



How Can We Redefine the Recurrence of AF after Catheter Ablation of AF?



Li-Wei Lo, MD., PhD.

Taipei Veterans General Hospital and National
Yang Ming Chiao Tung University
Taipei, Taiwan

Korean Heart Rhythm Society

COI Disclosure

Li-Wei Lo

The authors have no financial conflicts of interest
to disclose concerning the presentation



Disclosure

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- Consulting Fees: Boston Scientific, Biosense Webster Inc.



Outlines

- Current Definition of AF recurrence following catheter ablation.
- Relationships among AF burden, symptoms and QOL after ablation.
- AF burden and stroke risk, morbidity/mortality.
- Post ablation AF monitoring: Continuous, intermittent or symptomatic driven?



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Current Definition for AF Recurrence Following Ablation: From 2017 HRS Consensus Documents

e348

Early Recurrence After Ablation Definition and Incidence

Early recurrences of AF after AF ablation has been defined as any recurrence of AF >30 seconds during the first 3 months of follow-up. Late recurrence has been defined as any recurrence of AF >30 seconds between 3 and 12 months after AF.^{141,142,143} In using the term *early recurrence of AF* (ERAF) it is recognized that the early recurrence might be AFL or AT. Although we considered defining a new term, *early recurrence of ATAs*, post-AF ablation, for simplicity we have employed the term *early recurrence of AF*. Throughout the document and this section of the document, we note that recurrences can present in the form of AF, flutter, or tachycardia.

Why 30 Seconds?

Does it translate to symptoms or increased stroke risk, morbidity, mortality?



Paroxysmal AF Ablation 10-year Outcome is Suboptimal

Ten-year ablation outcomes of patients with paroxysmal atrial fibrillation undergoing pulmonary vein isolation

Wen-Han Cheng, MD,* Li-Wei Lo, MD,*† Yenn-Jiang Lin, MD,*† Shih-Lin Chang, MD,*† Yu-Feng Hu, MD,*† Yuan Hung, MD,† Fa-Po Chung, MD,*† Jo-Nan Liao, MD,*† Ta-Chuan Tuan, MD,*† Tze-Fan Chao, MD,*† Tseng-Ying Tsai, MD,* Shin-Huei Liu, MD,* Shih-Ann Chen, MD*†

From the *Division of Cardiology, Department of Medicine, Taipei Veterans General Hospital, Taipei, Taiwan, †Institute of Clinical Medicine and Cardiovascular Research Institute, National Yang-Ming University, Taipei, Taiwan, and ‡Division of Cardiology, Department of Medicine, Tri-Service General Hospital, National Defense Medical Center, Taipei, Taiwan.

BACKGROUND Pulmonary vein isolation (PVI) is commonly performed in patients with drug-refractory symptomatic paroxysmal atrial fibrillation (PAF). However, the very long-term follow-up result is limited.

OBJECTIVE We aimed to investigate 10-year ablation outcomes in patients with PAF and long-term follow-up results after PVI.

METHODS This study retrospectively enrolled 176 (131 men, mean age 51.2 ± 12.1 years) patients with drug-refractory symptomatic PAF who underwent electroanatomic-guided PVI. Ten-year follow-up was completed using medical records or telephonic interviews. Procedural characteristics at index procedures and long-term clinical outcomes were investigated.

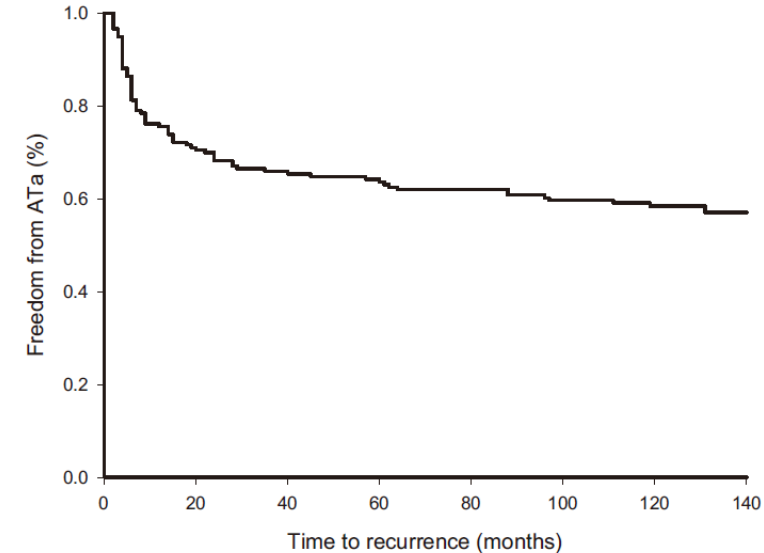
RESULTS After a mean follow-up period of 130.0 ± 10.8 months, sinus rhythm was achieved in 102 (58%) patients after a single procedure (including 14 (8%) patients on antiarrhythmic medications) and in 88% patients after multiple procedures (including 17 (10%) patients on antiarrhythmic medications). Left atrial diameter (odds

ratio 1.067; 95% confidence interval 1.009–1.127; $P = .023$) was the predictor of recurrent atrial tachyarrhythmia after a single ablation procedure. The single-procedure recurrence-free rates were similar between circumferential PVI and segmental PVI (59% and 50%; log-rank, $P = .251$). The recurrence patterns of both groups regarding the role of non-pulmonary vein and pulmonary vein triggers were similar.

CONCLUSION The single-procedure long-term efficacy was modest, with freedom from atrial fibrillation at 10 years being 58%. Those who had enlarged left atrial diameters have more atrial tachyarrhythmia recurrences. Ten-year single-procedure outcomes of the effects of circumferential PVI and segmental PVI in patients with PAF were similar.

KEYWORDS Atrial fibrillation; Left atrium; Long-term; Pulmonary vein isolation; Recurrence

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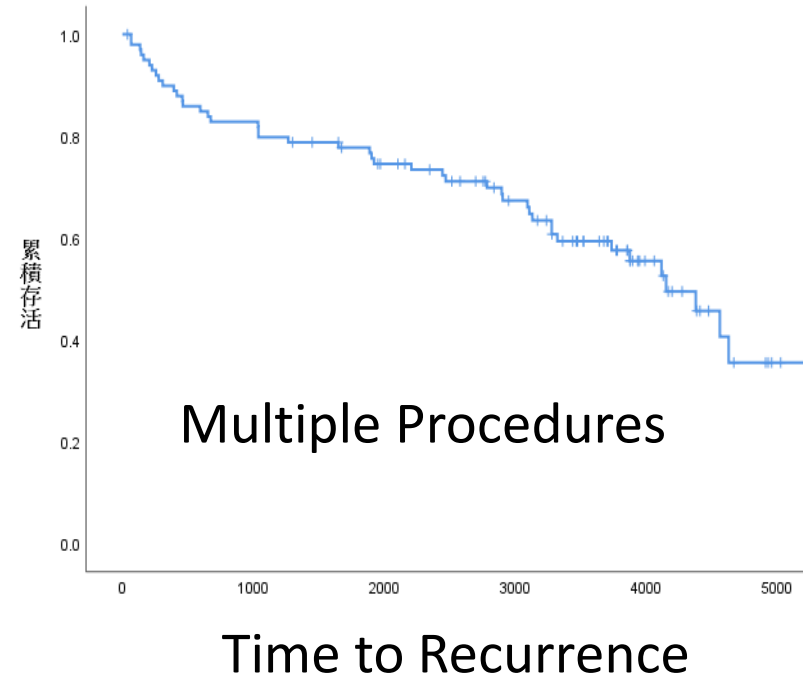
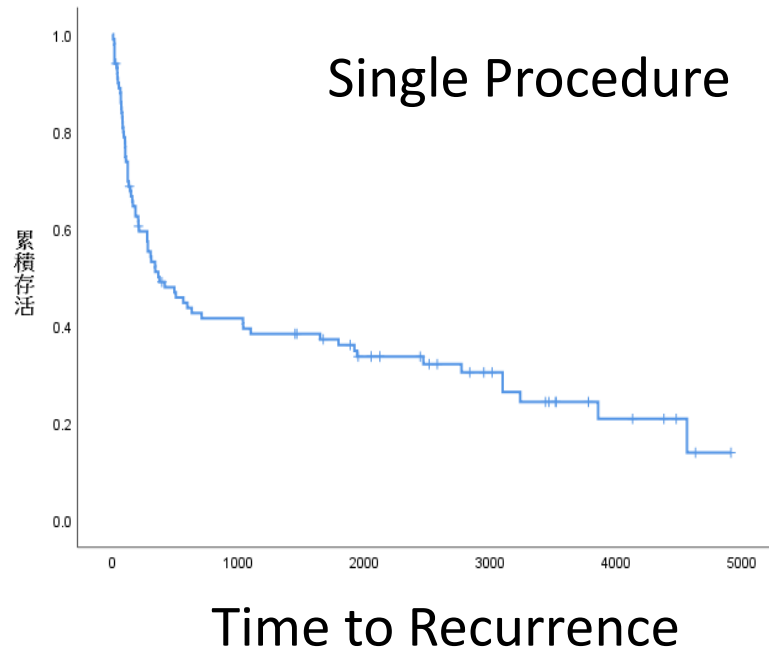


Single Procedure Long-Term Efficacy **58%**.

