Korean AdaptivCRT Registry Study:

*Real-world effectiveness of **automated dynamic optimization** and **left ventricular-only pacing** algorithm of CRT*

Dr. Seung-Jung Park

Samsung Medical Center
Sungkyunkwan University
School of Medicine
Seoul, Korea

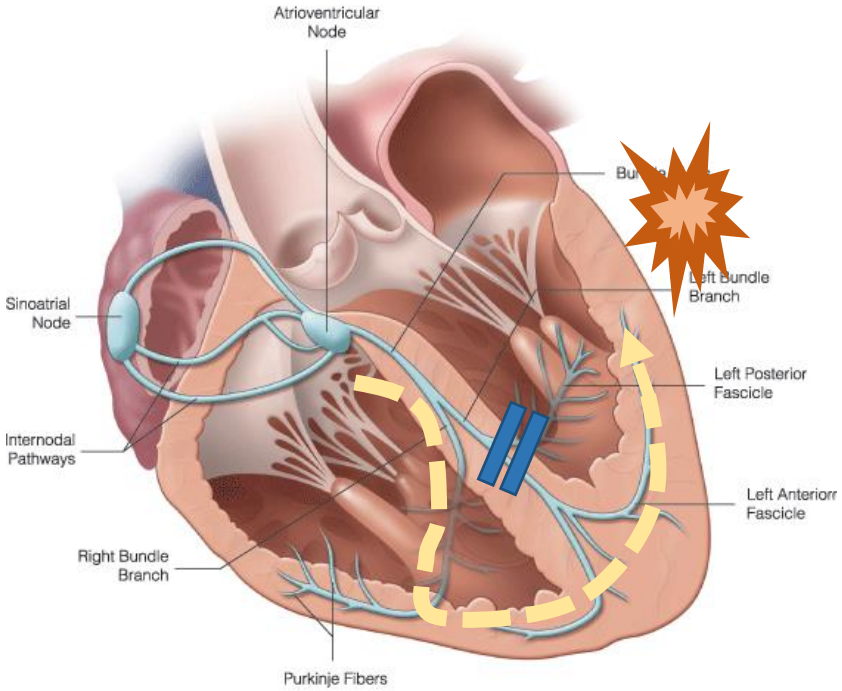
Korean Heart Rhythm Society

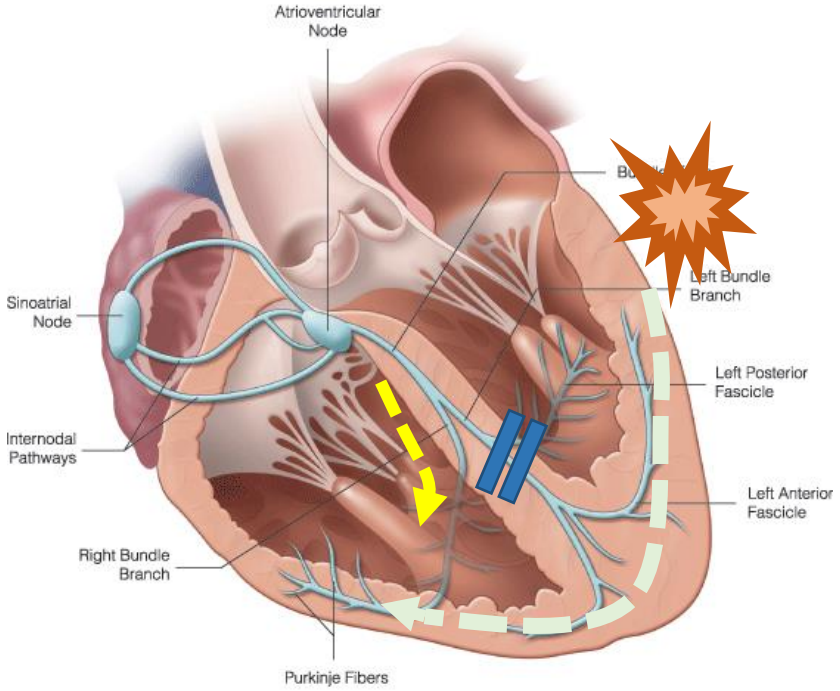
COI Disclosure

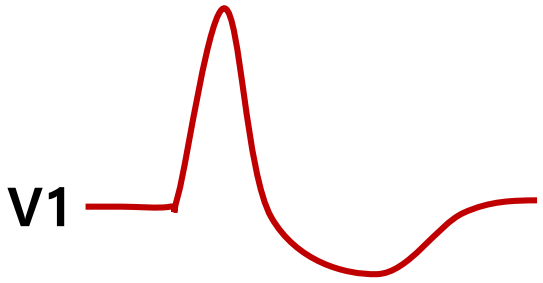
Relationships with commercial interests:

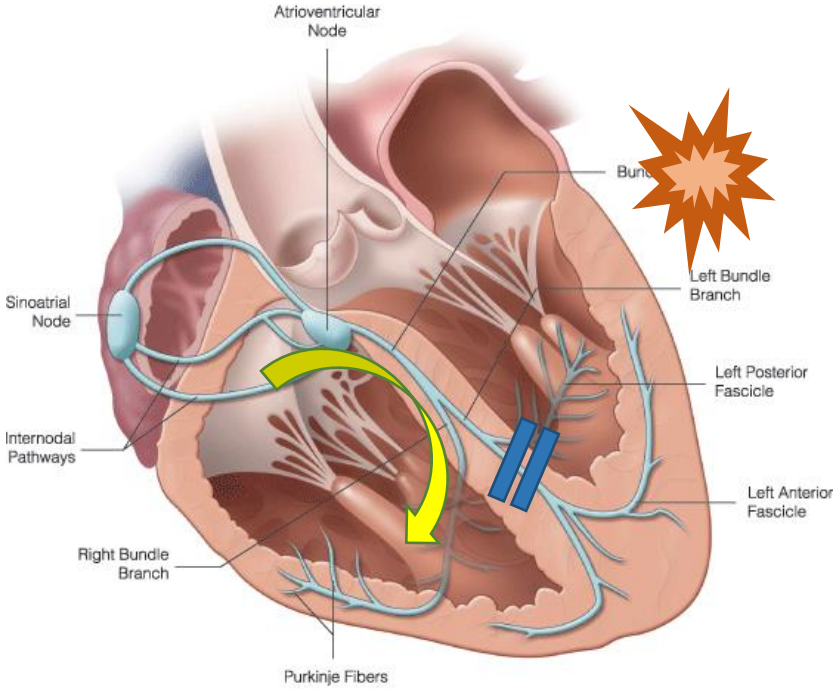
- Grants/Research Support:
  Boston Scientific, Biotronik, Abbott, Medtronic
- Speakers Bureau/Honoraria:
  Boston Scientific, Biotronik, Abbott, Medtronic, Phillips

