

Supplementary data

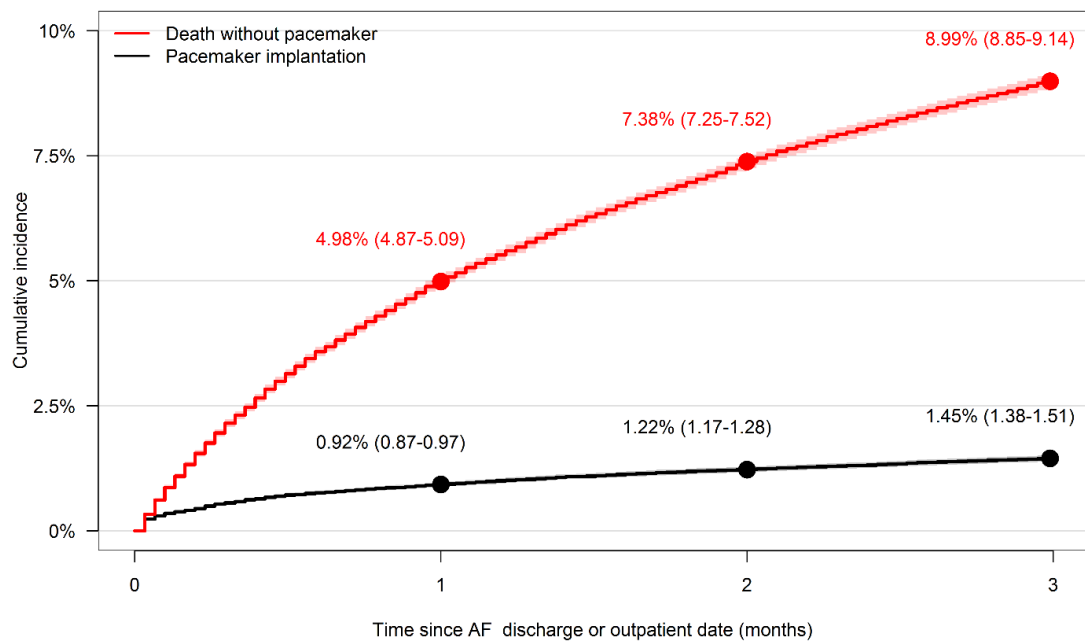
Risk Factors and a Novel 3-month Risk Score for Predicting Pacemaker Implantation in Patients with Atrial Fibrillation

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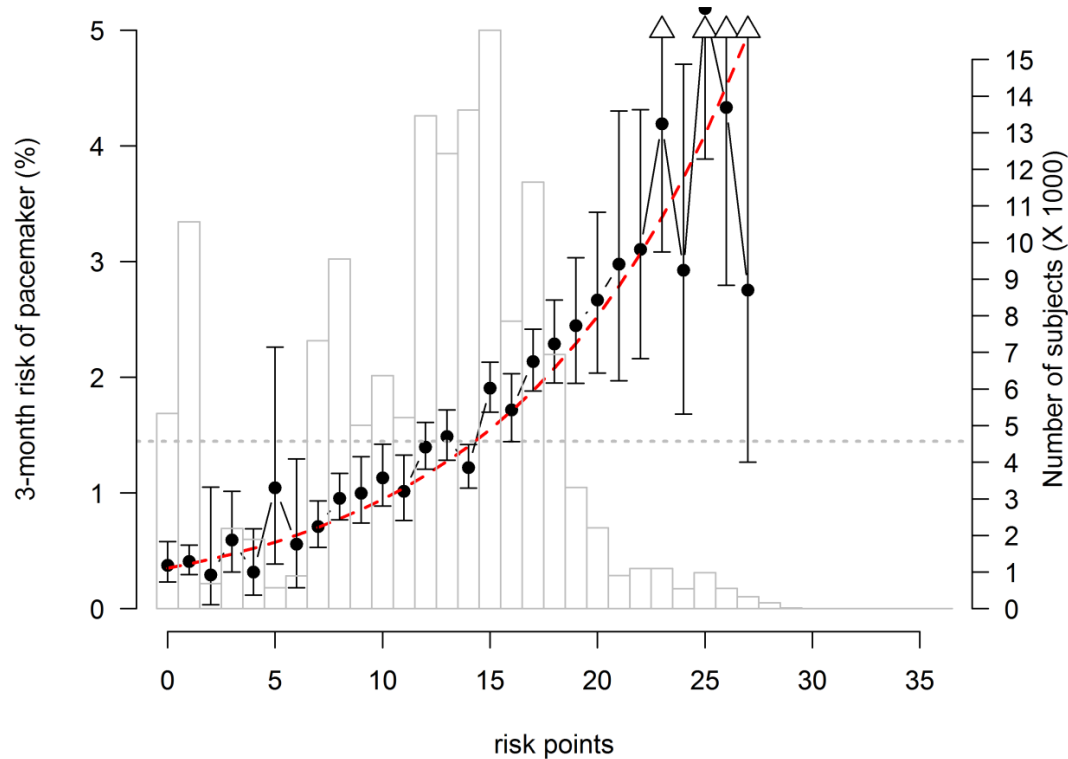
Supplemental Figures

