Remote Device Monitoring Beyond “EP Phone Home”

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February 8, 2019

SWEET 16

Device Monitoring in the 1980's

- 1982
- Steven Spielberg
- John Williams
- Budget $10.5 million
- Initial theater run >120 mil tkts

Device Monitoring in the 1980's

ET's makeshift communicator

By Mattingly23 - Own work, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=4415373

TTM for pacemakers

https://thoracickey.com/follow-up/

TTM (primitive remote monitoring)

- Introduced into clinical practice 1971
- Nonmagnet – assess rhythm (intrinsic or paced) and sensing
- Magnet – pacing capture and tracking battery (magnet rate)

Hayes et al Cardiac Pacing, Defibrillation, and Resynchonization 2013

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TMT (Threshold Margin Test)
3bts at 100 bpm
Amplitude of third pace decreased 25%
Failure to capture

A pacemaker should have a in person device check at least every:

A. 3 months
B. 6 months
C. 12 months
D. 24 months

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C. **12 months**
D. 24 months

Contemporary Remote Monitoring

Implanting Physician: JOSEPH GARD, MD OKLAHOMA HEART INS... Remote

FastPath® Summary

2 Alerts

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Battery
Longevity: 11.1-12.2 yrs

Implant Date:	Mar 23, 2017
Voltage	3.02 V
Magnet Rate	100.0 ppm
Battery Current	9 uA
Remaining Capacity to ERI	>95%

Test Results Jun 19, 2018 (A) Automatic

	Capture	Sense	Lead Impedance
V	**0.75V @ 0.4ms** (Bi) (A)	**10.0mV** (Bi) Jun 10 (A)	**400 Ω** (Bi) (A)
	0.75V @ 0.4ms (Bi) Dec 6, 2017	11.3mV (Bi) Dec 6, 2017	450 Ω (Bi) Dec 5, 2017

Parameters

Mode	VVIR
Base Rate	60 bpm

Capture & Sense	V
AutoCapture	On
Pulse Amplitude	1.0 V (A)
Pulse Width	0.4 ms
AutoSense	Off
Sensitivity	2.0 mV

Diagnostics Summary Since Mar 8, 2018

VP	95 %

Episodes Summary Since Mar 23, 2017

	Counts	EGMs
High Ventricular Rate	0	0
Magnet Response	0	0

Alerts

Device cybersecurity upgrade is available
V Percent Pacing Greater Than Limit

Implanting Physician: JOSEPH GARD, MD OKLAHOMA HEART INS... Remote

Test Results: Lead Impedance and Battery

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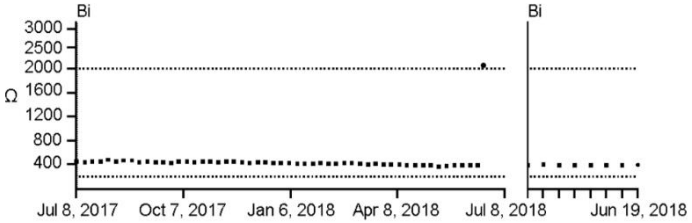
Ventricular Lead Monitoring: **400 Ω** (Bipolar) Jun 19, 2018

1-year trend (A) Auto Polarity Switch **Last 7 Days**



Programmed Pulse Configuration	Bipolar
V. Lead Monitoring	Monitor
Lower Limit	200 Ω
Upper Limit	2,000 Ω

Configurations	First Measurement	Lifetime Range
Bipolar	540 Ω (Mar 23, 2017)	350 - 550 Ω

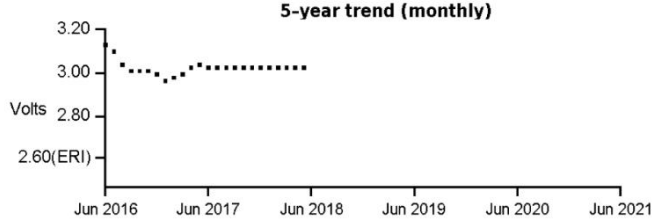
Battery Information
Longevity: 11.1-12.2 yrs

Voltage	3.02 V
Magnet Rate	100.0 ppm
Battery Current	9 uA
Remaining Capacity to ERI	>95%

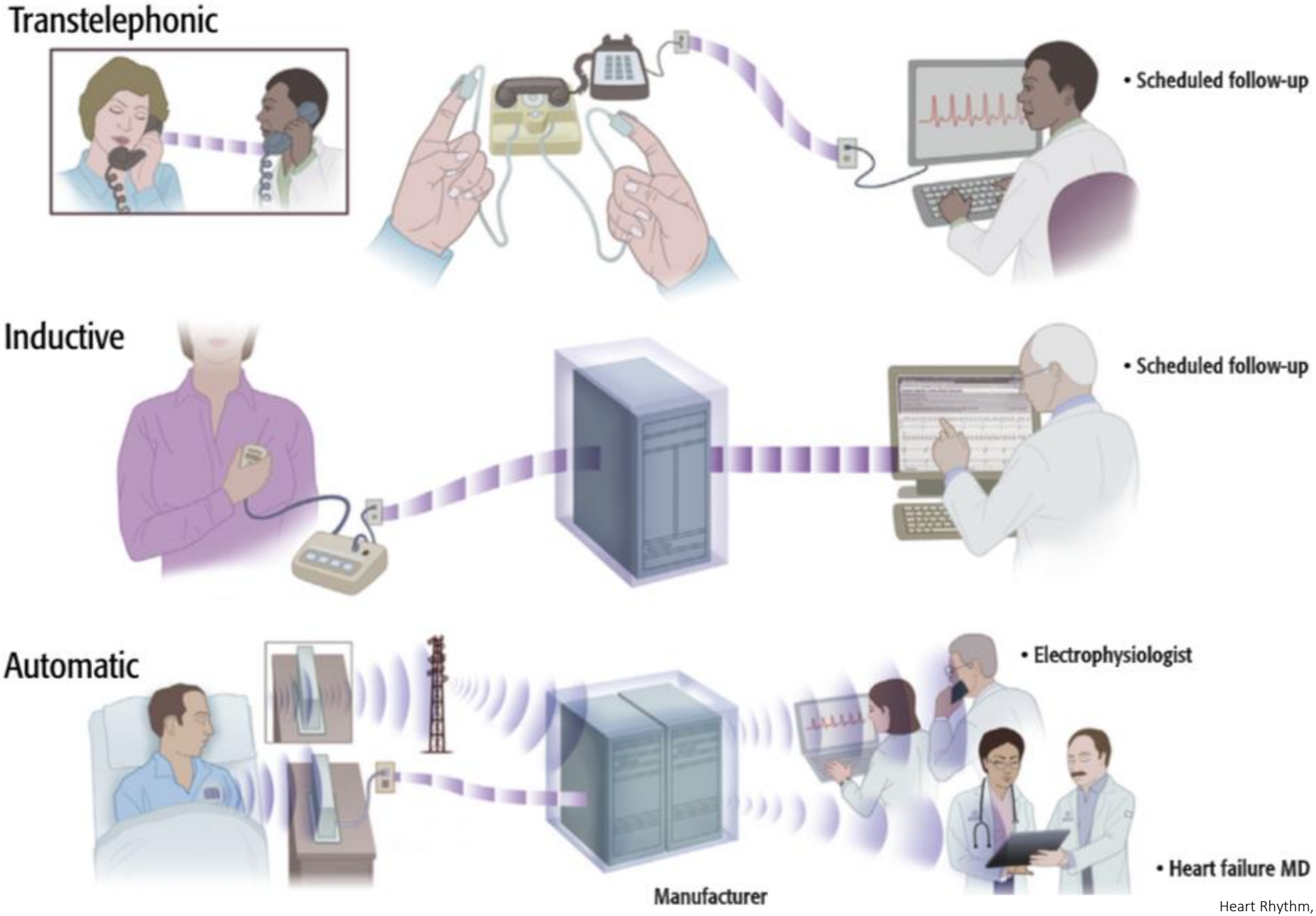
Longevity estimate is based on patient history

