# Heart Failure Optimization for Patients with CRT-D Devices


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# Disclosures

- Speaker/Honoraria for Medtronic, Abbott, Boston Scientific

# Introduction

- Cardiac resynchronization therapy (CRT) is one of the most effective therapies for heart failure with reduced ejection fraction
- In **appropriately selected patients**, CRT has the potential to:
  - Improve quality of life
  - Cause beneficial reverse remodeling
  - Reduce heart failure hospitalization rates and symptoms
  - Reduce all-cause mortality
  - Reduce mitral regurgitation

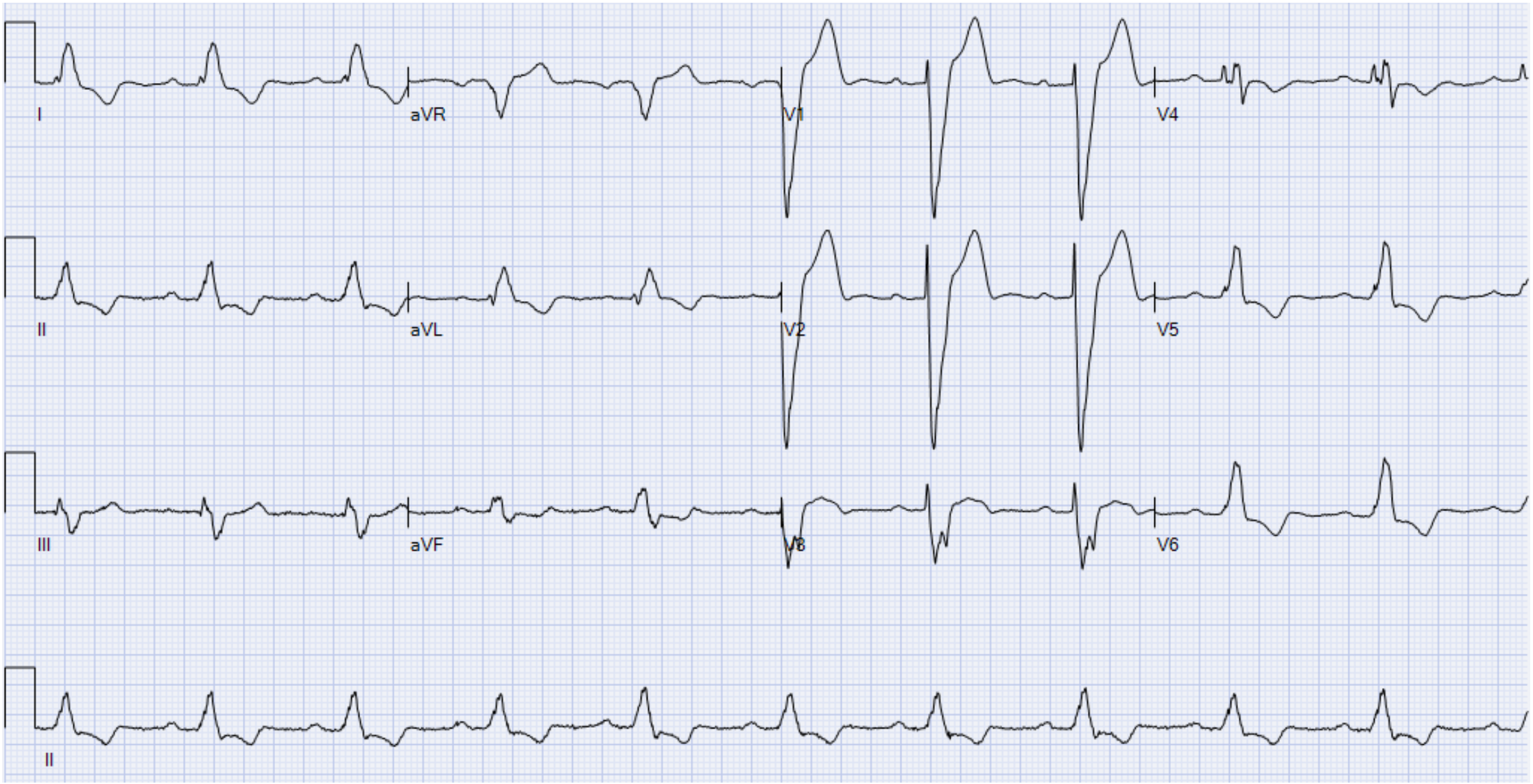
# Objectives

- Review optimal patient selection
- Review device implant considerations
- Review programming considerations
- Future directions

# Case

- 83-year-old referred for consideration of CRT-D in 2017
- Ischemic cardiomyopathy with remote myocardial infarction and CABGx3
- Recurrent episodes of heart failure exacerbation requiring hospitalization
- Functional class II with good quality of life
- Moderate dose Valsartan and Carvedilol
- Unable to tolerate spironolactone due to mild renal impairment
- September 2017:
  - **EF 17%** (wall motion study) at maximum tolerated doses

# Case



# Is He a Good Candidate for CRT?

## Step 1: Patient Selection

# When to Refer for ICD, CRT-P or CRT-D?

After a diagnosis of HFrEF, standard medical therapy should be initiated and titrated to **target** or **maximally tolerated** doses

Reassessment of the ejection fraction should be performed **3 months** after the achievement of target or maximally tolerated doses of GDMT

Includes switching to **ARNI** therapy in eligible patients and introduction of ivabradine if indicated

Exception: **high risk features**

(e.g. malignant sounding syncope)

# When is CRT Recommended?

Heart failure

LVEF ≤ 35%

LBBB

QRS duration ≥ 150 ms

NYHA II-IV symptoms

On guideline directed medical therapy

# When is CRT Recommended?

Heart failure

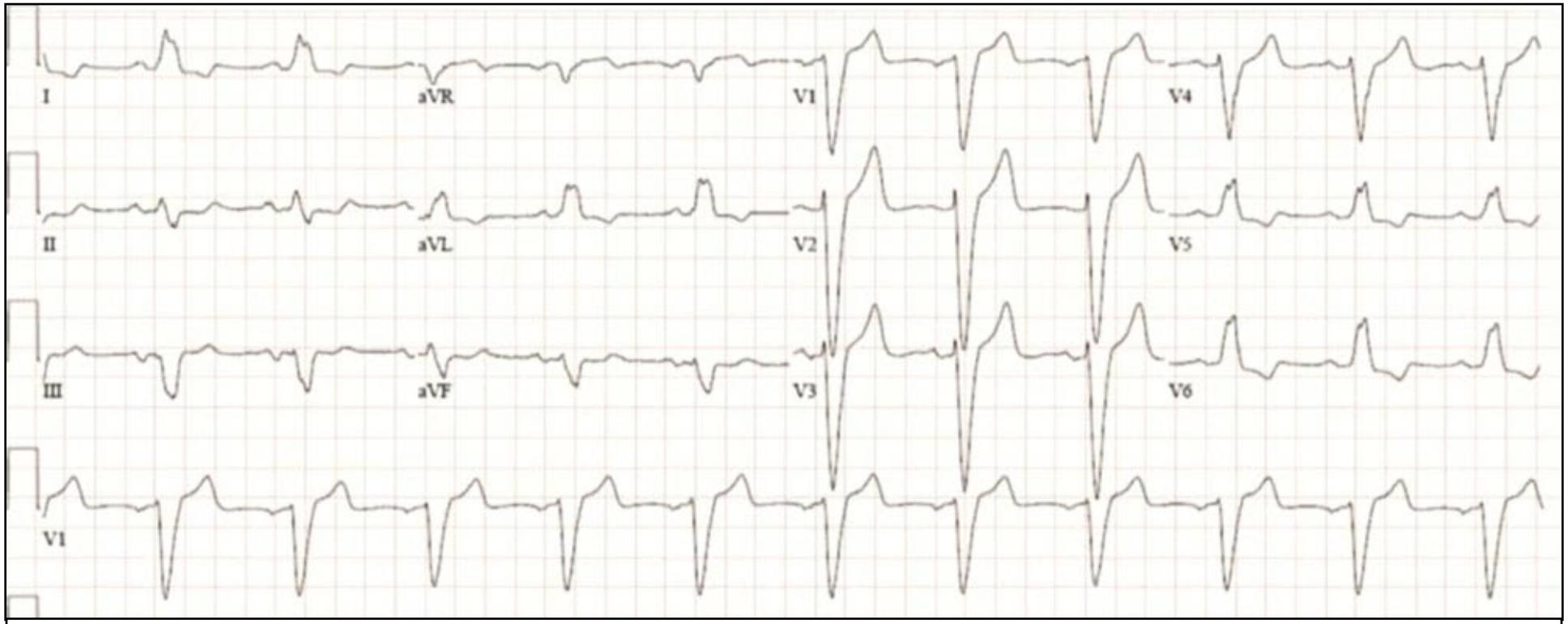
QRS duration ≥ 150 ms

**1** in **4** patients with systolic heart failure has dyssynchronous ventricular contraction

LBBB

On guideline directed medical therapy

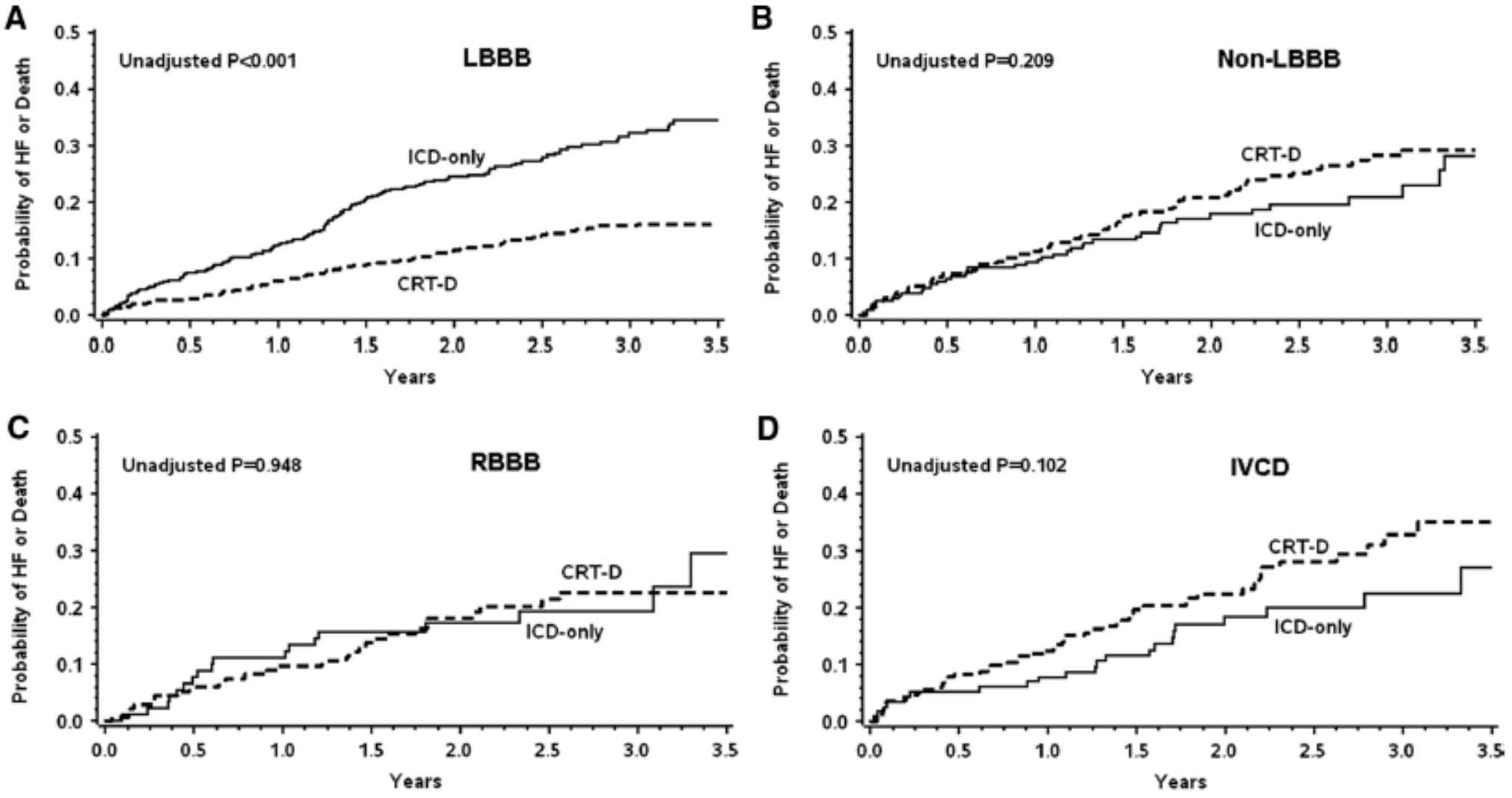
# What is Left Bundle Branch Block?