Supplementary Figure 1. Cumulative incidence 3-month.



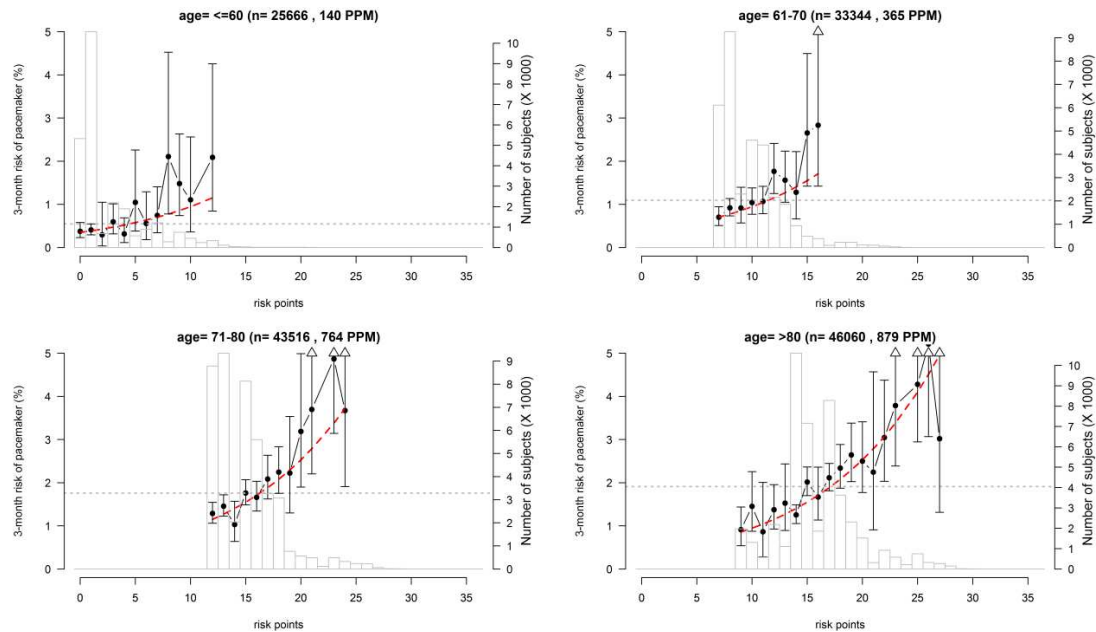
Supplemental Figure S1 legend. Cumulative incidence of permanent pacemaker (black) and all-cause mortality (red) for 3-months of follow-up.

Supplementary Figure 2. Risk points distribution full cohort.