Voltage Trend

5-year trend (monthly)



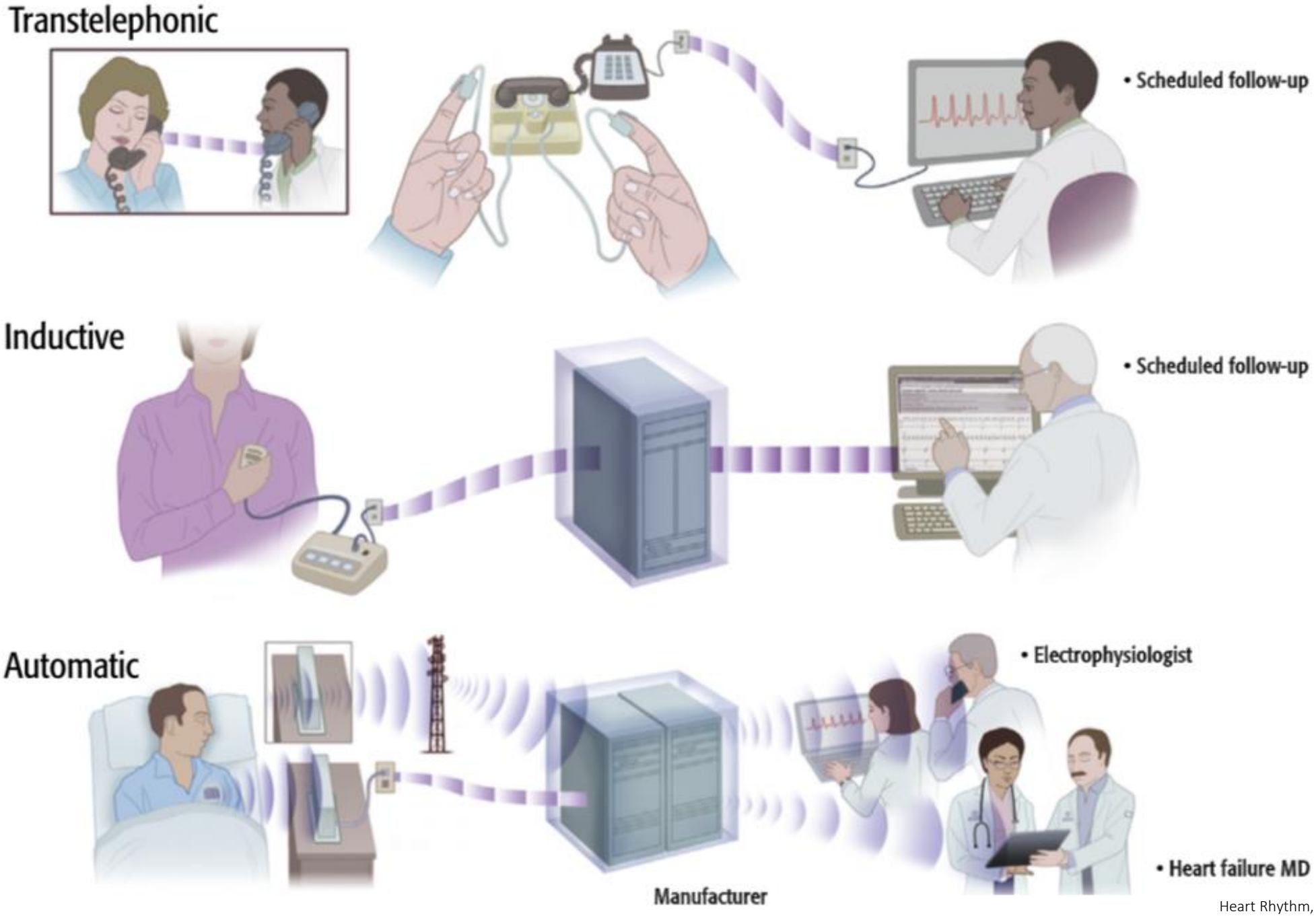
2 years, 0 months sampled



Heart Rhythm, Vol 12, No 7, July 2015

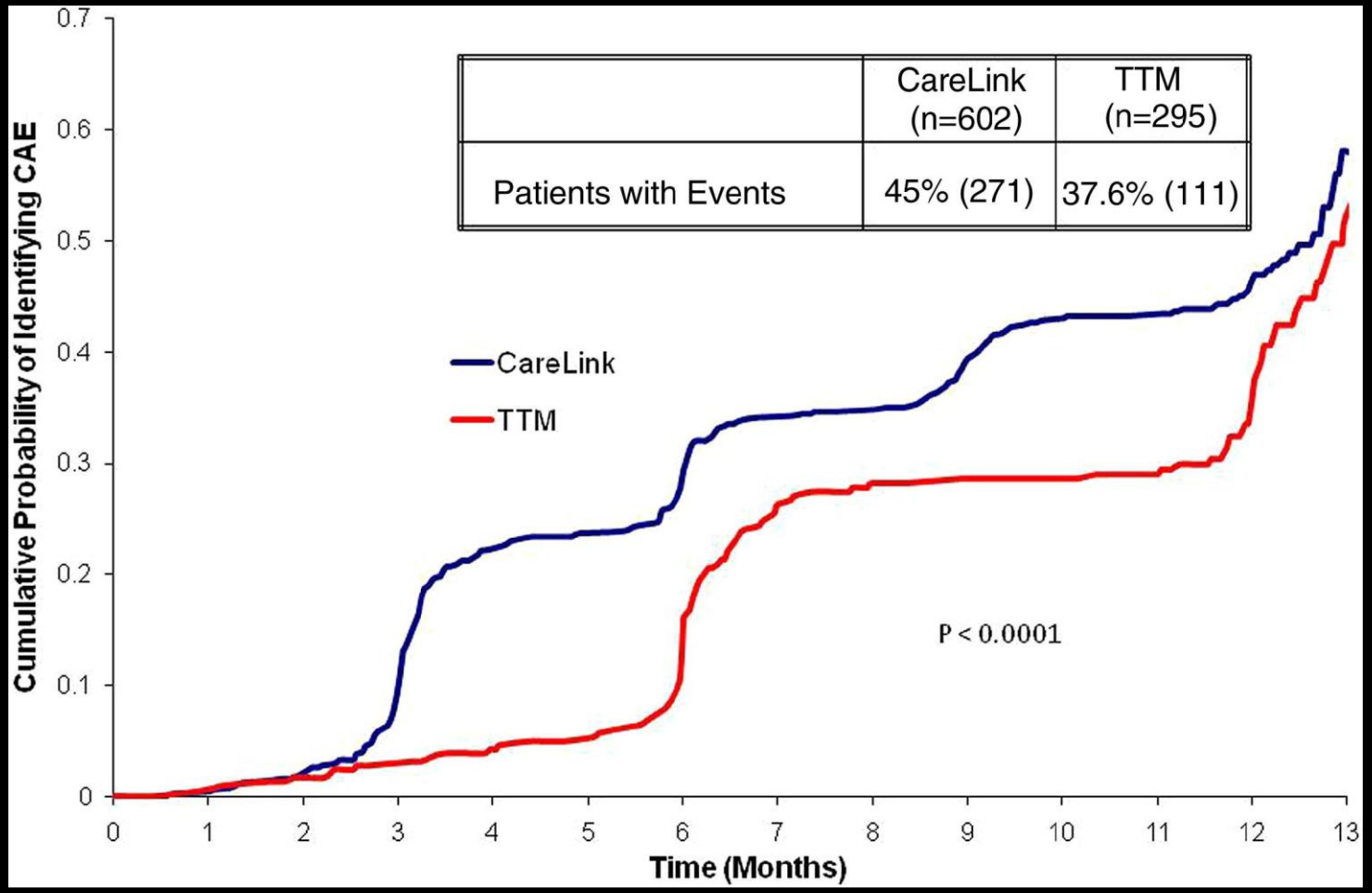
Remote Interrogation vs Remote Monitoring

- Remote Interrogation:
  - routine, scheduled, remote device interrogations
  - similar to in-office check
  - +/- capture threshold.
- Remote Monitoring:
  - automated transmission of data based on prespecified alerts related to device functionality and clinical events.
