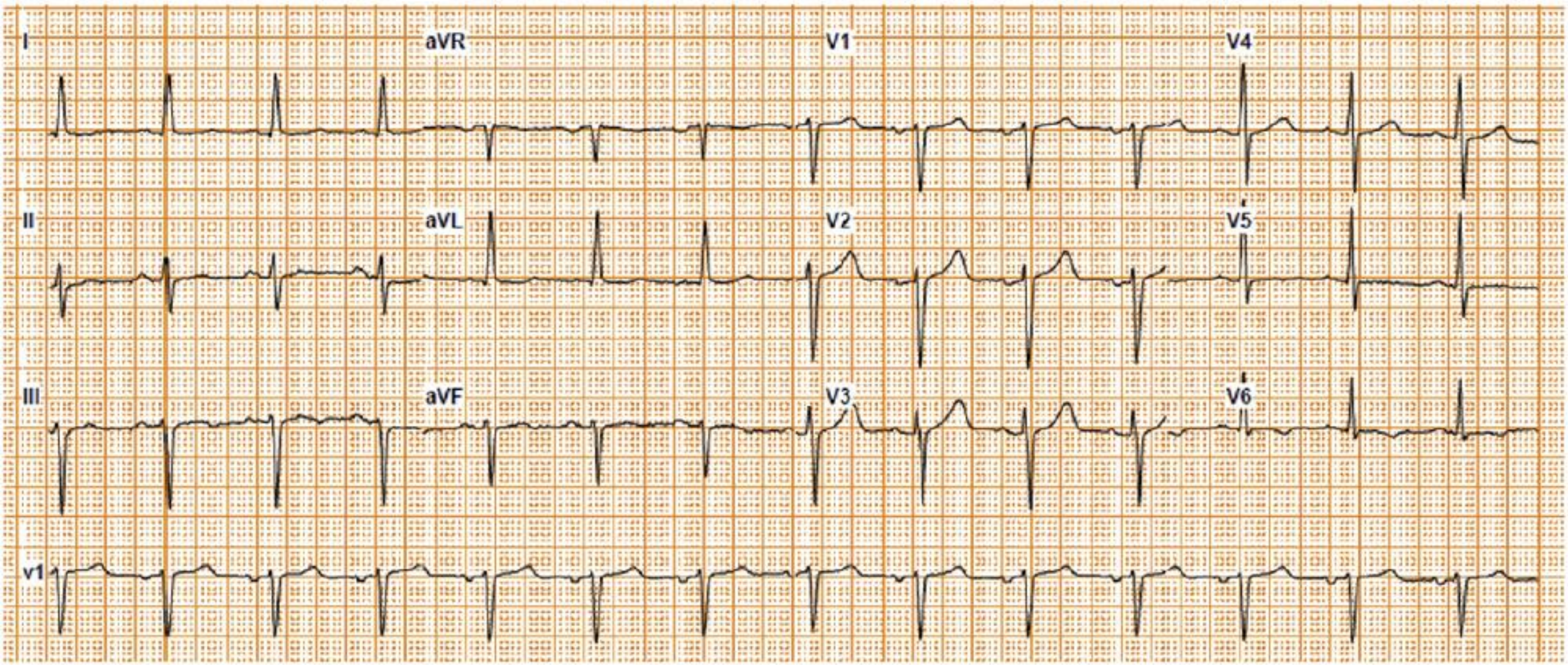


van Deursen et al, *J Electrocardiol* 2014;47:202-211

Time course of “LBBB” appearance

2009

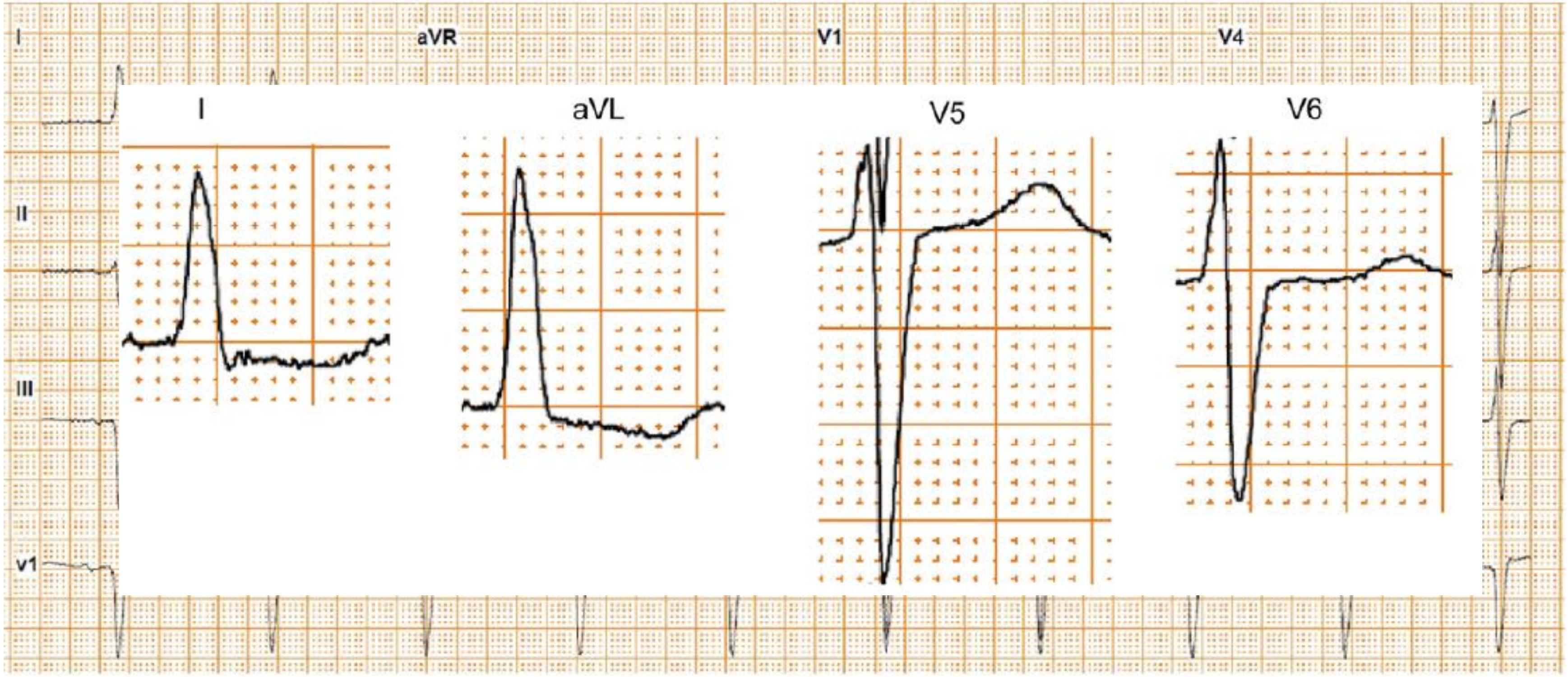
Initial ECG: QRS duration = 92 ms



Time course of "LBBB" appearance

