Optimization of CRT via EKG
Is simple better?

Winter Arrhythmia School
February 11, 2012
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Arrhythmia Service

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Goals

- Brief overview of EKG findings in cardiomyopathy
- Brief overview on newest studies on CRT programming
- Examples of CRT EKG

- Disclosure

None

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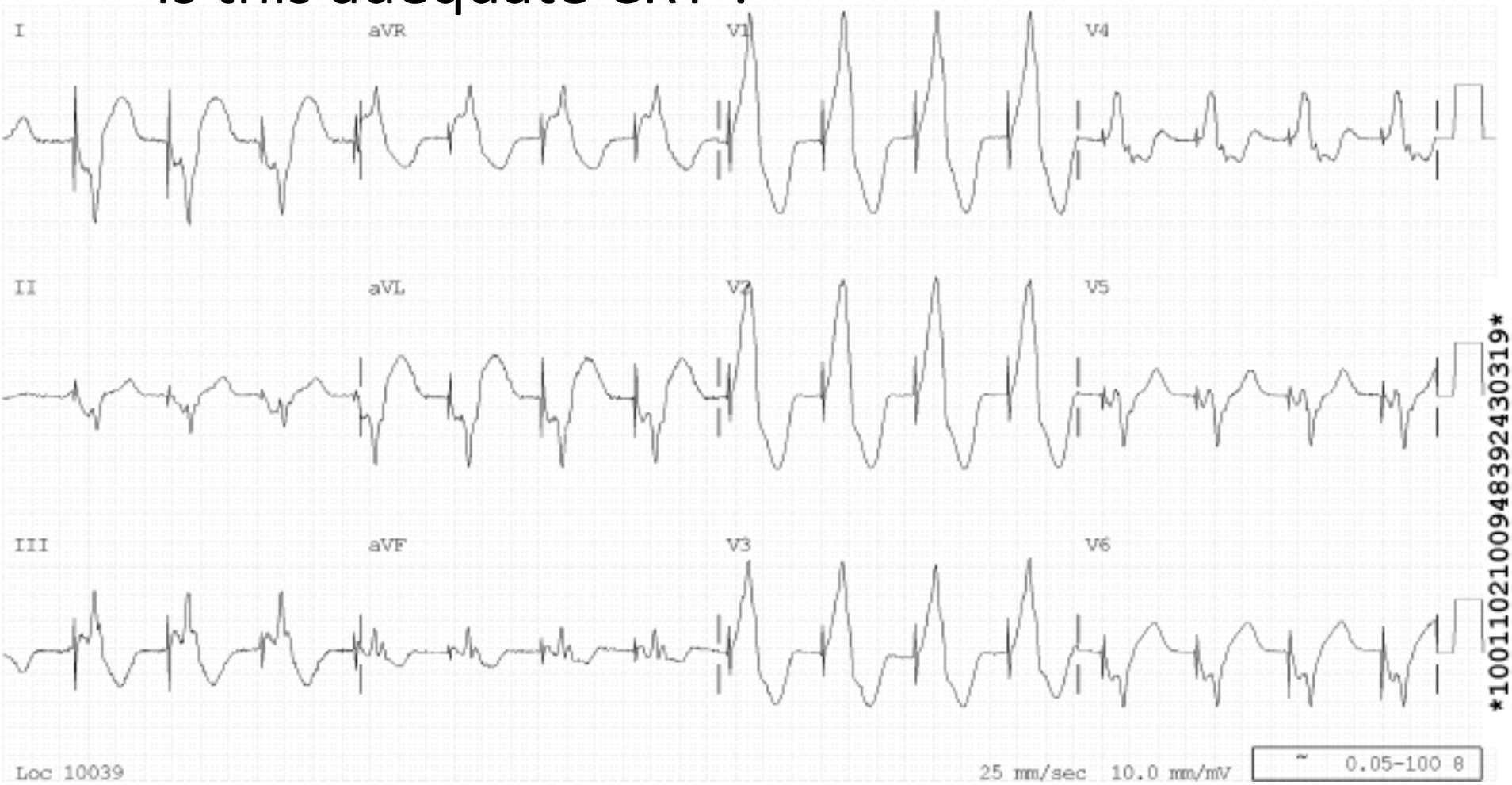
Is this adequate CRT ?



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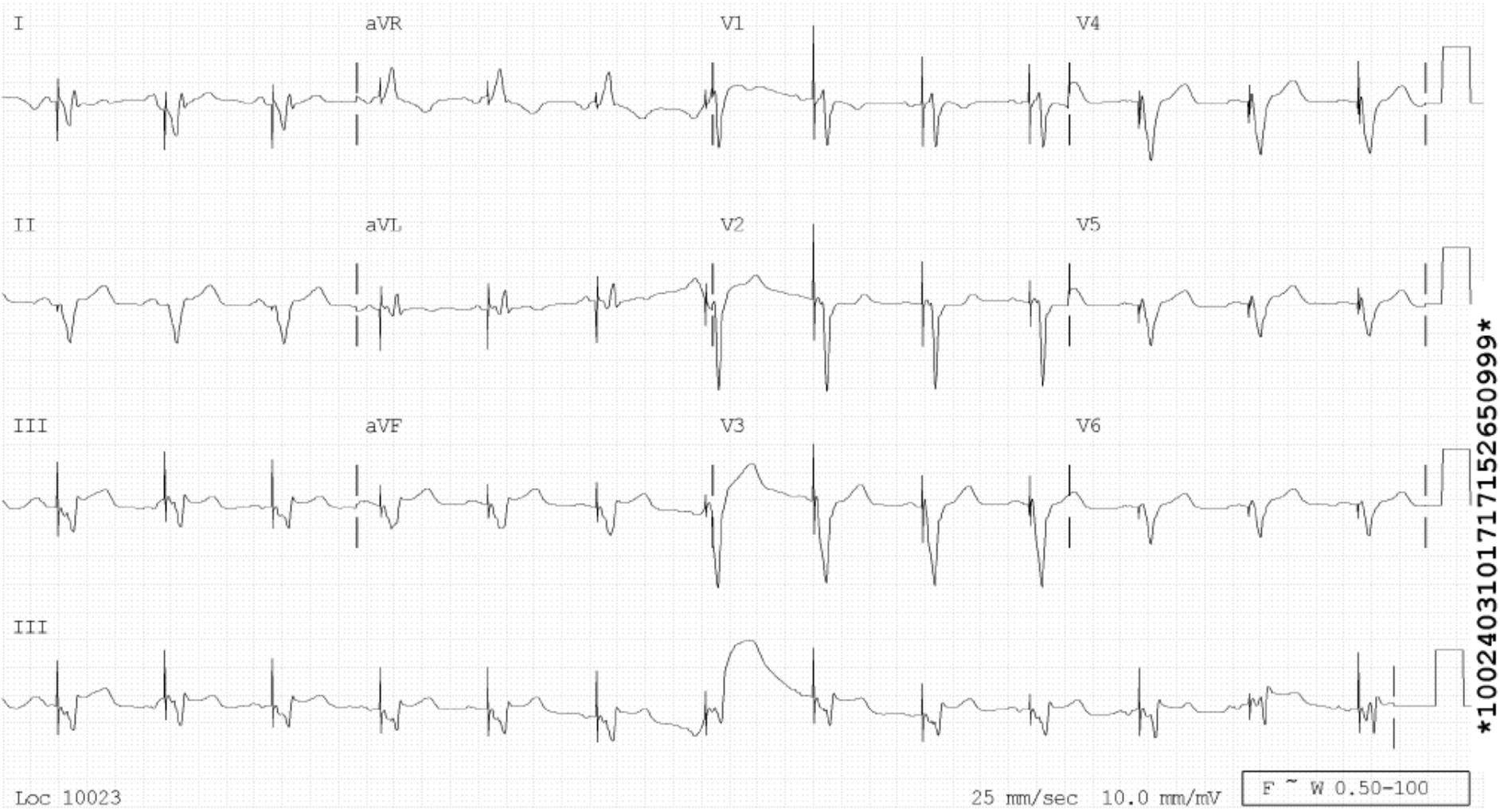
What about this one?



Cardiac resynchronization therapy (CRT)

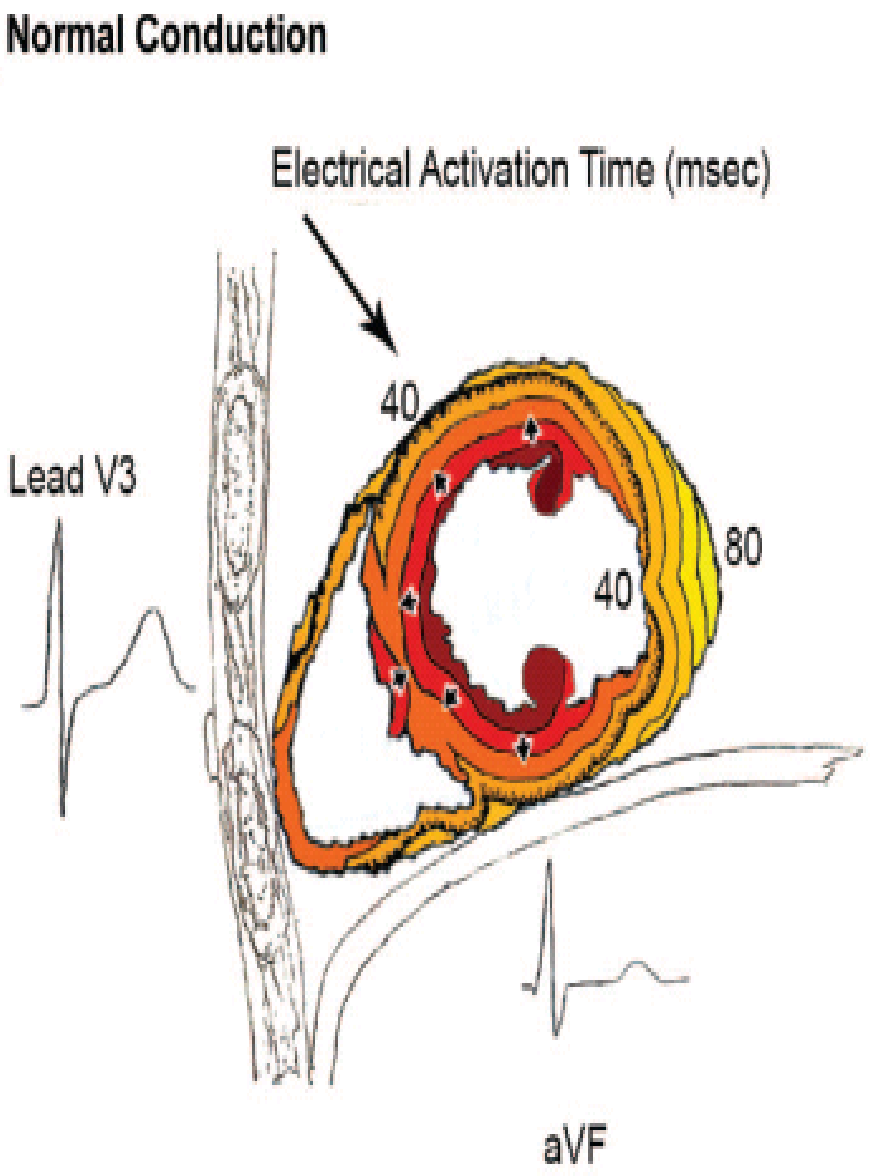
Class 1 indications:

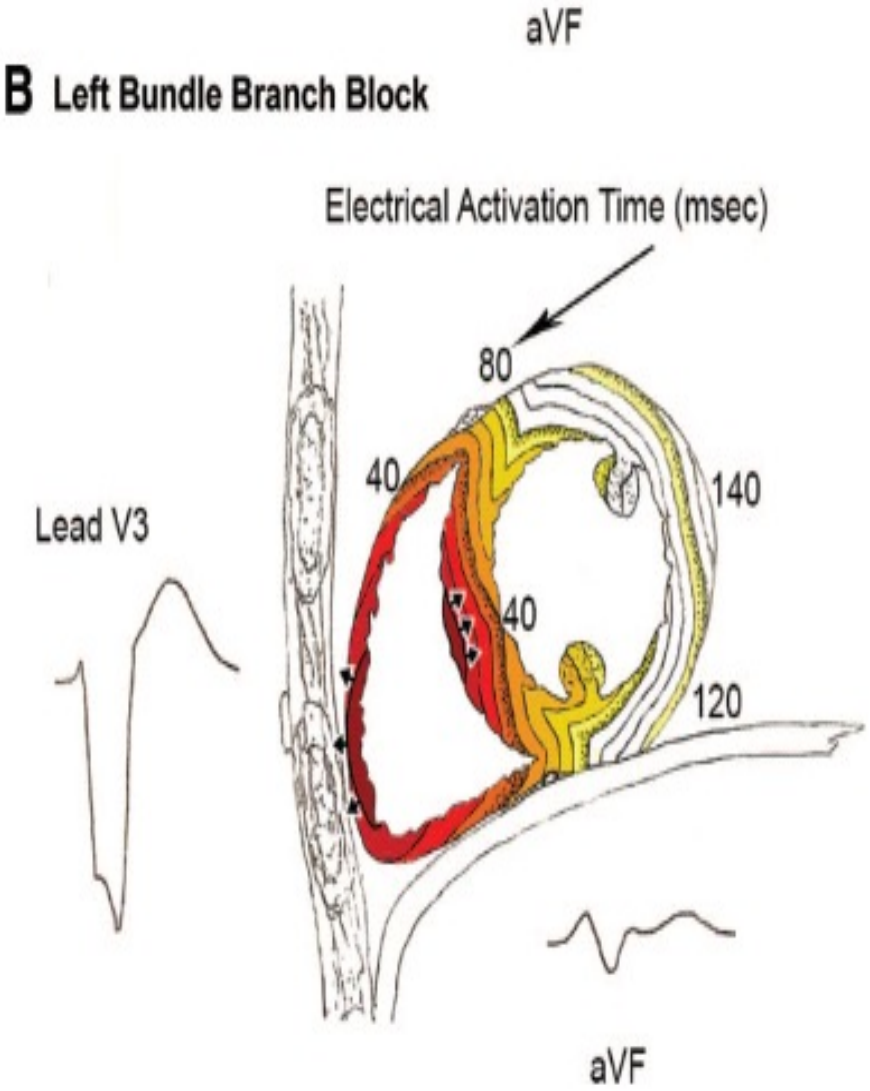
- LVEF ≤ 30%
- NYHA Class II-III
- QRS ≥ 120 msec (LBBB)

However only 2/3 of patients will benefit.

WHY?

ACC/AHA/HRS 2008 Guidelines





Sweeny et al, Circulation 2011

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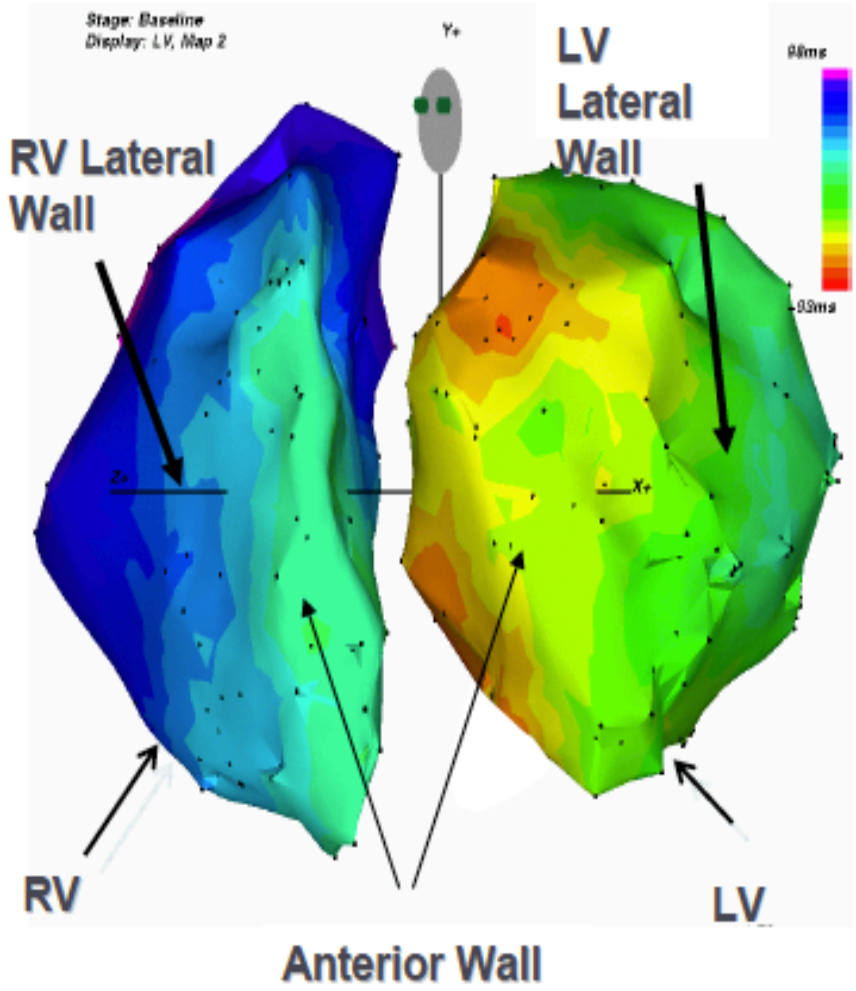
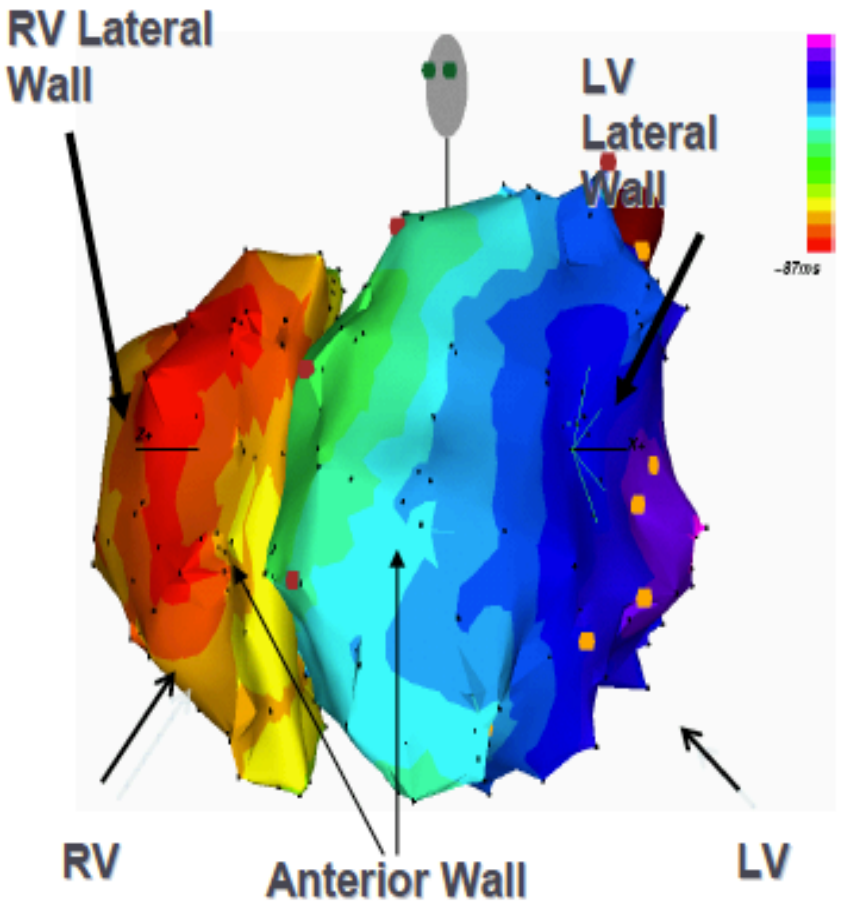
Right Bundle Branch Block