  - Alerts of abnormal device function or arrhythmia events.



Heart Rhythm, Vol 12, No 7, July 2015

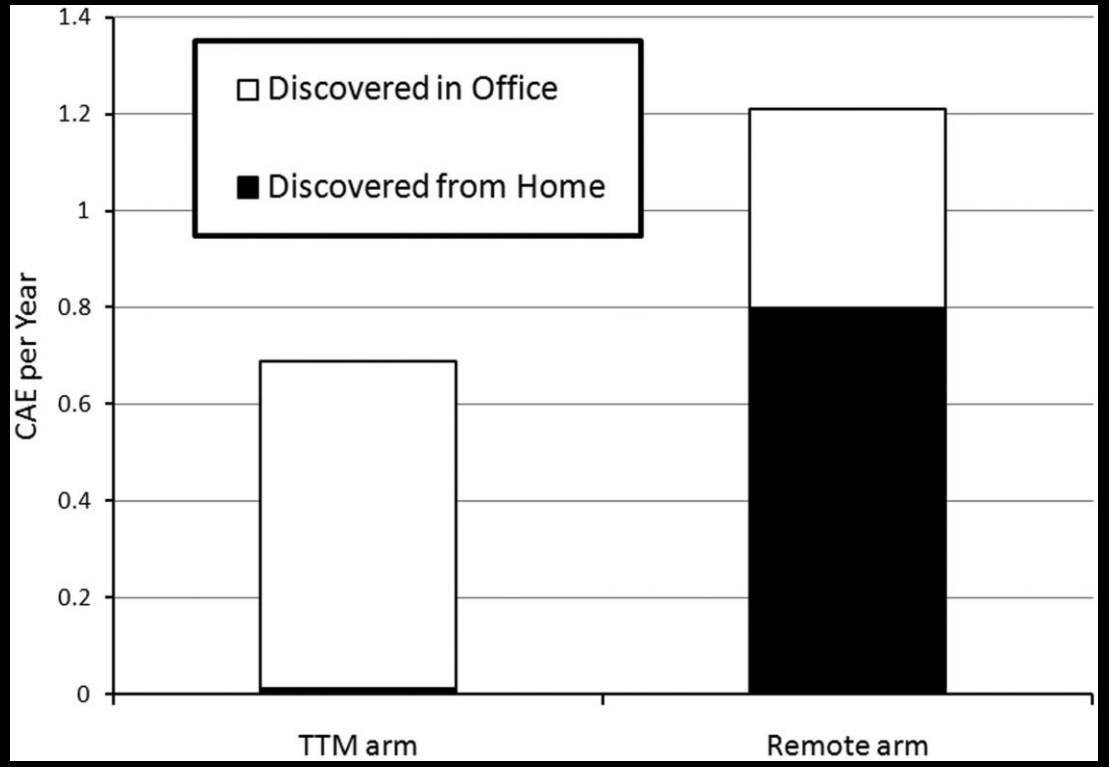
Benefit of RI for Identifying Clinically Adverse Events



J Am Coll Cardiol 2009;54:2012–9

Benefit of RI for Identifying Clinically Adverse Events

Among patients undergoing RI, 446 of 676 events (66%) were detected as compared with only 3 of 190 events (2%) in patients undergoing IPE+TTM.

