

Supplementary Materials

Supplementary Table S1. Baseline characteristics of patients with 1:1 matched study population

	Cardiac origin (n = 1,162)	Pulmonary origin (n = 1,162)	Total (n = 2,324)	p-value
Clinical characteristics				
Age, years	72.7 ± 14.0	73.7 ± 12.2	73.2 ± 13.2	0.419
Female sex, n (%)	642 (55.2)	687 (59.1)	1329 (57.2)	0.065
BMI (kg/m ²)	24.2 ± 4.7	24.3 ± 4.4	24.3 ± 4.5	0.650
Prior history of HF, n (%)	269 (23.1)	222 (19.1)	491 (21.1)	0.019
DM, n (%)	328 (28.2)	382 (32.9)	710 (30.6)	0.017
HTN, n (%)	426 (36.7)	401 (34.5)	827 (35.6)	0.298
CKD, n (%)	254 (21.9)	44 (3.8)	298 (12.8)	< 0.001
CAD, n (%)	222 (19.1)	145 (12.5)	367 (15.8)	< 0.001
MI, n (%)	75 (6.5)	44 (3.8)	119 (5.1)	0.005
COPD, n (%)	56 (4.8)	160 (13.8)	216 (9.3)	< 0.001
AF, n (%)	450 (38.7)	138 (11.9)	588 (25.3)	< 0.001
Laboratory findings				
LVEF (%)	45.6 ± 14.7	54.5 ± 13.1	48.1 ± 14.8	< 0.001
E/e'	17.3 ± 7.5	18.1 ± 7.0	17.5 ± 7.4	0.019
Laboratory findings				
BUN (mg/dL)	24.7 ± 15.7	23.5 ± 16.2	24.1 ± 16.0	< 0.001
Creatinine (mg/dL)	1.4 ± 1.3	1.3 ± 1.1	1.4 ± 1.2	0.225
eGFR (mL/min/1.73 m ²)	63.0 ± 30.4	65.2 ± 31.7	64.1 ± 31.1	0.229
NT-proBNP (pg/mL)	3566.0 [1086.0–8238.0]	663.0 [206.0–2479.0]	1777.0 [445.0–5492.0]	< 0.001

Log-NT-proBNP (pg/mL)	3.6 [3.0–3.9]	2.8 [2.3–3.4]	3.2 [2.6–3.7]	< 0.001
WBC ($10^9/\mu\text{L}$)	8.6 \pm 3.8	11.5 \pm 6.2	10.0 \pm 5.3	< 0.001
Neutrophil (%)	67.2 \pm 13.2	77.4 \pm 11.9	72.3 \pm 13.6	< 0.001
ESR (mm/h)	23.1 \pm 24.0	53.3 \pm 34.4	38.2 \pm 33.3	< 0.001
CRP (mg/dL)	1.8 \pm 3.0	11.2 \pm 10.5	6.7 \pm 9.2	< 0.001
ECG findings				
Heart rate (bpm)	79.5 \pm 18.5	81.5 \pm 19.7	80.6 \pm 19.1	0.042
PR interval (ms)	162.6 \pm 31.7	162.1 \pm 30.2	162.4 \pm 30.9	0.755
QRS duration (ms)	94.4 \pm 18.8	93.9 \pm 17.6	94.2 \pm 18.2	0.955
QT interval (ms)	389.9 \pm 46.1	388.8 \pm 49.9	389.3 \pm 48.1	0.482
Corrected QT interval (ms)	441.0 \pm 38.6	444.0 \pm 36.0	442.5 \pm 37.3	0.023
P axis	53.7 \pm 25.0	52.0 \pm 25.6	52.8 \pm 25.3	0.830
R axis	33.6 \pm 42.6	36.2 \pm 45.2	34.9 \pm 44.0	0.450
T axis	57.4 \pm 52.2	53.9 \pm 51.4	55.6 \pm 51.8	0.549
AI-ECG prediction probability				
Probability for pulmonary origin	0.10 [0.01–0.45]	0.88 [0.64–0.95]	0.54 [0.06–0.90]	< 0.001
Pulmonary causes, n (%)	268 (23.1)	929 (79.9)	1197 (51.5)	< 0.001
Probability for cardiac origin	0.90 [0.55–0.99]	0.12 [0.05–0.36]	0.46 [0.10–0.94]	< 0.001
Cardiac causes, n (%)	894 (76.9)	233 (20.1)	1127 (48.5)	< 0.001