Left Bundle Branch Block



Fantoni et al . JCE 2005

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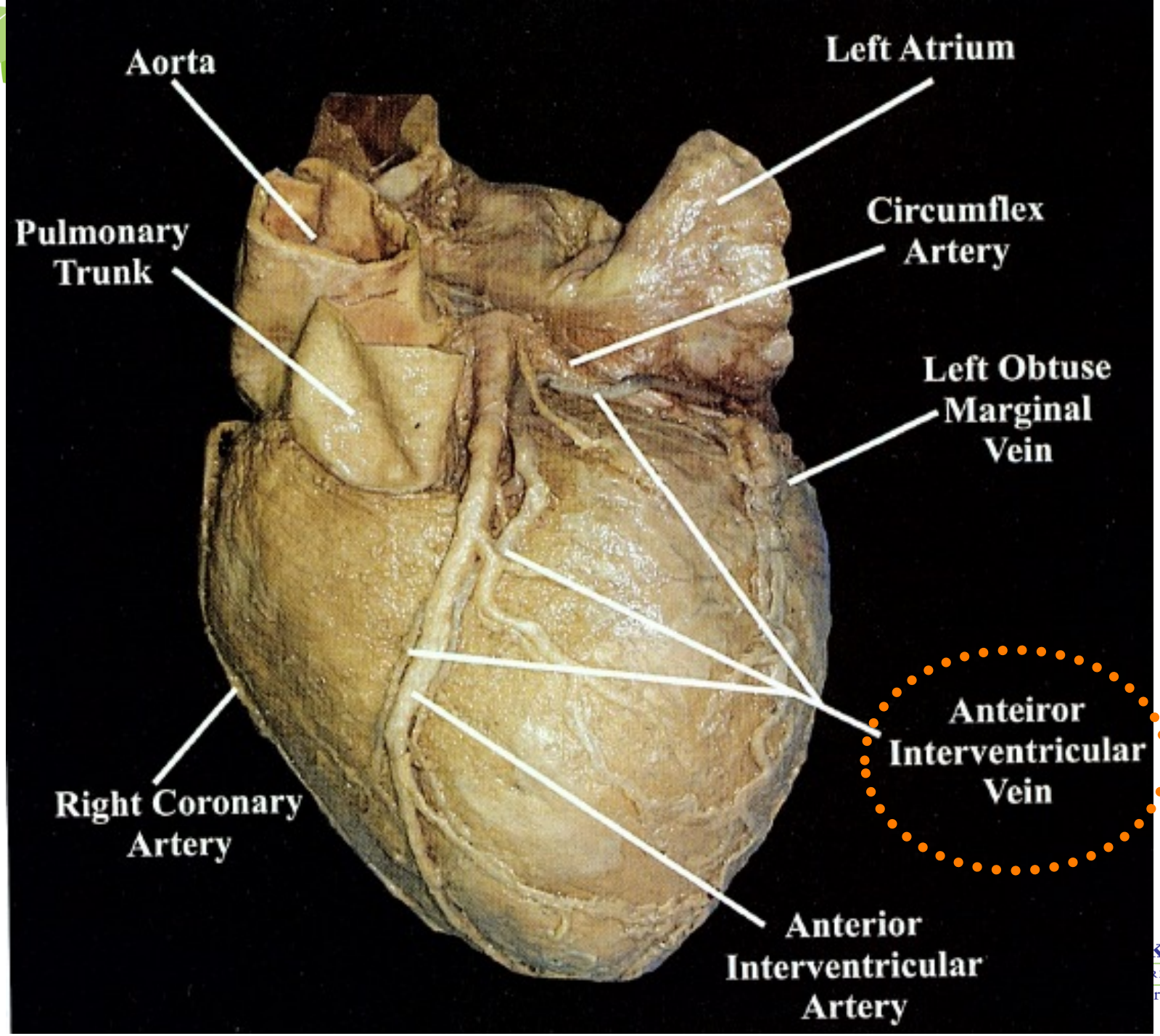
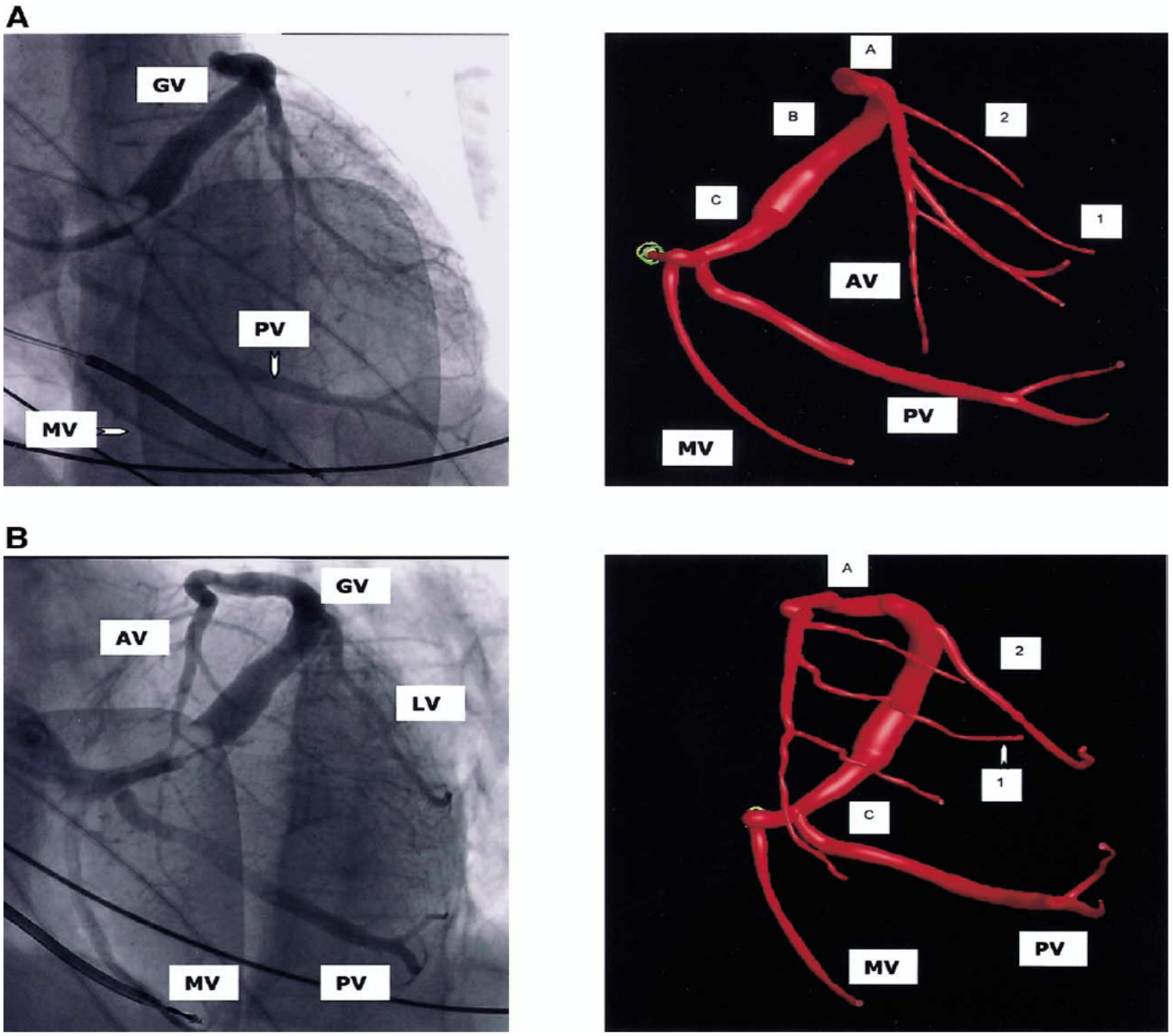

Aorta
Left Atrium
Pulmonary Trunk
Circumflex Artery
Left Obtuse Marginal Vein
Anteiror Interventricular Vein
Right Coronary Artery
Anterior Interventricular Artery



