Artificial Intelligence in EP: current status and future

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Application of AI on EP

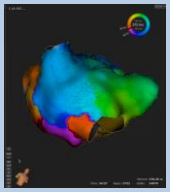
Input

Electrical Healthcare Records

- Natural language
- Patient characteristics
- Laboratory data
- Vital signs
- Medications
- …

Modalities

- ECG
- Echocardiogram
- CT, MRI, Nuclear imaging
- Pulse wave
- Clinical EP data
- …



Wearables

- Smart watch
- Implantable Loop Recorder
- Pacemaker, ICD, CRT
- …

Basic science

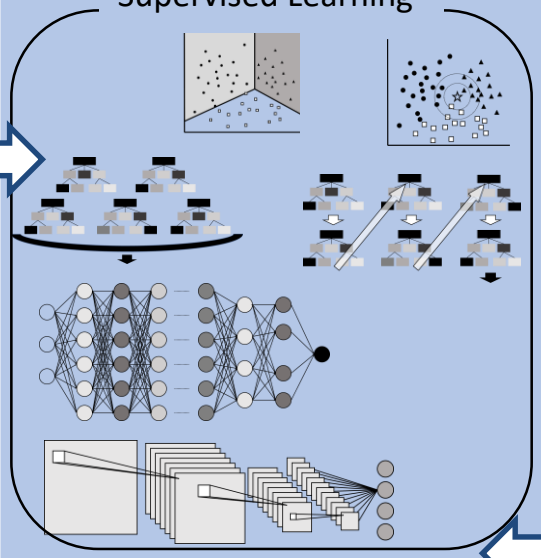
- Genomics
- Biomarkers
- Proteomics
- …

AI model

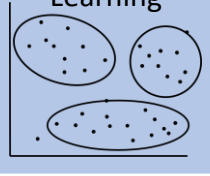
AI model development

- Data collection
- Programming
- Parameter setting
- Train, Validate, Test

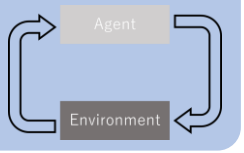
Supervised Learning



Unsupervised Learning



Reinforcement Learning



Study

Proof of Concept

Clinical Trial

Official Approval

Data/Outcome Feedback

Clinical application

Contribution of AI to the Clinical medicine

- Screening
- Checkup
- Diagnosis
- Treatment
- Prognosis prediction
- New findings
- …

Modified from Nakamura T, et al. J Cardiol 2022

Possibility of the application of AI in EP field

- Diagnosis
- Precision medicine / risk stratification
- Remote monitoring

AI for the prediction/detection of AF

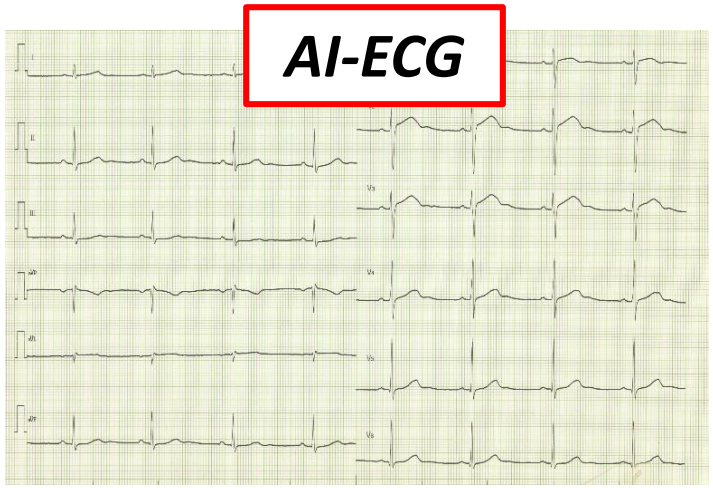
1. AI-ECG

2. Precision medicine / risk stratification

3. Remote monitoring

4. Trial for clinical application

12-lead ECG contains huge invisible information



Risk of arrhythmia

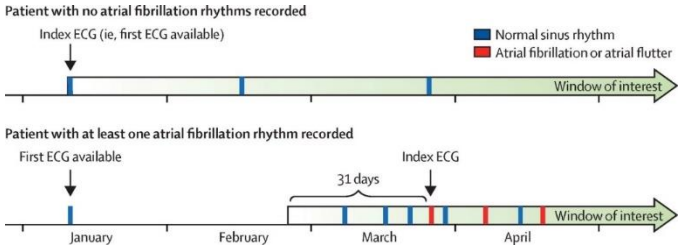
Risk of ischemia

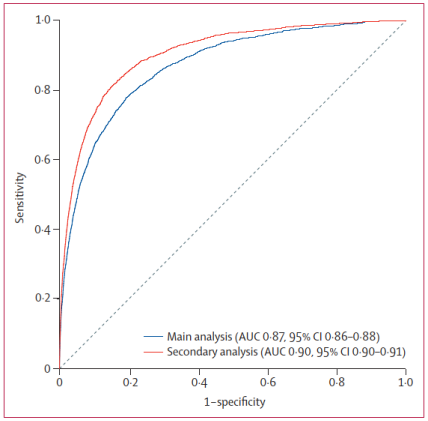
Risk of cardiac dysfunction

Prediction of newly onset AF by AI-ECG

An artificial intelligence-enabled ECG algorithm for the identification of patients with atrial fibrillation during sinus rhythm: a retrospective analysis of outcome prediction

Zachi I Attia, Peter A Noseworthy*, Francisco Lopez-Jimenez, Samuel J Asirvatham, Abhishek J Deshmukh, Bernard J Gersh, Rickey E Carter, Xiaoxi Yao, Alejandro A Rabinstein, Brad J Erickson, Suraj Kapa, Paul A Friedman*





	accuracy (%)	sensitivity (%)	Specificity (%)
Main	79.4	79.0	79.5
Secondary	83.3	82.3	83.4

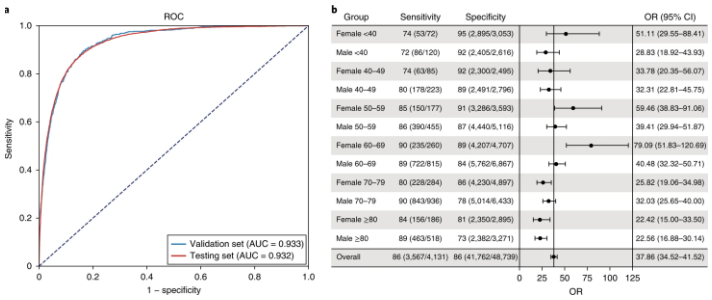
Attia Zi, et al., Lancet. 2019

Prediction of left ventricular dysfunction by AI-ECG

LETTERS | FOCUS
https://doi.org/10.1038/s41591-018-0240-2
nature medicine

Screening for cardiac contractile dysfunction using an artificial intelligence–enabled electrocardiogram

Zachi I. Attia[1], Suraj Kapa[1], Francisco Lopez-Jimenez[1], Paul M. McKie[1], Dorothy J. Ladewig[2], Gaurav Satam[2], Patricia A. Pellikka[1], Maurice Enriquez-Sarano[1], Peter A. Noseworthy[1], Thomas M. Munger[1], Samuel J. Asirvatham[1], Christopher G. Scott[3], Rickey E. Carter[4] and Paul A. Friedman[1]*



Attia ZI, Nat Med 2019; 25: 70

HRS 2022: AI-based app used to detect left-ventricular dysfunction

9th May 2022 3184

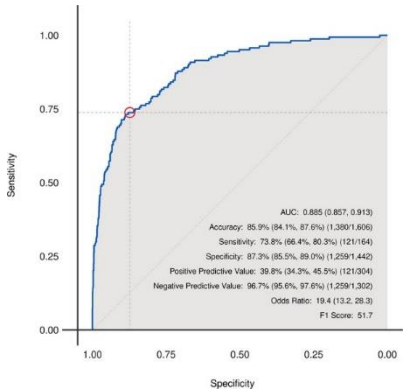
Use of an artificial intelligence (AI)-based app using electrocardiogram (ECG) signals recorded with an Apple Watch is able to identify left-ventricular dysfunction, research presented at the Heart Rhythm Society's 2022 annual meeting (HRS 2022, 29 April–1 May, San Francisco, USA) has found.

Circulation: Arrhythmia and Electrophysiology

ORIGINAL ARTICLE

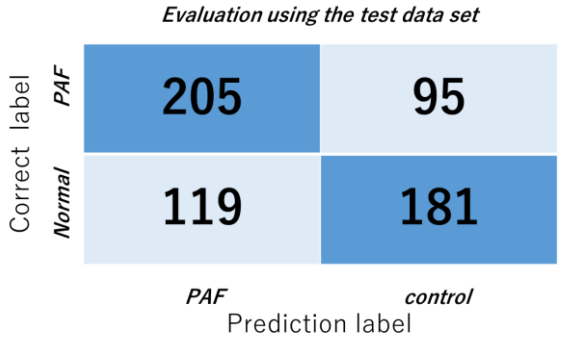
Artificial Intelligence-Enabled ECG Algorithm to Identify Patients With Left Ventricular Systolic Dysfunction Presenting to the Emergency Department With Dyspnea

Demilade Adedinsewo, MD, MPH; Rickey E. Carter, PhD; Zachi Attia, MSc; Patrick Johnson, BS; Anthony H. Kashou, MD; Jennifer L. Dugan, MD; Michael Albus, MD; Johnathan M. Sheele, MD, MPH; Fernanda Bellolio, MD, MS; Paul A. Friedman, MD; Francisco Lopez-Jimenez, MD, MSc; Peter A. Noseworthy, MD

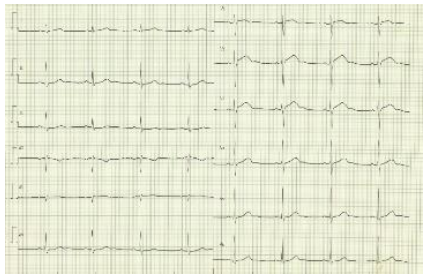


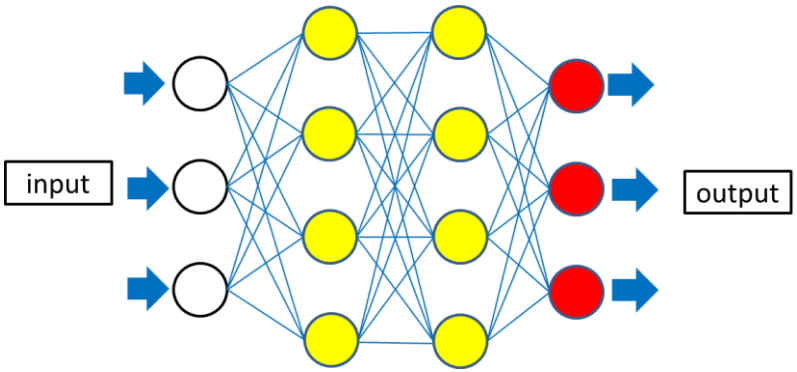
Adedinsewo D, Circ AE 2020; 13: e008437

Prediction of AF by AI-ECG

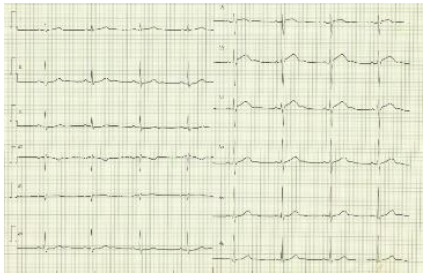


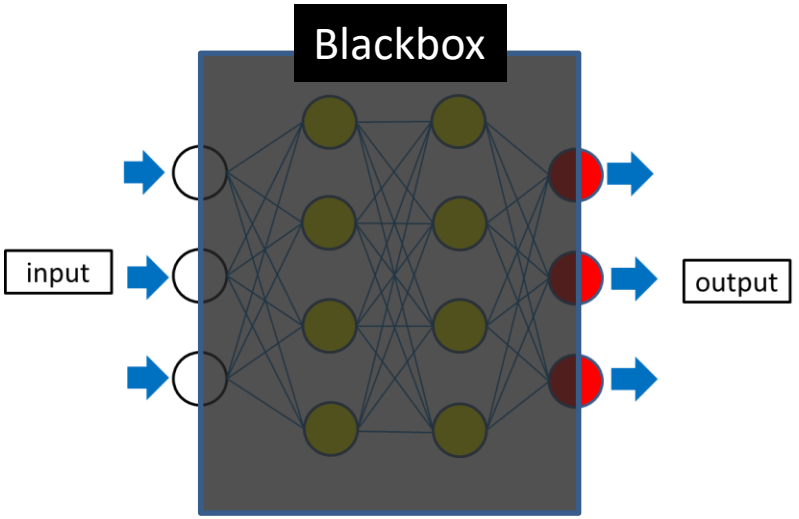
Lead	Accuracy (%)	sensitivity (%)	Specificity (%)	PPV (%)
12-lead	64.3 ±3.3	68.3 ±4.1	60.3 ±4.6	63.5 ±3.3