Variables are expressed as the mean \pm SD, median [IQR], or n (%). AI, artificial intelligence; AF, atrial fibrillation; BMI, body mass index; BUN, blood urea nitrogen; CAD, coronary artery disease; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; CRP, c-reactive protein; DM, diabetes mellitus; E, early mitral inflow; e', septal mitral annular velocity; ECG, electrocardiogram; eGFR, estimated glomerular filtration rate; ESR, erythrocyte sedimentation rate; HF, heart failure; HTN, hypertension; LVEF, left ventricular ejection fraction; MI, myocardial infarction; NT-proBNP, N-terminal pro-brain natriuretic peptide; WBC, white blood cell

Supplementary Table S2. Baseline characteristics of patients according to the age distribution of 65 years in the 1:1 matched study population

	Age ≥ 65 years				Age < 65 years			
	Cardiac origin (n = 853)	Pulmonary origin (n = 934)	Total (n = 1,787)	p-value	Cardiac origin (n = 309)	Pulmonary origin (n = 228)	Total (n = 537)	p-value
Clinical characteristics								
Age, years	79.6 ± 8.0	78.4 ± 7.3	79.0 ± 7.7	0.001	53.8 ± 8.8	54.6 ± 9.1	54.1 ± 8.9	0.162
Female sex, n (%)	404 (47.4)	553 (59.2)	957 (53.6)	< 0.001	238 (77.0)	134 (58.8)	372 (69.3)	< 0.001
BMI (kg/m ²)	23.6 ± 4.1	23.9 ± 4.1	23.7 ± 4.1	0.135	26.1 ± 5.6	26.0 ± 5.3	26.0 ± 5.5	0.880
Prior history of HF, n (%)	192 (22.5)	208 (22.3)	400 (22.4)	0.949	77 (24.9)	14 (6.1)	91 (16.9)	< 0.001
DM, n (%)	243 (28.5)	322 (34.5)	565 (31.6)	0.008	85 (27.5)	60 (26.3)	145 (27.0)	0.834
HTN, n (%)	349 (40.9)	360 (38.5)	709 (39.7)	0.330	77 (24.9)	41 (18.0)	118 (22.0)	0.070
CKD, n (%)	211 (24.7)	37 (4.0)	248 (13.9)	< 0.001	43 (13.9)	7 (3.1)	50 (9.3)	< 0.001
CAD, n (%)	164 (19.2)	139 (14.9)	303 (17.0)	0.017	58 (18.8)	6 (2.6)	64 (11.9)	< 0.001
MI, n (%)	52 (6.1)	42 (4.5)	94 (5.3)	0.160	23 (7.4)	2 (0.9)	25 (4.7)	0.001
COPD, n (%)	51 (6.0)	144 (15.4)	195 (10.9)	< 0.001	5 (1.6)	16 (7.0)	21 (3.9)	0.003
AF, n (%)	390 (45.7)	122 (13.1)	512 (28.7)	< 0.001	60 (19.4)	16 (7.0)	76 (14.2)	< 0.001
Laboratory findings								
LVEF (%)	47.2 ± 14.3	54.5 ± 13.2	49.6 ± 14.3	< 0.001	41.1 ± 15.0	53.8 ± 12.1	42.5 ± 15.3	< 0.001
E/e'	18.1 ± 7.6	18.1 ± 7.0	18.1 ± 7.4	0.536	15.0 ± 6.8	17.1 ± 5.5	15.1 ± 6.7	0.086
Laboratory findings								
BUN (mg/dL)	26.3 ± 16.4	25.0 ± 16.0	25.6 ± 16.2	0.015	20.3 ± 12.6	17.3 ± 15.6	19.0 ± 14.0	< 0.001
Creatinine (mg/dL)	1.4 ± 1.2	1.3 ± 0.9	1.4 ± 1.1	0.859	1.5 ± 1.7	1.2 ± 1.7	1.4 ± 1.7	< 0.001
eGFR (mL/min/1.73 m ²)	59.2 ± 29.0	61.6 ± 30.6	60.4 ± 29.9	0.199	73.4 ± 31.9	80.0 ± 31.7	76.2 ± 32.0	0.024
NT-proBNP (pg/mL)	4182.0	832.0	1990.5	< 0.001	1935.5	265.0	1074.0	< 0.001