Singh et al. JACC 2005, 46 PP 48-67

Fluoroscopic view - AP

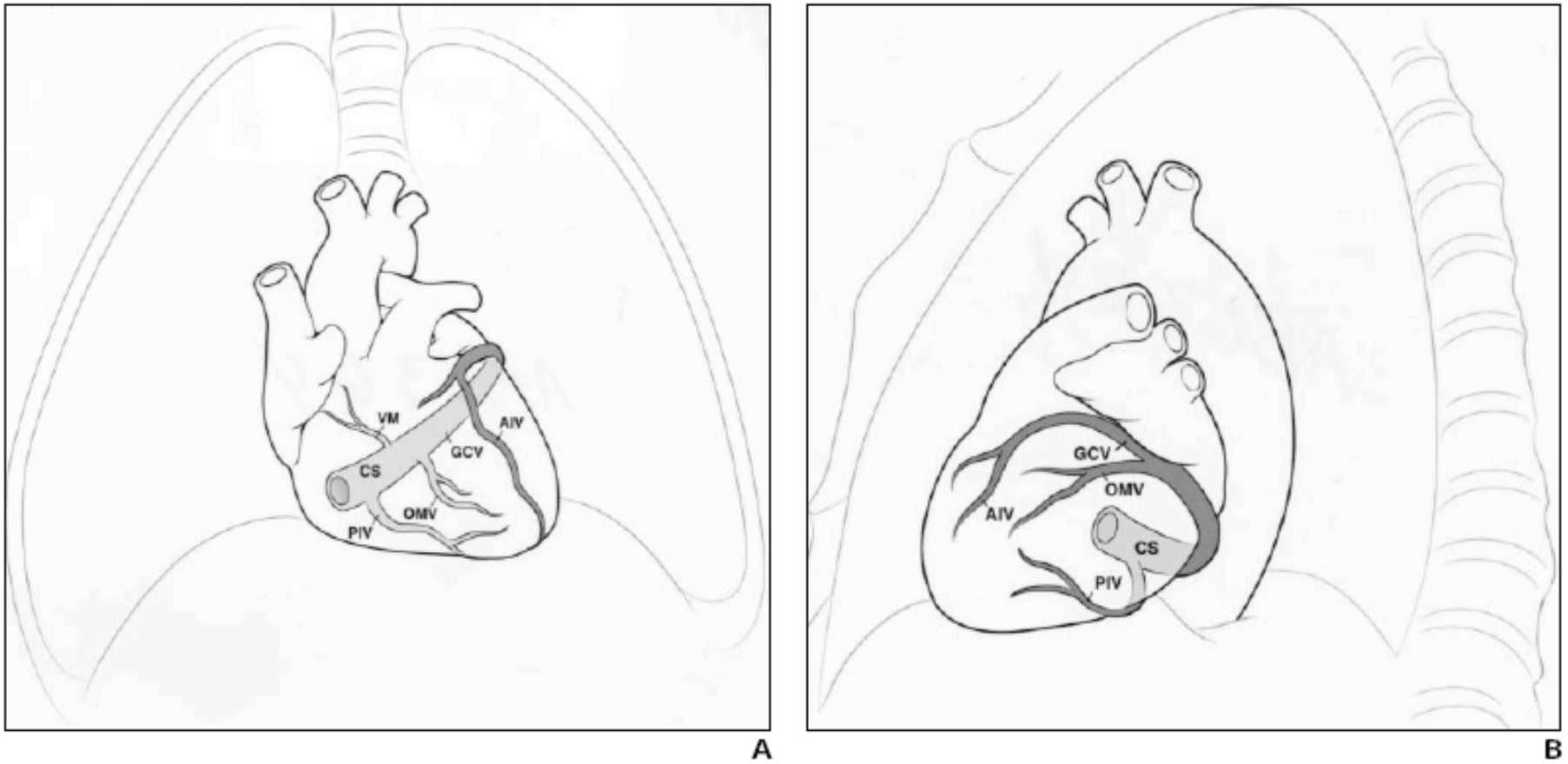
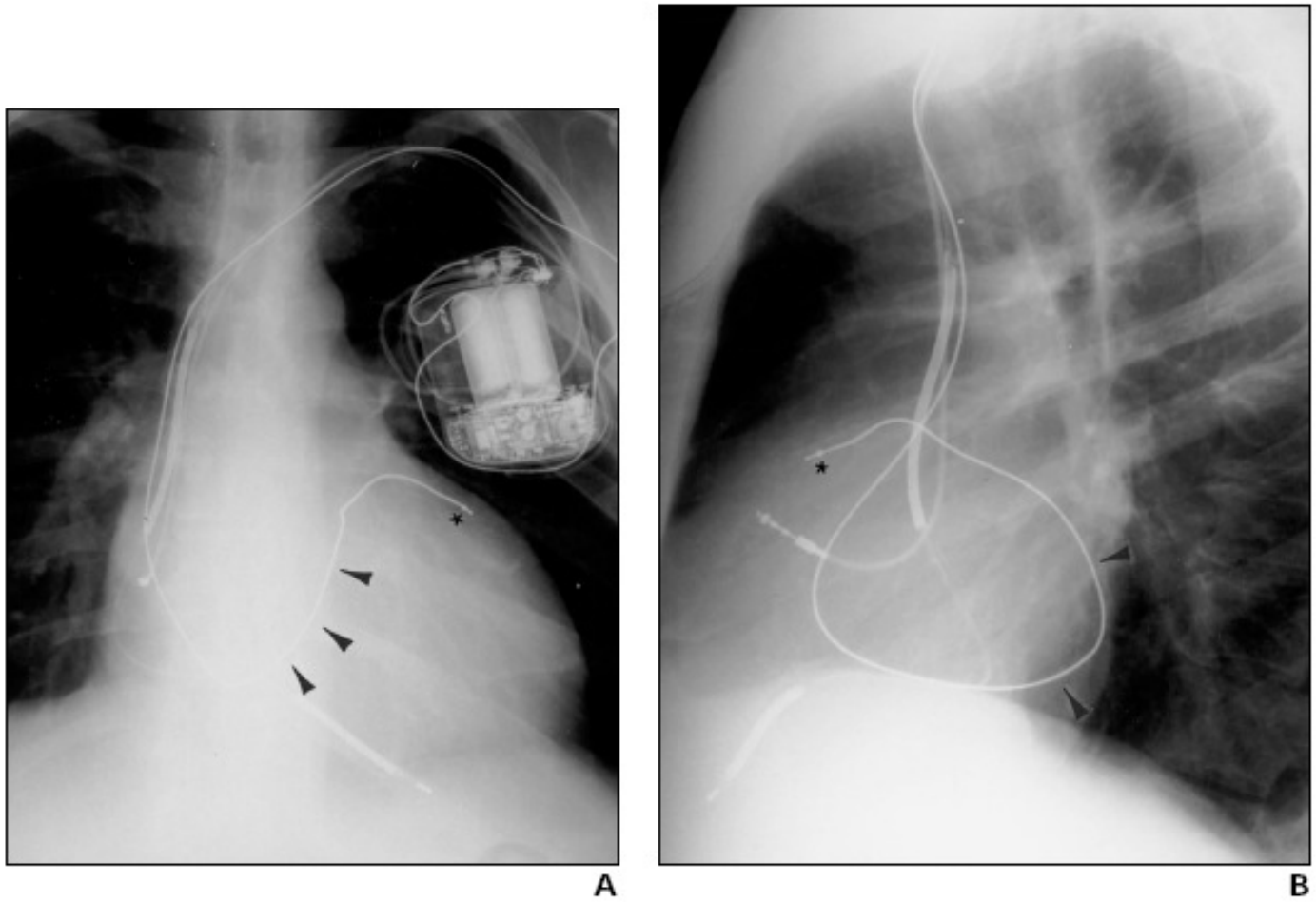
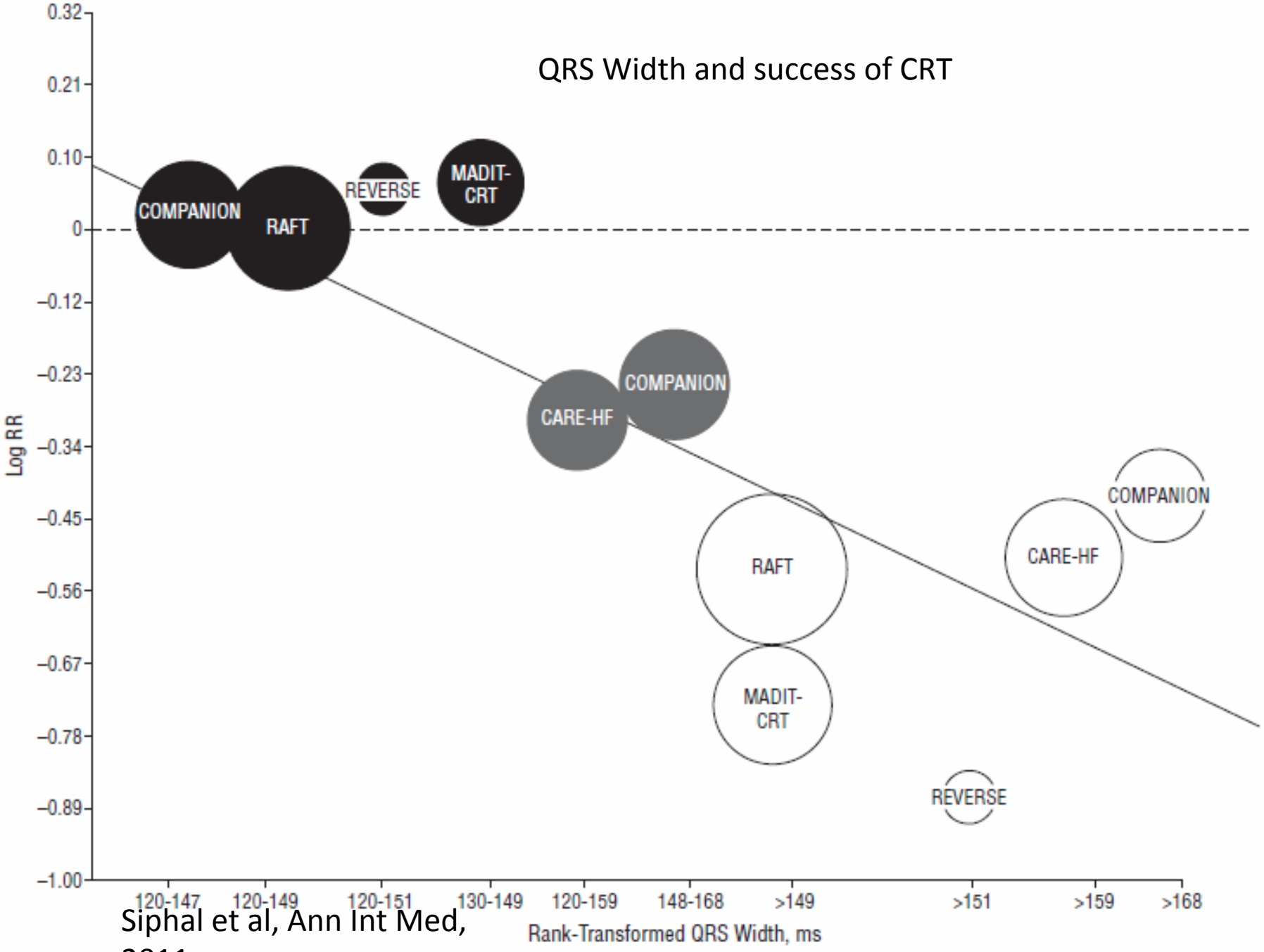


Fig. 1.—Major epicardial coronary veins.
A, Drawing in frontal projection shows that anterior interventricular (AIV) and obtuse marginal (OMV) veins drain into great cardiac vein (GCV). Oblique vein of Marshall (VM) drains into coronary sinus (CS) at level of venous valve of Vieussens, marking point of transition of coronary sinus and great cardiac vein in mid atrioventricular groove. Posterior interventricular vein (PIV) joins coronary sinus near ostium to right atrium.
B, Drawing in lateral projection shows that anterior interventricular vein (AIV) and obtuse marginal vein (OMV) drain into great cardiac vein (GCV). Posterior interventricular vein (PIV) joins coronary sinus (CS) near ostium to right atrium.