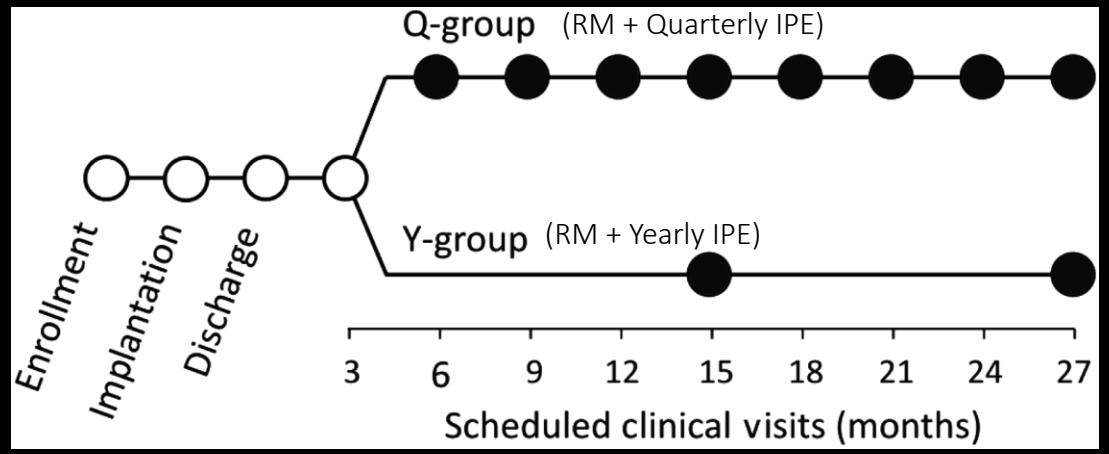


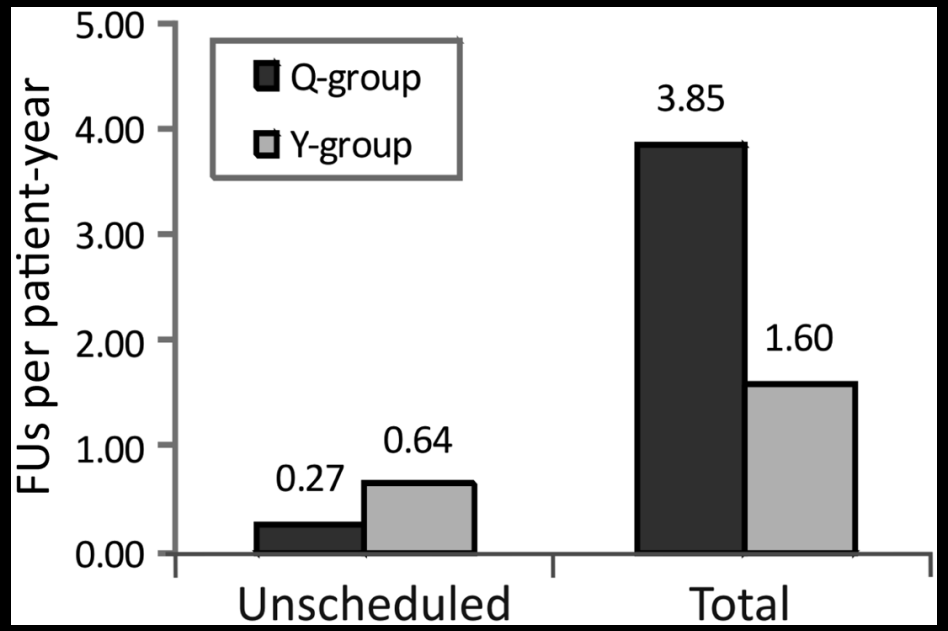
J Am Coll Cardiol 2009;54:2012–9

Table 3 CAE Summary

Event	No. of Events Reported per Patient	
	Remote Arm	TTM Arm
Composite CAEs	1.123	0.644
NSVT	0.517	0.308
AT/AF >48 h	0.198	0.105
Sensed ventricular rate >100 beats/min during AT/AF	0.188	0.098
Ventricular pacing ↑ 30%	0.101	0.064
New-onset AT/AF	0.061	0.037
Increase in ventricular pacing voltage threshold ≥1 V	0.018	0.017
Change in ventricular lead impedance	0.012	0.003
Loss of ventricular capture	0.010	0.000
Change in atrial lead impedance	0.010	0.003
Increase in atrial pacing voltage threshold ≥1 V	0.005	0.003
ERI/EOL	0.003	0.000
Loss of atrial capture	0.000	0.003

Remote Monitoring is Safe





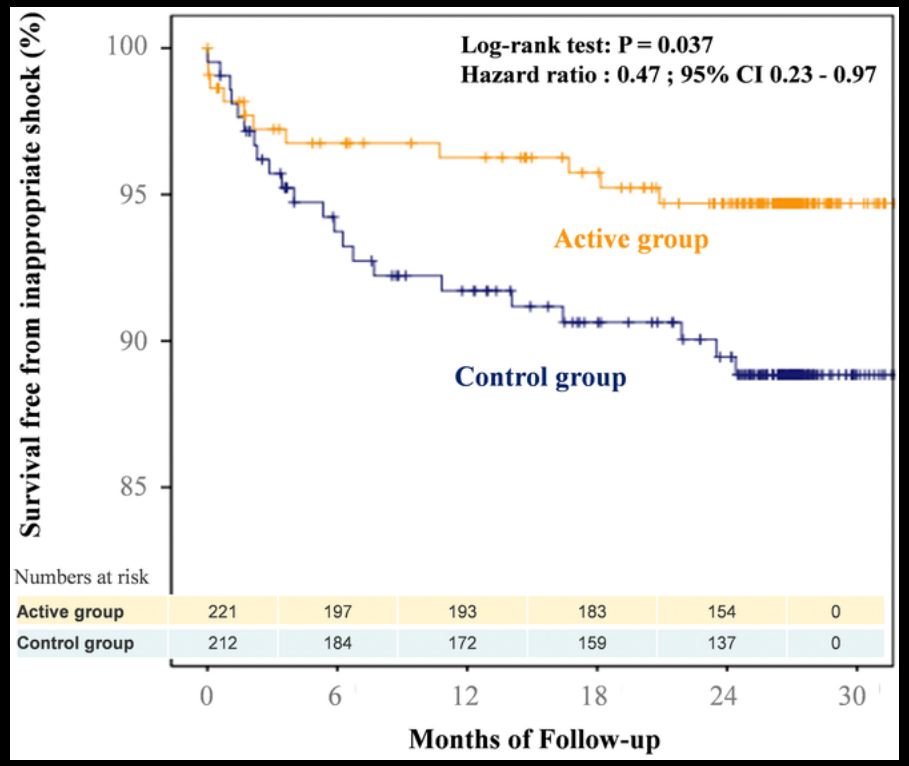
155 Patients with primary prevention ICD