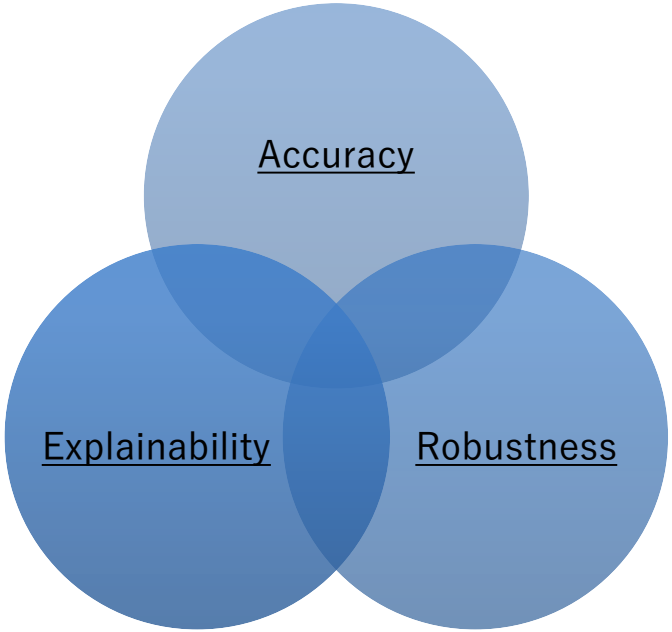




Problems should be solved for application of AI-ECG





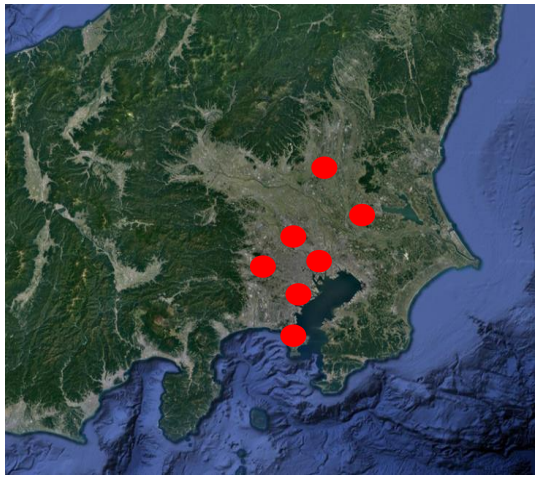


1. Accuracy
   - Overfitting
   - Quality of data
   - Number of data
2. Robustness
   - Stability of data
   - (institute, examiner, equipment)
3. Explainability

Multicenter study

Institutes

- *Tokyo Medical and Dental University*
- *Tsuchiura Kyodo Hospital*
- *Disaster Medical Center*
- *Yokohama City Minato Red Cross Hospital*
- *Yokosuka Kyosai Hospital*
- *Jichi Medical University*
- *Saitama Medical Center, Jichi Medical University*



Research period

2020/03 - 2022/01 Enrollment

- 2022/04 Data collection

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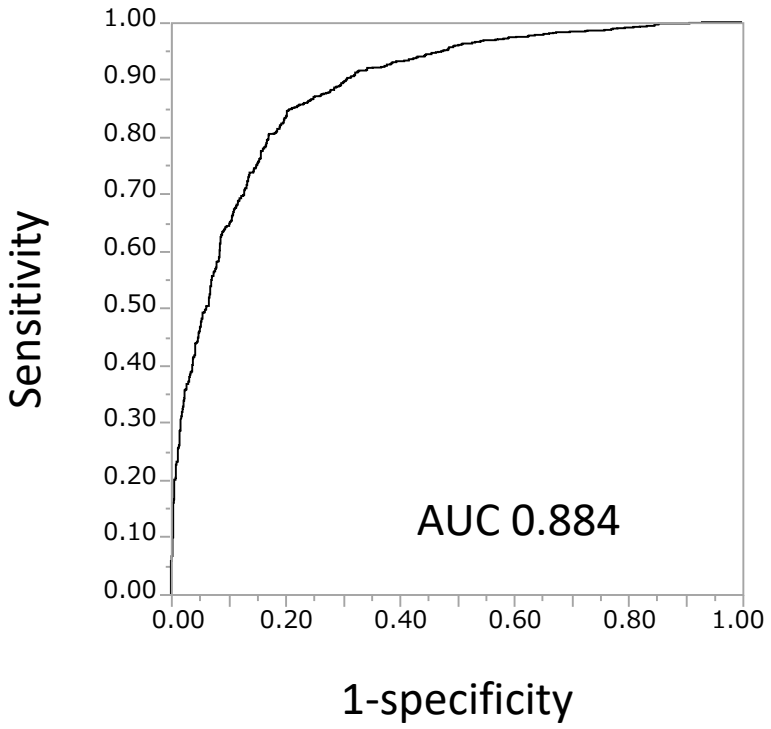
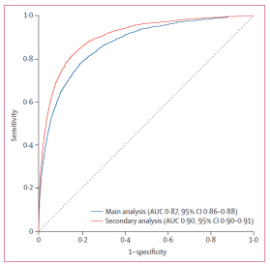
Improvement of accuracy to predict AF by AI-ECG



Odd's ratio 20.3

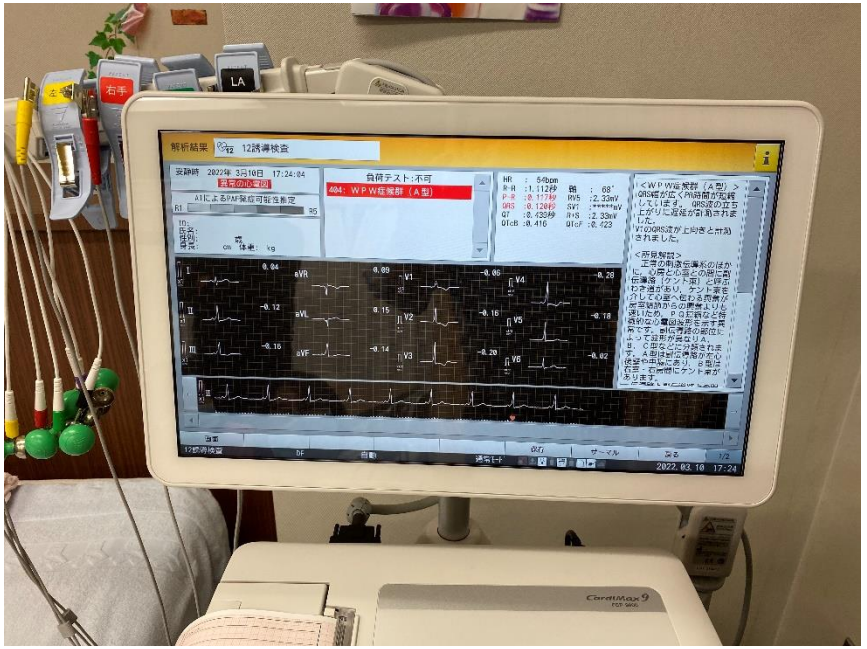
Accuracy	**0.817**
Precision	0.805
Recall	0.837
F1 score	0.820

		AF	
		(-)	(+)
AI-ECG	(-)	789	161
	(+)	200	827



Attia Zi, et al., Lancet. 2019

AI-ECG installed in conventional ECG machine



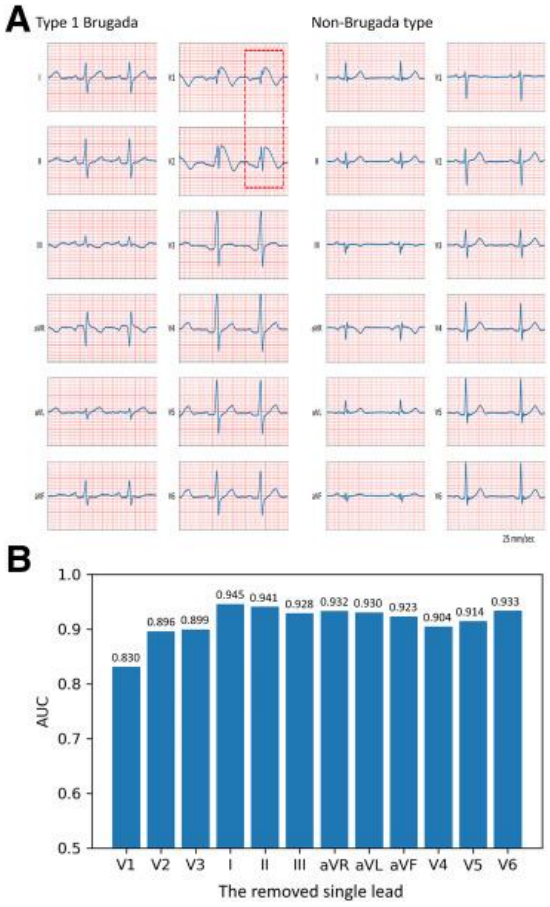
Prototype for research
Collaboration with Fukuda-denshi.

“Possibility of having AF by AI-ECG”

AI-ECG achieved the convenient usage for regular health check.