QRS >= 120ms, notched/slurred R wave in I aVL V5 V6
Absent q wave in I V5 V6
R peak time >60ms in V5 and V6
ST and T wave usually opposite to the QRS

**LBBB pattern does not necessarily mean LBBB**

# Does LBBB Really Matter? YES!




Zereba, Circulation, 2011

# Does Our Patient Fit Standard CRT Criteria?

Heart failure ✓

LVEF ≤ 35% ✓

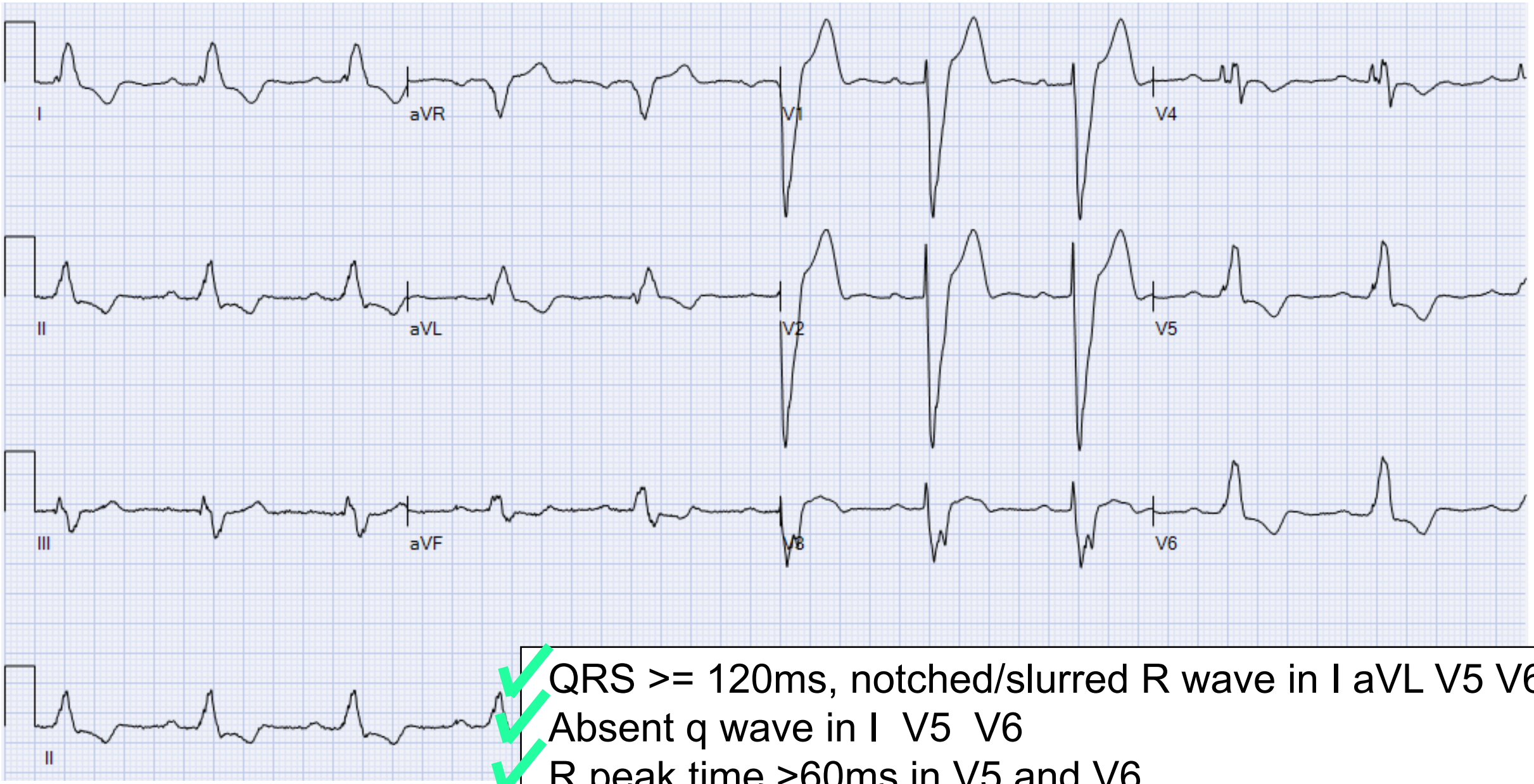
LBBB ✓

QRS duration ≥ 150 ms ✓

NYHA II-IV symptoms ✓

On guideline directed medical therapy ✓

(For the time in 2017)

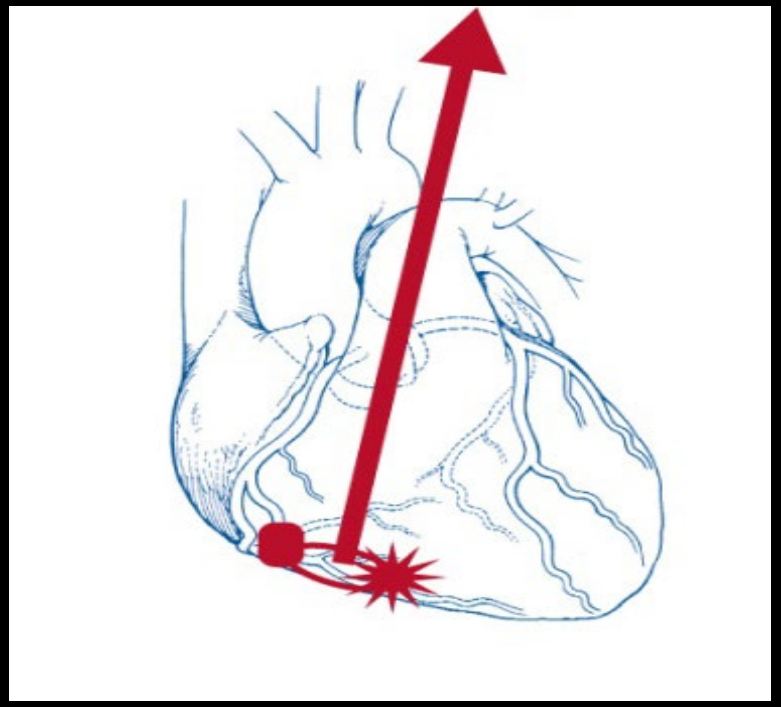



- ✓ QRS >= 120ms, notched/slurred R wave in I aVL V5 V6
- ✓ Absent q wave in I V5 V6
- ✓ R peak time >60ms in V5 and V6
- ✓ ST and T wave usually opposite to the QRS

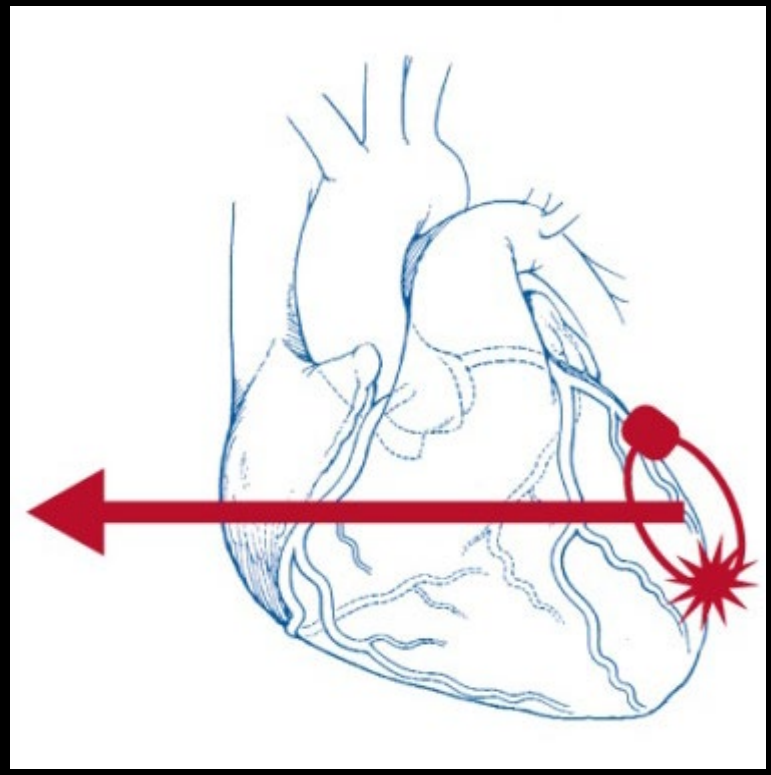
# What Does CRT Do?

- Designed to synchronize the mechanical activity of the ventricles
- Synchronizes the timing of the atria and ventricles among those in sinus rhythm

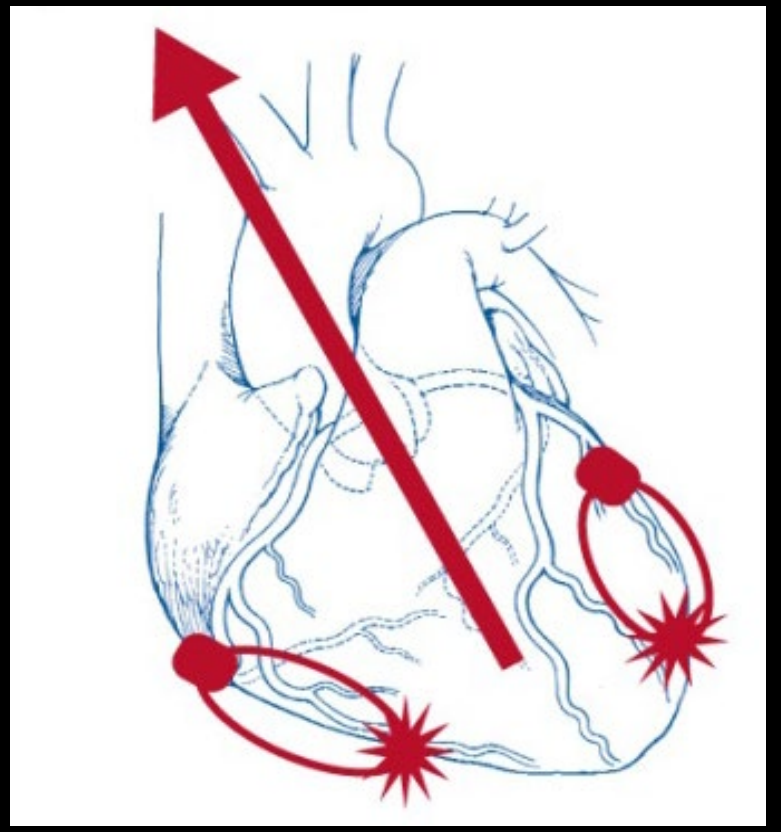
RV pacing



LV pacing



BiV pacing



# The Strength of the Recommendation Varies by Clinical Scenario

| Recommendations for LBBB, sinus rhythm, QRS duration ≥ 150 ms, NYHA class I–IV symptoms | | |
|---|---|---|
| COR | LOE | Recommendations |
| 1 | A | 1. In patients with LVEF ≤ 35%, sinus rhythm, LBBB with QRS duration ≥ 150 ms, and NYHA class II–IV symptoms on GDMT, CRT with BiV pacing is indicated to improve symptoms and reduce morbidity and mortality. |
| 2b | B-R | 3. In patients with LVEF ≤30%, sinus rhythm, LBBB, QRS duration ≥150 ms, and NYHA class I symptoms on GDMT, CRT with BiV pacing may be considered to reduce the risk of worsening HF and potentially improve LV remodeling. |

But does CRT work?

