



When and How to Monitor Subclinical AF



Park Young Jun

Yonsei University Wonju College of Medicine, Republic of Korea

Korean Heart Rhythm Society

COI Disclosure

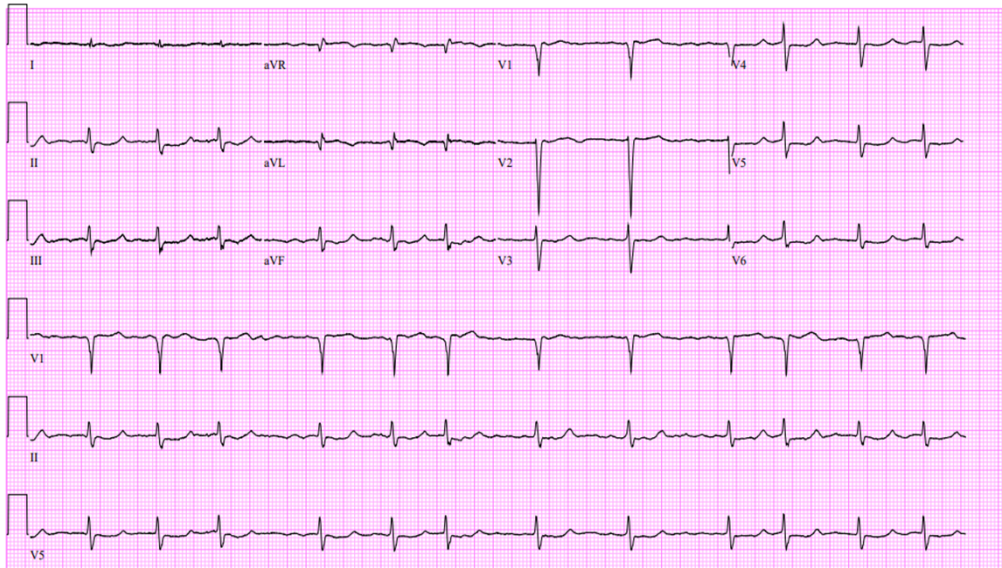
Park Young Jun

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



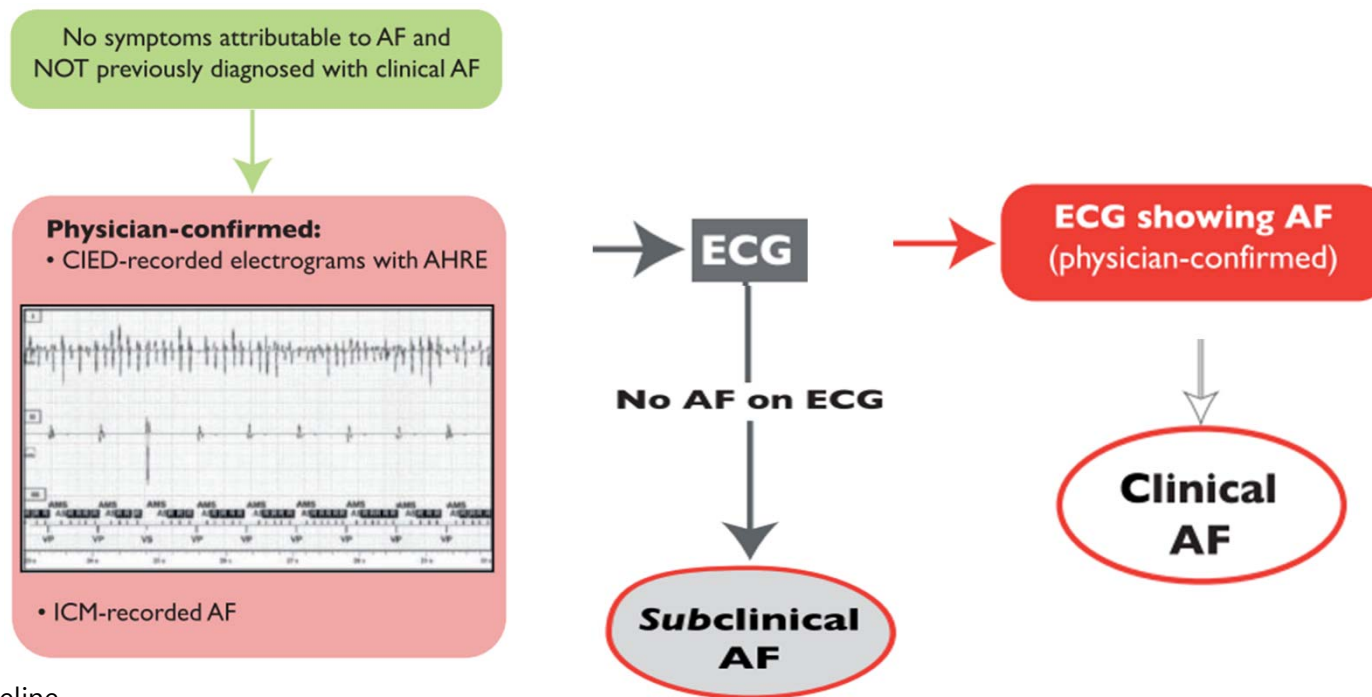
Clinical Atrial fibrillation

- Traditionally been defined by documentation of the arrhythmia on surface ECG
- Independent of the duration of the arrhythmia or the associated symptoms