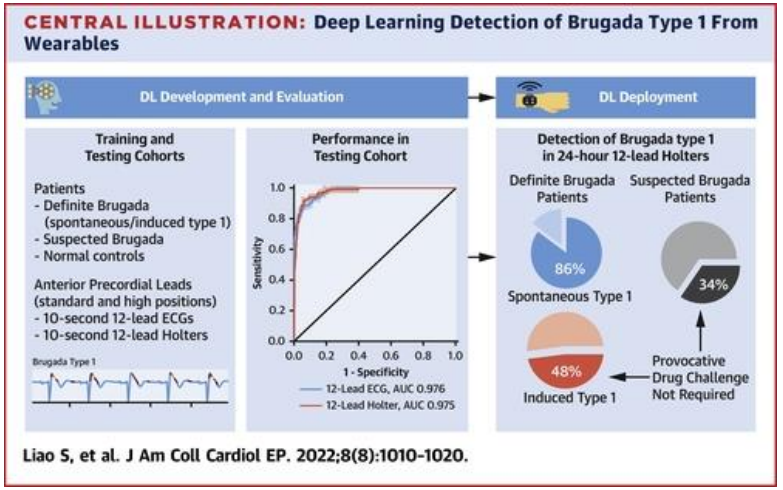
Diagnosis of Brugada syndrome with AI

A Deep Learning–Enabled Electrocardiogram Model for
the Identification of a Rare Inherited Arrhythmia : Brugada Syndrome



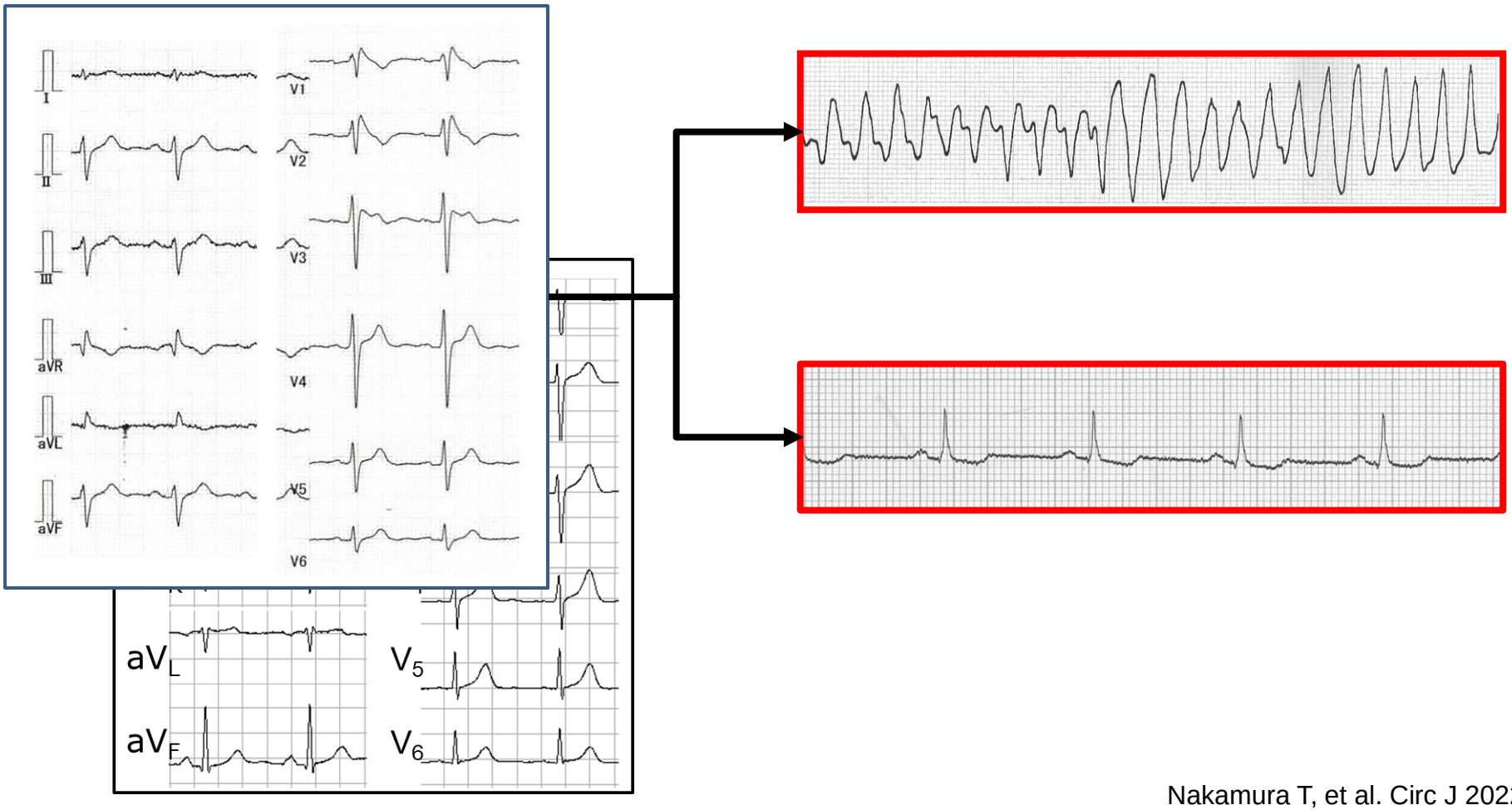
Liu CM, et al. Can J Cardiol 2022

Use of Wearable Technology and Deep Learning to Improve the Diagnosis of Brugada Syndrome



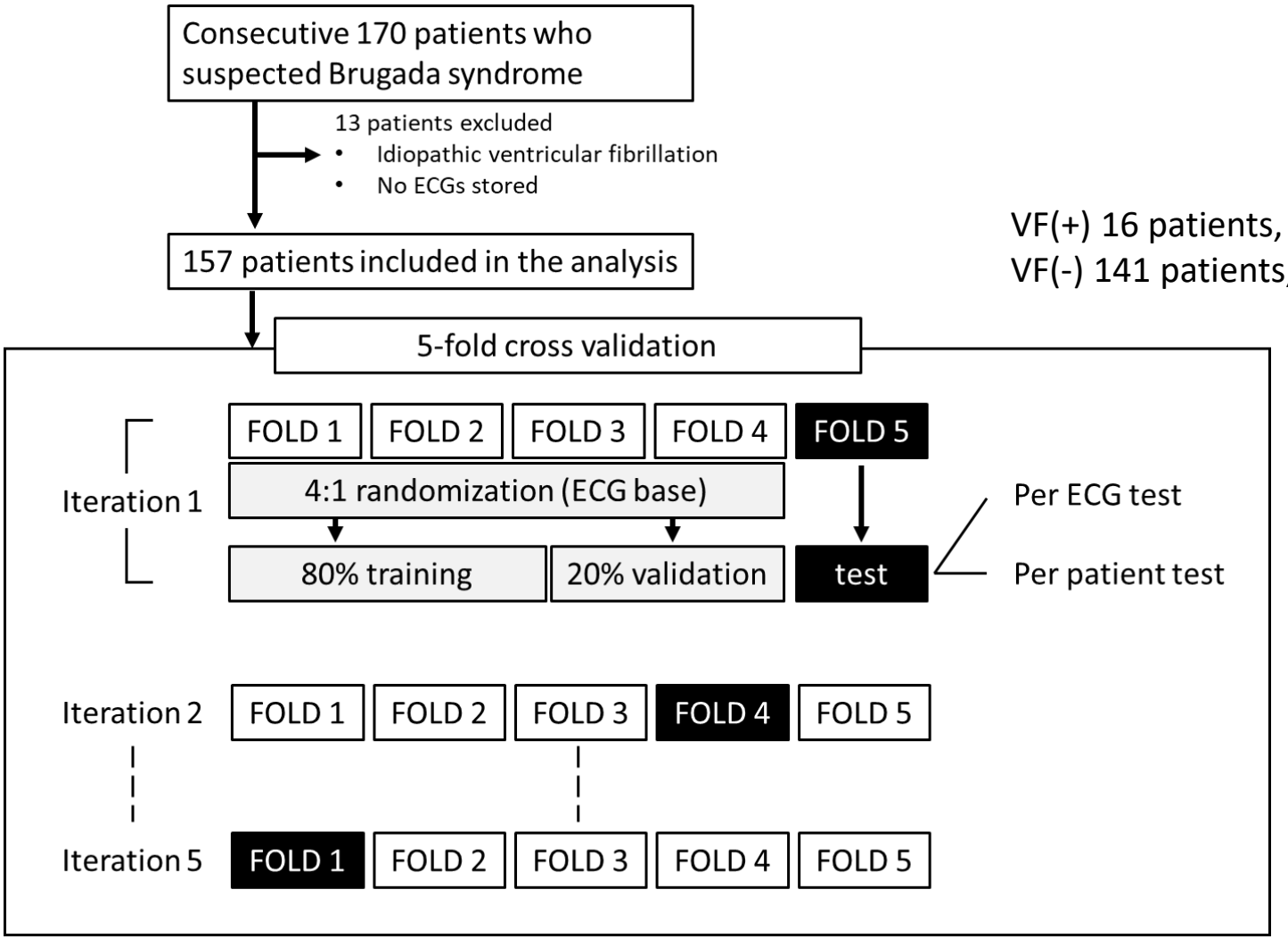
Liao S, et al. JACC EP 2022

Prediction of the Presence of Ventricular Fibrillation from a Brugada ECG Using Artificial Intelligence