	[1552.5–9029.0]	[262.0–2916.0]	[505.0–5837.0]		[486.0–5658.0]	[72.0–1074.0]	[189.0–3961.5]	
Log-NT-proBNP (pg/mL)	3.6 [3.2–4.0]	2.9 [2.4–3.5]	3.3 [2.7–3.8]	< 0.001	3.3 [2.7–3.8]	2.4 [1.9–3.0]	3.0 [2.3–3.6]	< 0.001
WBC (10 ⁹ /μL)	8.3 ± 3.6	11.6 ± 6.3	10.0 ± 5.4	< 0.001	9.4 ± 4.1	11.0 ± 5.7	10.0 ± 4.9	0.002
Neutrophil (%)	68.1 ± 13.0	77.8 ± 11.6	73.2 ± 13.2	< 0.001	64.7 ± 13.5	76.1 ± 12.8	69.6 ± 14.4	< 0.001
ESR (mm/h)	25.8 ± 23.9	53.7 ± 34.7	40.4 ± 33.1	< 0.001	15.5 ± 22.6	51.8 ± 33.2	30.9 ± 32.9	< 0.001
CRP (mg/dL)	1.9 ± 3.2	11.1 ± 10.5	6.8 ± 9.2	< 0.001	1.3 ± 2.5	11.6 ± 10.8	6.0 ± 9.1	< 0.001
ECG findings								
Heart rate (bpm)	81.7 ± 18.3	81.8 ± 18.5	81.7 ± 18.3	0.009	78.4 ± 18.5	81.5 ± 20.1	80.1 ± 19.5	0.965
PR interval (ms)	157.0 ± 24.1	158.4 ± 24.8	157.6 ± 24.4	0.149	165.8 ± 34.9	163.5 ± 31.8	164.6 ± 33.3	0.374
QRS duration (ms)	93.4 ± 16.5	94.0 ± 14.1	93.7 ± 15.5	0.552	94.9 ± 19.9	93.9 ± 18.6	94.4 ± 19.2	0.183
QT interval (ms)	379.1 ± 39.1	383.0 ± 39.2	380.7 ± 39.1	0.070	395.5 ± 48.5	390.7 ± 52.8	392.9 ± 50.9	0.274
Corrected QT interval (ms)	435.2 ± 32.0	439.6 ± 30.6	437.1 ± 31.5	0.232	443.9 ± 41.3	445.4 ± 37.5	444.7 ± 39.3	0.082
P axis	53.2 ± 19.8	53.5 ± 25.7	53.4 ± 22.5	0.710	53.9 ± 27.4	51.5 ± 25.6	52.6 ± 26.5	0.925
R axis	44.3 ± 40.6	43.5 ± 41.1	44.0 ± 40.8	0.076	28.1 ± 42.6	33.8 ± 46.3	31.2 ± 44.7	0.957
T axis	49.4 ± 38.6	50.0 ± 38.5	49.7 ± 38.6	0.150	61.5 ± 57.5	55.2 ± 54.9	58.1 ± 56.2	0.593
AI-ECG prediction probability								
Probability for pulmonary origin	0.10 [0.01–0.43]	0.87 [0.58–0.95]	0.53 [0.07–0.90]	< 0.001	0.09 [0.01–0.51]	0.91 [0.81–0.96]	0.60 [0.04–0.90]	< 0.001
Pulmonary causes, n (%)	189 (22.2)	721 (77.2)	910 (50.9)	< 0.001	79 (25.6)	208 (91.2)	287 (53.4)	< 0.001
Probability for cardiac origin	0.90 [0.57–0.99]	0.13 [0.05–0.42]	0.47 [0.10–0.93]	< 0.001	0.91 [0.49–0.99]	0.09 [0.04–0.19]	0.40 [0.10–0.96]	< 0.001
Cardiac causes, n (%)	664 (77.8)	213 (22.8)	877 (49.1)	< 0.001	230 (74.4)	20 (8.8)	250 (46.6)	< 0.001

Variables are expressed as the mean ± SD, median [IQR], or n (%). AI, artificial intelligence; AF, atrial fibrillation; BMI, body mass index; BUN, blood urea

nitrogen; CAD, coronary artery disease; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; CRP, c-reactive protein; DM, diabetes

mellitus; E, early mitral inflow; e', septal mitral annular velocity; ECG, electrocardiogram; eGFR, estimated glomerular filtration rate; ESR, erythrocyte sedimentation rate; HF, heart failure; HTN, hypertension; LVEF, left ventricular ejection fraction; MI, myocardial infarction; NT-proBNP, N-terminal pro-brain natriuretic peptide; WBC, white blood cell

Supplementary Table S3. Baseline characteristics of patients with a high probability of cardiac origin in the pulmonary origin group