CRT in LBBB



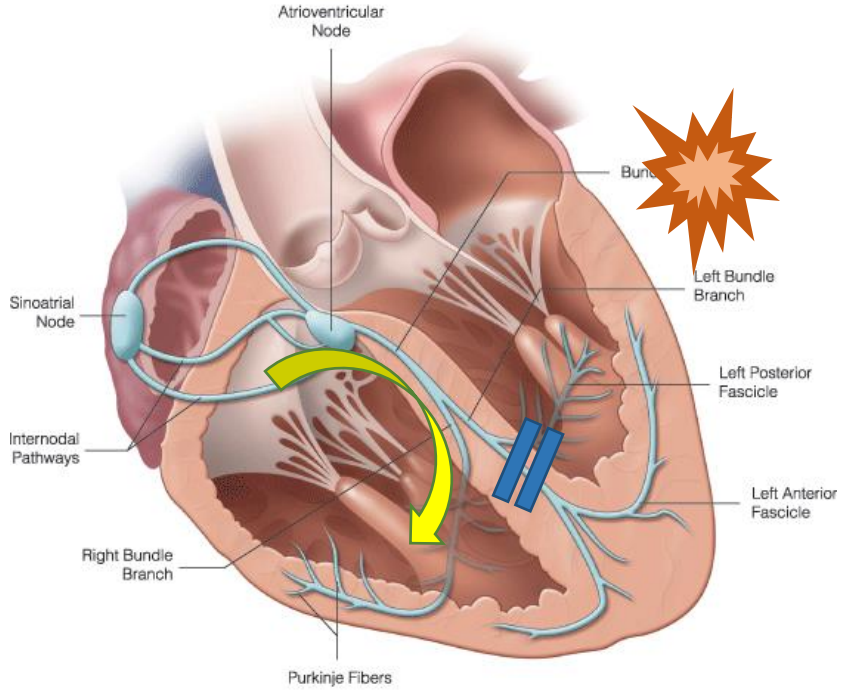




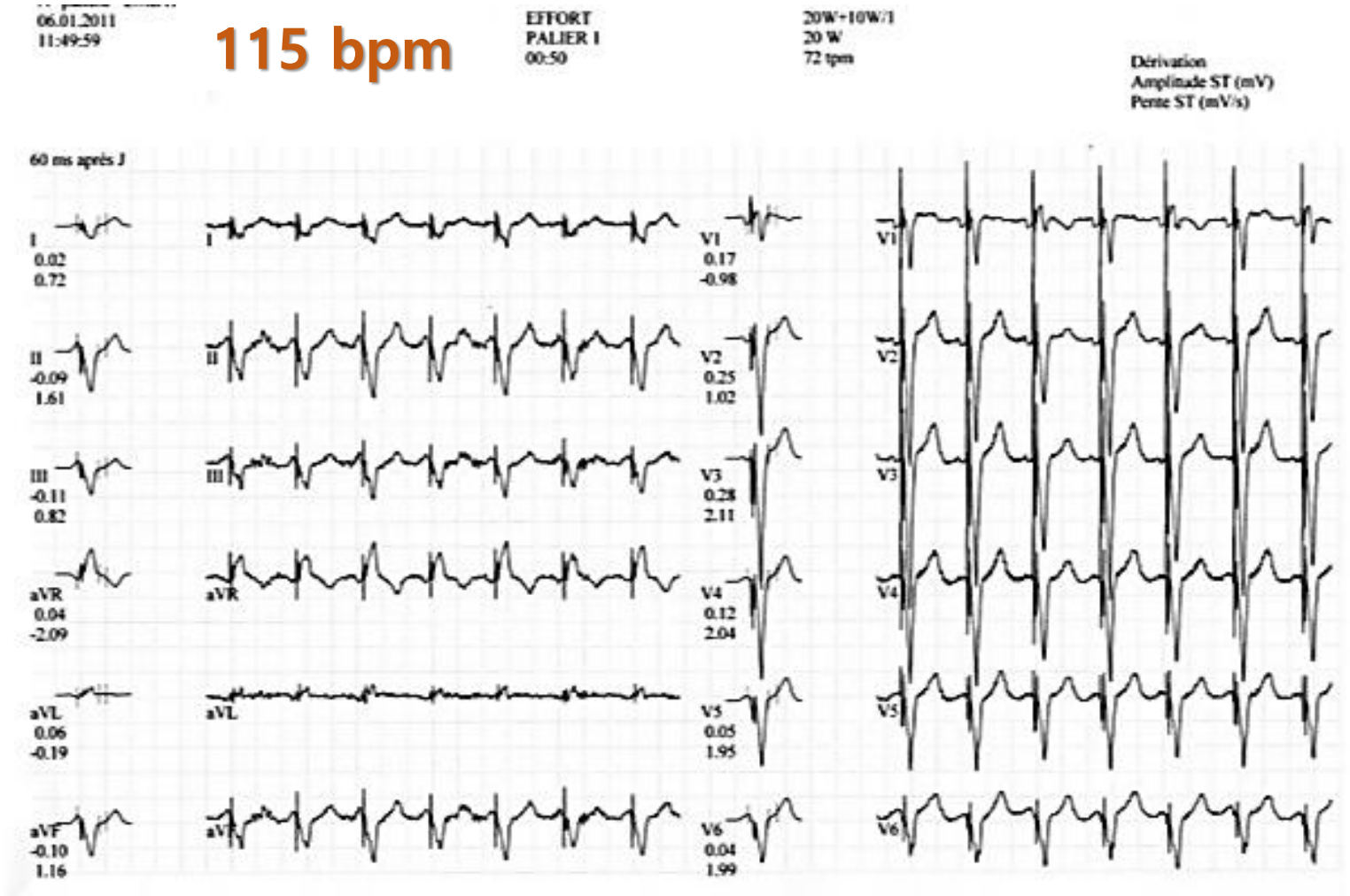


KHRS 2023

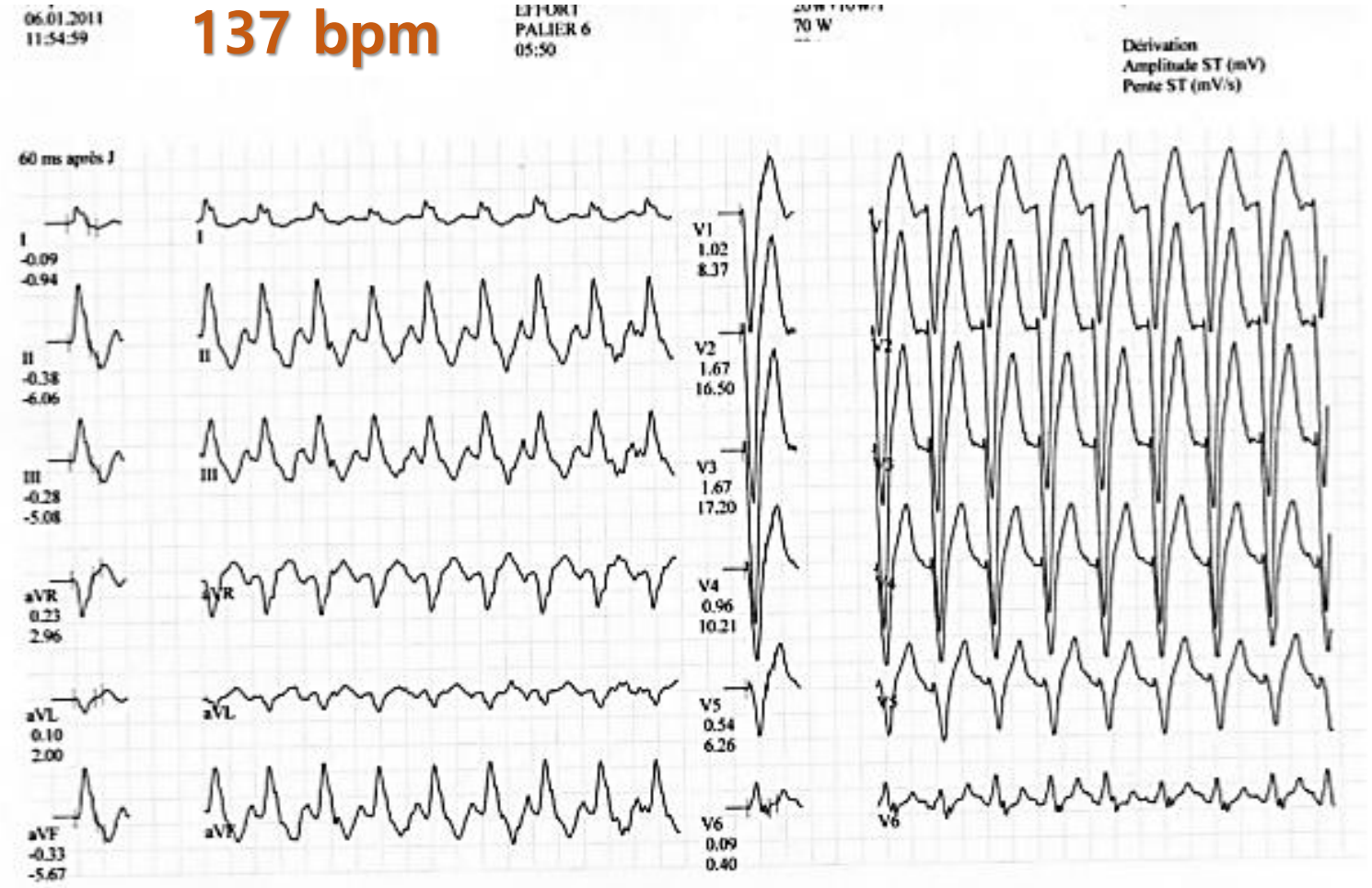
Intrinsic conduction changes according to patient's activity



BiV pacing during low grade activity

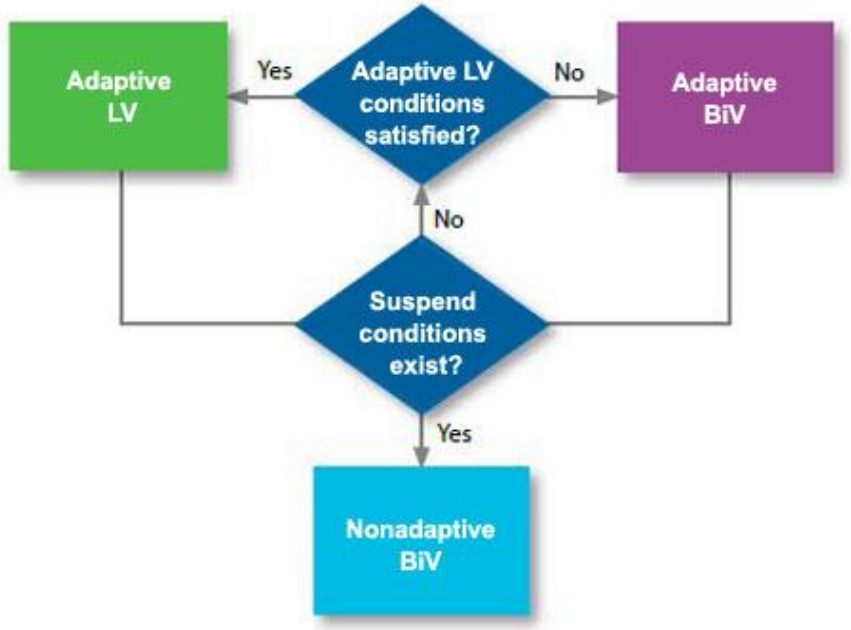


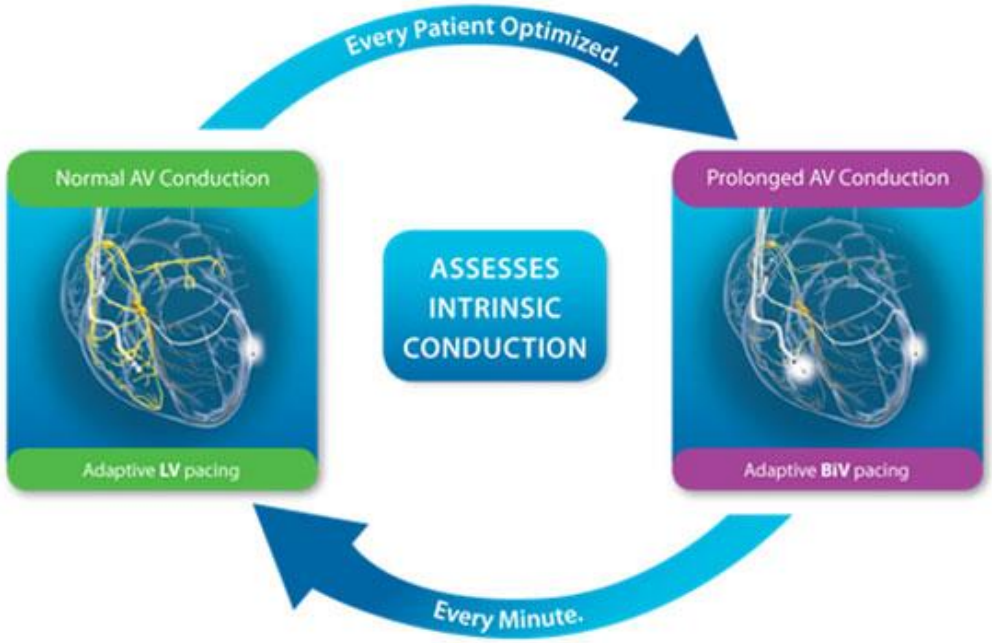
Loss of Effective BiV pacing during Exercise



Adaptive CRT

- AdaptivCRT **automatically** and **dynamically optimizes** the CRT pacing configuration (i.e., AV/V-V delays) according to intrinsic rhythm conduction status and level of patients' activity every minute.

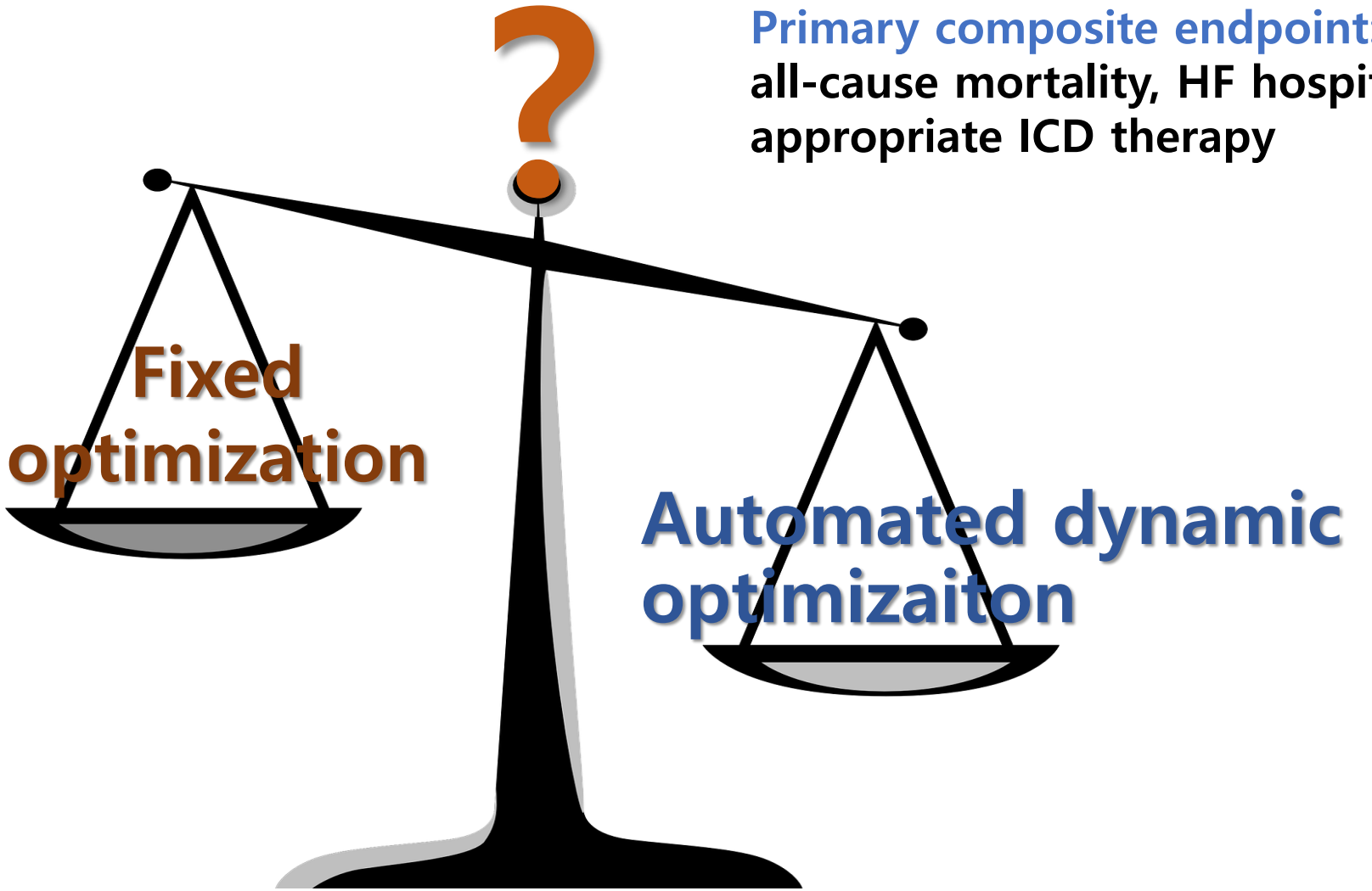




Adaptive CRT options

Non-Adaptive BiV	Conventional BiV pacing with **fixed AV/VV** interval & VV pacing configuration
Adaptive BiV	Biventricular pacing with Automatic **AV/VV** optimization & VV pacing configuration (LV→RV, RV→LV)
Adaptive BiV & LV	Adaptive **LV only** ←→ Adaptive **BiV** pacing