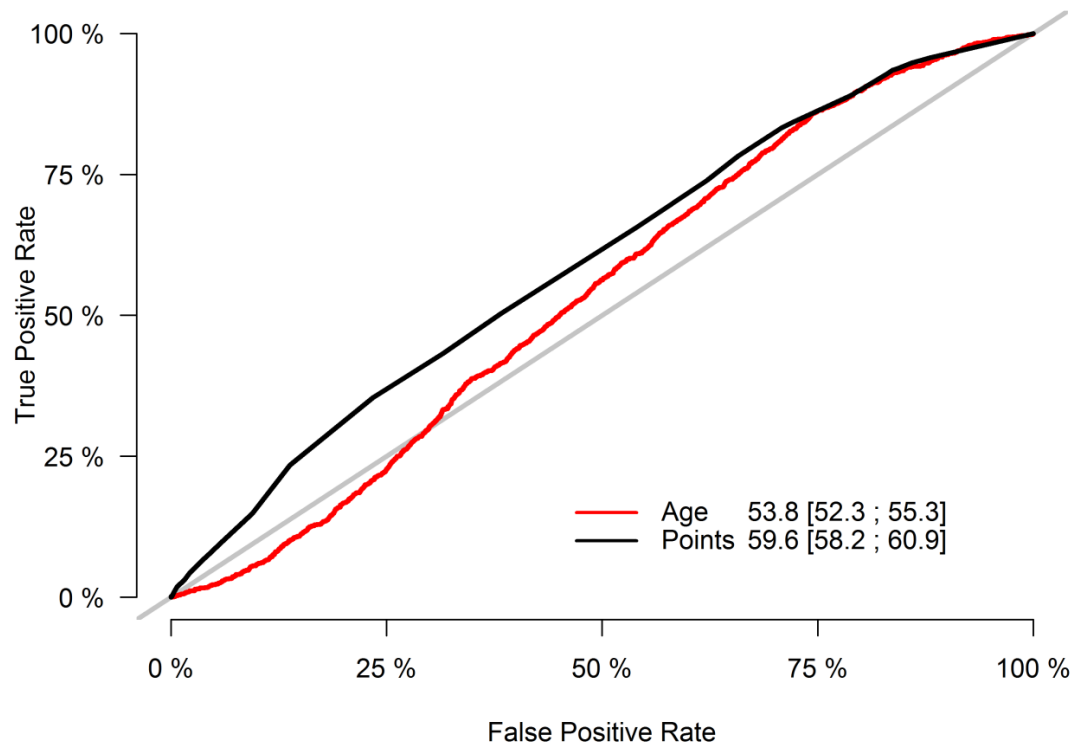
Supplemental Figure S2 legend. Distribution of risk points and 3-month risk of permanent pacemaker in the full cohort. Displayed are the estimated risk (dots, left axis) with 95% CIs and numbers of subjects per risk points (bars, right axis). The red dashed line displays the risk which is predicted by the logistic model. The dotted line displays the estimate of the marginal risk. A triangle indicates that the CI is truncated. Estimated risks and 95% CI are not shown when less than 200 subjects are observed with the corresponding number of points.

Supplementary Figure 3. Age-stratified distribution of risk points.



Supplemental Figure S3 legend. Distribution of risk points and 3-month risk of permanent pacemaker in the full cohort stratified by age group. Displayed are the estimated risk (dots, left axis) with 95% CIs and numbers of subjects per risk points (bars, right axis). The red dashed line displays the risk that is predicted by the logistic model. The dotted line displays the estimate of the marginal risk. A triangle indicates that the CI is truncated. Estimated risks and 95% CI are not shown when less than 200 subjects are observed with the corresponding number of points.

Supplementary Figure 4. Receiver operator characteristics curve 5-years prediction.



Supplemental Figure S4 legend. Receiver operator characteristics curve estimated from the validation cohort for a 5-year prediction. Area under the curve with 95% CI for the risk score compared to age alone. The risk score (points) performed significantly better than age as predictor ($p < 0.001$).