Multiple Procedure Long-Term Efficacy: **88 %** (1.23 ± 0.61 procedures)



Non-Paroxysmal AF Ablation 10-Year Outcome is Even Worse



Single Procedure Long-Term Efficacy **19%**.

Multiple Procedure Long-Term Efficacy: **55 %** (2.0 ± 1.6 procedures)

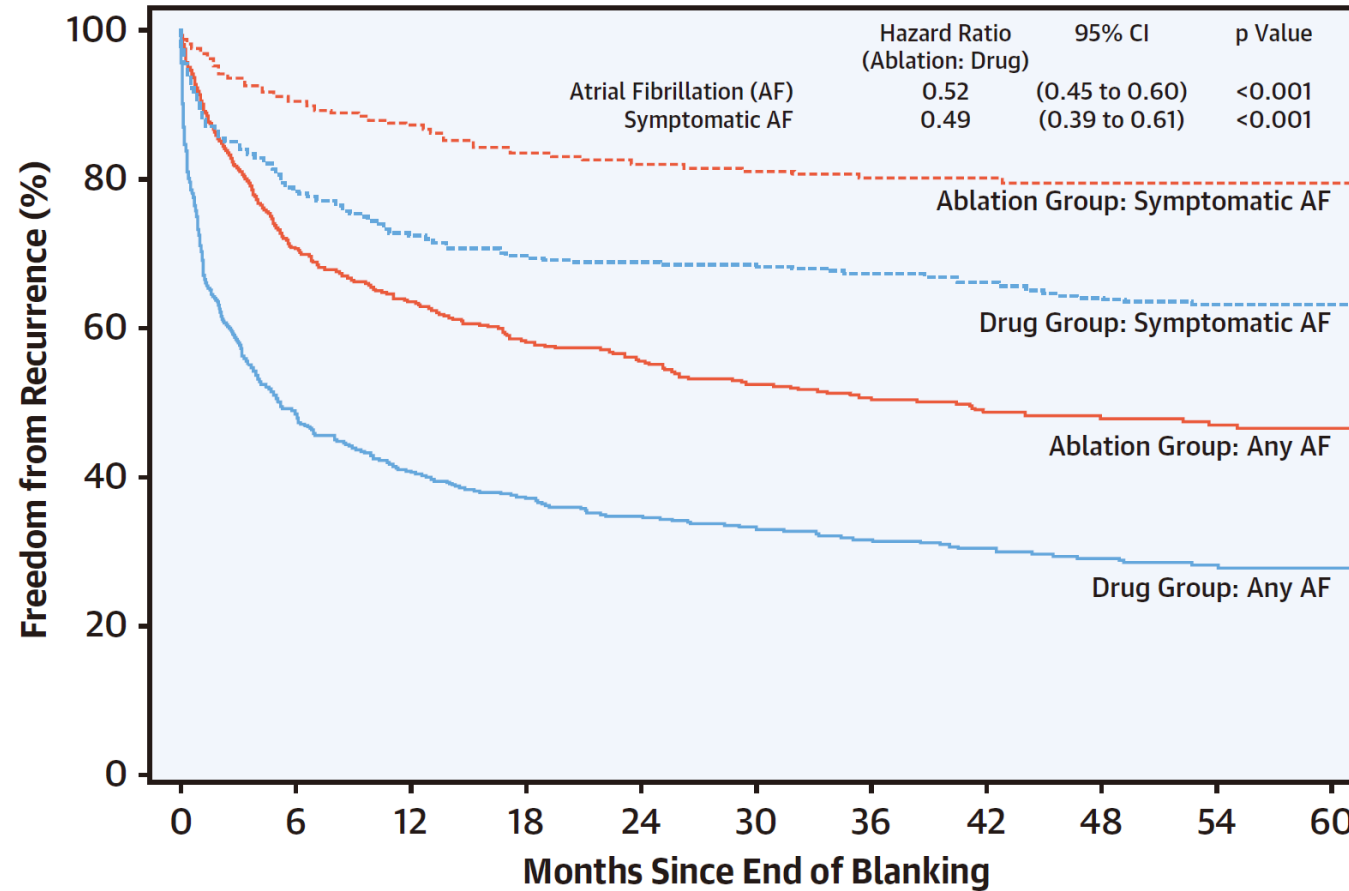


Outlines

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- AF burden and stroke risk, morbidity/mortality.
- Post ablation AF monitoring: Continuous, intermittent or symptomatic driven?



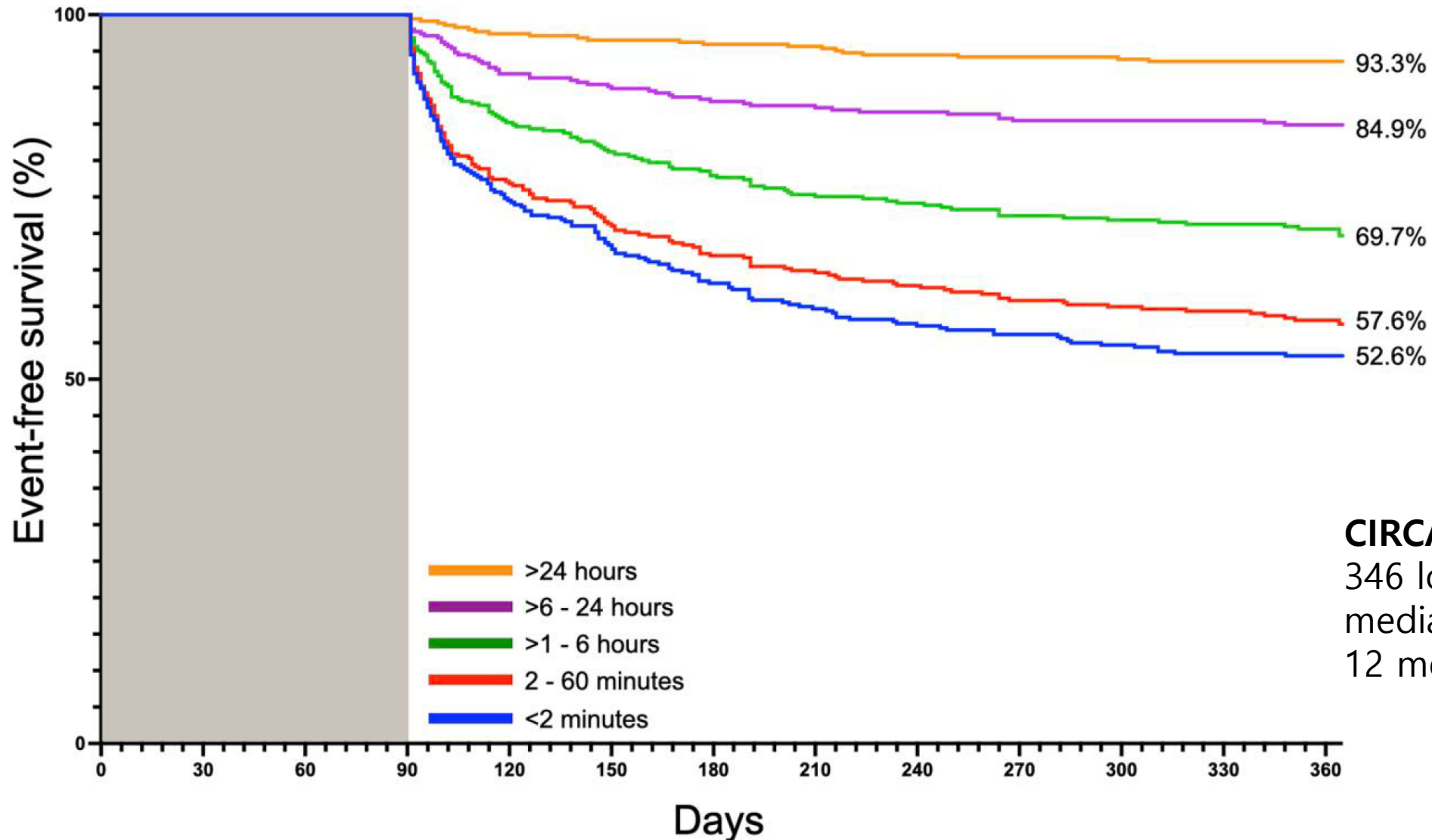
AF Recurrence: Symptoms are Unreliable



1. Symptoms driven TTM, 24hour loop, 96 hours monitor.
2. Ablation was associated with *~50% reduction in symptomatic or any AF.*
3. Only 18.4% in ablation arm and 23.1% of drug arm reported symptoms at first recurrence

	No. at risk	0	6	12	18	24	30	36	42	48	54	60
Ablation Group: Symptomatic AF	611	547	521	468	432	380	335	295	247	203	110	
Drug Group: Symptomatic AF	629	484	441	399	365	330	294	259	212	168	101	
Ablation Group: Any AF	611	430	380	327	290	239	199	162	133	103	57	
Drug Group: Any AF	629	303	251	211	180	156	130	114	93	73	40	