# Landmark Trial: MADIT-CRT

ESTABLISHED IN 1812 OCTOBER 1, 2009 VOL. 361 NO. 14

## Cardiac-Resynchronization Therapy for the Prevention of Heart-Failure Events

Arthur J. Moss, M.D., W. Jackson Hall, Ph.D., David S. Cannom, M.D., Helmut Klein, M.D., Mary W. Brown, M.S., James P. Daubert, M.D., N.A. Mark Estes III, M.D., Elyse Foster, M.D., Henry Greenberg, M.D., Steven L. Higgins, M.D., Marc A. Pfeffer, M.D., Ph.D., Scott D. Solomon, M.D., David Wilber, M.D., and Wojciech Zareba, M.D., Ph.D., for the MADIT-CRT Trial Investigators*

# CRT-D or ICD Only:

# MADIT-CRT

LVEF 30%
QRS>130
NYHA I - II

Primary end point was driven by heart failure events

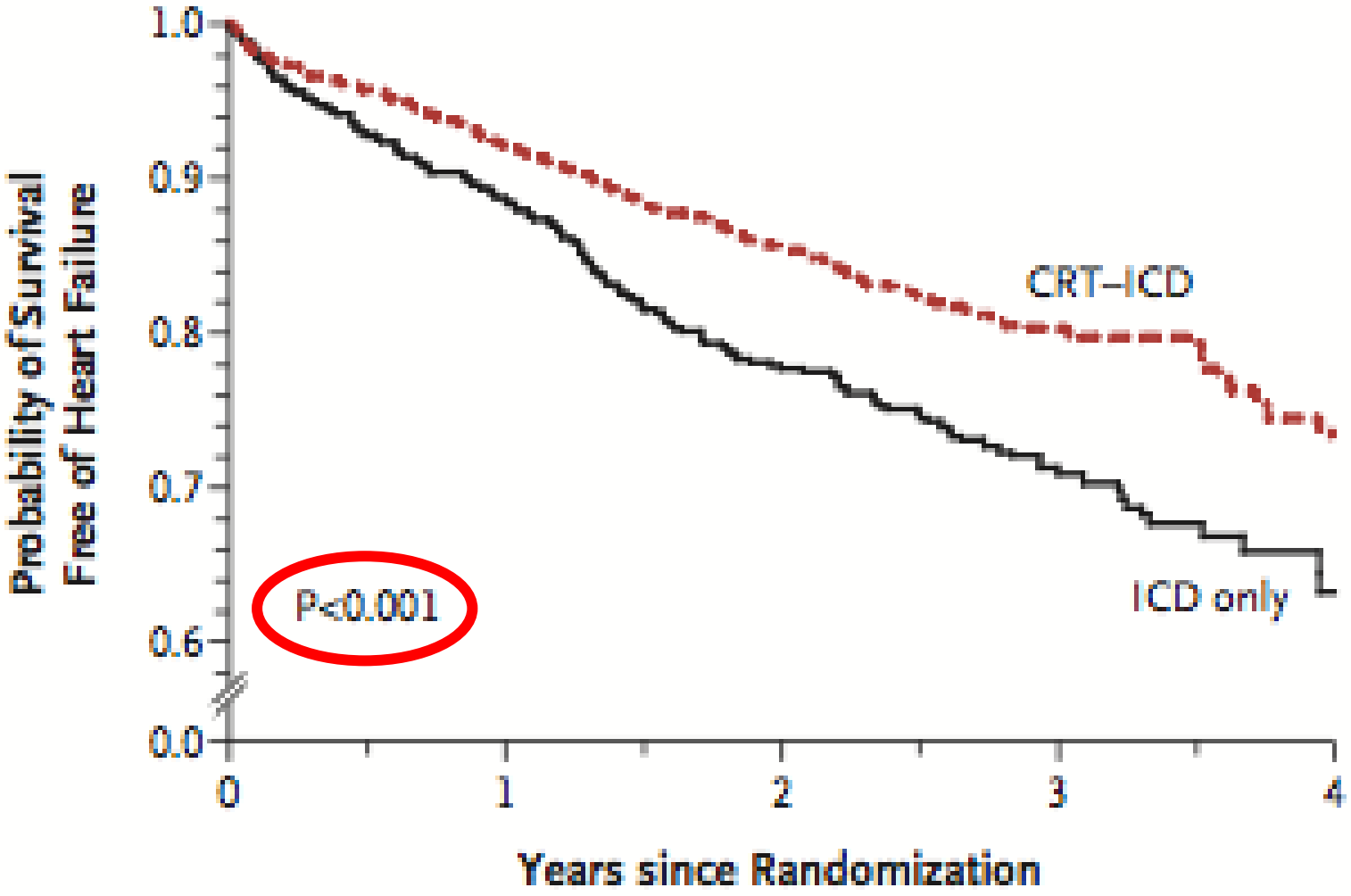
No difference in mortality

**Table 2. Risk of Death or Heart Failure.***

| Variable | ICD-Only Group | CRT–ICD Group | Hazard Ratio (95% CI)† | P Value |
|---|---|---|---|---|
| | *no. (%)* | | | |
| All patients | 731 | 1089 | | |
| Death or heart failure‡ | 185 (25.3) | 187 (17.2) | 0.66 (0.52–0.84)§ | 0.001§ |
| Heart failure only | 167 (22.8) | 151 (13.9) | 0.59 (0.47–0.74) | <0.001 |
| Death at any time¶ | 53 (7.3) | 74 (6.8) | 1.00 (0.69–1.44) | 0.99 |
| Patients with ischemic cardiomyopathy (NYHA class I or II)‖ | 401 | 598 | | |
| Death or heart failure‡ | 117 (29.2) | 122 (20.4) | 0.67 (0.52–0.88) | 0.003 |
| Heart failure only | 105 (26.2) | 96 (16.1) | 0.58 (0.44–0.78) | <0.001 |
| Death at any time¶ | 35 (8.7) | 53 (8.9) | 1.06 (0.68–1.64) | 0.80 |
| Patients with nonischemic cardiomyopathy (NYHA class II)‖ | 330 | 491 | | |
| Death or heart failure‡ | 68 (20.6) | 65 (13.2) | 0.62 (0.44–0.89) | 0.01 |
| Heart failure only | 62 (18.8) | 55 (11.2) | 0.59 (0.41–0.87) | 0.01 |
| Death at any time¶ | 18 (5.5) | 21 (4.3) | 0.87 (0.44–1.70) | 0.68 |

Moss et al. NEJM 361; 14. 2009.

# MADIT-CRT


Probability of Survival Free of Heart Failure
1.0
0.9
0.8
0.7
0.6
0.0
0
1
2
3
4
Years since Randomization
CRT–ICD
ICD only
P<0.001

# What About LBBB with QRS Duration 120–129 msec?

| Recommendations for LBBB, sinus rhythm, QRS duration 120–149 ms, NYHA class II–IV symptoms | | |
|---|---|---|
| COR | LOE | Recommendations |
| 1 | A | 1. In patients with select characteristics (eg, female sex) who have LVEF ≤35%, sinus rhythm, LBBB with QRS duration 120–149 ms, and NYHA class II–IV symptoms on GDMT, CRT with BiV pacing is recommended to reduce mortality and HF events and to improve LVEF. |
| 2a | B-R | 2. In patients who have LVEF ≤35%, sinus rhythm, LBBB with QRS duration 120–149 ms, and NYHA class II–IV symptoms on GDMT, CRT with BiV pacing is reasonable to reduce mortality and HF and to improve LVEF. |

# Predictors of Response to CRT

- Left bundle branch block
- Non-ischemic cardiomyopathy
- Female gender
- Sinus rhythm
- Wider QRS duration

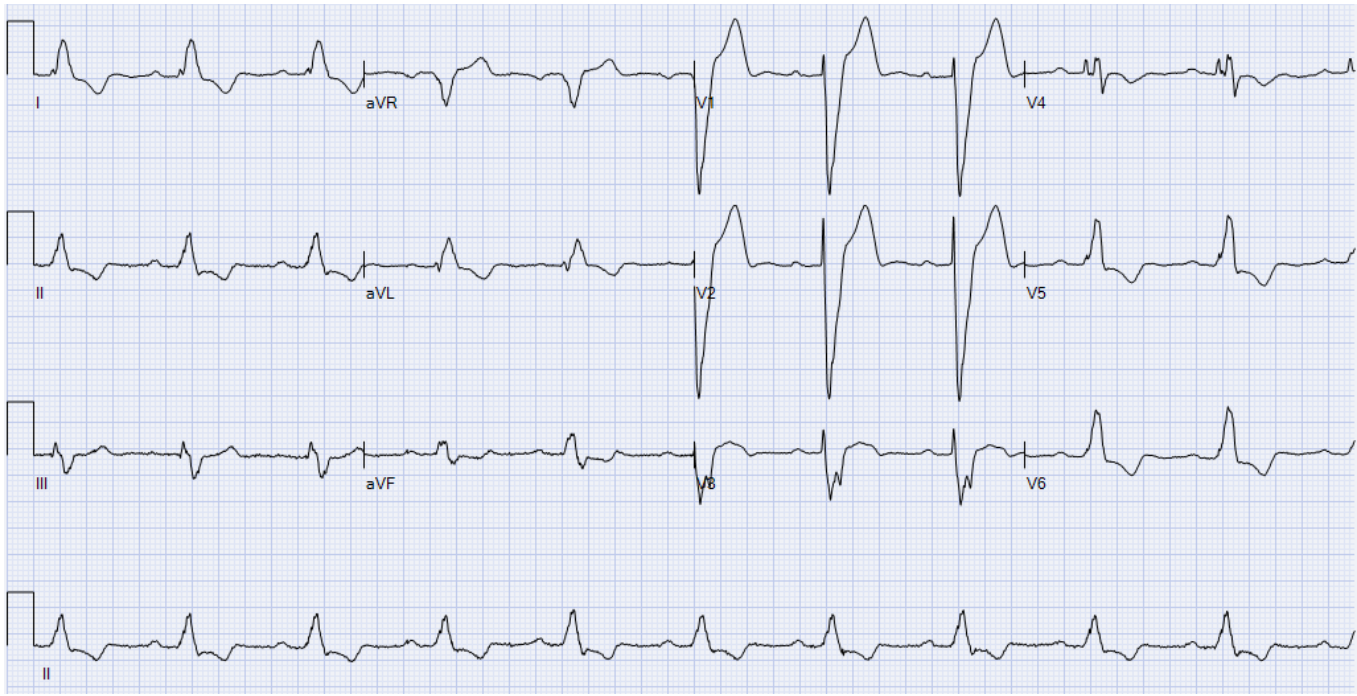
MORE LIKELY TO BE A RESPONDER TO CRT

# How Do We Define Response? It Varies by Study!

- **Response**:
  - LVESV ≥ 10%
  - LVEF improvement
  - All cause mortality
  - Heart failure hospitalization
  - LVESVi
  - Quality of life score
- **Non-response**: lack of improvement in NYHA class, death from CHF, heart transplant, lack of reduction in LVESVi ≥ 15%

