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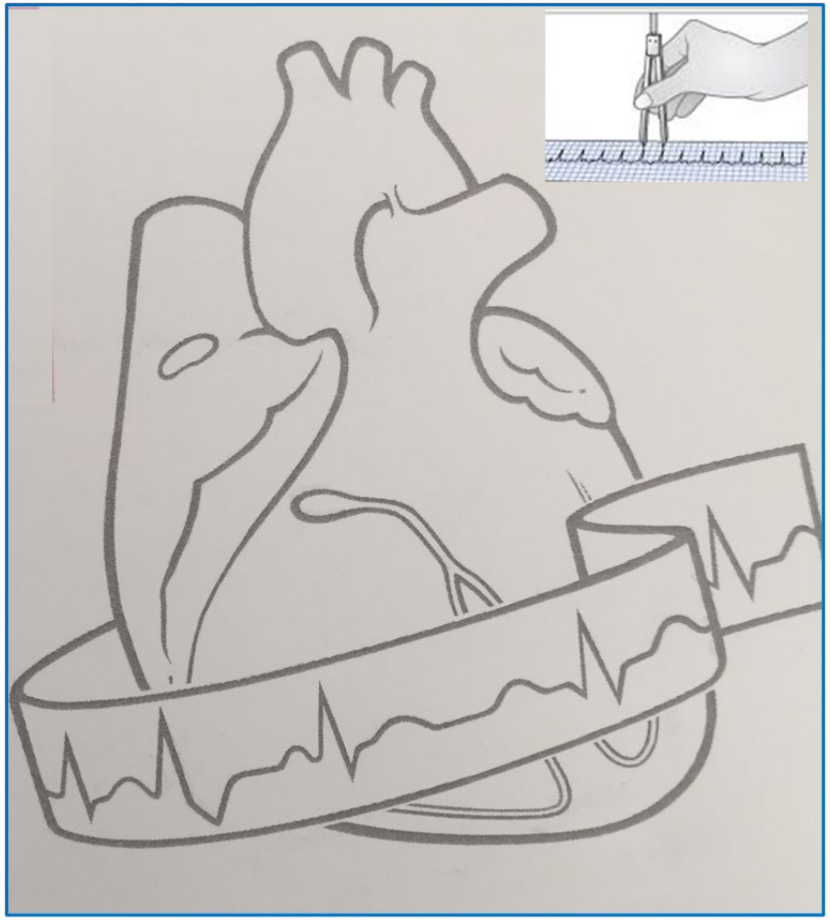


EKG

Emoke Posan

PartnerRe

AI-enabled EKG reading

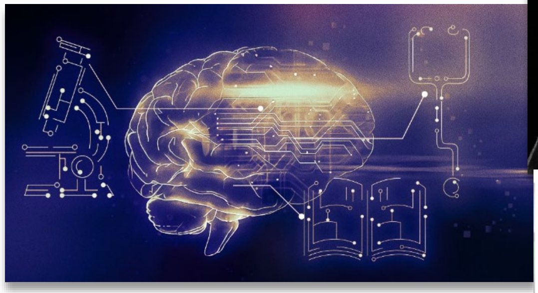
A NEW ERA

The Age of AI has begun

Artificial intelligence is as revolutionary as mobile phones and the Internet.

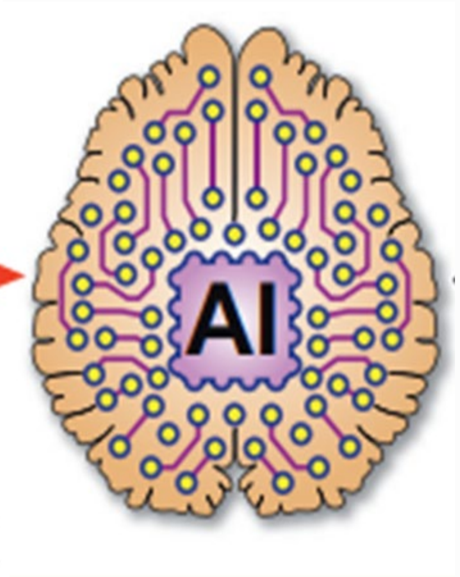
By **Bill Gates** | March 21, 2023 • 14 minute read

GatesNotes THE BLOG OF BILL GATES



"The development of AI is as fundamental as the creation of the microprocessor, the personal computer, the Internet, and the mobile phone [...] It will change the way people work, learn, travel, get health care, and communicate with each other."

-- Bill Gates

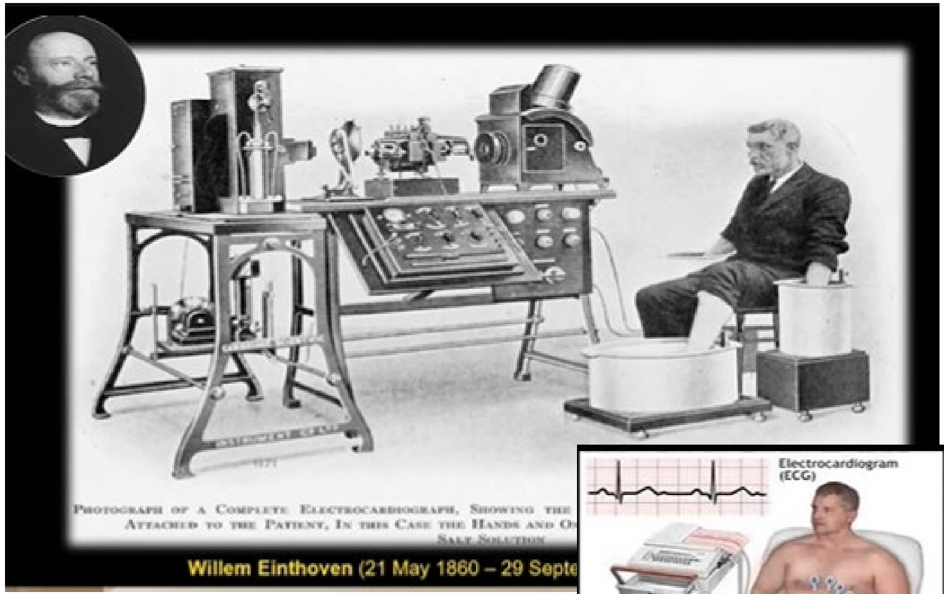


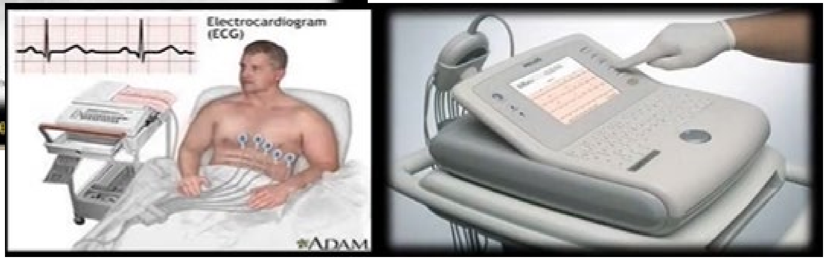
Bill Gates Wants to Out-Plan the Next Pandemic - The Atlantic

The Age of AI has begun | Bill Gates (gatesnotes.com)

Promise of AI-EKG

Centenary of EKG Discovery





The Nobel Prize in Physiology or Medicine 1924

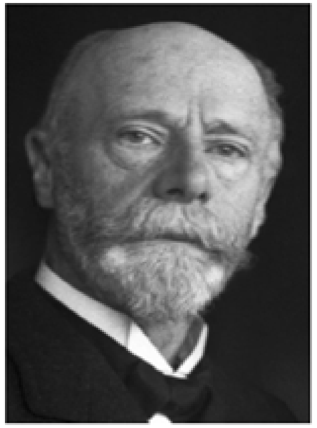
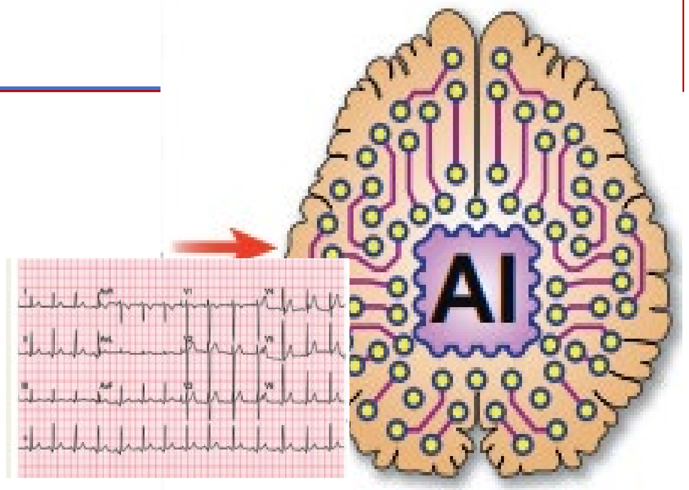


Photo from the Nobel Foundation archive.

