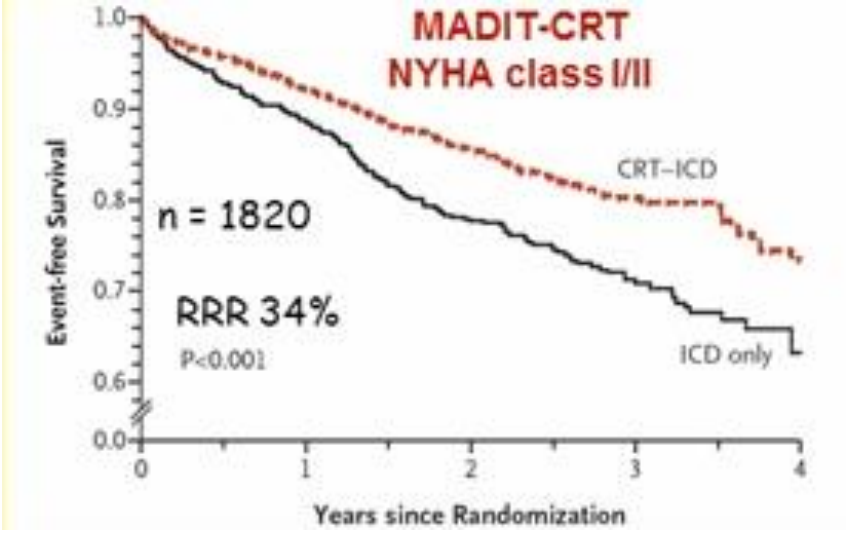
How to identify optimal ECG patterns for CRT

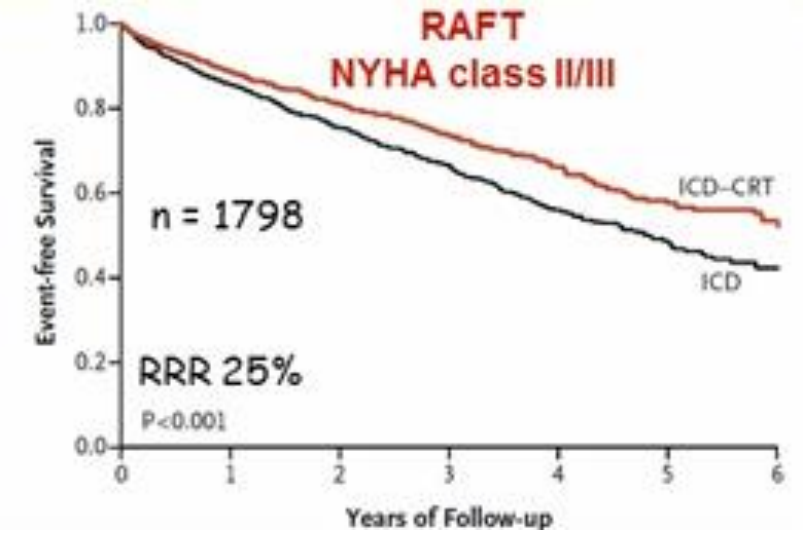
인하대 병원
심장내과
김대혁

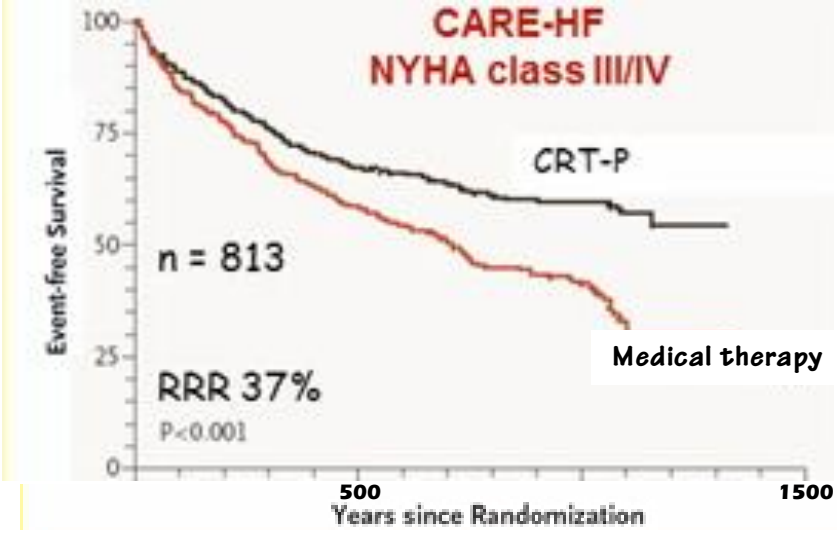
CRT

- **Interventricular dyssynchrony** : delayed activation of one ventricle with respect to the other
- **Intraventricular dyssynchrony** : late activation of the lateral region of the LV chamber vs activation of the septum.
- **CRT** : attempt to normalize the timing of activation of the left and right ventricle or lateral wall and septum----> improve the consequence of this impaired activation.

Effect of CRT in major clinical trials

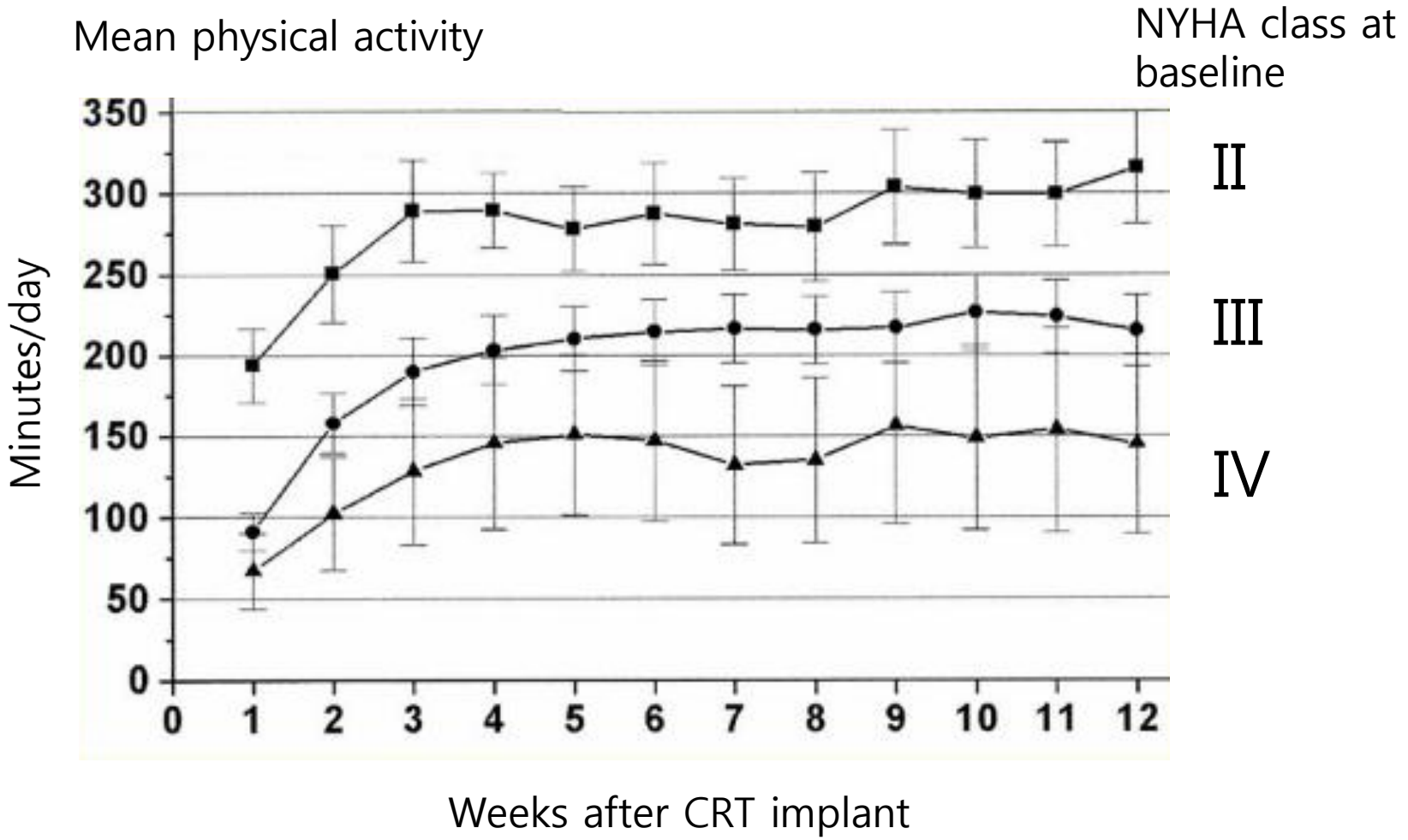






N Engl J Med 2009; 361:1329-38
N Engl J Med 2010;363:2385-95
N Engl J Med 2005;352 :1539-49

Effect of CRT are evident soon after implant



Am J Cardiol 2005;95:1104-7

Cardiac resynchronization therapy (CRT): Clinical trials, guidelines, and target populations

Cecilia Linde, MD, PhD,* Kenneth Ellenbogen, MD, FHRS,† Finlay A. McAlister, MD‡

*From the *Department of Cardiology, Karolinska University Hospital, Stockholm, Sweden, †VCU School of Medicine, Richmond, Virginia, and ‡University of Alberta, Edmonton, Canada.*

Over the last 10 years, several large, well-designed clinical trials have firmly established the role of cardiac resynchronization therapy (CRT) as a recommended treatment strategy for moderate-to-severe heart failure (HF). A review of the relevant results from the MUSTIC, MIRACLE, CONAK-CD, and MIRACLE ICD trials reveals that in patients with New York Heart Association (NYHA) class III–IV HF, CRT produces consistent improvements in quality of life, functional status, and exercise capacity while also providing strong evidence for reverse remodeling and diminished functional mitral regurgitation, resulting in reductions in both HF hospitalizations and all-cause morbidity and mortality. In patients with earlier NYHA class I–II HF, the benefit of CRT has been more controversial. The principal ongoing challenges addressed in this article include the substantial 30% of patients who receive a CRT device but fail to respond, the wide variations in how to define "response" vs "nonresponse," and how to identify patients who will benefit from CRT, especially narrow QRS (<120 ms), those with right bundle branch block, and those with mild-to-moderate (NYHA class I–II) HF. An important result of this uncertainty is the lack of a good sense of the optimal rate of CRT implantation, making consideration of the data reviewed in this article crucial for identifying important gaps of knowledge and mechanisms of action that need to be studied in the near future.

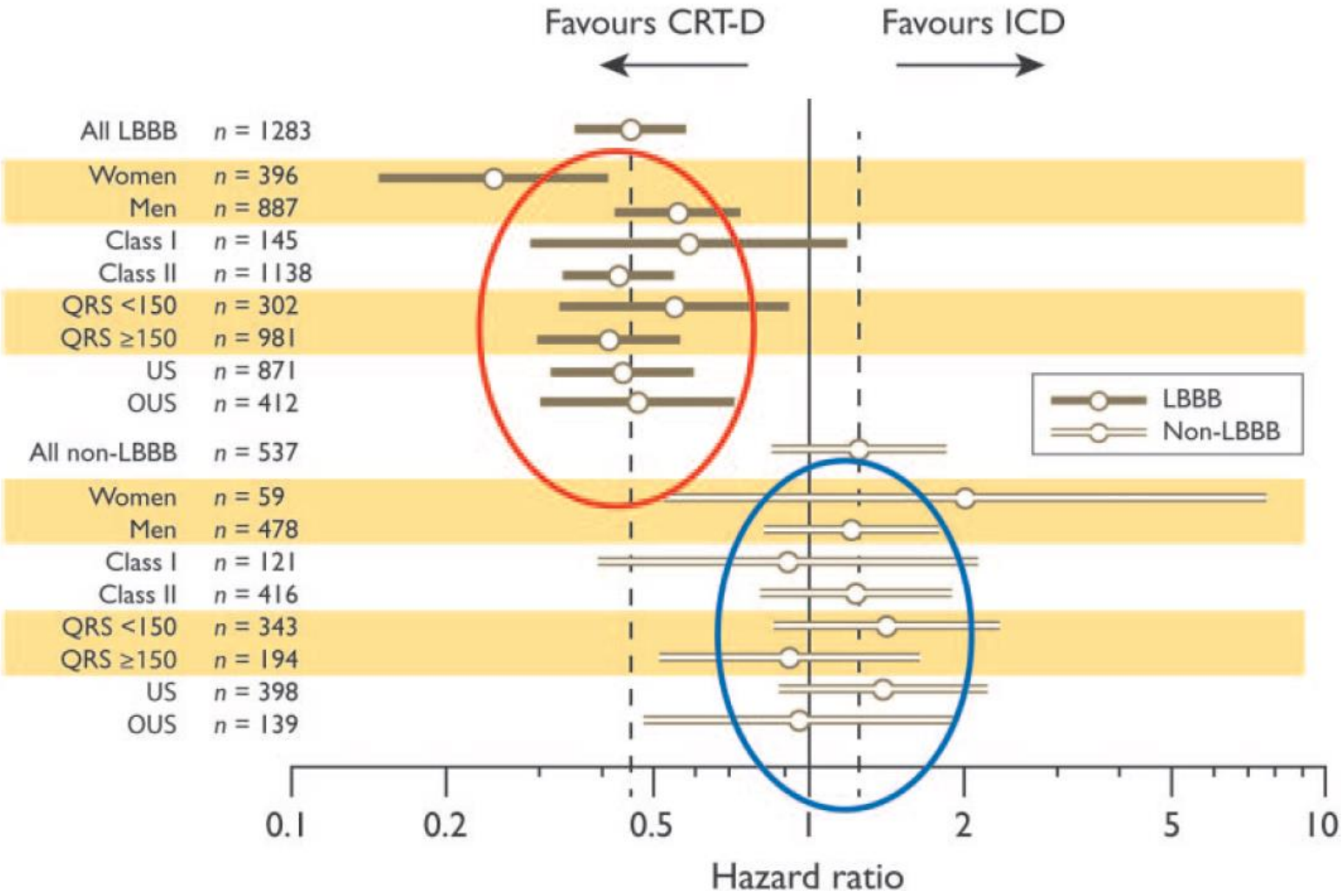
KEYWORDS Arrhythmia; Biventricular pacing; Cardiac resynchronization therapy (CRT); Dyssynchrony; Heart failure; Narrow QRS; Nonresponder

ABBREVIATIONS **ACE** = angiotensin-converting enzyme; **BiV** = biventricular; **CRT** = cardiac resynchronization therapy; **EF** = ejection fraction; **ESC** = European Society of Cardiology; **HF** = heart failure; **ICD** = implantable cardioverter-defibrillator; **LBBB** = left bundle branch block; **LV** = left ventricular; **NYHA** = New York Heart Association; **RBBB** = right bundle branch block

(Heart Rhythm 2012;9:S3–S13)

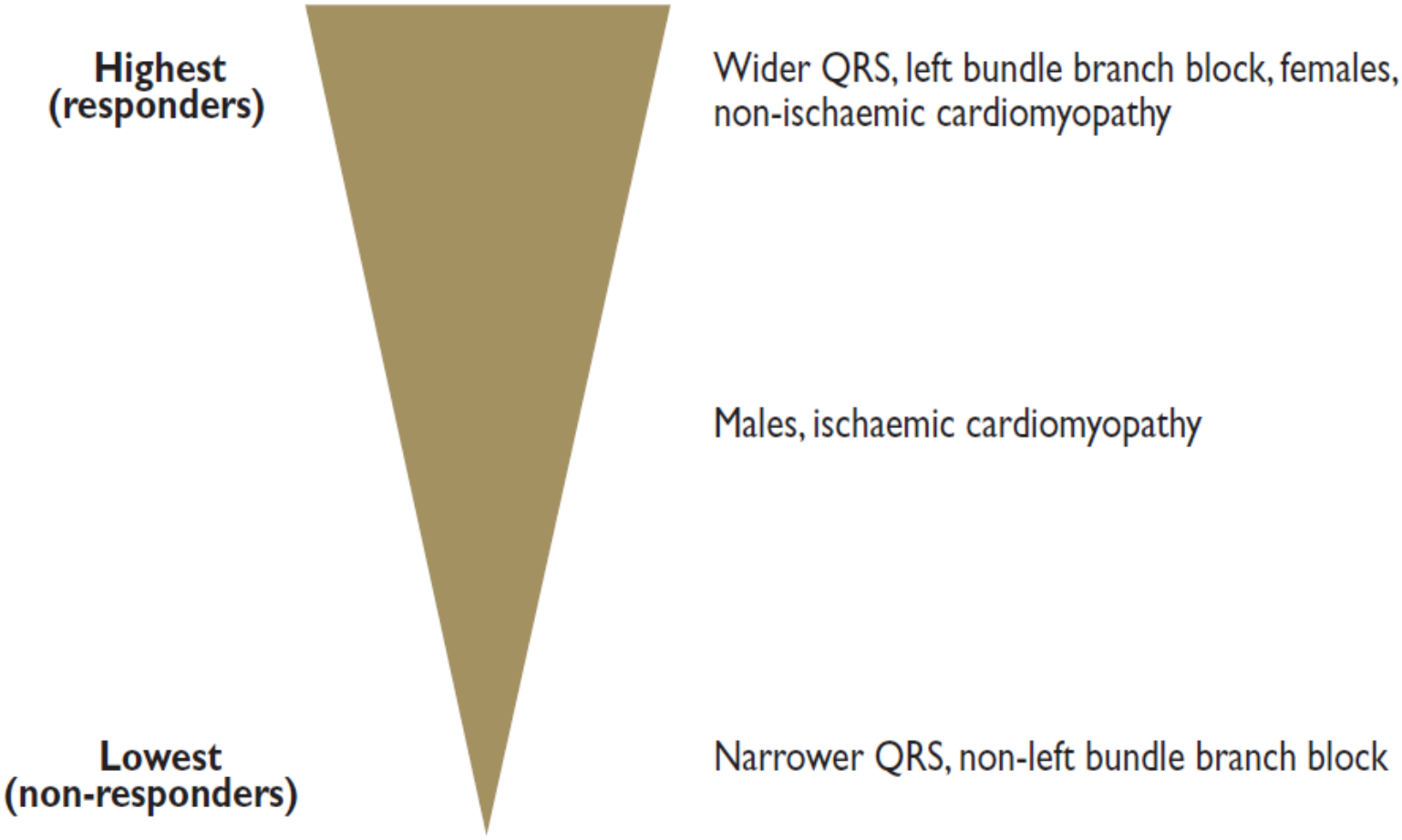
include the substantial 30% of patients who receive a CRT device
But failed to respond,