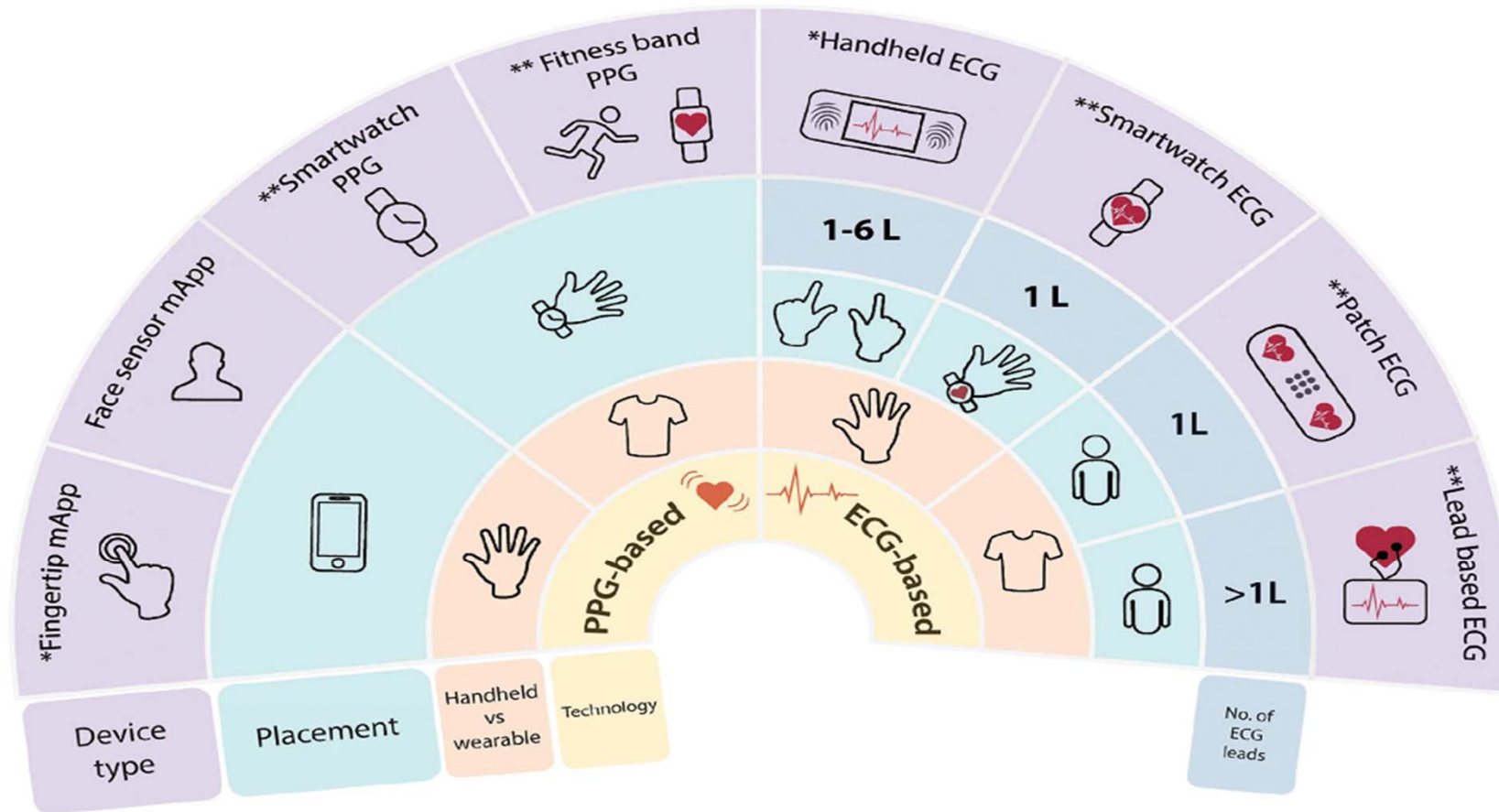


Subclinical AF

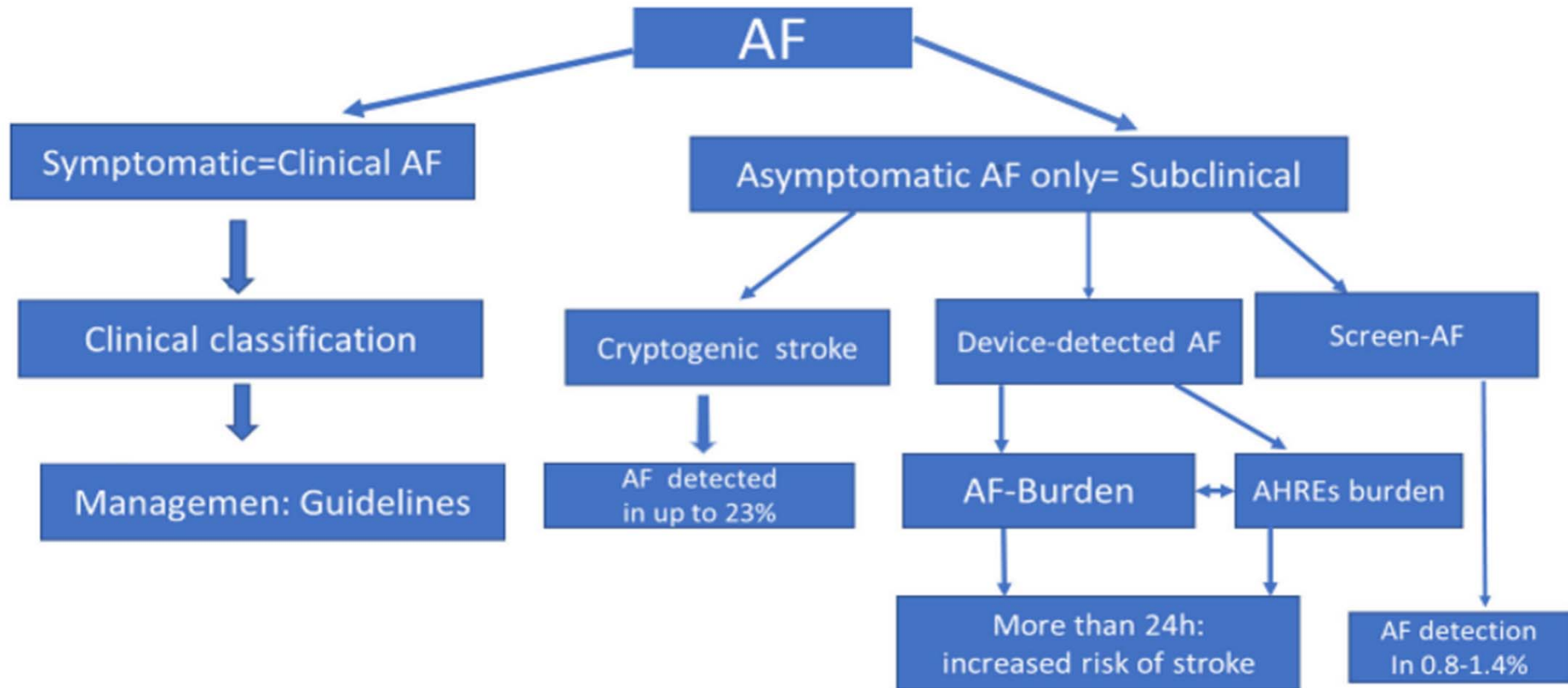
AHRE confirmed to be AF, AFL, or an AT, or AF episodes detected by insertable cardiac monitor or wearable monitor and confirmed by visually reviewed intracardiac electrograms or ECG-recorded rhythm



AF screening tools



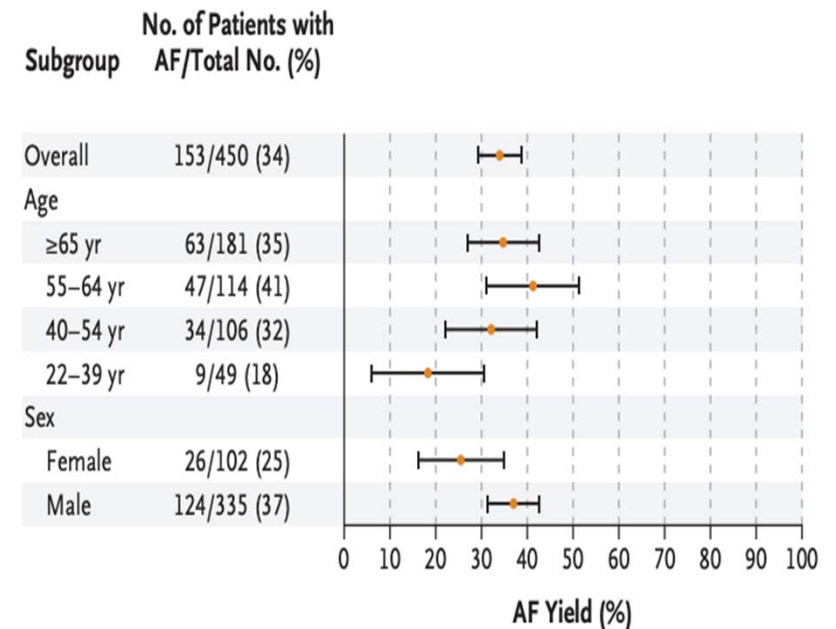
AF classification



Apple Heart (Apple watch)

:419,297 participants

Characteristic	Total Cohort (N=419,297)	Notification Subgroup (N=2161)	ECG Patch Subgroup (N=450)
Sex — no. (%)†			
Female	177,087 (42)	461 (21)	102 (23)
Male	238,700 (57)	1672 (77)	335 (74)
Other	396 (0.1)	0	0
Not reported	3,114 (0.7)	28 (1.3)	13 (2.9)
Age — yr	41±13	57±15	59±14
Age distribution — no. (%)			
≥65 yr	24,626 (5.9)	775 (36)	181 (40)
55–64 yr	42,633 (10)	556 (26)	114 (25)
40–54 yr	132,696 (32)	488 (23)	106 (24)
22–39 yr	219,179 (52)	341 (16)	49 (11)
Not reported	163 (<0.1)	1 (<0.1)	0



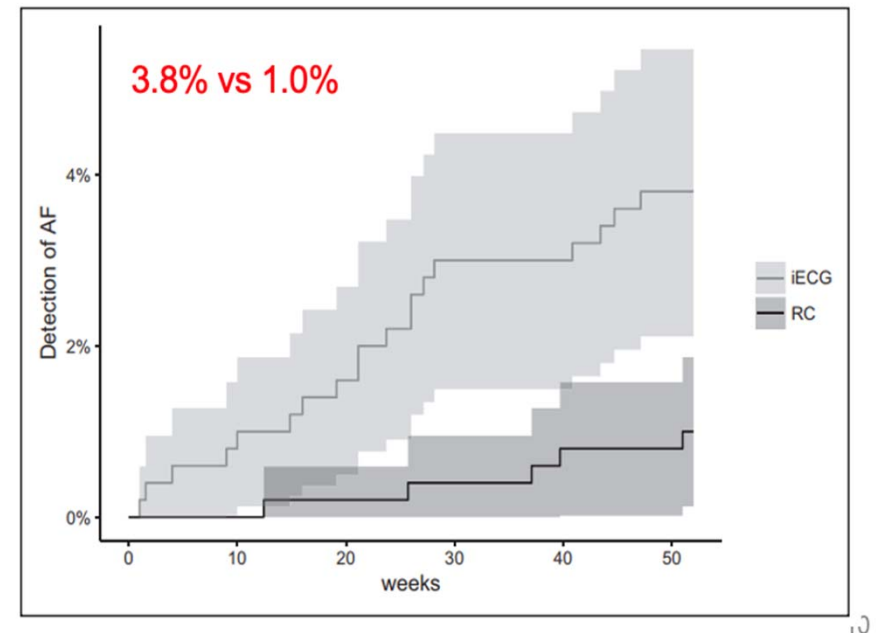
- 2161 participants (0.52%) received notifications of irregular pulse
- 450 participants who returned ECG patches, atrial fibrillation was present in 153(0.04%)



REHEARSE-AF (Handheld ECG)