Willem Einthoven

The Nobel Prize in Physiology or Medicine 1924 was awarded to Willem Einthoven "for his discovery of the mechanism of the electrocardiogram"

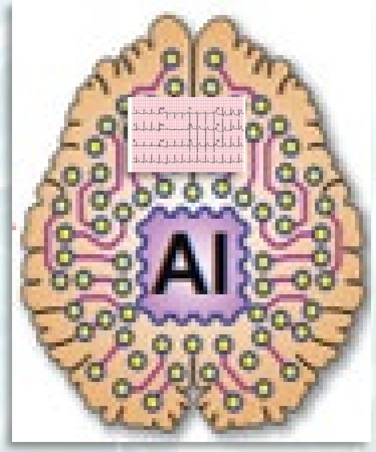


Unlocked Potentials in EKG innovation

doi:10.1093/eurheartj/ehab649
Wikipedia – Einthoven

AI- enabled EKG reading – “AI-EKG”

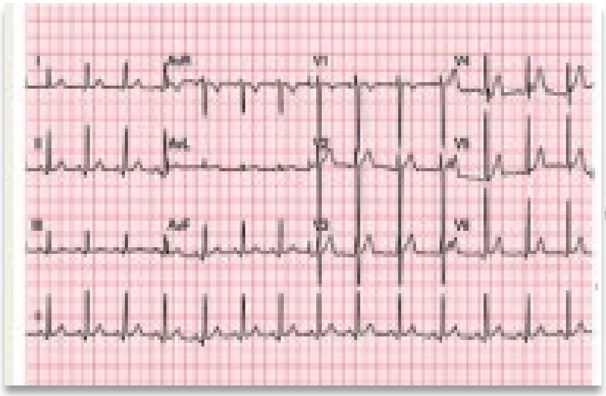
What is AI-EKG?

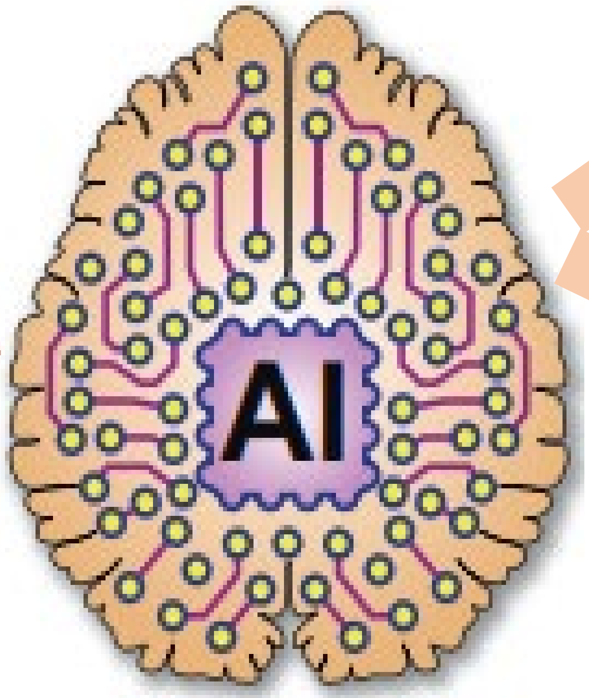


EKG reading Beyond human capacity

Extracting additional information

AI application to the EKG





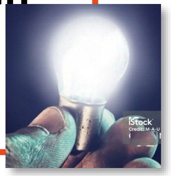
Streamlining Human Capability
Augment currently performed human skills

Scalable, Precise
Fast, More Consistent

Beyond human capability

Extract information from an EKG *beyond which* a human can typically perform

Value Added EKG reading



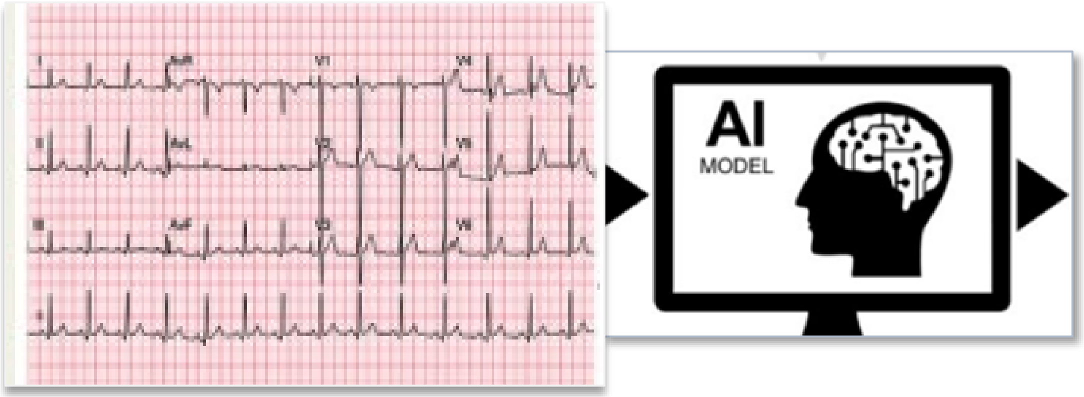
→ Ability to diagnose conditions not previously identifiable by an EKG

AI-EKG for enhanced diagnosis and prognosis – Deep Learning

doi:10.1093/eurheartj/ehab649

Future EKG reading

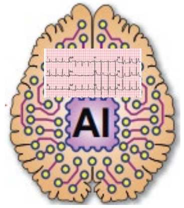
PROBALISTIC INTERPRETATION vs ‘normal/abnormal’



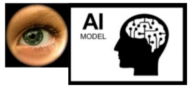
Estimated age:	39.5 years
Probability male:	99%
Estimated EF:	55%
Probability of low EF:	0.5%
Probability of undetected AF:	0.3%
Probability of HCM:	0.2%
Probability of aortic stenosis:	< 0.01%
Probability of cardiac amyloidosis:	0.03%

Application of artificial intelligence to the electrocardiogram, EHj (2021) 42, 4717

AGENDA:



➢ **SEING BEYOND HUMAN INTERPRETATION**



2 EXAMPLES - and 3 'detours'

- **Background, Basic principles**
- **First Hypothesis testing, training and outcomes**
- **Performance of algorithm**
- **Case examples**
- **Clinical Utility- examples**

- **± Case examples**
- **± Methodology insight**

➢ **Overview**

- **AREAS with Major development-**
- **Settings/form factors in which it can be used**

➢ **Challenges ±**

➢ **Summary/Conclusion**

➢ **Current status - Where are we at?**

doi:10.1093/eurheartj/ehab649

AI-EKG Background

Course of a Disease

I feel good!

SYMPTOMS AND SIGNS

Tests (time and cost))
diagnosis, treatment

Maybe LATE! **First signs: MI, Stroke, SCD**

Underlying physiological process starts many years earlier

Background

Course of a Disease

I feel good!