# Back to Our Patient …

- **FAVORS CRT:**
  - LBBB
  - QRS duration > 150 ms
  - Maximum tolerated GDMT
  - Symptomatic (FC III)
- **AGAINST CRT:**
  - Male gender
  - Ischemic cardiomyopathy



# Step 2: Lead Placement

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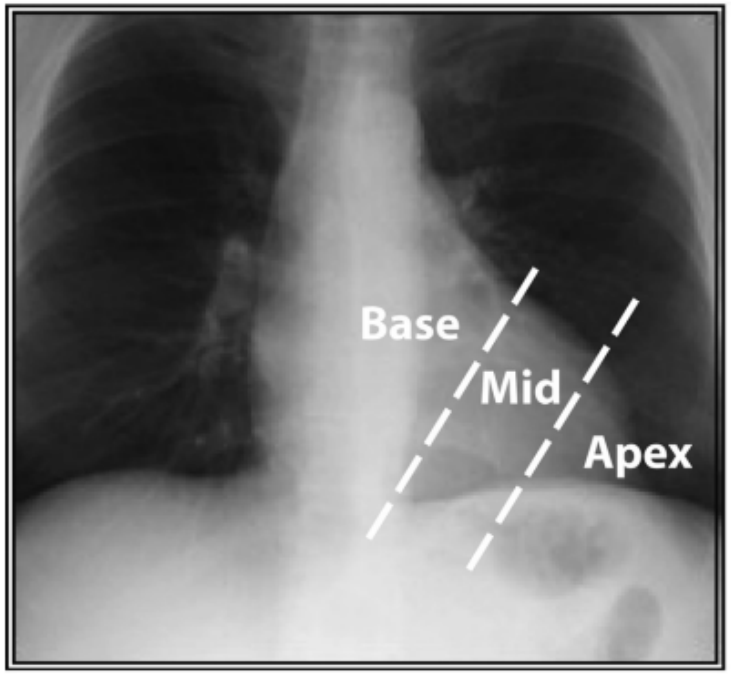
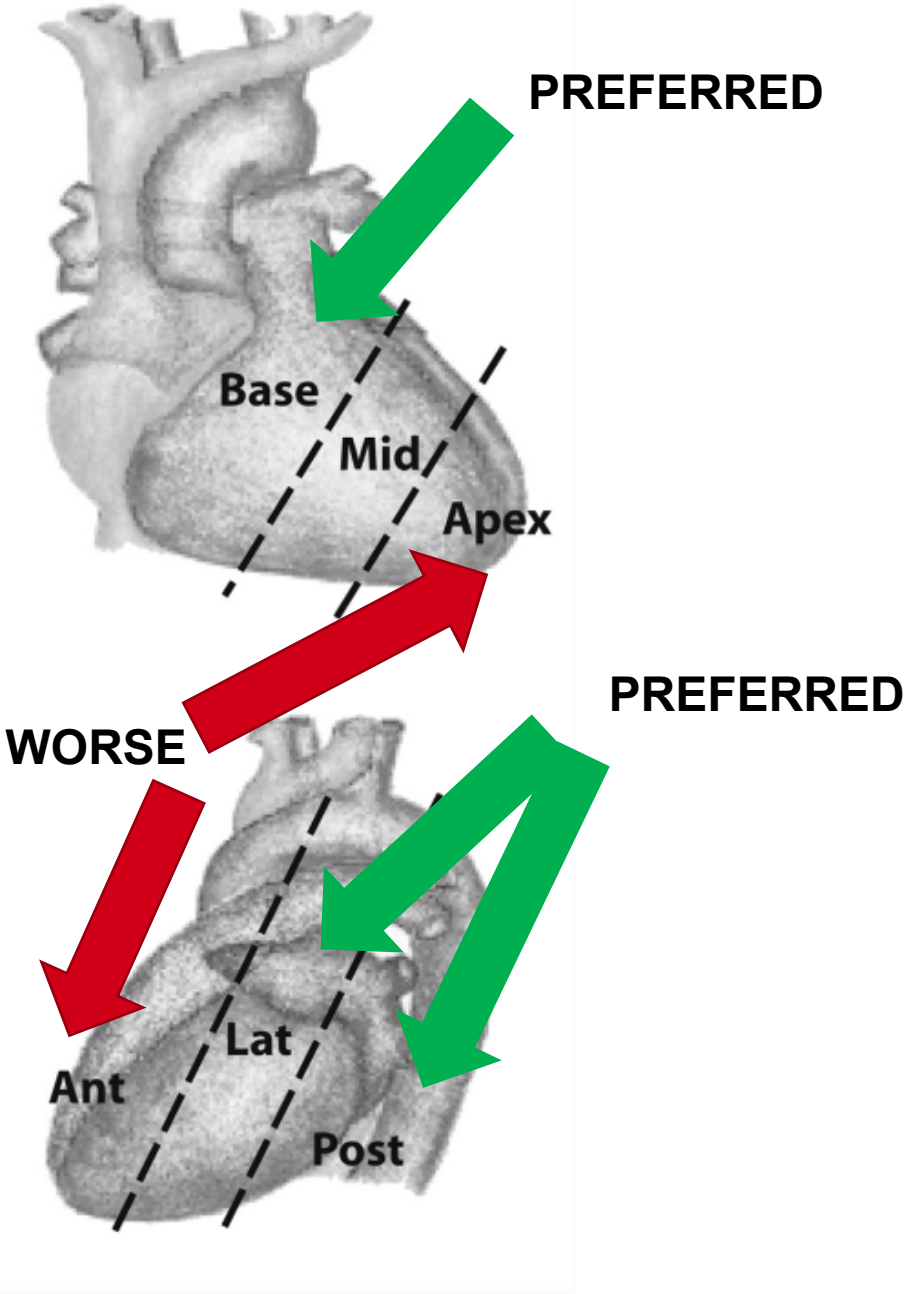
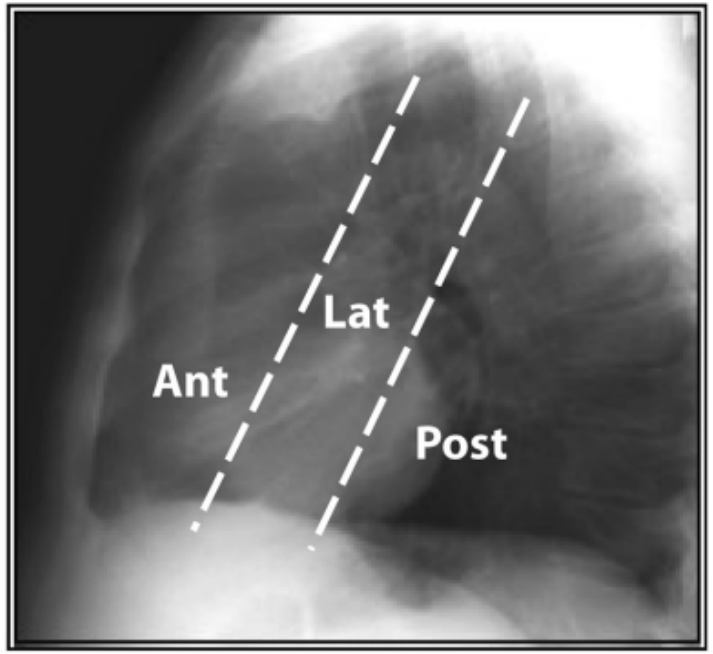
- In a standard CRT-D device – the right ventricular lead is usually placed at the apex
  - Based on lead performance (pacing, sensing, defibrillation)
- What about optimal LV lead position?
  - Worse outcomes if the LV lead is placed in the apical region
  - Attempts should be made to place the LV lead in a non-apical LV epicardial region (e.g. posterior or posterolateral position)
  - Attempt to achieve anatomic and electrical separation of the leads