Nakamura T, et al. Circ J 2022

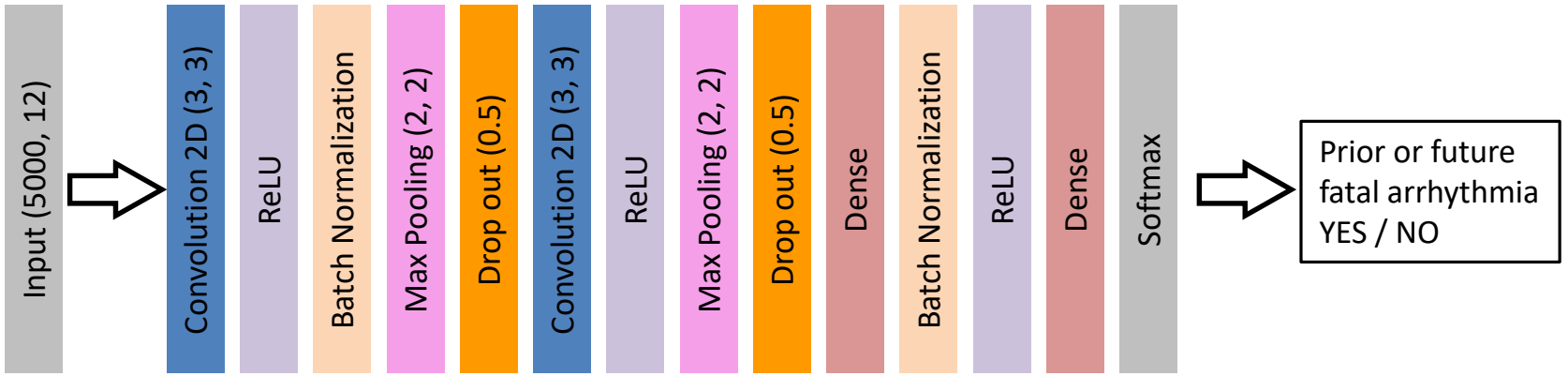
Data collection and deep learning



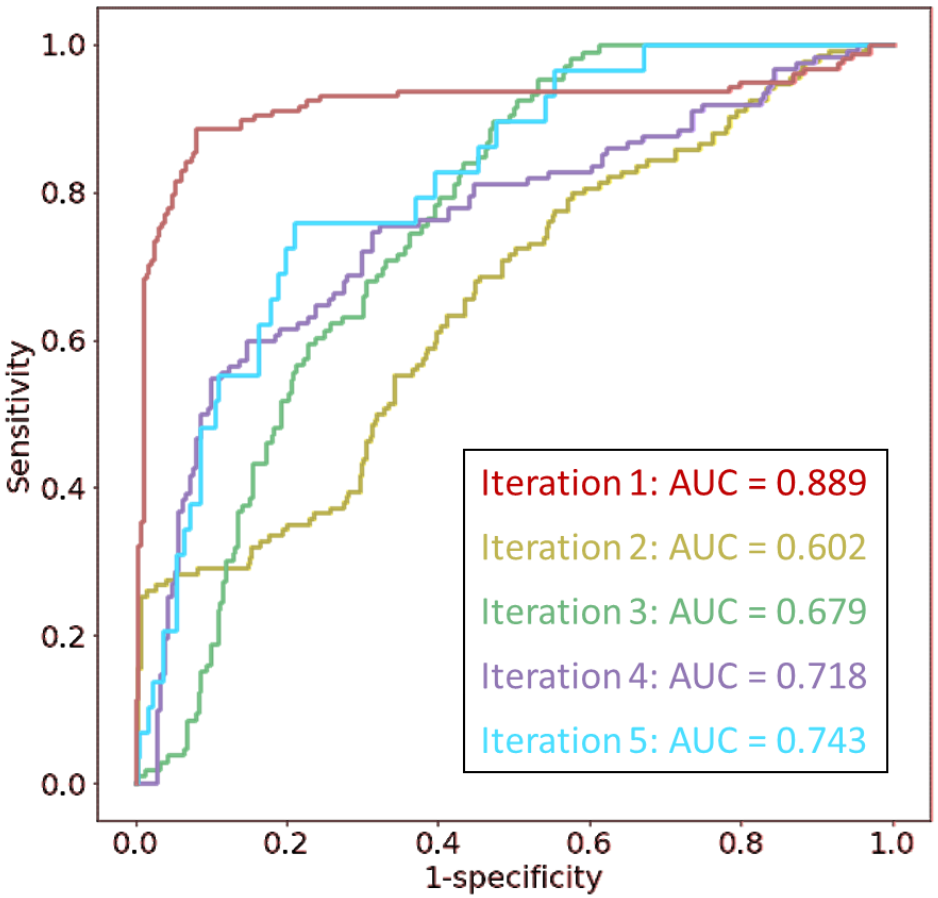
2,053 ECGs

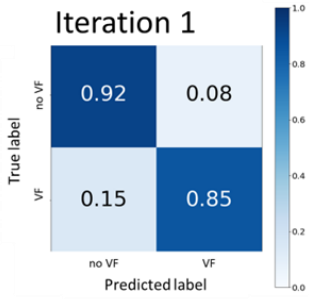
VF(+) 16 patients, 549 ECGs
VF(-) 141 patients, 1,504 ECGs

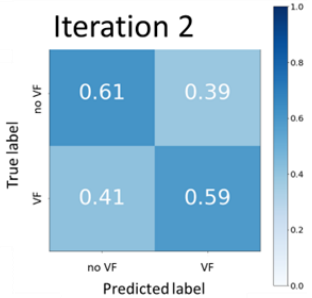
Convolutional deep learning model

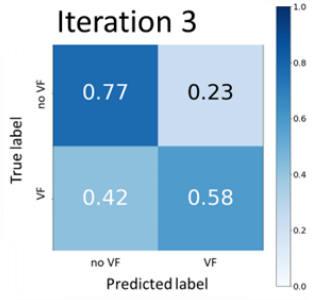


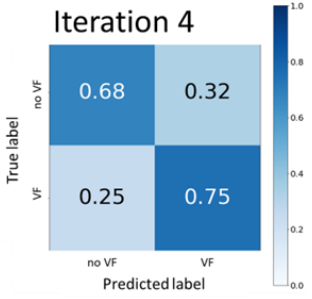
Prediction of ventricular tachyarrhythmia in patients with Brugada type ECG

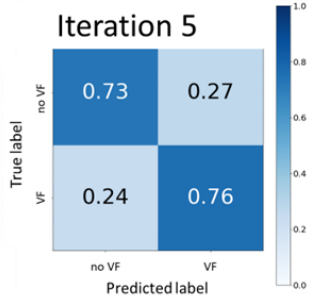




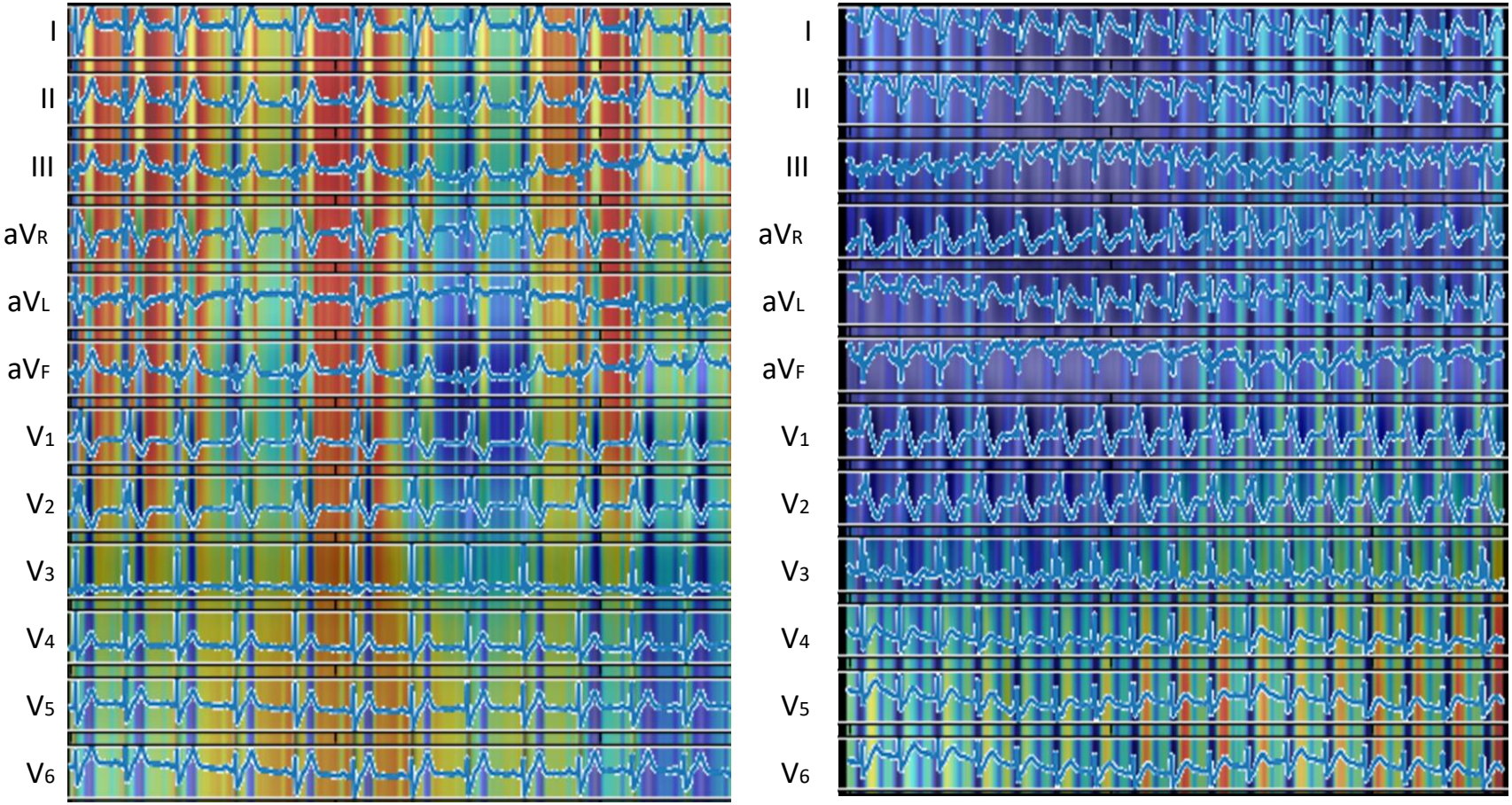






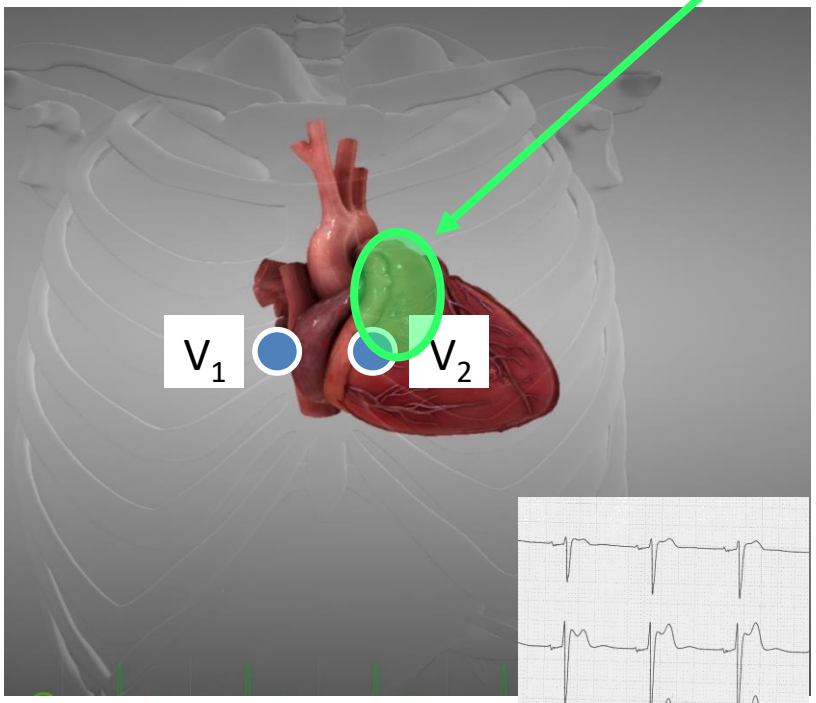


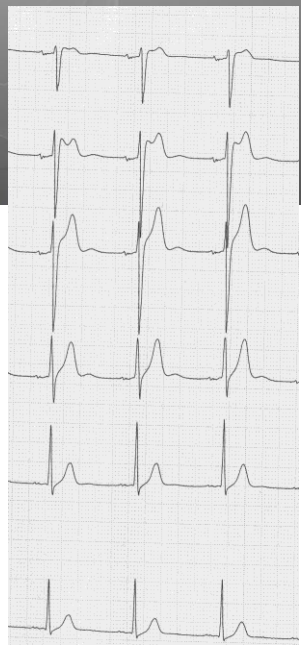
Explainable AI module (Grad-CAM) for the prediction of cardiac events in patients with Brugada syndrome



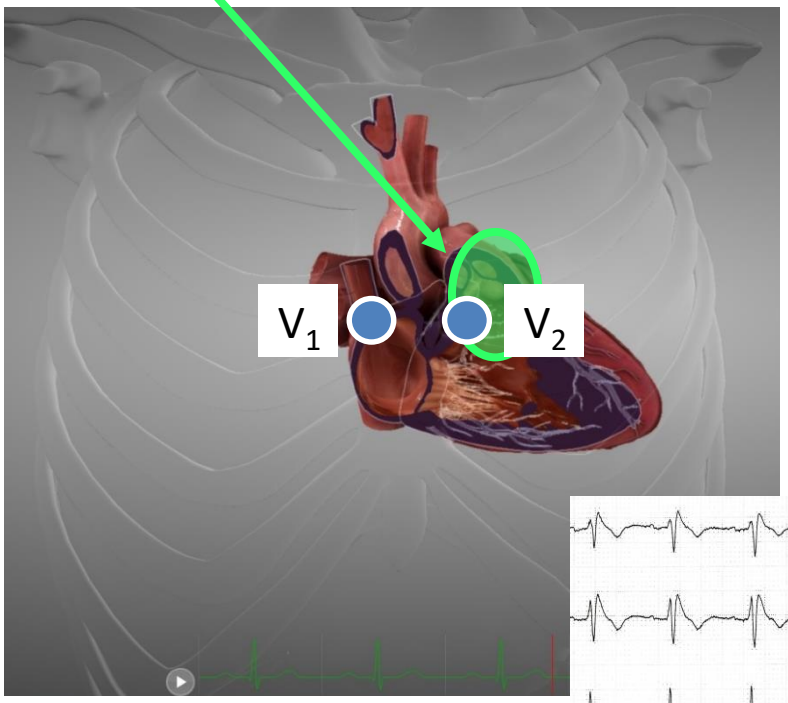
Saliency map illustrated that DL focused on diastolic phase periodically.