SYMPTOMS AND SIGNS

Tests (time and cost))
diagnosis, treatment

?LATE!
First signs: Stroke, MI, SCD

Silent –Asymptomatic LV dysfunction

6.5xrisk clinical CHF, 1.6xrisk death

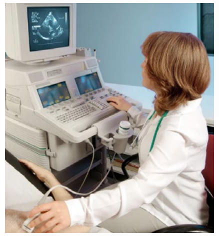
Early diagnosis can mitigate the risk

~2%
Global population

7M
Americans

~9%
>60y od

Treatments lower mortality and HHF



IDENTIFICATION REQUIRES EXPENSIVE, NOT READILY AVAILABLE TESTS

NT-proBNP

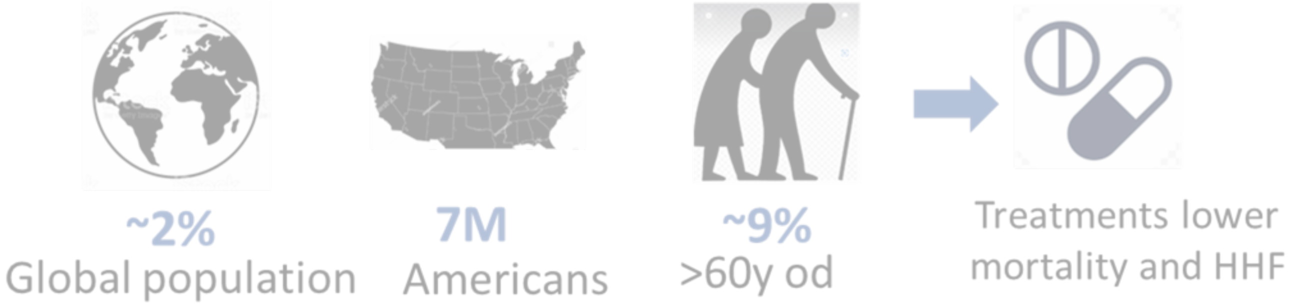
Application of artificial intelligence to the electrocardiogram, European Heart Journal (2021) 42, 4717–4730
Attia ZI. Screening for cardiac contractile dysfunction using an AI-enabled electrocardiogram. Nat Med. 2019 Jan;25(1):70-74.
https://www.dreamstime.com/doctor-holding-urine-sample-acr-albumin-creatinine-ratio-diagnosis-renal-kidney-disease-image274639370

Background

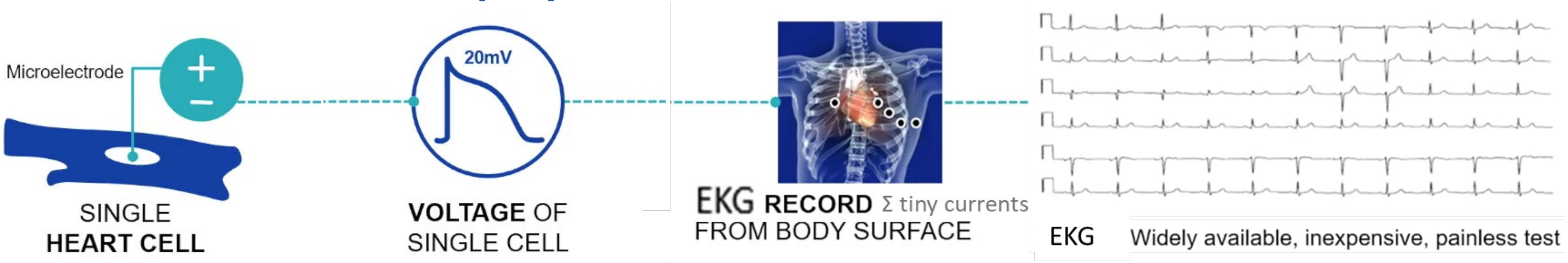
Course of a Disease

Silent LV dysfunction

6.5xrisk clinical CHF, 1.6xrisk death



From Action Potential (AP) to EKG … to all functions



The EKG - cumulative recording at a distance (the body surface) of the AP of millions of individual cardiomyocytes

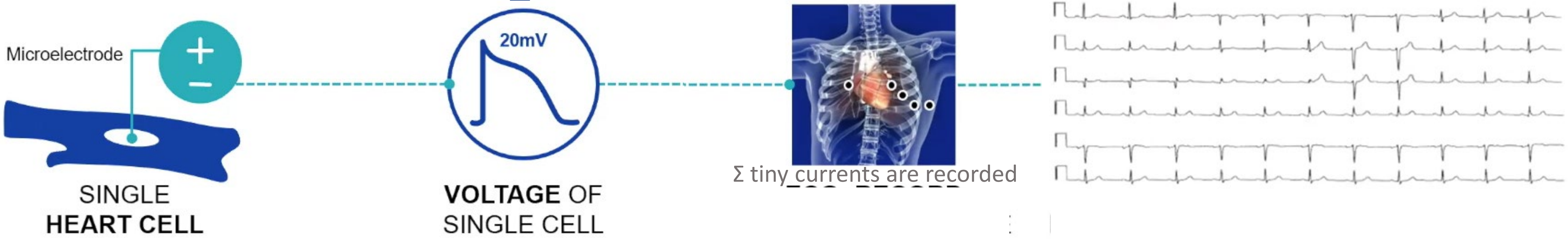
Application of artificial intelligence to the electrocardiogram, European Heart Journal (2021) 42, 4717–4730
Attia ZI. Screening for cardiac contractile dysfunction using an AI-enabled electrocardiogram. Nat Med. 2019 Jan;25(1):70-74.

Background

Silent LV dysfunction

CURRENTS AND THEIR PROPAGATIONS ARE SENSITIVE TO CONDITIONS AND CHANGES

Disease process will initially will affect the voltage (in time) before it manifests other ways



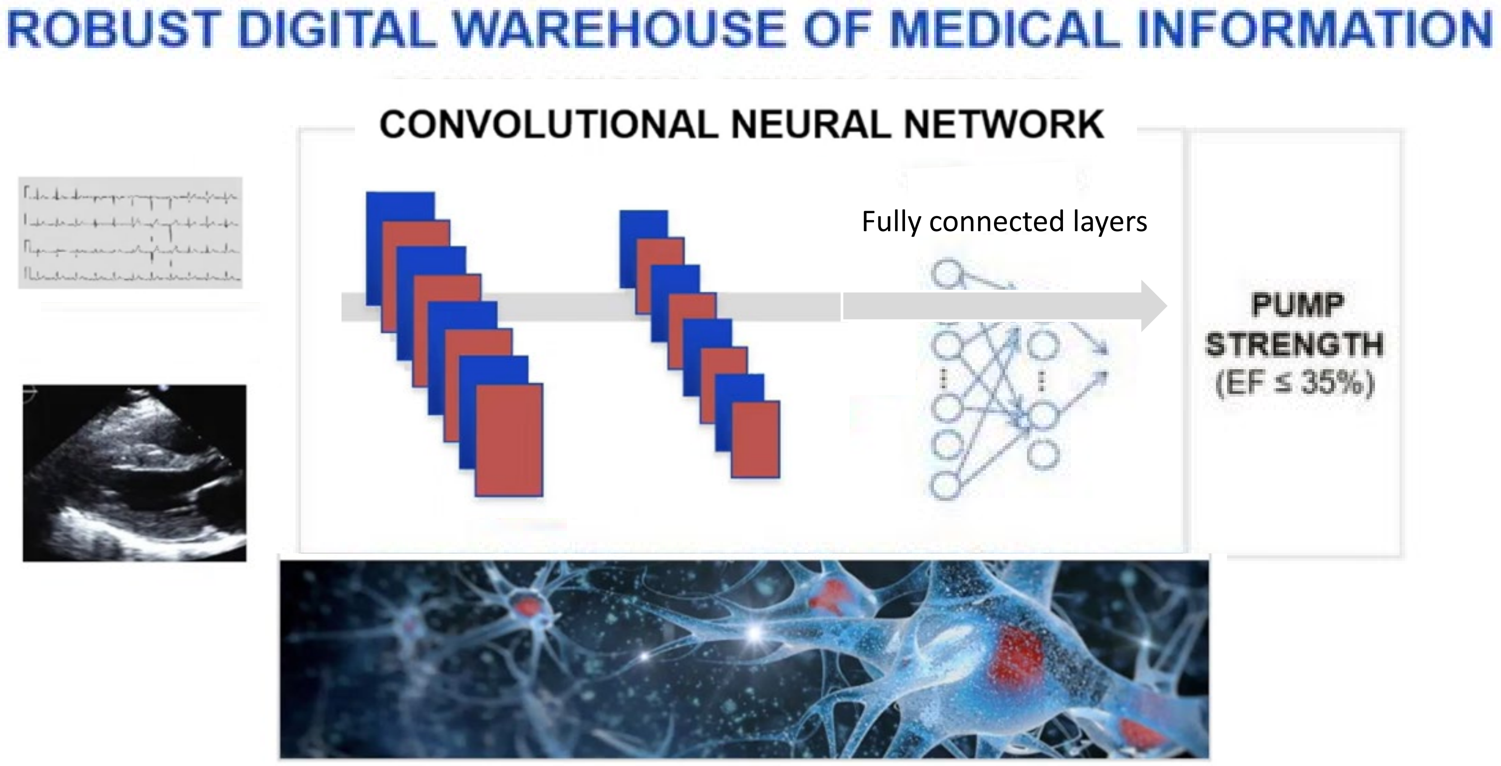
Σ tiny currents are recorded

Application of artificial intelligence to the electrocardiogram, European Heart Journal (2021) 42, 4717–4730