# Chest X-Ray: PA VIEW

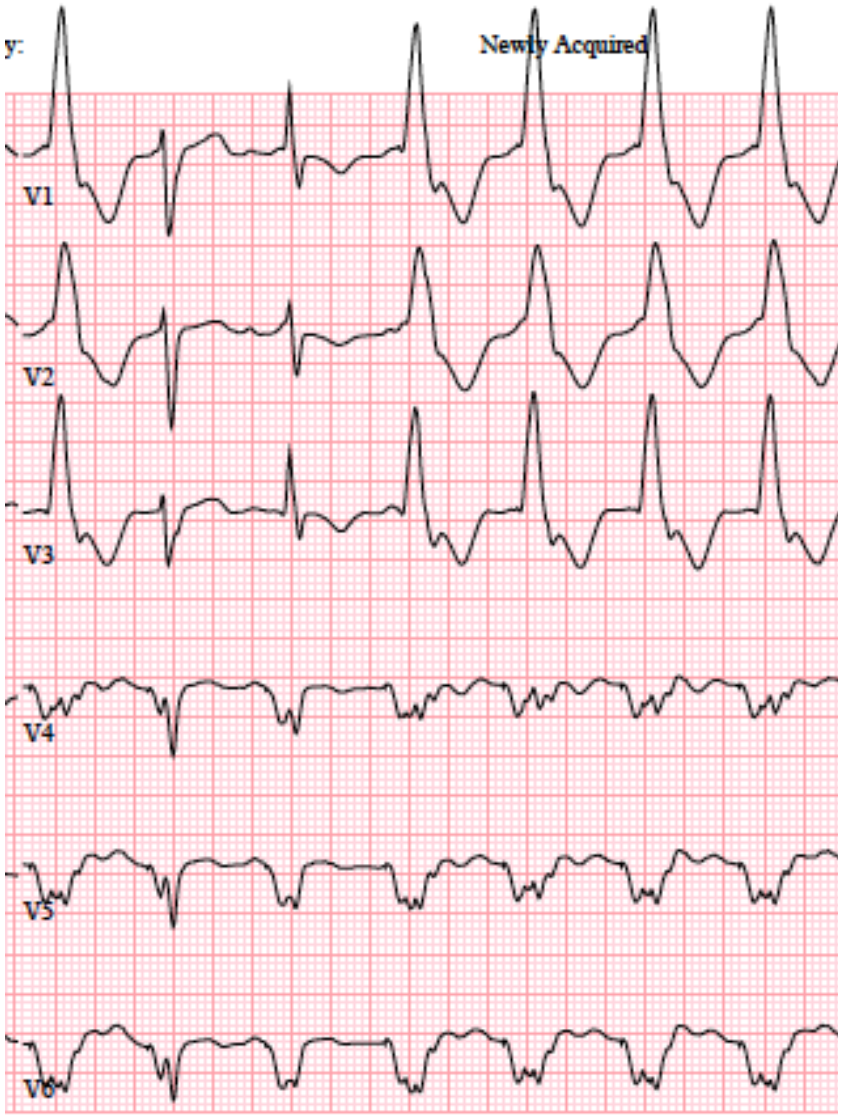



# Chest X-Ray: LATERAL VIEW

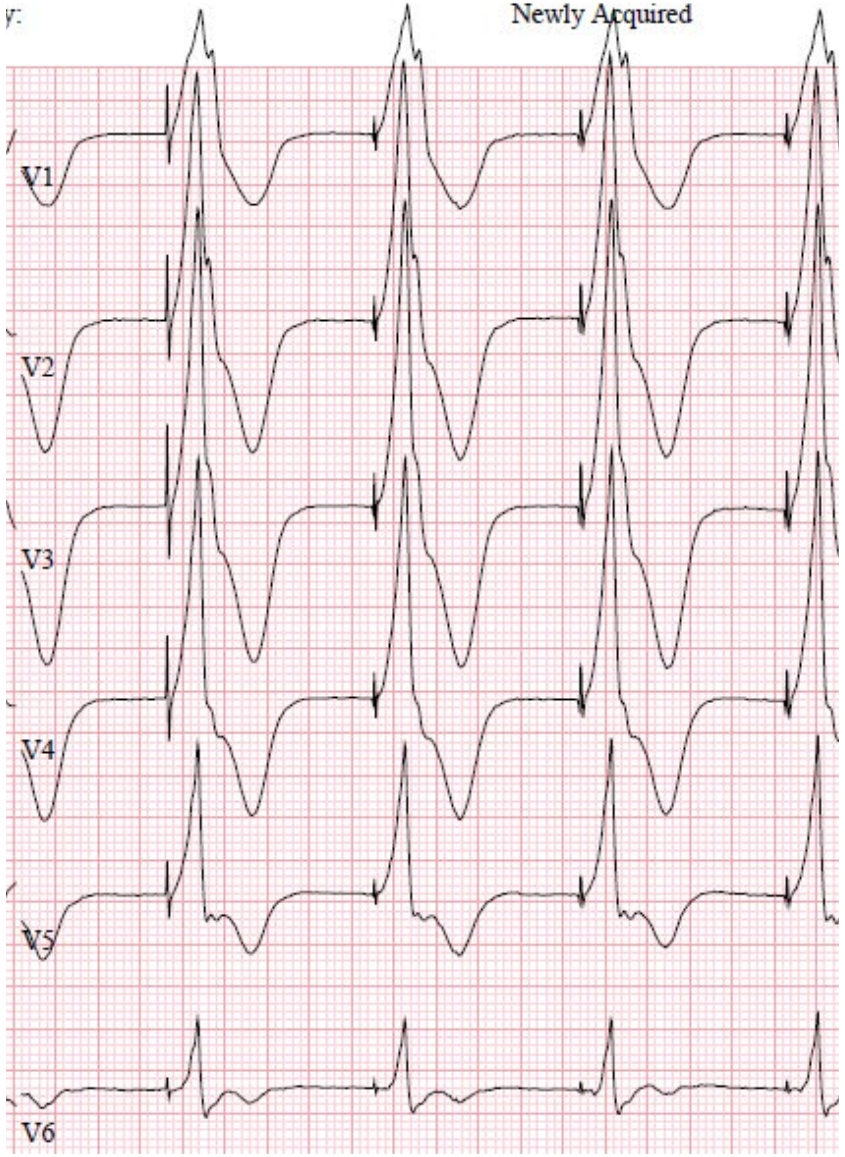


# APICAL LV PACING



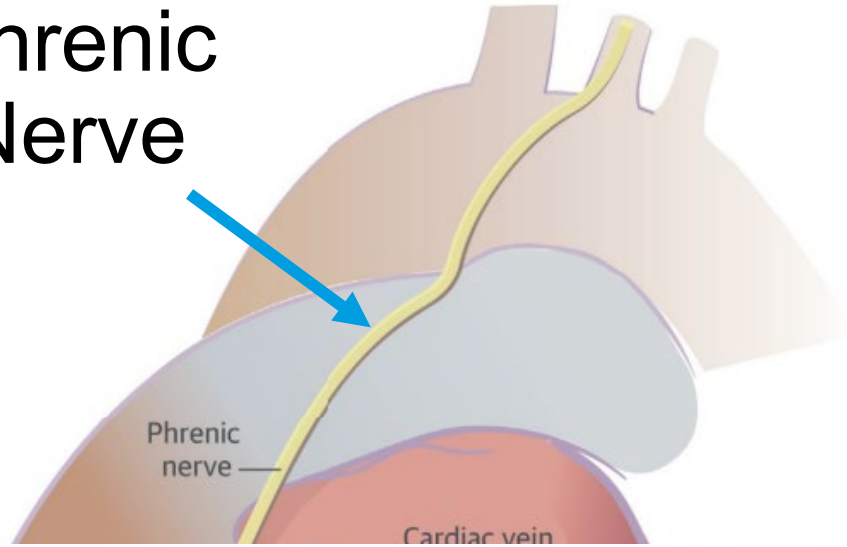

V4-6 NEGATIVE: APICAL

# BASAL LV PACING




V4-6 NEGATIVE: APICAL

## Phrenic Nerve

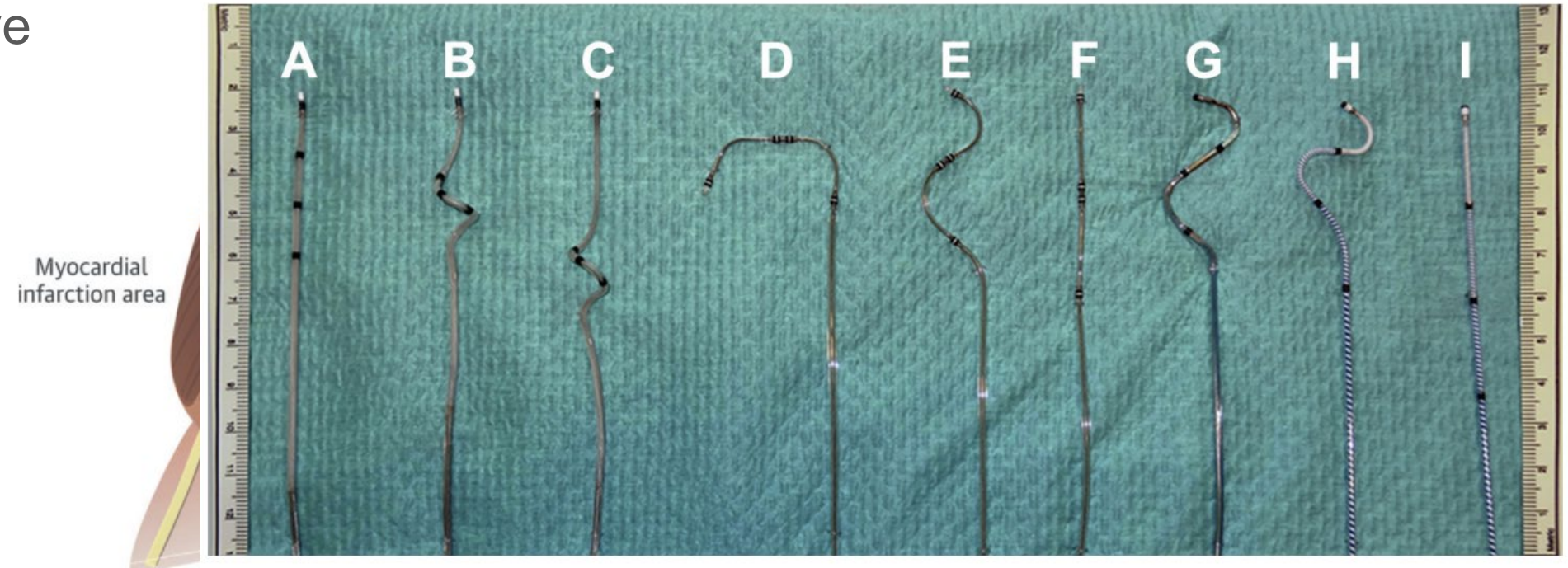


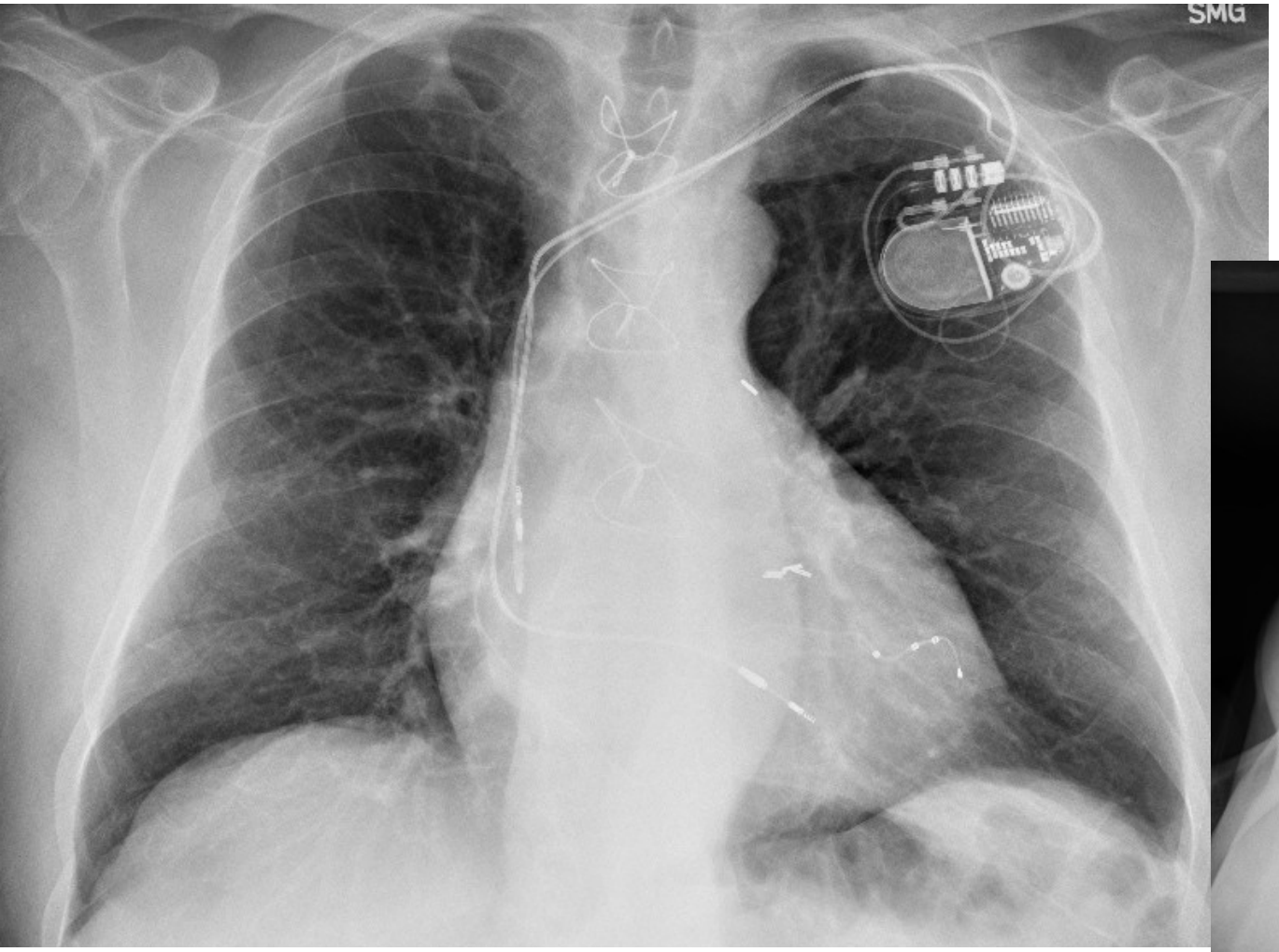

**Potential Limitations**:

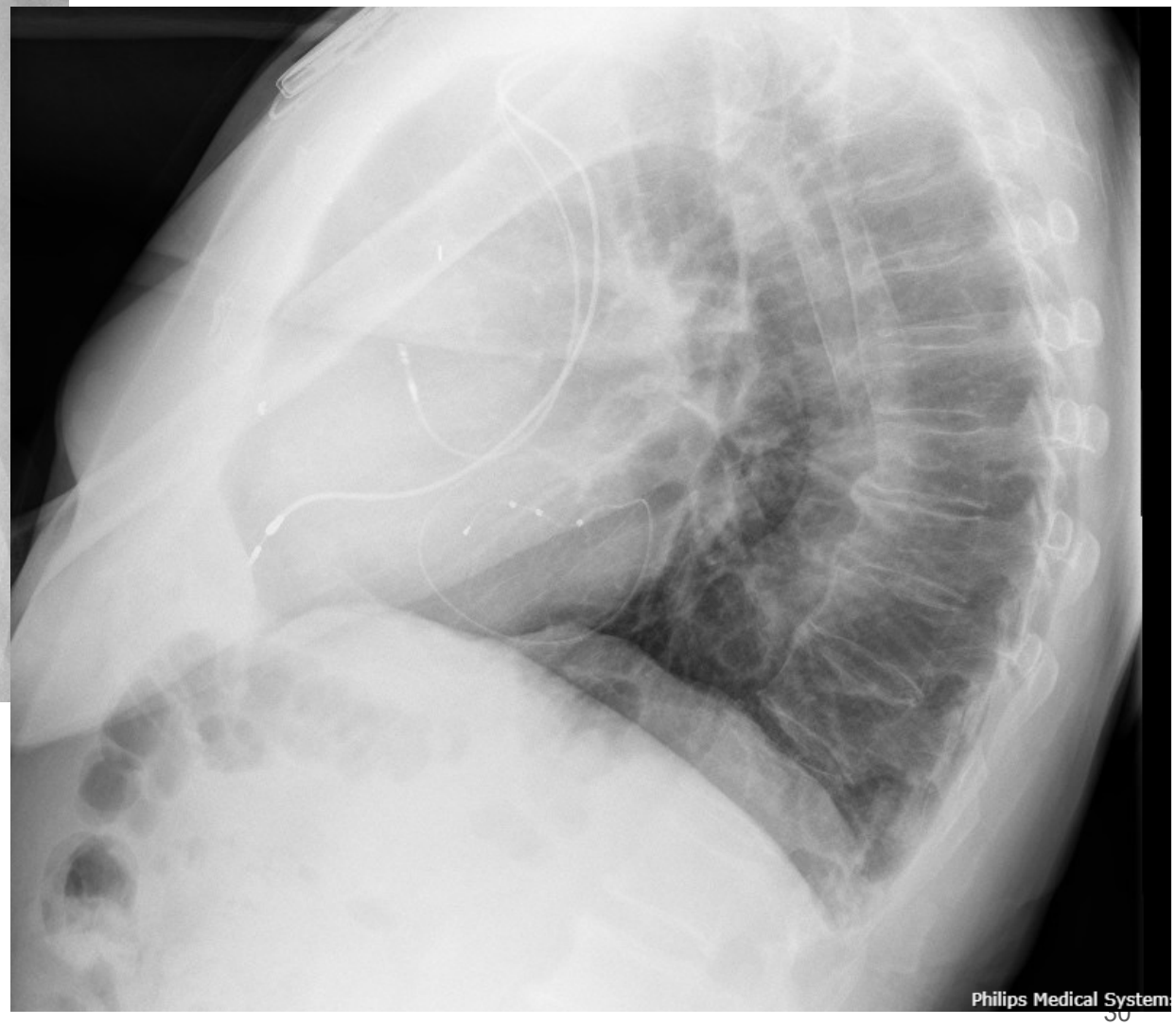
- High thresholds
- Poor anatomical target
- Phrenic nerve capture