No significant difference was found in mortality, hospitalization rate, or hospitalization length

58% reduction in FU visits for the Y-group

Eur Heart J. 2013;35(2):98-105

RM Reduces Inappropriate Shocks



ECOST study *JCE 2014; 25: 763-770*

RM allows early detection of:

- SVT
- Oversensing
- Lead malfunction

RM reduces inappropriate shocks most commonly by detecting

A. SVT
B. Oversensing
C. Lead malfunction

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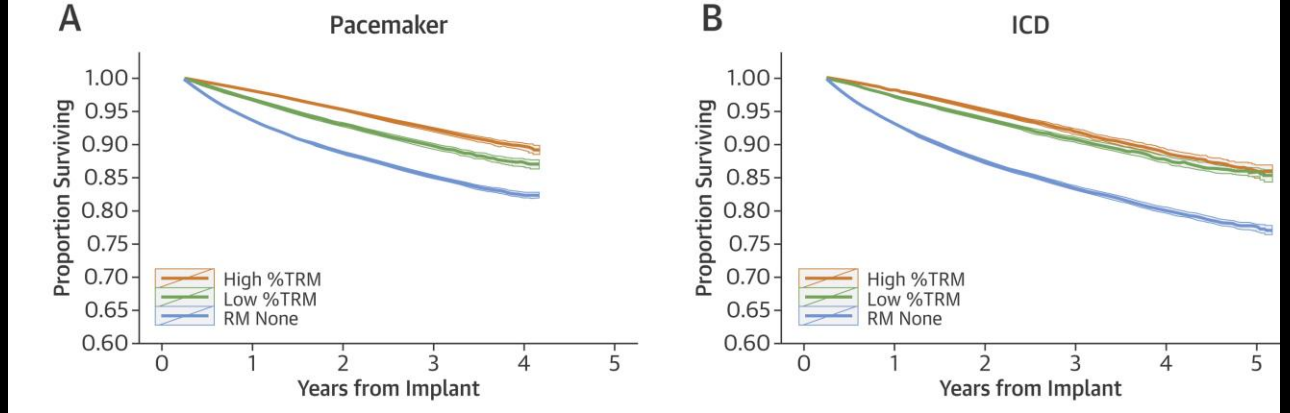


- - - Number at Risk - - -

High %TRM	31,652	30,843	28,227	12,170	1,101
Low %TRM	22,930	21,988	20,164	10,197	1,152
RM None	60,494	55,934	50,463	24,026	2,183

- - - Cox Survival - - -

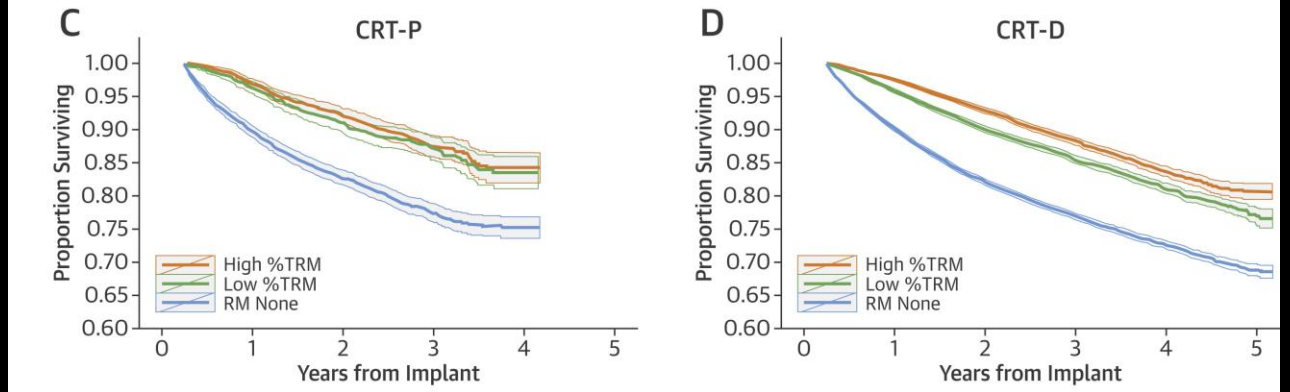
High %TRM vs. RM None HR: 1.93 [1.84–2.02], p<0.001
Low %TRM vs. RM None HR: 1.45 [1.38–1.51], p<0.001
High %TRM vs. Low %TRM HR: 1.31 [1.24–1.39], p<0.001
Mean follow-up: 2.73 (0.85) years

- - - Number at Risk - - -

High %TRM	19,427	18,913	17,454	9,971	4,067	354
Low %TRM	20,355	19,530	18,094	12,057	5,761	709
RM None	45,232	41,196	36,847	23,050	10,140	1,211

- - - Cox Survival - - -

High %TRM vs. RM None HR: 2.24 [2.13–2.36], p<0.001
Low %TRM vs. RM None HR: 1.78 [1.69–1.87], p<0.001
High %TRM vs. Low %TRM HR: 1.26 [1.18–1.34], p<0.001
Mean follow-up: 3.07 (1.15) years



- - - Number at Risk - - -

High %TRM	1,991	1,918	1,710	631	47
Low %TRM	1,634	1,552	1,398	611	45
RM None	4,281	3,776	3,288	1,244	101

- - - Cox Survival - - -

High %TRM vs. RM None HR: 1.82 [1.58–2.11], p<0.001
Low %TRM vs. RM None HR: 1.79 [1.54–2.09], p<0.001
High %TRM vs. Low %TRM HR: 1.01 [0.83–1.22], p<0.929
Mean follow-up: 2.56 (0.89) years