Attia ZI. Screening for cardiac contractile dysfunction using an AI-enabled electrocardiogram. Nat Med. 2019 Jan;25(1):70-74.
Wearables, telemedicine and AI in arrhythmias (escardio.org)

HYPOTHESIS TESTING

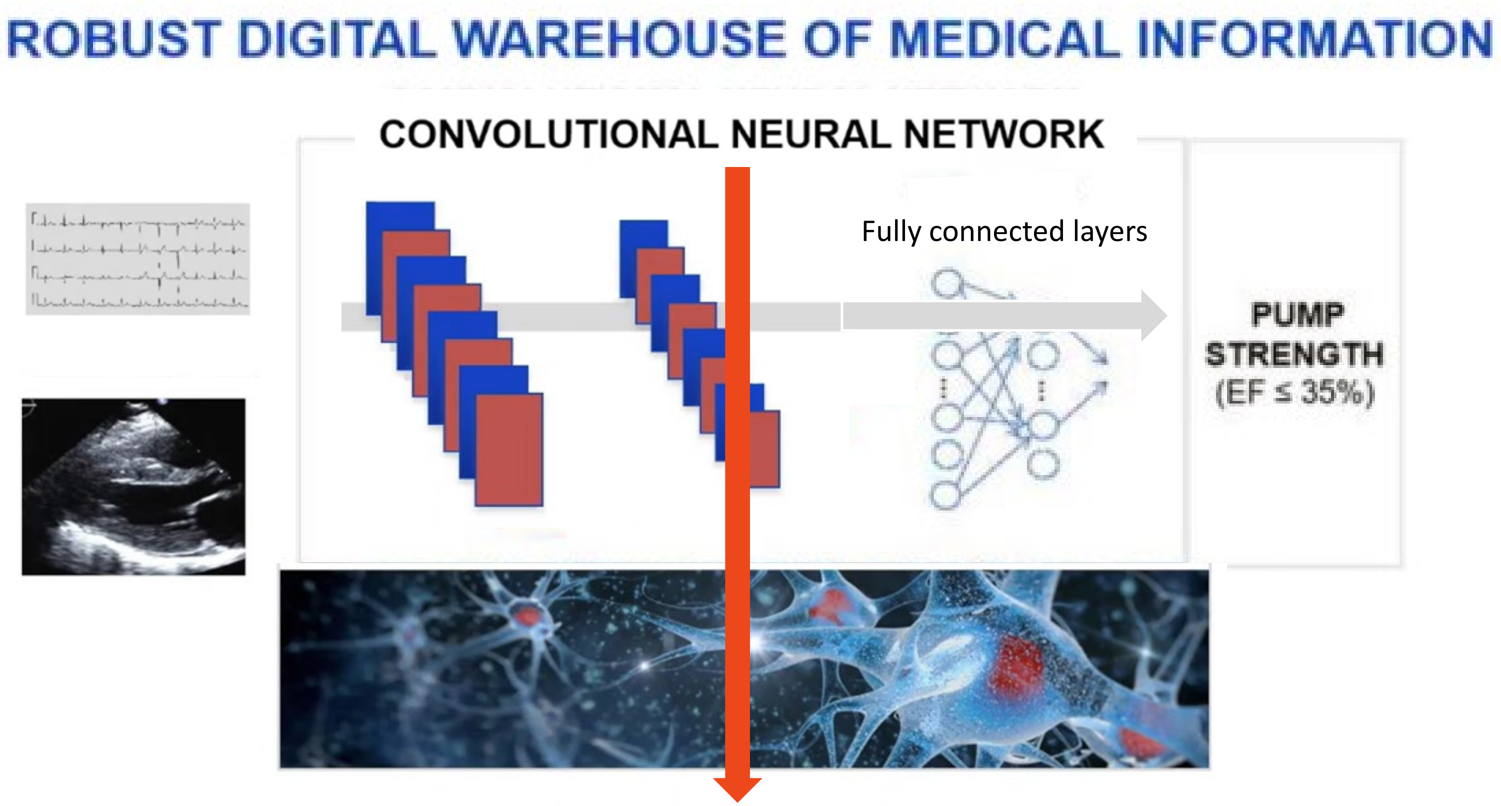
Engineered and trained a network to recognize LVSD (DL)



AI-EKG for enhanced diagnosis and prognosis - Deep Learning

Application of artificial intelligence to the electrocardiogram, EHJ (2021doi:10.1093/eurheartj/ehab649

HYPOTHESIS TESTING



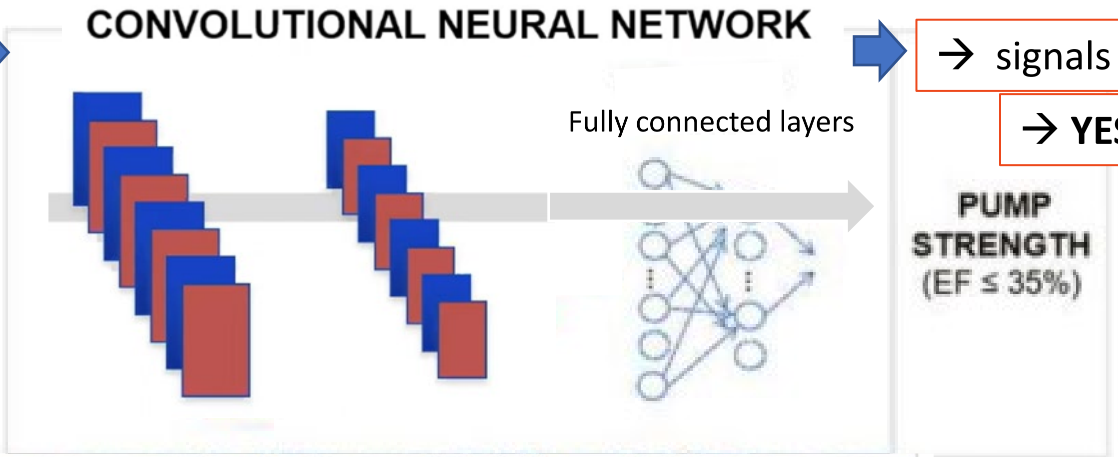
→ to mimic/model human cortex
→ each neuron is a mathematical formula
→ Neurons are connected & Many layers-"deep"

Application of artificial intelligence to the electrocardiogram, EHJ (2021doi:10.1093/eurheartj/ehab649

HYPOTHESIS TESTING

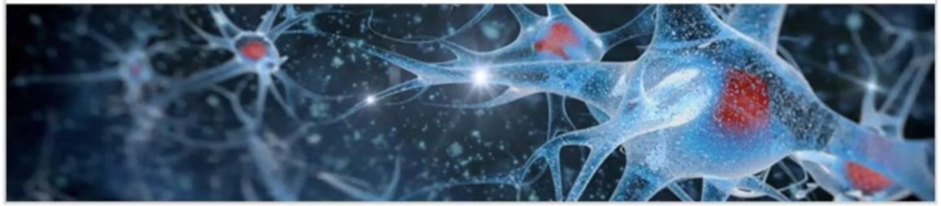
I want to know if this EKG is Low EF or Not

voltage time wavefront
12-lead EKG
Repeat 54000x



→ signals correlates with Low EF

→ **YES / NO**



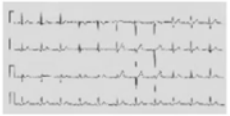
Large digital warehouse (600k pts- -<u>98K paired EKG with echo</u>) → 54k system **<u>training</u>**