2015

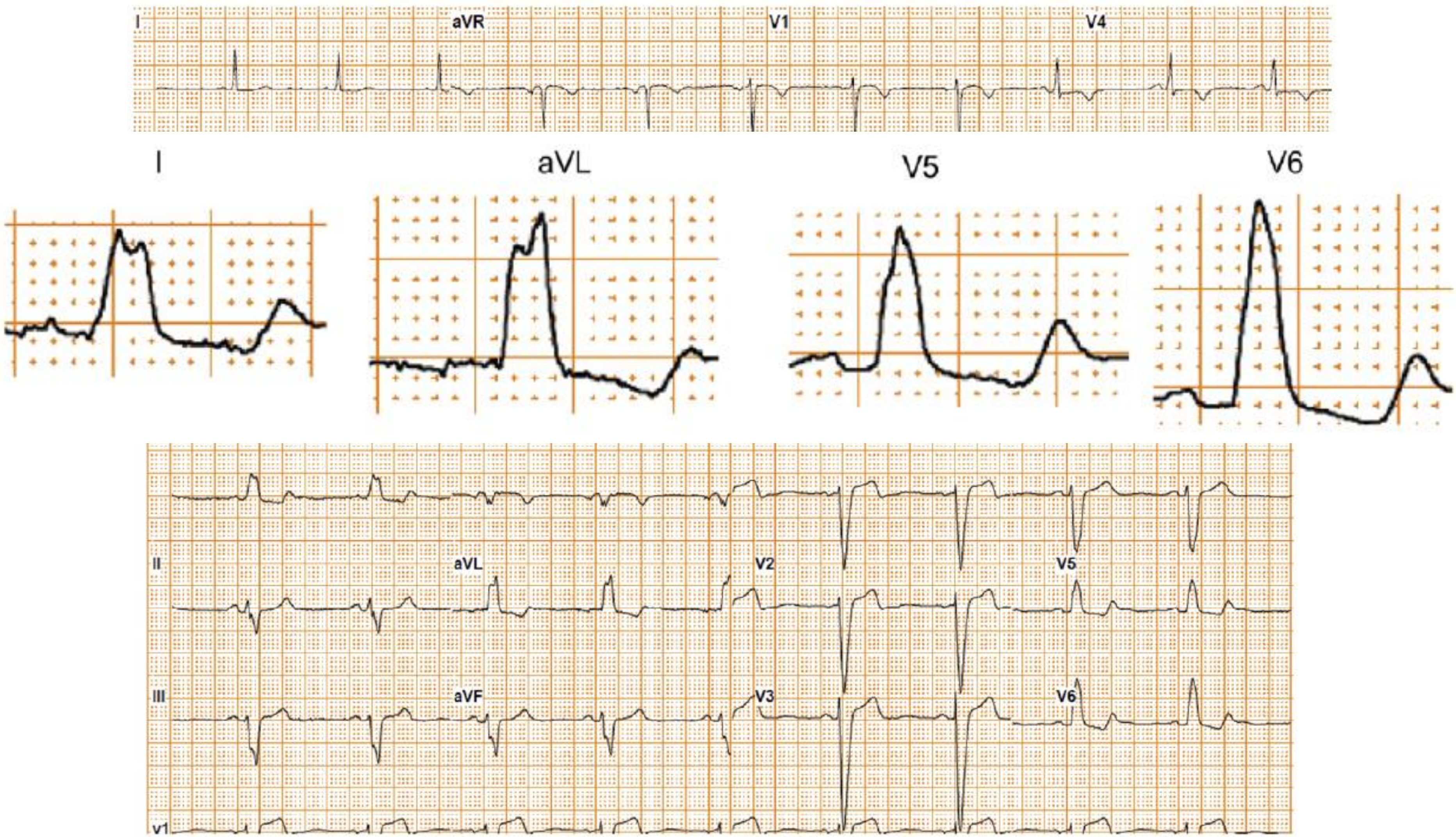
ECG after 6.5 years: QRS duration = 142 ms



Gradual widening due to LV hypertrophy, with mild axis shift (LAFHB)
No QRS notching

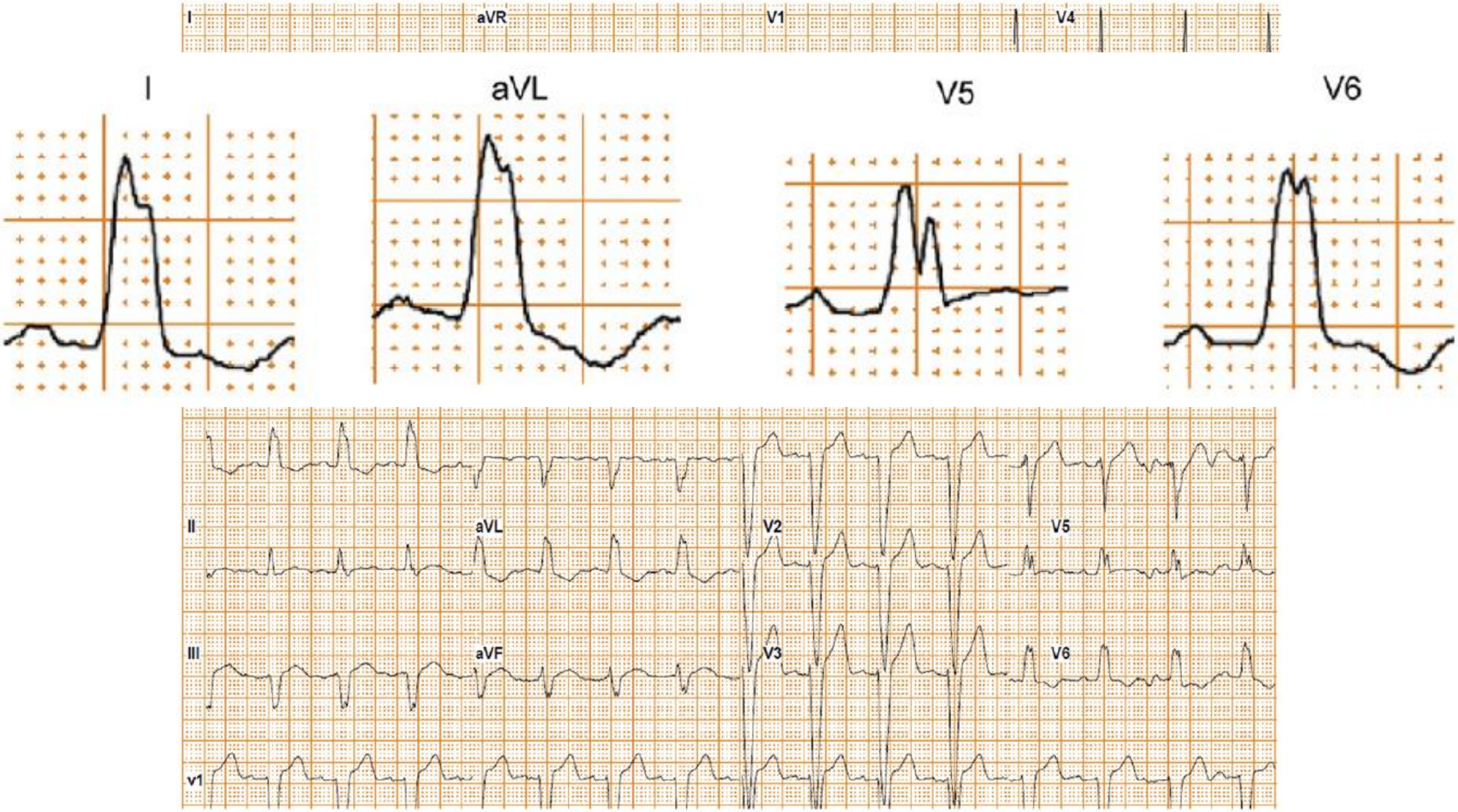
Sudden change to LBBB (1)