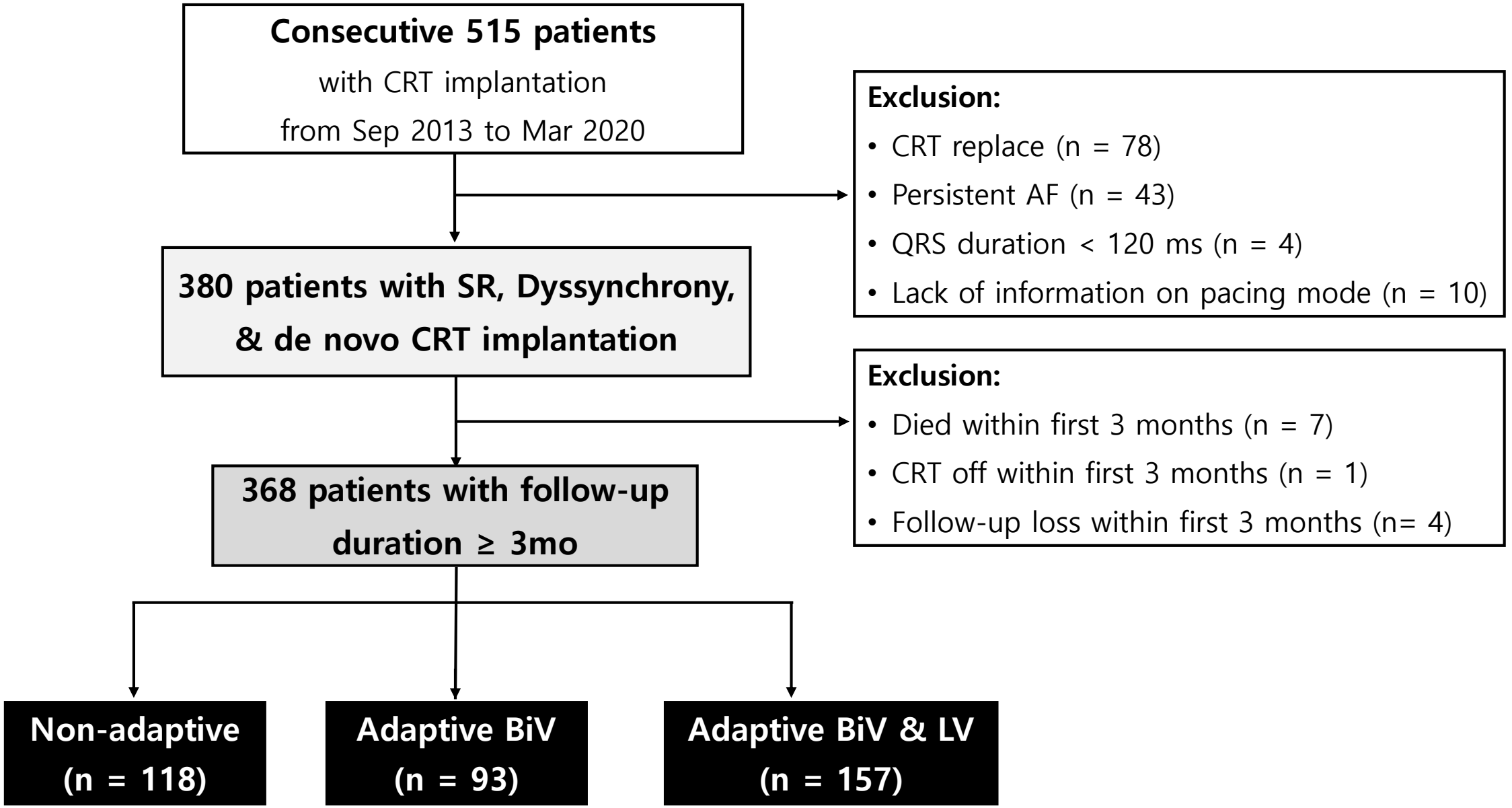
Korean AdaptivCRT Registry Study



Primary composite endpoint:
all-cause mortality, HF hospitalization, and appropriate ICD therapy

Study design

- Retrospective, multi-centered study
- **25 tertiary centers** in Korea
- Enrollment period: September **2013** to march **2020**
- Inclusion criteria
  - Patients ≥ 19 years old
  - CRT-indicated patients with symptomatic HF, NYHA Fc II-IV
  - CRT implantation with **adaptive CRT algorithm**
- Exclusion criteria
  - CRT generator or lead replacement
  - QRS duration <120 ms
  - Persistent atrial fibrillation


Consecutive 515 patients
with CRT implantation
from Sep 2013 to Mar 2020
Exclusion:
• CRT replace (n = 78)
• Persistent AF (n = 43)
• QRS duration < 120 ms (n = 4)
• Lack of information on pacing mode (n = 10)
380 patients with SR, Dyssynchrony, & de novo CRT implantation
Exclusion:
• Died within first 3 months (n = 7)
• CRT off within first 3 months (n = 1)
• Follow-up loss within first 3 months (n= 4)
368 patients with follow-up duration ≥ 3mo
Non-adaptive (n = 118)
Adaptive BiV (n = 93)
Adaptive BiV & LV (n = 157)

Baseline characteristics

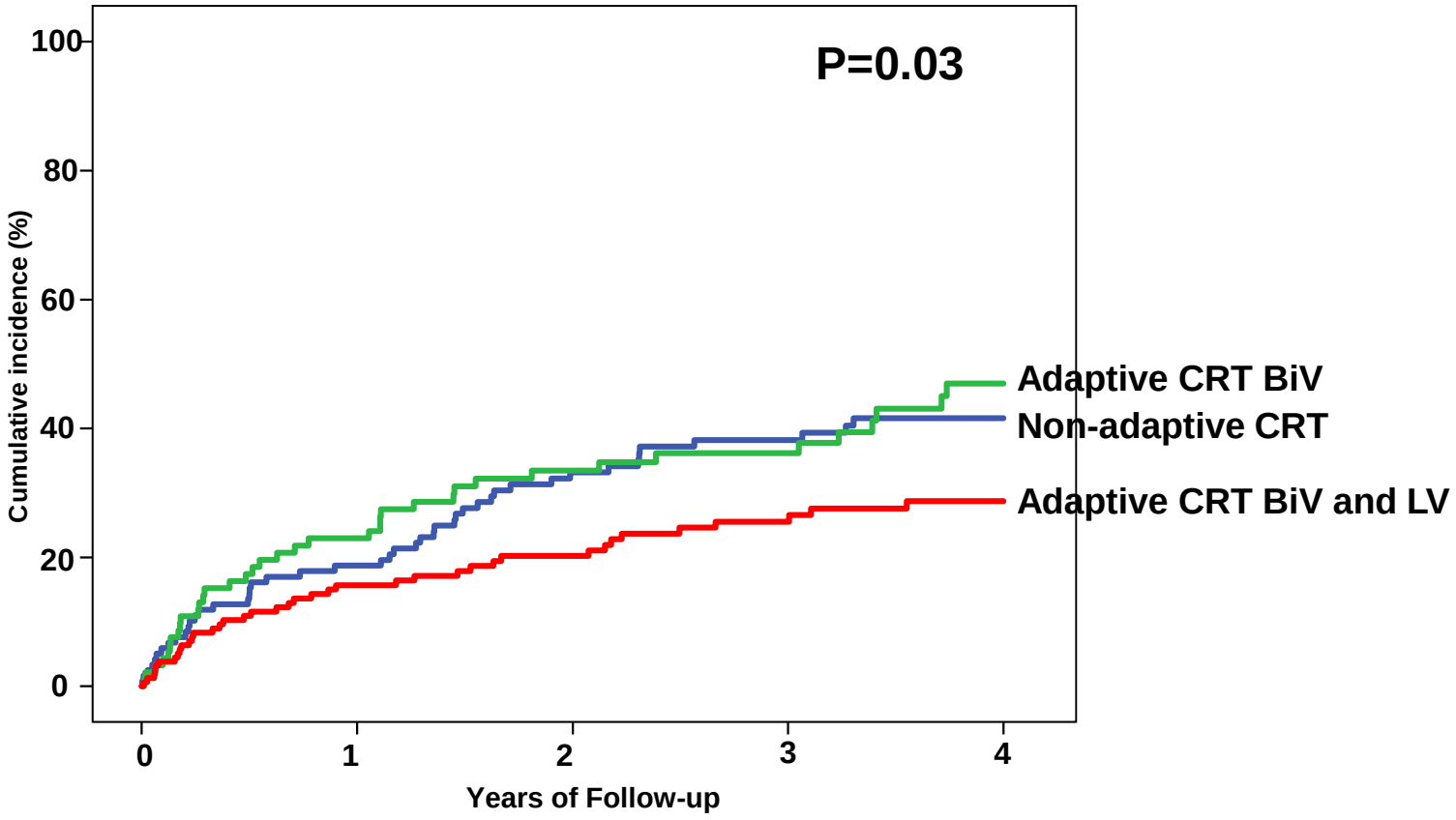
	Nonadaptive CRT (n = 118)	Adaptive BiV (n = 93)	Adaptive BiV and LV (n = 157)	P-value
Age	65.1 ± 12.0	67.3 ± 12.9	66.8 ± 11.7	0.37
Male	79 (64.2)	50 (58.8)	97 (60.6)	0.71
BMI	23.9 ± 3.5	24.0 ± 4.0	23.7 ± 3.8	0.80
NYHA class II	25 (20.3)	19 (22.6)	37 (23.6)	0.81
NYHA class III or IV	98 (79.7)	64 (76.2)	119 (77.2)	0.72
Ischemic CMP	16 (13.0)	22 (25.9)	28 (17.5)	0.06
Hypertension	67 (54.5)	56 (65.9)	87 (54.4)	0.17
Diabetes	46 (37.4)	40 (47.1)	76 (47.5)	0.19
Chronic kidney disease	27 (22.0)	18 (21.2)	40 (25.0)	0.74
Cerebrovascular disease	10 (8.1)	11 (12.9)	15 (9.4)	0.50

Baseline characteristics

	Nonadaptive CRT (n = 118)	Adaptive BiV (n = 93)	Adaptive BiV and LV (n = 157)	P-value
Paroxysmal AF	23 (18.7)	15 (17.6)	21 (13.1)	0.40
PR inerval, ms	194.2 ± 43.8	200.4 ± 50.9	189.4 ± 32.8	0.17
QRS duration, ms	170.4 ± 23.0	169.2 ± 25.7	163.9 ± 19.2	0.04
LBBB	101 (82.1)	64 (75.3)	143 (89.4)	0.02
LVEF, %	**24.8 ± 6.7**	**25.1 ± 5.8**	**24.3 ± 6.0**	**0.66**
LVEDD, mm	66.8 ± 8.9	65.9 ± 8.6	66.6 ± 8.9	0.65
LVESD, mm	56.6 ± 10.2	55.8 ± 9.3	58.4 ± 10.0	0.10
Beta blocker	101 (82.1)	61 (71.8)	123 (76.9)	0.21
ACE inhibitor or ARB	102 (82.9)	77 (90.6)	142 (88.8)	0.20
Aldosterone antagonist	87 (70.7)	54 (63.5)	119 (74.4)	0.21
De novo CRT	92 (74.8)	60 (70.6)	151 (94.4)	<0.001
LV lead (RAO) non-apical	119 (96.7)	80 (94.1)	151 (94.4)	0.58
LV lead (LAO) lateral	123 (100.0)	85 (100.0)	152 (95.0)	0.005