:1000 patients age >65 with C-V score >2 Twice weekly, 30sec, 12months

	iECG (n=500)	RC (n=501)	P Value
Sex, M/F, n (%)	241/259 (48/52)	225/276 (45/55)	0.30
Mean age (SD), y	72.6 y (5.4)	72.6 y (5.4)	0.98
Age 65–74 y, n	328	330	0.93
Age ≥75 y, n*	172	171	0.93
Heart failure, n (%)	5 (1)	9 (2)	0.28
Hypertension, n (%)	268 (54)	272 (55)	0.75
Diabetes mellitus, n (%)	129 (26)	140 (28)	0.43
Stroke or TIA, n (%)	35 (7)	28 (6)	0.37
Vascular disease, n (%)	71 (14)	79 (16)	0.50
CHADS-VASc score (SD)	3.0 (1.0)	3.0 (1.0)	0.57



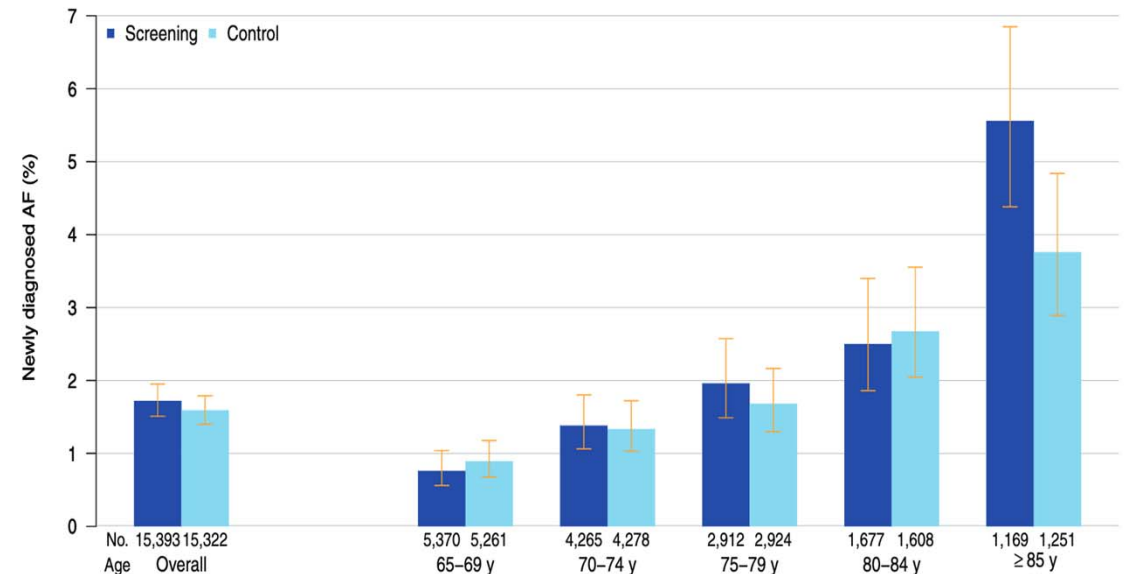
- 72.6yrs , 53% were female, CHADS-VASc score 3.0
- 19 in the iECG group were diagnosed with AF versus 5 in the RC arm (HR 3.9))



SCREEN-AF Study (Patch)

: 30 715 participants ages ≥ 65 years, without AF, Two weeks continuous ECG(Patch)

Patient characteristics		
Total number	15 393	15 322
Age, mean (SD), y	73.9 (6.8)	74.0 (6.9)
Age, >75 y, n (%)	5758 (37.4)	5783 (37.7)
Female sex, n (%)	9184 (59.7)	8907 (58.1)
Race and ethnicity, n (%)*		
White	12 688 (82.4)	12 641 (82.5)
Black	811 (5.3)	717 (4.7)
Hispanic	334 (2.2)	304 (2.0)
Other	1259 (8.2)	1347 (8.8)
Height, mean (SD), cm*	164.9 (10.5)	164.7 (10.5)
Weight, mean (SD), kg*	75.8 (17.6)	76.3 (17.9)
Body mass index, mean (SD), kg/m ² *	27.7 (5.5)	28.0 (5.5)
Systolic blood pressure, mean (SD), mm Hg*	131.4 (16.5)	131.0 (16.7)
Diastolic blood pressure, mean (SD), mm Hg*	74.9 (8.6)	73.9 (8.7)
Oral anticoagulant, n (%)	518 (3.4)	530 (3.5)
Antihypertensive, n (%)	8134 (52.8)	7843 (51.2)
Hypertension, n (%)	11 573 (75.2)	11 519 (75.2)
Myocardial infarction, n (%)	1095 (7.1)	1075 (7.0)

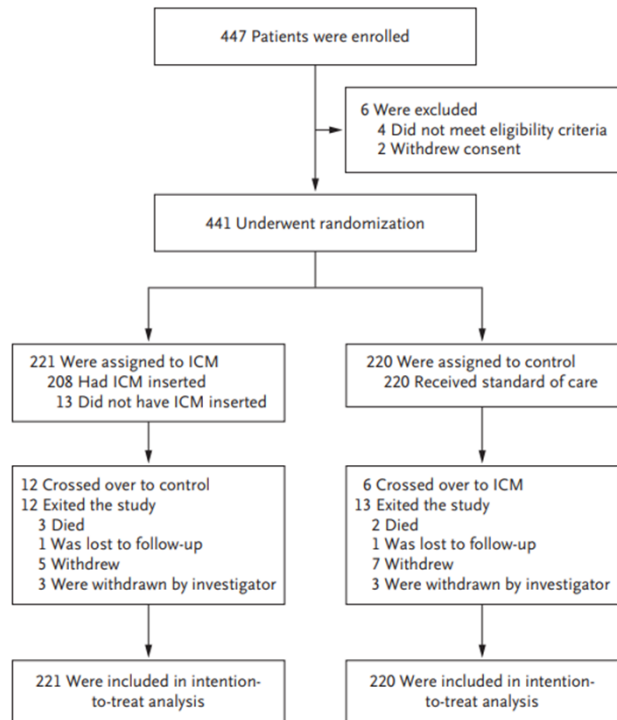


- 1.72% of individuals in the screening group had new AF diagnosed at 1 year versus 1.59% in the control group
- New AF diagnoses in the screening and control groups were greater among those aged ≥ 85 years (5.56% versus 3.76%),

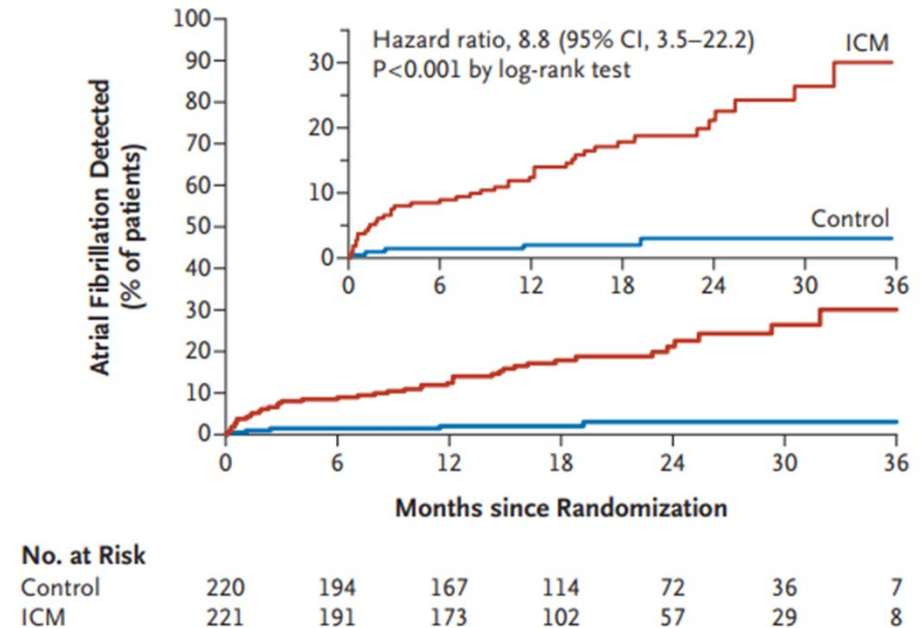


CRYSTAL AF: SCAF incidence

:441 patients with cryptogenic stroke. >40 yrs without known AF, implant ILR



C Detection of Atrial Fibrillation by 36 Months



- By 36 months, atrial fibrillation had been detected in 30.% of patients in the ICM group (42 patients) versus 3.0% of patients in the control group (5 patients)