A. Initial ECG: QRS duration = 76 ms

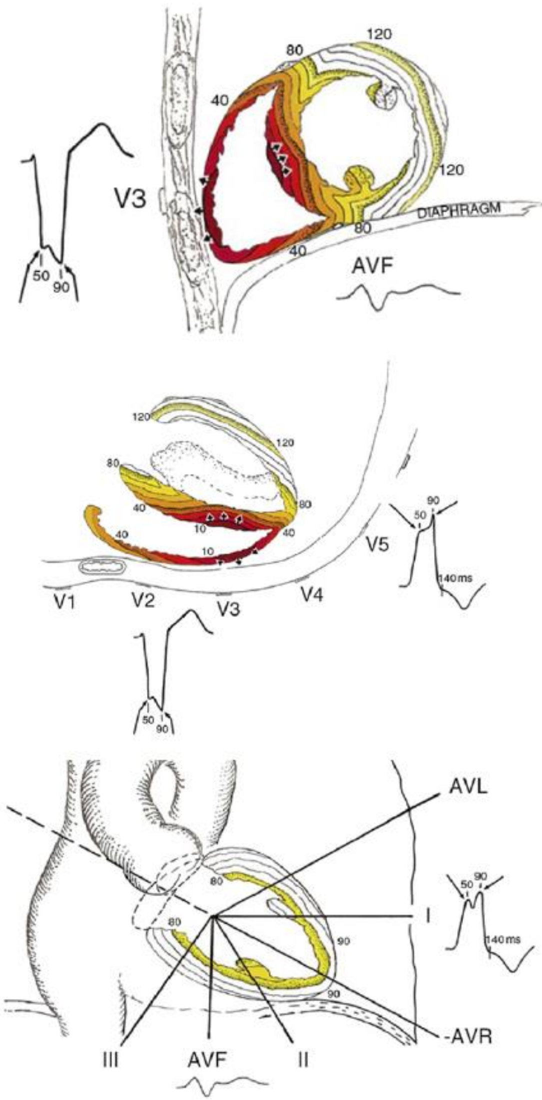


Sudden change to LBBB (2)

A. Initial ECG: QRS duration = 92 ms



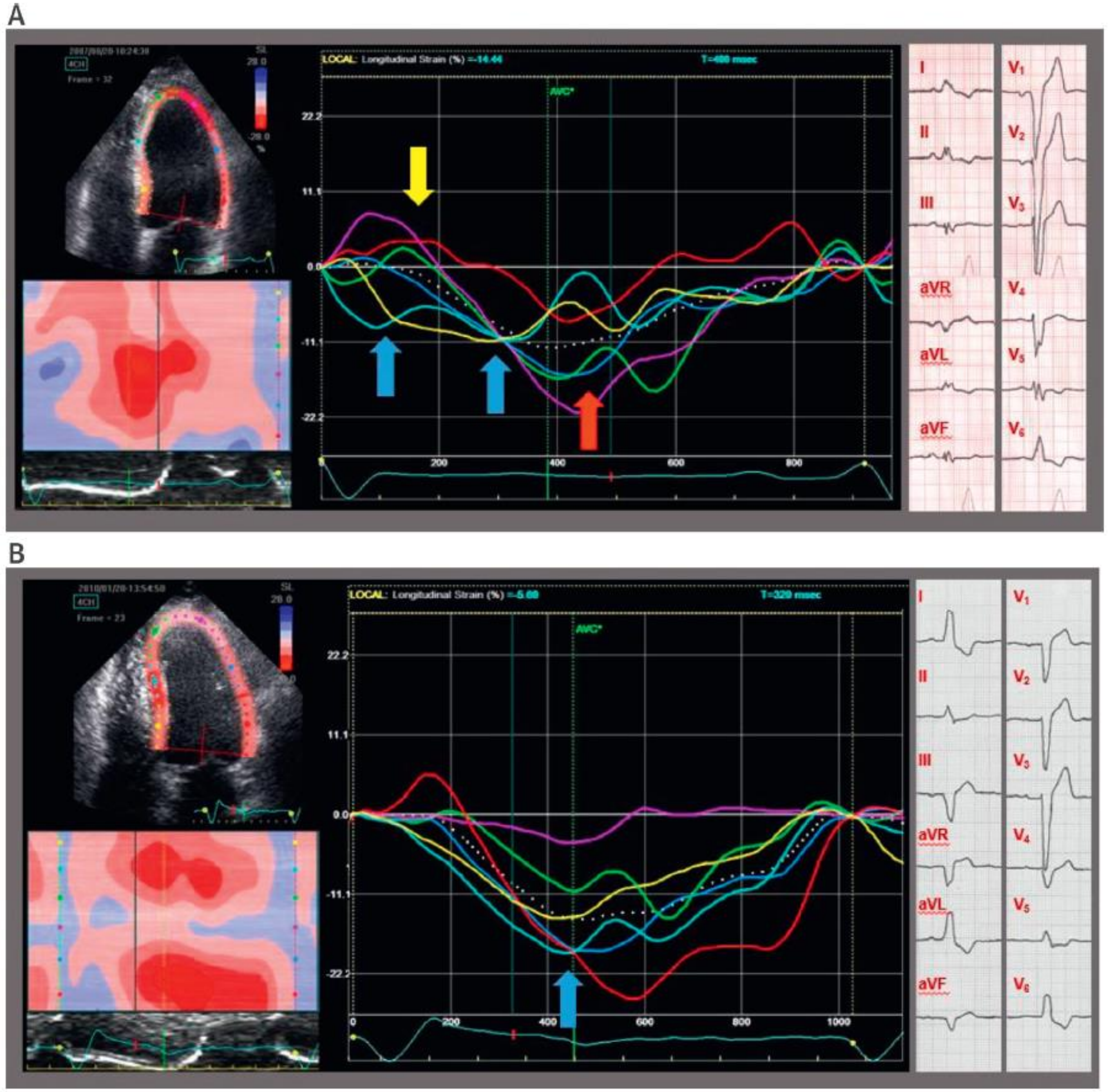
Mid-QRS notching



- The first notch represents the time when the electrical depolarization wave front reaches the endocardium of the LV (after proceeding through the septum).
- The second notch occurs when the depolarization wave front begins to reach the epicardium of the posterolateral wall.
- The reason there is little change in QRS amplitude between the 2 notches is that the magnitude and direction of the mean electrical vector (seen on a vectorcardiogram) remains approximately constant as depolarization does not proceed through the LV cavity.
- These notches are best seen in leads I, aVL, V1, V2, V5, and V6.

DG Strauss *Am J Cardiol* 2011

Importance of LBBB QRS morphology and mechanical synchrony



"True" LBBB and dyssynchrony

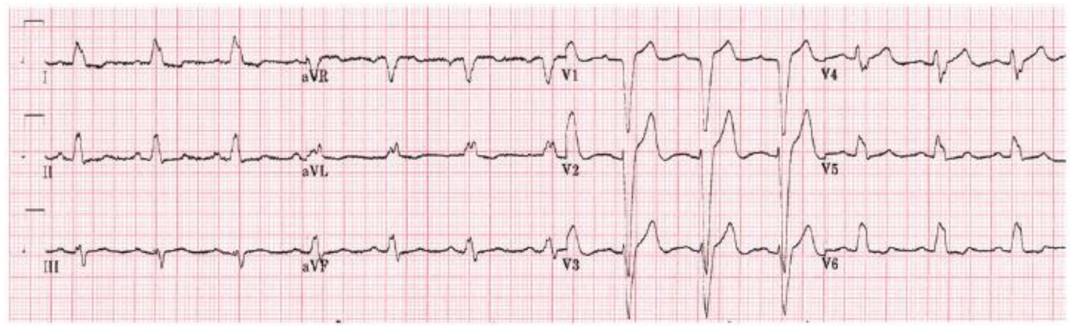
Atypical LBBB and synchronous LV contraction