AF Recurrence: Success Rates Vary with Definition of AF

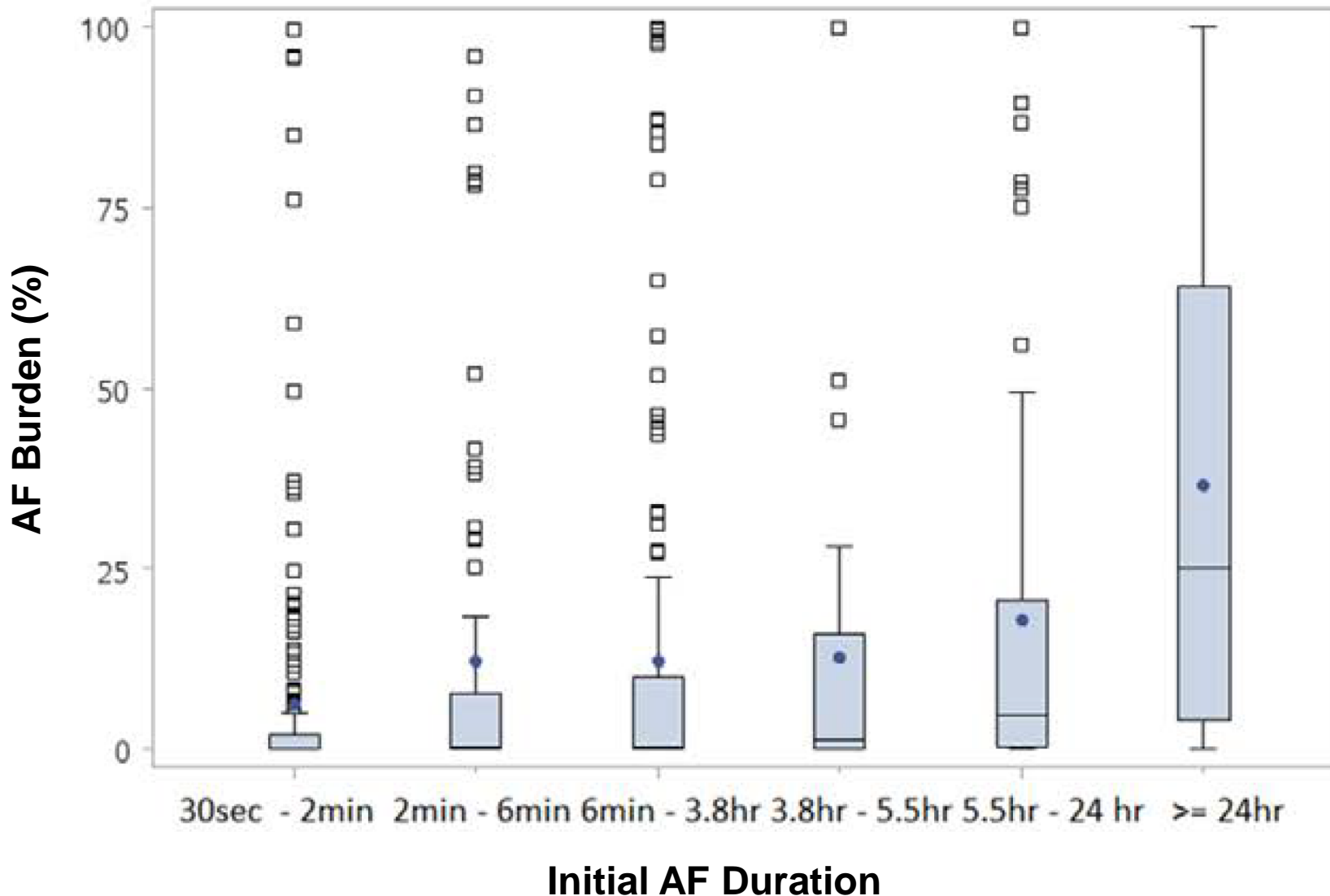


CIRCA-DOSE trial:

346 low burden PAF patients,
median 60y/o, 33.3% Female,
12 months f/u.



Does Short AF Episodes Matter?

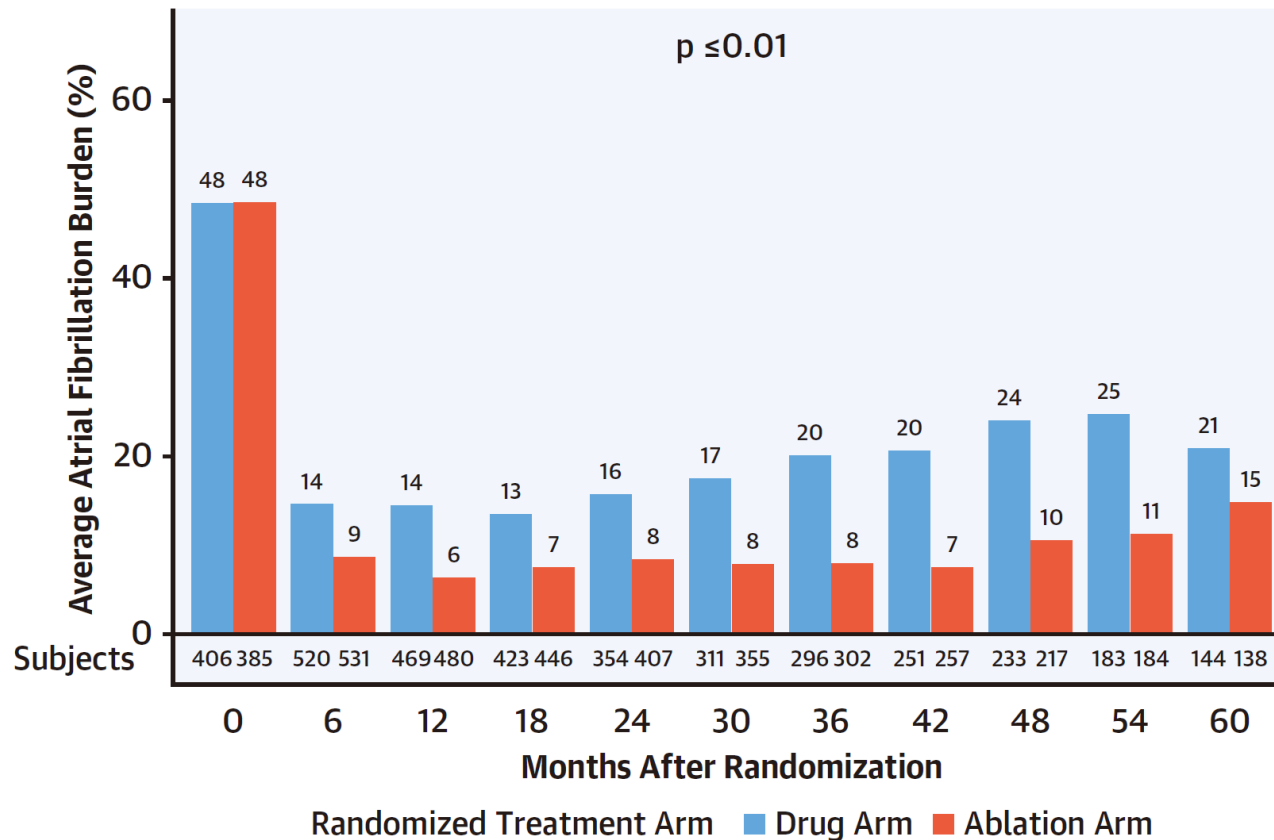


1. Prospective registry of 615 patients (72 y/o) with PPM detected AF. (Medtronic)
2. Median AF burden over 3.7 year range (0.08 to 25%).
3. AF duration → AF burden
3.8 hours → 9.5%
30s -3.8 hrs → 0.2%

Initial shorter AF episodes = less likely to have longer future episodes.

AF Burden: A Better Measure?

FIGURE 3 AF Burden Assessed at 6-Month Intervals in 1,240 Patients Using the CABANA ECG Holter Monitors



Relative reduction:

Abl arm: 69 to 88%

AAD arm: 48 to 73%

Absolute reduction:

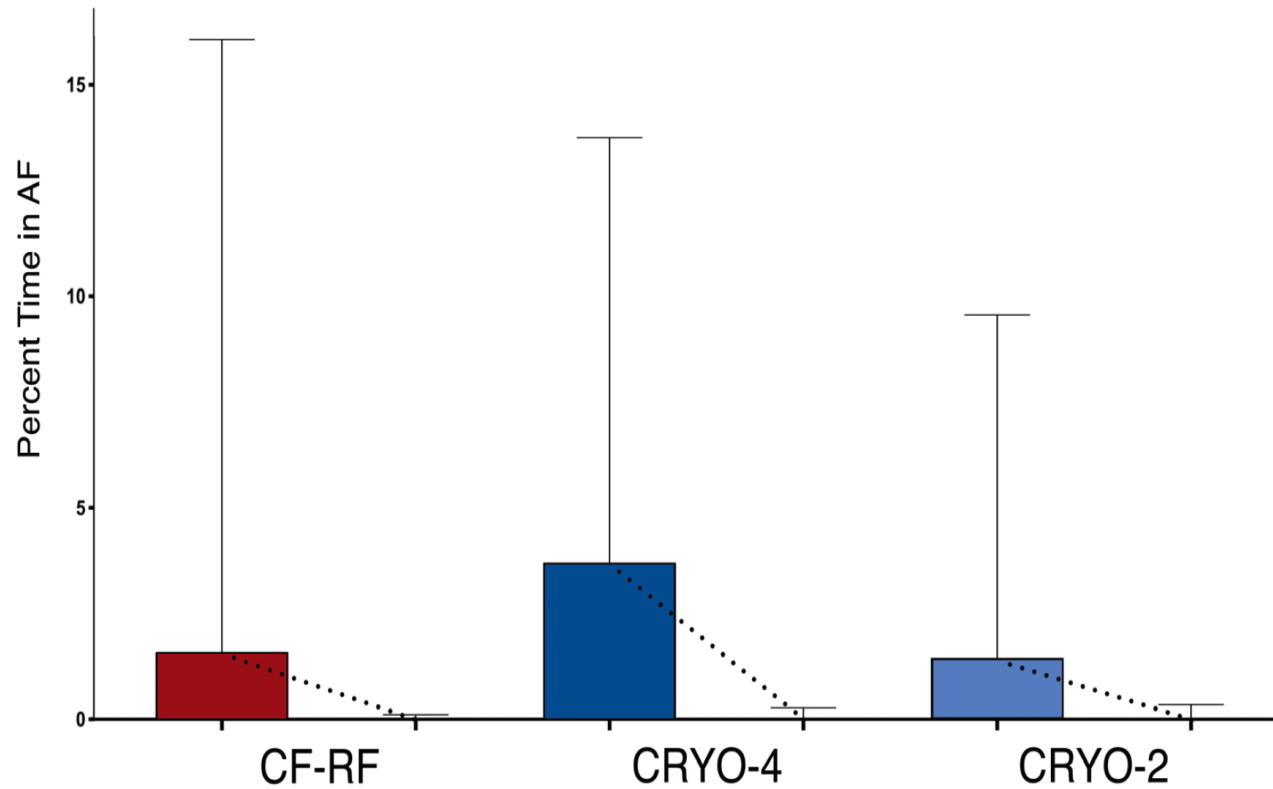
Abl arm: 33 to 42%

AAD arm: 23 to 35%

In CABANA follow-up study, catheter ablation was effectively *reducing the recurrence of AF burden* compared with drug therapy over 5 years f/u.

The percentage AF burden is shown according to randomized treatment groups as assessed at each of the 6-month Holter recording timepoints. Patient population shown in [Figure 1](#). Abbreviations as in [Figures 1 and 2](#).

AF Burden: A Better Measure?



	CF-RF	CRYO-4	CRYO-2
AF Burden median (IQR)	Pre 1.57 (0.08, 16.09) Post 0.00 (0.00, 0.11)	Pre 3.71 (0.22, 13.78) Post 0.00 (0.00, 0.24)	Pre 1.46 (0.09, 9.17) Post 0.01 (0.00, 0.34)
Median reduction in AF burden compared to baseline	99.34% (67.76, 100.00)	99.93% (65.31, 100.00)	98.40% (56.24, 100.00)

Relative reduction:
 Abl arm: 69 to 88%
 AAD arm: 48 to 73%

Absolute reduction:
 Abl arm: 33 to 42%
 AAD arm: 23 to 35%

Medium burden in CIRCA-DOSE Trial:
>98% burden reduction by continuous monitoring.
 (LINQ ILR)

AF Burden and Healthcare Utilization

Take Home Message

AF recurrence, as defined by 30-seconds of arrhythmia, lacks clinical relevance. AF episode duration >1 hour or burden >0.1% are associated with increased rates of healthcare utilization.

Atrial fibrillation recurrence and healthcare utilization



Duration > 1 hour vs. ≤ 1 hour

Emergency department visit
RR 3.2, 95% CI 2.0–5.3

Hospitalization
RR 5.3, 95% CI 2.9–9.6

Cardioversion
RR ∞

Repeat ablation procedure
RR 27.1, 95% CI 10.5–71.0



AF burden > 0.1% vs. ≤ 0.1%

Emergency department visit
RR 2.4, 95% CI 1.9–3.9

Hospitalization
RR 6.8, 95% CI 3.6–13.0

Cardioversion
RR 9.1, 95% CI 3.3–25.6

Repeat ablation procedure
RR 21.8, 95% CI 9.2–52.2

CIRCA-DOSE subanalysis

346 low-burden PAF pts,
median 60 y/o
female 33.3%
1 year f/u.

Associations of AF Burden and HRQoL

Table 2. Atrial Fibrillation (AF) Burden and Quality of Life at Baseline, 6 Months, and 12 Months

Time	AF burden, median (IQR)			AFEQT score, median (IQR)	
	Time in atrial fibrillation, %	Absolute difference in time in AF, min of AF/d ^a	Relative difference in AF burden, %	Score	Absolute difference ^b
Preablation baseline	2.02 (0.12 to 11.91)	NA	NA	53.70 (38.88 to 71.30)	NA
6 mo Postablation	0 (0 to 0.01)	-24.62 (-153.22 to -0.86) ^c	-100 (-100 to -67.09)	92.59 (77.78 to 98.15)	30.09 (14.81 to 45.89) ^c
12 mo Postablation	0	-23.90 (-161.14 to -0.86) ^c	-100 (-100 to -71.00)	93.52 (81.48 to 99.07)	32.33 (17.78 to 48.79) ^c

Abbreviations: AFEQT, Atrial Fibrillation Effect on Quality of Life; IQR, interquartile range; NA, not applicable.

^a Differences in AF burden are calculated as the AF burden at 6 months or 12 months minus the preablation AF burden.

^b Differences in AFEQT score was calculated as the score at 6 months or 12 months minus the preablation score.

^c $P < .05$.

Sub-study of CIRCA-DOSE Trial:

1. Dose dependent relationship: 1 point improvement in AFEQT QoL score for every:
 - a. 15.8 min reduction in absolute daily AF burden
 - b. 0.63% reduction in relative daily AF daily burden

Monitoring After AF Ablation: LINQ AF Study

Table 3 Episode-based PPV, proportion of episodes without EGM, and total AF episode count analysed for the three different AF detection durations

AF detection duration	AF	No AF	PPV (%)	P-value	No EGM	Total
≥2 min	18 819	7890	70.5		16 964	43 673
≥6 min	11 903	2645	81.8	<0.001 ^a	7076	21 624
≥10 min	9751	1604	85.9	<0.001 ^a	4292	15 647

AF, atrial fibrillation; EGM, electrogram; PPV, positive predictive value.
^aP-value for PPV comparison between ≥2 min and ≥6 to ≥10 min detection durations.

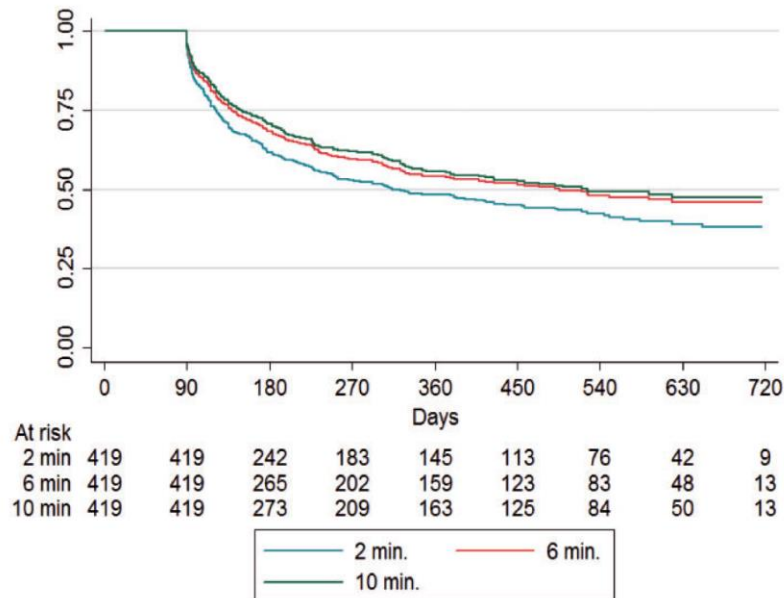


Figure 1 Continuous recurrence analysis: time to first AF episode ≥2, ≥6, and ≥10 min, after a 3 month blanking period. AF, atrial fibrillation.

- 419 patients (53% PAF), with continuous rhythm monitoring for 15 months.
- Patients with exclusive short arrhythmia episodes (<6 min) were extremely rare (<10%).
- **AF detection duration > 6 min and AF burden >0.1% (10min/week)** as a standardized outcome definition for AF studies.
- Post ablation NOAC therapy is based on CHA2DS2-VASc score, but the *stroke risk assessment scores are developed from persistent/permanent AF cohorts.*
- Redefine recurrence still CANNOT correlate with hard clinical AF outcome.