- - - Number at Risk - - -

High %TRM	14,850	14,423	13,128	7,040	2,511	179
Low %TRM	14,867	14,151	12,817	7,854	3,279	333
RM None	31,758	28,231	24,632	14,400	5,599	542

- - - Cox Survival - - -

High %TRM vs. RM None HR: 2.11 [2.00–2.22], p<0.001
Low %TRM vs. RM None HR: 1.64 [1.57–1.72], p<0.001
High %TRM vs. Low %TRM HR: 1.28 [1.20–1.36], p<0.001
Mean follow-up: 2.91 (1.14) years

RM Survival Benefit

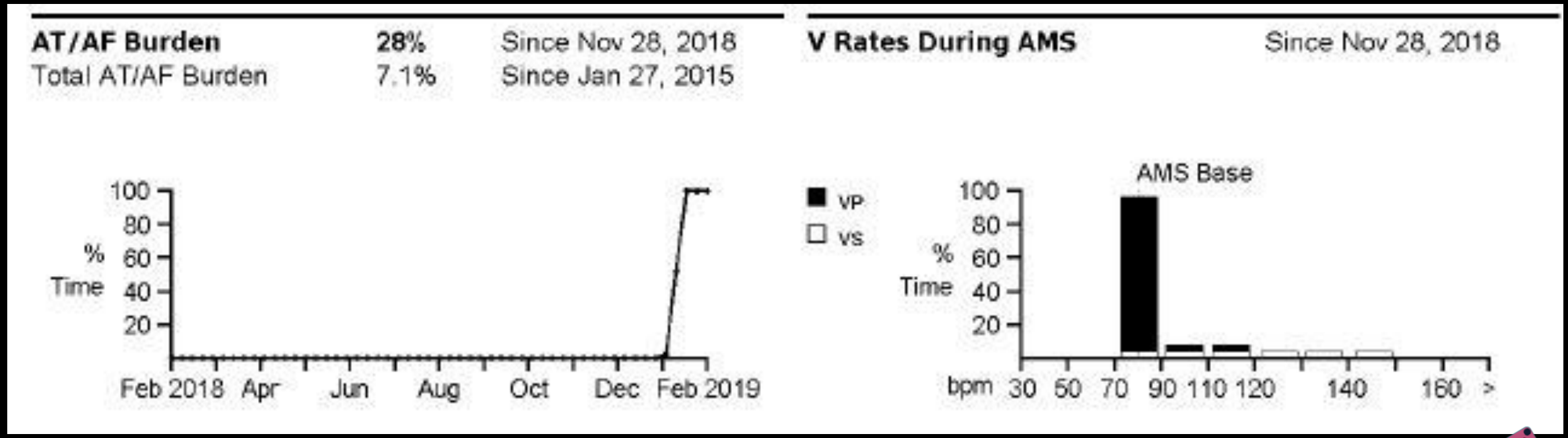
High percent time RM