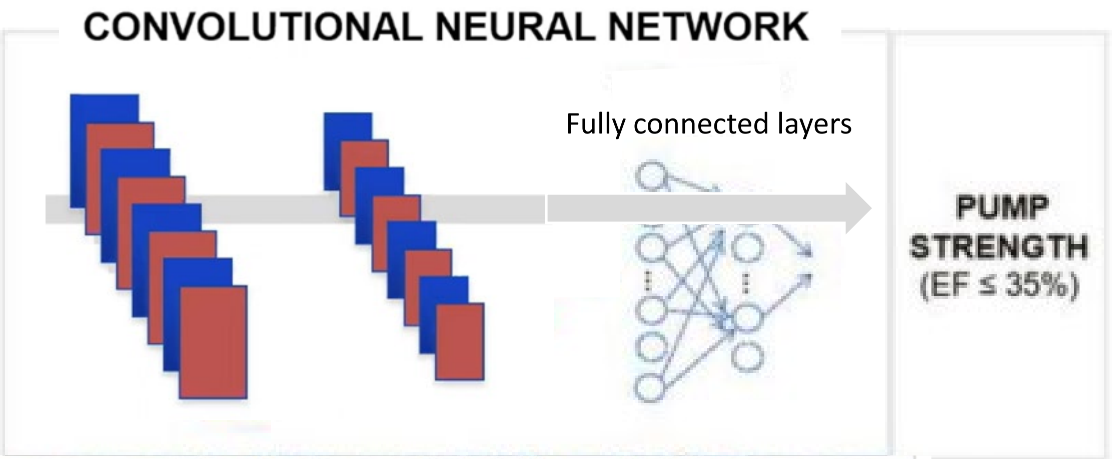
Application of artificial intelligence to the electrocardiogram, EHJ (2021doi:10.1093/eurheartj/ehab649

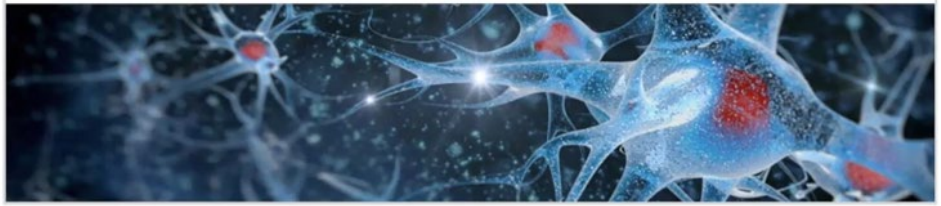
HYPOTHESIS TESTING

DNN Trained (optimized) → **Tested** → Validated

- → **Training n= 36 000**
- → Testing ~9000
- → Validation: ~53 000







Training: ← robust, large datasets, massive computer power

Once trained, it can be run on 12-lead, single lead

Application of artificial intelligence to the electrocardiogram, EHJ (2021doi:10.1093/eurheartj/ehab649

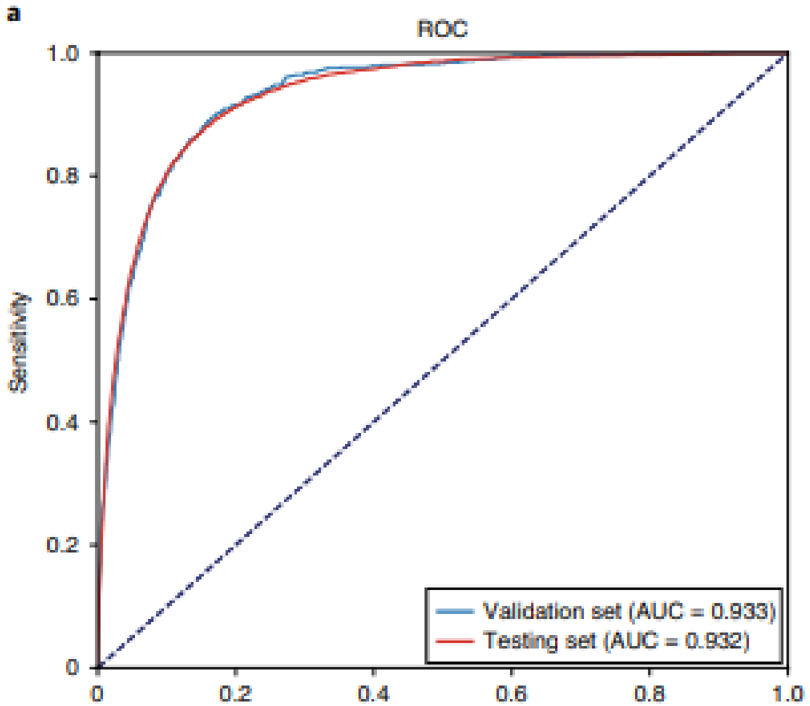
TESTING ← EKGs unknown to the network

Screening for cardiac contractile dysfunction using an AI–EKG

TEST PERFORMANCE

RECEIVER OPERATING CHARACTERISTICS

SENSITIVITY



1 – SPECIFICITY

1-Specificity Probability that a true negative will test positive. = FP

AREA UNDER THE CURVE OF EF

AUC – 0.93

PERFECT – 1.0

BNP and NT-proBNP -

To screen for systolic & diastolic dysfunction

NT-proBNP AUC 0.7-0.8

Treadmill test = 0.85

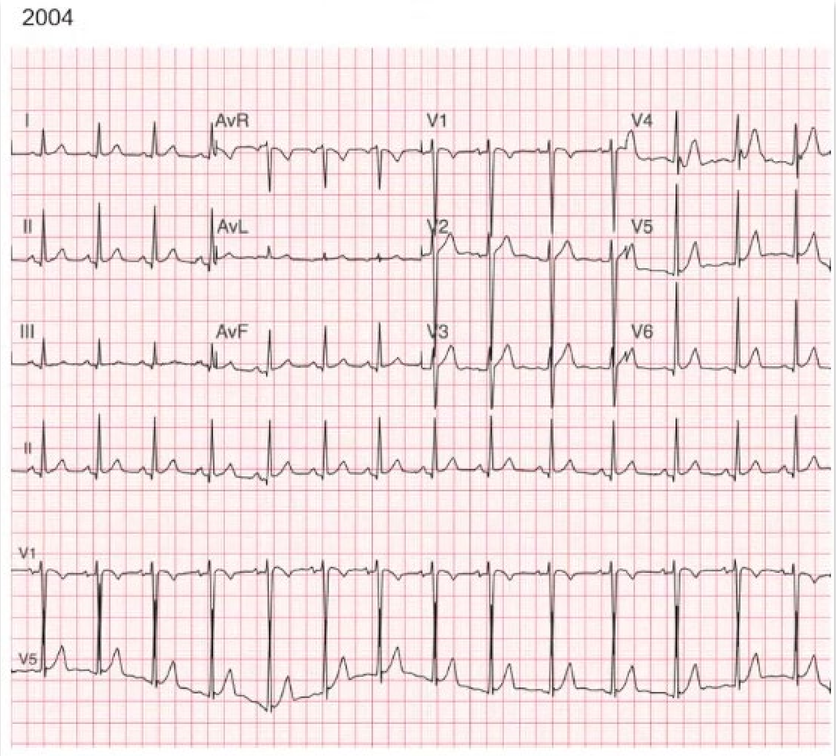
PAP Smear = 0.7

Mammogram = 0.85

Attia ZI. Screening for cardiac contractile dysfunction using an ai-enabled electrocardiogram. Nat Med. 2019 Jan;25(1):70-74.