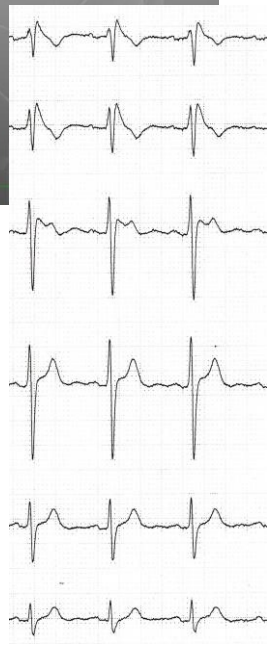
Movement of heart position by breathing





Exhale





Inhale

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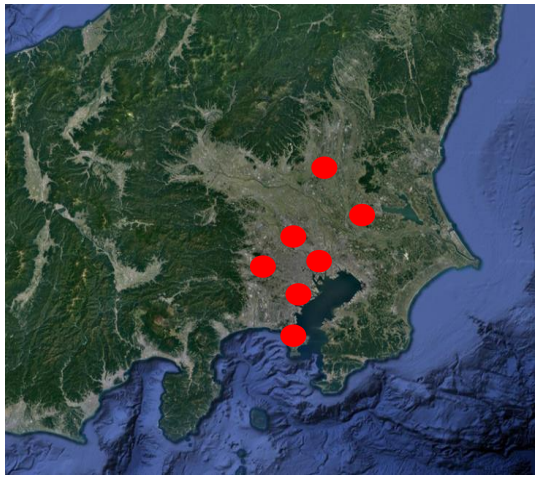

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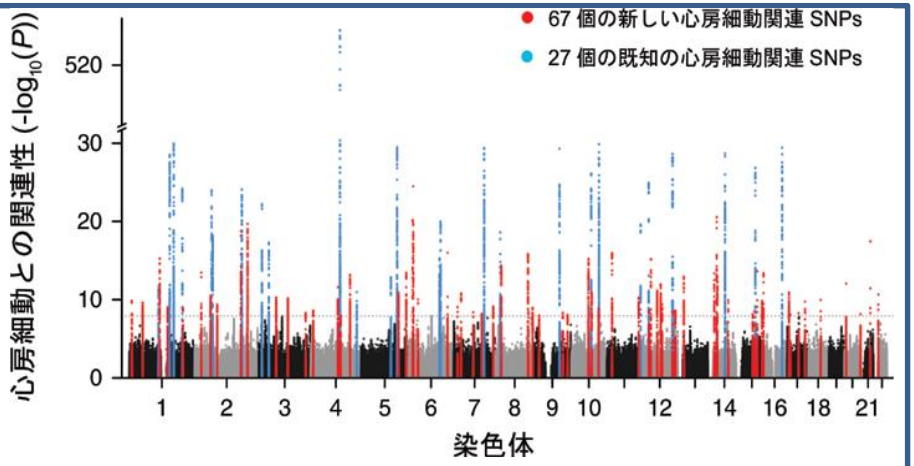
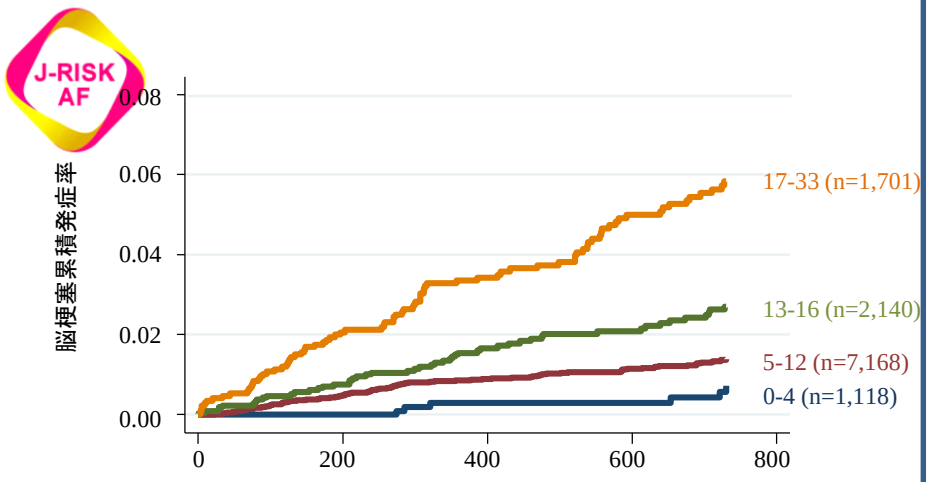
SNPs associated with AF



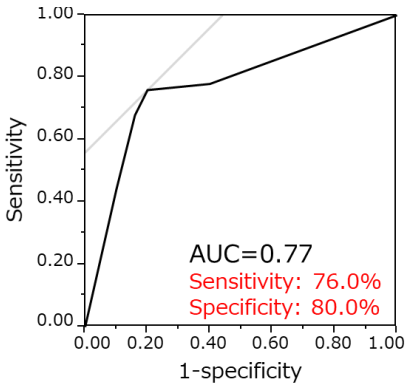
(Roselli C, Tanaka T, et al. *Nat. Genet.* 2018;50:1225-1233、**知財第5791171号**
C12N 15/09 20060101AFI12015091BHJP, C12Q1 1/68 20060101ALI20150917BHJP)

Clinical information and blood test



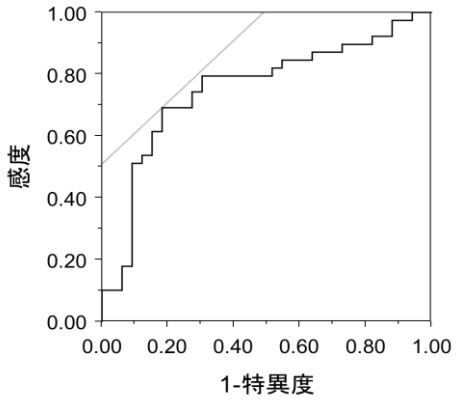
(Okumura K, Tomita H, et al. Late Breaking Cohort Studies, JCS 2017)

miRNA panel

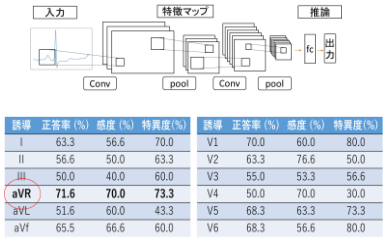


(*Circ. J.* 2018;82:965-973)

cell-free DNA



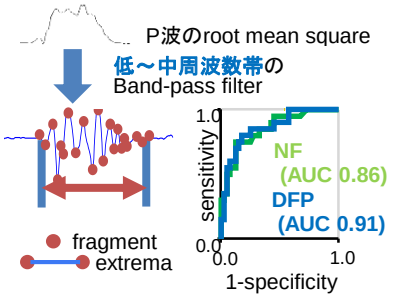
(Sci Rep. 2021)



誘導	正答率 (%)	感度 (%)	特異度(%)
I	63.3	56.6	70.0
II	56.6	50.0	63.3
III	50.0	40.0	60.0
aVR	71.6	70.0	73.3
aVL	51.6	60.0	43.3
aVf	65.5	66.6	60.0

誘導	正答率 (%)	感度 (%)	特異度(%)
V1	70.0	60.0	80.0
V2	63.3	76.6	50.0
V3	55.0	53.3	56.6
V4	50.0	70.0	30.0
V5	68.3	63.3	73.3
V6	68.3	56.6	80.0

(unpublished data;**特願2020-004651**)

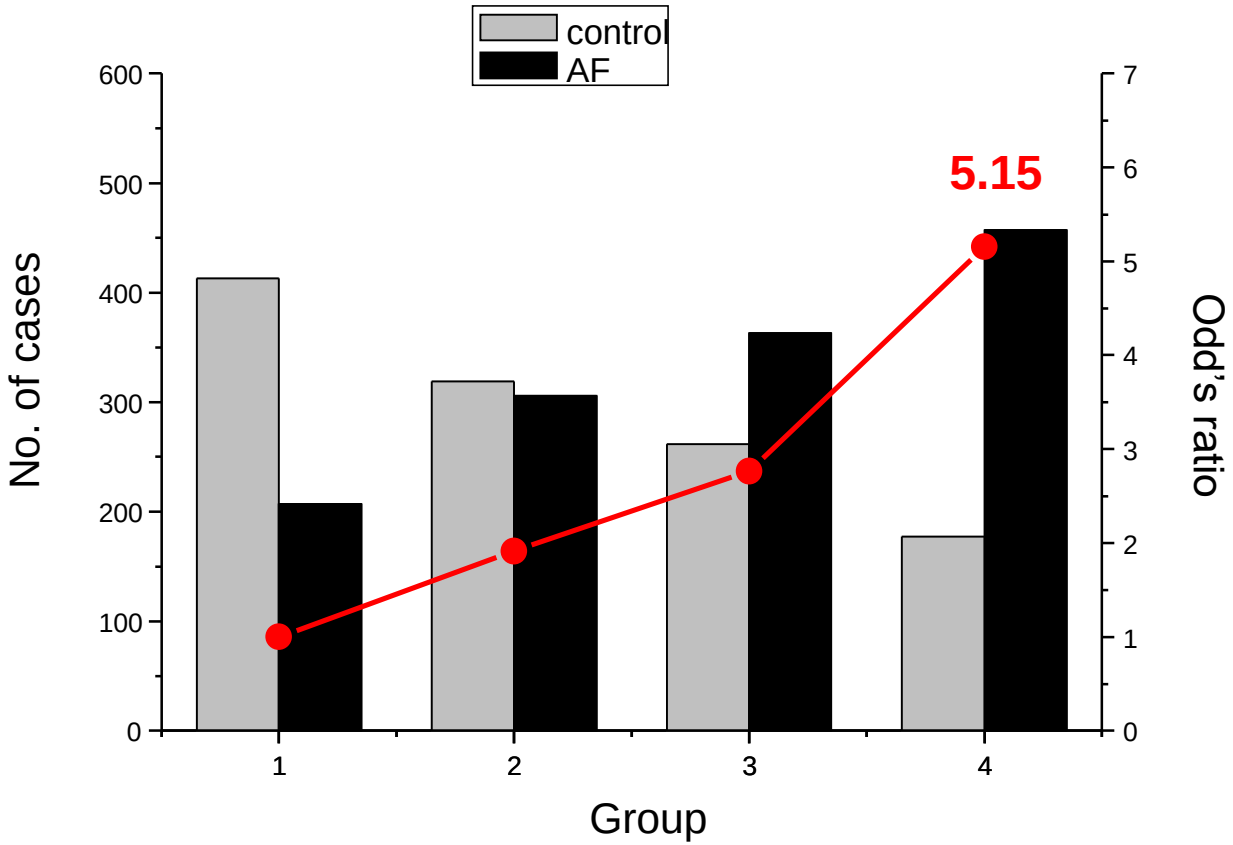


(unpublished data;**特願2019-042717**)