	AI-ECG prediction probability ≥ 0.90 (n = 65)	AI-ECG prediction probability 0.80-0.89 (n = 30)	AI-ECG prediction probability 0.70-0.79 (n = 34)	Total (n = 129)	p-value
True cardiac causes, n (%)	53 (81.5)	23 (76.7)	20 (58.8)	96 (74.4)	0.046
Clinical characteristics					
Age, years	70.6 ± 15.6	77.0 ± 9.5	71.2 ± 16.8	72.3 ± 14.9	0.137
Female sex, n (%)	15 (23.1)	10 (33.3)	22 (65.7)	47 (36.4)	<0.001
BMI (kg/m ²)	23.5 ± 4.2	22.1 ± 3.4	23.5 ± 4.3	23.2 ± 4.1	0.331
Prior history of HF, n (%)	15 (23.1)	7 (23.3)	3 (8.8)	25 (19.4)	0.193
DM, n (%)	17 (26.2)	6 (20.0)	6 (17.6)	29 (22.5)	0.587
HTN, n (%)	20 (30.8)	9 (30.0)	9 (26.5)	38 (29.5)	0.903
CKD, n (%)	8 (12.3)	2 (6.7)	0 (0.0)	10 (7.8)	0.065
CAD, n (%)	24 (36.9)	3 (10.0)	6 (17.6)	33 (25.6)	0.009
MI, n (%)	9 (13.8)	0 (0.0)	2 (5.9)	11 (8.5)	0.069
COPD, n (%)	10 (15.4)	6 (20.0)	2 (5.9)	18 (14.0)	0.209
AF, n (%)	14 (21.5)	8 (26.7)	2 (5.9)	24 (18.6)	0.071
Laboratory findings					
LVEF (%)	45.1 ± 16.2	56.0 ± 12.2	53.8 ± 15.5	49.2 ± 15.9	0.018
E/e'	19.0 ± 7.5	15.2 ± 5.6	16.3 ± 6.4	17.6 ± 7.0	0.130
Laboratory findings					
BUN (mg/dL)	31.7 ± 24.8	28.3 ± 16.5	22.2 ± 10.2	28.4 ± 20.3	0.084
Creatinine (mg/dL)	2.4 ± 2.8	1.4 ± 0.9	1.1 ± 0.5	1.8 ± 2.1	0.007
eGFR (mL/min/1.73m ²)	55.2 ± 63.8	55.5 ± 24.3	70.7 ± 34.3	59.4 ± 50.3	0.313
NT-proBNP (pg /mL)	3306.0 [1050.5-9967.5]	1479.5 [518.0-4979.0]	3125.0 [576.0-4568.0]	2442.5 [638.0-6982.0]	0.174
Log-NT-proBNP (pg /mL)	3.5 [3.0-4.0]	3.2 [2.7-3.7]	3.5 [2.8-3.6]	3.4 [2.8-3.8]	0.176

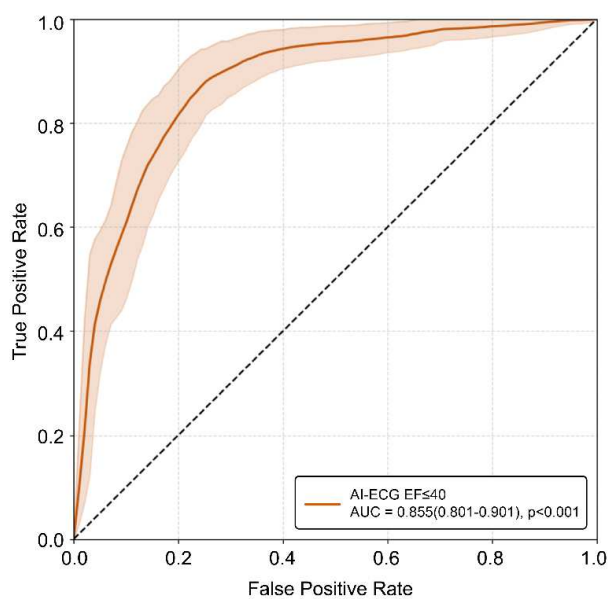
WBC ($10^3/\mu\text{L}$)	10.2 ± 4.6	10.6 ± 8.2	13.3 ± 6.9	11.1 ± 6.3	0.082
Neutrophil (%)	76.8 ± 10.3	73.9 ± 15.7	79.3 ± 11.3	76.8 ± 12.1	0.206
ESR (mm/h)	44.8 ± 36.6	53.6 ± 31.9	53.8 ± 33.8	49.2 ± 34.9	0.357
CRP (mg/dL)	8.4 ± 8.1	11.6 ± 11.7	14.4 ± 12.1	10.7 ± 10.4	0.020
ECG findings					
Heart rate (bpm)	95.7 ± 25.0	96.6 ± 25.1	93.1 ± 21.5	95.2 ± 24.2	0.840
PR interval (ms)	163.7 ± 28.9	154.9 ± 37.4	156.1 ± 40.2	159.7 ± 34.6	0.579
QRS duration (ms)	110.5 ± 26.5	96.3 ± 18.8	98.0 ± 24.2	104.0 ± 25.2	0.015
QT interval (ms)	383.3 ± 57.6	362.4 ± 40.0	393.7 ± 74.4	381.3 ± 60.2	0.135
Corrected QT interval (ms)	471.8 ± 46.6	451.0 ± 37.8	478.8 ± 62.6	468.9 ± 50.6	0.094
P axis	39.0 ± 30.8	41.8 ± 25.9	40.0 ± 23.9	39.8 ± 28.0	0.946
R axis	6.7 ± 58.2	25.7 ± 39.8	31.1 ± 38.7	17.5 ± 51.0	0.061
T axis	74.6 ± 78.5	41.9 ± 79.0	68.0 ± 67.6	65.4 ± 77.0	0.186