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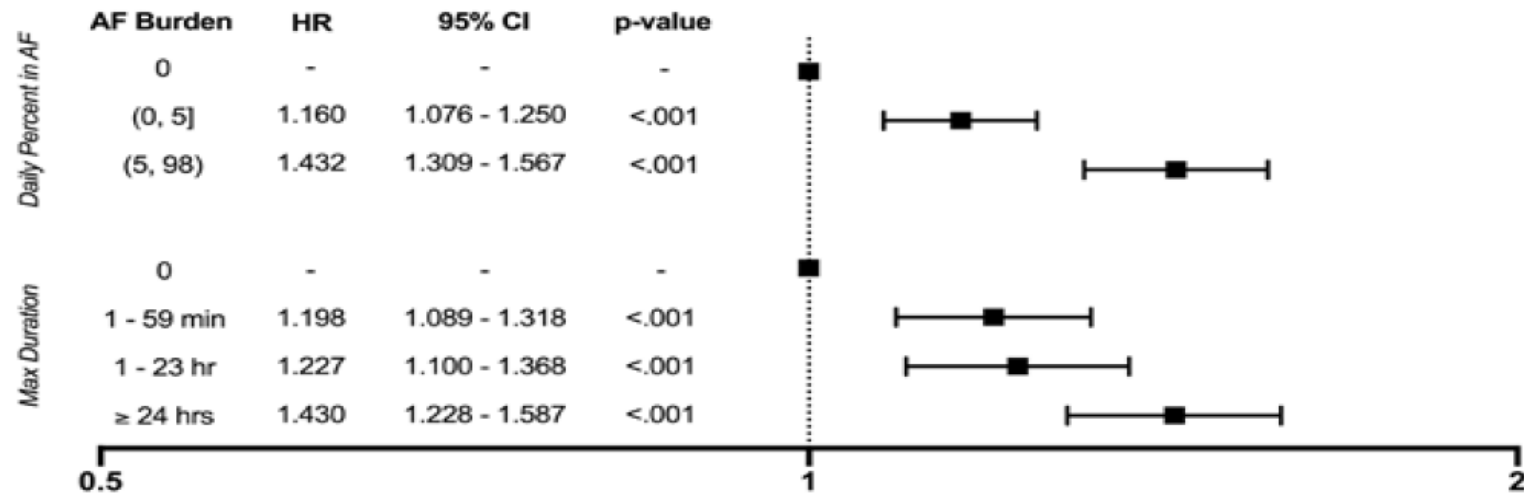
AF Burden and Stroke Risk

<i>Non-anticoagulated patients</i>		CHA₂DS₂-VASc Score				
		0	1	2	3-4	≥5
Maximum Daily AF Duration		n=2922 (13.4%)	n=2151 (9.9%)	n=4554 (20.9%)	n=7164 (32.9%)	n=4977 (22.9%)
	No AF n=16815 (77.2%)	0.33% 40 events	0.62% 46 events	0.70% 95 events	0.83% 139 events	1.79% 157 events
	AF 6 min–23.5 h n=3381 (15.5%)	0.52% 11 events	0.32% 4 events	0.62% 17 events	1.28% 42 events	2.21% 36 events
	AF >23.5h n=1572 (7.2%)	0.86% 4 events	0.50% 3 events	1.52% 19 events	1.77% 28 events	1.68% 13 events

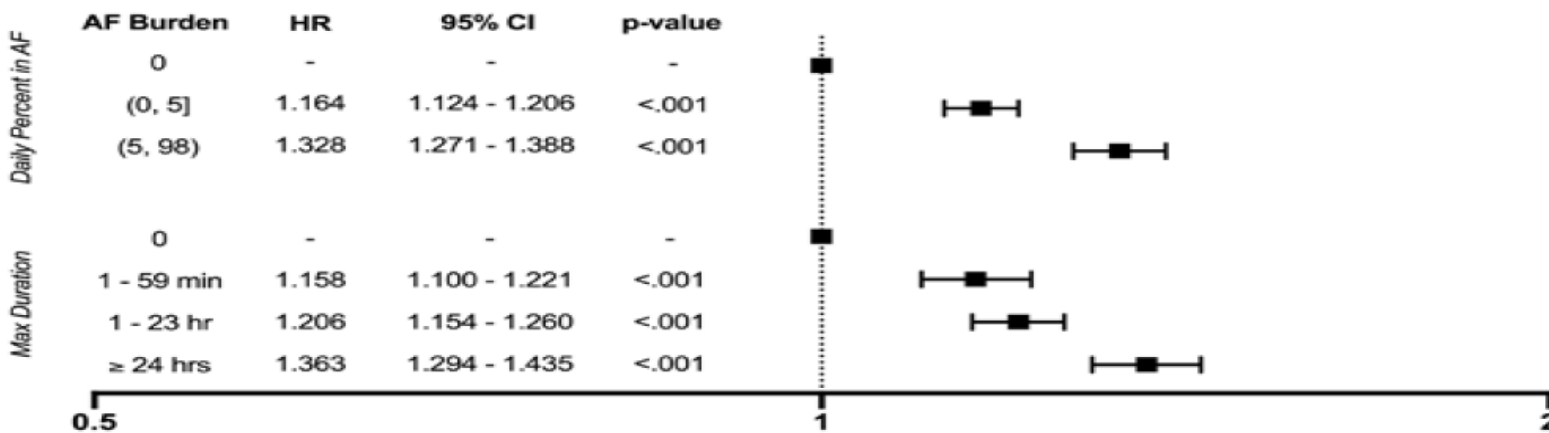
1. 21768 CIED patients, mean age 68.6 y/o, and 63% male.
2. Increasing **AF duration** (p<0.001) and increasing **CHA₂DS₂-VASc score** (p<0.001) were significantly associated with annualized risk of SSE.
3. SSE rates: Low in score 0-1, regardless of AF duration, **>1% if score 2 with > 23.5 hour** or **if score 3 with > 6 min AF**, and ≥ 5 even without AF.



Association of AF Burden and All-cause Mortality



Risk of all-cause mortality at 1 year



Risk of all-cause hospitalization at 1 year.

CIED data from the Merlin.net remote monitoring database (Abbott) to Medicare claims from 2010 to 2016. 39,710 pts with new CIED implants. Mean age 77 y/o, 61% Male, med C HA2DS2-VASc 4.9.


1. **Increasing AF burden or longest AF episodes** both associated with increasing risk of **all cause mortality**. (AF burden 0% → 8.54% 1-yr mor. 0-5% → 8.9%, 5-98% → 10.9%)
2. As continuous variable: HR1.061 for every 10% increase in AF burden.

Outlines

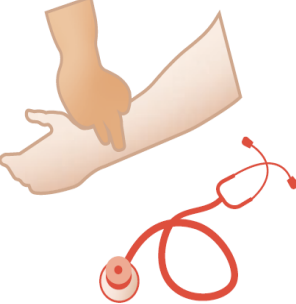
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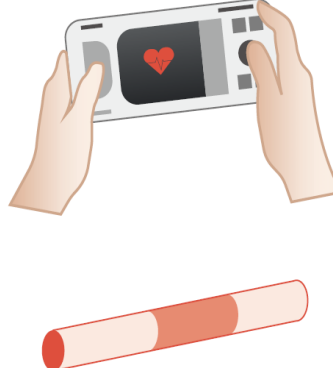
Post-Ablation AF Monitoring




Patient initiated (or medical professional) oscillometric blood pressure cuff



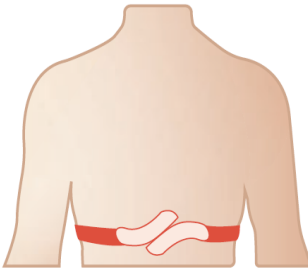
Pulse palpitation, auscultation




Patient initiated (or medical professional) intermittent ECG rhythm strip using smartphone or dedicated connectable device




Intermittent smartwatch ECG initiated by semi-continuous photoplethysmogram with prompt notification of irregular rhythm or symptoms




Wearable belts for continuous recordings




Stroke unit/in hospital telemetry monitoring



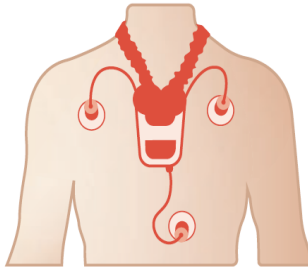
Patient initiated photoplethysmogram on smartphone



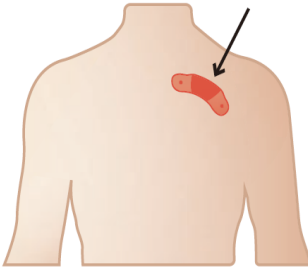
Semi-continuous photoplethysmogram on a smartwatch or wearable



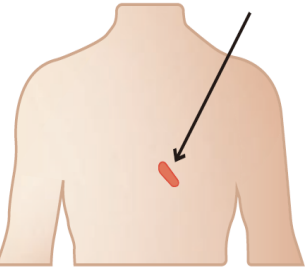
Patient initiated (or medical professional) intermittent ECG rhythm strip using smartphone or dedicated connectable device



Long-term Holter



1-2 week continuous ECG patches



Implantable cardiac monitors



Post-Ablation AF Monitoring

Table 5 Sensitivity and specificity of various AF screening tools considering the 12-lead ECG as the gold standard¹⁷³