Optimal LV lead placement by fluoroscopic views

Fig. 4.—Biventricular pacing using anterior interventricular vein in 57-year-old man with idiopathic dilated cardiomyopathy.
A, Frontal chest radiograph shows left ventricular pacing lead extending from right atrium retrograde into coronary sinus, through greater cardiac vein (*arrowheads*), and into anterior interventricular vein (*asterisk*) located on surface of left ventricle.
B, Lateral chest radiograph shows left ventricular pacing lead extending from right atrium into coronary sinus and through greater cardiac vein (*arrowheads*) into anterior interventricular vein (*asterisk*) located on surface of left ventricle.





Siphal et al, Ann Int Med, 2011

MADIT - CRT

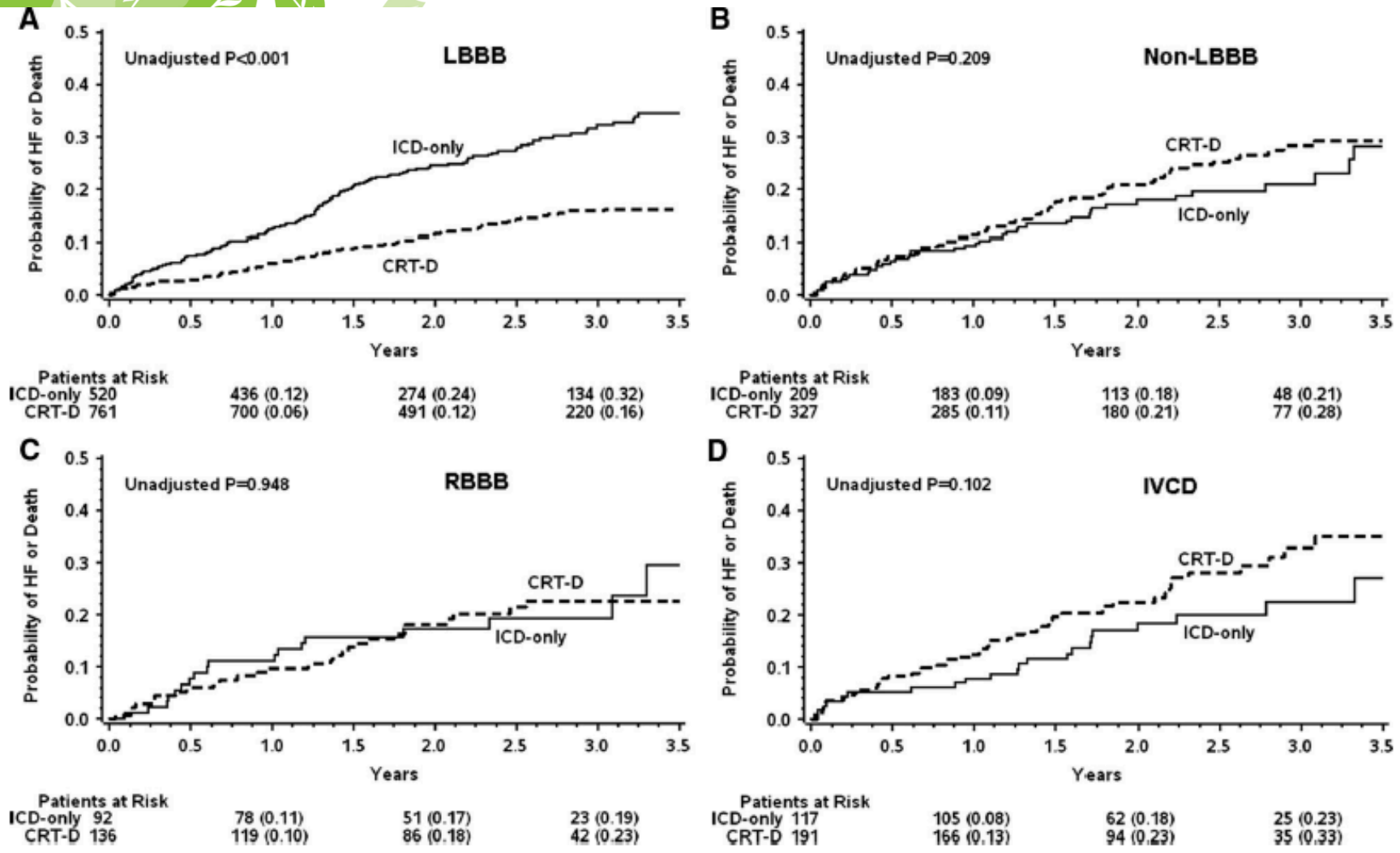


Figure 2. Cumulative probability of heart failure (HF) event or death according to treatment (cardiac resynchronization therapy with defibrillator [CRT-D] versus implantable cardioverter defibrillator [ICD] only) in patients with left bundle-branch block (LBBB), non-LBBB, right bundle-branch block (RBBB), and intraventricular conduction disturbances (IVCD) in Multicenter Automatic Defibrillator Implantation Trial–Cardiac Resynchronization Therapy (MADIT-CRT) patients.

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Zareba et al . Circulation 2011

Table 3. Hazard Ratios for CRT-D vs ICD-Only for Primary End Point by QRS Morphology and Duration for Each Sex

	Males			Females		
	n	HR (95% CI)	*P*	n	HR (95% CI)	*P*
QRS duration						
<140 ms	240	1.69 (0.97–2.95)	0.063	61	0.20 (0.06–0.66)	0.008
140–159 ms	465	0.77 (0.52–1.12)	0.164	178	0.31 (0.15–0.63	0.001
160–179 ms	417	0.51 (0.33–0.79)	0.003	153	0.42 (0.19–0.94)	0.036
≥180 ms	242	0.50 (0.28–0.89)	0.019	61	0.33 (0.09–1.23)	0.100
QRS morphology						
LBBB*	887	0.56 (0.42–0.75)	<0.001	394	0.25 (0.15–0.41)	<0.001
Non-LBBB	477	1.25 (0.84–1.85)	0.273	59	1.55 (0.41–5.88)	0.516
RBBB	210	0.94 (0.52–1.72)	0.841	18	NA	
IVCD	267	1.49 (0.89–2.52)	0.133	41	1.31 (0.33–5.26)	0.701

CRT-D indicates cardiac resynchronization therapy with implanted defibrillator; ICD, implantable cardioverter-defibrillator; HR, hazard ratio; 95% CI, 95% confidence interval; LBBB, left bundle-branch block; RBBB, right bundle-branch block; IVCD, intraventricular conduction disturbances; and NA, not available.

Unadjusted hazard ratios are presented.

*P=0.006 for interaction comparing HR=0.56 in males vs HR=0.25 in females (differences in hazard ratios of other QRS categories by sex were not significant).

Zareba et al . Circulation 2011

What about AV delay?