Clinical factors influencing the likelihood to response to CRT



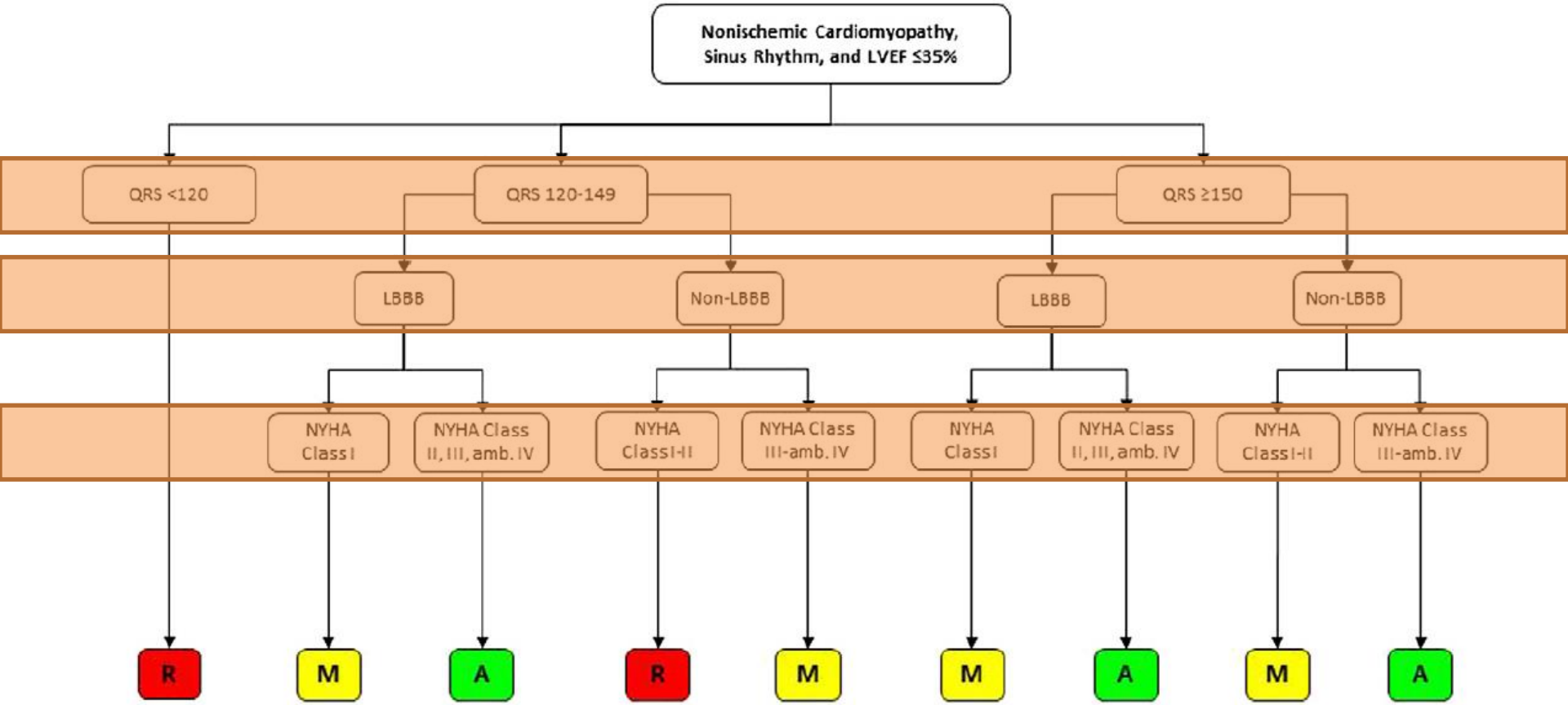
Eur Heart J 2013;34:2281-2329 . 2013 ESC guideline

Magnitude of benefit from CRT



Eur Heart J 2013;34:2281-2329 . 2013 ESC guideline

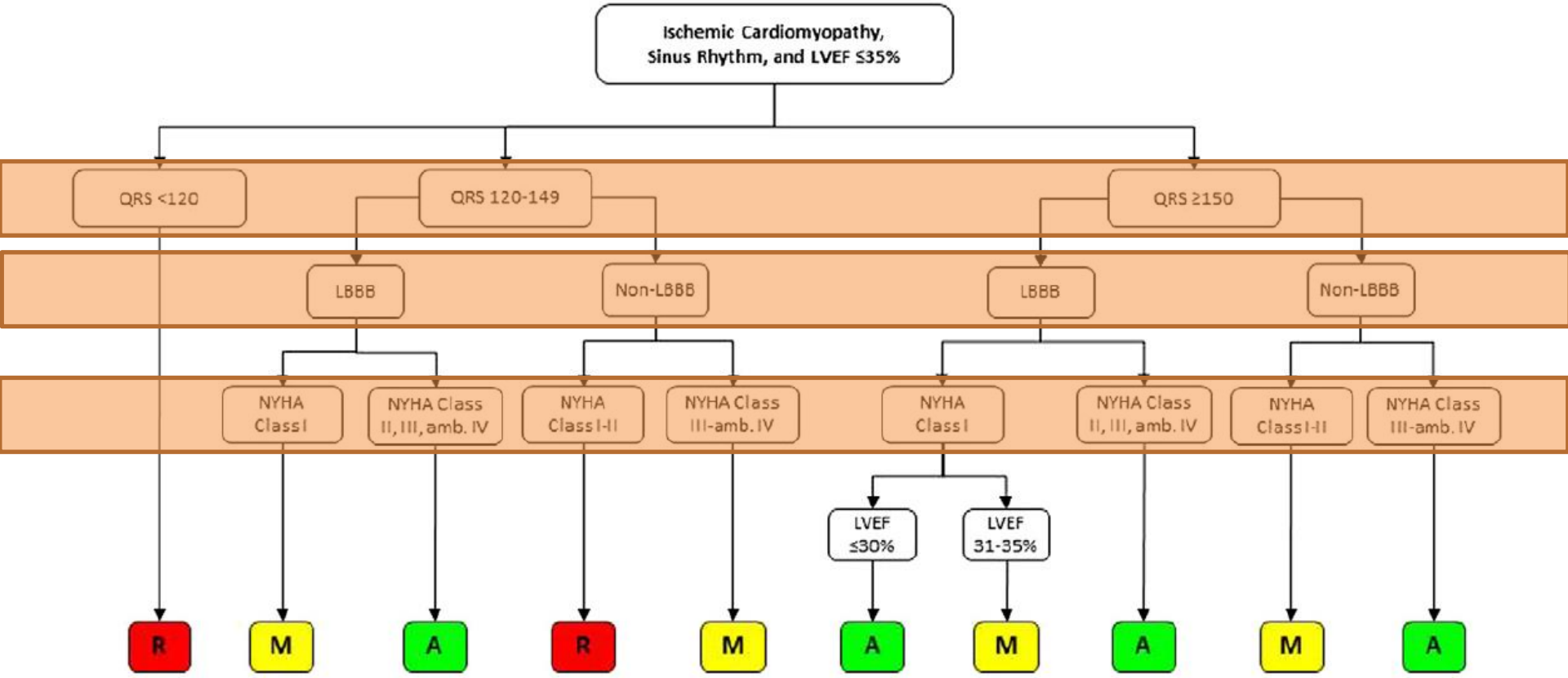
Appropriate use criteria for CRT



A = Appropriate; amb = ambulatory; CRT = cardiac resynchronization therapy; LBBB = left bundle branch block; LVEF = left ventricular ejection fraction; M = May Be Appropriate; NYHA = New York Heart Association; R = Rarely Appropriate.

JACC 2013;61:1318-68. ACCF/HRS/AHA/ASE/HFSA/SCAI/SCCT/SCMR

Appropriate use criteria for CRT



A = Appropriate; amb = ambulatory; CRT = cardiac resynchronization therapy; LBBB = left bundle branch block; LVEF = left ventricular ejection fraction; M = May Be Appropriate; NYHA = New York Heart Association; R = Rarely Appropriate.

JACC 2023;61:1318-68. ACCF/HRS/AHA/ASE/HFSA/SCAI/SCCT/SCMR

Cause that contribute to the degree of response to CRT

- Type of underlying heart ds(ischemic vs non-ischemic)
- Type of ventricular conduction disturbance(LBBB vs non-LBBB)
- Suboptimal pharmacological medical Tx.
- Presence of (supra)ventricular arrhythmias
- Position of LV lead
- Timing of RV and LV pacing/Atrioventricular interval

Am J Cardiol 2011;108:409-415

Optimization of CRT

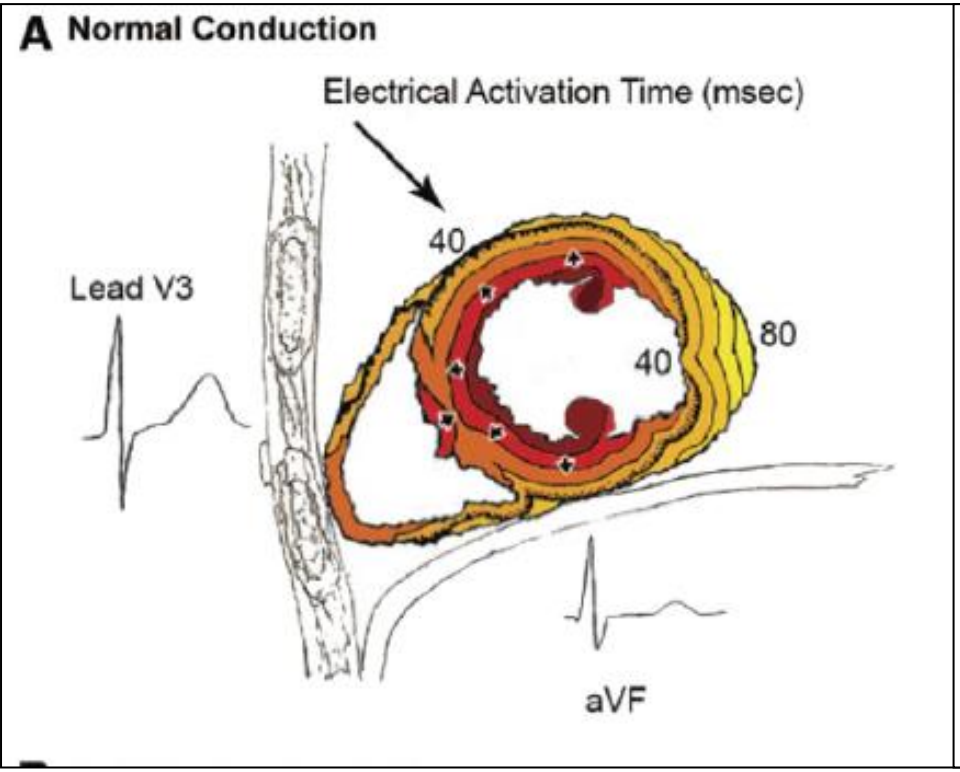
- How to achieve biventricular pacing as close to 100% as possible
- How to select the best LV lead position
- How to program the AV interval in order to achieve the max. contribution of LA contraction to LV filling
- How to eliminate the residual LV dyssynchrony through device VV interval optimization.

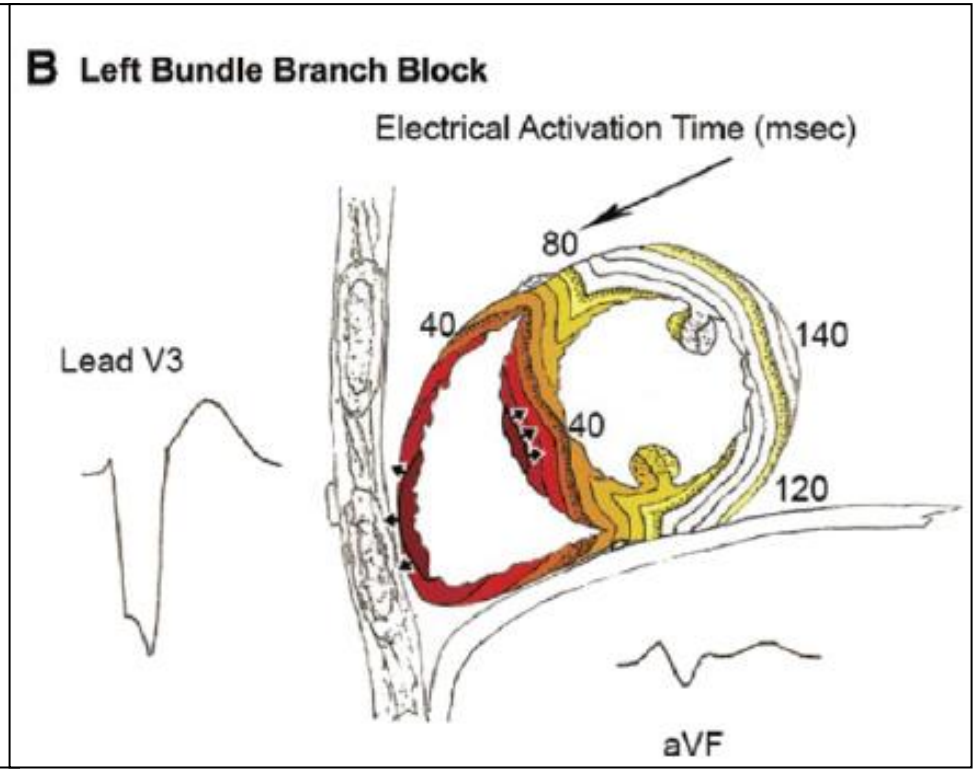
Strategy for using the standard 12-lead ECG for evaluation and improving application of CRT

- To assess the electrical substrate of a patient: presence of a **typical LBBB pattern** and **absence of scar**
- To assess the **QRS pattern** during LV pacing in order to judge its **proper position**
- For optimization of the programmed **AV delay** and **VV interval**

True LBBB

Normal Conduction vs LBBB





- During LBBB development

  1) QRS duration prolongs by more than 40ms

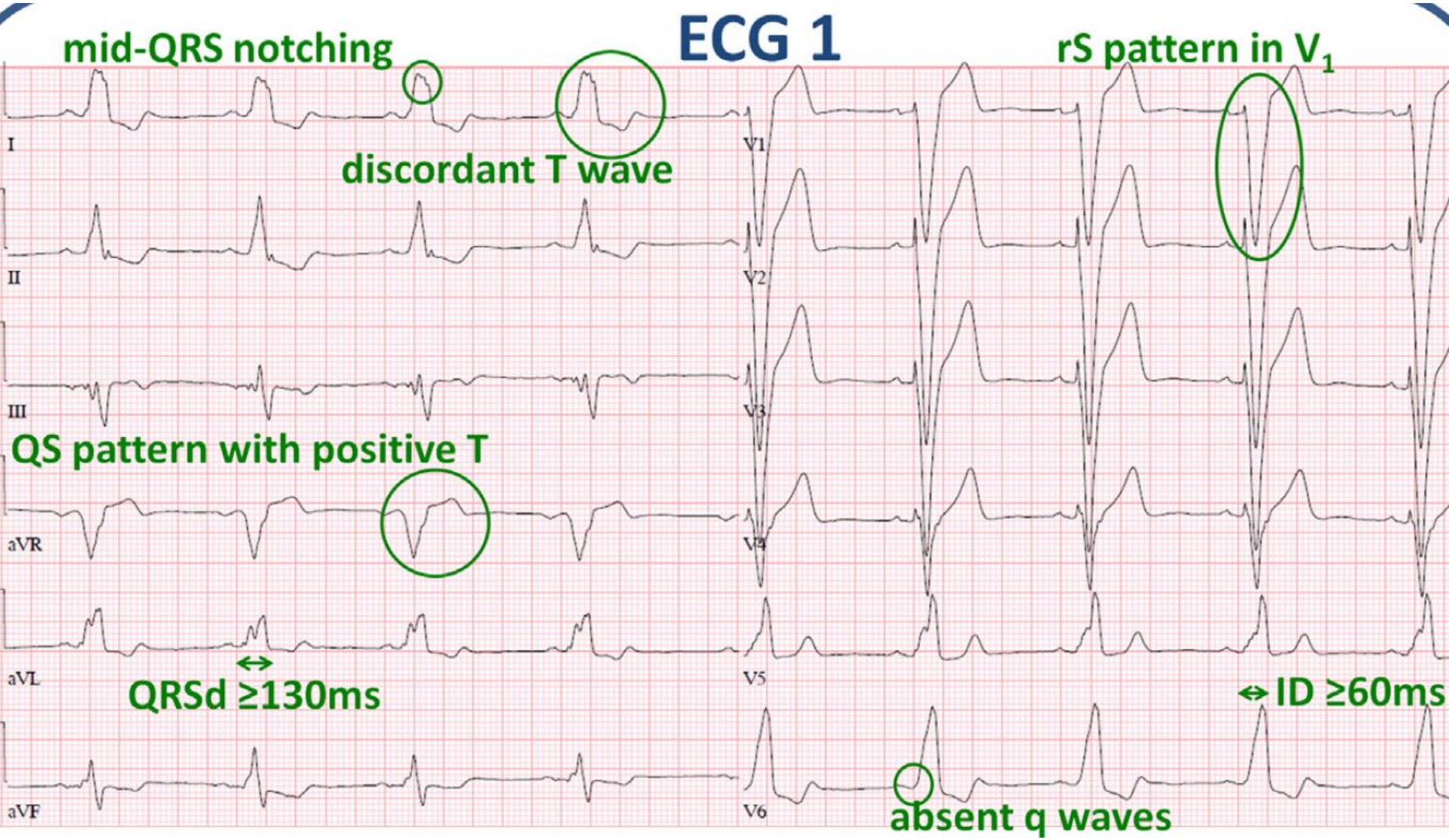
  2) Initial electrical force(QRS morphology) must change because of the different activation of septum