Supplemental Tables**Supplementary Table 1. Administrative codes used in the study**

	ICD-10
Atrial Fibrillation	ICD-10: I48
Valvular AF	AF with presence of Rheumatic heart valve disease: ICD8: 4240, 4241, 39500-39502, 39508, 39509, 39600-39604, 39608, 39609 ICD10: Z952, Z954, I05, I06, I080A, I081A, I082A, I083A Prostatic heart valve KFKD, KFKH, KFMD, KFMH, KFGE, KFJF
Heart Failure	Cardiomyopathy: I42 Heart failure: I50, I110 Lung edema: J81,
ACS/AP/AMI/Ischemic Heart Disease	Ischemic Heart Disease: I20-I25 <ul style="list-style-type: none"> • Angina pectoris: I20 • Acute myocardial infarction: I21, I22 • Complications to AMI: I23, • Other forms of ischemic heart disease: I24, I25
Chronic Obstructive Pulmonary Disease	J42, J43, J44
Diabetes Mellitus	Insulin: A10A Non-Insulin: A10B

Chronic kidney disease	N02, N03, N04, N05, N06, N07, N08, N11, N12, N14, N18, N19, N26,N158, N159, N160,N162, N163, N164,N168 Q61, E102, E112,E132,E142, I120, M321B
Syncope	DR559
Autoimmune disorders	Systemic lupus erythematosus: M32, Rheumatoid arthritis: M05, scleroderma: M34
Congenital heart diseases	DQ20, DQ21, DQ24
Percutaneous Coronary Intervention	KFNG00, KFNG02, KFNG05, KFNG10, KFNG12, KFNG96
Sick sinus node syndrome	I495, tachycardia-bradycardia syndrome: I495b
Atrio-ventricular block	1 st degree: I440, 2 nd degree type 1: I441b, 2 nd degree type 2: I441C, 3 rd degree: I442, unspecified: I443
Unspecified bradycardia	DR001
Coronary Artery Bypass Grafting	KFNA, KFNB, KFNC, KFND, KFNE, KFNH20
Permanent pacemaker implantation	procedure code; KFPE00, KFPE10, KFPE20, KFPE96; surgery code: BFCA0-08, BFCA6-63, BFCB03 Atrial single chamber: BFCA02, BFCA62, BFCA64, KFPE10 Ventricle single chamber: BFCA01, BFCA08, BFCA61, BFCA63, KFPE00 Dual chamber: BFCA03, BFCA07, KFPE20 Cardiac resynchronization therapy pacemaker (CRT-P): BFCA04, BFCA05, BFCA06 Cardiac resynchronization therapy with implantable cardiac defibrillator (CRT-D): BFCB03

	Unspecified: KFPE96, BFCA0, BFCA6, or more than 1 code from different pacemaker type (example; if both BFCA01 and BFCA03 was present)
Cardioversion	BFFA00, BFFA01, BFFA04
Radiofrequency ablation for atrial fibrillation	BFFB04,
Hypertension as usage of combination of at least two of the seven different drugs classes at the same time.	<ol style="list-style-type: none"> 1. Non-Loop: Thiazides C02L, C02DA, C07B, C07D, C09XA52, C03A, C03EA; Low-ceiling diuretics (excl. thiazides): C03B, C03X, C07C, C08G, C09BA, C09DA; Potassium-sparing agents (spiron): C03D, C03E, C03EB 2. Loop: High-ceiling diuretics (Loop) C03C, C03EB 3. Antiadrenergic agents: C02A, C02B, C02C 4. Beta blockers: C07A, C07B, C07C, C07D, C07F 5. Vasodilators: C02DB, C02DD, C02DG 6. Calcium channel blockers: C08, C09BB, C09DB 7. Renin angiotensin systeminhibitors & Angiotensin II receptor blockers: :C09AA, C09BA, C09BB, C09CA, C09DA, C09DB, C09XA02, C09XA52
Anticoagulants	VKA: B01AA NOAC: B01AE, B01AF
Acetylsalicylic acid	B01AC06, N02BA01
Verapamil, Diltiazem	C08D
Amiodarone	C01BD01

Flecainide	C01BC
Digoxin	C01AA

Footnote. ICD-10, procedure codes and ATC codes for all variables.

Supplementary Table 2. Pacemaker type

	Those with receiving a pacemaker
n	8348
Pacemaker Type	
Unspecified (%)	974 (11.7)
CRT-P (%)	244 (2.9)
CRT-D (%)	254 (3.0)
Single chamber ventricle (%)	2546 (30.5)
Single chamber atrial (%)	327 (3.9)
Dual chamber (%)	4003 (48.0)

Supplementary Table 3. Baseline characteristics of the cohort excluding those receiving pacemaker or died during initial hospitalization.