**Helpful Tools**

- Quadripolar leads
- Different lead shapes



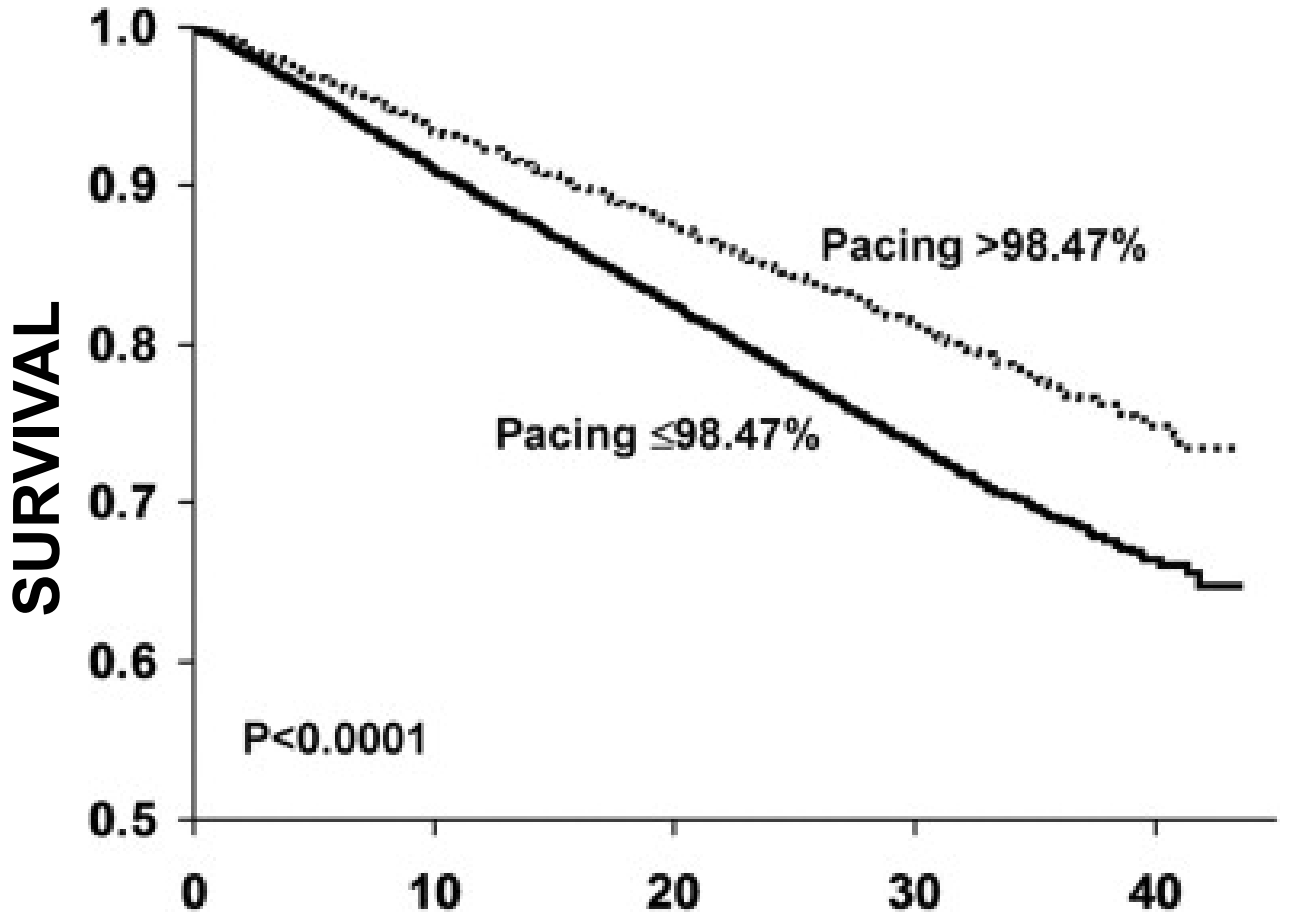

SMG


Philips Medical System

# Step 3: Device Programming

# Ensure Effective CRT Delivery

- Achieve biventricular pacing as close to 100% as possible
- Increased percentages of biventricular pacing is associated with a significant mortality reduction
- The optimal cut-point value: 98.57%

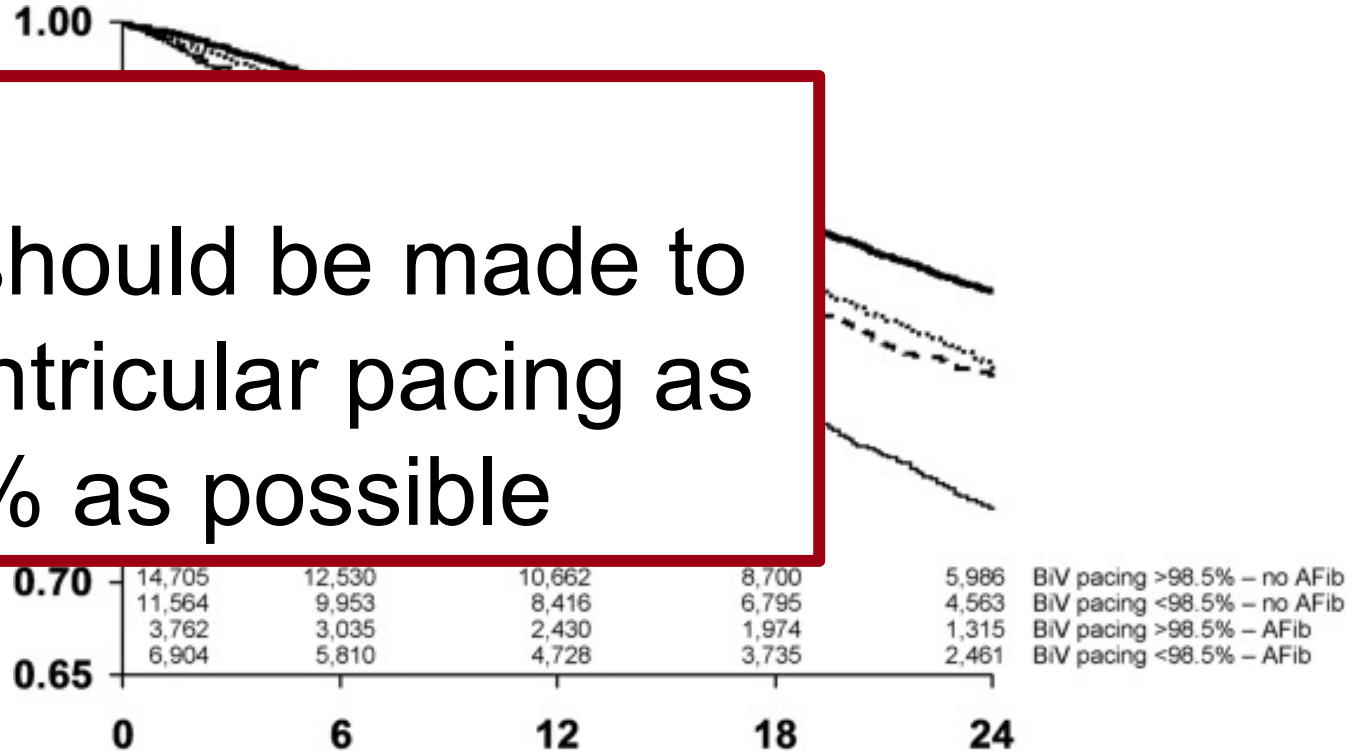



Hayes et al. Heart Rhythm. 2011. 8 (9); 1469 – 1475.