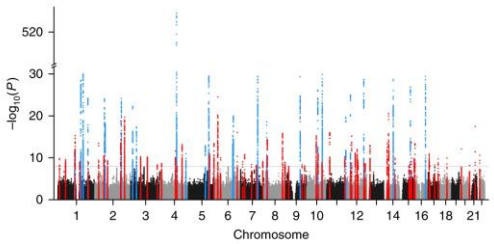
Novel biomarkers (miRNA and cfDNA)

AI-ECG

Risk stratification of AF using Genetic Risk Score (GRS)



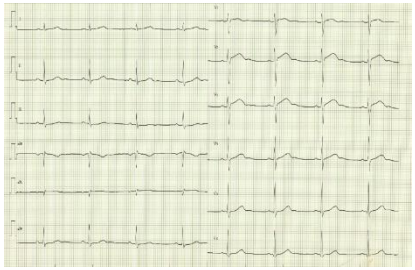
Genotyping



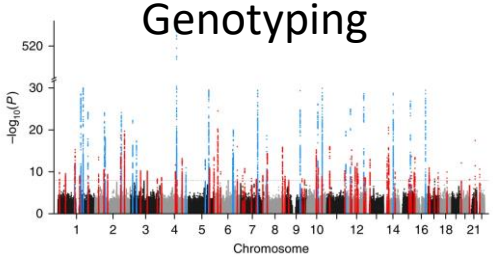
GRS was calculated using 106 SNPs.

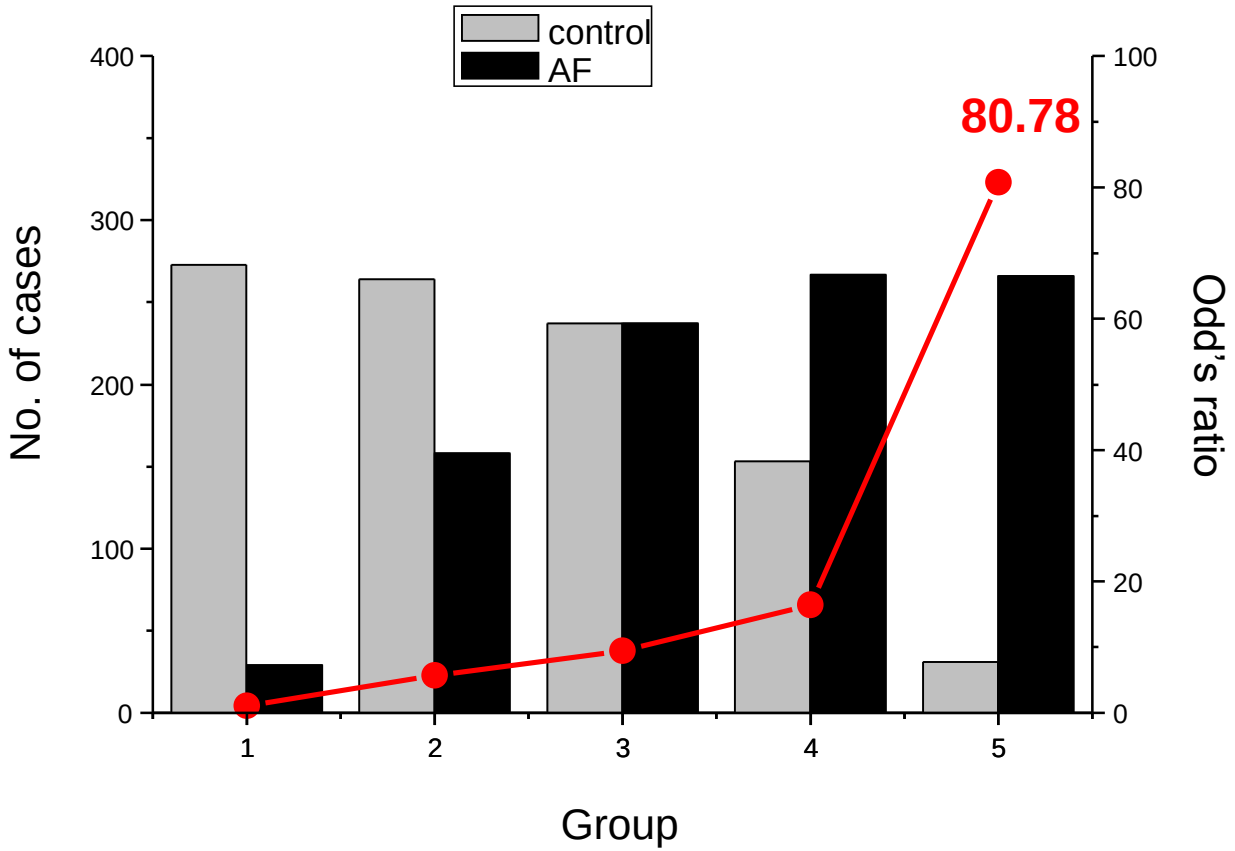
Combined analysis of GRS and AI-ECG

AI-ECG



Genotyping

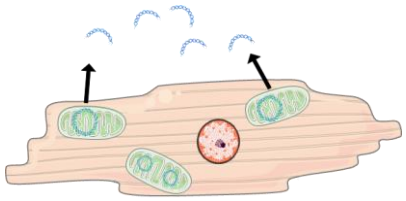




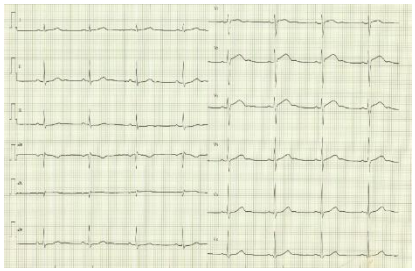
GRS group score (1-4) + AI-ECG score (0-1)