Low percent time RM

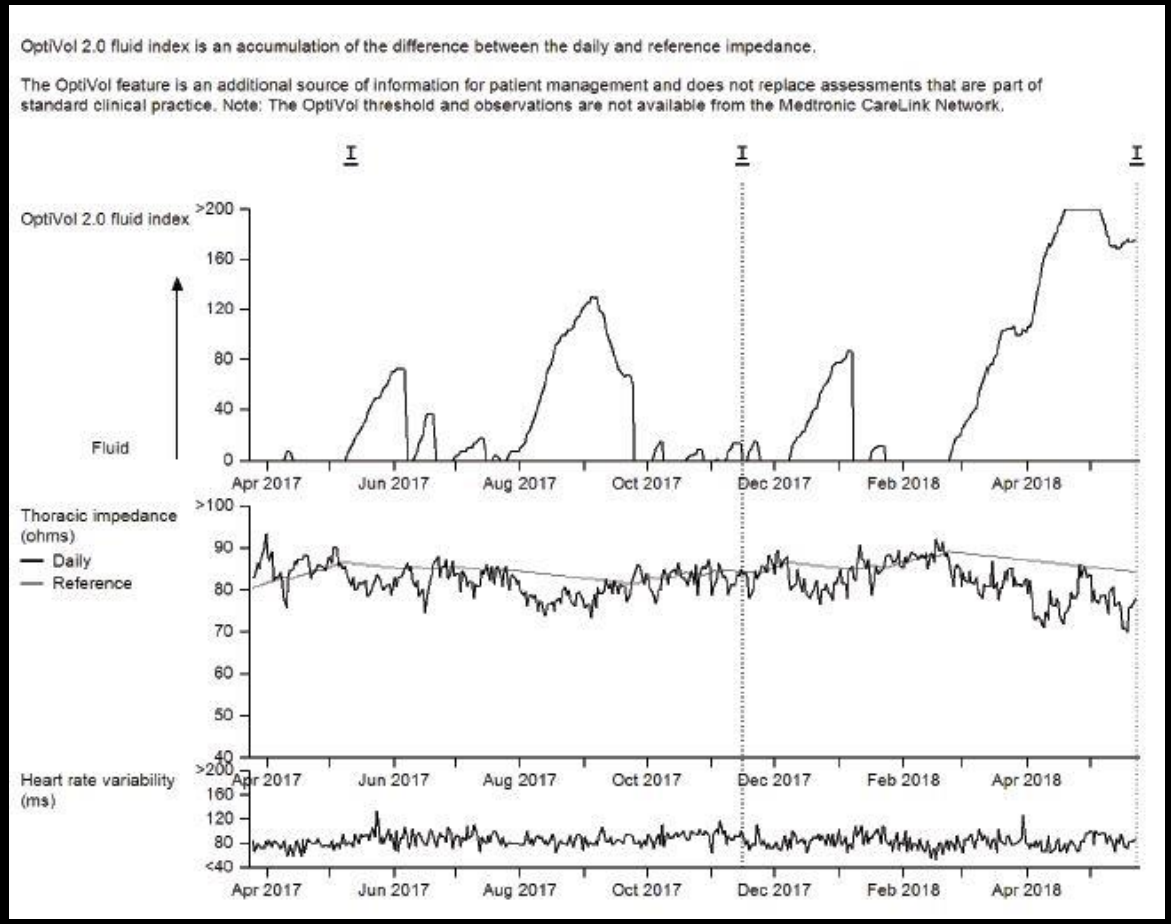
No RM

J Am Coll Cardiol 2015;65:2601–10

RM in Clinical Practice: AF



RM in Clinical Practice: CHF



RM in Clinical Practice: BiV pacing %

Diagnostics Summary

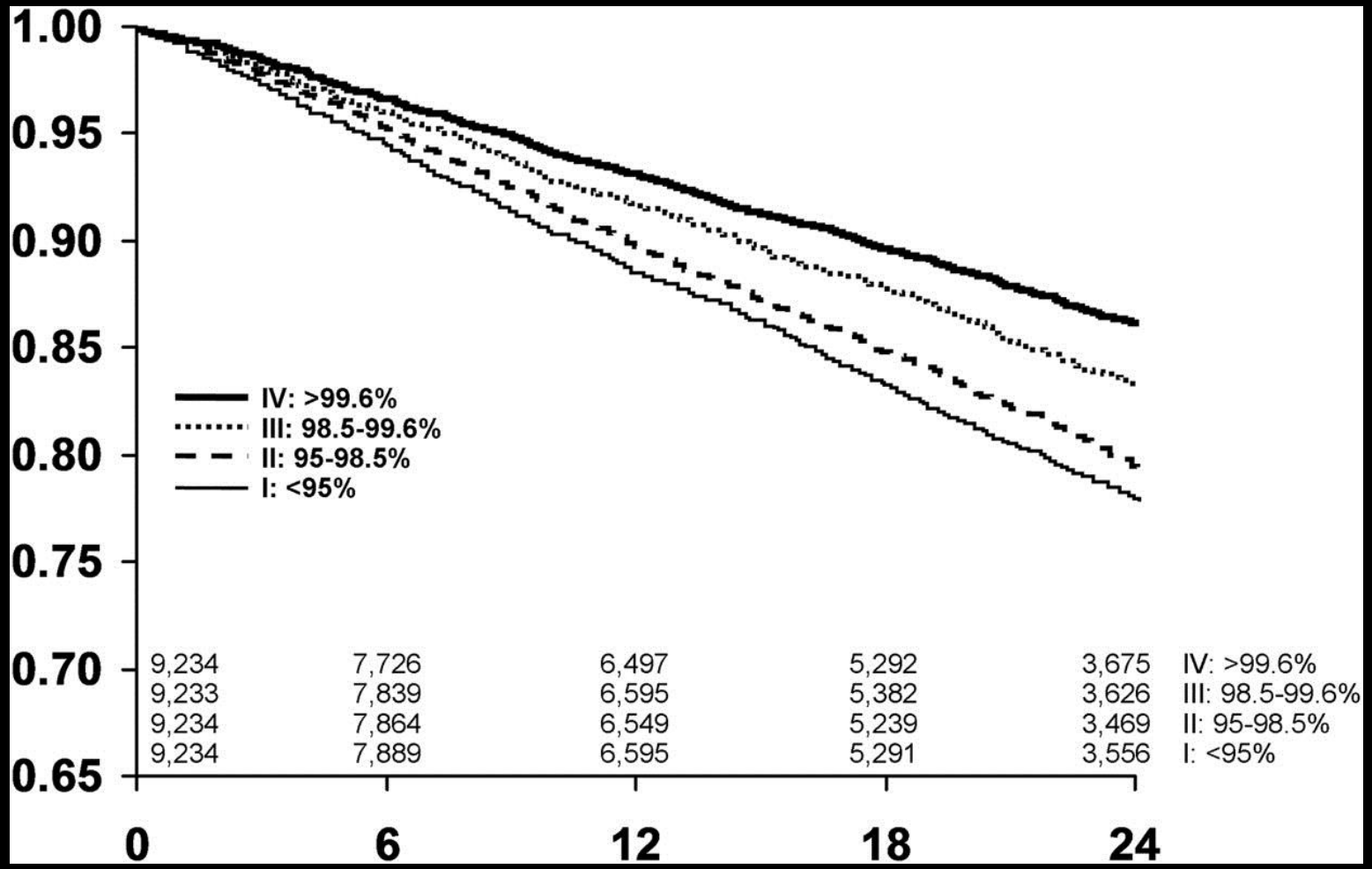
Events	Since Sep 25, 2018	Lifetime
AP	52%	24%
RVP	n/a	0%
BP	90%	62%
VSt	n/a	0%

Includes time in AMS

Events	Since Sep 25, 2018
AS-VP	30%
AS-VS	<1%
AP-VP	60%
AP-VS	1.4%
PVC	7.5%, 1.2M counts