Variables are expressed as mean ± SD, median [IQR], or n (%). AI, artificial intelligence; AF, atrial fibrillation; BMI, body mass index; BUN, blood urea nitrogen; CAD, coronary artery disease; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; CRP, c-reactive protein; DM, diabetes mellitus; E, early mitral inflow; e', septal mitral annular velocity; ECG, electrocardiogram; eGFR, estimated glomerular filtration rate; ESR, erythrocyte sedimentation rate; HF, heart failure; HTN, hypertension; LVEF, left ventricular ejection fraction; MI, myocardial infarction; NT-proBNP, N-terminal pro brain natriuretic peptide; WBC, white blood cell

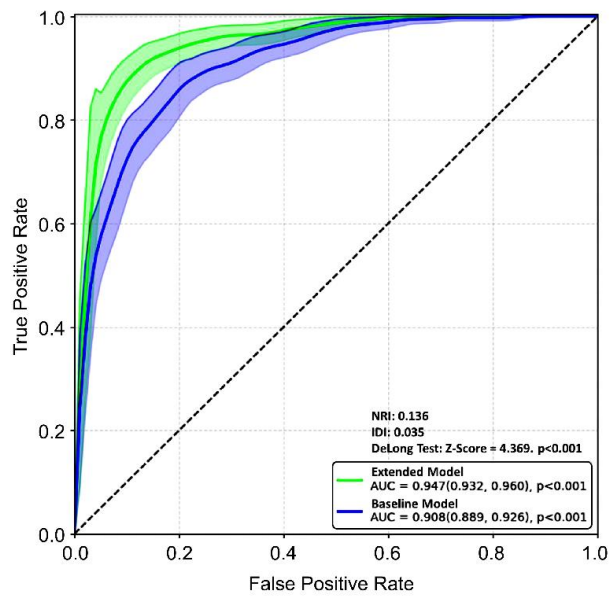
Supplementary Table S4. Detailed characteristics of the patients with pulmonary origin that were misinterpreted by AI-ECG as 'cardiac origin'

Cases in which AI-ECG misinterpreted patients admitted with pulmonary origin as those with 'cardiac origin' in (n = 33)	
Characteristics	
Abnormal ECG	
WPW	1
LBBB	3
RBBB	5
LVH	7
RVH	1
ST-T segment anomaly	4
Poor R progression pattern	1
Pacemaker rhythm	1
Abnormal lung condition	
Lung cancer	4
Tb destroyed lung	1
Empyema thorax	1
Emphysema lung	1
No definite abnormal condition	4

AI, artificial intelligence; ECG, electrocardiogram; LBBB, left bundle branch block; LVH, left ventricular hypertrophy; RBBB, right bundle branch block; RVH, right ventricular hypertrophy; Tb, tuberculosis; WPW, Wolff-Parkinson-White



Supplementary Figure S1. AUROC curve of an AI-ECG model predicting patients with an LVEF $\leq 40\%$ after pre-training. AI, artificial intelligence; AUROC, area under the receiver operating characteristic curve; ECG, electrocardiogram; EF, ejection fraction; LVEF, left ventricular ejection fraction.



Supplementary Figure S2. AUROC curves comparing the diagnostic performance of the baseline and extended models. The blue line indicates the baseline model, including clinical, laboratory, and echocardiographic parameters, as demonstrated in Table 2. The green line indicates the extended model, including all parameters from the baseline model plus the AI-ECG probability. AI, artificial intelligence; AUC, area under the curve; AUROC, area under the receiver operating characteristic curve; ECG, electrocardiogram; IDI, integrated discrimination improvement; NRI, net reclassification improvement.