Combined analysis of GRS, AI-ECG, and cfDNA

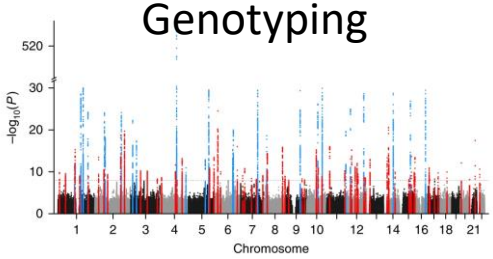
Cell-free DNA

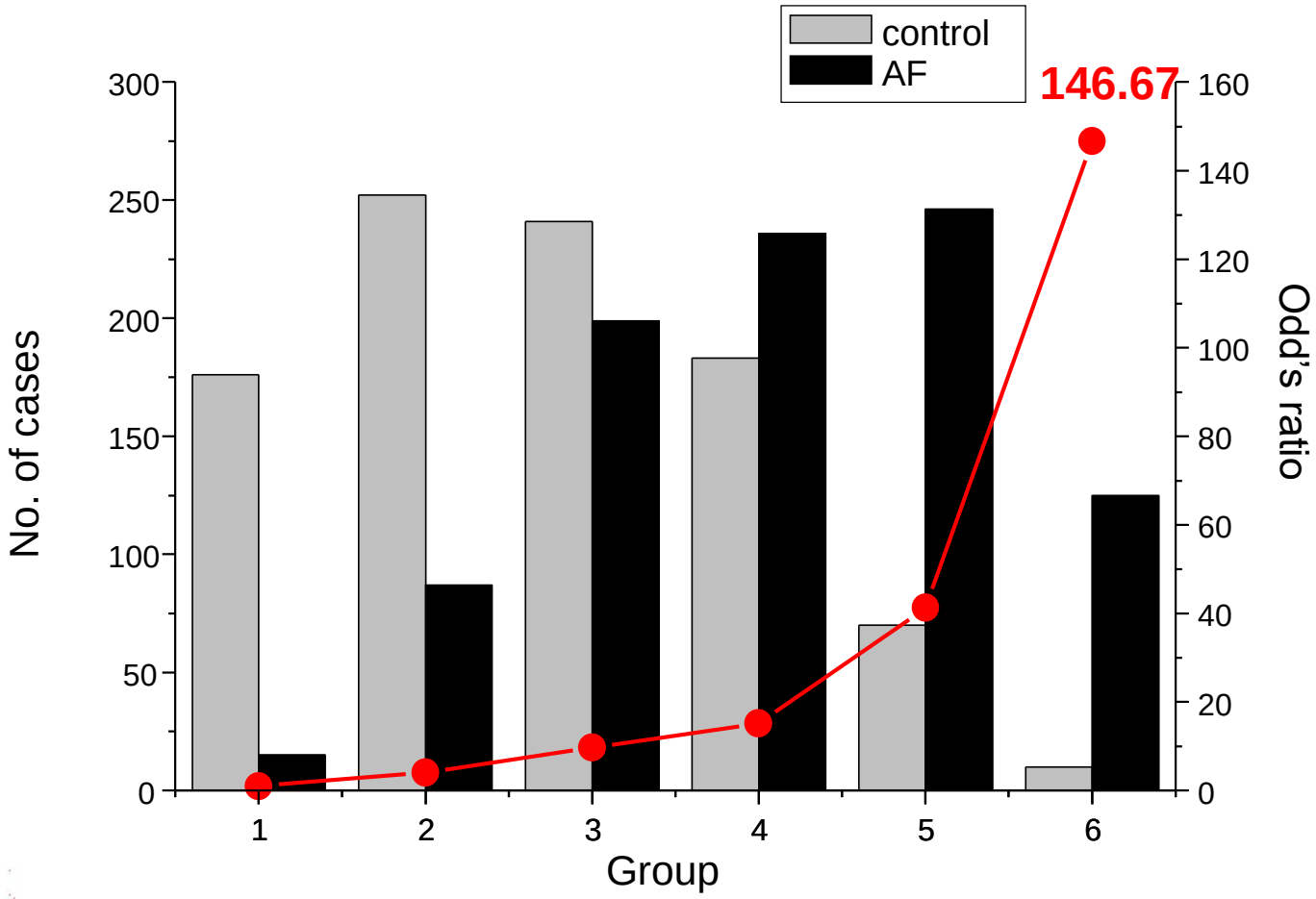


AI-ECG



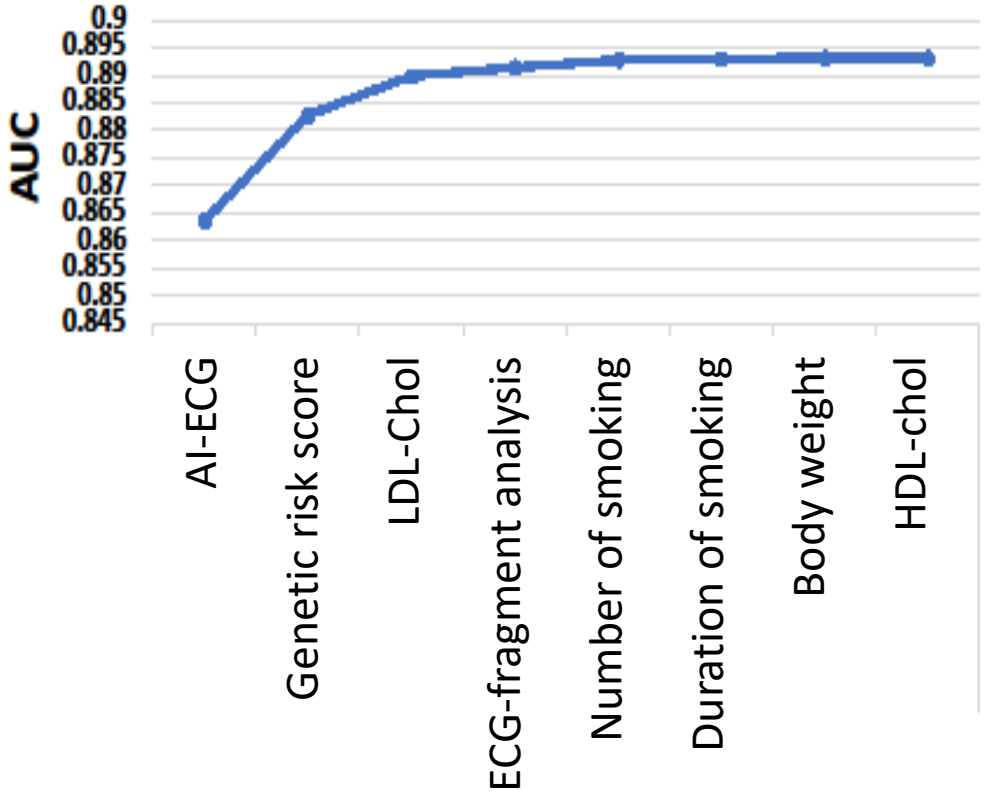
Genotyping





GRS group score (1-4) + AI-ECG score (0-1) + cfDNA score (0-1)

Search for important feature value by light GBM



AI for the prediction/detection of AF

1. AI-ECG

2. Precision medicine / risk stratification

3. Remote monitoring

4. Trial for clinical application

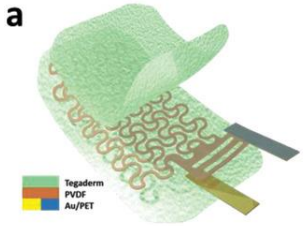
Modalities for remote monitoring

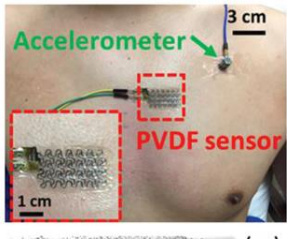
- ECG, Electrocardiography

- PPG, Photoplethysmography

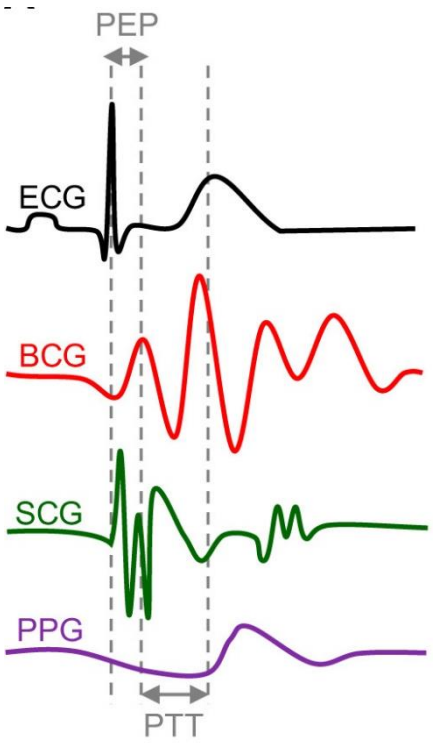
- BCG, Ballistocardiography

- SCG, Seismocardiography





- MCG, Magnetocardiography



Ha T, et al. Adv Sci 2019
Etemadi M, et al. J Applied Phyiol 2018

AI-based diagnosis/detection of AF

4G/3G

ECG

Bluetooth

AI-based detection of AF by PPG and acceleration data

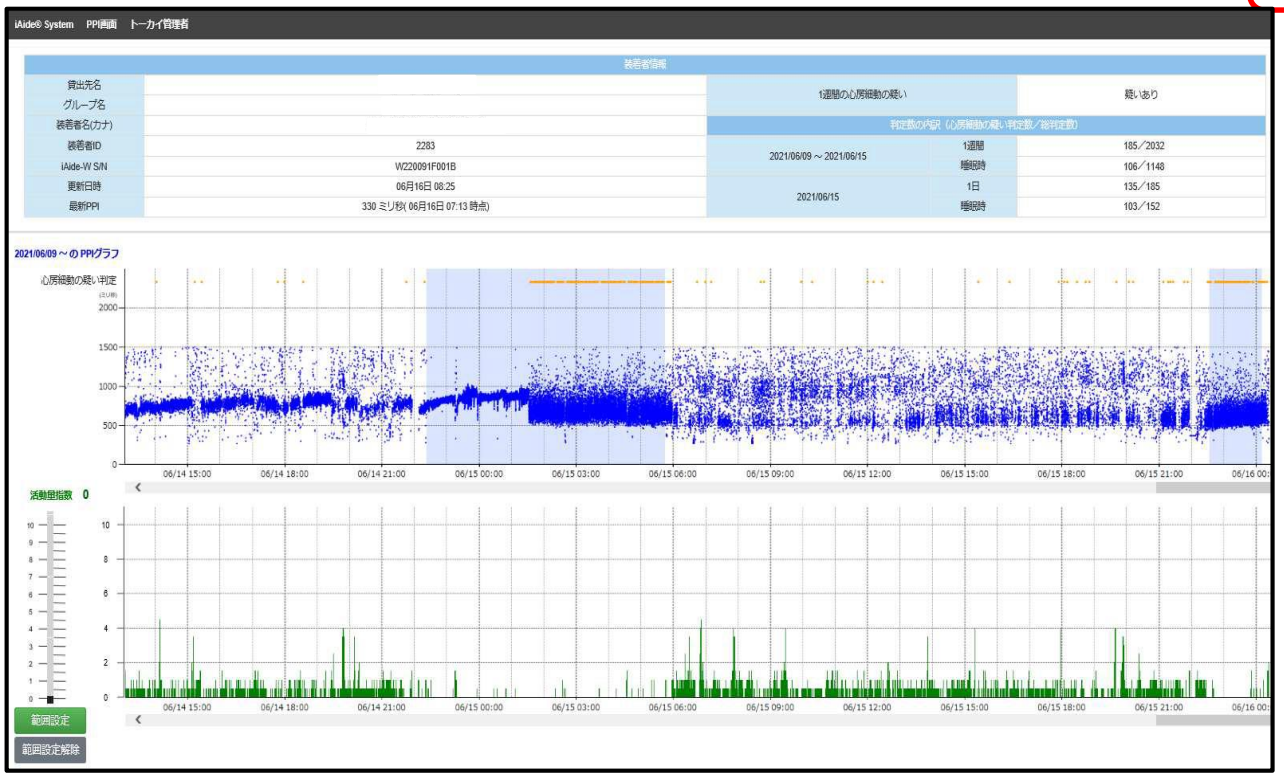
Automatic diagnosis

4G/3G

PPG

acceleration

Bluetooth



AI for the prediction/detection of AF

1. AI-ECG

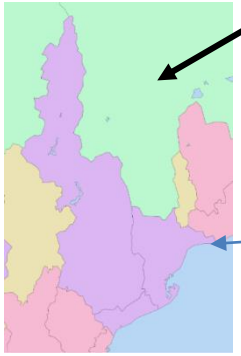
2. Precision medicine / risk stratification

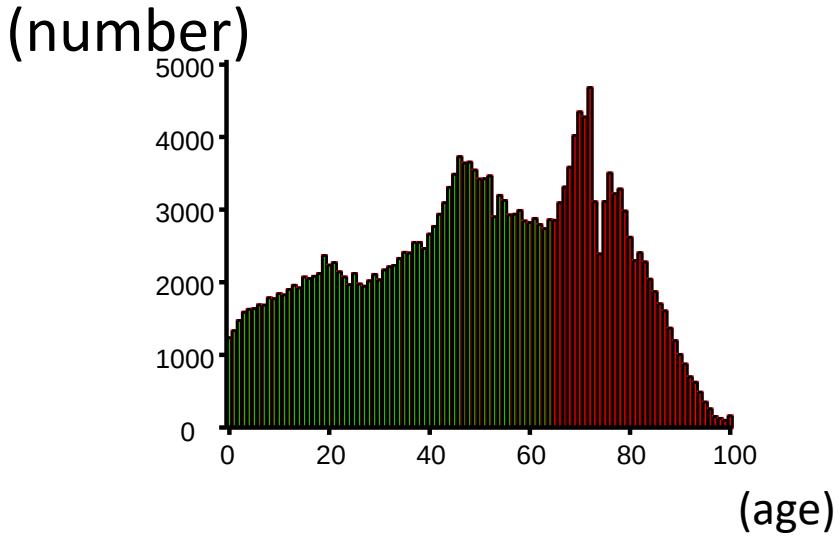
3. Remote monitoring

4. Trial for clinical application

Stroke Prevention by early detection of AF in Shimizu (SPAFS)