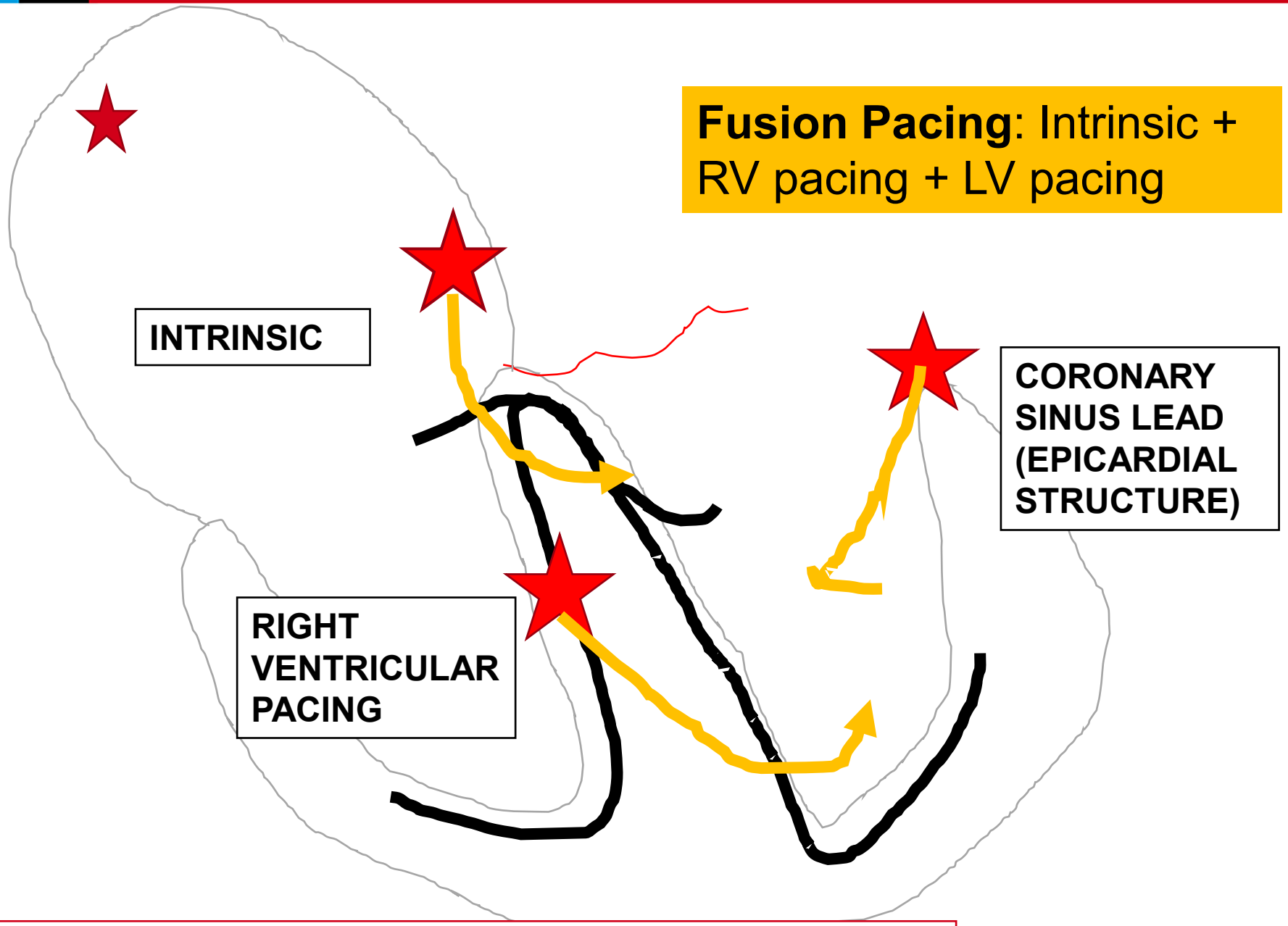
# Ensure Effective CRT Delivery

- The influence of the percentage of biventricular pacing and

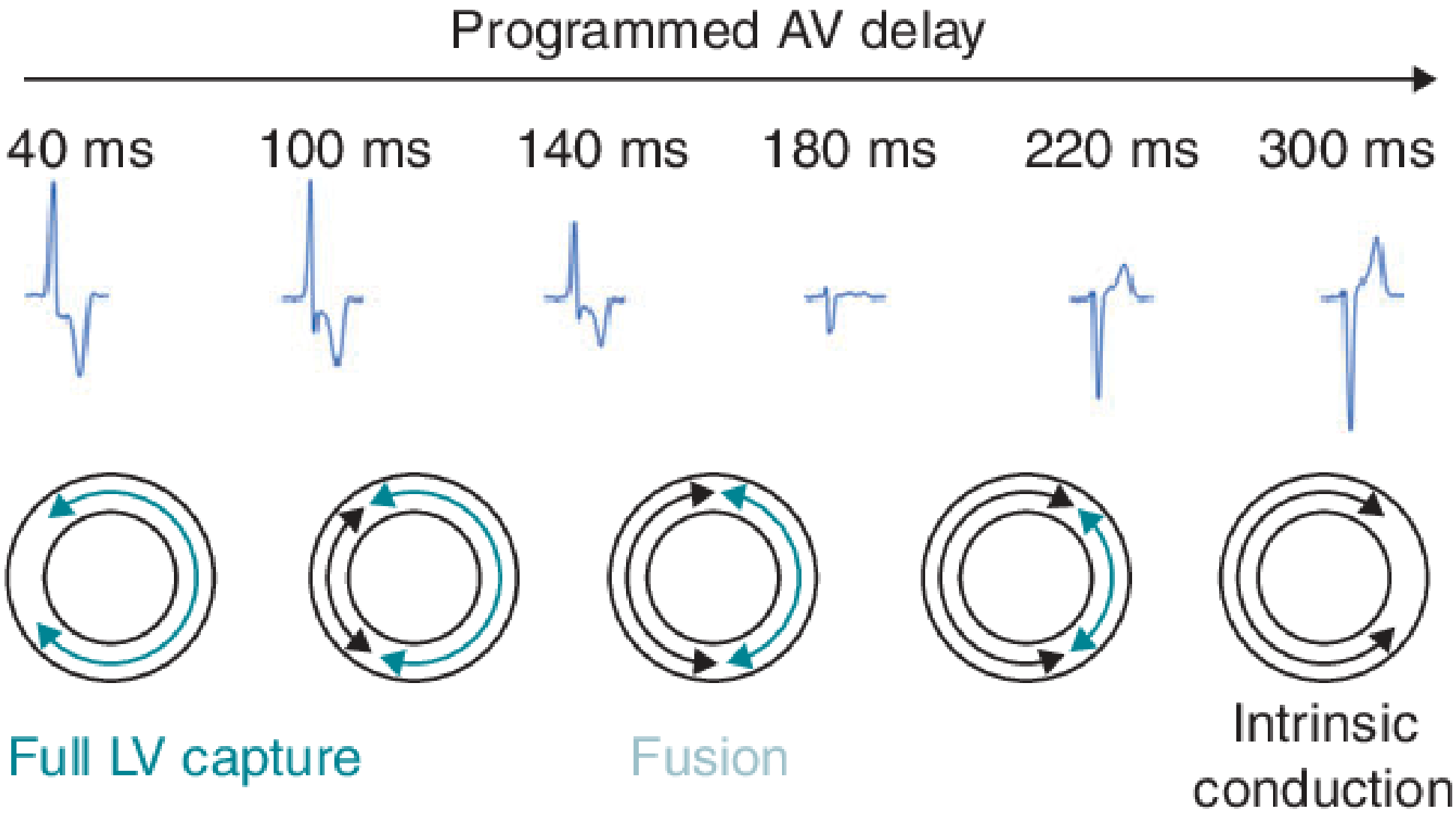
**Conclusion**:
Every effort should be made to achieve biventricular pacing as close to 100% as possible



**Fusion Pacing**: Intrinsic + RV pacing + LV pacing




When there is an intrinsic ventricular rhythm


Programmed AV delay
40 ms
100 ms
140 ms
180 ms
220 ms
300 ms
Full LV capture
Fusion
Intrinsic conduction