N Risum *JACC* 2015

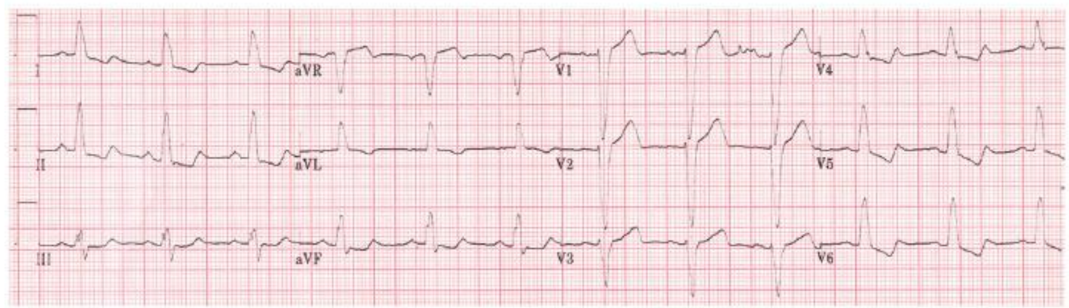
Mid-QRS notching predicts response

<u>Y Tian *Europace* 2013</u>

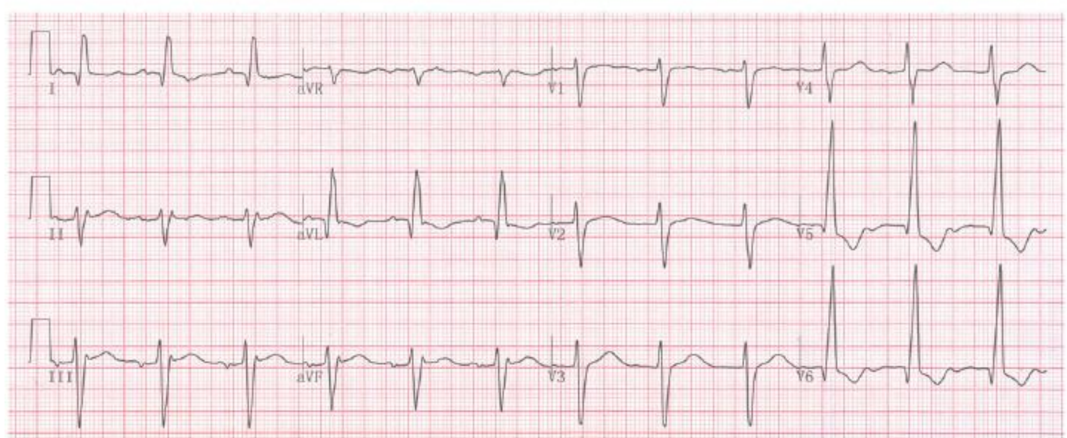
True LBBB = QRS >130 ms and notching in at least 2 leads