Shimizu ward, Shizuoka City



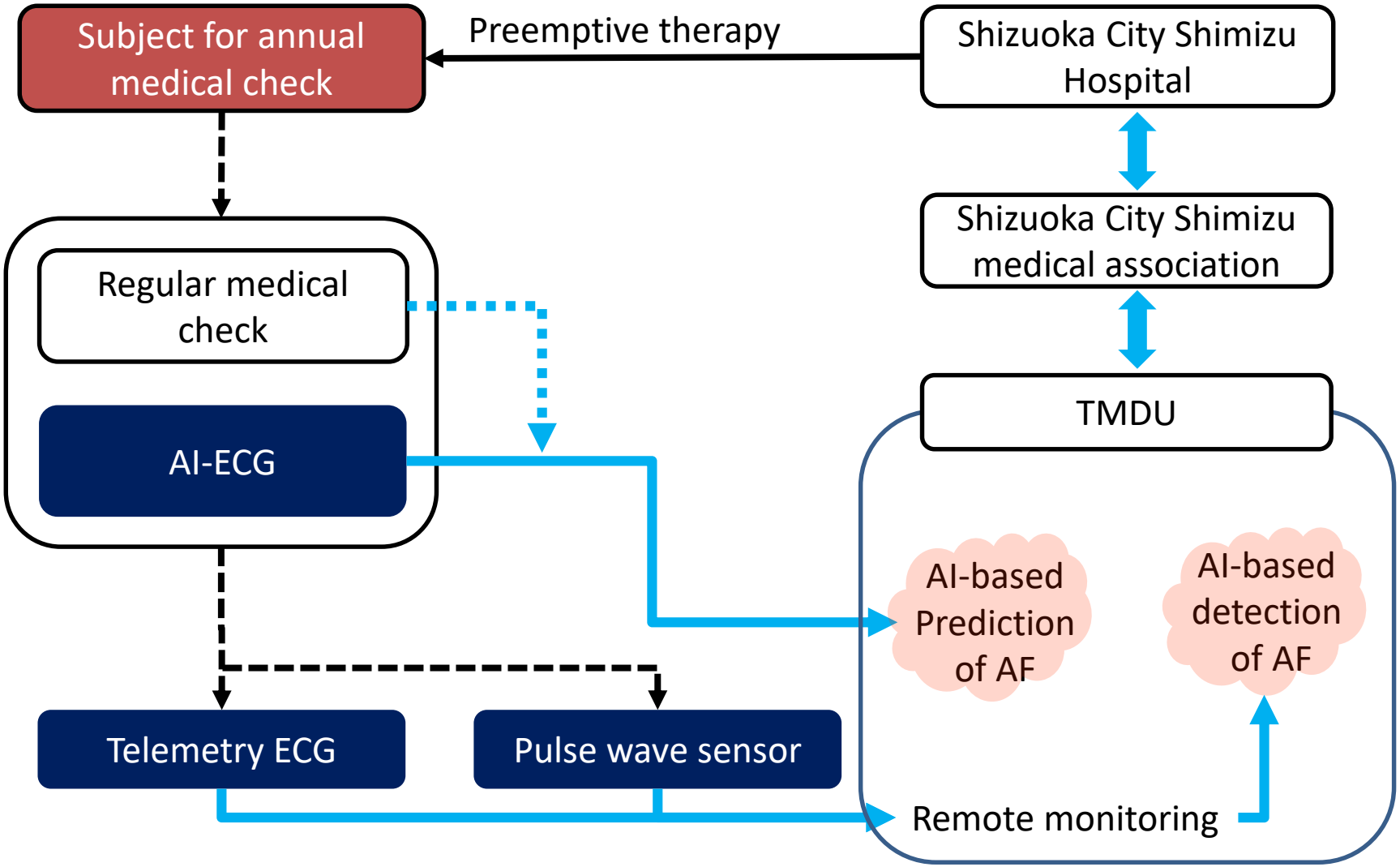


Population in Shimizu: 234,625

>40 y.o. 154,330 (65.8%)

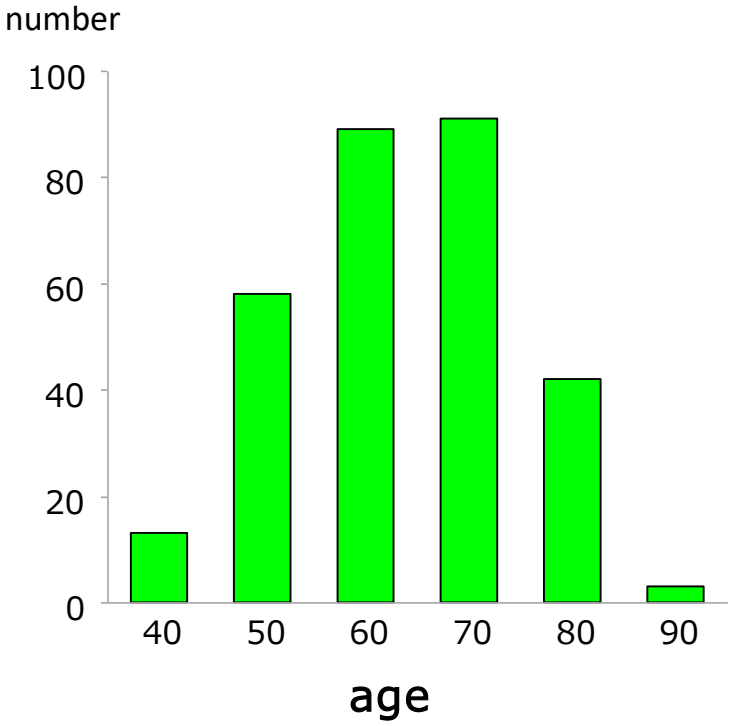
>65 y.o. 76,086 (32.4%)

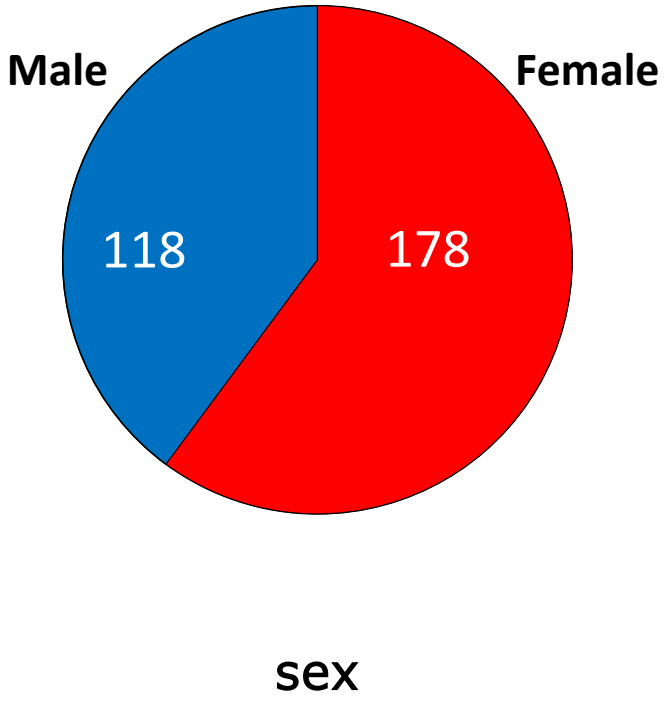
Stroke prevention by Prediction of AF in Shimizu (SPAFS)



Result of SPAFS

296 subjects were enrolled in the project.





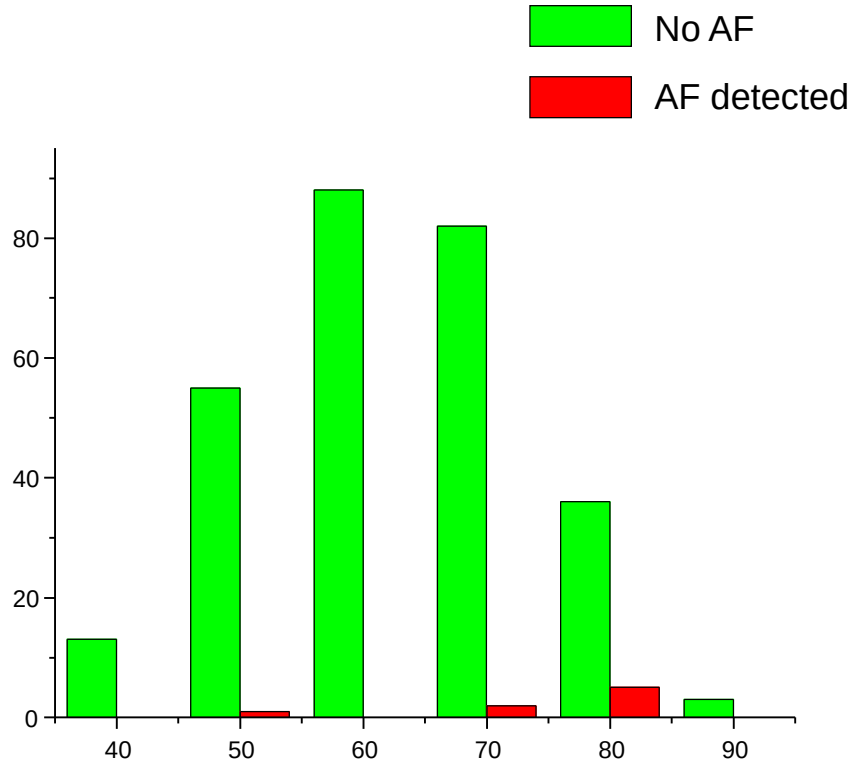
Newly detected AF patients.

296

Detection of undiagnosed AF

8

7 for anticoagulation.
3 for catheter ablation.



Report of SPAFS

SPAFS 結果通知書

SPAFSMemberID：**

** ** 様

SPAFSProjectID：**

この度は、静岡市・静岡市清水医師会・東京医科歯科大学による「ＡＩ及びリモートテクノロジーを用いた心房細動の早期発見により清水区を日本で一番脳梗塞の少ないまちにする地域医療プロジェクト」（略称：SPAFS）にご参加頂き、まことにありがとうございました。
結果を以下にお示しします。

検査日：2022年**月**日

1 特殊心電図検査による発作性心房細動の発症予測

ＡＩ判定対象外

＊この結果はあくまでも研究段階の予測値であり、確定したものではありません

2 遠隔モニタリング機器による心房細動の検出

あり

＊モニタリングを行った期間において、心房細動発作が生じていたかどうかを表します

3 医療機関受診の必要性

要受診

心房細動は無症状であっても治療が必要な場合があります。また、当面は治療の必要がなくても経過観察が必要な場合もあります。このため、医療機関受診の必要性が「要受診」となった方は、専門医への受診と相談をお勧めいたします。
心房細動の治療に関しては医療機関の制約はありませんが、本報告書の結果に関するご質問や、本報告書をふまえた診療については、下記のお問い合わせ先までご連絡下さい。

Risk prediction by AI-ECG

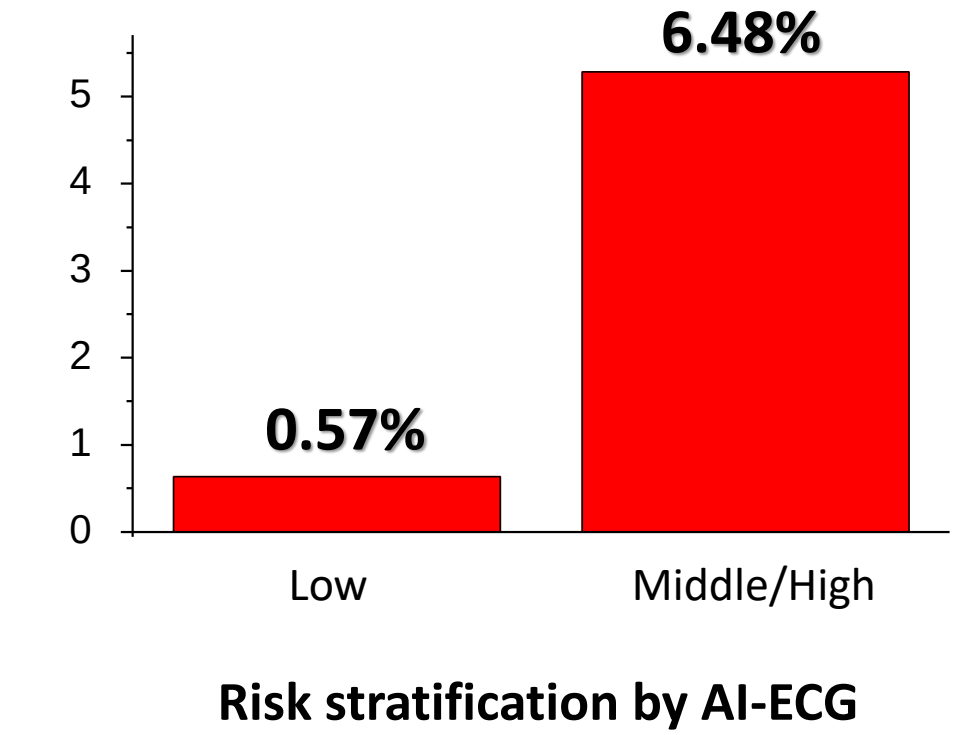
Low / middle / high risk

Detection of AF by remote monitoring

AF / no AF

The accuracy of risk stratification by AI-ECG

Odd's ratio 12.2



Possibility of the application of AI in EP field

- Diagnosis
- Precision medicine / risk stratification
- Remote monitoring

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Thank you for paying attention!