# How and why may an individual's AV delay change?

Minutes or hours

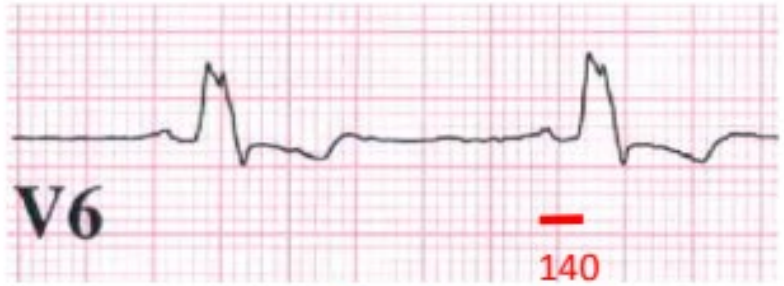
Variation in Activity

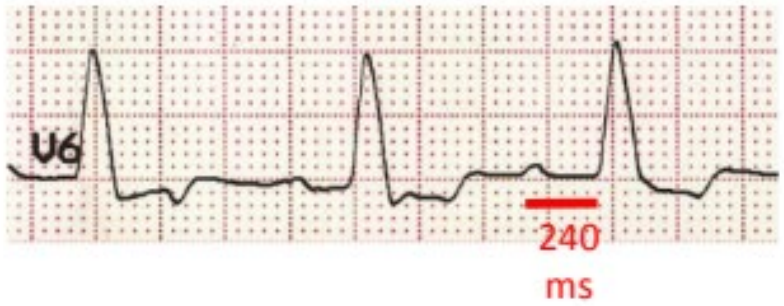
Days or weeks




Change of Meds

Months or years

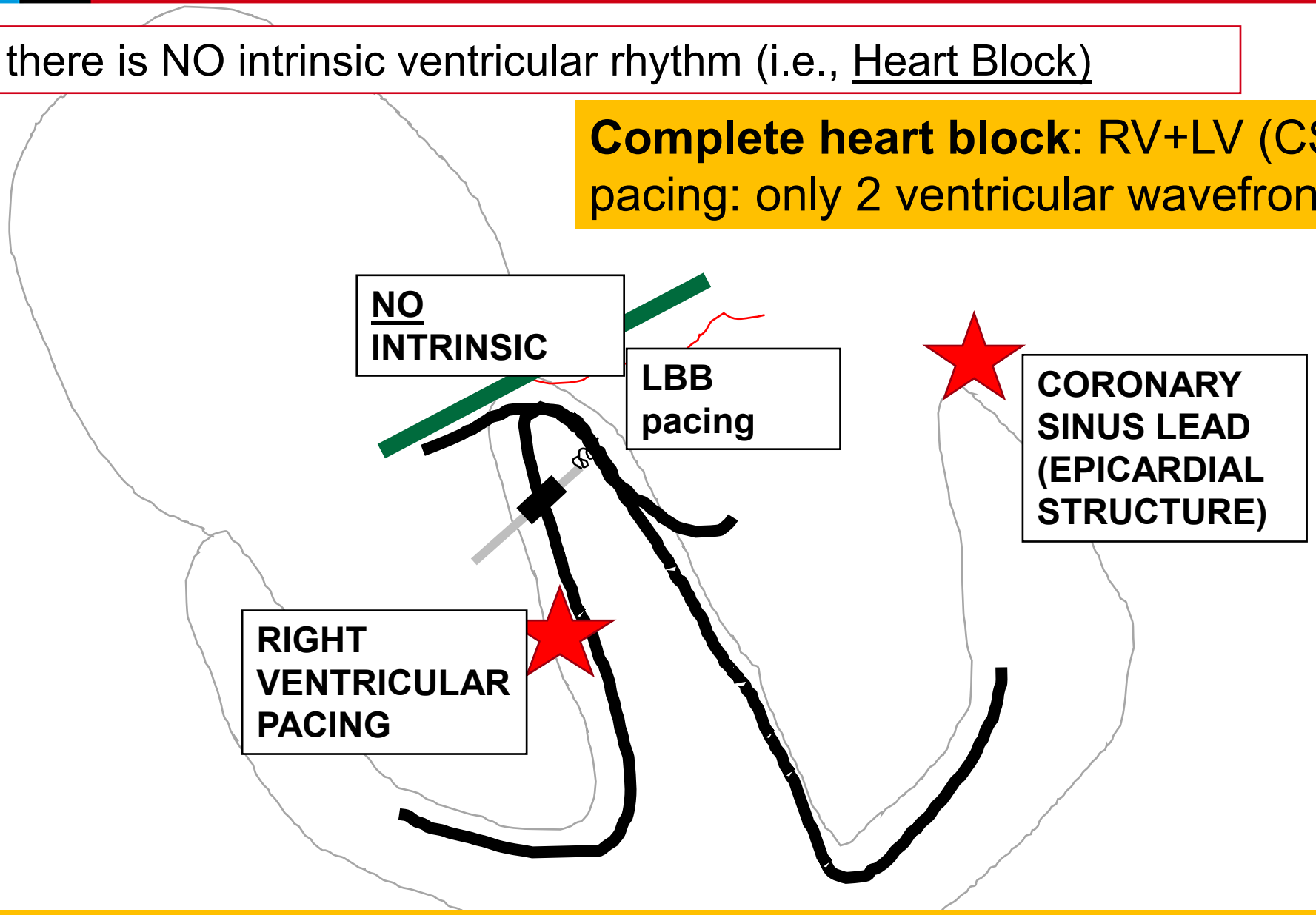



Disease Progression

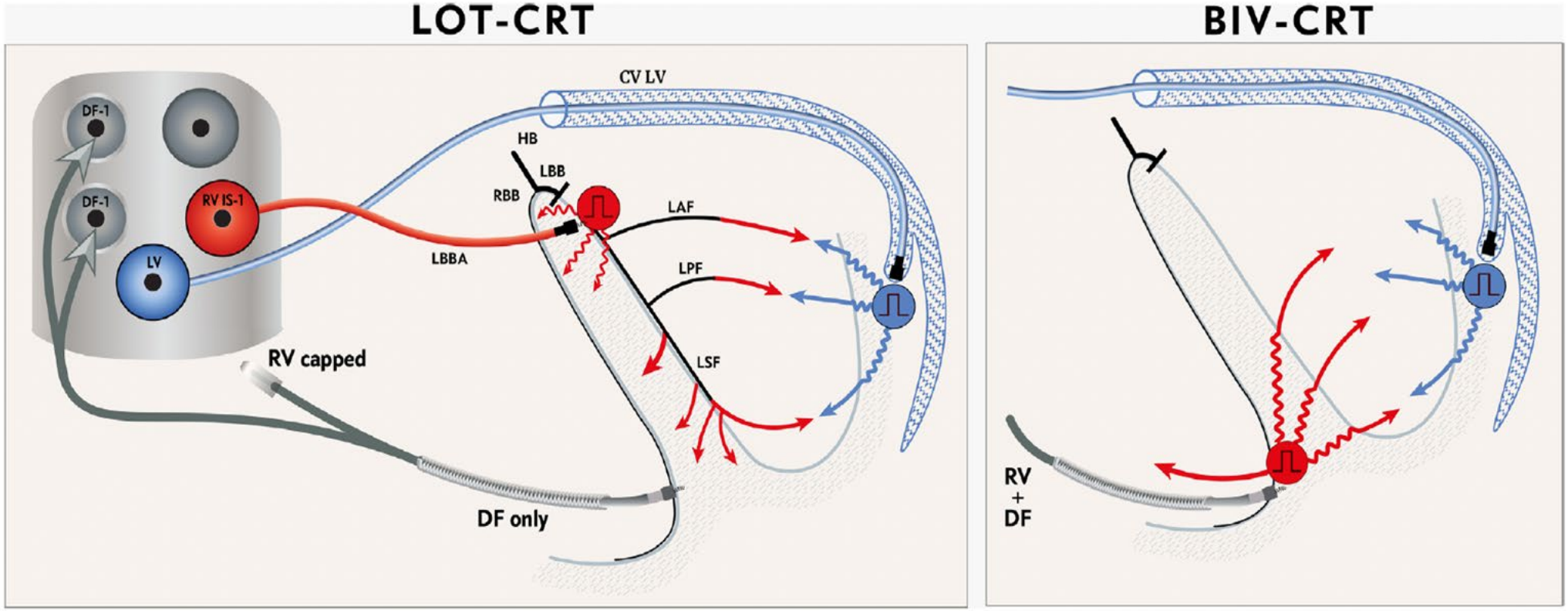
When there is NO intrinsic ventricular rhythm (i.e., Heart Block)

**Complete heart block**: RV+LV (CS) pacing: only 2 ventricular wavefronts




"Up to 1/3rd of CRTs do not improve after biventricular pacing".
-Non-response is not necessarily a failure of CRT, but of appropriate pt selection.

# Left Bundle Branch Optimized CRT




Jastrzebski, Heart Rhythm 2021

# Step 3: Device Programming

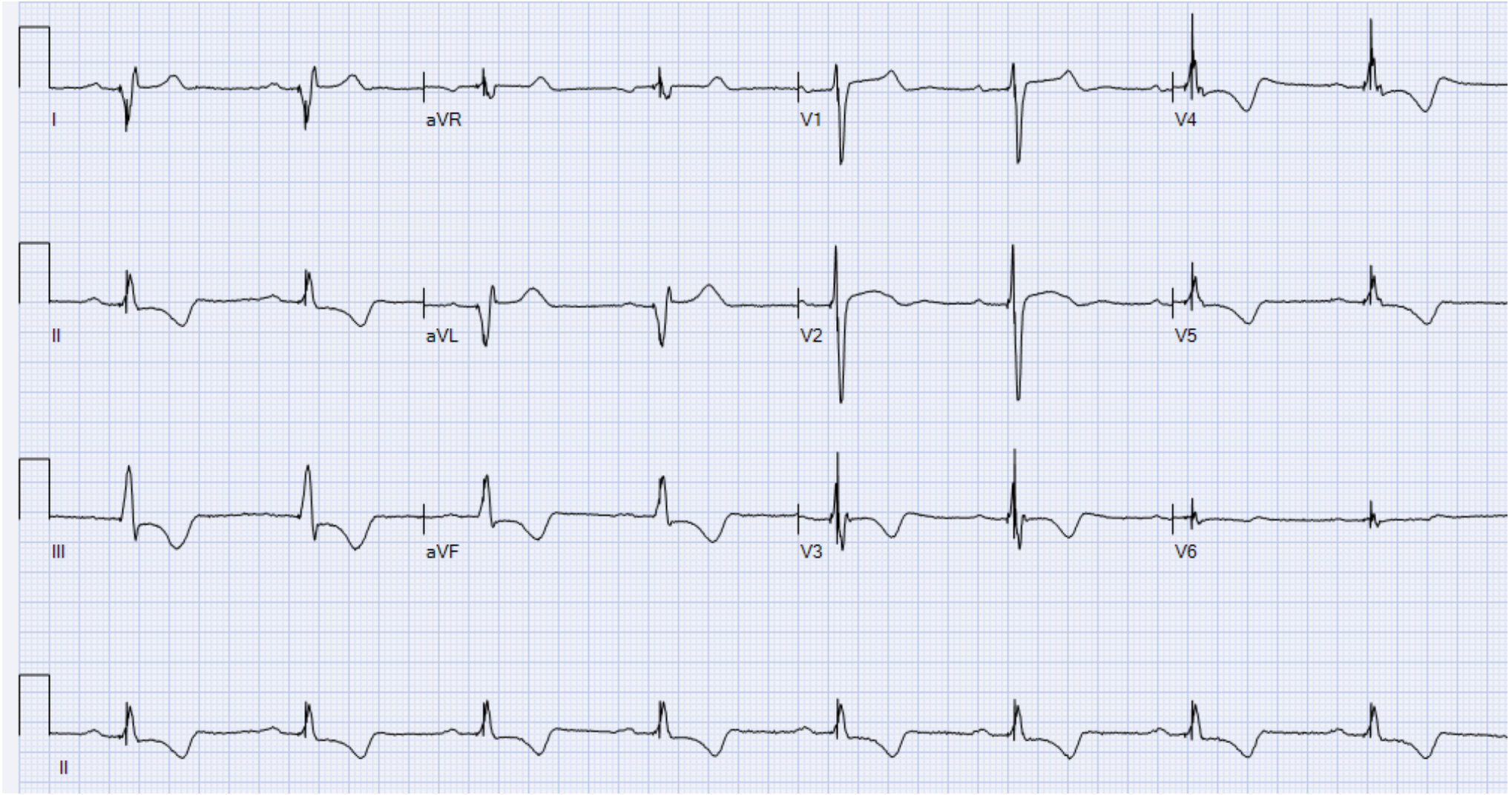
**What Doesn't Work:**

- Echo CRT Optimization
  - Lots of enthusiasm
  - Neutral

**What We Can Program:**

- Atrioventricular intervals (static and dynamic algorithms)
- Fusion with intrinsic conduction on the surface ECG
- Optimal RV activation (adaptive CRT versus SYNC AV) in sinus rhythm
- Narrowing of the QRS duration

# Back to Our Patient



# Back to Our Patient

- As of 2024:
  - Now 89 years old
  - No further episodes of decompensated heart failure
  - Improvement in functional capacity/functional class
  - Continues to have an excellent quality of life
  - Ejection fraction has improved to 38% (echo)

# “Don’t Just Fit and Forget”

- The trigger for referral for CRT should be target dose or maximum tolerated GDMT for HFrEF
- Common limitations include hypotension, bradycardia, pauses, renal injury or some combination
- Blood pressure has been shown to improve after CRT (e.g. COMPANION, CARE-HF) and there is protection from bradycardia, pauses, AV conduction abnormalities
- Crucial to continue the optimization process of medical therapy after CRT implantation
- Similarly – important that the device lab continue to assess that the device is optimally programmed during follow-up based on best evidence

# Future Directions

- LOT – CRT
  - Left bundle branch area pacing-optimized cardiac resynchronization therapy
  - Combines LBBAP and CRT (eliminates RV apical pacing)
- CRT for mild to moderately reduced EF and LBBB
  - Can we improve the progression of heart failure with earlier intervention in heart failure with mild-moderately reduced EF (HFmmrEF)

# Conclusions

- CRT is an important tool in the care of patients with LBBB, heart failure and LV systolic dysfunction
- Must be combined with guideline directed medical therapy
- We need to continue to optimize our patients even after we have declared them “optimized”
  - Uptitrate medications
  - Optimize device programming
- Patient selection is key
- Surgical technique and device programming should incorporate best evidence to enhance likelihood of response

# Q&A Period

# THANK YOU!

## Please remember to complete the session evaluation

**Next Up! Please make your way down to the *Exhibit Hall (Samuel ABC) for a Health Break* and then proceed to the *Champlain Ballroom for Plenary 2 Clinical Pearls and Conundrums in HF Clinical Care* beginning at 3:00 pm.**