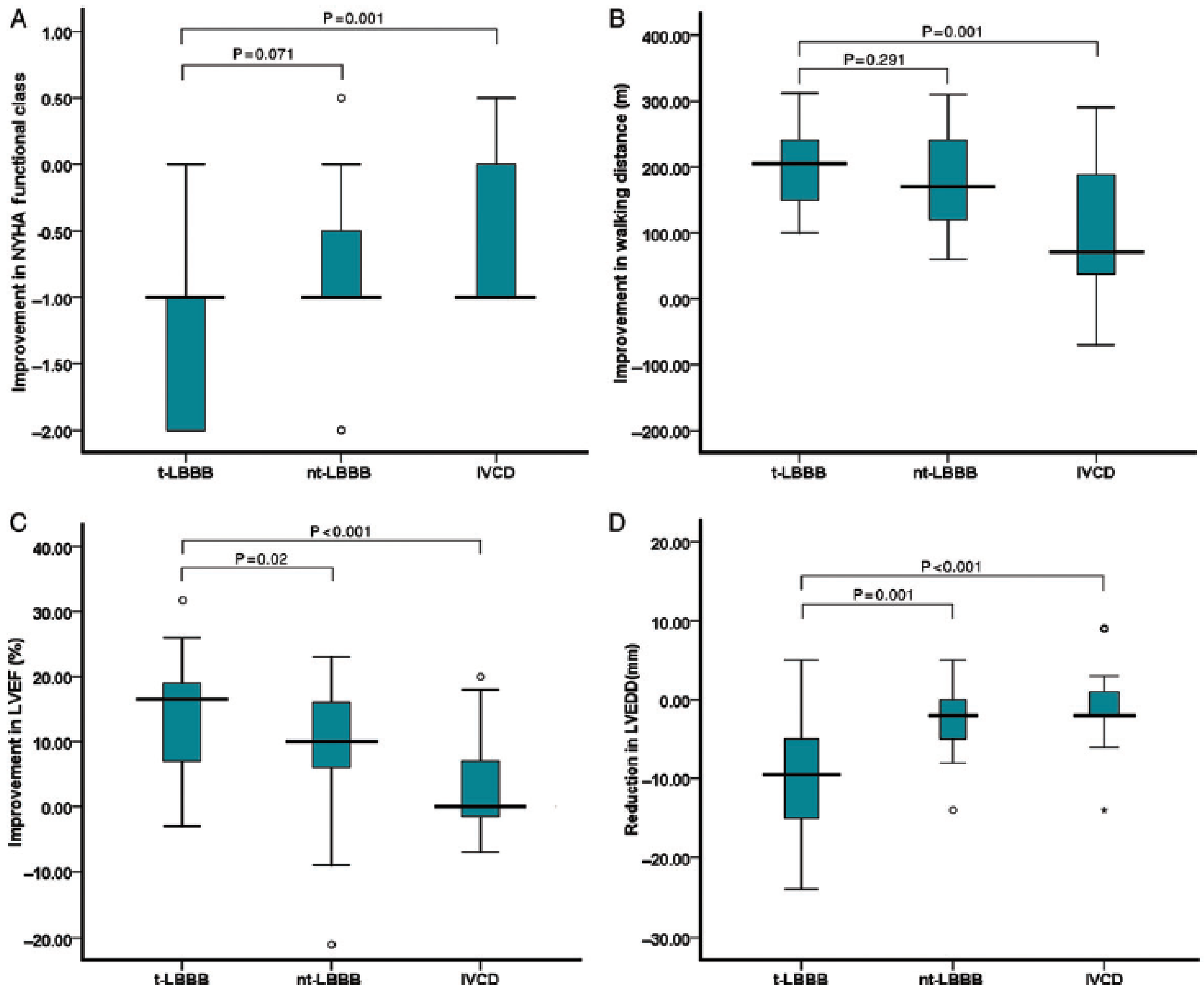
Non-true LBBB



IVCD



Mid-QRS notching predicts response

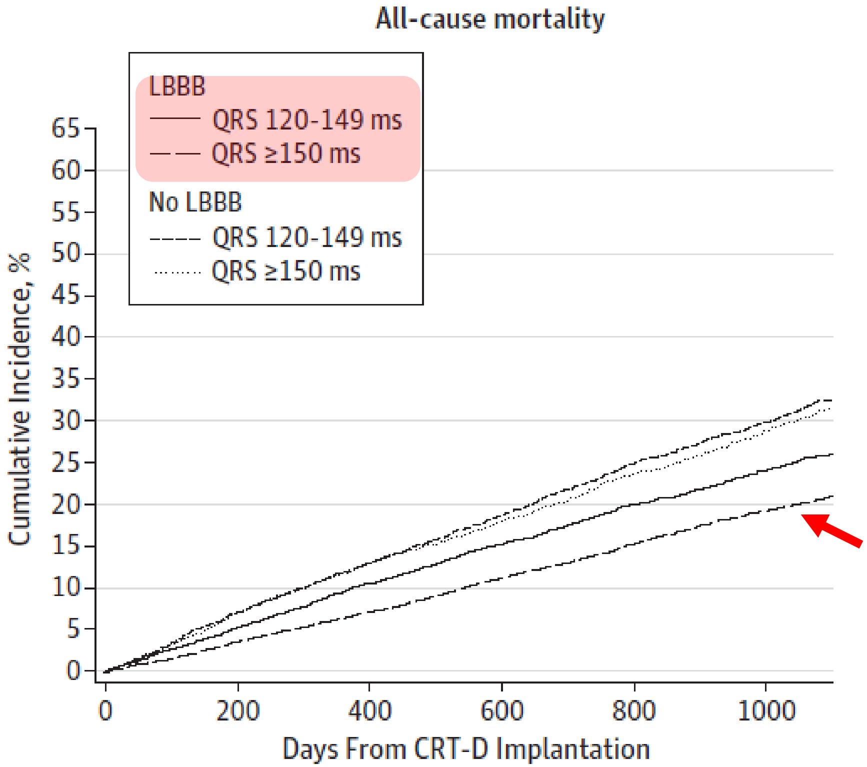


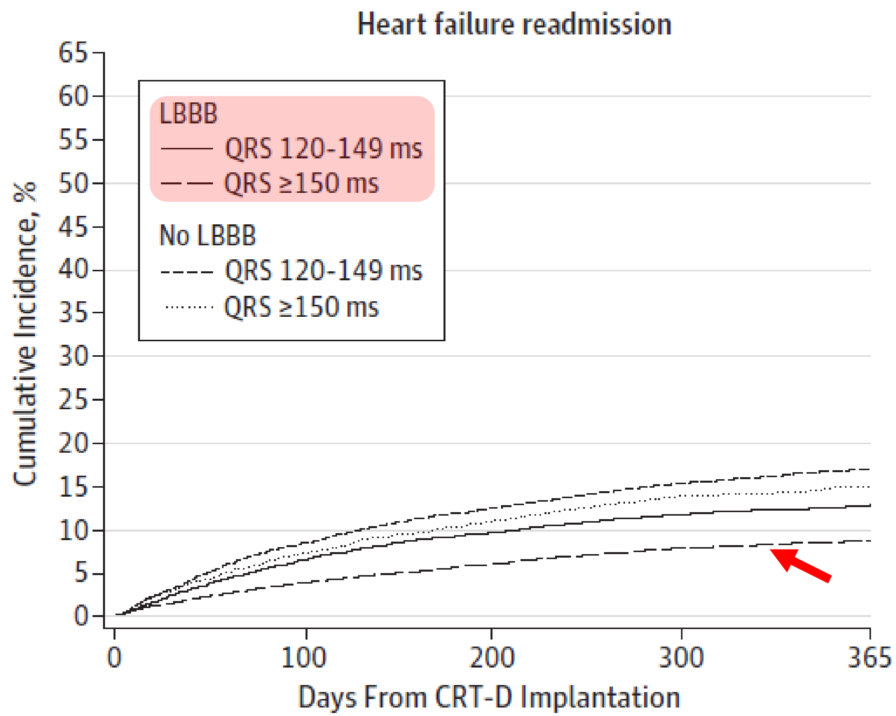
Y Tian *Europace* 2013

Is LBBB important in the "real world"

QRS Duration, Bundle-Branch Block Morphology, and Outcomes Among Older Patients With Heart Failure Receiving Cardiac Resynchronization Therapy

Pamela N. Peterson, MD, MSPH; Melissa A. Greiner, MS; Laura G. Qualls, MS; Sana M. Al-Khatib, MD, MHS; Jeptha P. Curtis, MD; Gregg C. Fonarow, MD; Stephen C. Hammill, MD; Paul A. Heidenreich, MD; Bradley G. Hammill, MS; Jonathan P. Piccini, MD, MHS; Adrian F. Hernandez, MD, MHS; Lesley H. Curtis, PhD; Frederick A. Masoudi, MD, MSPH
JAMA August 14, 2013 Volume 310, Number 6





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JAMA August 14, 2013 Volume 310, Number 6

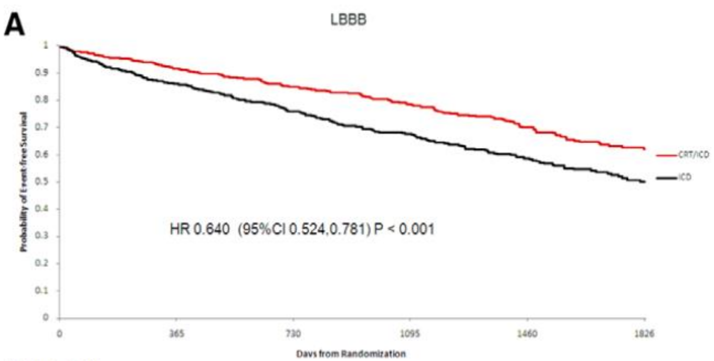
No difference between narrow and wide LBBB, but significant difference between the two narrow groups and between the two non-LBBB groups

	LBBB		No LBBB	
Outcome	QRS ≥150 ms	QRS 120-149 ms	QRS ≥150 ms	QRS 120-149 ms
No.	9889	6259	3306	4715
3-y Mortality, No. (%)	1859 (20.9)	1511 (26.5)	929 (30.7)	1380 (32.3)
Adjusted HR (99% CI)	1 [Reference]	1.30 (1.18-1.42)	1.34 (1.20-1.49)	1.52 (1.38-1.67)
1-y All-cause re-admission, No. (%)	3752 (38.6)	2760 (44.8)	1489 (45.7)	2301 (49.6)
Adjusted HR (99% CI)	1 [Reference]	1.18 (1.10-1.26)	1.16 (1.08-1.26)	1.31 (1.23-1.40
1-y Cardiovascular readmission, No. (%)	1927 (19.8)	1552 (25.1)	873 (26.8)	1372 (29.5)
Adjusted HR (99% CI)	1 [Reference]	1.27 (1.17-1.38)	1.29 (1.17-1.44)	1.47 (1.34-1.62)
1-y Heart failure re-admission, No. (%)	845 (8.7)	794 (12.9)	491 (15.1)	793 (17.1)
Adjusted HR (99% CI)	1 [Reference]	1.47 (1.30-1.67)	1.62 (1.40-1.87)	1.92 (1.68-2.20)

What about RBBB and NIVCD?