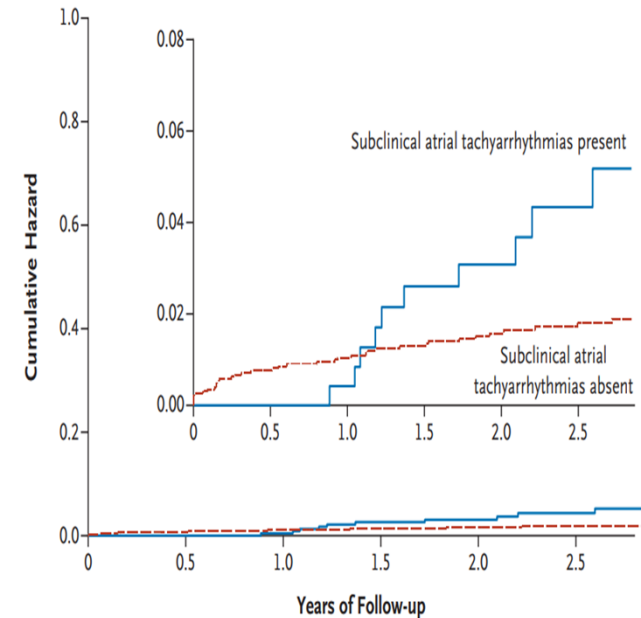


ASSERT: SCAF and stroke

:2580 pacemaker patients over 65 yrs with HTN, without known AF

Table 1. Baseline Characteristics of the Patients.*

Characteristic	Device-Detected Subclinical Atrial Tachyarrhythmia		P Value
	Yes (N = 261)	No (N = 2319)	
Age — yr	77±7	76±7	0.13
Male sex — no. (%)	147 (56.3)	1359 (58.6)	0.48
Systolic blood pressure while sitting — mm Hg	137±20	138±19	0.38
Heart rate — beats/min	68±12	70±12	0.001
Body-mass index‡	28±5	27±5	0.43
Risk factors for stroke — no. (%)			
Prior stroke	18 (6.9)	168 (7.2)	0.84
Prior transient ischemic attack	13 (5.0)	113 (4.9)	0.94
History of heart failure	39 (14.9)	335 (14.4)	0.83
Diabetes mellitus	59 (22.6)	674 (29.1)	0.03
Prior myocardial infarction	32 (12.3)	427 (18.4)	0.01
CHADS ₂ score§	2.2±1.1	2.3±1.0	0.47
Sinus-node disease, with or without atrioventricular-node disease — no. (%)	130 (49.8)	964 (41.6)	0.01
Atrioventricular-node disease, without sinus-node disease — no. (%)	132 (50.6)	1279 (55.2)	0.16
Atrial lead in septal position — no. (%)	101 (38.7)	972 (41.9)	0.32
Duration of hypertension >10 yr — no. (%)	115 (44.1)	965 (41.6)	0.45
Left ventricular hypertrophy on ECG — no. (%)	6 (2.3)	105 (4.5)	0.09
Time from implantation of pacemaker or ICD to enrollment — days	25±22	29±40	0.04



No. at Risk

Subclinical atrial tachyarrhythmias present	261	249	238	218	178	122
Subclinical atrial tachyarrhythmias absent	2319	2145	2070	1922	1556	1197

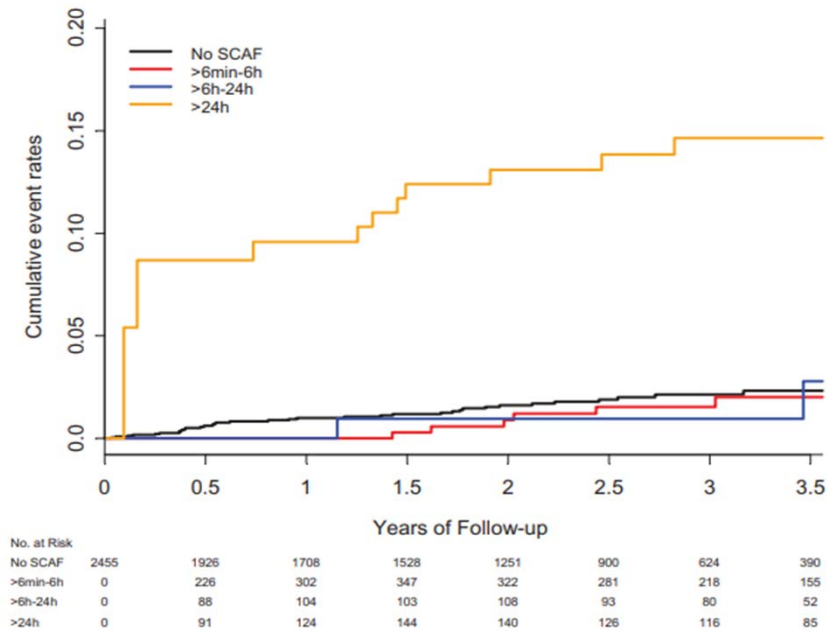
- By 3 months, SCAF detected in 261 patients (10.1%)
- Subclinical atrial tachyarrhythmias were associated with an increased risk of ischemic stroke or systemic embolism (HR 2.49)



SCAF duration and stroke: ASSERT trial analysis

:2580 pacemaker patients over 65 yrs with HTN, without known AF

	No SCAF (N=1562)	SCAF >6 min-6 h (N=462)	SCAF >6 h-24 h (N=169)	SCAF >24 h (N=262)
Age (years), mean ± SD	76.0 ± 6.7	76.9 ± 6.5	76.2 ± 6.9	77.2 ± 7.0
Male, n (%)	887 (56.8)	254 (55.0)	104 (61.5)	183 (69.8)
Systolic blood pressure (sitting, mmHg), mean ± SD	137.8 ± 19.4	139.0 ± 19.5	139.5 ± 19.8	136.3 ± 19.1
Heart rate (bpm), mean ± SD	70.0 ± 11.7	70.1 ± 12.0	68.7 ± 10.3	67.7 ± 11.2
BMI (kg/m ²), mean ± SD	27.3 ± 4.8	27.5 ± 4.9	27.4 ± 5.2	28.3 ± 5.0
Prior stroke, n (%)	116 (7.4)	30 (6.5)	15 (8.9)	16 (6.1)
Prior TIA, n (%)	77 (4.9)	21 (4.5)	9 (5.3)	13 (5.0)
History heart failure, n (%)	222 (14.2)	70 (15.2)	27 (16.0)	43 (16.4)
Diabetes mellitus, n (%)	470 (30.1)	110 (23.8)	48 (28.4)	77 (29.4)
Prior MI, n (%)	300 (19.2)	68 (14.7)	30 (17.8)	48 (18.3)
CHADS ₂ score, mean ± SD	2.3 ± 1.0	2.2 ± 1.0	2.3 ± 1.0	2.3 ± 1.0
CHA ₂ DS ₂ -VASc score, mean ± SD	4.0 ± 1.3	3.9 ± 1.3	4.0 ± 1.4	4.0 ± 1.2
Sinus node disease with or without atrioventricular-node disease, n (%)	668 (42.8)	194 (42.0)	74 (43.8)	120 (45.8)
Atrioventricular node disease without sinus-node disease, n (%)	776 (49.7)	240 (51.9)	87 (51.5)	129 (49.2)
Atrial lead septal position, n (%)	66 (4.2)	25 (5.4)	3 (1.8)	10 (3.8)
Duration hypertension >10 years, n (%)	629 (40.3)	208 (45.0)	72 (42.6)	119 (45.4)
Aspirin, n (%)	987 (63.2)	267 (57.8)	102 (60.4)	168 (64.1)
Beta-blocker, n (%)	599 (38.3)	138 (29.9)	67 (39.6)	104 (39.7)
Statin, n (%)	773 (49.5)	200 (43.3)	87 (51.5)	124 (47.3)



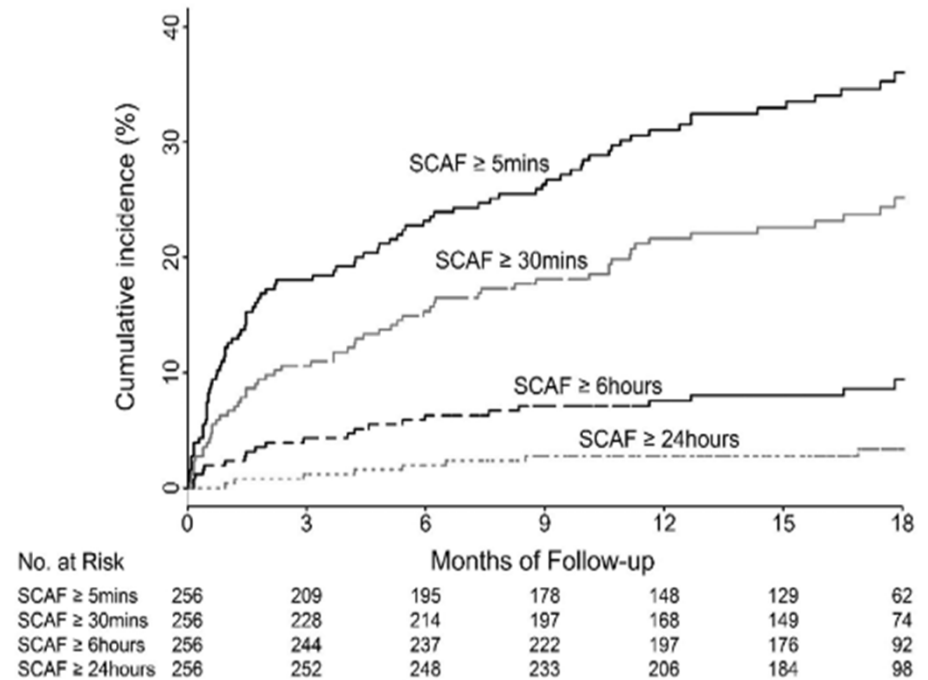
- SCAF duration >24 h was associated with a significant increased risk of subsequent stroke or systemic embolism (HR 3.2)
- SCAF between 6 min and 24 h was not significantly different from patients without SCAF