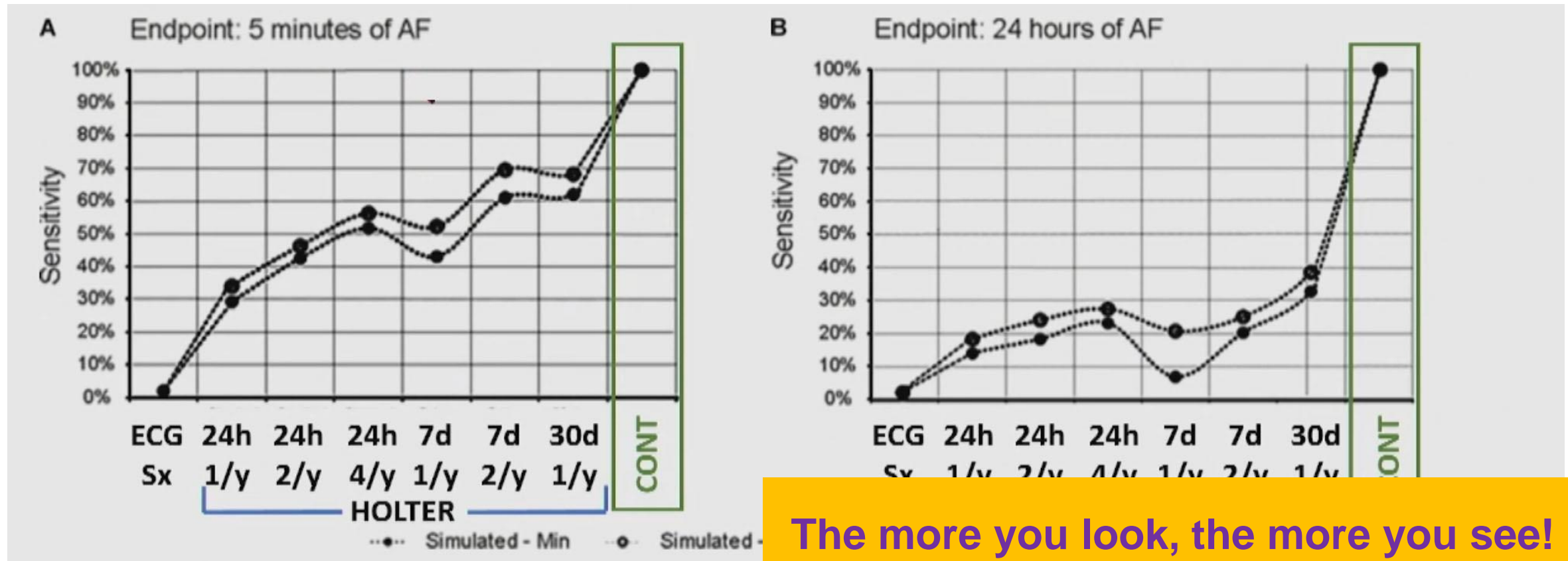
	Sensitivity	Specificity
Pulse taking ²⁰³	87 - 97%	70 - 81%
Automated BP monitors ^{204–207}	93 - 100%	86 - 92%
Single lead ECG ^{208–211}	94 - 98%	76 - 95%
Smartphone apps ^{188,189,191,195,212,213}	91.5 - 98.5%	91.4 - 100%
Watches ^{196,198,213,214}	97 - 99%	83 - 94%

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AF = atrial fibrillation; BP = blood pressure; ECG = electrocardiogram.



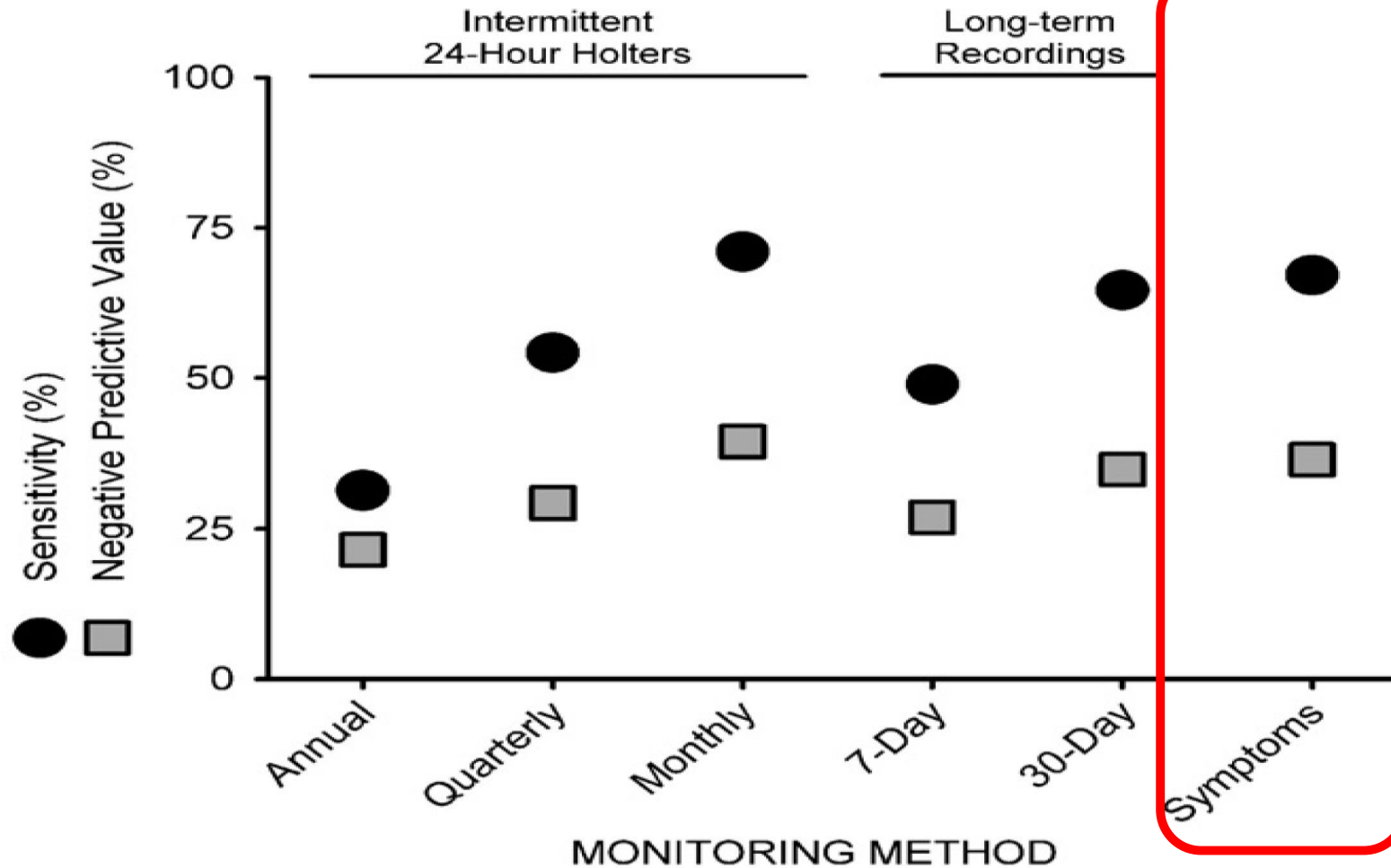
Intermittent vs. CIED Monitoring for AF



The more you look, the more you see!

1. 1-year data from 568 patients with PPM and AF.
2. Simulated: 24 hours (x2 per year), 7-day (x1 per year), and 30-day Holter (x1 per year).
3. Sensitivity for detecting 5 min AF: 44.4%, 50.4%, 65.1%; 24-hour AF: 19.9%, 21.8% 36.0%.
4. Lower risk of stroke: AF free with CHADS2 ≤ 2 or AF-5 min with CHADS2 ≤ 1 or AF-24 hours with CHADS2 =0.