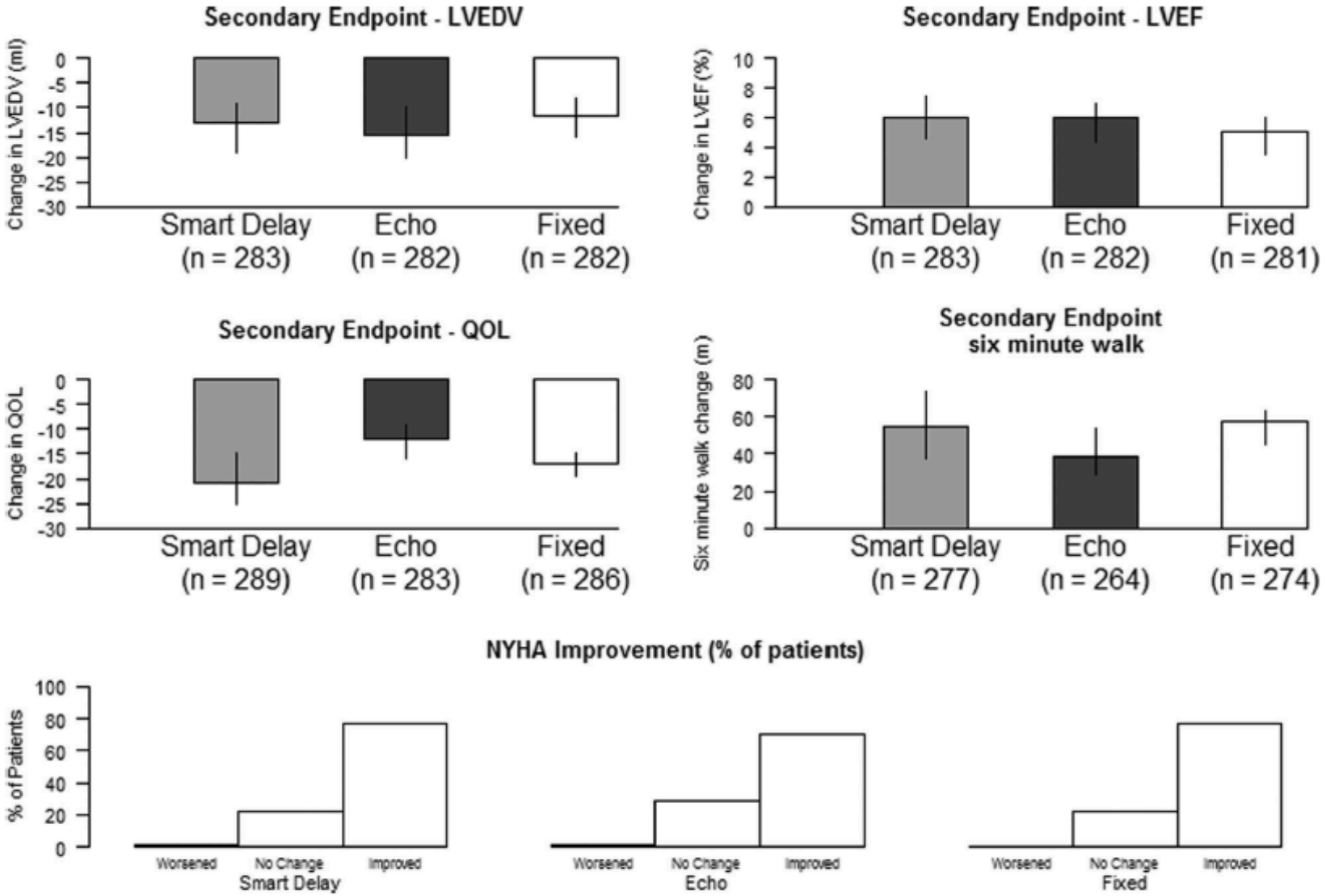
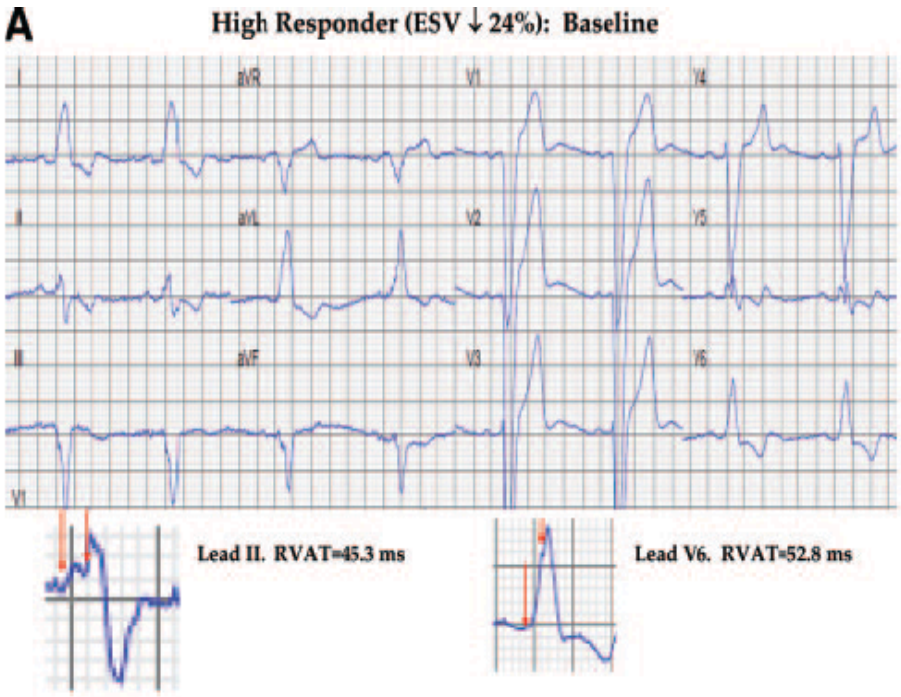
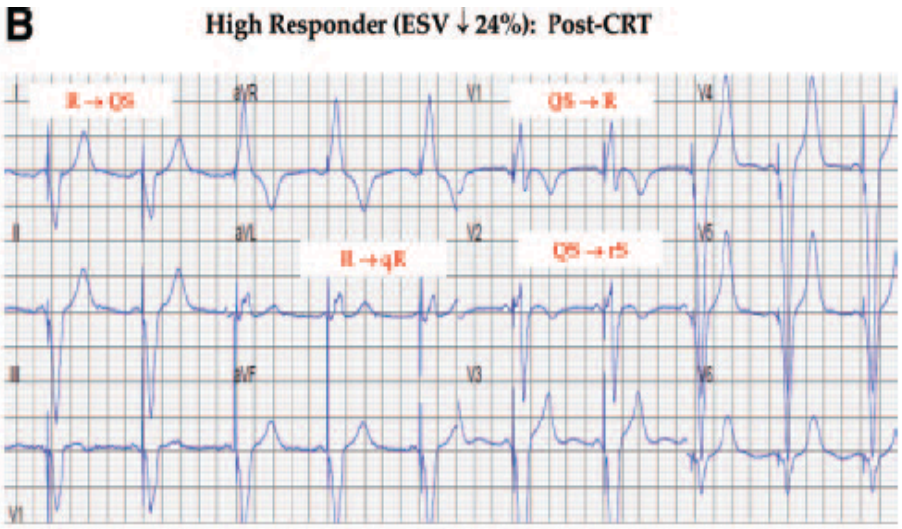


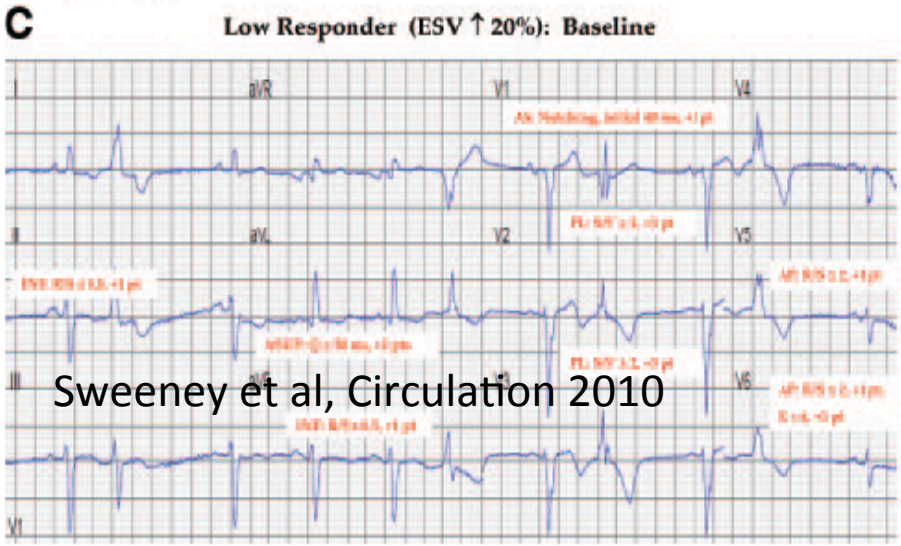
Figure 3. Median and 95% confidence interval for the secondary structural end points of echocardiographic LVEDV and LVEF and the functional end points of 6-minute walk distance, QOL changes, and percent of patients by NYHA classification between baseline and the 6-month follow-up.

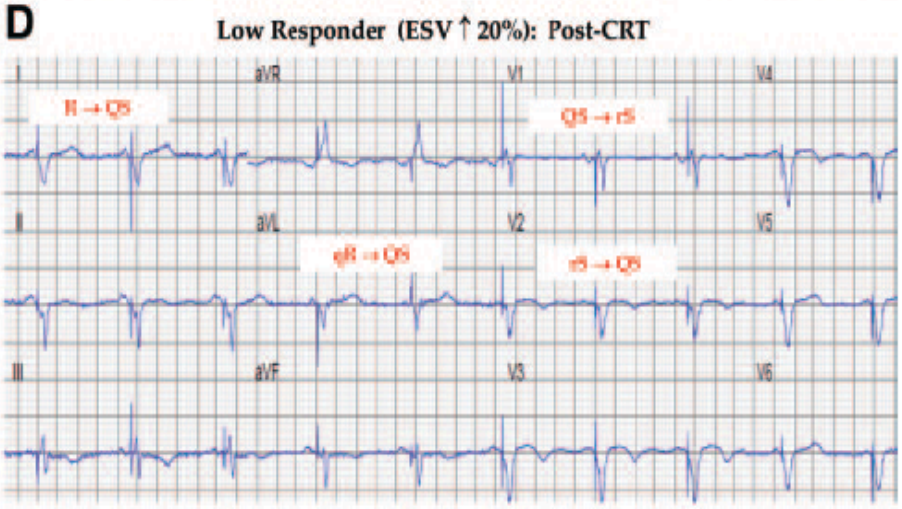
SMART AV trial, Ellebogen et al, Circulation 2011

What to look for on the surface EKG?









Sweeney et al, Circulation 2010

Table 3. Evidence for Ventricular Activation Fusion During Simultaneous Biventricular Pacing

Frontal plane electric axis	
Median absolute axis change, ° (25th, 75th percentile)	85 (47, 131)
RADEV	136 (67.7)
RSA	118 (58.4)
RIA	18 (8.9)
IRSA	25 (12.4)
LADEV	35 (17.3)
Normal axis	6 (3.0)
Axis quadrant shift	180 (89.1)
Rightward: normal/LADEV→RADEV	134 (66.3)
RSA	116 (57.4)
RIA	18 (8.9)
Incomplete rightward: normal/LADEV→IRSA	25 (12.4)
Leftward: normal→LADEV	16 (7.9)
Other	5 (2.5)
Activation wavefront reversal in pivotal leads	
I: Q emergence, S emergence, R regression	144 (71.3)
R, Rs, rS, RS→QS	104 (51.5)
R, Rs, rS, RS→Qr	8 (4.0)
R, Rs, rS, RS→qR	21 (10.4)
R, Rs, rS, RS→QR	11 (5.4)
aVL: Q emergence, S emergence, R regression	59 (29.2)
R, Rs, rS, RS→QS	27 (13.4)
R, Rs, rS, RS→Qr	4 (2.0)
R, Rs, rS, RS→qR	24 (11.9)
R, Rs, rS, RS→QR	4 (2.0)
V_1: R emergence, QS regression	
QS or rS→R, Rs, RS	100 (49.5)
V_2: R emergence, QS or rS regression	
QS or rS→R, Rs, RS	48 (23.8)
Mean R amplitude change ≥50% in expected direction for pivotal leads	
I and aVL	121 (59.9)
V_1 and V_2	100 (49.5)

Values in parentheses are percentages unless indicated otherwise.