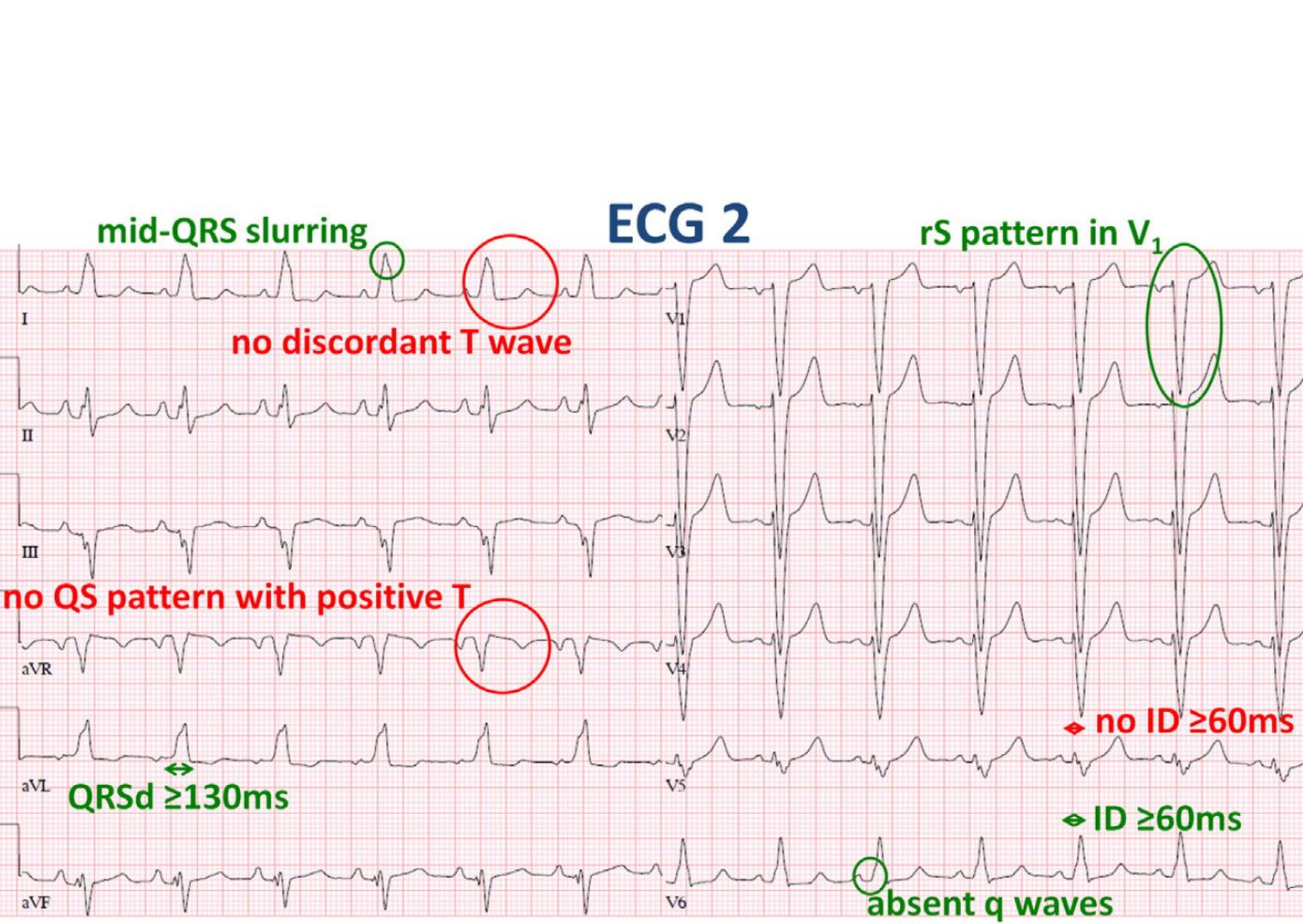
Criteria of LBBB

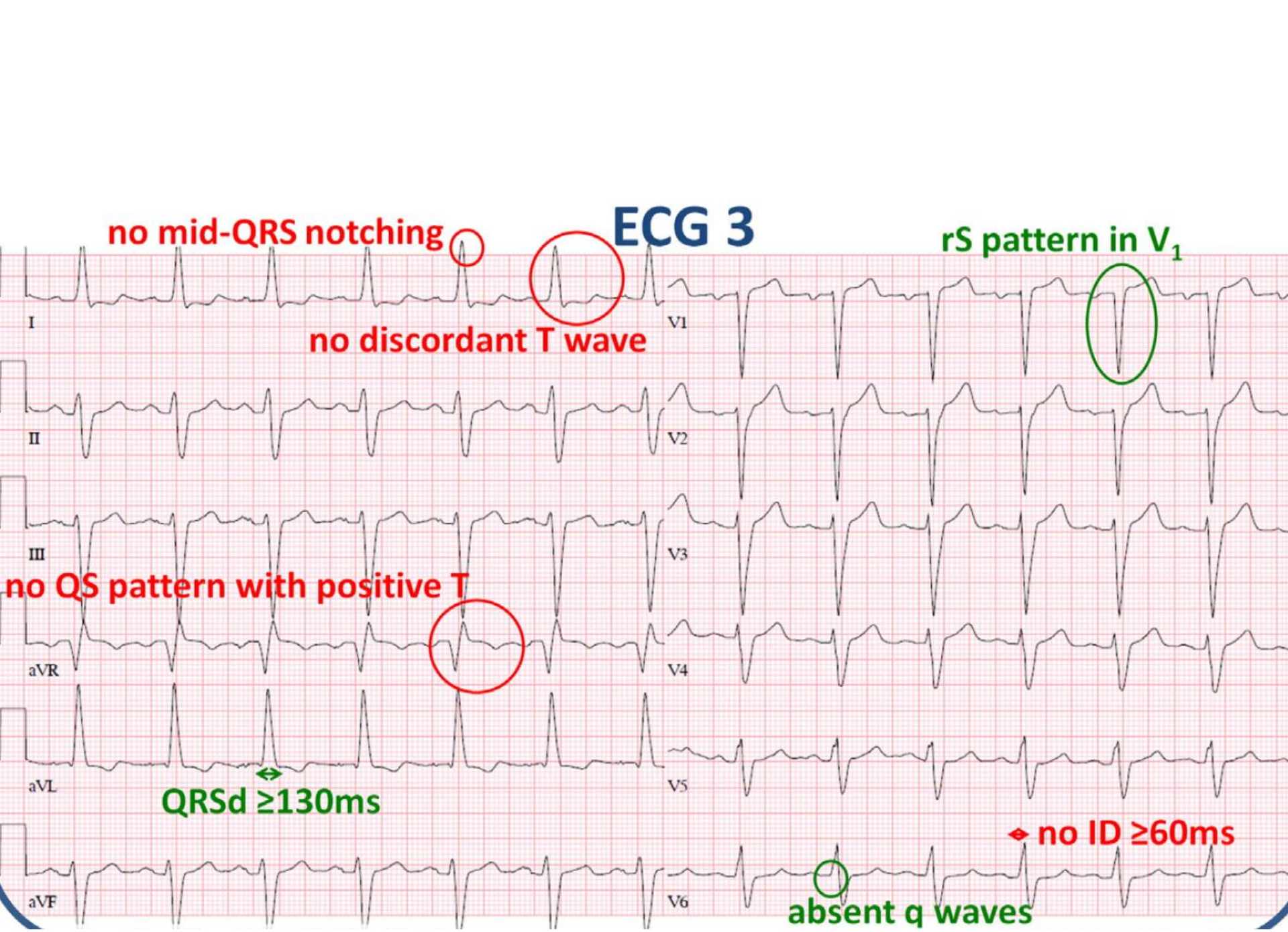
ECG parameters for complete LBBB according to guidelines of European Society of Cardiology (ESC) [11], American Heart Association (AHA)/American College of Cardiology Foundation (ACCF)/Heart Rhythm Society (HRS) [12], Strauss et al. [13], MADIT-CRT [14] and REVERSE [15] clinical CRT trials.

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 ≥60 ms	No	Yes	No	No	No
ID R in V_6 ≥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

ID : intrinsicoid deflection defined as time from start QRS to R peak


ECG 1
mid-QRS notching
discordant T wave
rS pattern in V1
QS pattern with positive T
QRSd ≥130ms
ID ≥60ms
absent q waves
I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6


ECG 2
mid-QRS slurring
no discordant T wave
rS pattern in V1
no QS pattern with positive T
no ID ≥60ms
QRSd ≥130ms
ID ≥60ms
absent q waves
I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6


ECG 3
no mid-QRS notching
no discordant T wave
rS pattern in V1
no QS pattern with positive T
QRSd ≥130ms
no ID ≥60ms
absent q waves
I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6

3D contact and Noncontact mapping of patients with LBBB by conventional ECG criteria

Location of LV Breakthrough Site	Site of Line of Block				Pathogenesis: DCM/CAD	QRS Duration		Time to LV Breakthrough		Time of Total LV Activation		Distance From LV Breakthrough Site to Line of Block
	None	Ant	Lat	Inf		Automatic, ms	Maximum, ms	NCM, ms	CM, ms	NCM, ms	CM, ms	NCM, mm
Anterior (n=2)			2		2/0	100±9	136±11	11±3	5±0	86±20	94±32	98±6
Septal (n=22)												
Basal (n=4)		1	2	1	2/2	149±20	168±24	16±25	13±18†	107±30	114±28	92±35†
Middle (n=4)	1	2		1	3/1	149±35	167±34	38±25	25±36	82±20	99±16	63±15
Apical (n=14)		9	4	1	10/4	168±17*	195±29*	59±25*	62±22*	101±20	106±17	63±10*
P					0.681	0.03	0.035	0.010	0.001	0.346	0.648	0.009

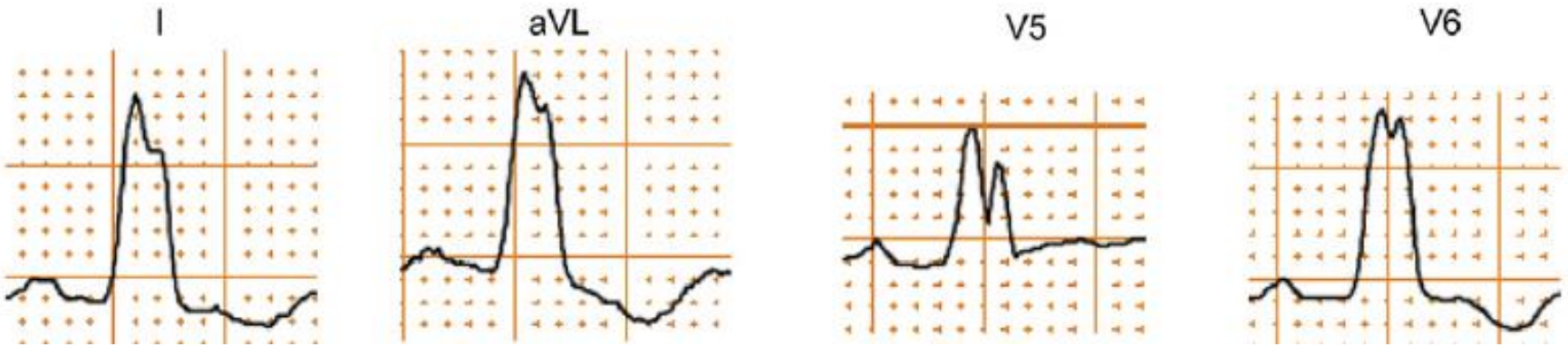
Ant indicates anterior; Lat, lateral; Inf, inferior; CAD, coronary artery disease; DCM, idiopathic dilated cardiomyopathy; CM, contact mapping; and NCM, noncontact mapping.

*Statistical difference between anterior and septal-apical at the level of significance $P<0.05$.

†Statistical difference between septal-basal and septal-apical at the level of significance $P<0.05$.

- 1/3rd of patients did not have significant delay between the start of activation of the RV endocardium and the start of activation of the LV endocardium

Circulation 2004;109:1133-1139



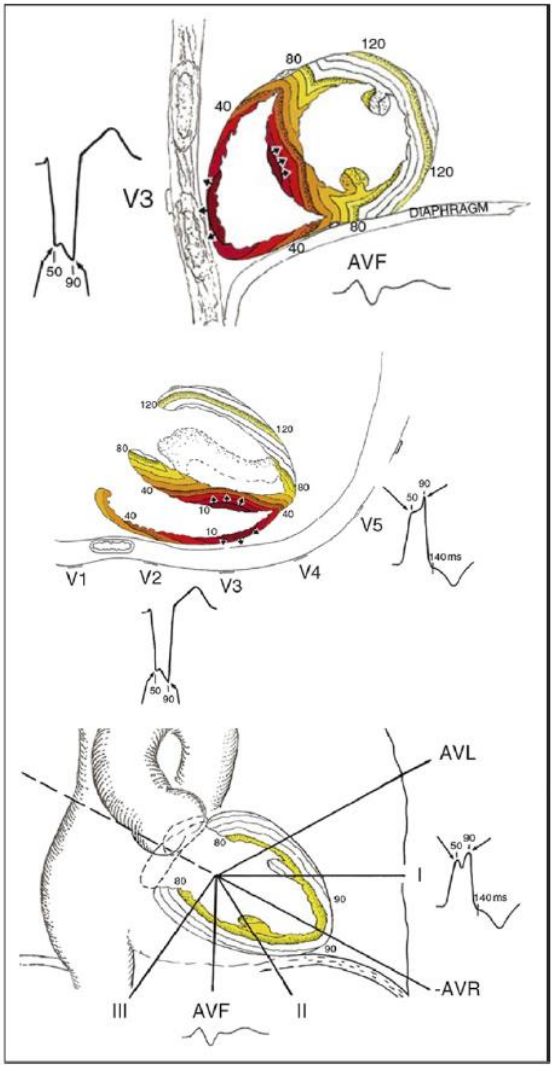
ECG parameters for complete LBBB according to guidelines of European Society of Cardiology (ESC) [11], American Heart Association (AHA)/American College of Cardiology Foundation (ACCF)/Heart Rhythm Society (HRS) [12], Strauss et al. [13], MADIT-CRT [14] and REVERSE [15] clinical CRT trials.

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 ≥60 ms	No	Yes	No	No	No
ID R in V_6 ≥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

ID : intrinsicoid deflection defined as time from start QRS to R peak

Notch at QRS

- First notch : time when the electrical depolarization wave front reaches the endocardium of the LV(after proceeding through the septum)
- Second notch : occur when the depolarization wave front begins to reach the epicardium of the posterolateral wall.
- These notches are best seen in lead I, aVL, V_1, V_2, V_5 and V_6



Am J Cardiol 2011;107:927-934

Diagnostic performance of different LBBB definition for prediction of CRT response(>15% reduction in end-systolic LV volume

LBBB definition	OR	95% CI	*P*-value	Sensitivity	Specificity
ESC guideline	3.225	1.285–8.095	0.011	64%	64%
AHA/ACCF/HRS guideline	3.700	1.386–9.871	0.007	55%	75%
Strauss et al.	11.813	3.359–41.544	<0.001	94%	43%
MADIT-CRT	3.556	0.741–17.069	0.095	96%	14%
REVERSE	3.900	0.625–24.746	0.124	97%	11%

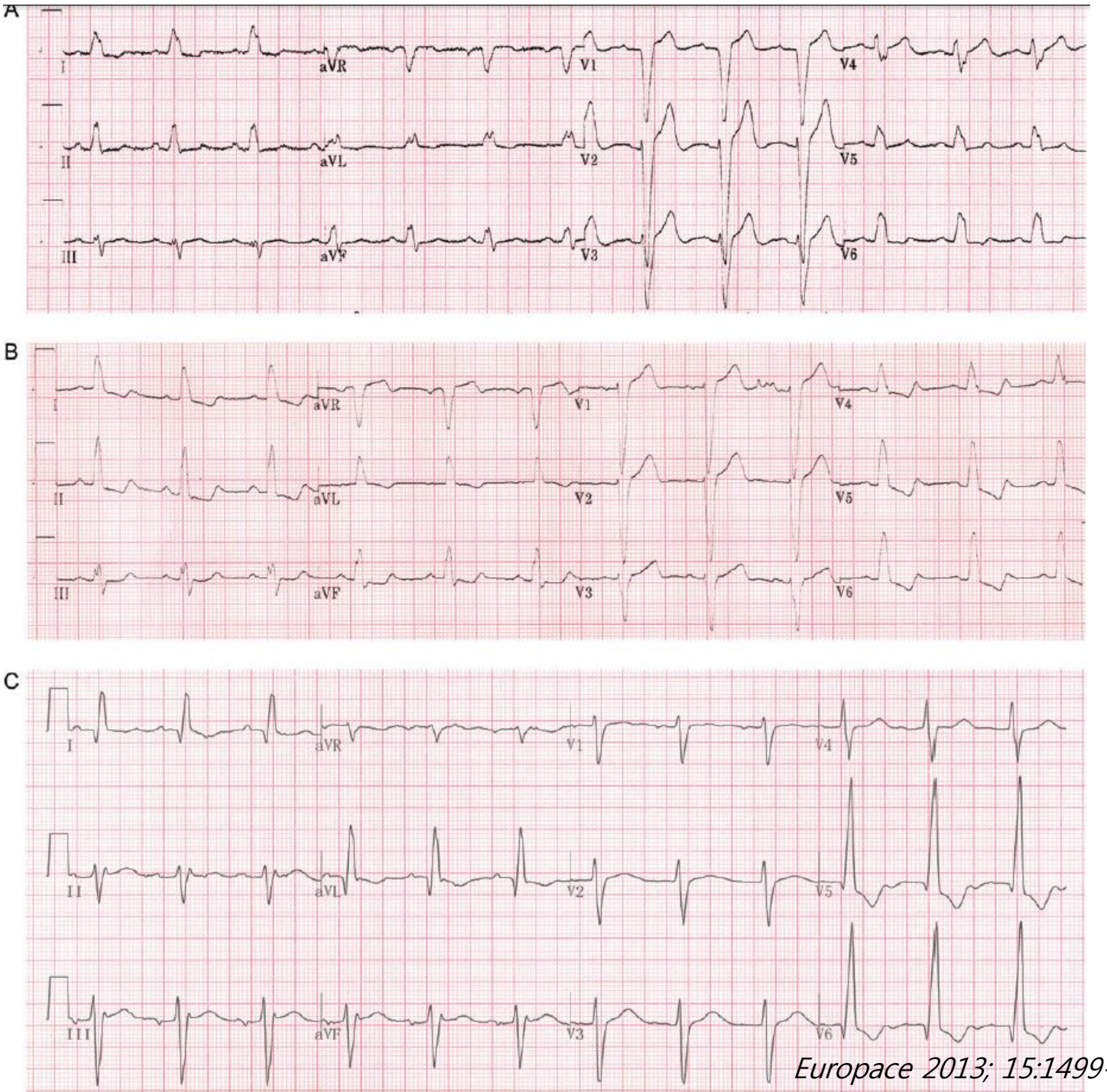
Presented are odds ratios (OR) with 95% confidence interval (CI) and, accordingly, *P*-values, sensitivity and specificity.

J of electrocardiography 2014

True LBBB

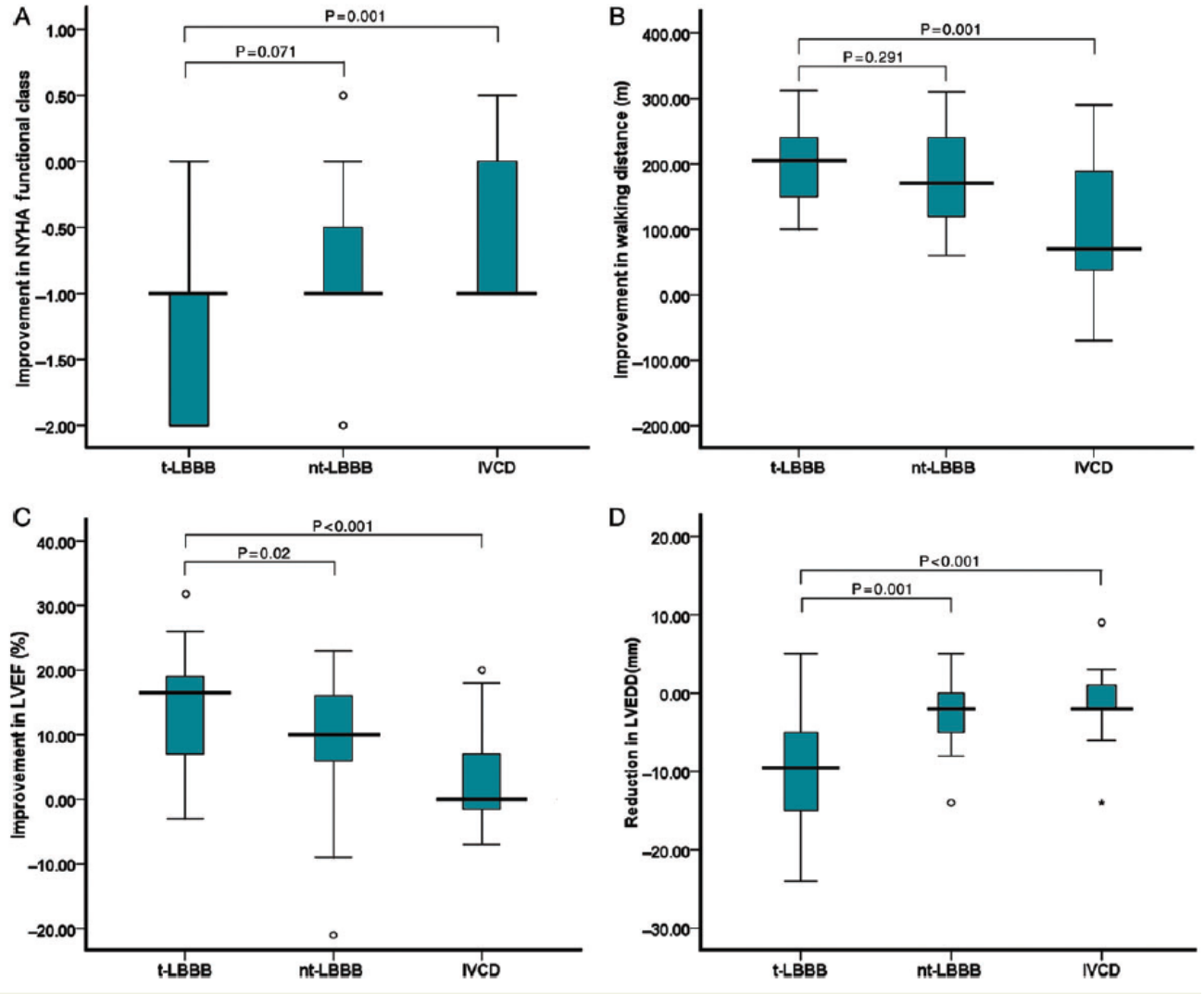
Non-true LBBB

IVCD



Europace 2013; 15:1499-1506

Clinical and Echocardiographic improvement 6 month after CRT



Europace 2013; 15:1499-1506

Difference in relevant characteristics of super-responder, responder, and non-responder