ASSERT II: SCAF incidence

:256 patients over 65 yrs with risk factors, without known AF, implant ILR

	Overall (n=256)	SCAF (n=90)	No SCAF (n=166)	P Value
Age, y (SD)	73.9 (6.2)	75.3 (6.9)	73.1 (5.7)	0.008
Female sex, n (%)	88 (34.4)	33 (36.7)	55 (33.1)	0.57
White, n (%)	246 (96.1)	89 (98.9)	157 (94.6)	0.17
History of hypertension, n (%)	188 (73.4)	62 (68.9)	126 (75.9)	0.23
Systolic blood pressure, mm Hg (SD)	137.9 (19.2)	134.6 (18.5)	139.7 (19.4)	0.043
Resting sinus rate, bpm (SD)	64.6 (10.2)	65.7 (9.6)	64.0 (10.5)	0.19
History of heart failure, n (%)	22 (8.6)	3 (3.3)	19 (11.4)	0.027
Diabetes mellitus, n (%)	64 (25.0)	16 (17.8)	48 (28.9)	0.049
Prior stroke, TIA, or systemic embolism, n (%)	123 (48.0)	47 (52.2)	76 (45.8)	0.33
Vascular disease, n (%)	82 (32.0)	22 (24.4)	60 (36.1)	0.06
Sleep apnea, n (%)	29 (11.3)	9 (10.0)	20 (12.0)	0.62
BMI, kg/m ²	28.7 (4.6)	28.6 (5.3)	28.8 (4.3)	0.79



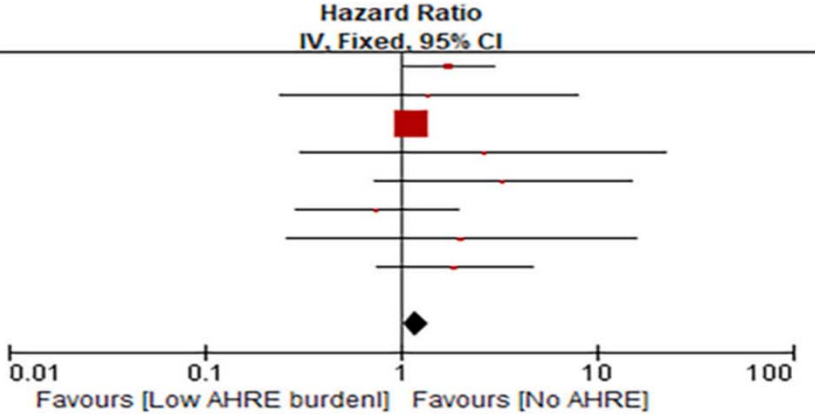
- Baseline age was 74 years, mean CHA2DS2-VASc score was 4.1 ± 1.4
- SCAF ≥ 5 minutes was detected in 90 patients (detection rate, 34.4%/y)
- Baseline predictors of SCAF were increased, left atrial dimension, and blood pressure



SCAF duration and stroke: meta-analysis

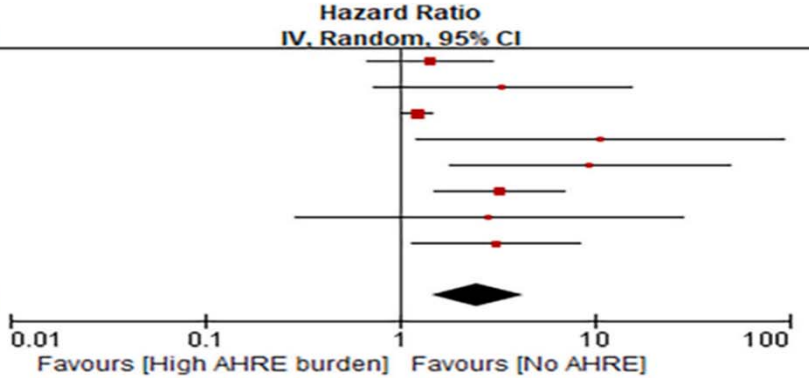
Study or Subgroup	log[Hazard Ratio]	SE	Weight	Hazard Ratio IV, Fixed, 95% CI
Boriani G 2014	0.5653	0.2783	8.4%	1.76 [1.02, 3.04]
Botto G L 2009	0.3293	0.8961	0.8%	1.39 [0.24, 8.05]
Kaplan R M 2019	0.1222	0.0885	82.9%	1.13 [0.95, 1.34]
Park Y J 2021	0.9746	1.0948	0.5%	2.65 [0.31, 22.65]
Shanmugam N 2012	1.1939	0.7697	1.1%	3.30 [0.73, 14.92]
Van Gelder I C 2017	-0.2877	0.4848	2.8%	0.75 [0.29, 1.94]
Wang S H 2015	0.708	1.0485	0.6%	2.03 [0.26, 15.85]
Witt C T 2015	0.6313	0.4689	3.0%	1.88 [0.75, 4.71]
Total (95% CI)			100.0%	1.20 [1.03, 1.41]

Heterogeneity: $\text{Chi}^2 = 6.74$, $\text{df} = 7$ ($P = 0.46$); $I^2 = 0\%$
 Test for overall effect: $Z = 2.29$ ($P = 0.02$)



Study or Subgroup	log[Hazard Ratio]	SE	Weight	Hazard Ratio IV, Random, 95% CI
Boriani G 2014	0.3646	0.3754	17.6%	1.44 [0.69, 3.01]
Botto G L 2009	1.209	0.7774	8.6%	3.35 [0.73, 15.37]
Kaplan R M 2019	0.207	0.0955	25.0%	1.23 [1.02, 1.48]
Park Y J 2021	2.3674	1.1064	5.1%	10.67 [1.22, 93.31]
Shanmugam N 2012	2.2407	0.8433	7.7%	9.40 [1.80, 49.08]
Van Gelder I C 2017	1.1756	0.3895	17.2%	3.24 [1.51, 6.95]
Wang S H 2015	1.0543	1.1695	4.7%	2.87 [0.29, 28.40]
Witt C T 2015	1.141	0.5064	14.0%	3.13 [1.16, 8.44]
Total (95% CI)			100.0%	2.52 [1.46, 4.37]

Heterogeneity: $\text{Tau}^2 = 0.30$; $\text{Chi}^2 = 19.11$, $\text{df} = 7$ ($P = 0.008$); $I^2 = 63\%$
 Test for overall effect: $Z = 3.31$ ($P = 0.0009$)