Sweeney et al, Circulation 2010

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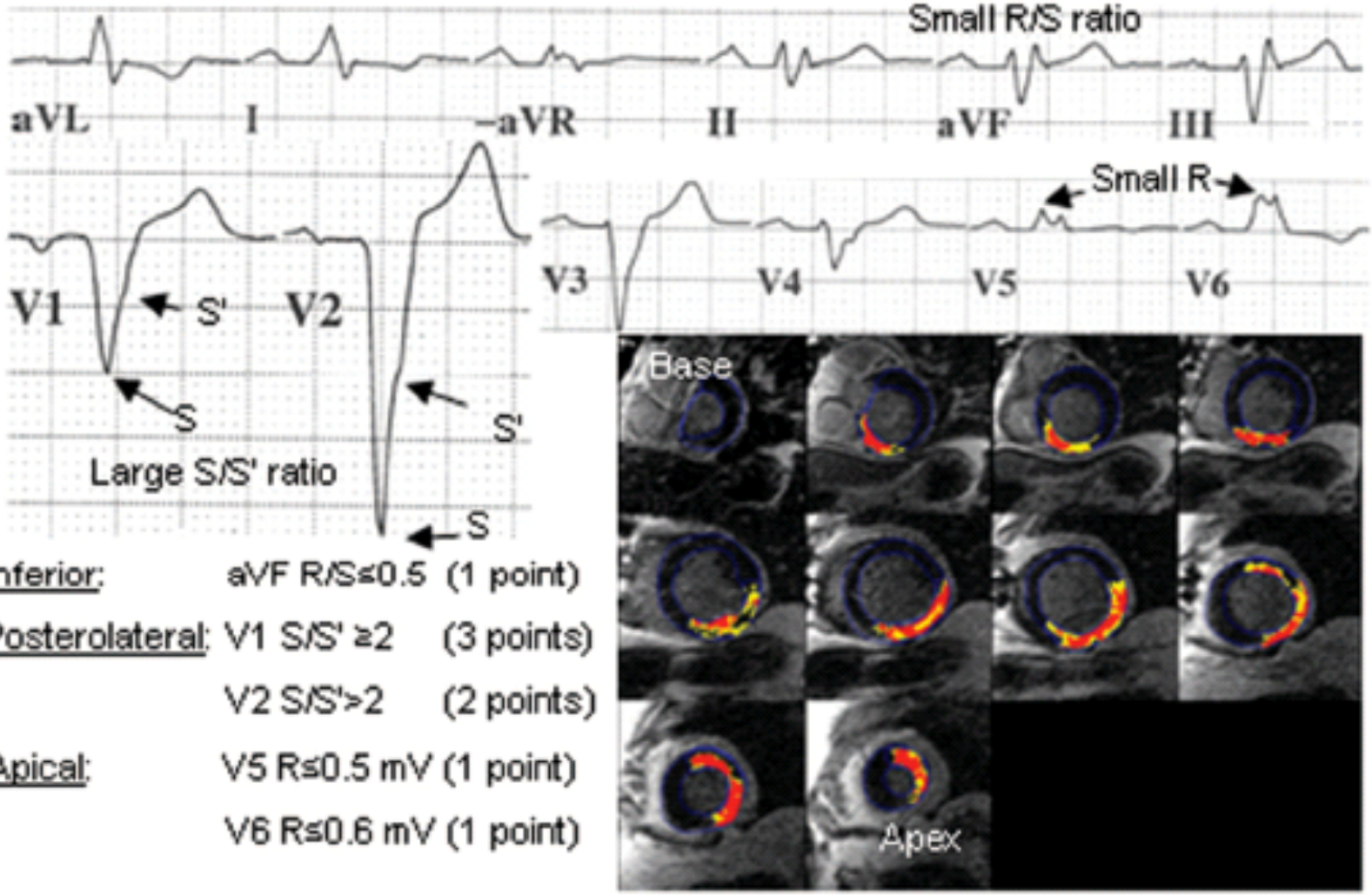
Other factors for achieving successs

- Avoid right atrial pacing
- Control atrial arrthythmias
- Avoid pacing scar
- Left ventricular lead placement

Quantification of scar (Selvester QRS score of LBBB)

B



Inferior:	aVF R/S≤0.5	(1 point)
Posterolateral:	V1 S/S' ≥2	(3 points)
	V2 S/S'>2	(2 points)
Apical:	V5 R≤0.5 mV	(1 point)
	V6 R≤0.6 mV	(1 point)

QRS-scar = 24% LV (8 QRS pts) **CMR-scar = 23% LV** (17% core; 12% gray)

Prospect - EKG

Table 5. Summary of LVESV Response Using Dichotomized LV-Paced QRS Width by Cause of Cardiomyopathy

Explanatory Variable	Cause of Cardiomyopathy	Statistic	Response (95% CI)	P Value of Interaction
LV-paced QRS width (≤200 vs >200 ms)	Overall	OR	2.27 (1.04–4.97)	. . .
		P value	0.04	
	Ischemic	OR	1.35 (0.46–3.91)	0.04
		P value	0.58	
	Non-ischemic	OR	5.12 (1.47–17.81)	
		P value	0.01	

Hsing et al, JCE 2011

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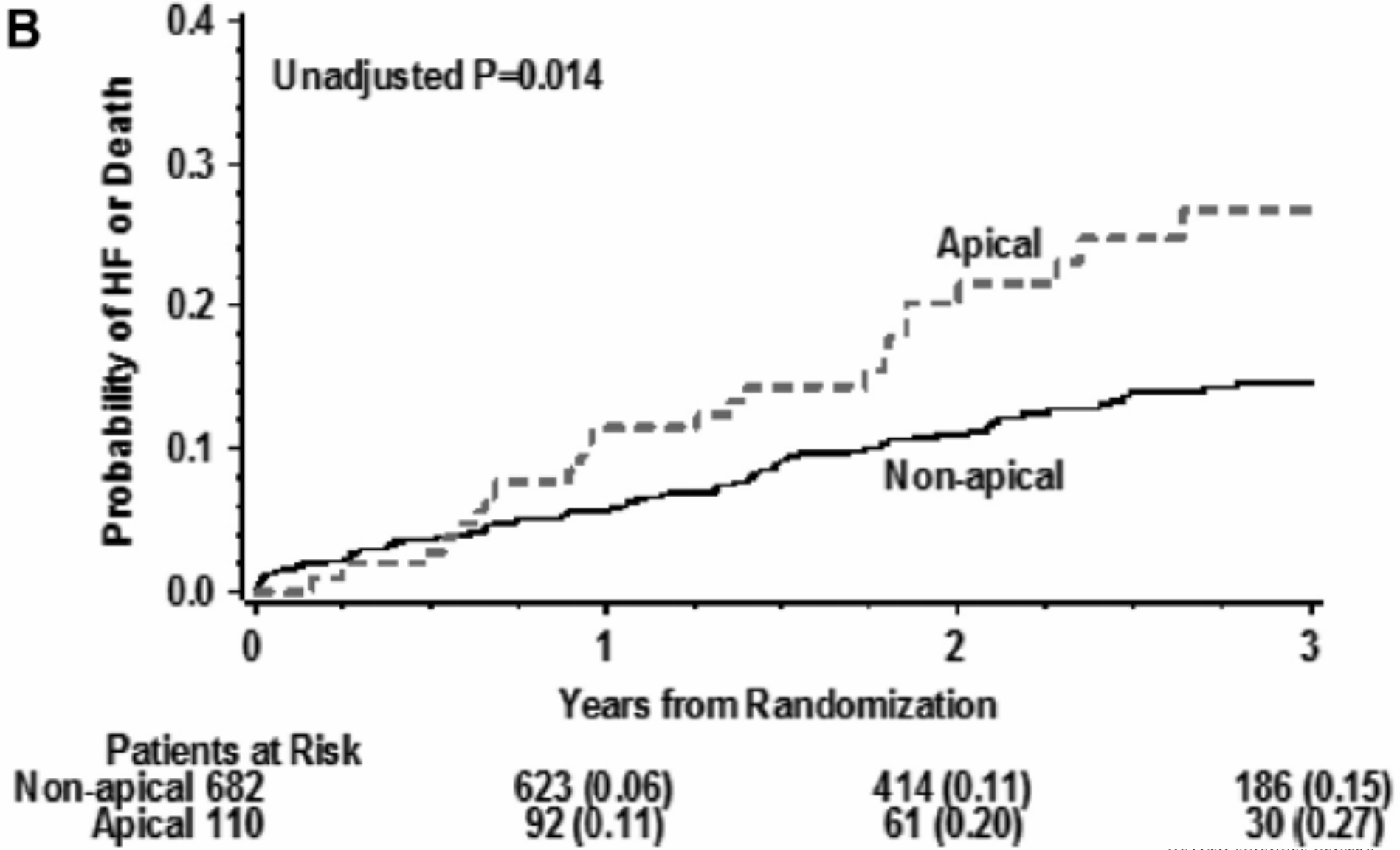
Any difference in apical vs non apical position