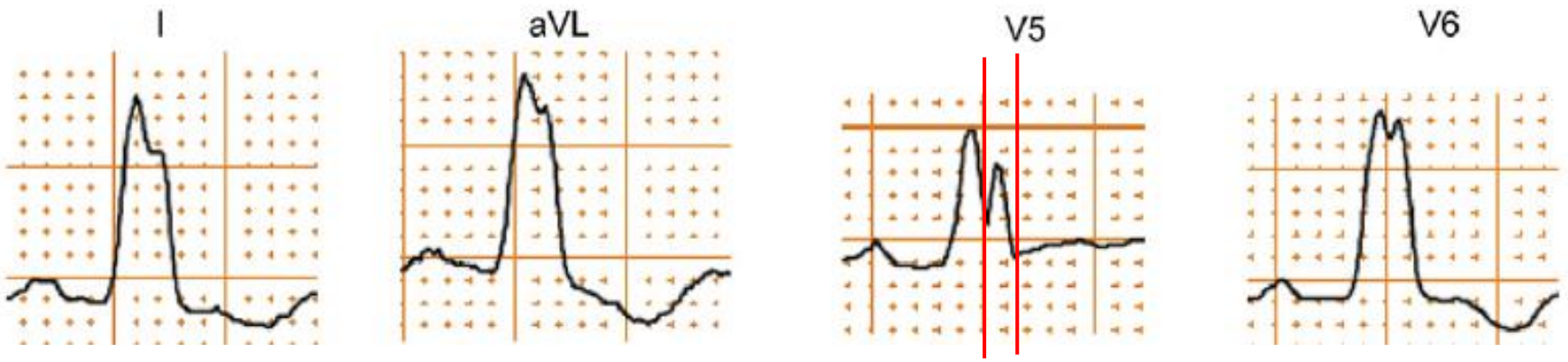
Variable	Super, $n = 10$	Responders, $n = 31$	Non-responders, $n = 17$
Gender (male)	7 (70.0%)	27 (87.1%)	16 (94.1%)
Age (years)	56.8 ± 13.3	61.0 ± 9.8	59.0 ± 14.1
HF duration (months)	21.1 ± 28.4	40.9 ± 32.9	56.5 ± 53.0
Non-ischaemic aetiology (*n*)	10 (100.0%)	23 (74.2%)	13 (76.5%)
NYHA class	2.9 ± 0.6	3.2 ± 0.5	3.5 ± 0.5
QRS duration pre-CRT (ms)	165.0 ± 17.2	161.0 ± 19.0	157.9 ± 15.3
QRS duration post-CRT (ms)	127.8 ± 29.1	132.5 ± 20.9	147.4 ± 22.9
QRS shortening after CRT (*n*)	10 (100.0%)	27 (79.4%)	12 (70.6%)
IVCD	1 (10%)	6 (22.6%)	12 (70.6%)
t-LBBB (n=22)	8 (80.0%)	14 (45.2%)	0 (0%)
LVEDD (mm)	68.2 ± 8.2	76.7 ± 10.4	76.3 ± 12.0
LVEF (%)	29.0 ± 5.3	26.5 ± 4.2	27.5 ± 7.8
MR (grade)	0.9 ± 0.6	1.7 ± 0.8	1.7 ± 0.8

Europace 2013; 15:1499-1506

Analysis of Ventricular Activation using ECG

LV activation time

- RVAT(RV activation time) :
- LVAT(LV activation time) :



Circulation 2010; 121:626-634. Sweeney et al

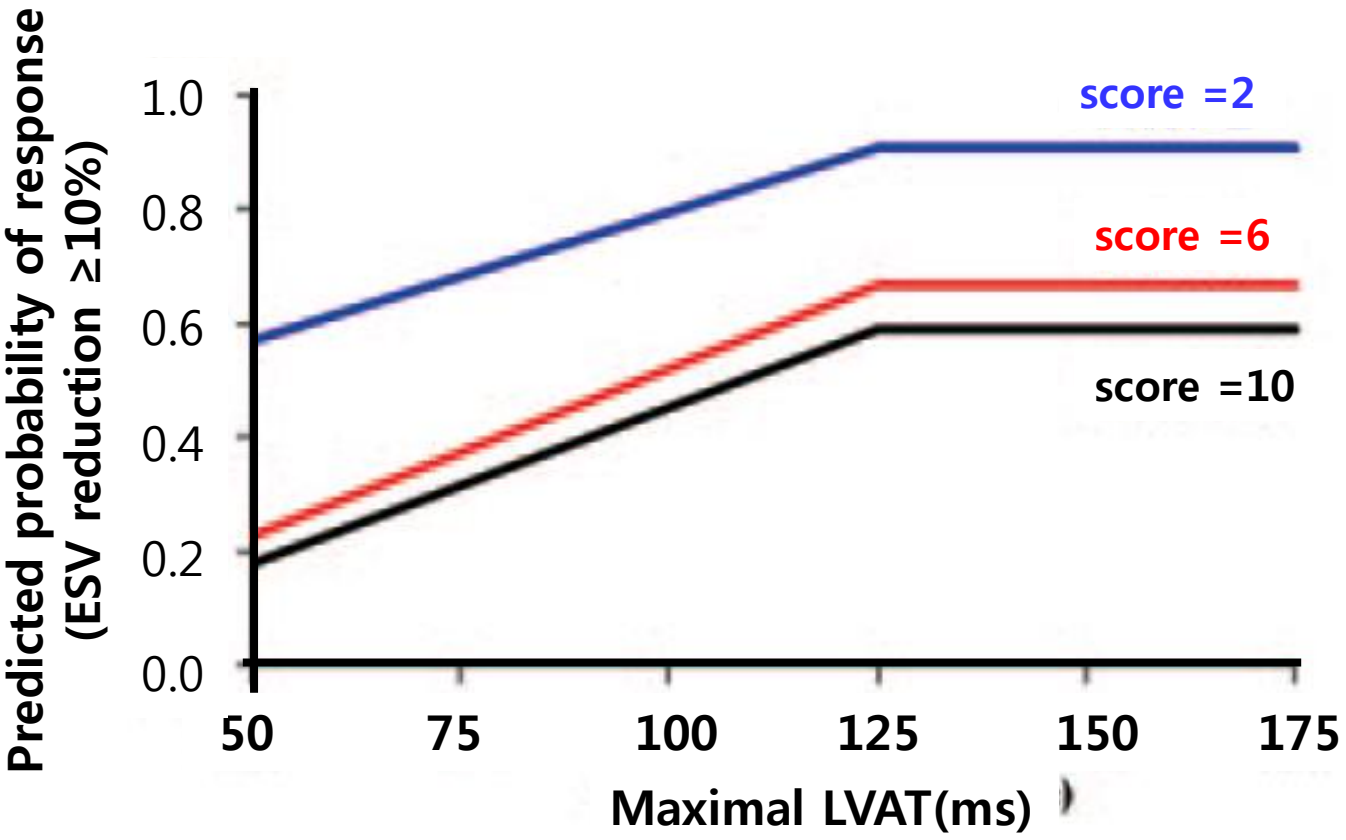
QRS Score for LV Scar

Points	Lead	Criterion
Inferior		
1	II	Q ≥30 ms
2		Q ≥40 ms
3	aVF	Q ≥30 ms
4		Q ≥40 ms
5		Q ≥50 ms
6		Q/R ≥0.5
7		Q/R ≥1
Anterior		
1	V_1	Any Q
2		S ≥1.8 mV
3	V_2	Any Q or R ≤0.1 mV or R ≤10 ms or $RV_2 \leq RV_1$
4	V_3	Any Q or R ≤0.2 mV or R ≤20 ms
5	V_4	Q ≥20 ms
6		Q/R ≥1 or R ≤0.7 mV or R/S ≤1 or notched R
7		Q/R ≥2 or R/S ≤0.5
Anterolateral		
1	I	Q ≥30 ms
2		Q/R ≥1 or R ≤0.2
3	aVL	Q ≥30 ms
4		Q/R ≥1
Apical		
1	V_5	Q ≥30 ms
2		Q/R ≥0.5 or R ≤0.7 mV or R/S ≤2 or notched R
3		Q/R ≥1 or R/S ≤1
4	V_6	Q ≥30 ms
5		Q/R ≥1/3 or R ≤0.6 mV or R/S ≤3 or notched R
6		Q/R ≥1 or R/S ≤1
Posterolateral		
1	V_1	R/S ≥1
2		R ≥0.6 mV or R ≥40 ms
3		R ≥1 mV or R ≥50 ms
4		S ≤0.3 mV
5	V_2	R ≥1.5 mV or R ≥50 ms
6		R ≥2 mV or R ≥60 ms
7		R/S ≥1.5
8		S ≤0.4 mV

One point is awarded for each criterion met. Notched R indicates a notch that begins within the 1st 40 ms; Q = Q wave; Q/R = ratio of Q wave to R wave; R = R wave; R/S = ratio of R wave to S wave; $RV_2 < RV_1$ = R wave in lead V2 less than or equal to R wave in lead V_1; S = S wave.

Circulation 2010; 121:626-634. Sweeney et al

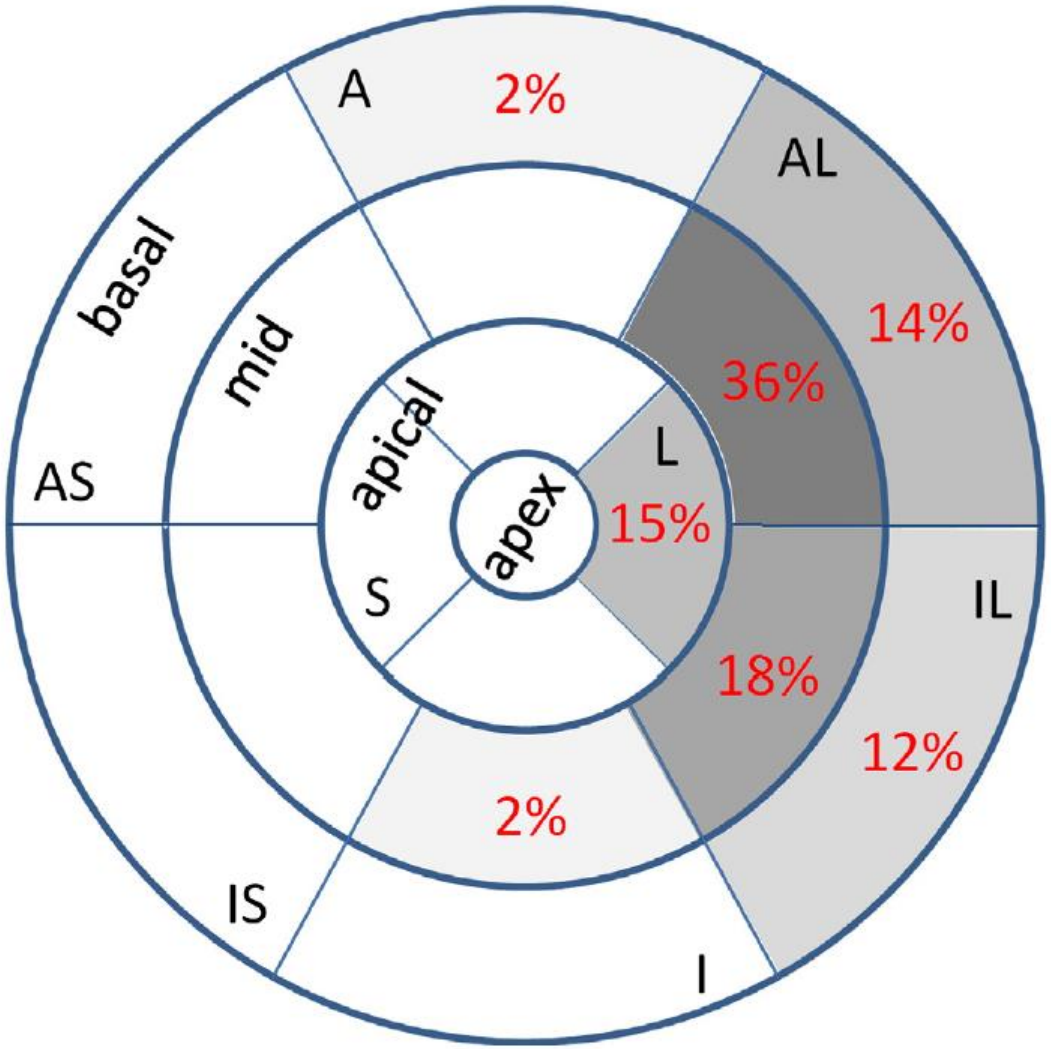
Probability of reverse remodeling by baseline QRS score and $LVAT_{max}$



Circulation 2010; 121:626-634. Sweeney et al

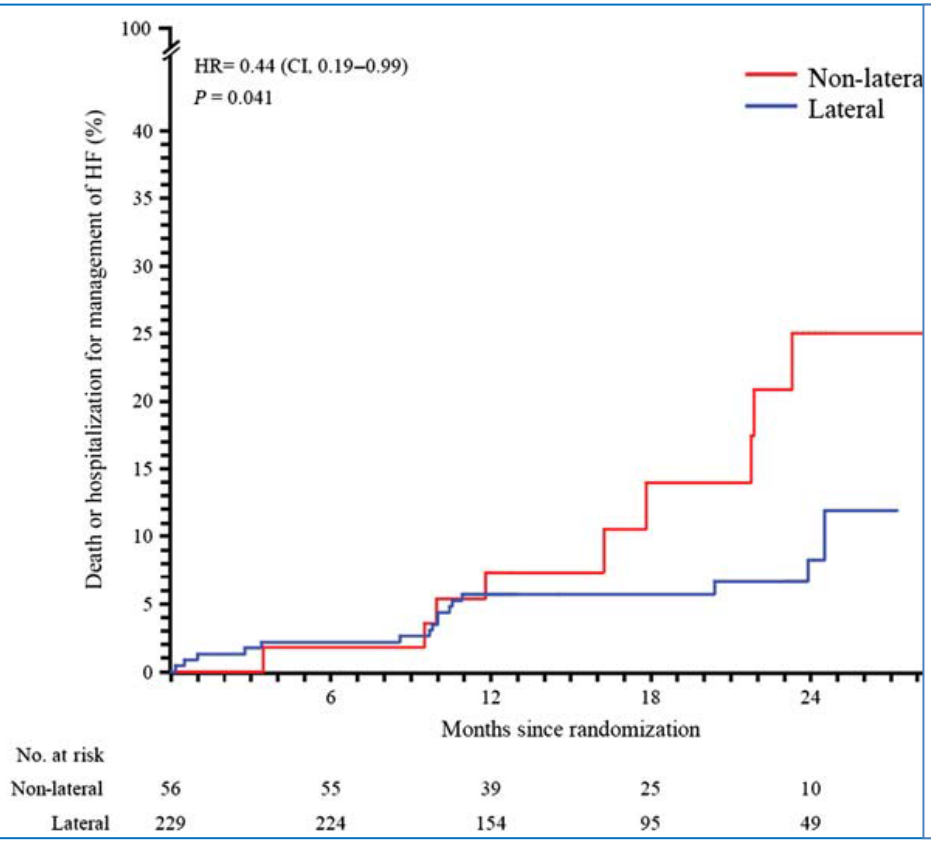
Concept of identification of the LV Lead position by LV-paced QRS morphology

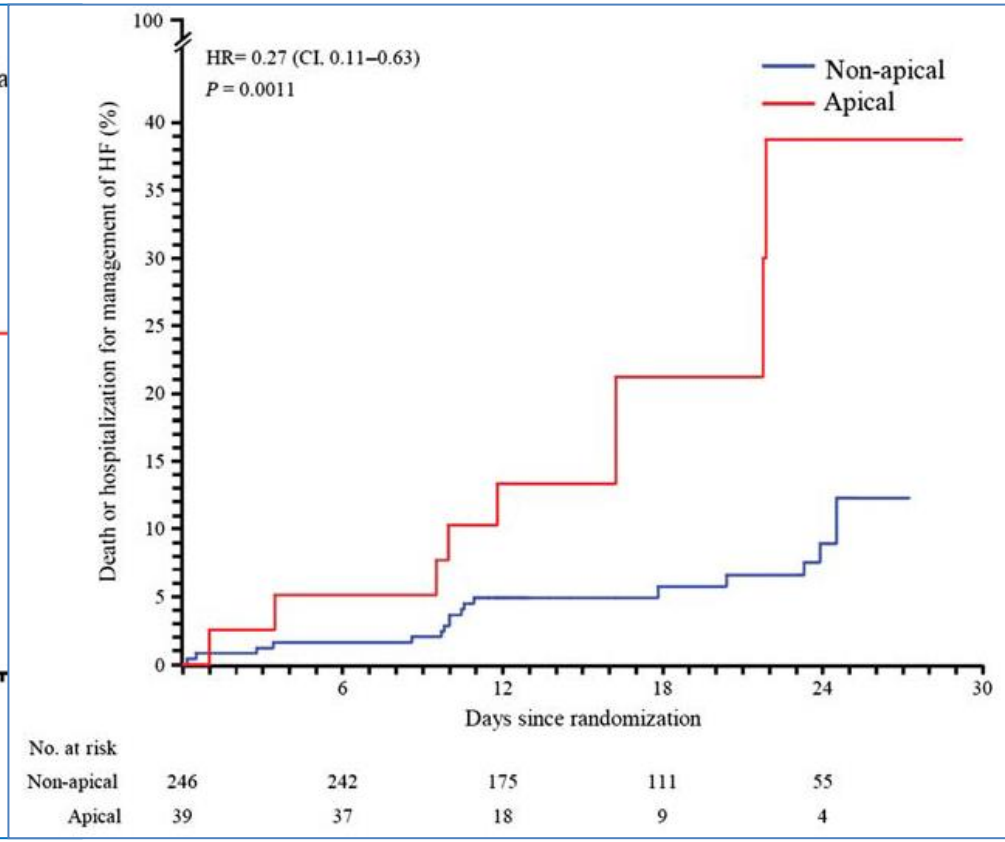
Distribution of LV lead positions in 98 consecutive CRT patient by AHA standarized 17-segment Model