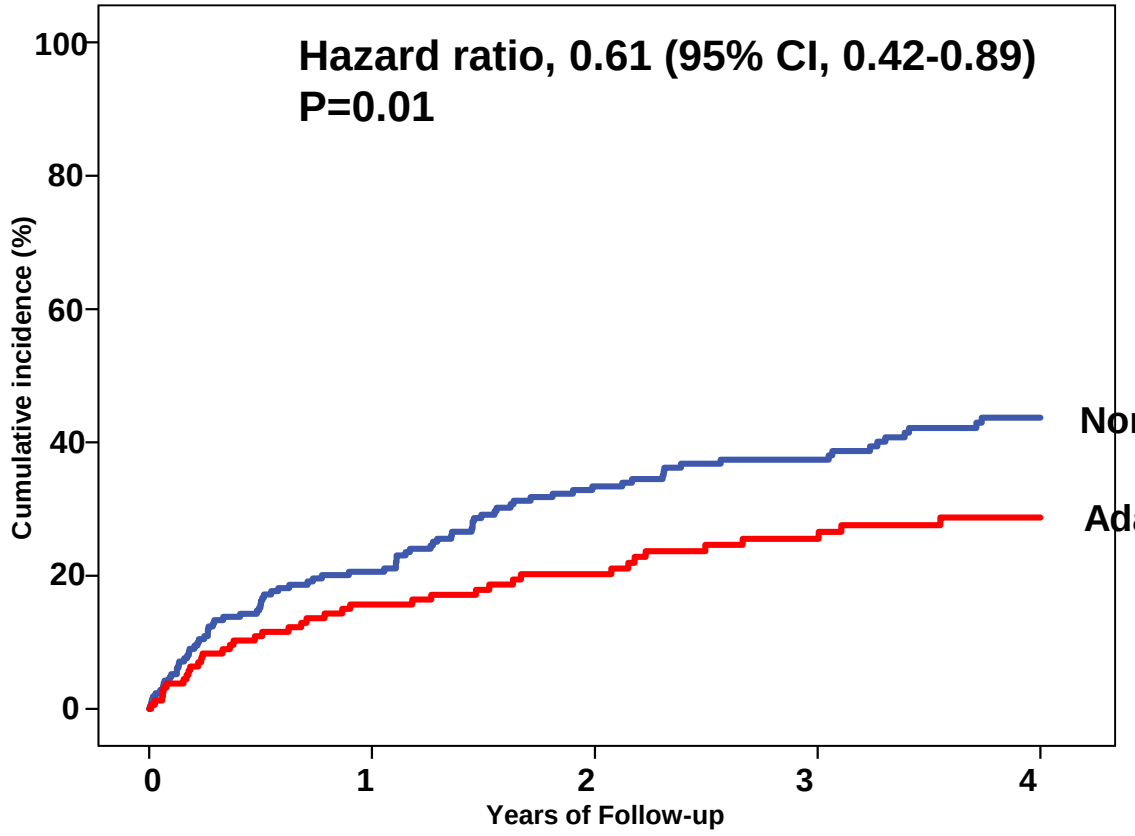
Primary endpoint

A composite of death, HF hospitalization, and appropriate ICD therapy



No. at Risk					
Non-adaptive CRT	118	93	72	55	45
Adaptive CRT BiV	93	69	53	40	26
Adaptive CRT BiV and LV	157	118	93	74	55

Primary endpoint



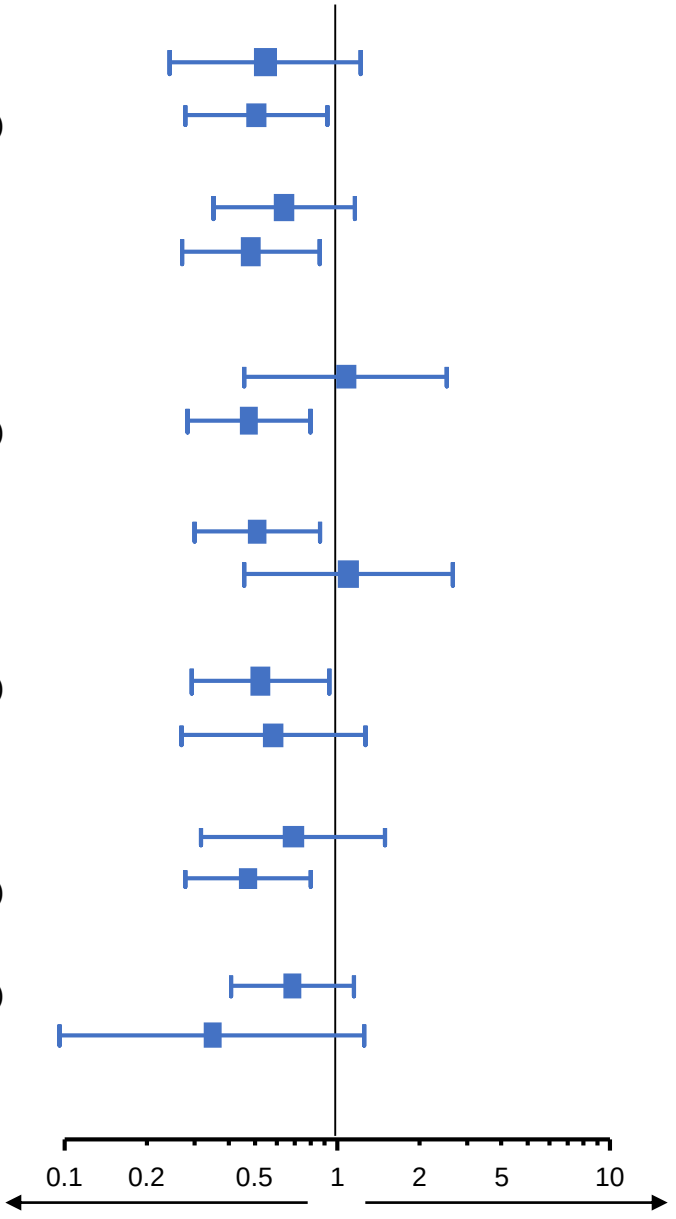
No. at Risk					
Non-adaptive CRT + Adaptive CRT BiV	211	162	125	95	71
Adaptive CRT BiV and LV	157	118	93	74	55

Primary and secondary end point

End point	Non-adaptive + Adaptive BiV (n= 211)	Adaptive BiV and LV (n = 157)	Hazard ratio	P value
Primary end point				
A composite of death, HF hospitalization, and appropriate ICD therapy	84 (43.7)	39 (28.7)	0.60 (0.42-0.89)	0.010
Secondary end point				
All-cause death	30 (17.9)	9 (7.2)	0.40 (0.19-0.84)	0.016
Cardiac death	20 (11.9)	4 (3.3)	0.27 (0.09-0.78)	0.016
Hospitalization due to HF	58 (30.9)	33 (24.9)	0.77 (0.50-1.18)	0.22
Defebrillator therapy for ventricular arrhythmia	32 (16)	10 (7.1)	0.41 (0.20-0.83)	0.014

Data presented as n (%). Percentages are 4-year Kaplan–Meier estimates.

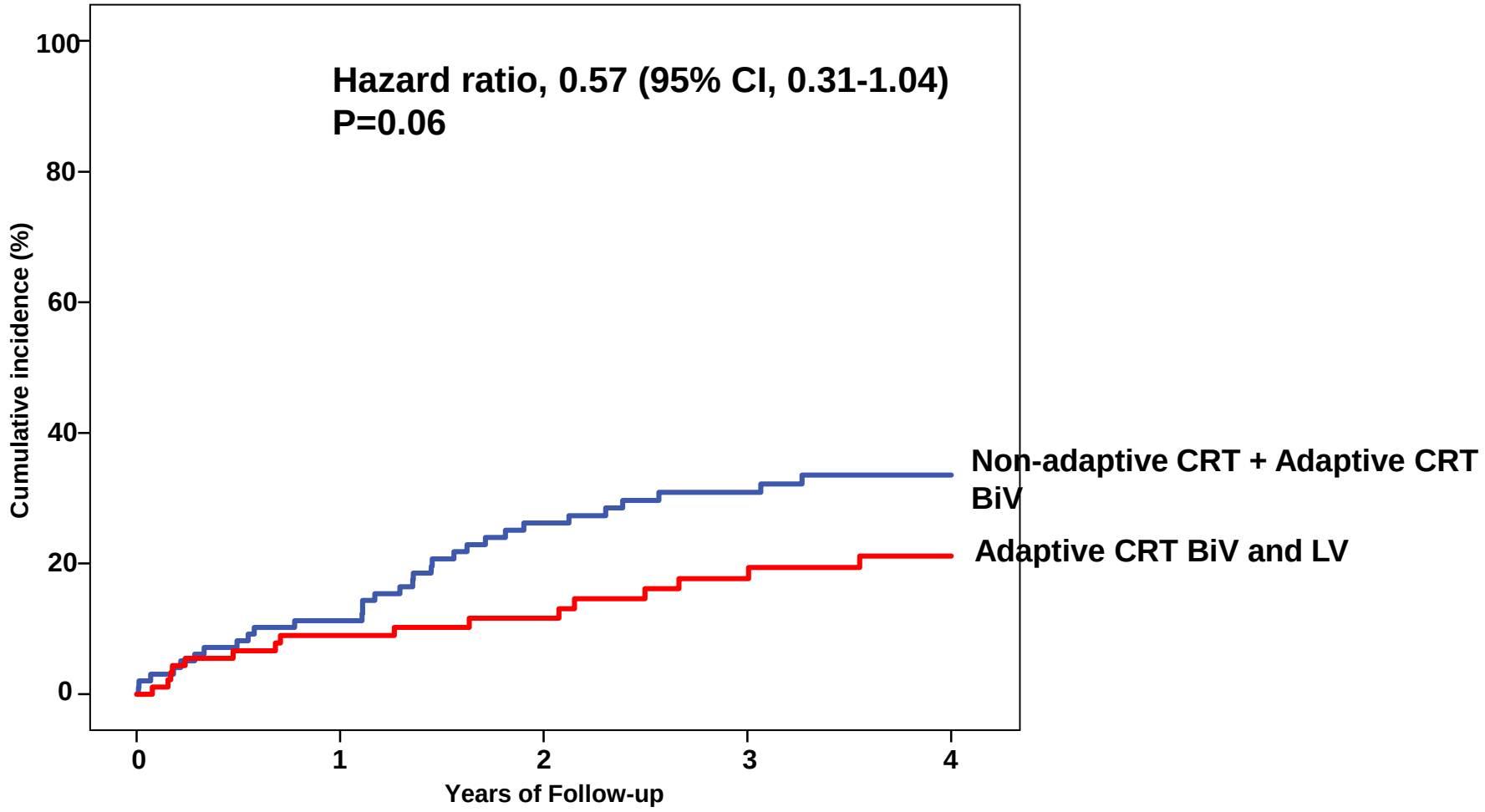
Subgroup	Non-adaptive CRT and adaptive BiV No. of events / total no. of patients (cumulative incidence, %)	Adaptive BiV and LV No. of events / total no. of patients (cumulative incidence, %)	Hazard ratio (95% CI)	P value
Age				
<65 years	31/79 (41.1%)	12/55 (24.3%)	0.58 (0.30-1.12)	0.11
≥65 years	54/129 (47.5%)	26/105 (29.3%)	0.56 (0.35-0.89)	0.01
Sex				
Male	54/129 (45.8%)	26/97 (30.9%)	0.65 (0.41-1.04)	0.07
Female	31/78 (43.1%)	12/63 (22.5%)	0.44 (0.23-0.86)	0.02
Cardiomyopathy				
ICMP	17/38 (50.3%)	12/28 (47.8%)	1.02 (0.49-2.14)	0.96
N-ICMP	68/170 (43.5%)	26/132 (23.2%)	0.48 (0.30-0.75)	0.001
Bundle branch block				
LBBB	60/165 (39.1%)	2V143 (22.1%)	0.51 (0.33-0.81)	0.004
None LBBB	25/43 (74.4%)	11/17 (71.7%)	1.21 (0.59-2.47)	0.60
PR interval				
PR ≤ 200 msec	43/113 (40.6%)	24/104 (27.3%)	0.60 (0.37-0.99)	0.04
PR > 200 msec	23/60 (42.7%)	12/48 (28.2%)	0.70 (0.35-1.40)	0.31
QRS duration				
QRS < 150 msec	22/40 (59.7%)	15/38 (48.8%)	0.76 (0.40-1.47)	0.42
QRS ≥ 150 msec	63/168 (41.1%)	23/122 (21.7%)	0.48 (0.30-0.77)	0.002
Indication of CRT				
De novo	53/152 (37.4%)	36/151 (27.8%)	0.71 (0.46-1.08)	0.11
Upgrade	32/56 (66.4%)	2/9 (22.2%)	0.27 (0.07-1.14)	0.07