	Overall
n	148,586
Sex, male (%)	76,492 (51.5)
Age (median [IQR])	74 [64.5-82.5]
Comorbidities, n (%)	
Ischemic heart disease	31,202 (21.0)
Heart failure	24,393 (16.4)
Valvular atrial fibrillation	1,807 (1.2)
Congenital heart disease	400 (0.3)

Chronic obstructive pulmonary disease	16,227 (10.9)
Autoimmune disorders	1,622 (1.1)
Chronic kidney disease	5,670 (3.8)
Syncope	8,119 (5.5)
Hypertension	58,568 (39.4)
Sick sinus node (%)	802 (0.5)
AV block grade 2 (%)	216 (0.1)
AV block grade 1 (%)	201 (0.1)
Bradycardia, unspecified (%)	898 (0.6)
Procedures	
PCI	4,581 (3.1)
CABG	2,232 (1.5)
Pharmacotherapy	
Loop diuretics	28,084 (18.9)
Non-loop diuretics	45,121 (30.4)
RAS-inhibitors	44,837 (30.2)
Beta-blocker	38,017 (25.6)
CCBs	33,040 (22.2)
ASA	49,354 (33.2)

Supplementary Table 2 footnote. Autoimmune disorders are systemic lupus erythematosus, rheumatoid arthritis and scleroderma. Abbreviations: IQR; interquartile range, AV;

atrioventricular, PCI; percutaneous coronary intervention, CABG; coronary artery bypass graft, RAS-inhibitors; renin-angiotensin inhibitors, CCBs; calcium channel blockers, ASA; acetylsalicylic acid.

Supplementary Table 4

Examples	Risk factors of PPM observed in this patient and corresponding points of Figure 3 (in brackets)*	Risk score (summation of points)
67-year-old male, first time admitted for AF. A medical history of ischemic heart disease and hypertension.	<ul style="list-style-type: none"> • Sex: male (1) • Age: 67 years, no heart failure (8) • Ischemic heart disease (2) • Hypertension (3) 	14 (=1+8+2+3)
78-year-old female, first-time visiting outpatient clinic for AF. A medical history of diabetes and prior syncope.	<ul style="list-style-type: none"> • Age: 78 years, no heart failure (13) • Prior syncope (9) • Diabetes mellitus (1) 	23 (=13+9+1)

Footnote. Examples of how to use the produced risk score. * risk points (in brackets) are sex, male (1), hypertension (3), valvular atrial fibrillation (2), diabetes (1), ischemic heart disease (2),

syncope (9), congenital heart disease (8), age if heart failure not present; 61-70 (8), 71-80 (13), >80 (14) years, age if heart failure present; ≤60 (6), 61-70 (10), 71-80 (13), >80 (11) years.