False positive for Low EF - EXAMPLE

AI EKG: positive for Low EF

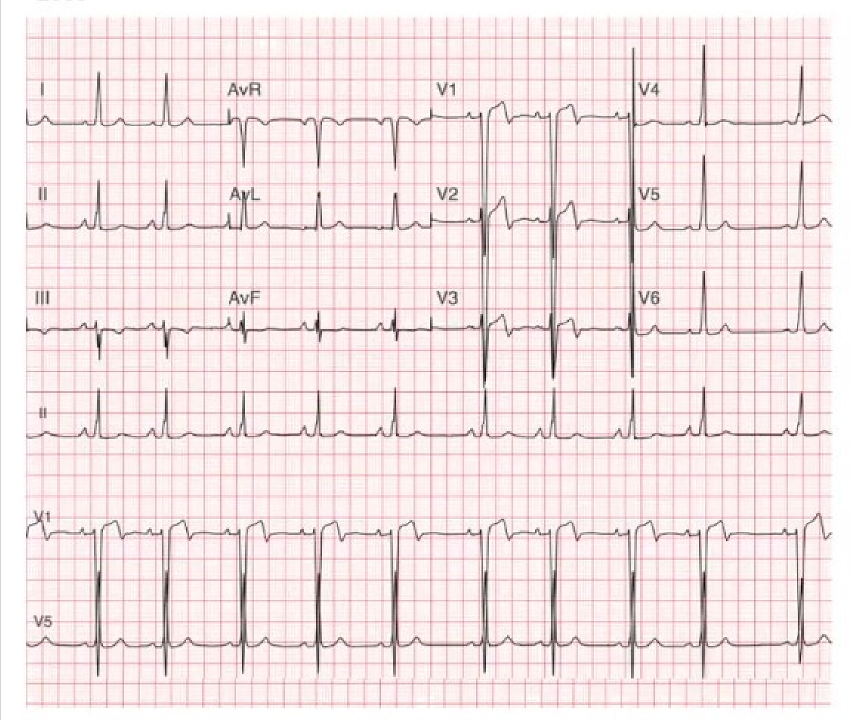


Echo EF: 50%

False Positive

AI EKG: positive for Low EF

5 years later at age 33

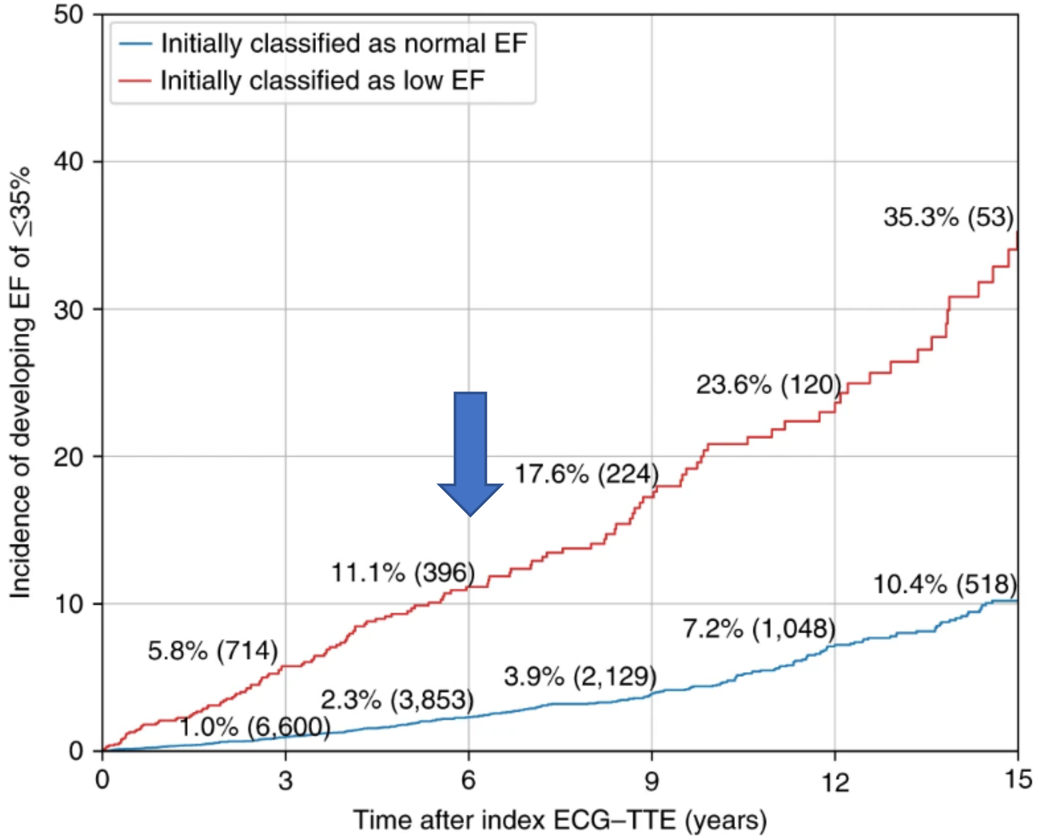


Echo EF: 31%

Application of artificial intelligence to the electrocardiogram, European Heart Journal (2021) 42, 4717–4730 STATE OF THE ART REVIEW doi:10.1093/eurheartj/ehab649

LONG-TERM OUTCOME WITH A 'FALSE POSITIVE' - LOW EF AI- EKG

Long-term outcome of patients with an ECHO EF of ≥50% at the time of initial classification Low-EF on AI-EKG



INCIDENCE OF DEVELOPING LOW EF

OVER 6 YEAR – ~5X RISK

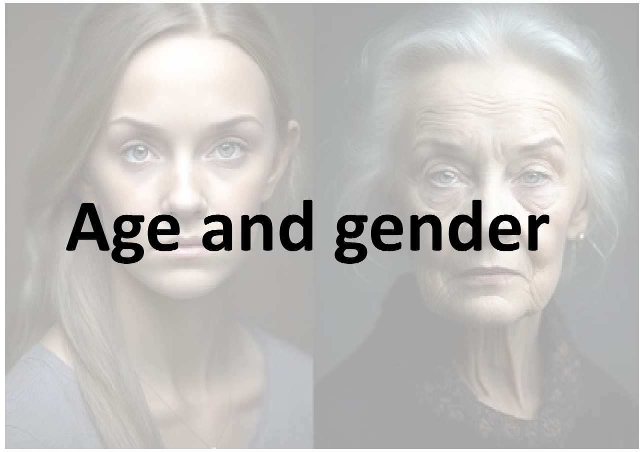
PREDICT THE DISEASE - before it becomes manifest

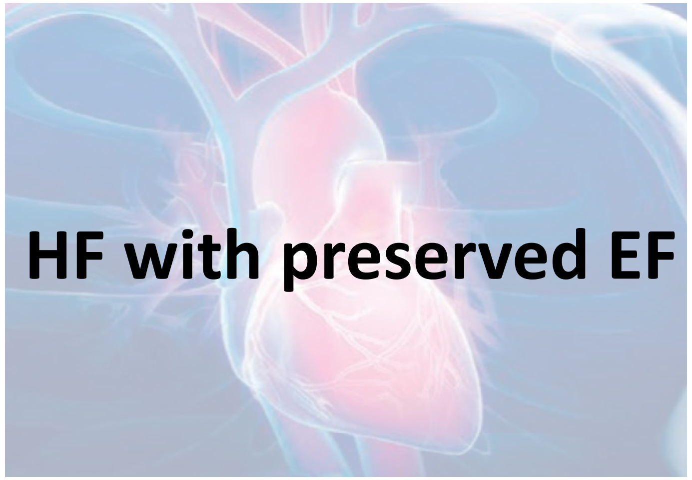
→ Select pts to Arrange Imaging Follow up in high risk groups

AI disease 'previvor'

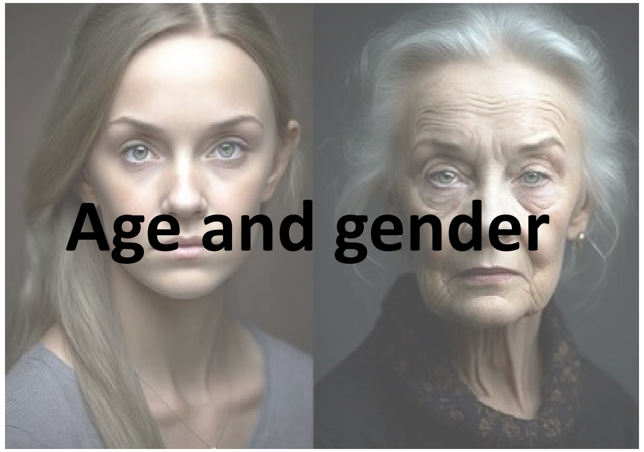
Attia ZI. Screening for cardiac contractile dysfunction using an ai-enabled electrocardiogram. Nat Med. 2019 Jan;25(1):70-74.