Predictors for composite outcome

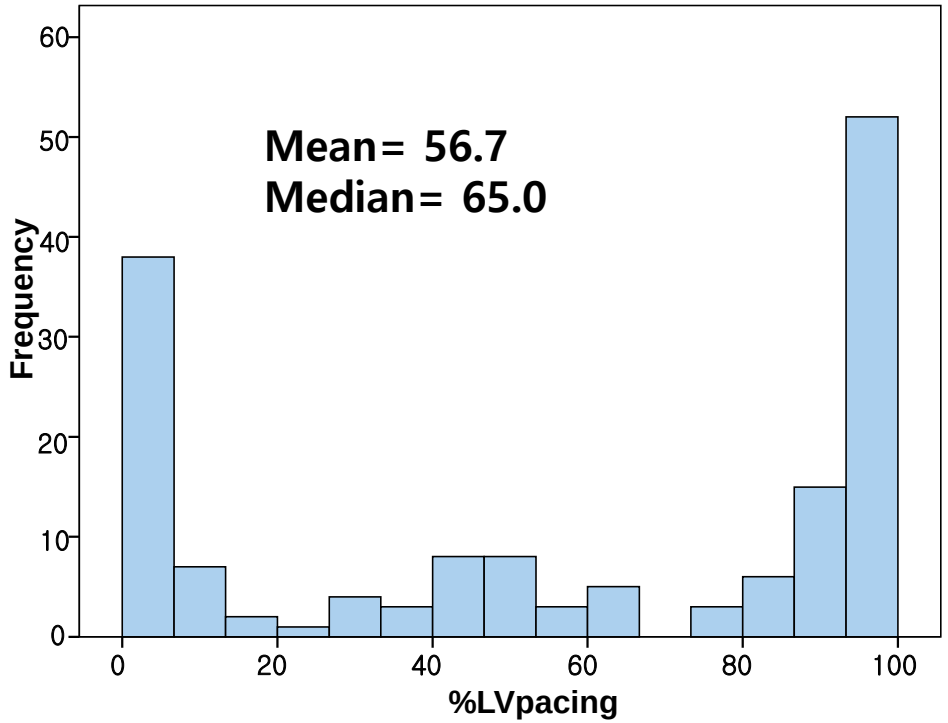
Variable	Univariate analysis			Multivariate analysis		
	Hazard ratio	95% CI	P value	Hazard ratio	95% CI	P value
Age	1.01	0.99-1.01	0.70	0.99	0.98-1.01	0.83
Sex (male)	1.22	0.84-1.76	0.30			
Hypertension	1.01	0.70-1.43	0.98			
Diabetes	0.94	0.66-1.35	0.75			
Ischemic CMP	1.68	1.11-2.55	0.02	1.44	0.93-2.24	0.10
Paroxysmal AF	2.19	1.46-3.30	<0.001	1.97	1.31-2.98	0.001
QRS duration≥150	0.52	0.35-0.76	0.001	0.57	0.39-0.85	0.006
Reprogramming	1.53	0.97-2.40	0.07			
Adaptive BiV and LV	0.61	0.42-0.89	0.01	0.65	0.44-0.95	0.03

Patients with LBBB and PR≤200ms (subgroup)



No. at Risk					
Non-adaptive CRT + Adaptive CRT BiV	99	85	67	53	42
Adaptive CRT BiV and LV	92	73	60	49	41

Divide the Adaptive BiV and LV group



Non-adaptive
(n = 118)

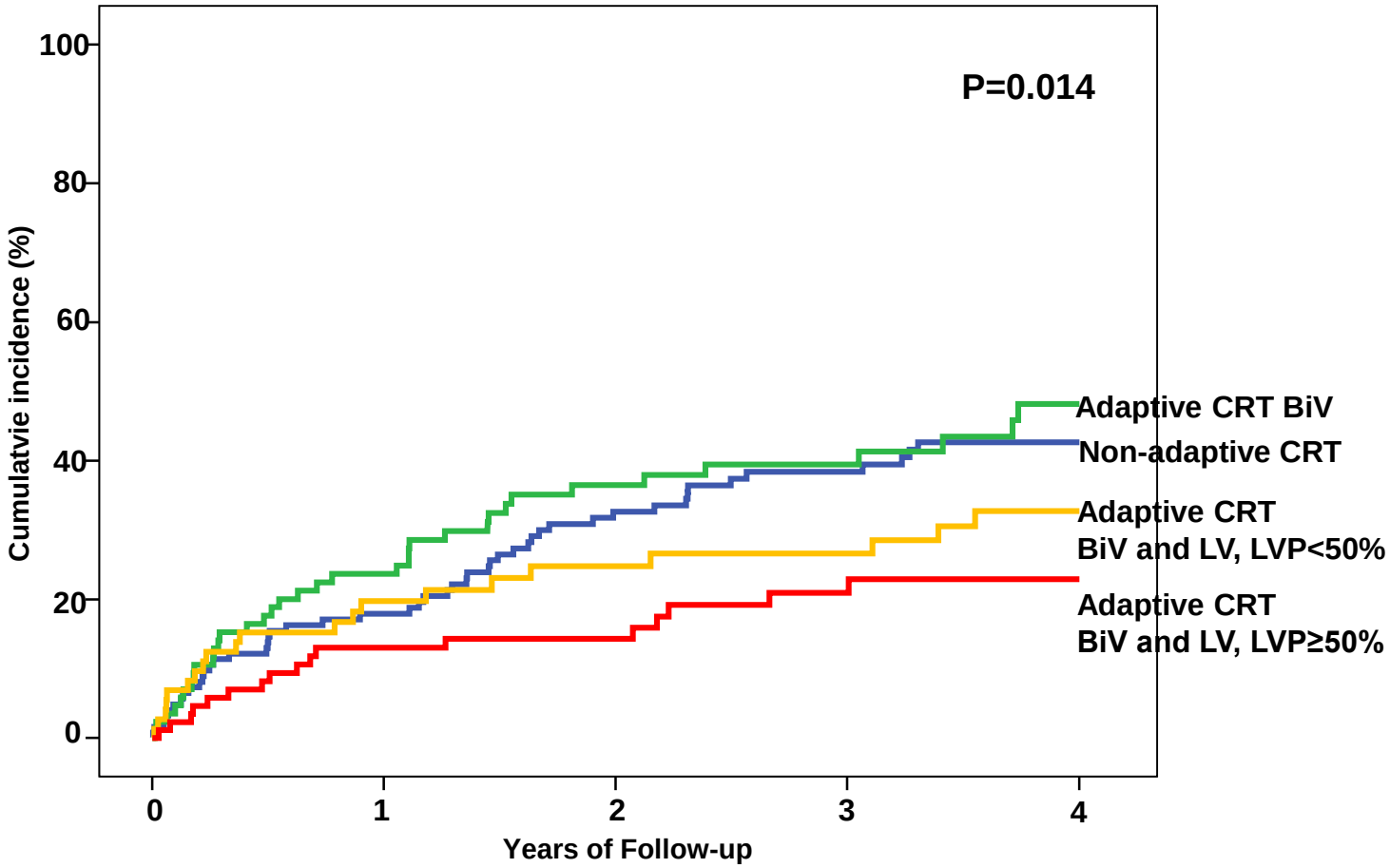
Adaptive BiV
(n = 93)

Adaptive BiV and LV
(n = 157)

Adaptive BiV and LV
LV pacing < 50% (n = 73)

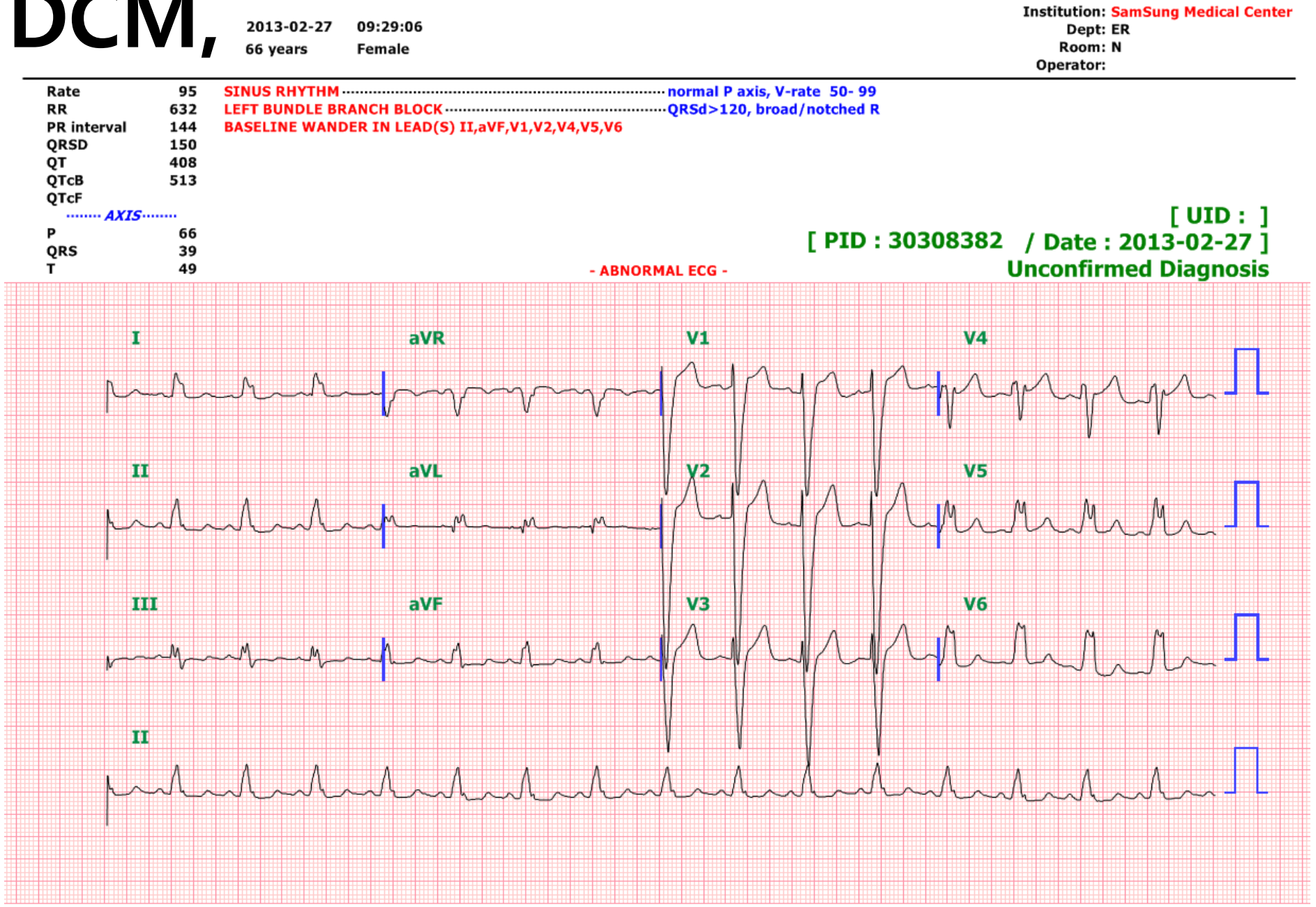
Adaptive BiV and LV
LV pacing ≥ 50% (n = 84)

A higher LV-only pacing percentage (≥50%) showed better clinical outcomes.