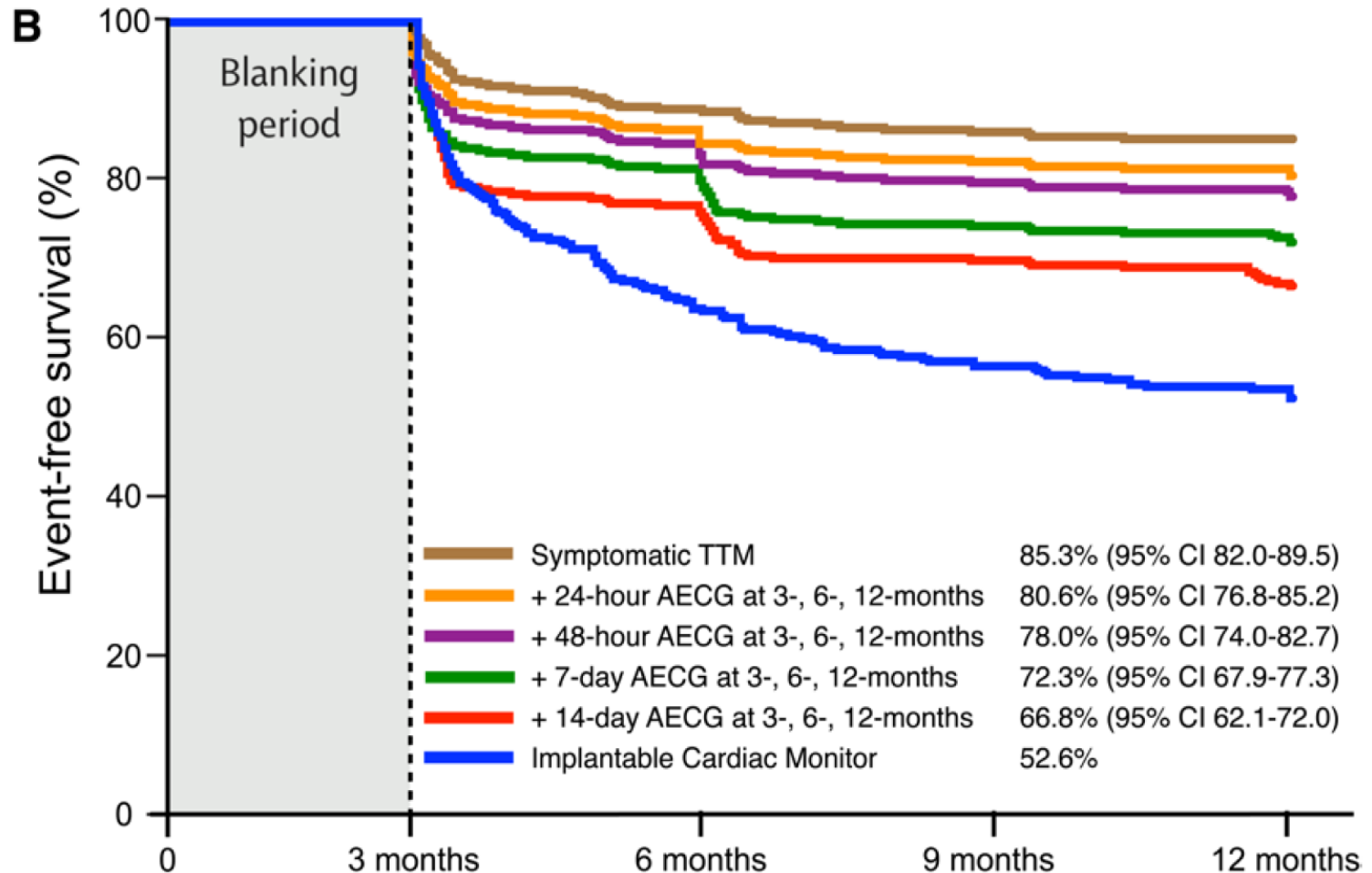
Intermittent vs. Symptom-based Monitoring



all $p < 0.001$ vs. Continuous Monitoring

1. 574 PPM patients for over 1 year.
2. Simulated 24 hours, 7 days, and 30 days Holter.
3. Underestimation of AF with sensitivity of 31-71% and NPV 21-39%.
4. Symptom-based monitoring: Sensitivity: 67.1%, NPV 36.4%
5. Intermittent and symptom-based monitoring is highly inaccurate for identifying patients with any or long-duration AT/AF and for assessing AT/AF burden.

Intermittent vs. ICM in AF Post-Ablation



CIRCA-DOSE Sub-study:

1. 346 patients with ICM and *computer simulation* of non-invasive monitor.
2. Most noninvasive monitoring strategies had *poor sensitivity* for detecting arrhythmia recurrence.
3. *Slight gain (5-10%)* with addition of symptomatic TTM.
4. AF detection improves with *increasing duration and intensity of monitoring*.
5. Serial long-term (**7-14 day**) intermittent monitors accumulating at least **28 days** annually estimates of AF burden comparable with ICM.

Continuous Rhythm Monitoring

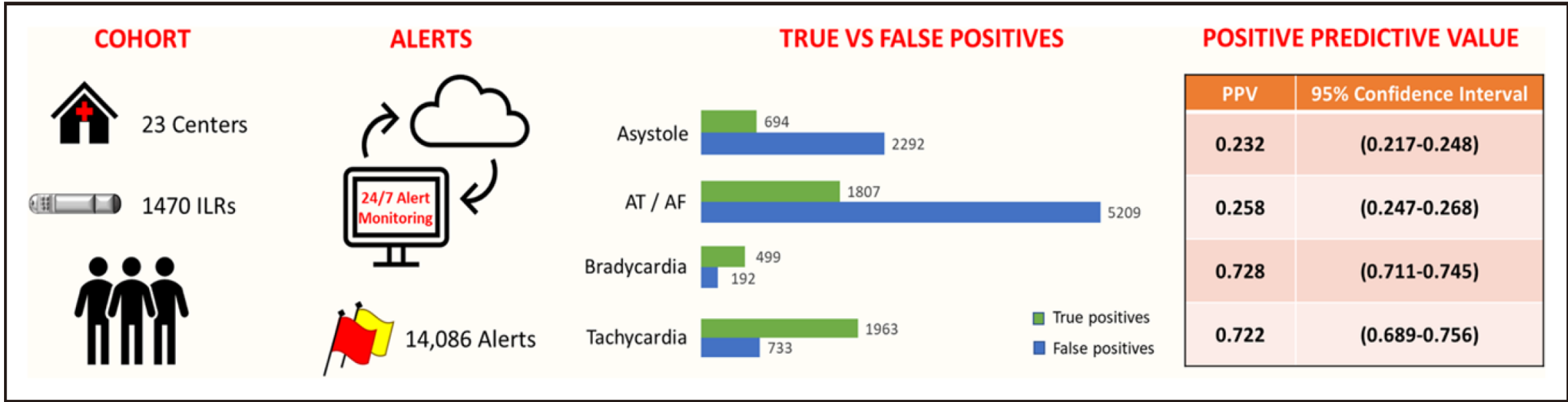


Figure. The number of implantable loop recorders contributing to the remote monitoring alert burden during the 6-mo monitoring period and proportions of true-positive and false-positive alerts in each alert category.

AF indicates atrial fibrillation; AT, atrial tachycardia; ILR, implantable loop recorder; and PPV, positive predictive value.

Gold Standard is continuous monitoring with CIEDs (ICM or existing PPM, ICD).

1. Patient acceptance, costs/lack of reimbursement, invasive.
2. False positive/alerts.



Rhythm Monitoring Using Wearables

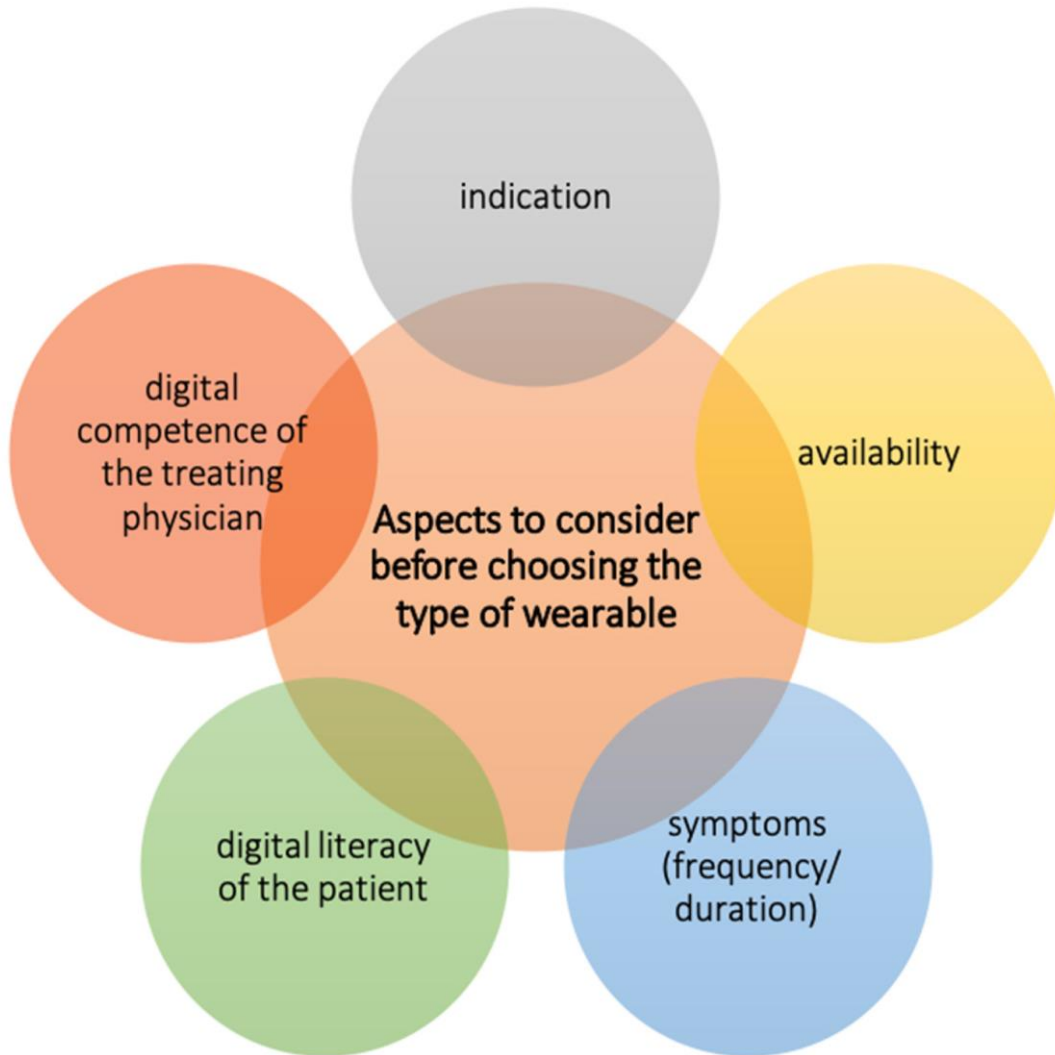


Figure 2. Aspects to consider before choosing the type of wearable.