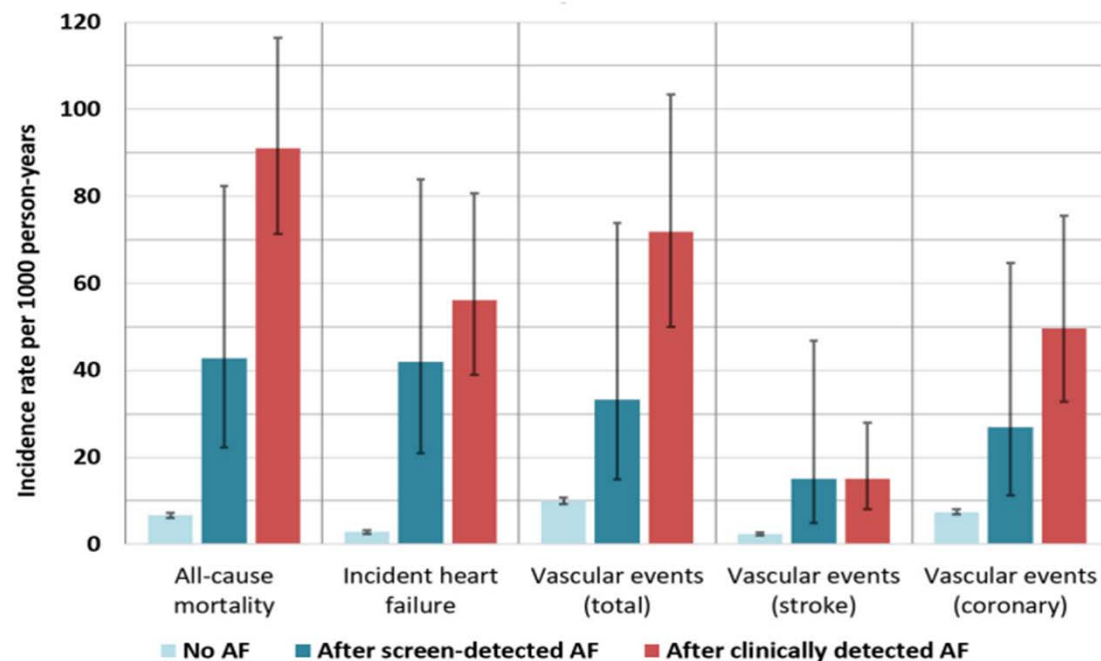
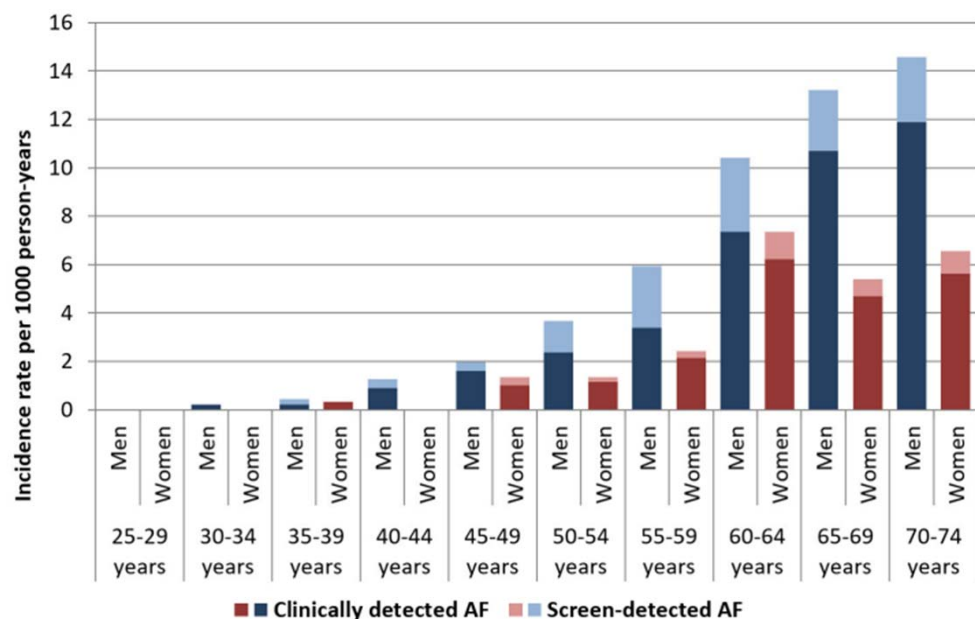


- Low duration of SCAF was not increase risk of stroke.
- High duration of SCAF was significantly associated with stroke[HR 2.52]



Screen detected AF outcome

:8265 participants without AF, regular inspections every 3 years

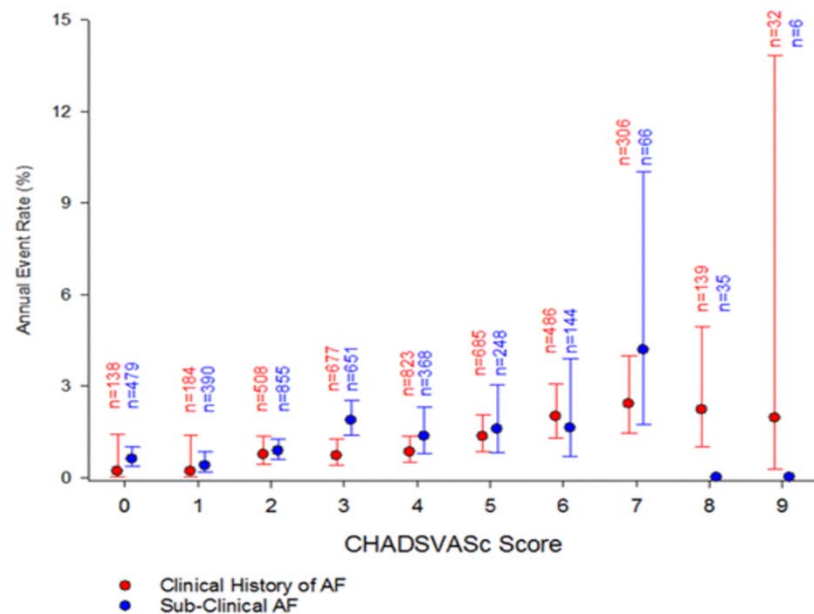


- During a follow-up of 9.8 ± 2.3 years, 265 participants (3.2%) developed incident AF, of whom 60 (23%) had screen-detected AF.
- Screen detected significantly associated with mortality (HR 2.21), incident HF (HR 4.90)



SCAF burden, CHA2DS2-VASc and stroke

:21768 CIED patients without OAC



		CHA ₂ DS ₂ -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

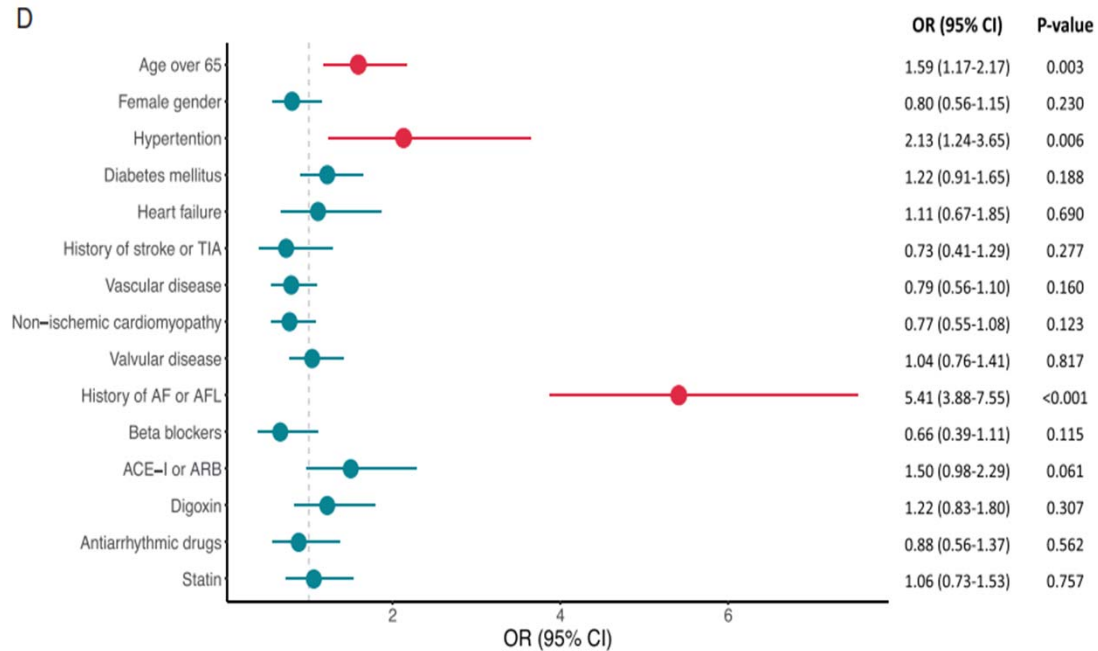
- Age 68.6 year, 63% male.
- AF duration and CHA2DS2-VASc score were significantly associated with stroke.



SCAF risk factor

:2718 CIED patients with ≥ 1 CHA2DS2-VASc

	Overall		Low-risk group (CHA ₂ DS ₂ = 1 or 2)		High-risk group (CHA ₂ DS ₂ \geq 3)		RR (95% CI) ^a
	Number of patients	Incidence rate (100 patient-years)	Number of patients	Incidence rate (100 patient-years)	Number of patients	Incidence rate (100 patient-years)	
AHRE \leq 6 min	292	5.364	167	5.60	125	5.076	0.906 (0.73-1.13)
6 min < AHRE \leq 6 h	653	11.995	341	11.439	312	12.669	1.11 (0.97-1.27)
6 h < AHRE \leq 24 h	369	6.778	182	6.105	187	7.593	1.24 (1.03-1.50)
AHRE > 24 h	182	3.343	82	2.751	100	4.061	1.48 (1.11-1.96)