F/66, DCM,

LV EF
=17%



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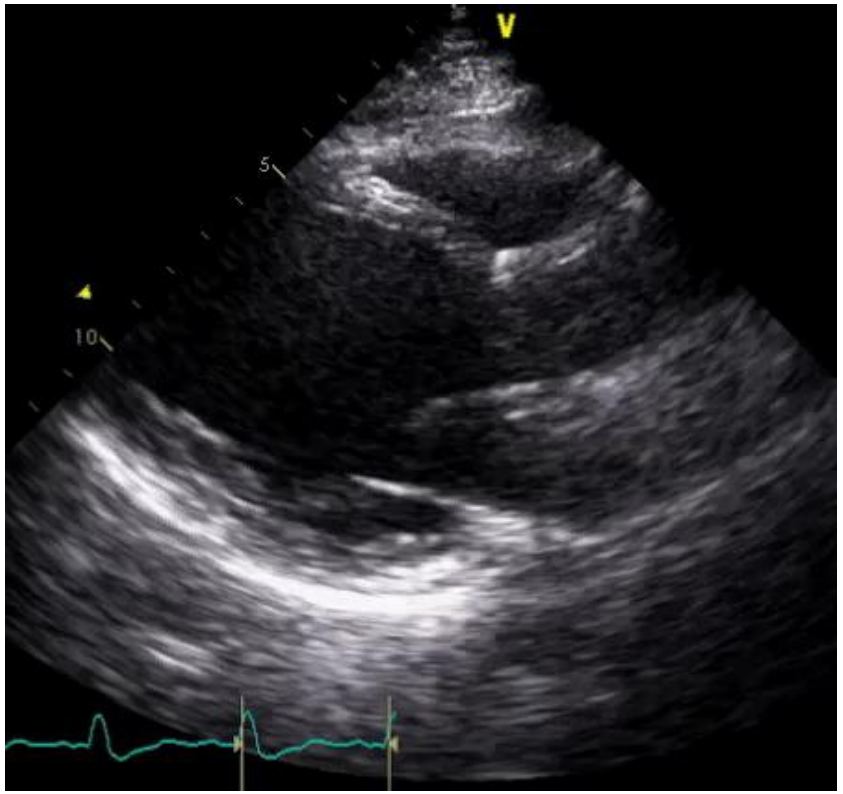
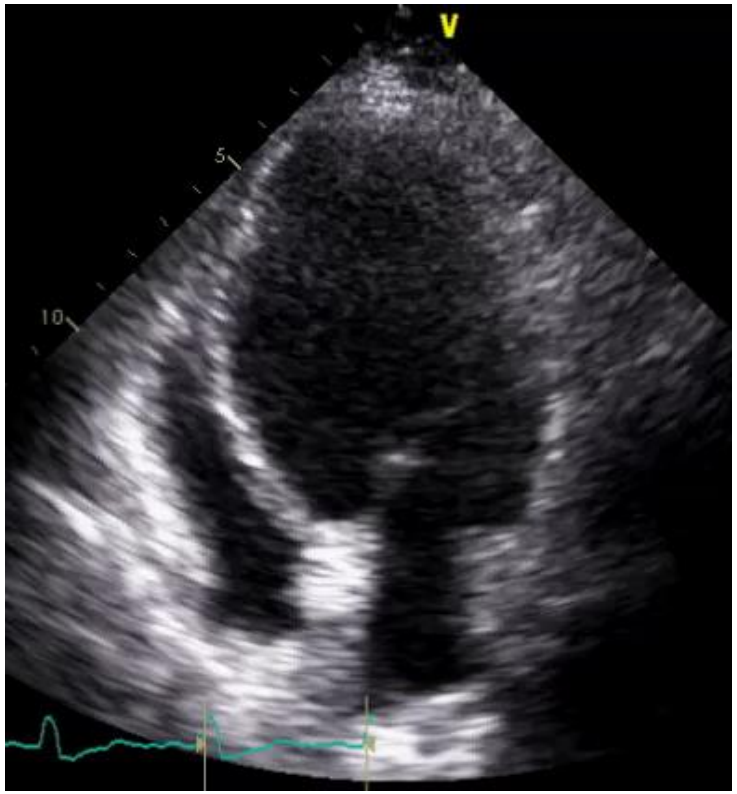
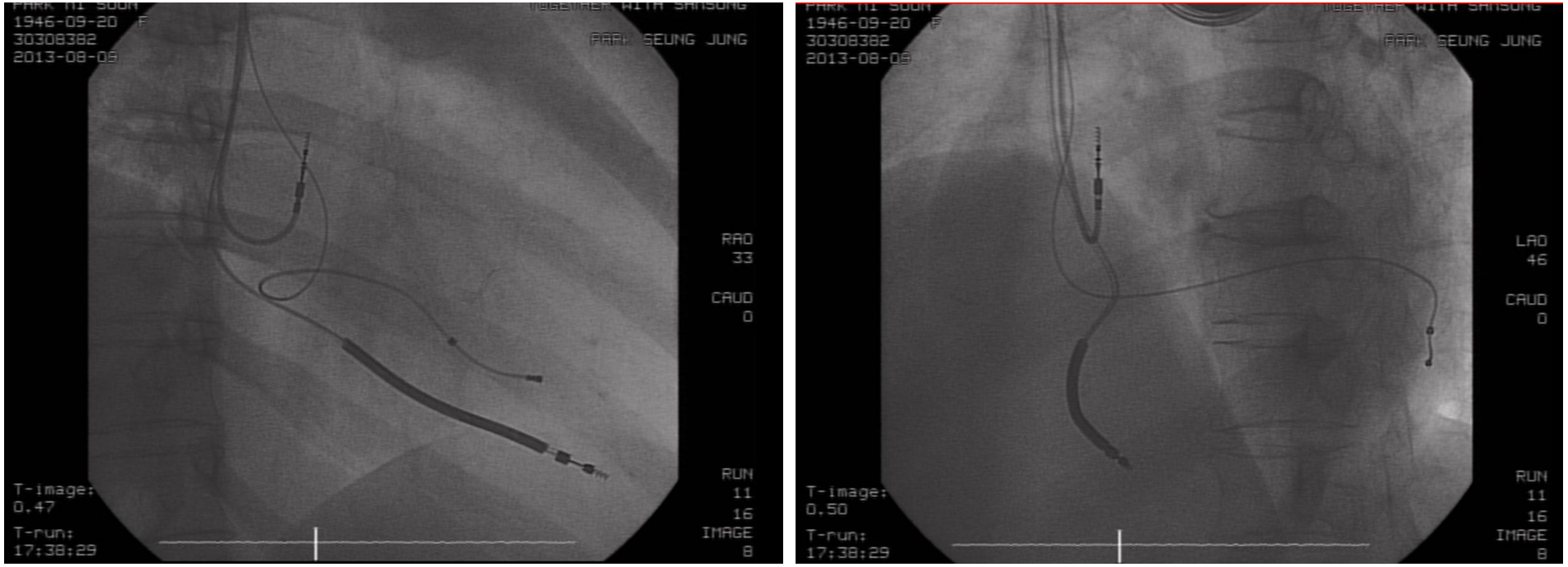
Baseline Echo





CRT-D implantation

- AUG. 2013



6mo f/u

2013-08-26 14:04:13
66 years Female

Institution: SamSung Medical Center
Dept: IM2
Room: N
Operator:

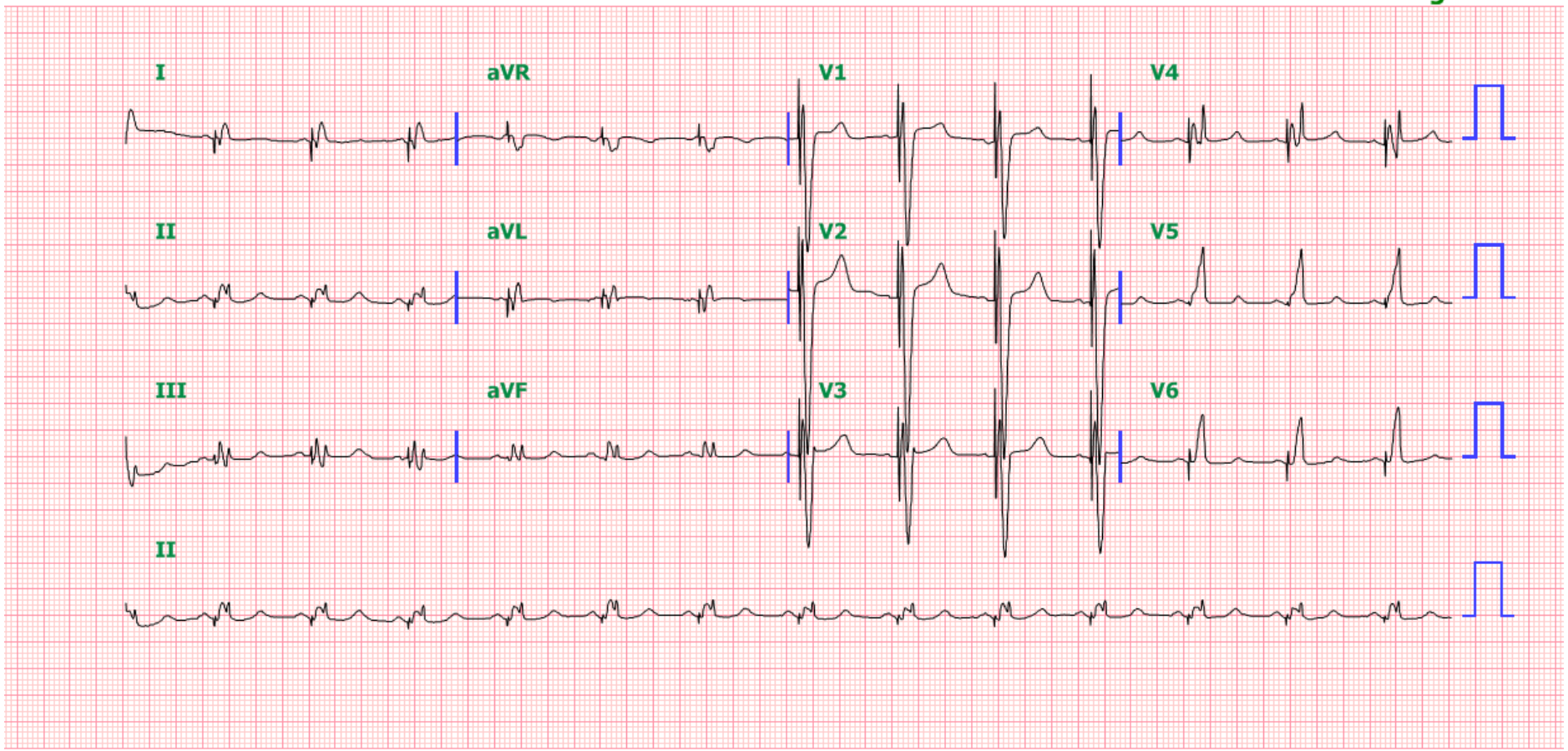
Rate	82
RR	732
PR interval	144
QRSD	116
QT	416
QTcB	486
QTcF	
..... AXIS	
P	170
QRS	62
T	88

ATRIAL-SENSED VENTRICULAR-PACED RHYTHM ..... ventricular pacing tracks p-waves
NO FURTHER ANALYSIS ATTEMPTED DUE TO PACED RHYTHM
BASELINE WANDER IN LEAD(S) II,III,aVL,aVF