SupplementaryTable 5

Points	TP (%)	FP (%)	PPV (%)	NPV (%)	Positive (n)	Negative (n)
0	98.6 [96.9-99.5]	96.3 [96.1-96.5]	1.4 [1.3-1.6]	99.4 [98.8-99.8]	28634	1083
1	96.4 [94.2-98.0]	89.0 [88.6-89.3]	1.5 [1.4-1.7]	99.5 [99.2-99.7]	26466	3251
2	96.2 [93.9-97.8]	88.5 [88.1-88.8]	1.5 [1.4-1.7]	99.5 [99.2-99.7]	26320	3397
3	95.9 [93.6-97.6]	87.0 [86.6-87.3]	1.5 [1.4-1.7]	99.6 [99.3-99.7]	25879	3838
4	95.5 [93.0-97.2]	85.7 [85.3-86.1]	1.6 [1.4-1.7]	99.5 [99.3-99.7]	25513	4204
5	94.7 [92.1-96.7]	85.3 [84.9-85.7]	1.6 [1.4-1.7]	99.5 [99.2-99.7]	25398	4319
6	94.3 [91.6-96.3]	84.8 [84.4-85.2]	1.6 [1.4-1.7]	99.5 [99.2-99.7]	25238	4479
7	93.3 [90.5-95.5]	84.0 [83.5-84.4]	1.6 [1.4-1.7]	99.4 [99.1-99.6]	24988	4729
8	89.7 [86.4-92.5]	79.8 [79.4-80.3]	1.6 [1.4-1.7]	99.3 [99.0-99.5]	23768	5949
9	85.6 [81.9-88.9]	73.4 [72.8-73.9]	1.6 [1.5-1.8]	99.2 [99.0-99.4]	21851	7866
10	84.7 [80.9-88.0]	71.9 [71.3-72.4]	1.7 [1.5-1.8]	99.2 [99.0-99.4]	21409	8308
11	81.3 [77.3-85.0]	66.8 [66.3-67.4]	1.7 [1.5-1.9]	99.2 [99.0-99.4]	19917	9800
12	78.7 [74.5-82.5]	62.9 [62.4-63.5]	1.8 [1.6-2.0]	99.2 [99.0-99.3]	18770	10947
13	72.2 [67.7-76.5]	55.1 [54.5-55.6]	1.8 [1.6-2.1]	99.1 [99.0-99.3]	16438	13279

14	58.6 [53.7-63.4]	39.4 [38.8-40.0]	2.1 [1.8-2.4]	99.0 [98.9-99.2]	11790	17927
15	51.0 [46.1-55.8]	32.6 [32.1-33.2]	2.2 [1.9-2.5]	99.0 [98.8-99.1]	9776	19941
16	43.3 [38.5-48.2]	24.6 [24.2-25.1]	2.4 [2.1-2.8]	98.9 [98.8-99.1]	7403	22314
17	27.5 [23.3-32.1]	14.5 [14.1-15.0]	2.6 [2.2-3.1]	98.8 [98.7-98.9]	4376	25341
18	19.1 [15.5-23.2]	9.8 [9.4-10.1]	2.7 [2.2-3.4]	98.7 [98.6-98.9]	2942	26775
19	11.7 [8.8-15.2]	6.2 [6.0-6.5]	2.6 [1.9-3.4]	98.7 [98.5-98.8]	1878	27839
20	8.4 [5.9-11.5]	4.6 [4.3-4.8]	2.5 [1.8-3.5]	98.6 [98.5-98.8]	1377	28340
21	8.1 [5.7-11.2]	4.1 [3.9-4.3]	2.8 [1.9-3.8]	98.7 [98.5-98.8]	1232	28485
22	7.4 [5.1-10.4]	3.6 [3.4-3.9]	2.8 [1.9-4.0]	98.6 [98.5-98.8]	1095	28622
23	5.5 [3.5-8.1]	2.7 [2.5-2.8]	2.9 [1.8-4.3]	98.6 [98.5-98.8]	801	28916
24	4.8 [2.9-7.3]	2.2 [2.0-2.4]	3.0 [1.8-4.6]	98.6 [98.5-98.8]	664	29053
25	3.8 [2.2-6.1]	1.6 [1.5-1.8]	3.2 [1.9-5.2]	98.6 [98.5-98.8]	494	29223
26	2.6 [1.3-4.7]	0.8 [0.7-0.9]	4.5 [2.3-7.9]	98.6 [98.5-98.7]	244	29473
27	1.2 [0.4-2.8]	0.5 [0.4-0.5]	3.6 [1.2-8.1]	98.6 [98.5-98.7]	140	29577
28	0.2 [0.0-1.3]	0.1 [0.1-0.2]	2.9 [0.1-15.3]	98.6 [98.5-98.7]	34	29683
29	0.0 [0.0-0.9]	0.0 [0.0-0.0]	0.0 [0.0-41.0]	98.6 [98.5-98.7]	7	29710

Footnote. True positives, false positives, positive predictive value, and negative predictive value estimates from the validation cohort (with 95% CI) for the 3-month risk of PPM. Number of observed positives and negatives subjects given for each cutoff, that is, numbers of subjects

whom are given more points (positive) or less or as many points (negative) than the specific number of points.