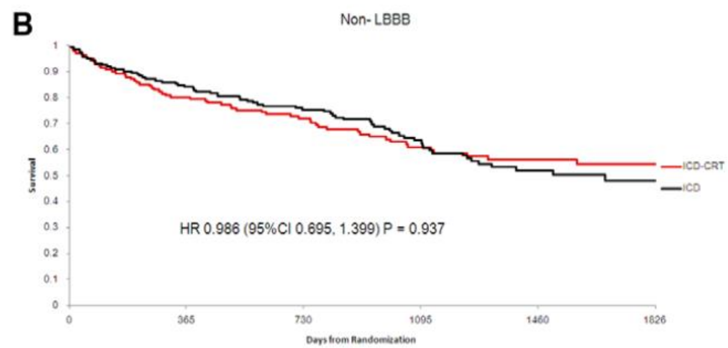
RAFT Trail subanalysis: QRS morphology

DH Birnie *Circ Heart Failure* 2013



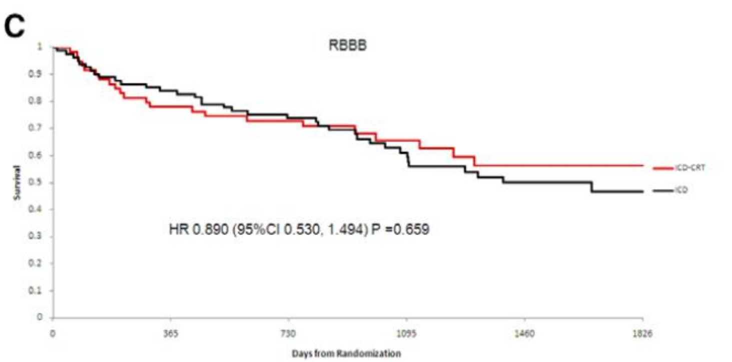
Patients at risk

ICD	594	543	426	302	196	89
ICD-CRT	581	499	370	253	149	70



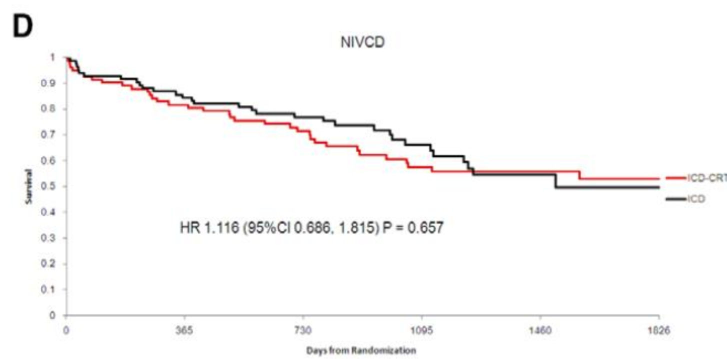
Patients at risk

ICD	143	113	88	59	35	17
ICD-CRT	165	139	110	65	34	13



Patients at risk

ICD	60	46	38	23	14	8
ICD-CRT	81	68	55	35	22	11



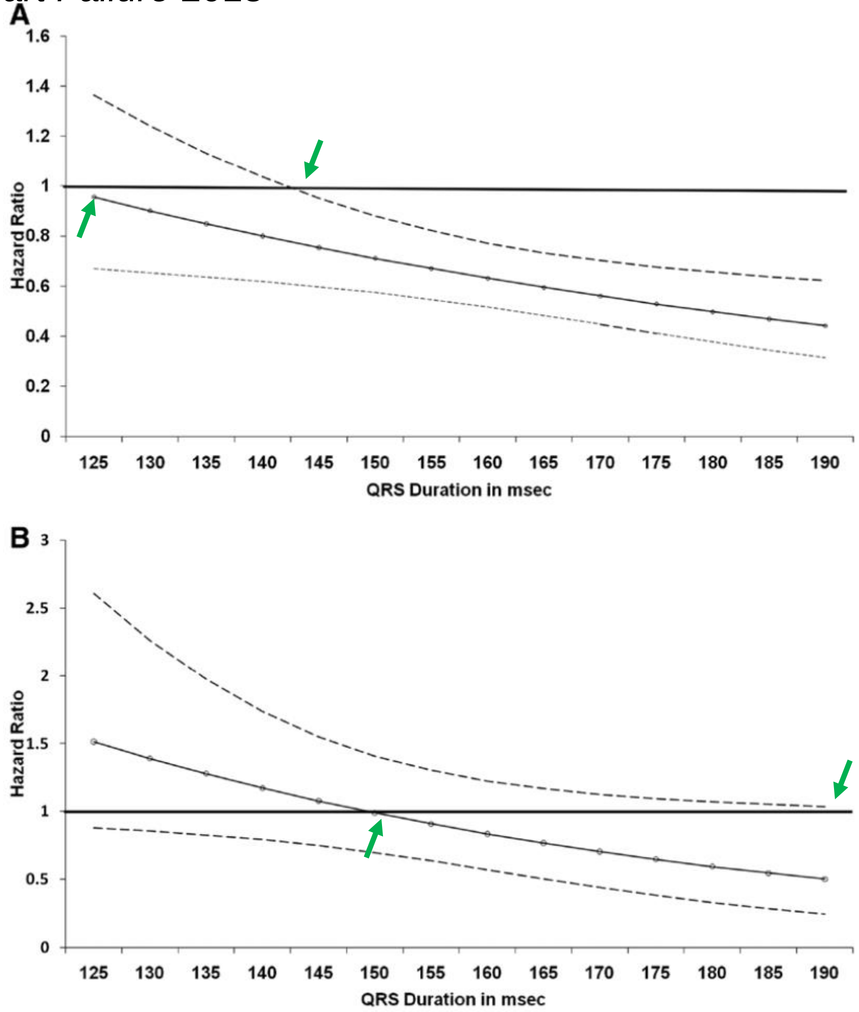
Patients at risk

ICD	83	67	50	36	21	9
ICD-CRT	84	71	55	35	30	5

What about RBBB and NIVCD?

RAFT Trail subanalysis: QRS duration

DH Birnie *Circ Heart Failure* 2013



LBBB

Non-LBBB

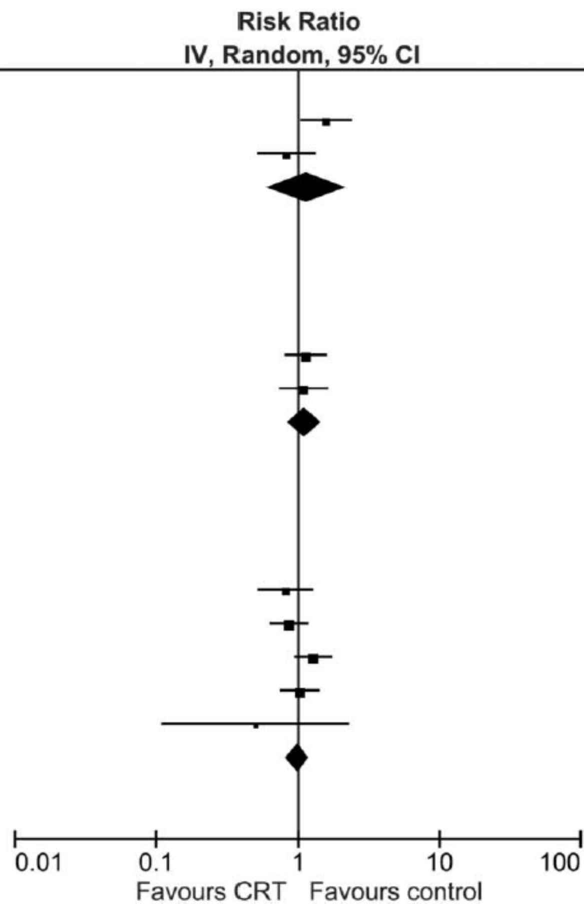
What about RBBB and NIVCD?

C Cunnington *Heart* 2015 Meta-analysis of RCTs that evaluated non-LBBB patients. 1766 out of 6523 had non-LBBB

Table 2 Partici... CRT

Study	QRS morphology
MADIT-CRT[5 15 20]	Non-LBBB
CARE-HF[1 18]	RBBB
COMPANION[2]	Non-LBBB
RAFT[4 12]	Non-LBBB
REVERSE[6 14]	Non-LBBB

Study or Subgroup	Risk Ratio IV, Random, 95% CI
Death	
MADIT-CRT (non-LBBB)	1.57 [1.03, 2.39]
RAFT (non-LBBB)	0.82 [0.51, 1.32]
Subtotal (95% CI)	**1.15 [0.61, 2.16]**
Heterogeneity: $Tau^2 = 0.16$; $Chi^2 = 4.02$, df = 1 (P = 0.04); $I^2 = 75\%$	
Test for overall effect: Z = 0.42 (P = 0.67)	
Heart failure	
MADIT-CRT (non-LBBB)	1.13 [0.80, 1.60]
RAFT (non-LBBB)	1.09 [0.73, 1.62]
Subtotal (95% CI)	**1.11 [0.86, 1.45]**
Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.02$, df = 1 (P = 0.89); $I^2 = 0\%$	
Test for overall effect: Z = 0.80 (P = 0.42)	
Death or heart failure	
CARE-HF (RBBB)	0.81 [0.52, 1.28]
COMPANION (non-LBBB)	0.86 [0.63, 1.17]
MADIT-CRT (non-LBBB)	1.27 [0.94, 1.73]
RAFT (non-LBBB)	1.03 [0.75, 1.42]
REVERSE (non-LBBB)	0.50 [0.11, 2.29]
Subtotal (95% CI)	**0.99 [0.82, 1.20]**
Heterogeneity: $Tau^2 = 0.01$; $Chi^2 = 4.95$, df = 4 (P = 0.29); $I^2 = 19\%$	
Test for overall effect: Z = 0.09 (P = 0.92)	



Is the ECG enough?
Should only LBBB patients receive CRT?