QRSd=150ms→ 116ms

[UID :]
[PID : 30308382 / Date : 2013-08-26]
Unconfirmed Diagnosis

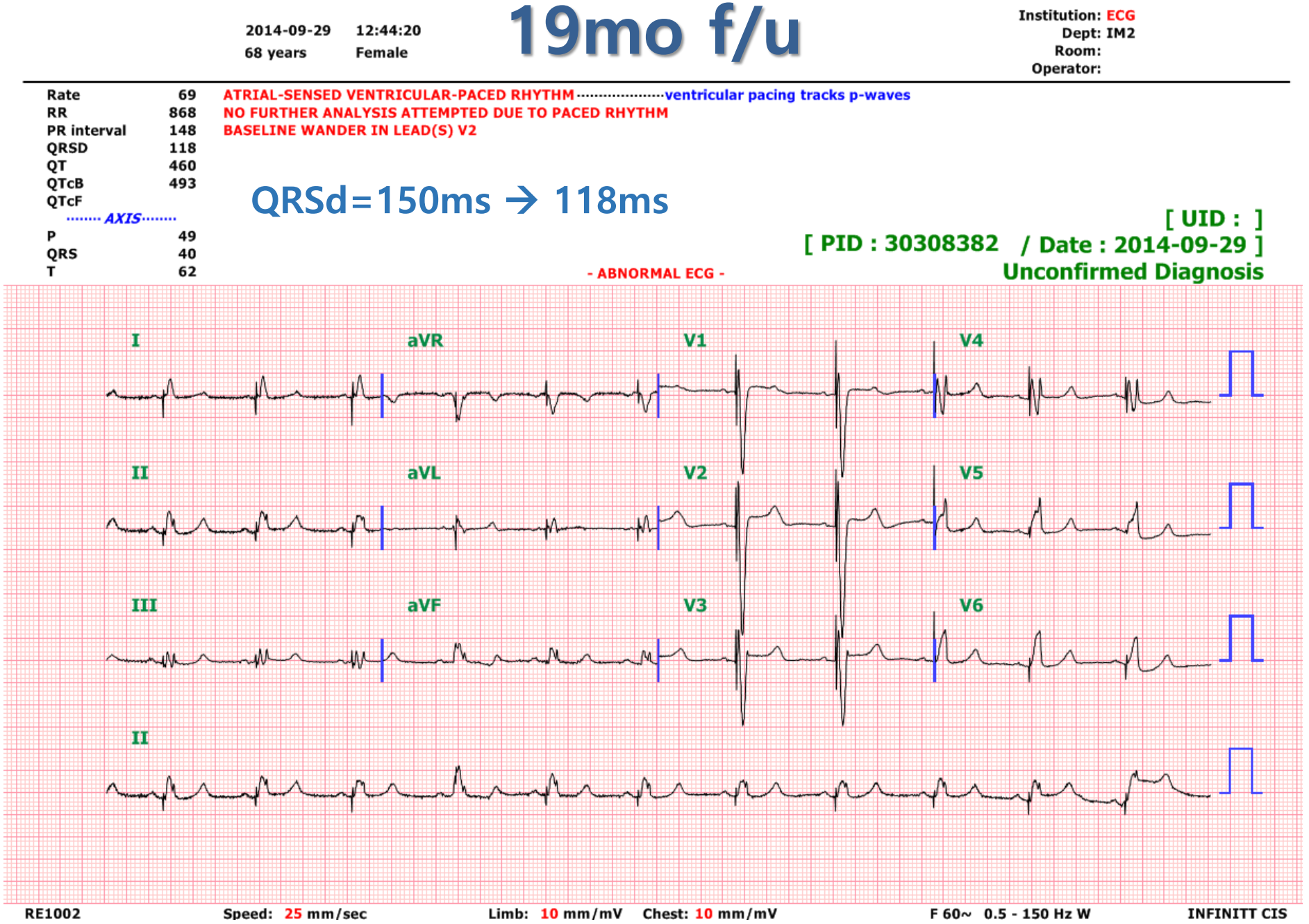
- ABNORMAL ECG -



RE1002 Speed: 25 mm/sec Limb: 10 mm/mV Chest: 10 mm/mV F 60~ 0.5 - 100 Hz W INFINITT CIS

KHRS 2023

19mo f/u


2014-09-29 12:44:20
68 years Female
Institution: ECG
Dept: IM2
Room:
Operator:
Rate 69
RR 868
PR interval 148
QRSD 118
QT 460
QTcB 493
QTcF
AXIS
P 49
QRS 40
T 62
ATRIAL-SENSED VENTRICULAR-PACED RHYTHM
ventricular pacing tracks p-waves
NO FURTHER ANALYSIS ATTEMPTED DUE TO PACED RHYTHM
BASELINE WANDER IN LEAD(S) V2
QRSd=150ms → 118ms
[UID :]
[PID : 30308382 / Date : 2014-09-29]
Unconfirmed Diagnosis
- ABNORMAL ECG -
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II
RE1002
Speed: 25 mm/sec
Limb: 10 mm/mV
Chest: 10 mm/mV
F 60~ 0.5 - 150 Hz W
INFINITT CIS

25mo f/u

2015-03-16 12:52:37
68 years Female

Institution: SamSung Medical Center
Dept: IM2
Room: N
Operator:

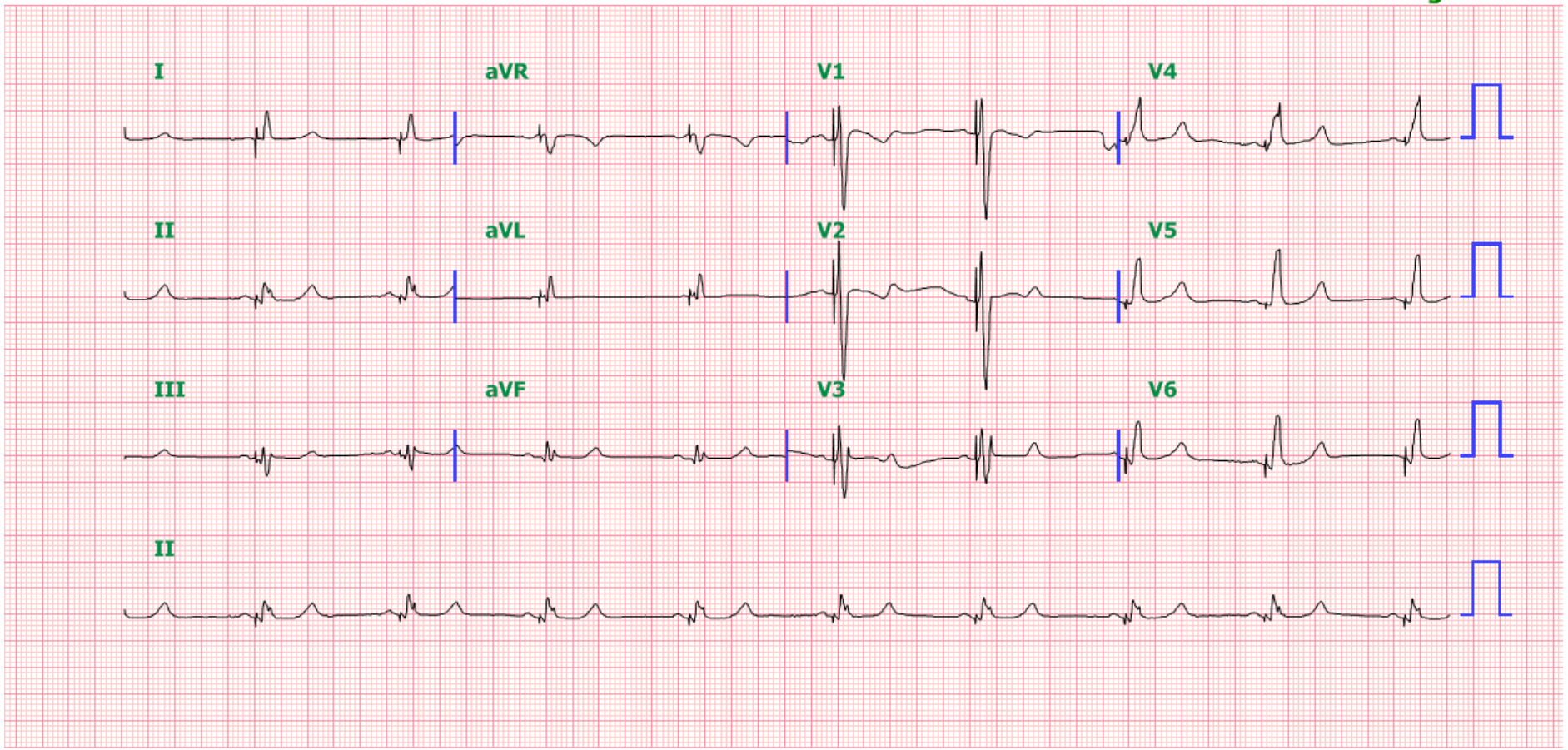
Rate	55
RR	1092
PR interval	156
QRSD	112
QT	500
QTcB	479
QTcF	486
····· AXIS ·····	
P	42
QRS	32
T	63

ATRIAL-SENSED VENTRICULAR-PACED RHYTHM ····· ventricular pacing tracks p-waves
NO FURTHER ANALYSIS ATTEMPTED DUE TO PACED RHYTHM

QRSd=150ms → 112ms

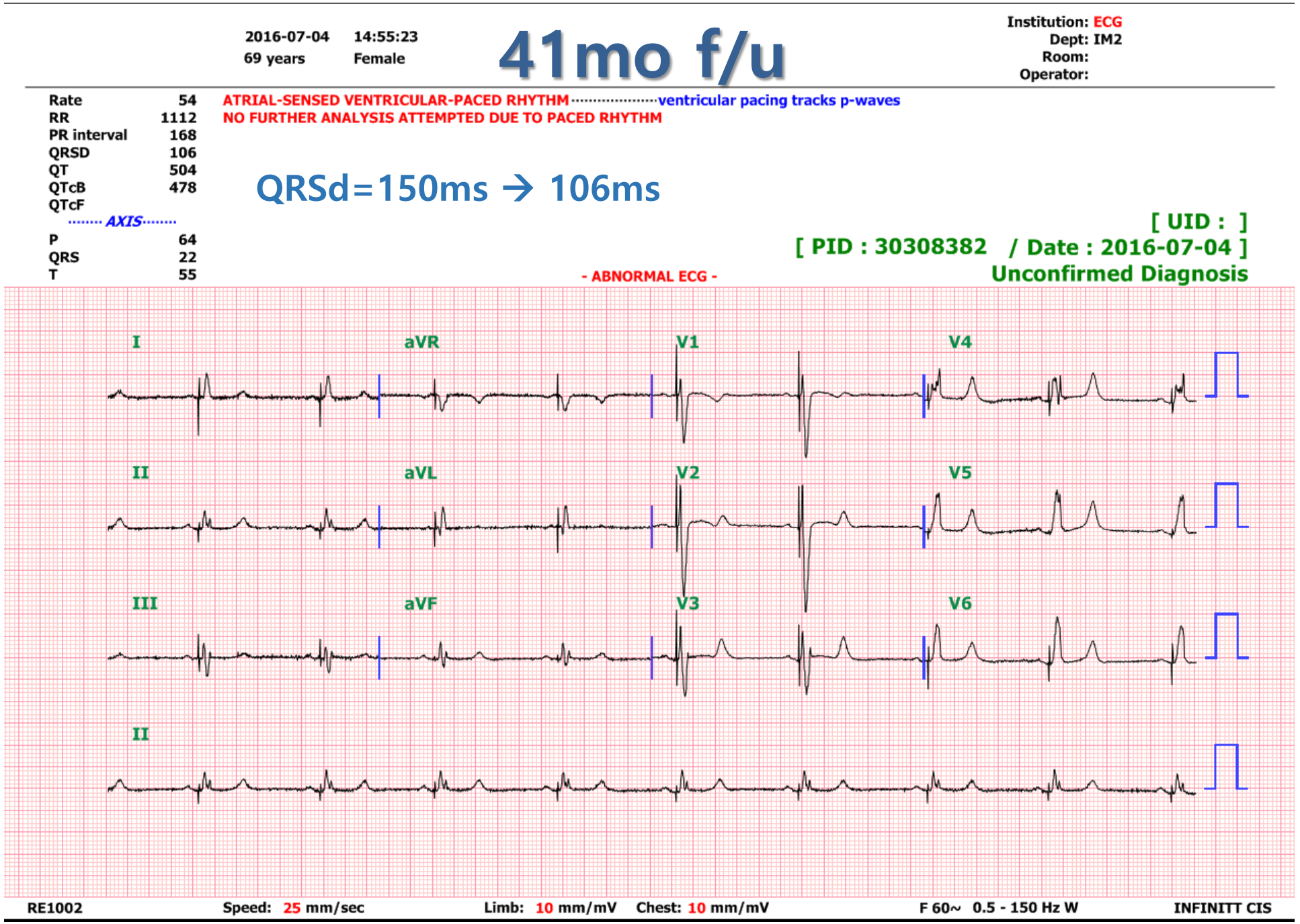
[UID :]
[PID : 30308382 / Date : 2015-03-16]
Unconfirmed Diagnosis