Int J Cardiovasc Imaging 2002; 18:539-542

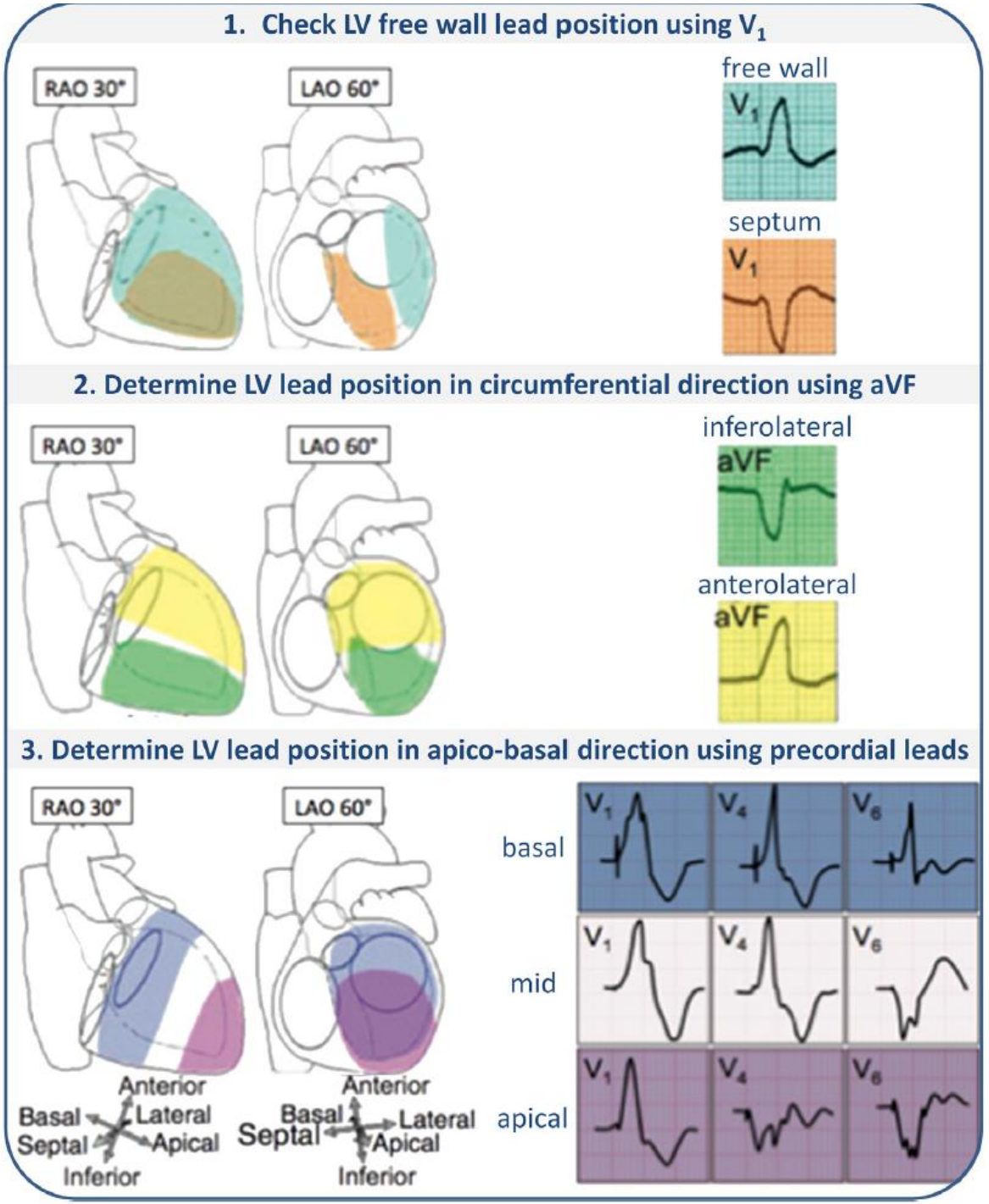
Site of left lead vs response to CRT





Eur Heart J 2012;33: 2662-2671

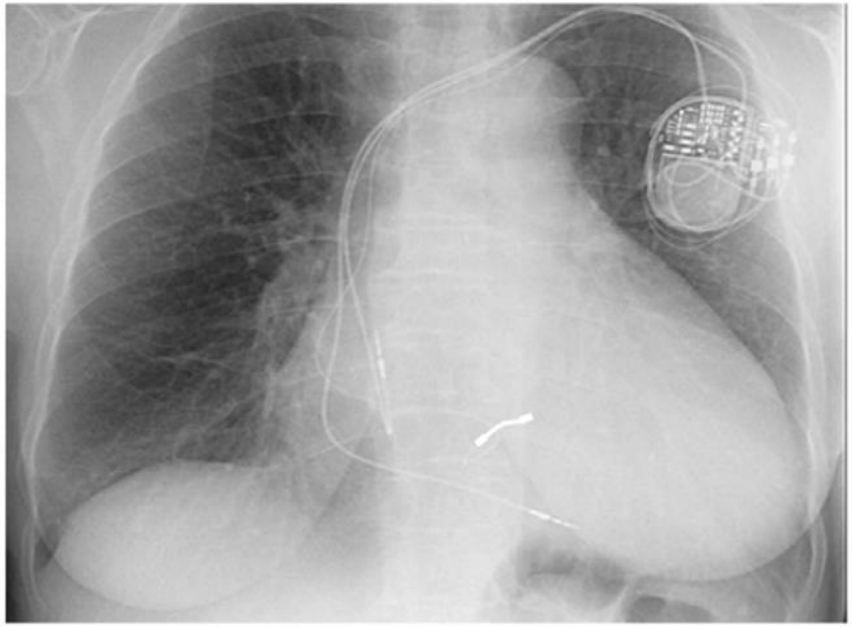
LV Pacing



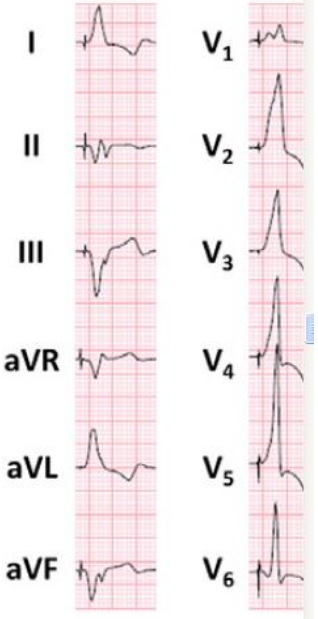
Rev Esp Cardiol 2012; 65:939-955

Radiograph and ECG -basal inferolateral

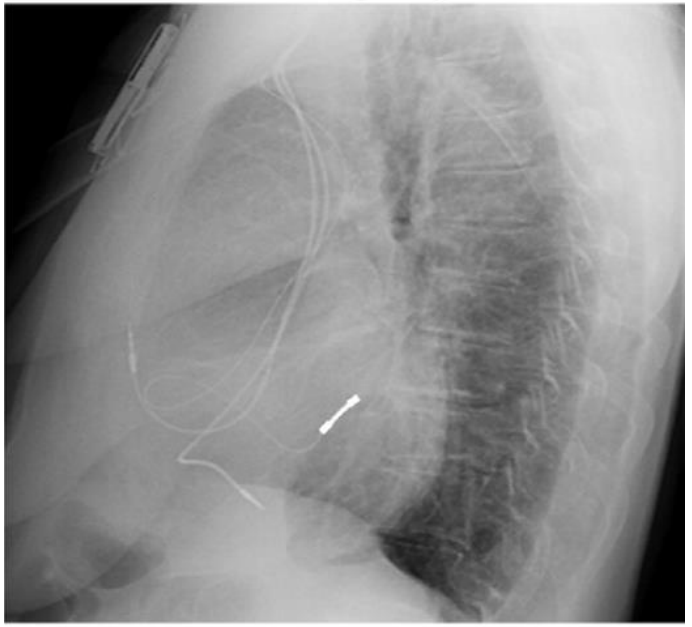
Antero-posterior chest radiograph



LV paced 1 lead ECG

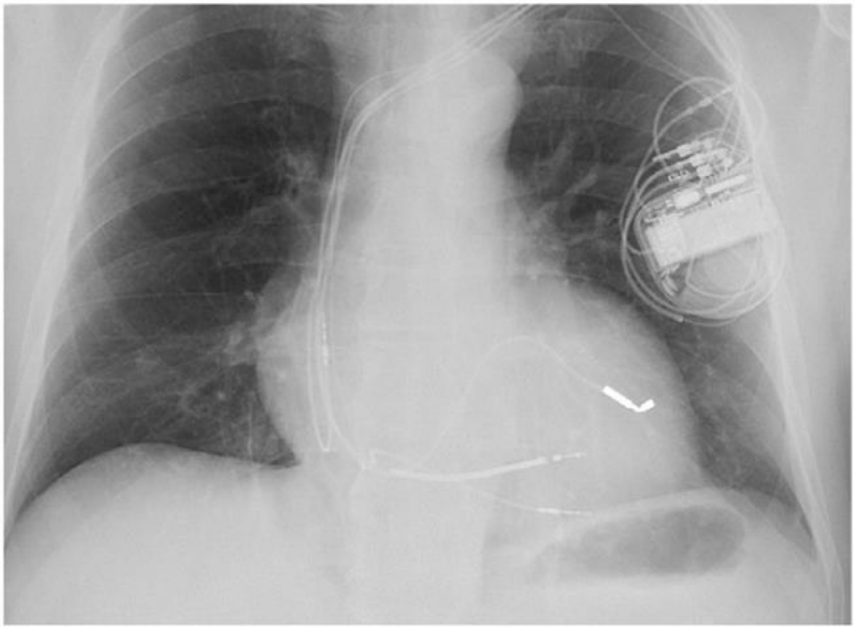


Lateral chest radiograph

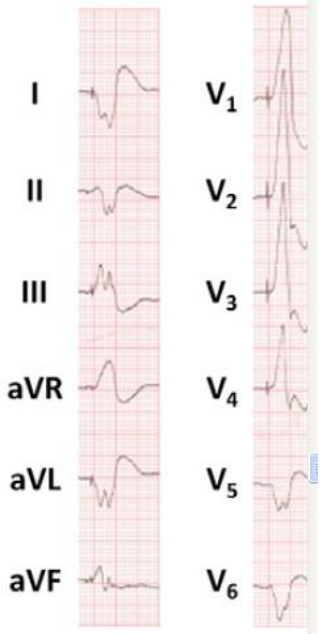


Radiograph and ECG -mid anterolateral

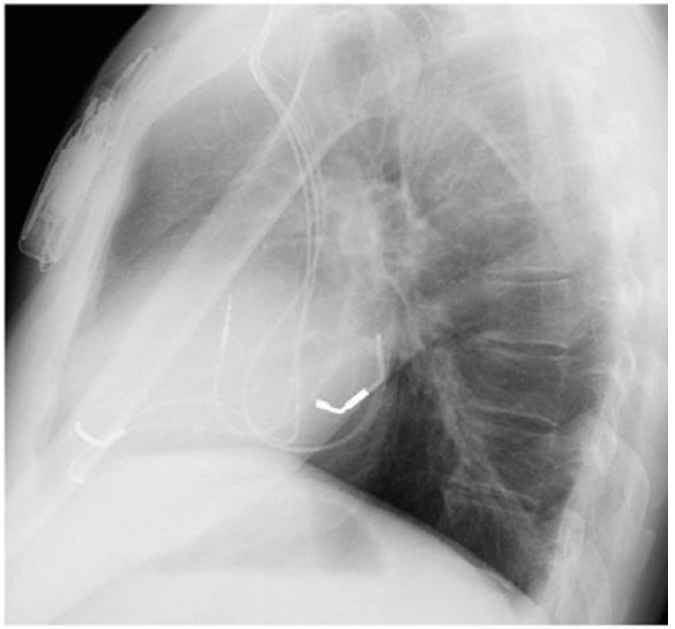
Antero-posterior chest radiograph



LV paced 12-lead ECG

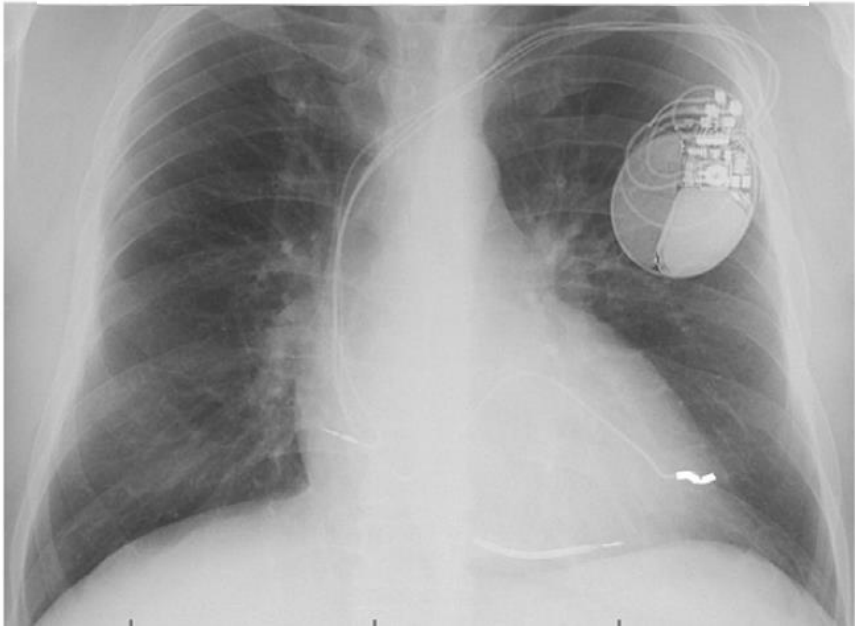


Lateral chest radiograph

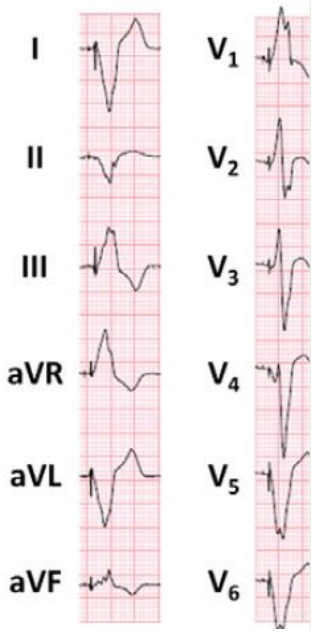


Radiograph and ECG -apical lateral

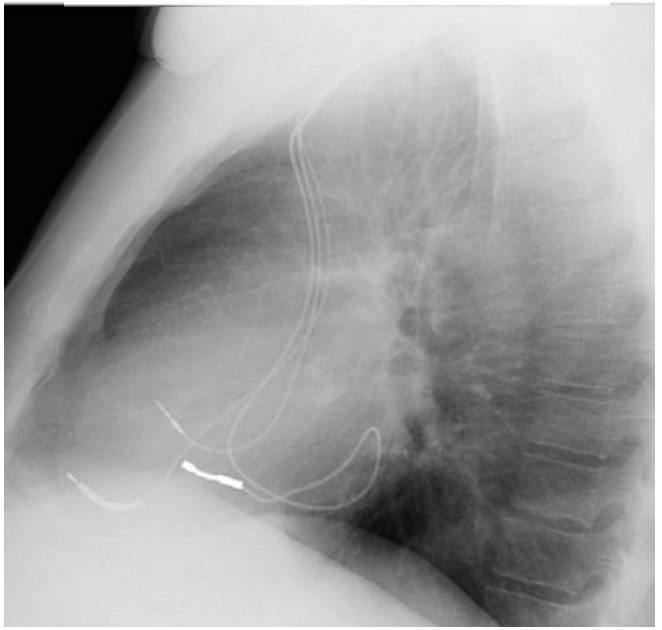
Antero-posterior chest radiograph



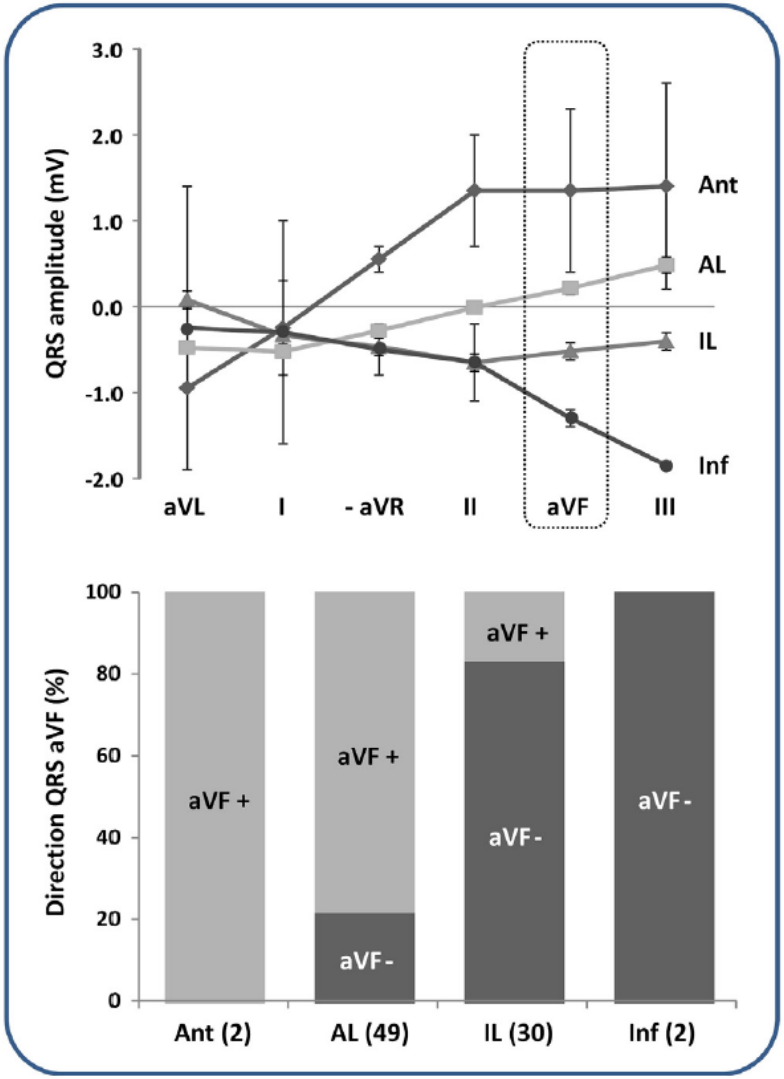
LV paced 12-lead ECG

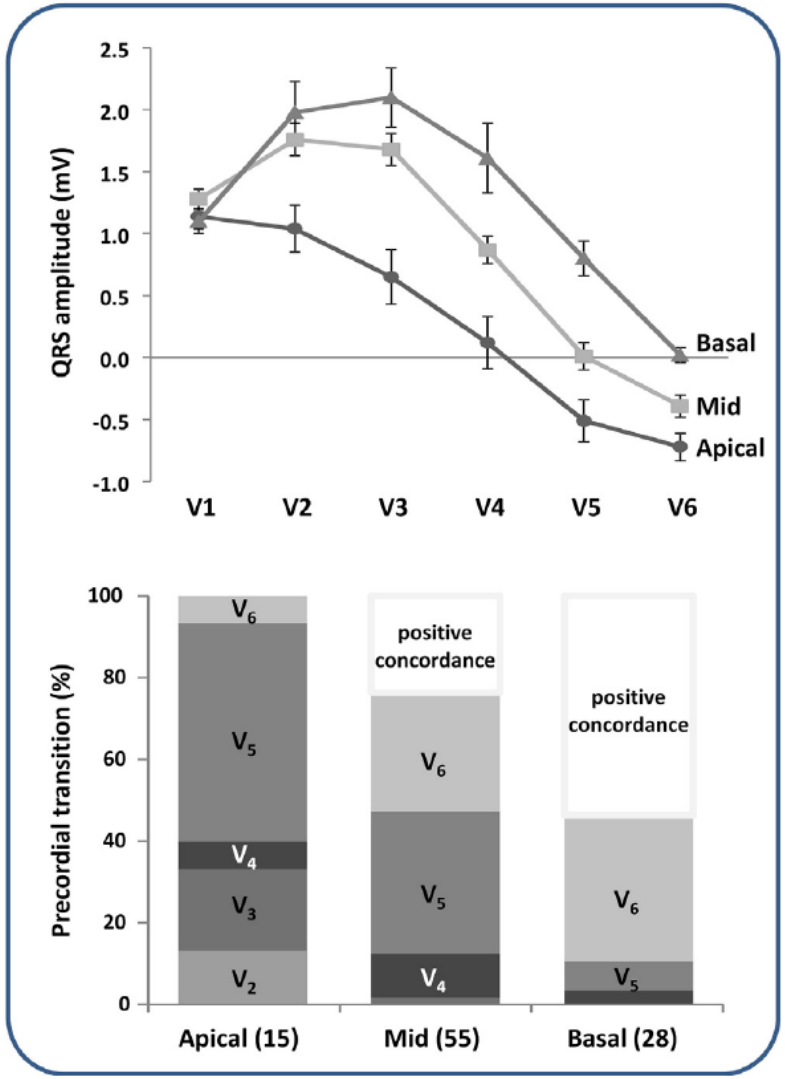


Lateral chest radiograph



Evaluation of the concept of ECG-based estimation of LV lead position

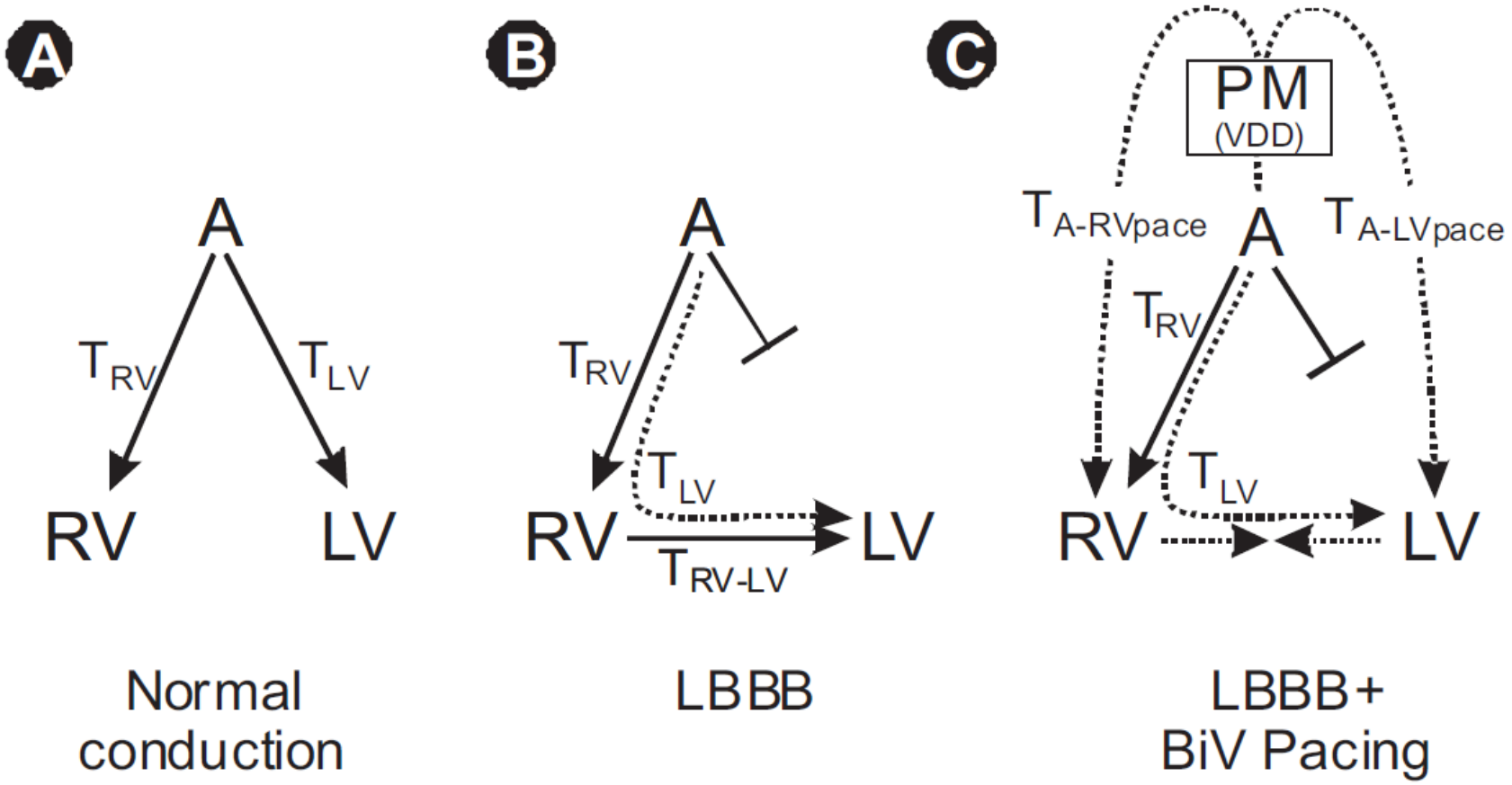




- Both avoidance of fractionation and large QRS width can be indirect tools to prevent LV pacing in a region of poor conduction due to scar or fibrosis

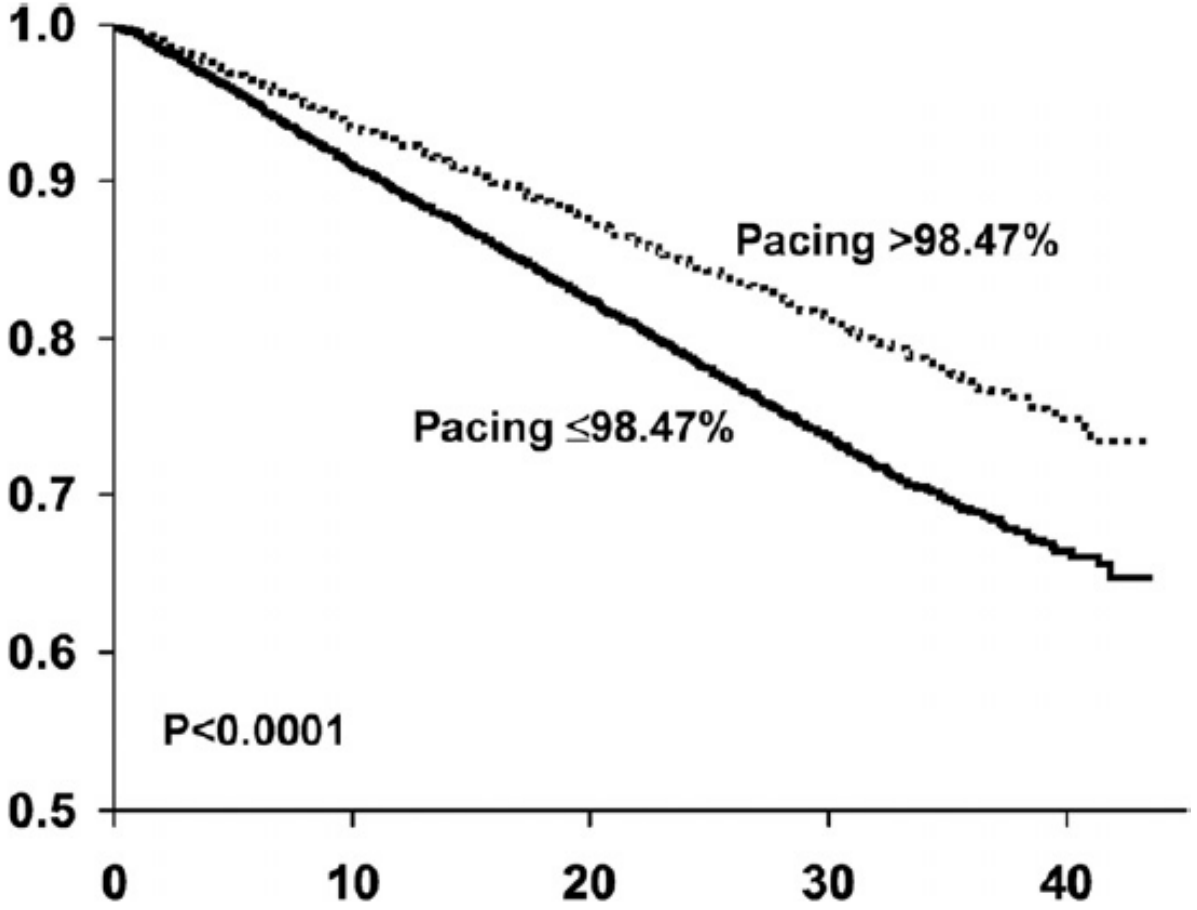