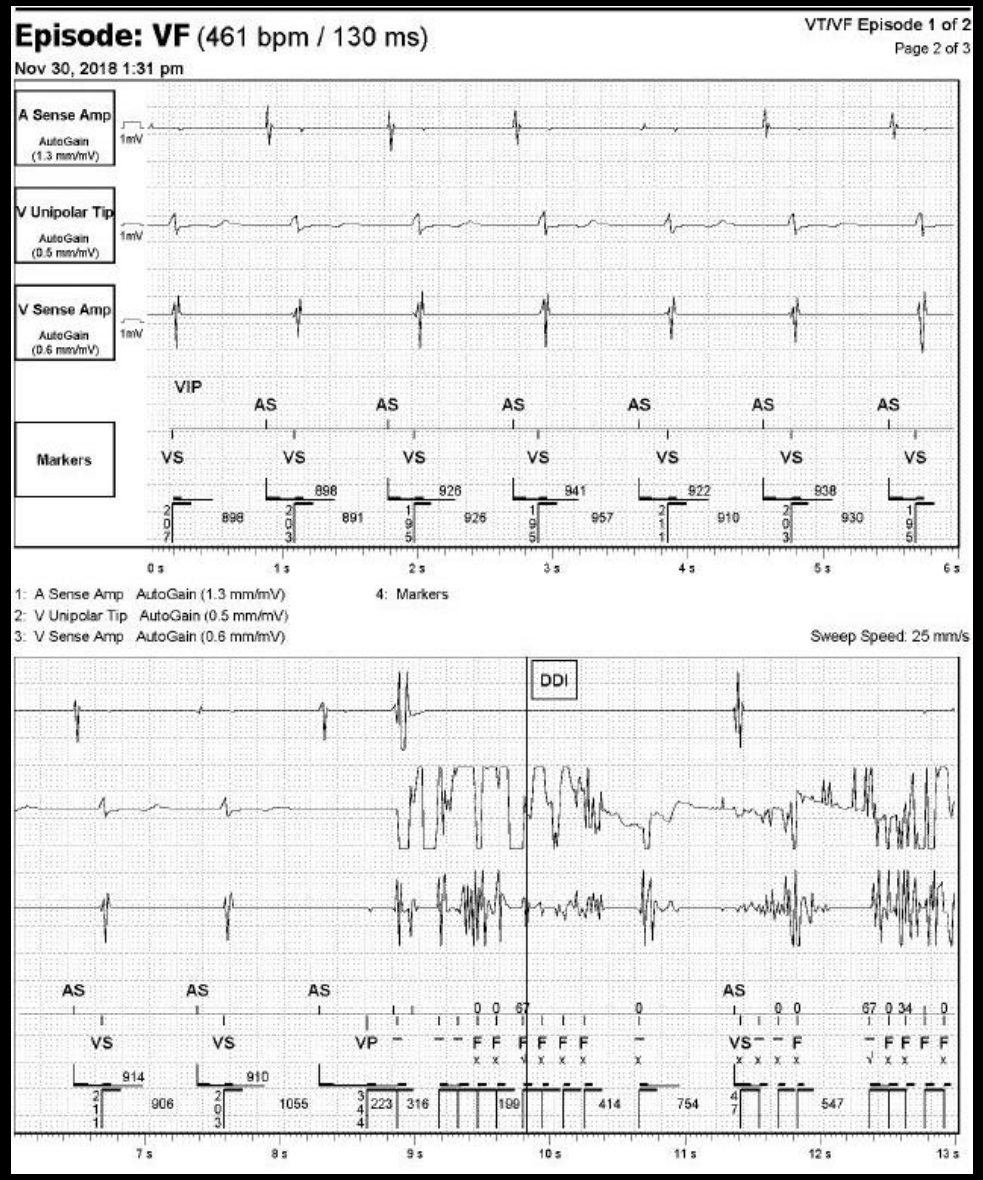
Excludes time in AMS

Maximize BiVentricular Pacing % Survival Benefit

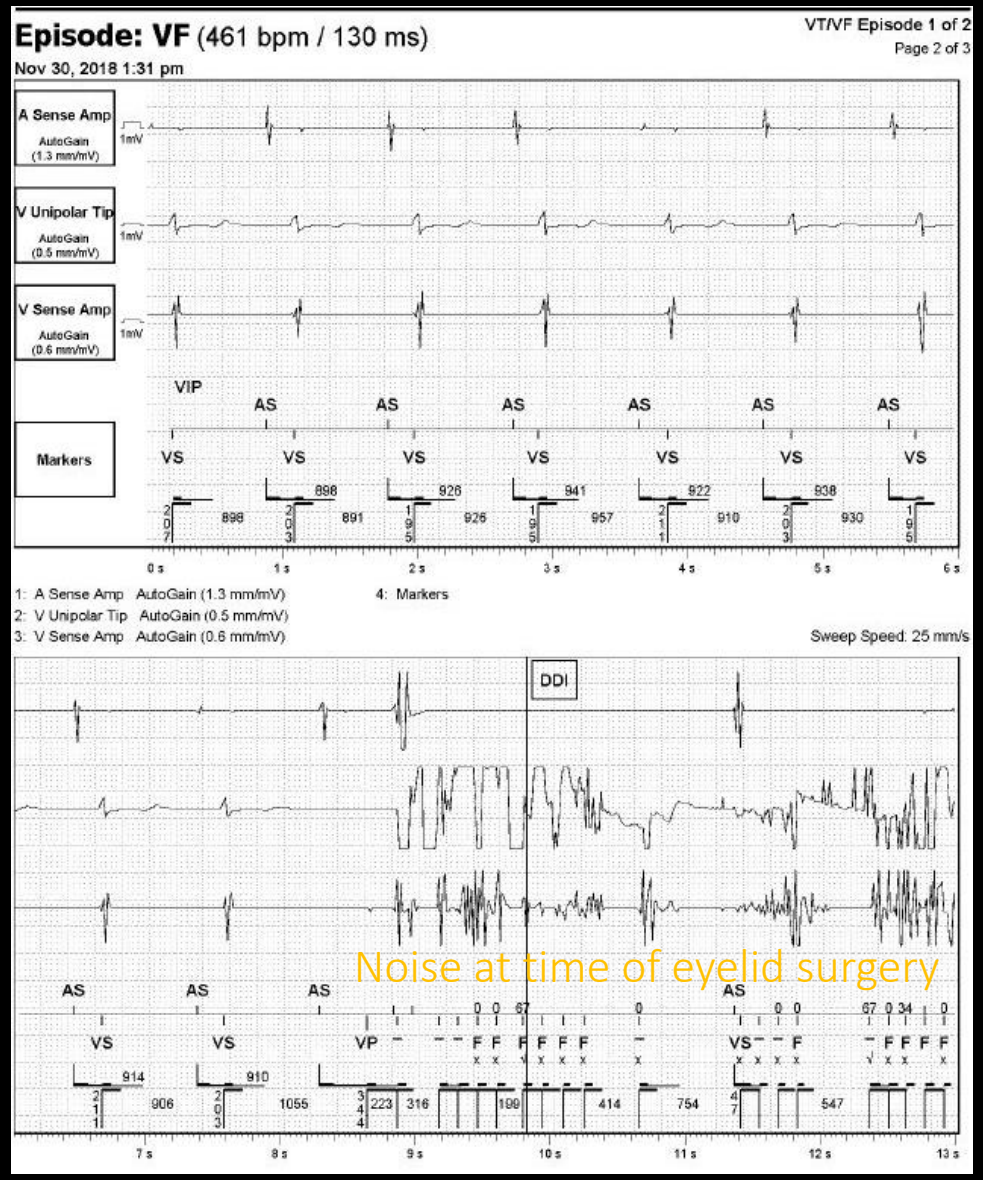


Hayes et al Heart Rhythm 2011;8:1469 –1475

RM in Clinical Practice: Alert for ”VF” episode



RM in Clinical Practice: Alert for ”VF” episode



ILR inserted for syncope in setting of LBBB

Recommended Routine Device Follow-up

- RM combined with annual IPE is preferred to calendar based IPE (1A)
  - FU 3-12 months for PPM's
  - FU 3-6 months for ICD's
- Offer RM to all device patients (1A)

RM Benefits Patients

- Detect clinically relevant device issues more efficiently
- Detect arrhythmias such as AF
- Reduces inappropriate ICD shocks
- Allows monitoring of CHF diagnostics