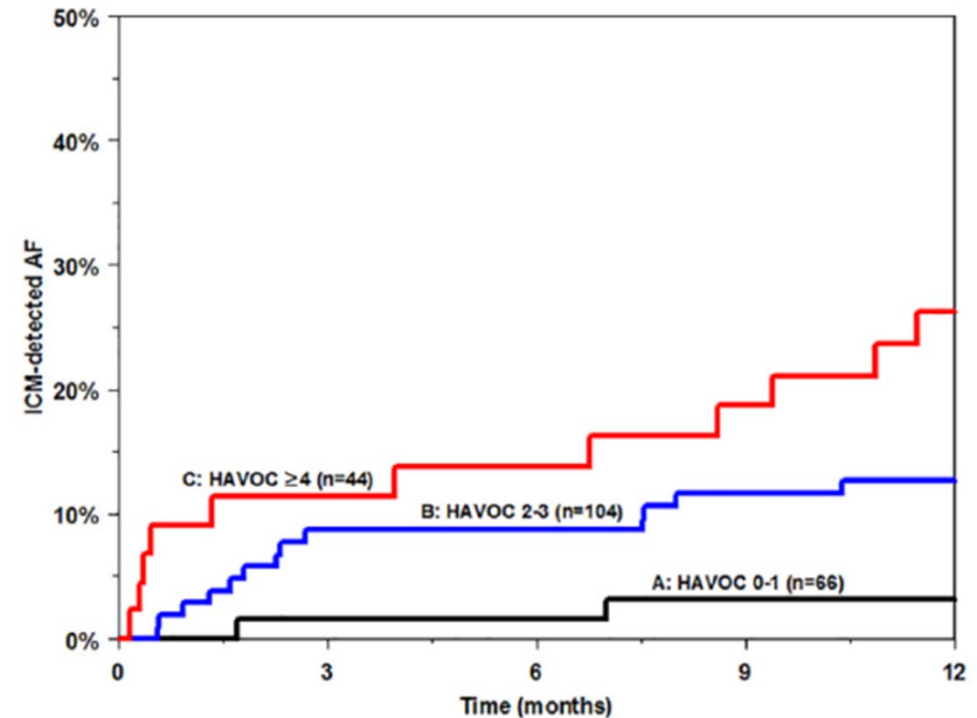
- The incidence rates of AHRE >6 h were significantly higher in patients at high risk of thromboembolism (CHA₂DS₂ score \geq 3) compared to those at low risk.
- Older age, hypertension, history of AF/AFL was associated with AHRE >24 h



Cryptogenic stroke patients - AF predictor

:CRYSTAL AF subgroup analysis

Risk-stratification score	Components
HAVOC ⁷⁹	<ul style="list-style-type: none">• Hypertension: 2 points• Age \geq 75 years: 2 points• Valvular heart disease: 2 points• Vascular disease (peripheral): 1 point• Obesity (BMI > 30 kg/m²): 1 point• Congestive heart failure: 4 points• Coronary artery disease: 2 points

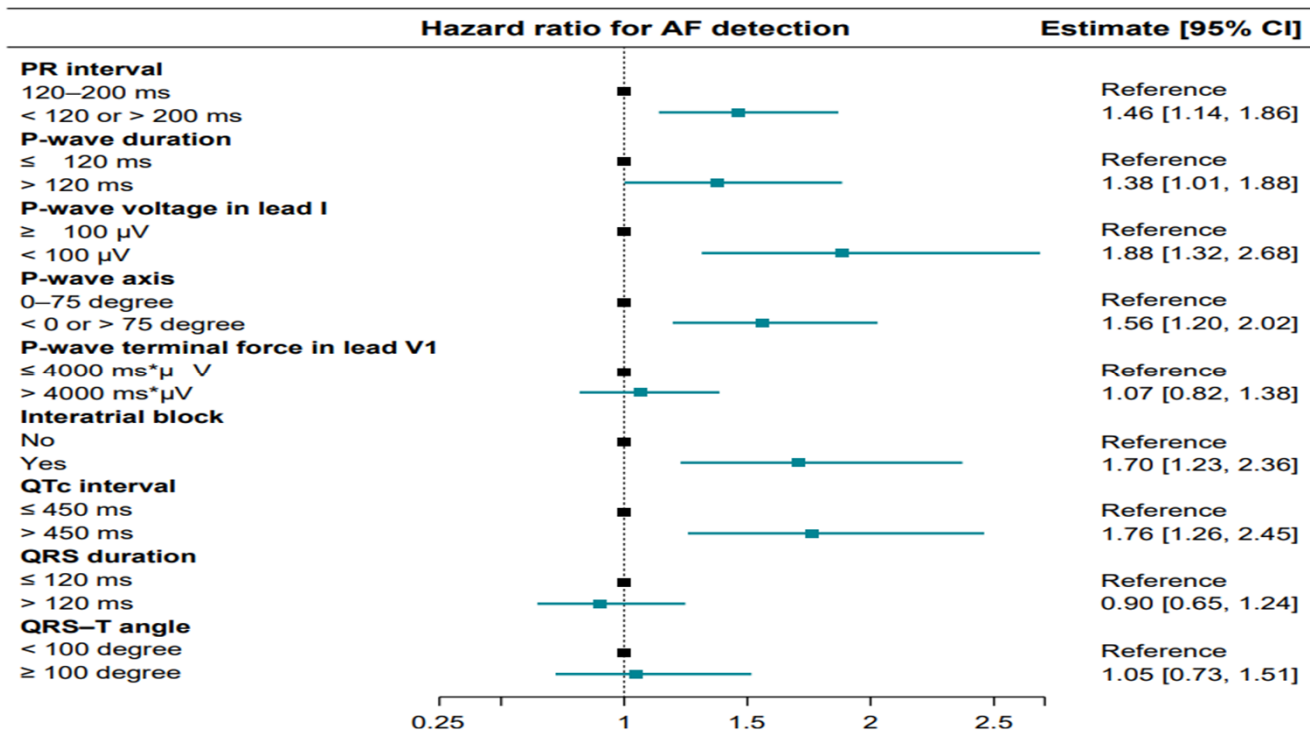


- The HAVOC score was significantly higher among patients with AF than without AF
- AF increased significantly across the HAVOC score groups



Electrocardiographic marker of SCAF

:LOOP trial subgroup analysis(1370 ILR patients)



Ful 3.19 years
 Mean age 74.7 yrs
 Male 53.4%
 419(30.6%) developed AF

- P-wave duration (PWD), P-wave terminal force in Lead V1, and interatrial block (IAB) further demonstrated significant associations with SCAF



SCAF and anticoagulation

:10212 CIED patients with ≥ 2 CHA₂DS₂-VASc

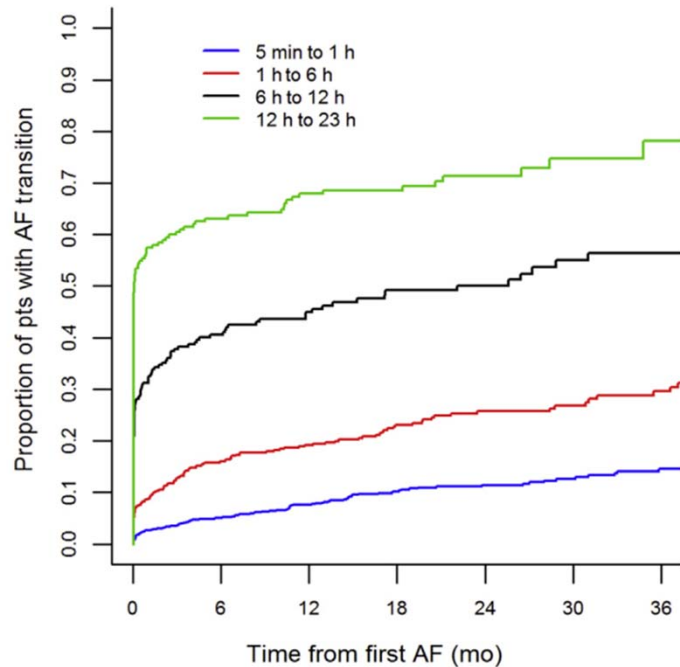
Device-Detected AF Burden	Total		No OAC*		OAC*		P Value†
	n/N (%)	IR (95% CI)	n/N (%)	IR (95% CI)	n/N (%)	IR (95% CI)	
AF >6 min‡							
Stroke	72/2101 (3.4)	9.9 (7.8–12.4)	66/1829 (3.6)	10.3 (8.1–13.1)	6/272 (2.2)	6.6 (2.9–14.6)	0.28
Death	587/2101 (27.9)	92.5 (85.3–100.3)	518/1829 (28.3)	93.3 (85.6–101.7)	69/272 (25.4)	87.1 (68.6–110.3)	0.60
AF >1 h‡							
Stroke	58/1712 (3.4)	9.8 (7.6–12.7)	51/1439 (3.5)	10.2 (7.8–13.5)	7/273 (2.6)	7.7 (3.7–16.2)	0.50
Death	503/1712 (29.4)	99.4 (91.1–108.5)	429/1439 (29.3)	100.4 (91.3–110.3)	74/273 (27.1)	94.4 (75.1–118.5)	0.63
AF >6 h‡							
Stroke	47/1279 (3.7)	10.7 (8.1–14.3)	41/1016 (4.0)	11.7 (8.6–15.8)	6/263 (2.3)	6.9 (3.1–15.5)	0.23
Death	395/1279 (20.9)	106.1 (96.1–117.1)	324/1016 (31.9)	108.7 (97.5–121.2)	71/263 (27.0)	95.8 (75.9–120.9)	0.34
AF >24 h‡							
Stroke	35/818 (4.3)	12.5 (9.0–17.4)	31/594 (5.2)	14.9 (10.5–21.2)	4/224 (1.8)	5.6 (2.1–14.8)	0.04
Death	297/818 (36.3)	129.0 (115.1–144.5)	234/594 (39.4)	139.3 (122.5–158.3)	63/224 (28.1)	101.1 (79.0–129.4)	0.02