AV-delay optimization using the biventricular-paced ECG

Concept of CRT



Heart Rhythm 2007; 4:75-82

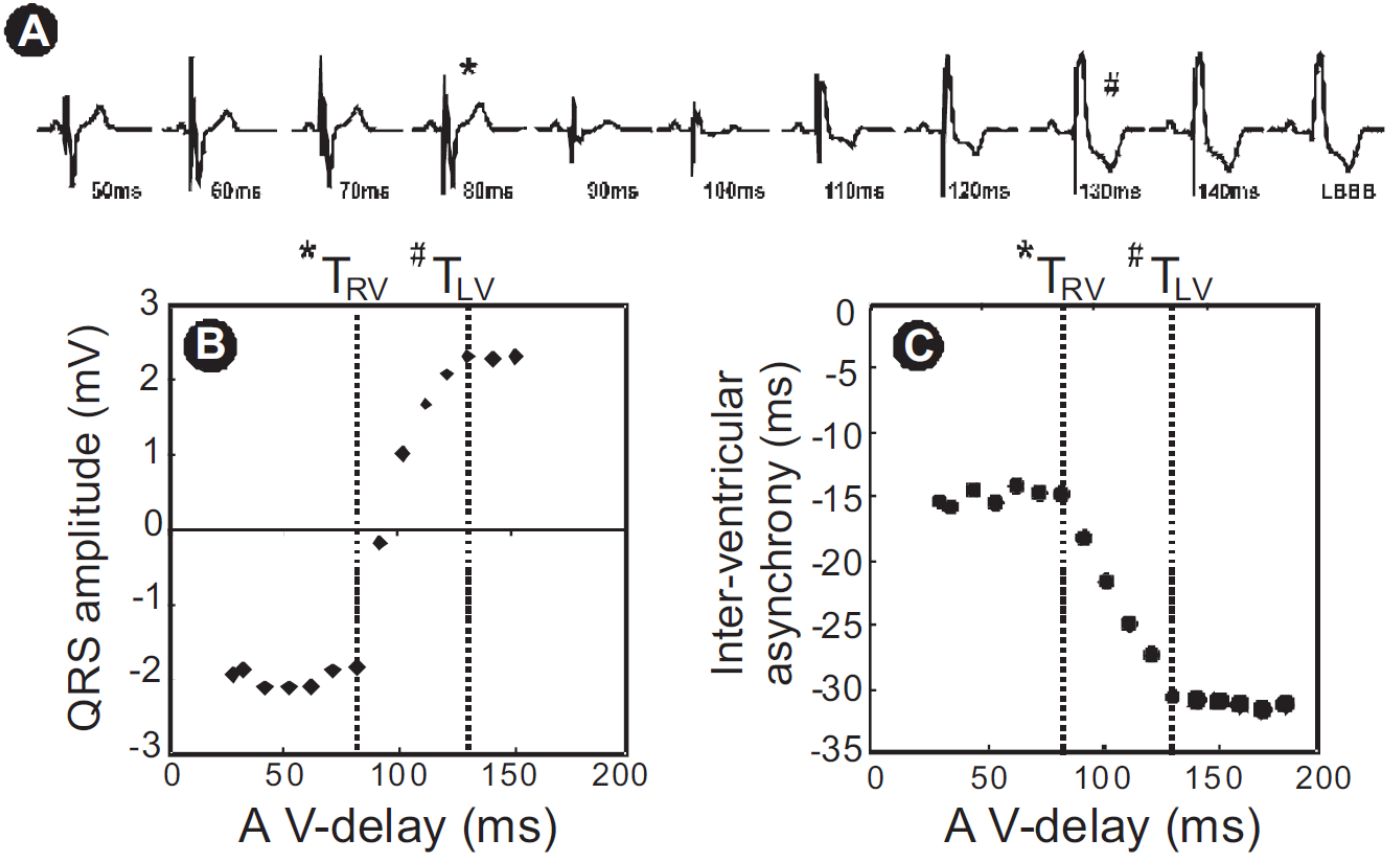
Survival vs Pacing rate



Heart rhythm 2011;8: 1469-1475

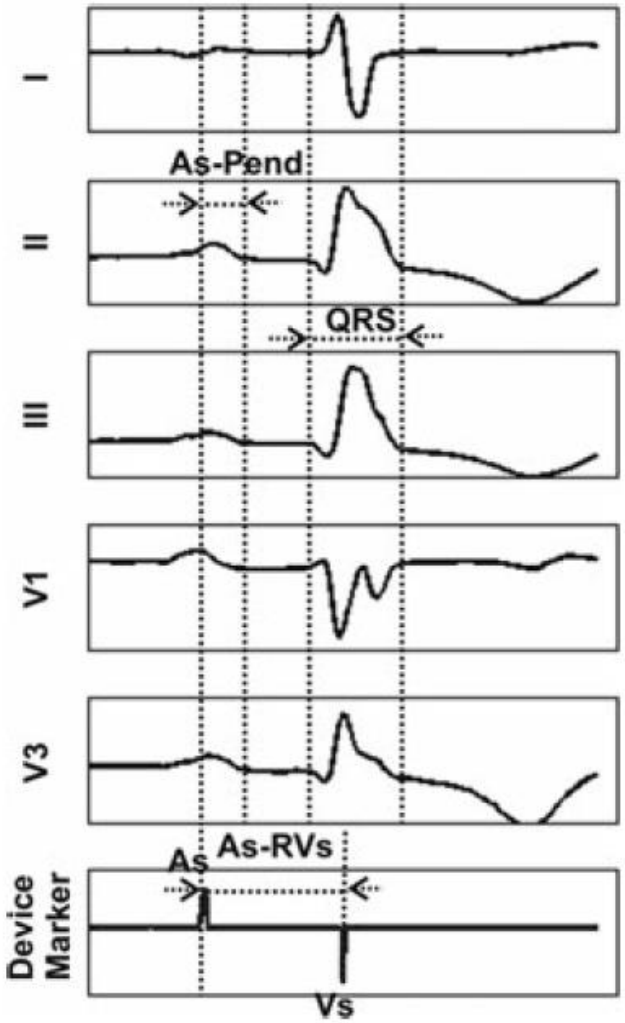
Identification method of the onset of intrinsic ventricular activation

The AV delay before the change in QRS morphology (**asterix**) indicates the time of onset of intrinsic ventricular activation during stepwise increasing the AV delay with simultaneous BiV pacing



Heart Rhythm 2007; 4:75-82

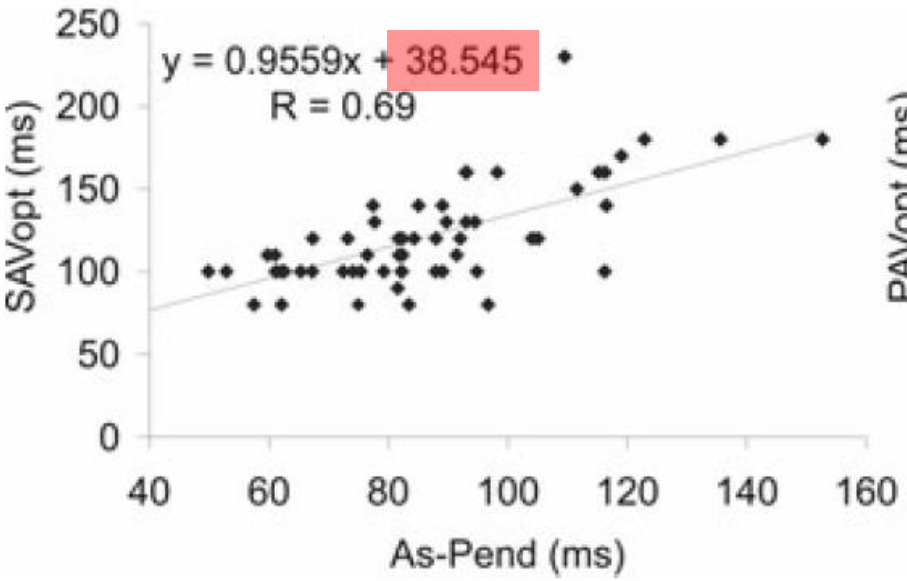
Correlation between the Echo-optimal SAV and PAV delays and electrocardiographic parameters

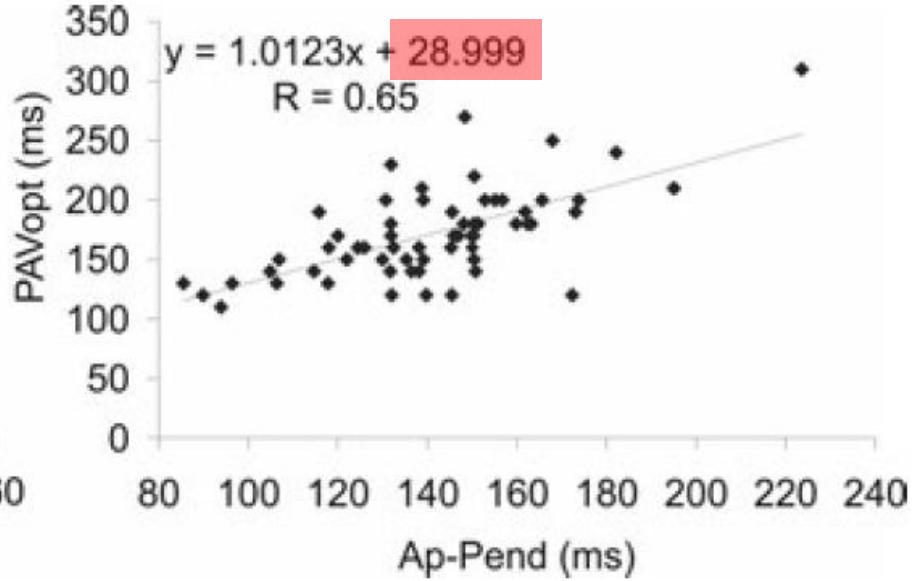


		Correlation with SAVopt	
Parameter	**Mean ± SD**	**Correlation Coefficient (R)**	**P**
As-Pend, ms	86 ± 22	0.69	<0.0001
As-RVs, ms	215 ± 58	0.45	0.0003
QRS, ms	154 ± 30	0.24	0.014
		Correlation with PAVopt	
Parameter	**Mean ± SD**	**Correlation Coefficient (R)**	**P**
Ap-Pend, ms	141 ± 25	0.65	<0.0001
Ap-RVs, ms	278 ± 63	0.60	<0.0001
QRS, ms	155 ± 29	0.20	0.038

J Cardiovasc Electrophysiol 2010; 21:1226-1232

Simple method of providing 30-40ms separation between the end of the P-wave and Ventricular pacing pulse for optimal AV delay





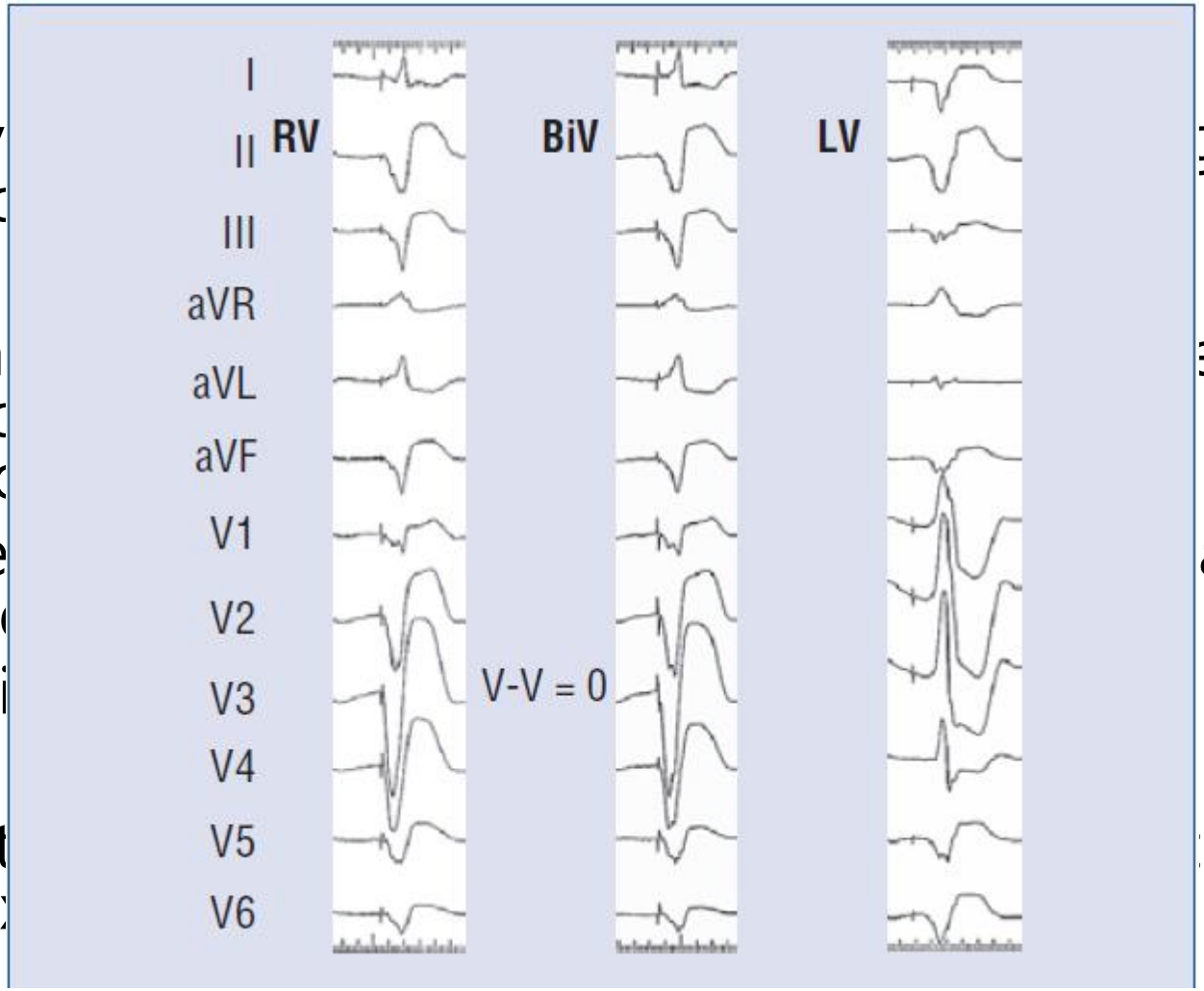
- SAV_{ECG}=min { As-Pend+40ms, As-RVs-50ms }
- PAV_{ECG}=min { Ap-Pend+30ms, Ap-RVs-50ms }