MADIT CRT- Singh et al, Circulation 2011

MADIT-CRT

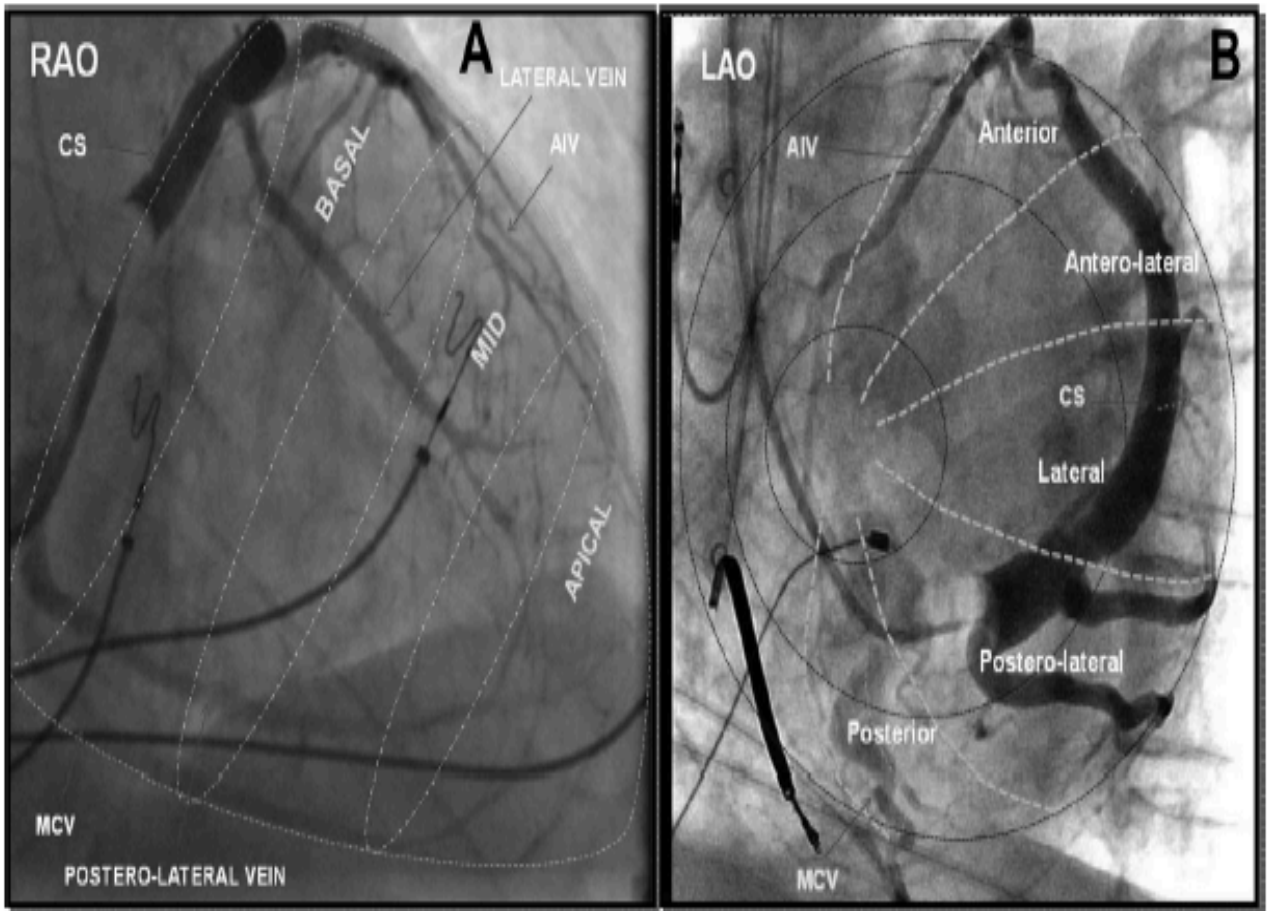


Figure 1. Angiographic classification of left ventricular lead position. A, Right anterior oblique (RAO) view representative of the long axis of the heart. This view enables segmentation of the heart into basal, midventricular (MID), and apical segments. B, Left anterior oblique (LAO) view used to divide the left ventricular wall along the short axis of the heart into 5 equal parts; anterior, anterolateral, lateral, posterolateral, and posterior. For the analysis, the anterolateral, lateral, and posterolateral segments were grouped together as the lateral wall. AIV indicates anterior interventricular vein; CS, coronary sinus; and MCV, middle cardiac vein.

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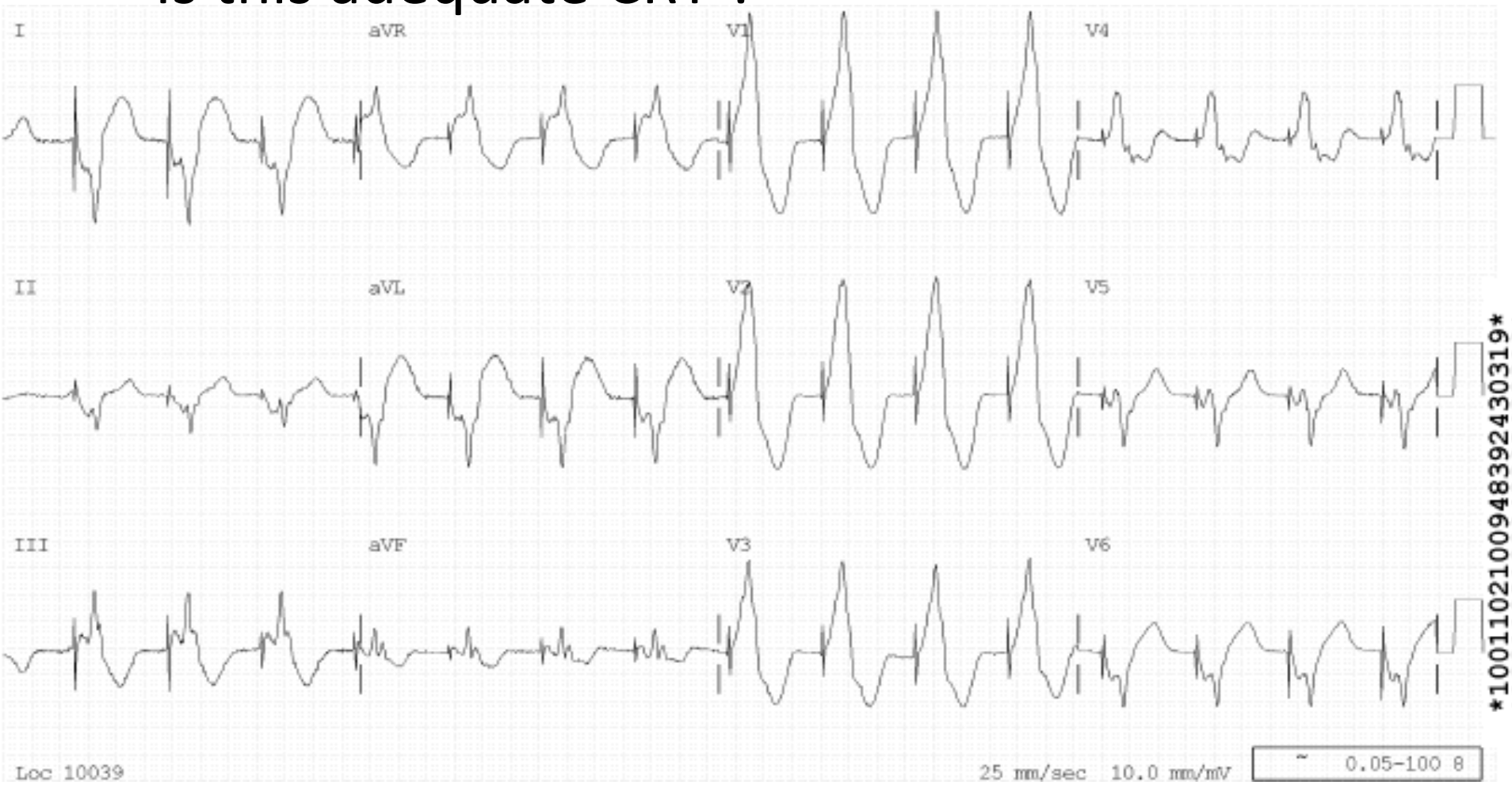
Is this adequate CRT ?



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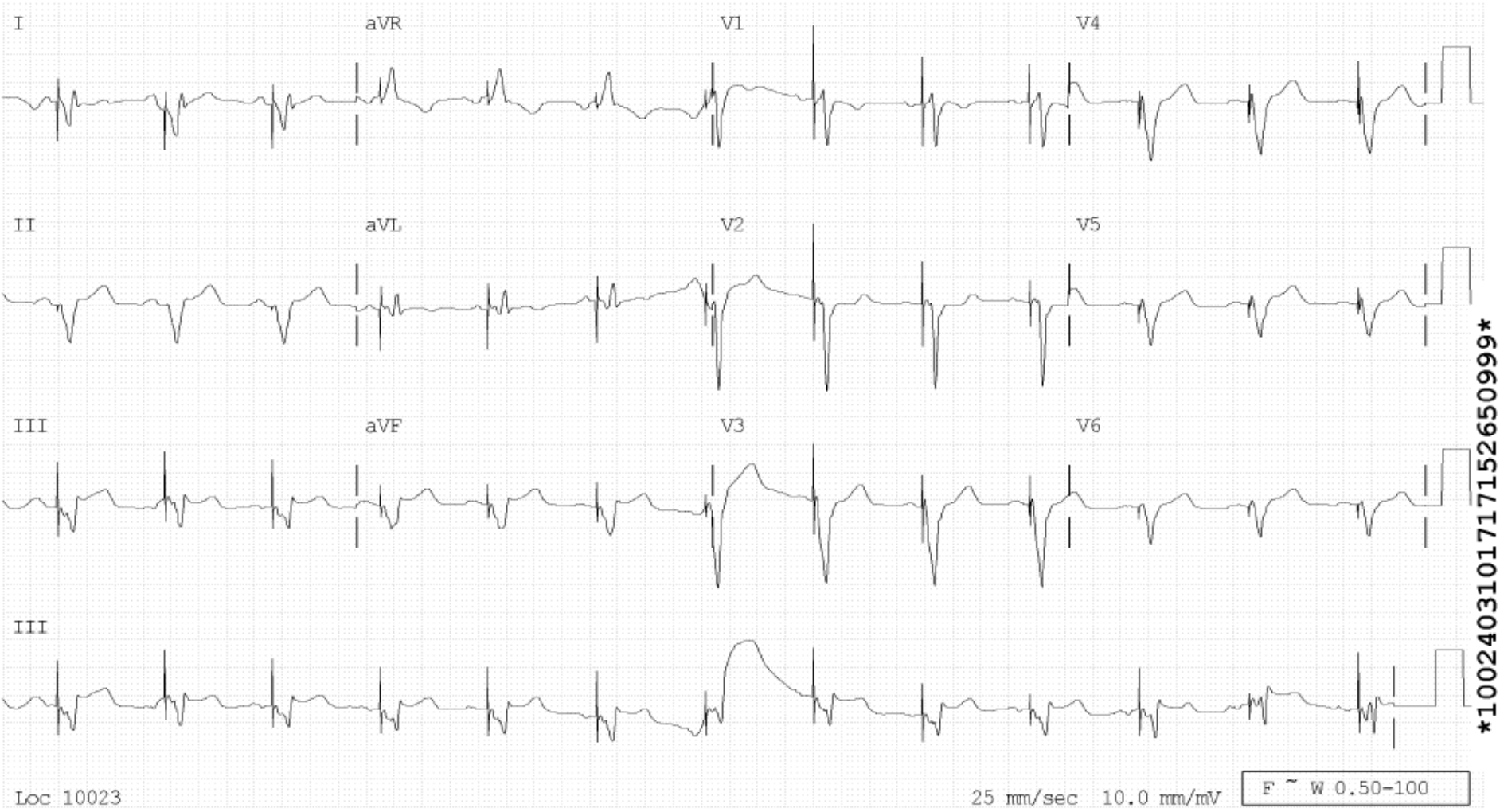

Conclusion

- EKG/QRS morphology during LV lead placement
- Change RV-LV delay : Lead III R – QS, Lead V1 QS – R
- AV delay - perhaps programmed to AV delay of 120 msec, or 50% of native PR interval if QRS > 150 msec