DETOUR - Major ‘linked’ developments

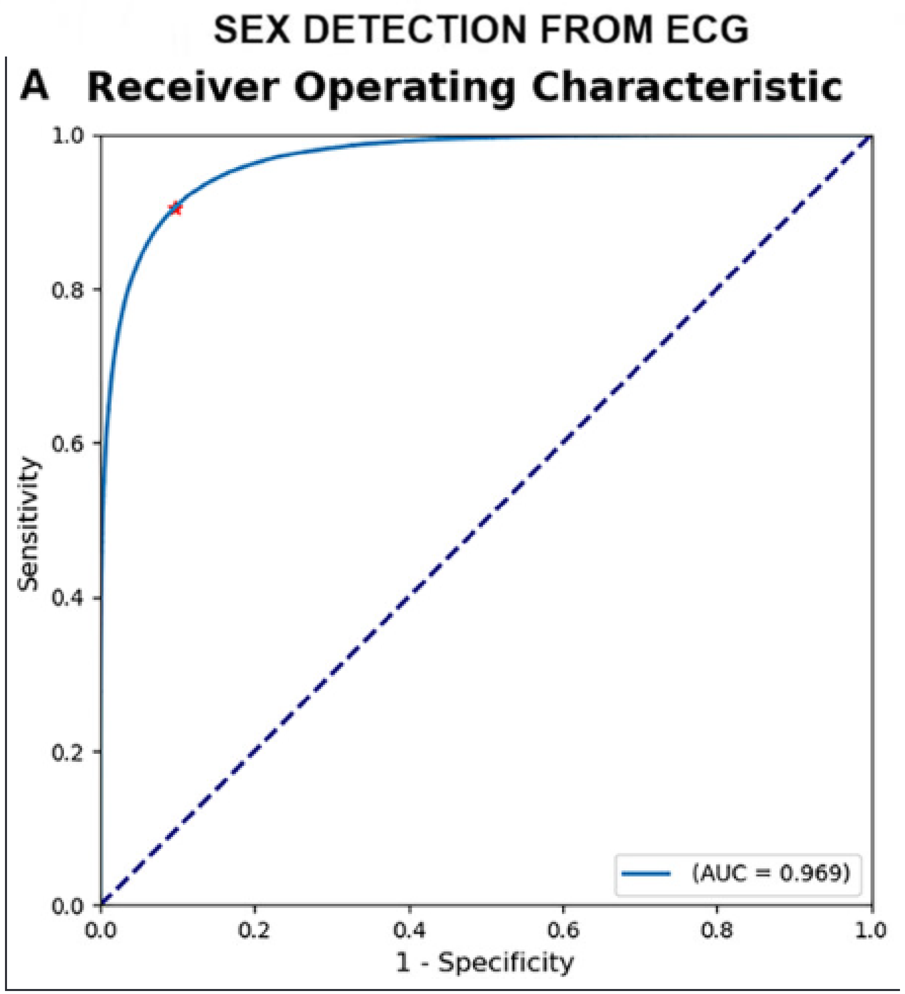




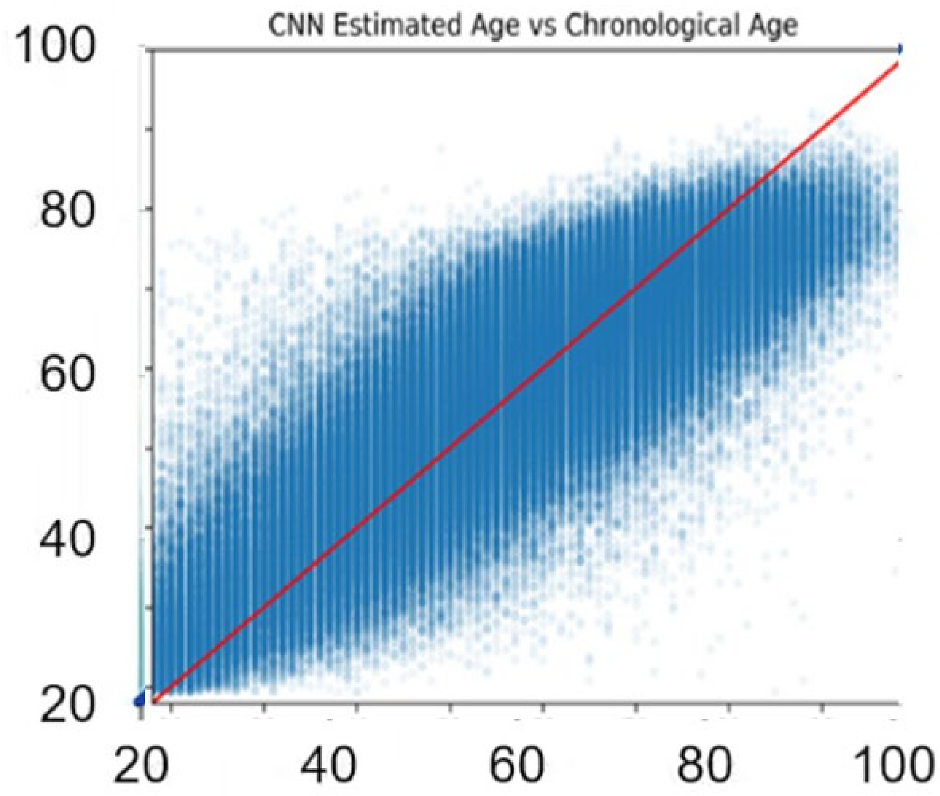
DETOUR - Major ‘linked’ developments



GENDER AND AGE FROM AI-EKG

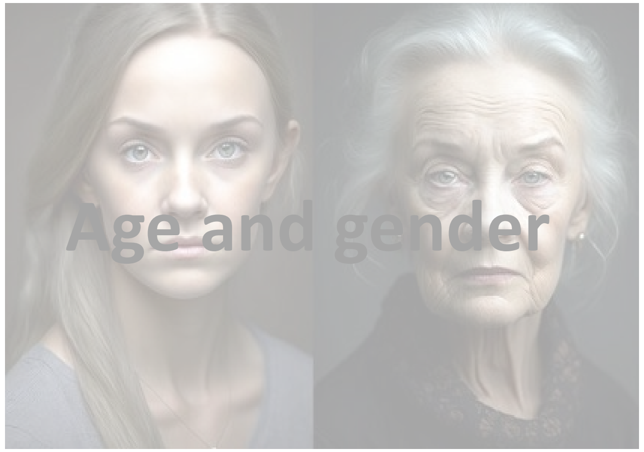


(CNN)-predicted age
vs reported age.



https://www.ahajournals.org/doi/epub/10.1161/CIRCEP.119.007284

DETOUR - Major 'linked' developments



CLINICAL UTILITY?