- 4570 (45%), 3969 (39%), 3263 (32%), and 2469 (24%) had device-detected AF >6 minutes, >1 hour, >6 hours, and >24 hours
- OAC prescription after device-detected AF >24 hours was associated with reduced stroke risk (HR 0.28)



SCAF progression

:5580 CIED patients without AF



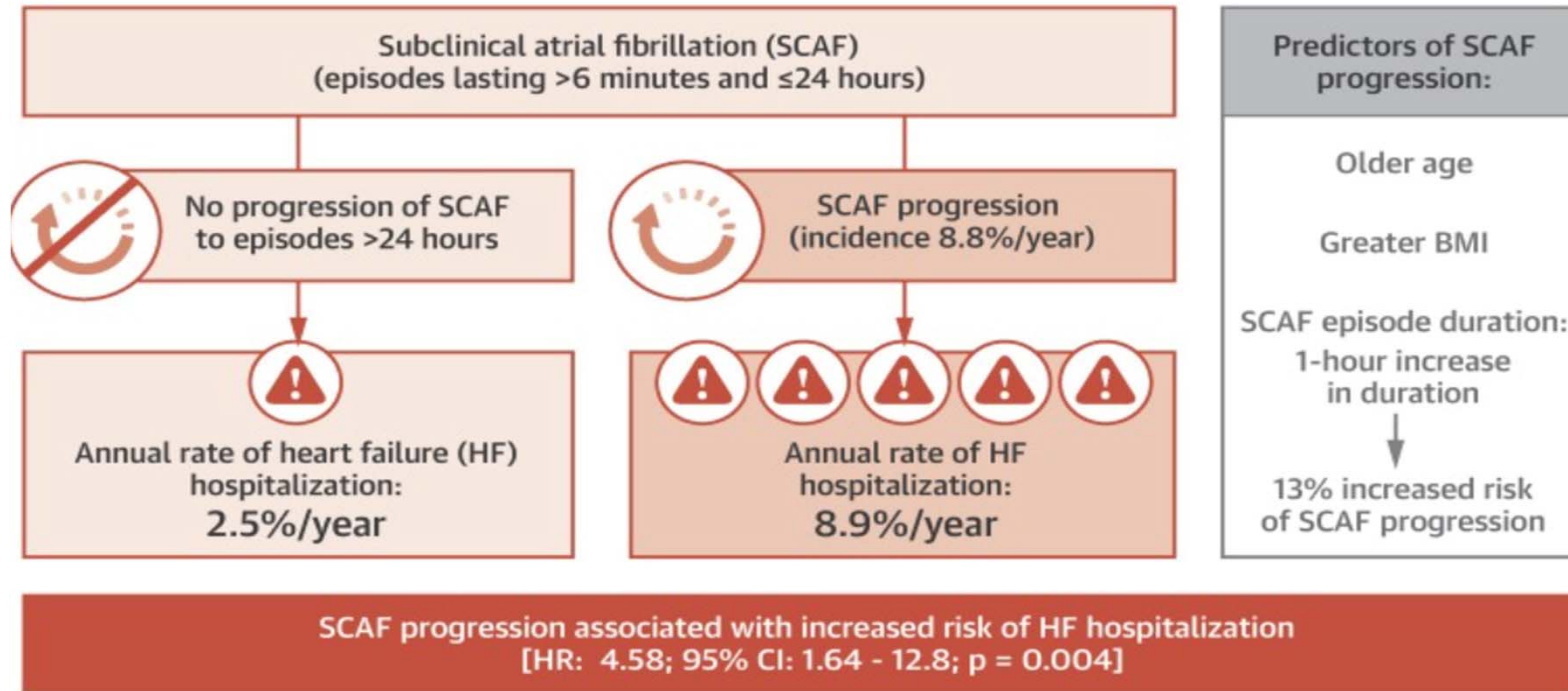
Parameter	Univariate		Multivariate*	
	HR (95% CI)	P value	HR (95% CI)	P value
Male sex [†]	1.78 (1.42-2.22)	<.001	1.77 (1.41-2.21)	<.001
Age ≥ 75 y	1.32 (1.10-1.58)	.003		
Diabetes	1.09 (0.88-1.33)	.430		
Prior stroke	1.13 (0.73-1.75)	.586		
Hypertension	1.26 (1.04-1.52)	.017		
Heart failure	1.19 (0.99-1.42)	.060		
CHADS ₂ ≥ 2 [†]	1.45 (1.21-1.73)	<.001	1.44 (1.20-1.72)	<.001
CRT	1.26 (1.06-1.50)	.008		

- AF burden of 5 minutes, was detected in 2244 patients (34%)
- 1091 (49.8%) transitioned to a higher AF-burden threshold during follow-up



SCAF progression and outcome

:ASSERT subgroup analysis



- Older age, greater BMI, and longer SCAF duration within the first year were independent
- SCAF progression was strongly associated with HF hospitalization.



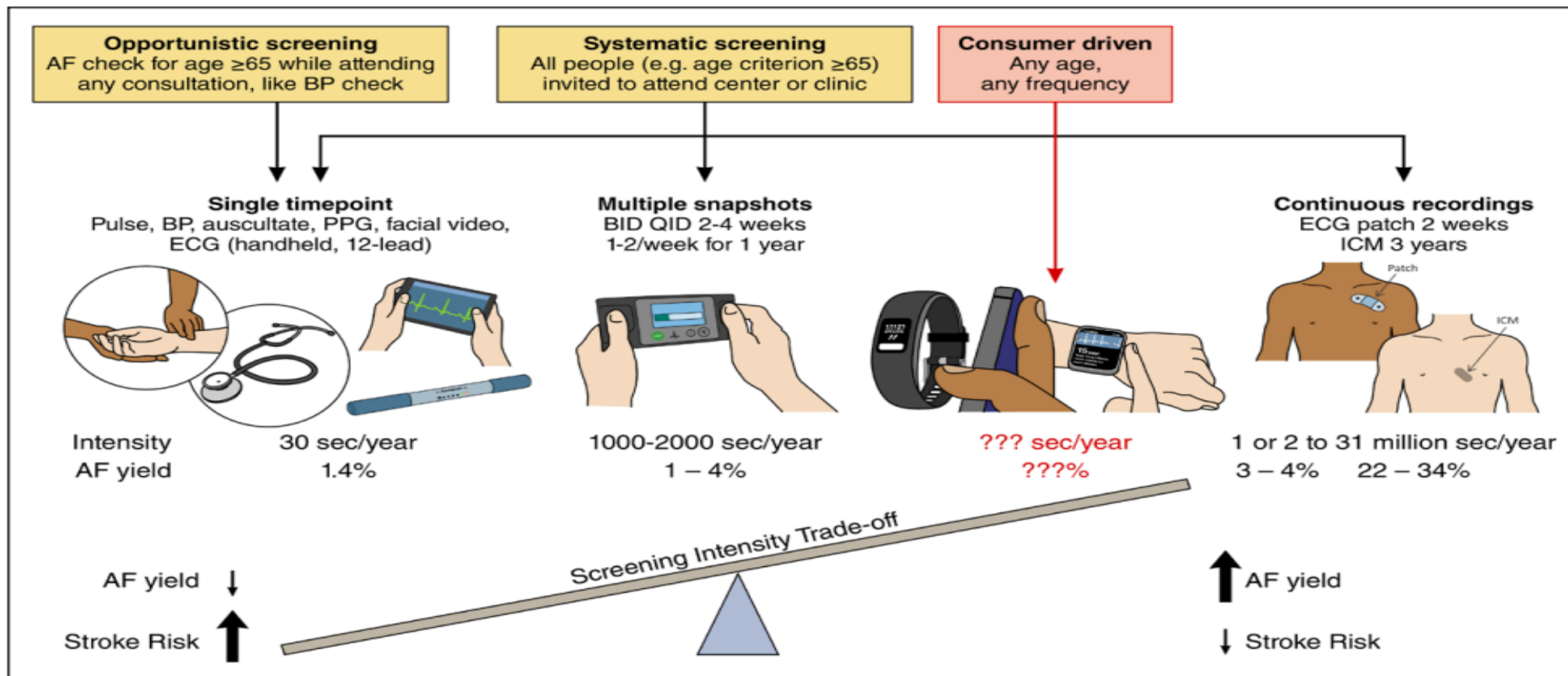


Table 5 Sensitivity and specificity of various AF screening tools considering the 12-lead ECG as the gold standard¹⁷³

	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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Conclusion

- Subclinical AF is common
- SCAF Detection rate
Apple watch: 0.04% Handheld: 3%, patch ECG: 1.72%, ILR 30%
- SCAF burden(duration, risk factor) associated stroke.
- Select a modality and duration according to the patient's risk.
- SCAF is progressive, periodic evaluation is essential.



Thank you for your attention