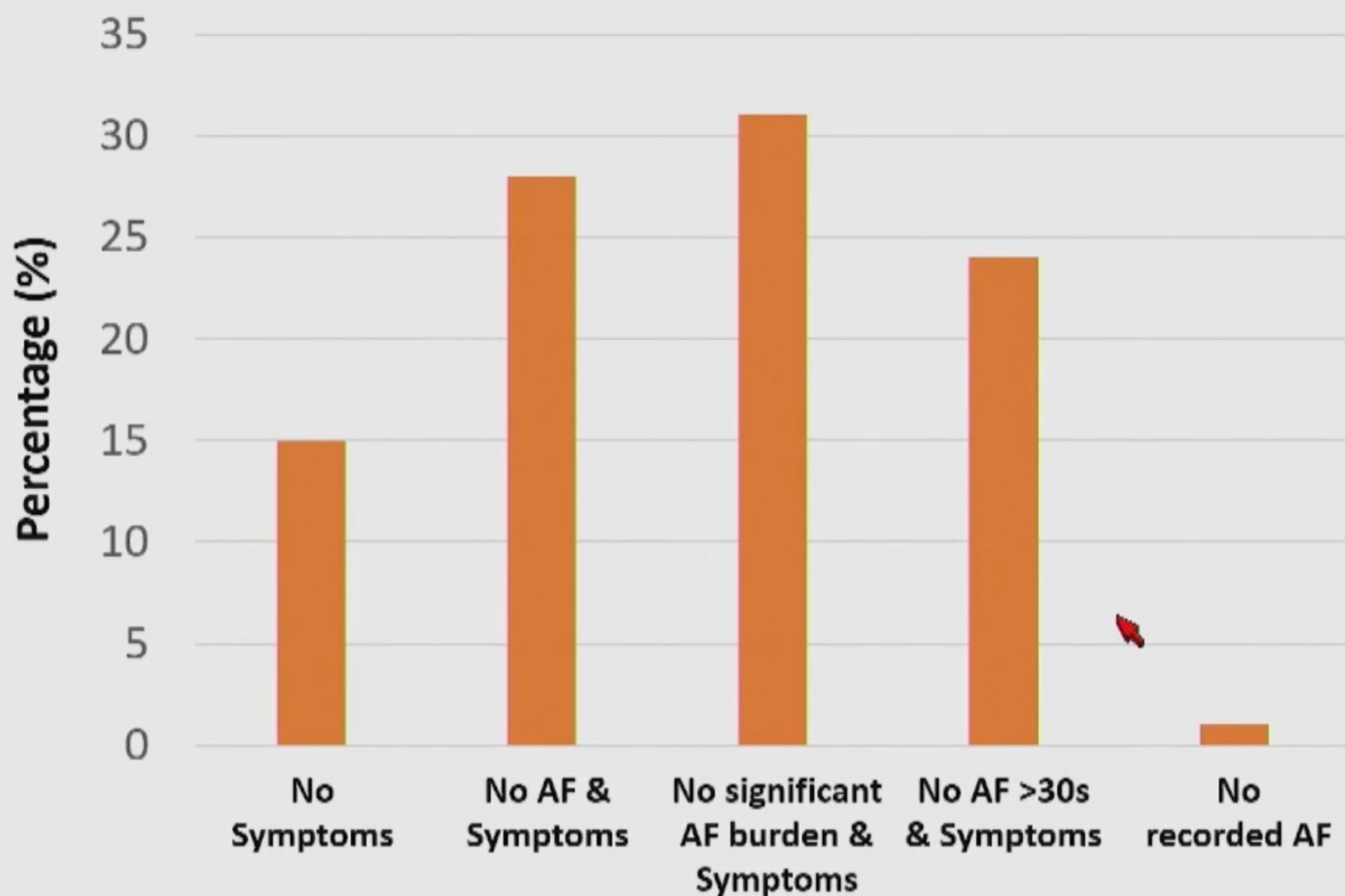
- **Advantages**

- May increase AF detection
- Higher availability
- May guide AF management.

- **Disadvantages**

- Patient compliance
- Not validated in post-abl AF.
- Lack of physician reimbursement.
- Lack of infrastructure/integration.
- Data overload.
- Variable signal quality, false +ve.

What is AF recurrence? EHRA 2022 Survey



- 107 respondents from 21 ESC jurisdictions
- $\frac{3}{4}$ senior EPs

EHRIS 2022 Surveys

1. More than **80%** of physicians perform routine monitoring after AF ablation.
2. **51%** of them preferring a long-term monitoring strategy.
3. **Cost** was reported to have an impact on the choice of monitoring strategy.
4. Self-screening was recommended by most (71%) of the physician.
5. For most physician, *the combination of the absence of symptoms and ECG endpoints* defines a successful result after AF ablation.

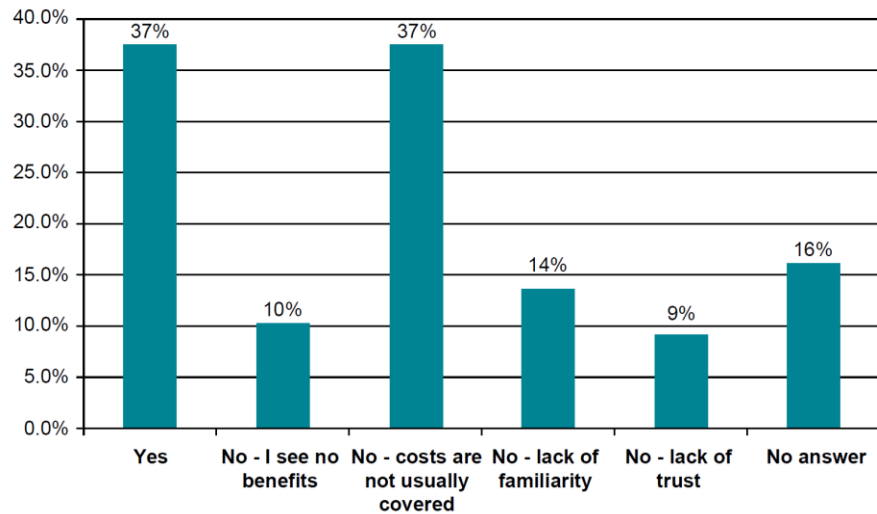


Figure 1 Use of smartphones/wearables for recurrence monitoring after AF ablation (with more than one negative answer allowed).

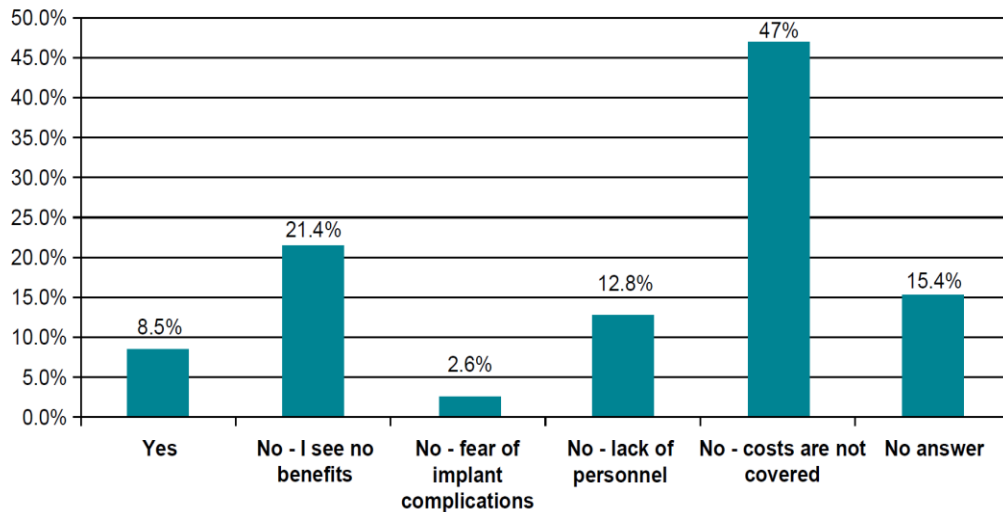


Figure 2 Use of implantable loop recorders for recurrence monitoring after AF ablation (with more than one negative answer allowed).

Take Home Messages:

Relevant Measures of AF Ablation Success

- AF detection improves with **increasing duration** and **intensity** of monitoring.
- Serial long-term (**7-14 day**) intermittent monitors accumulating at least **28 days** annually estimates of AF burden comparable with ICM.
- **AF burden (Duration > 5 min, burden >0.1%)** a better indicator for the definition of recurrence, initial shorter AF episodes = less likely to have longer future episodes.
- Increasing **AF burden** and increasing **CHA2DS2-VASc score**: significantly associated with annualized risk of SSE.
- For most physician, the combination of the **absence of symptoms and ECG endpoints (AF burden)** defines a successful result after AF ablation.

Thank You For Your Attention !