J Cardiovasc Electrophysiol 2010; 21:1226-1232

VV-interval optimization using the biventricular-paced ECG

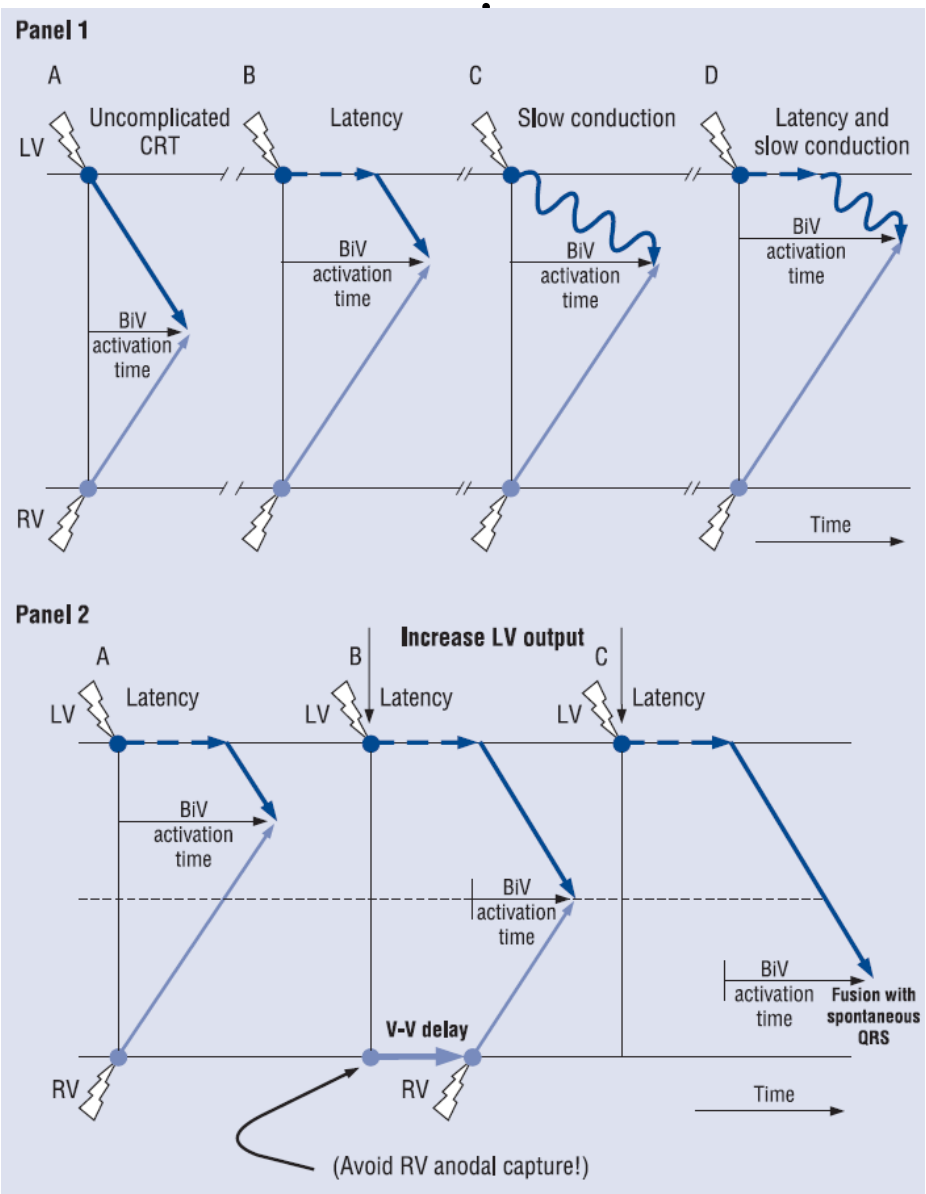
Simultaneous BiV pacing don't always result in best synchronization

- Delay
  laten
- LV pa
  laten
  QRS
  - slowe
    to en
  - high
- So, it
  pre-e



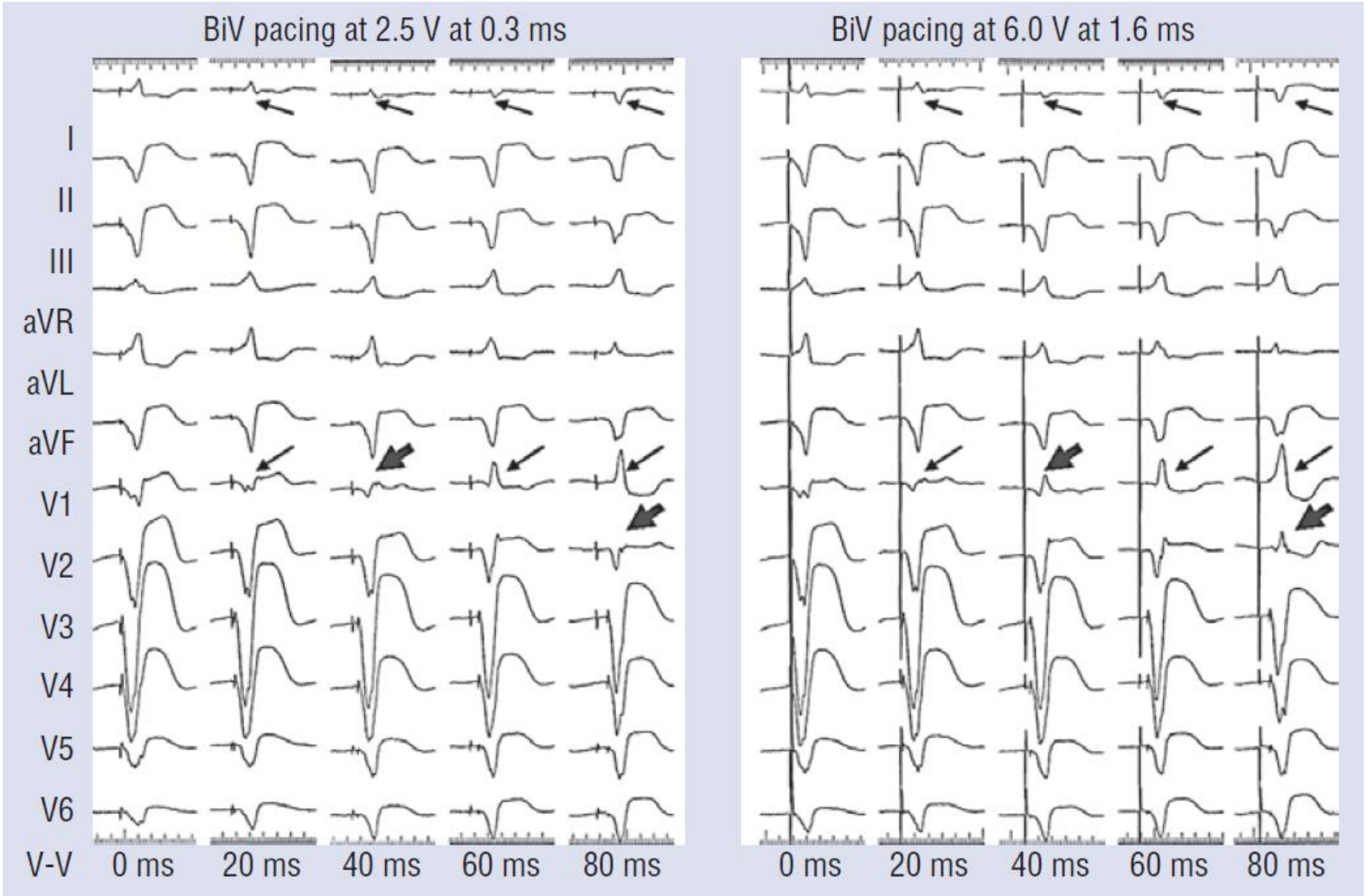
Pacing Clin Electrophysiol 2010; 33:1382-1391

Diagrammatic representation of the significance of LV latency and slow conduction during Bi-V



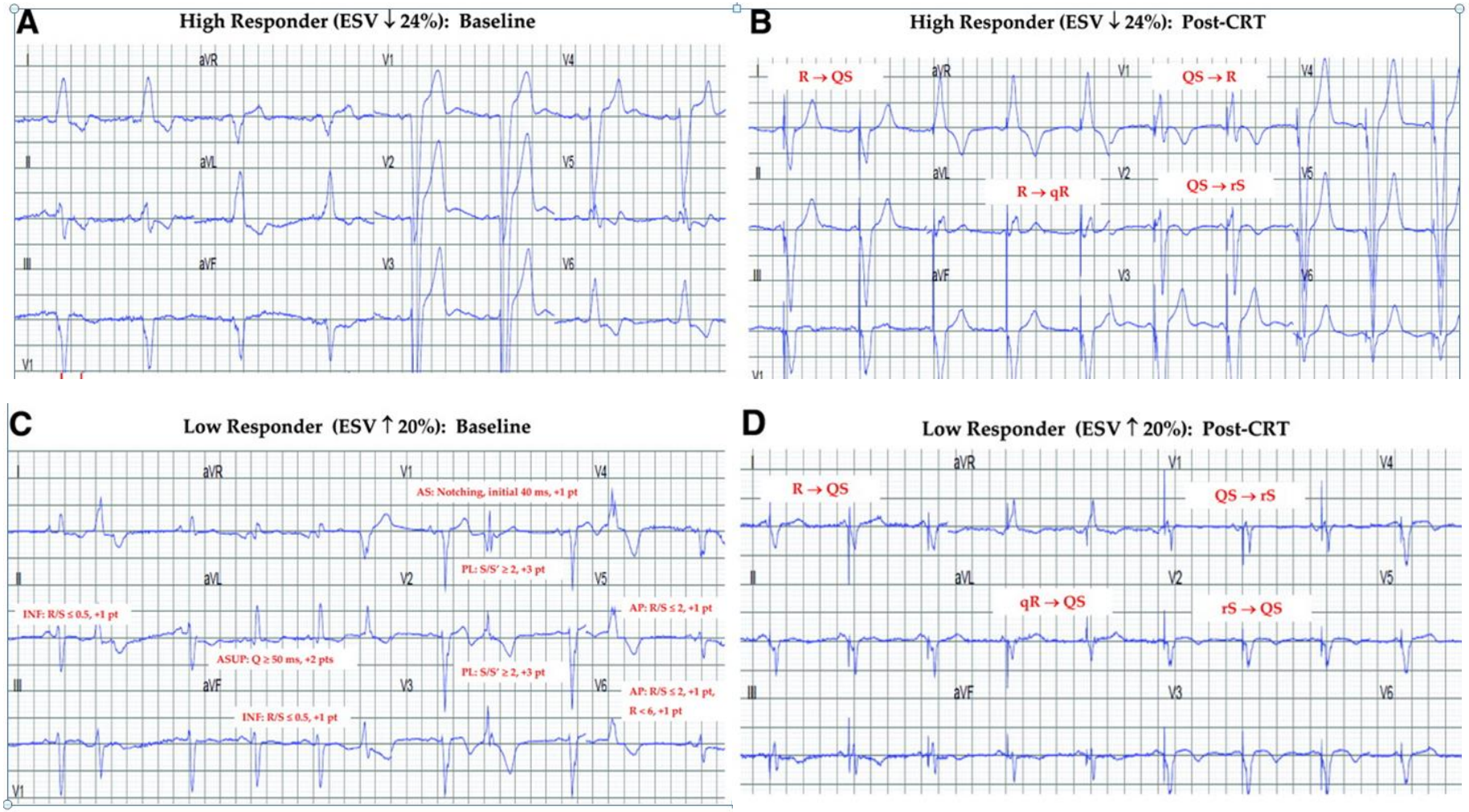
Cardiol J 2011; 18:610-624

Impact of progressive LV pre-excitation during Bi-V pacing



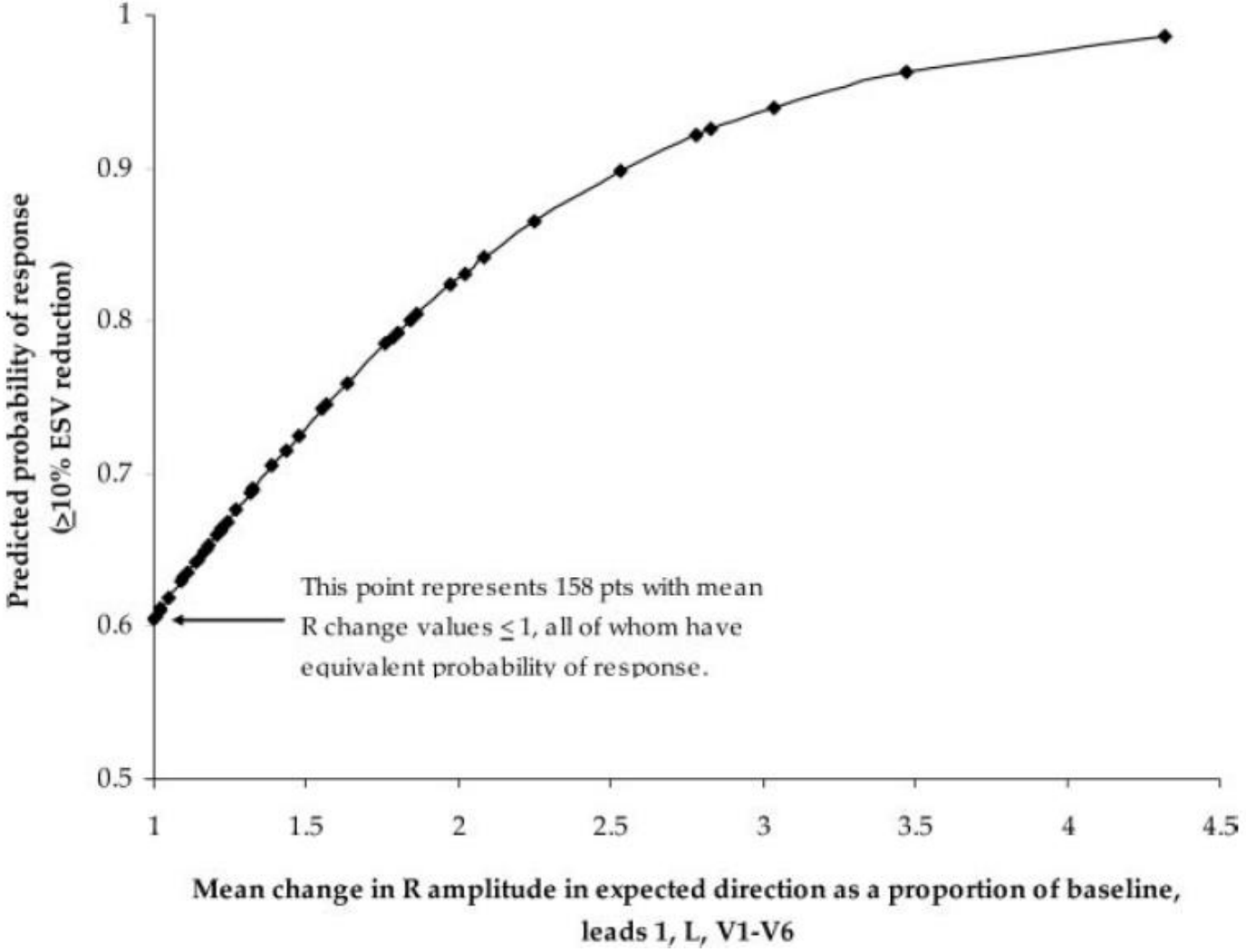
Cardiol J 2011; 18:610-624

I. Best predictor was an increase in R-wave amplitude in V_1 and V_2



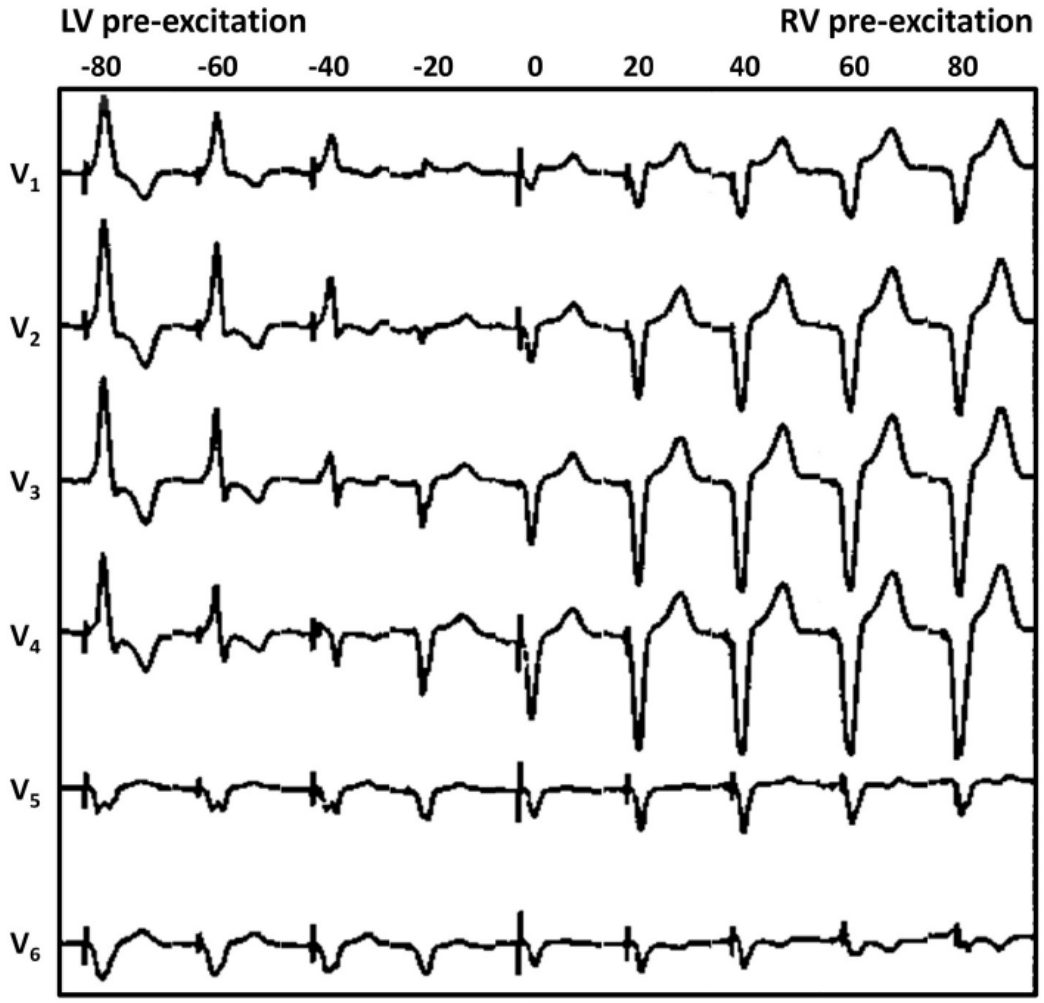
Circulation 2010; 121:626-634. Sweeney et al