- ABNORMAL ECG -



RE1002 Speed: 25 mm/sec Limb: 10 mm/mV Chest: 10 mm/mV F 60~ 0.05 - 150 Hz W INFINITT CIS

41mo f/u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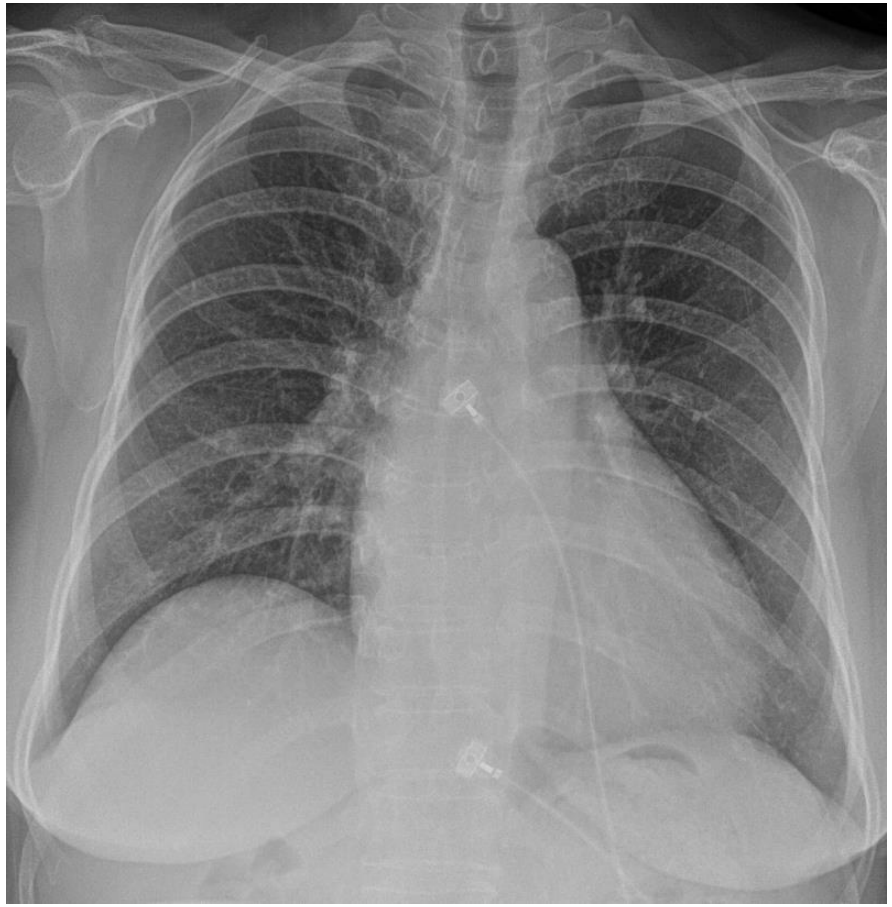
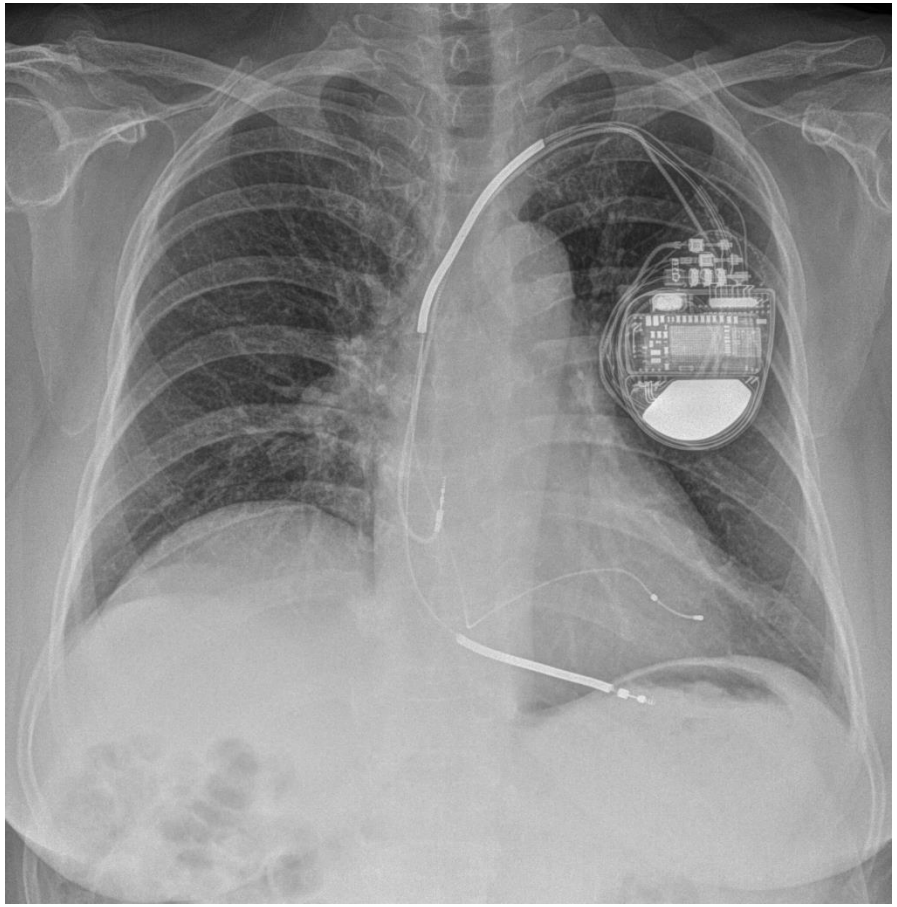
69 years Female
Institution: ECG
Dept: IM2
Room:
Operator:
Rate 54
RR 1112
PR interval 168
QRSD 106
QT 504
QTcB 478
QTcF
AXIS
P 64
QRS 22
T 55
ATRIAL-SENSED VENTRICULAR-PACED RHYTHM
ventricular pacing tracks p-waves
NO FURTHER ANALYSIS ATTEMPTED DUE TO PACED RHYTHM
QRSd=150ms → 106ms
[UID :]
[PID : 30308382 / Date : 2016-07-04]
Unconfirmed Diagnosis
- ABNORMAL ECG -
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II
RE1002
Speed: 25 mm/sec
Limb: 10 mm/mV
Chest: 10 mm/mV
F 60~ 0.5 - 150 Hz W
INFINITT CIS

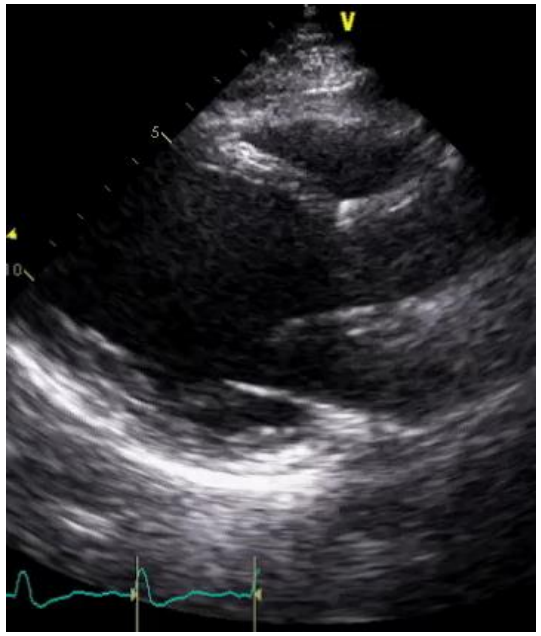


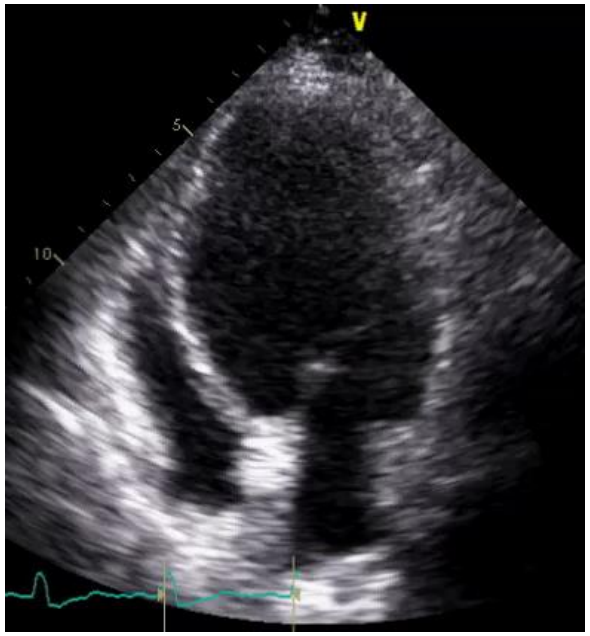


Pre-CRT

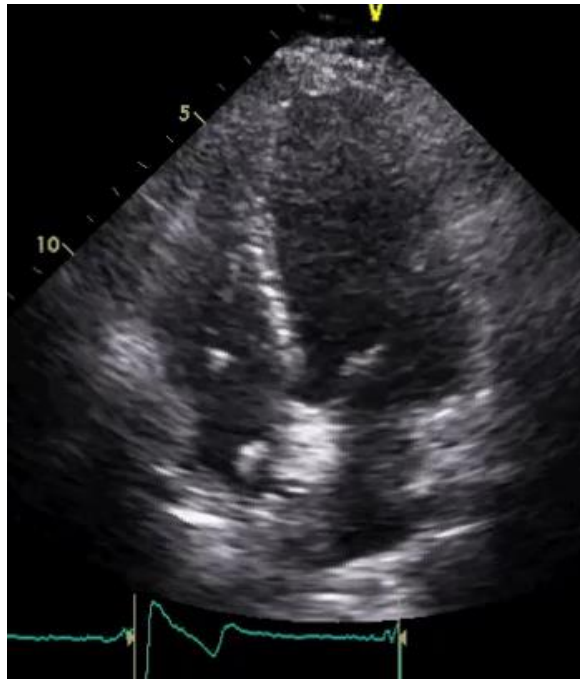
2year f/u

Baseline





36mo FU



KHRS 2023

Conclusion

- Dynamic algorithm-based optimization with adaptive CRT showed better clinical outcomes compared to conventional BiV CRT in real-world clinical data.

- LV-only pacing can be a useful alternative to BiV pacing and may be considered in non-responders to conventional BiV CRT, particularly when AV conduction is intact and LBBB is present.

경청해주셔서 감사합니다.

Retrospective analysis of the efficacy of **adaptive CRT** vs. conventional CRT

- **** COVID-19 pandemic**
- **2021-12: 1차 데이터 수집 완료 (~ 20 개월)**
- **2022-06: 추가 data 수집, 데이터 수집 기간 연장**
  adpative pacing mode, pacing percentage, etc
- **2022. 10 Data adjudication: (~3yrs, 4.5yrs)**
  death (cardiac vs. non-cardiac),
  admission (HF-related or not),
  arrhythmic events (appropriate vs. inappropriate)

Retrospective multicenter study comparing the **adaptive** and **conventional** CRT

- **2018-06: Study IRB approval**
- 2018-11: retrospective protocol revision
- 2019-11: CRF revision
- **2020-01: KHRS 동계 학회**
- 2020-03: IRB process: participating centers
  planned to visit each center and data collection (6months)

**** COVID-19 pandemic**