Some people with RBBB and/ot NIVCD still respond.

This could be due to

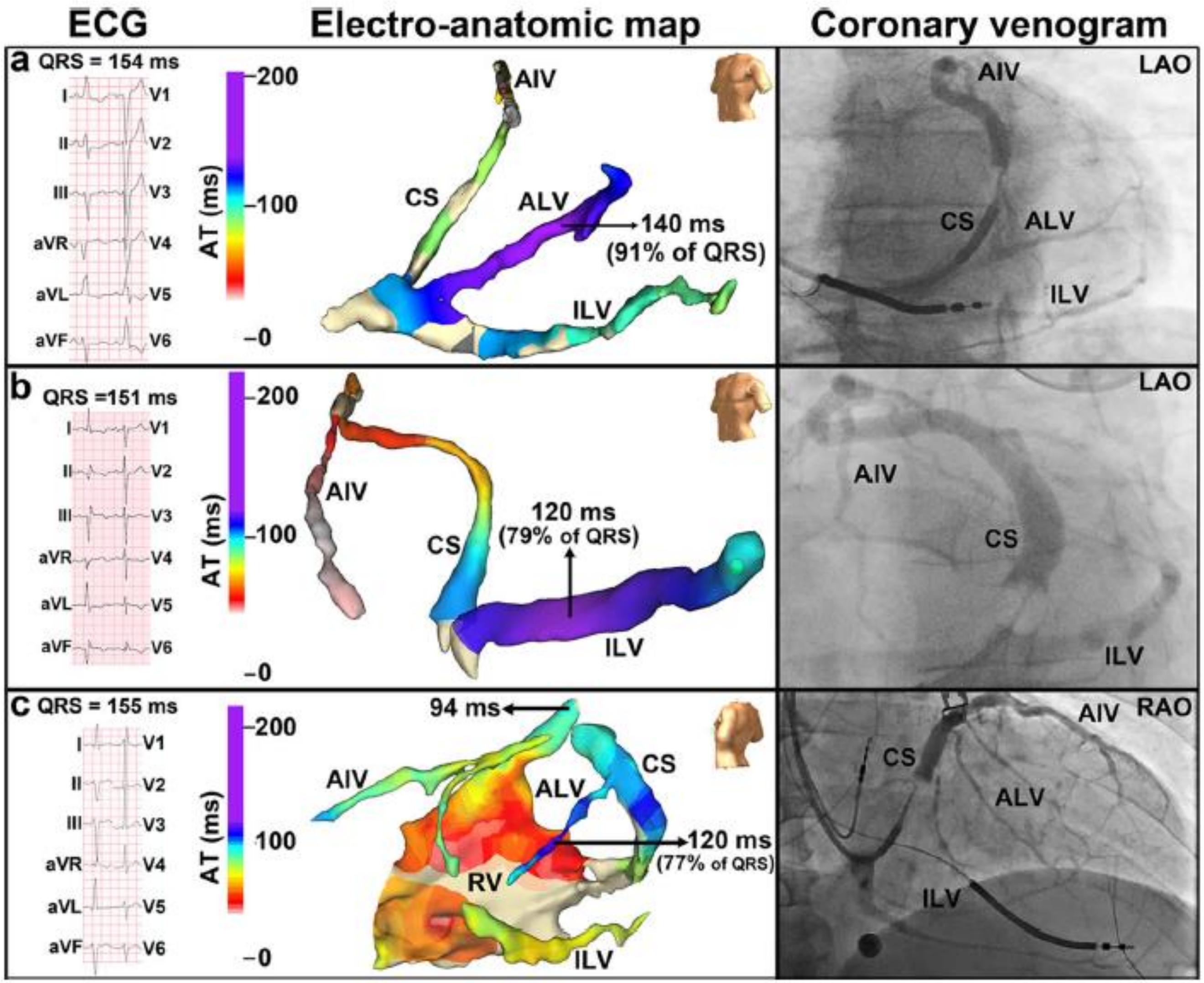
- Placebo effect
- AV resynchronisation – do they have profound 1st degree heart block?
- Resynchronisation - Inter- and left intraventricular dyssynchrony was present and has been improved