Greater changes in R-wave amplitudes after CRT, indicative of wavefront fusion, predict higher probability of response



Circulation 2010; 121:626-634

II. QRS pattern during BiV pacing at various VV intervals – QRS vector

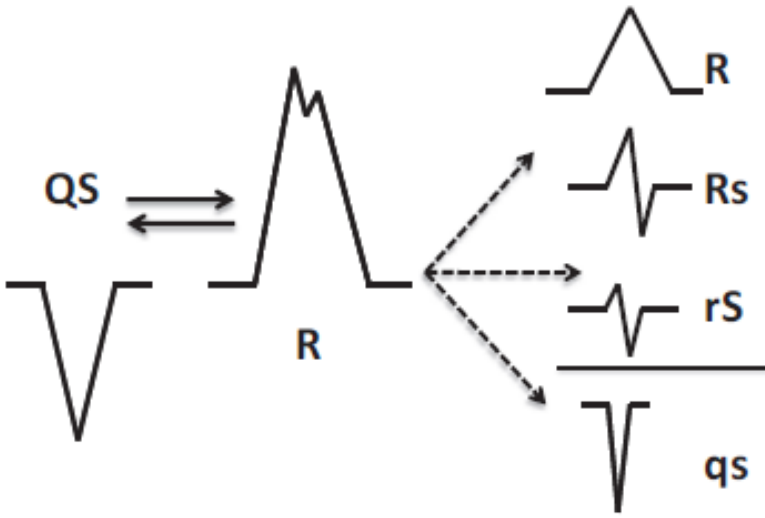
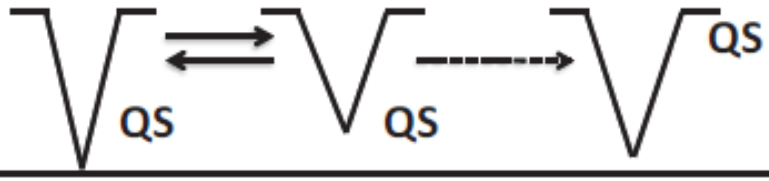


Lead V1-V3 help to identify contribution from LV pacing and show the gradual change of the QRS complex with changing VV interval

VV interval optimization

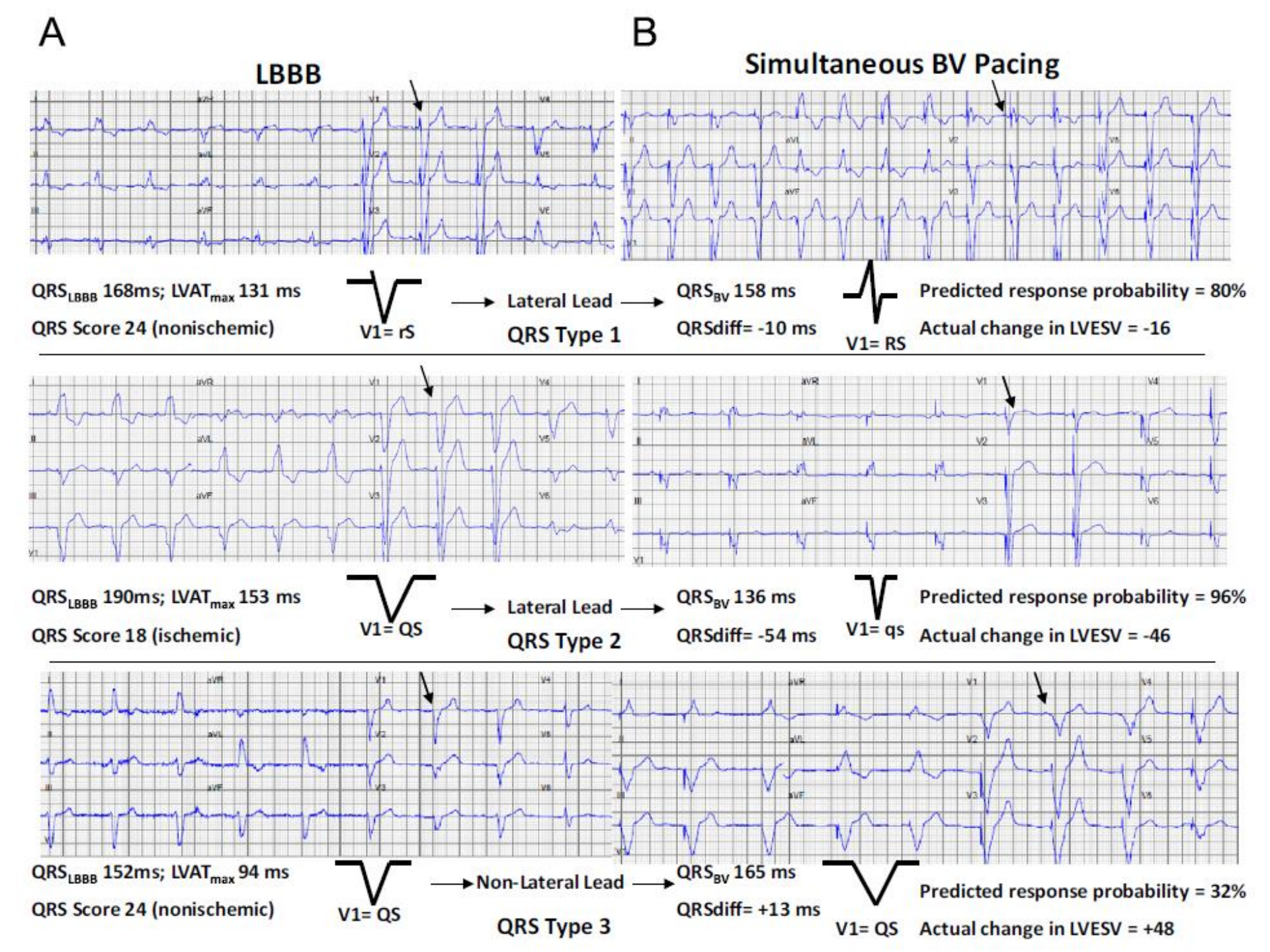
- QRS vector reflect electrical dyssynchrony.
- QRS vector amplitude halfway in between RV and LV pacing and minimal QRS vector area both reflect optimal resynchronization and timing of stimulation interval in CRT.
- The QRS morphology in lead V1-V3 that resembles a value halfway in between RV and LV pacing should probably b aimed for.

III. QRS fusion complex analysis

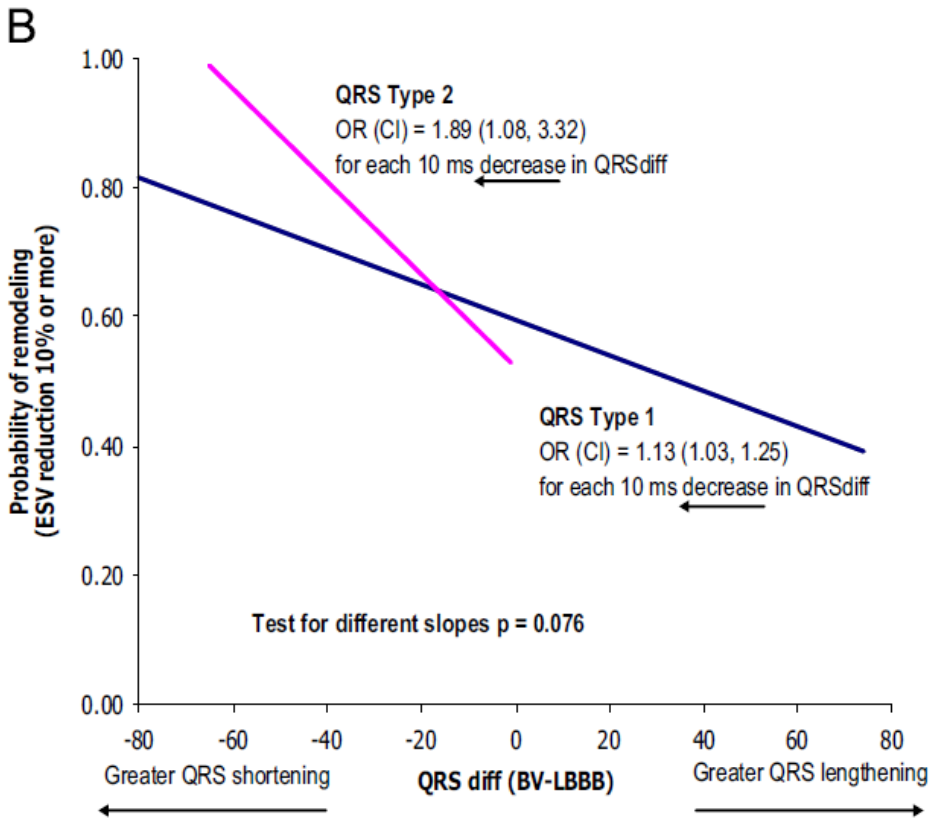
LBBB/ RV Pacing	LV Pacing	BV Pacing	QRSdiff ($QRS_{BV} - QRS_{LBBB}$)	QRS Fusion Type*
			(+, 0, -)	**1** QRS conformational change
			(-)	**2** QRS normalization
			(+)	**3** Persistent LBBB

From leads V_1-V_2

Heart Rhythm 2014; 11:806-813


A
LBBB
B
Simultaneous BV Pacing
QRS$_{LBBB}$ 168ms; LVAT$_{max}$ 131 ms
QRS Score 24 (nonischemic)
V1= rS
Lateral Lead
QRS Type 1
QRS$_{BV}$ 158 ms
QRSdiff= -10 ms
V1= RS
Predicted response probability = 80%
Actual change in LVESV = -16
QRS$_{LBBB}$ 190ms; LVAT$_{max}$ 153 ms
QRS Score 18 (ischemic)
V1= QS
Lateral Lead
QRS Type 2
QRS$_{BV}$ 136 ms
QRSdiff= -54 ms
V1= qs
Predicted response probability = 96%
Actual change in LVESV = -46
QRS$_{LBBB}$ 152ms; LVAT$_{max}$ 94 ms
QRS Score 24 (nonischemic)
V1= QS
Non-Lateral Lead
QRS Type 3
QRS$_{BV}$ 165 ms
QRSdiff= +13 ms
V1= QS
Predicted response probability = 32%
Actual change in LVESV = +48

LV reverse remodeling by QRS fusion types



LVESV measure	QRS type 1 (n = 267)	QRS type 2 (n = 66)	*P*
LVESV—baseline	173 (130, 224)	182 (134, 229)	.54
LVESV—6 mo	135 (94, 196)	145 (94, 172)	.94
ΔLVESV	−26 (−56, −3.0)	−43 (−68, −18)	.035
ΔLVESV (% of baseline)	−16 (−34, −2.0)	−23 (−39, −10)	.15
LVESV reduction ≥10%	166 (62)	50 (76)	.034

Values are presented as mean +/- SD, n (%) or as median (25th, 75th percentile).

LV = left ventricular; LVESV = left ventricular end-systolic volume.

*Includes all LV lead sites.

Heart Rhythm 2014; 11:806-813

Conclusion

Guide for CRT evaluation and optimization using the 12 lead ECG

1. Perform baseline ECG before CRT implantation
   - ☞ Evaluate accurate Ix for CRT by identificatin of ventricular conduction disturbance like LBBB, LVAT and QRS score
2. Perform baseline ECG during
   a) LV pacing (overdrive VVI mode to exclude fusion with intrinsic activation)
      - ☞ Evaluate LV lead position from LV paced QRS morphology
      - ☞ Evaluate LV pacing latency interval
   b) Simultaneous Bi-V pacing(overdrive VVI mode)
      - ☞ Evaluate contribution of LV pacing (latency interval)

Conclusion

Guide for CRT evaluation and optimization using the 12 lead ECG

3. Identify onset of intrinsic ventricular activation via stepwise increase of the AV-delay during simultaneous BiV pacing starting with a short AV-delay; the onset can be identified as the AV-delay where the QRS morphology change.
4. Program sensed AV-delay in a way that the pacing pulse occurs 40ms after the P wave(special attention for the terminal negative part in V_1); the AV-delay must preferably be shorter than that with onset of intrinsic ventricular activation.
5. Increase lower rate above underlying rhythm and program paced AV-delay in a way that the pacing pulse occurs 30ms after the paced P wave; AV delay must preferably be shorter than that with onset of intrinsic ventricular activation.

Conclusion

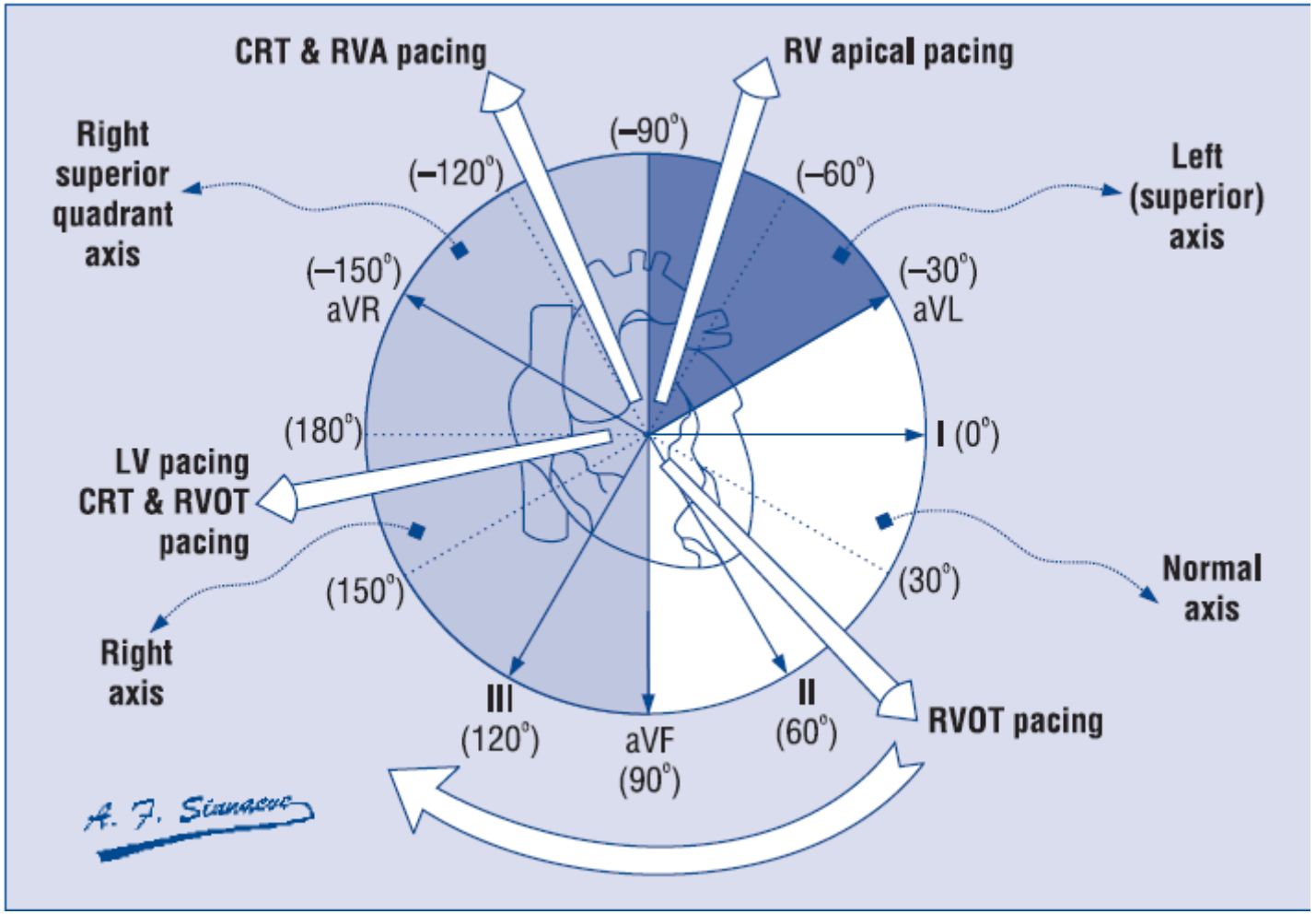
Guide for CRT evaluation and optimization using the 12 lead ECG

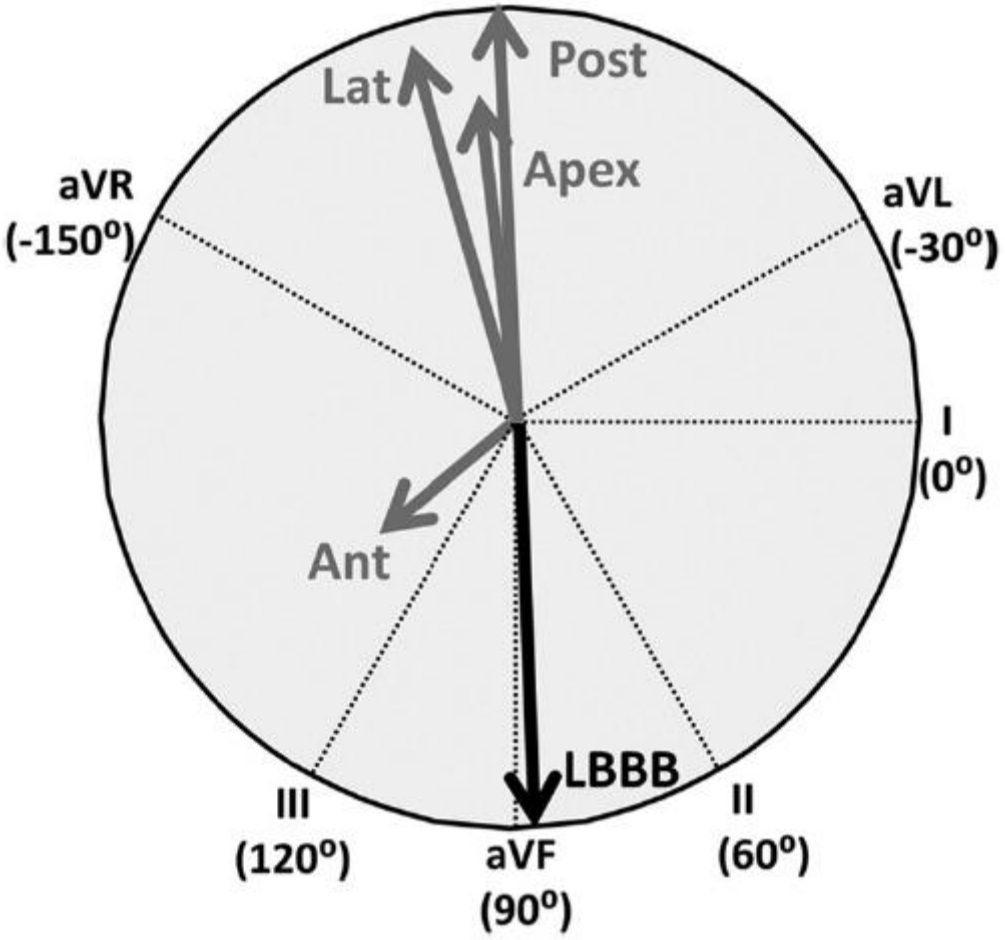
6. Program the VV-interval at a value with the QRS amplitude in lead V_{1-3} halfway in between RV and LV pacing; prefer a Rs over a rS pattern in lead V_1

Or

7. Program the VV-interval to lead the type 2 or type I BV fusion pattern in the lead V_1 If LV lead is in the lateral site.

경청해 주셔서 감사합니다.


CRT & RVA pacing
RV apical pacing
Right superior quadrant axis
Left (superior) axis
(–90°)
(–120°)
(–60°)
(–150°) aVR
(–30°) aVL
(180°)
I (0°)
LV pacing CRT & RVOT pacing
Normal axis
(150°)
(30°)
Right axis
III (120°)
aVF (90°)
II (60°)
RVOT pacing
A. F. Stanacor



Circ Arrhythmia Electrophysiol 2012; 5:544-522