A minority of NIVCD or RBBB patients may still have LV dyssynchrony and delay

LBBB

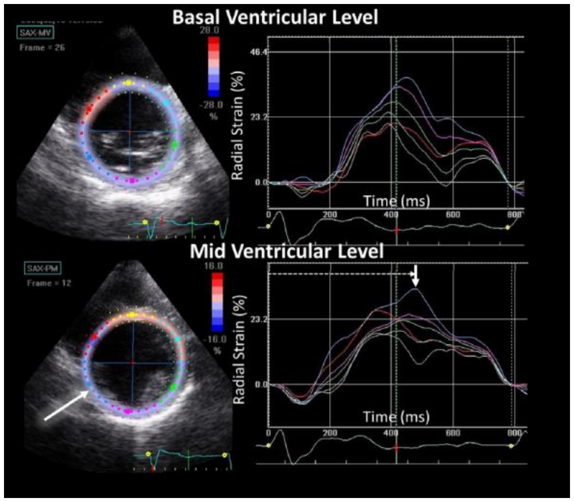
NIVCD

RBBB
+
LAFB

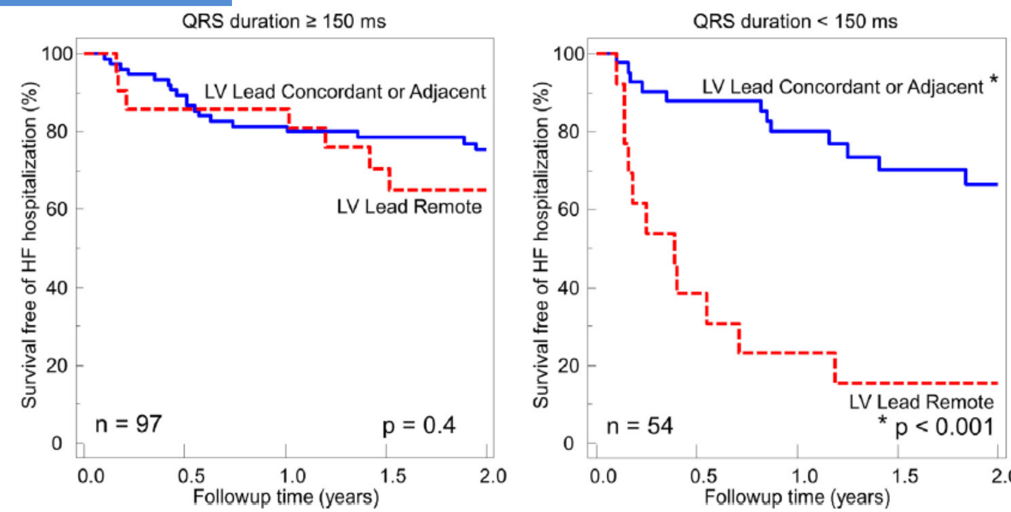


Targeted LV lead placement

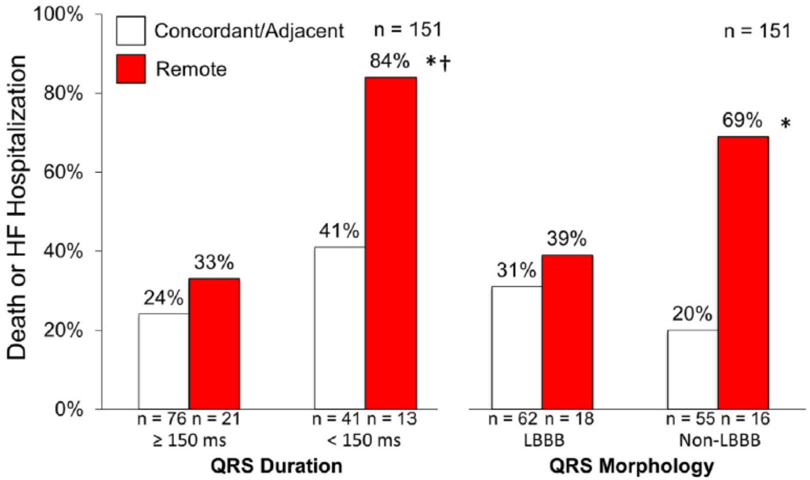
JJ Marek *Am J Cardiol* 2014: STARTER trial subanalysis



Primary Endpoint Stratified by QRS duration

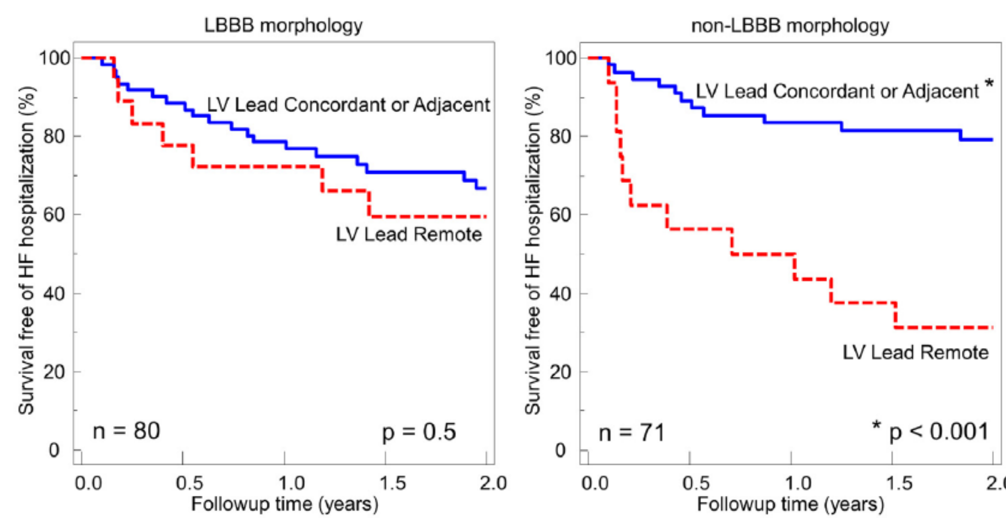


Primary Event Rates by QRS duration and QRS morphology



* p < 0.01 vs. LV Lead Concordant or Adjacent; † p < 0.01 vs. Remote QRS ≥ 150 ms

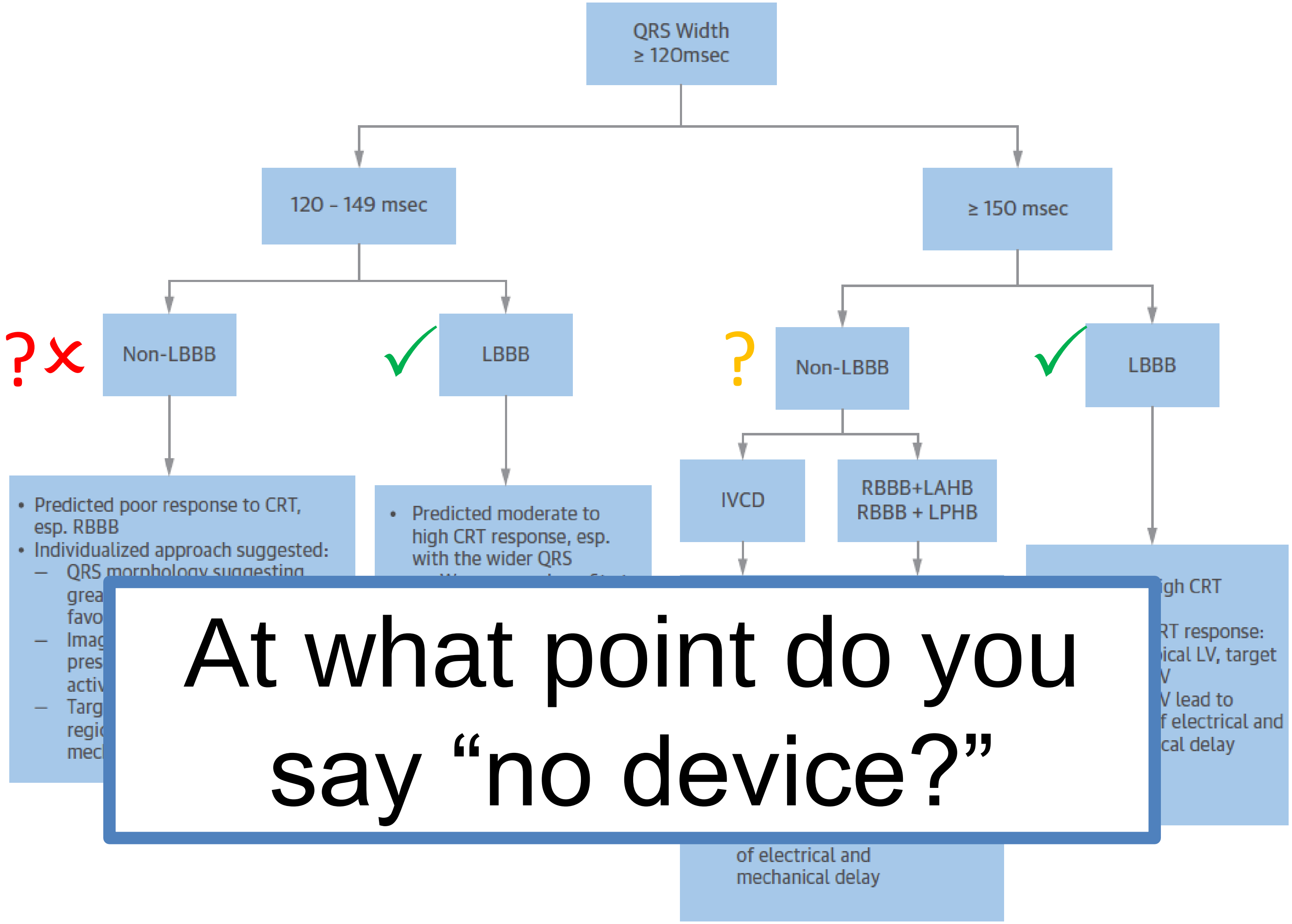
Primary Endpoint Stratified by QRS morphology



Is the ECG enough? Why don’t all LBBB patients respond?

- It was not a “LBBB-mediated” cardiomyopathy
- Failure to correct the dyssynchrony (lead position, programming etc)
- Not dyssynchronous (not “true” LBBB)

Summary: Predicting response from the 12 lead ECG



At what point do you say "no device?"