Consumer-grade wearable EKG

AI-EKG on APPLE WATCH – SINGLE LEAD LV SYSYTOLIC DYSFUNCTION

Can a Watch Detect LV SYSYTOLIC DYSFUNCTION? Mayo Apple WATCH study

nature medicine

Article https://doi.org/10.1038/s41591-022-02053-1

Prospective evaluation of s… enabled detection of left ve… dysfunction

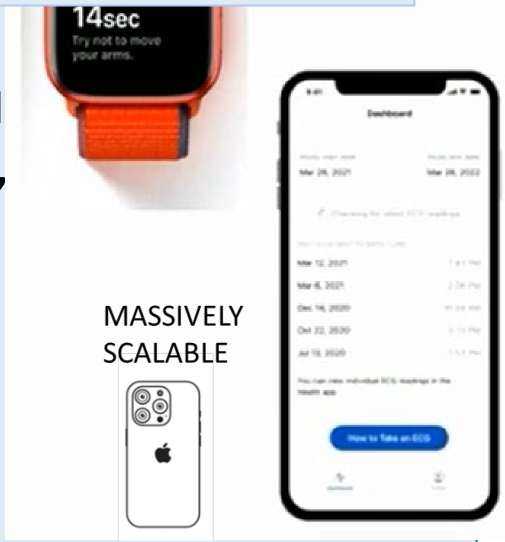
Powerful test result – AUC 0.88

(vs AUC .93 on 12-lead)

Non-clinical environment! 12→ 1 lead

Major messages:

- 12-lead model can be modified and extrapolated to singl…
- Potential to diagnose disease from 'anywhere': 'unform'…
  - Massive scalable tech for screening, dx, monitoring
  - New dimensions of Trials



MASSIVELY SCALABLE

Artificial intelligence

Smartwatch detection of l… ventricular dysfunction

Artificial intelligence (AI) algorithms applied to electrocardiograms (ECGs) recorded by smartwatches can identify individuals with left ventricular dysfunction, according to a study published in *Nature Medicine*. "There is a huge need for

npj | digital medicine www.nature.com/npjdigitalmed

Yale University

ARTICLE OPEN

Detection of left ventricular systolic dysfunction from single-lead electrocardiography adapted for portable and wearable devices

Akshay Khunte[1], Veer Sangha[1], Evangelos K. Oikonomou[2], Lovedeep S. Dhingra[2], Arya Aminorroaya[2], Bobak J. Mortazavi[3,4], Andreas Coppi[4,5], Cynthia A. Brandt[6,7], Harlan M. Krumholz[2,4,8] and Rohan Khera[2,4,6,9]

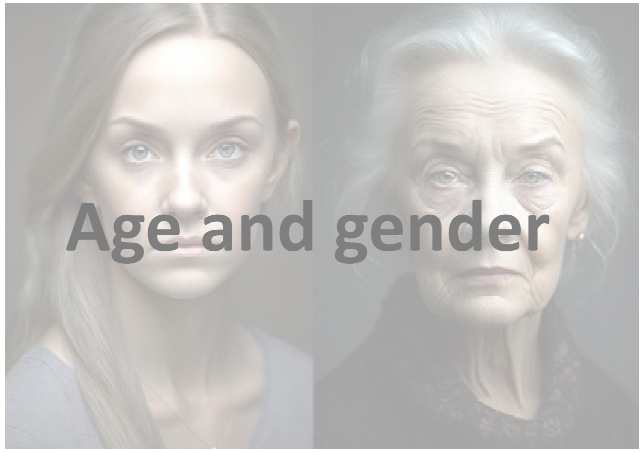
…from consumer watch ECG recordings

Nat. Med. 2022
doi.org/10.1038/s41591-022-02053-1

Heart Rhythm Society

New App for Apple Watch Uses Artificial Intelligence to Detect Left-Ventricular Dysfunction

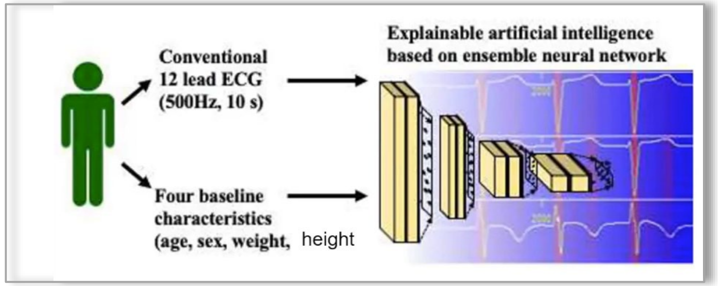
Major ‘linked’ developments



AI-EKG for HFpEF ✓

Artificial intelligence assessment for early detection of heart failure with preserved ejection fraction based on electrocardiographic features

Joon-myoung Kwon[1,2,3,4], Kyung-Hee Kim[2,5]*, Howard J. Eisen[6], Younghoon Cho[4], Ki-Hyun Jeon[2,5], Soo Youn Lee[2,5], Jinsik Park[5], and Byung-Hee Oh[5]



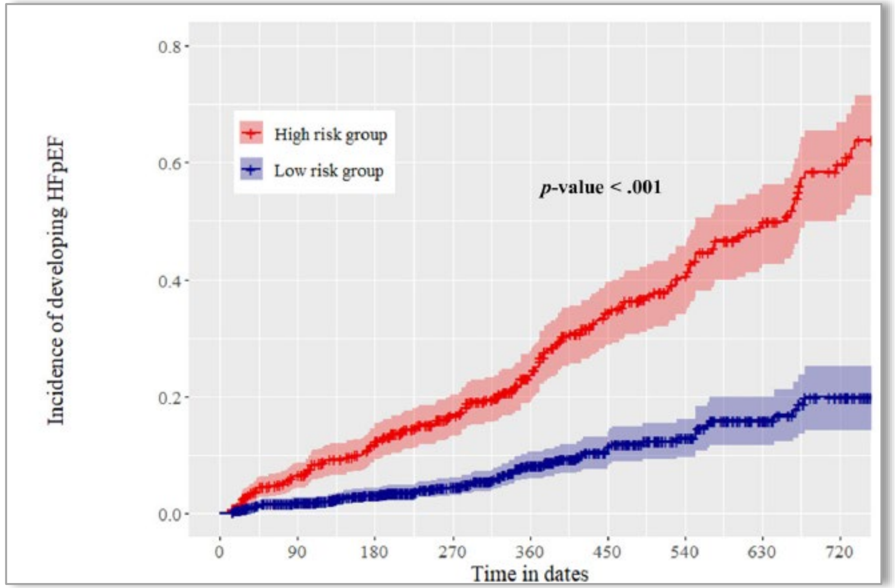
Sample 1: 32 671 ECGs of 20 169 patients (4048 with HFpEF) in Hospital 1
Sample 2: 11 955 ECGs of 11 955 patients (1708 with HFpEF) in Hospital 2

AI ECG Diastolic Dysfunction Predicts Survival – Even When Echocardiographic Grade is the Same

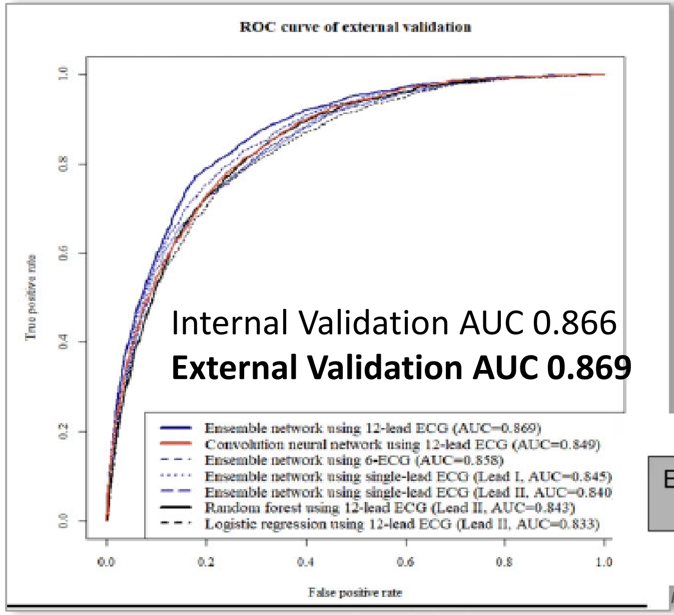
MAYO CLINIC

Eunjun Lee et al ACC 2023

HFpEF development prediction



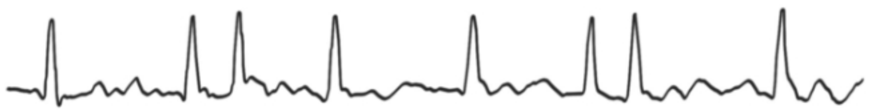
HFpEF detection among pts with normal LVSF



External validated DLM:
PPV 42% NPV 96%

rt J Digit Health, https://doi.org/10.1093/ehjdh/ztaa015

Atrial Fibrillation



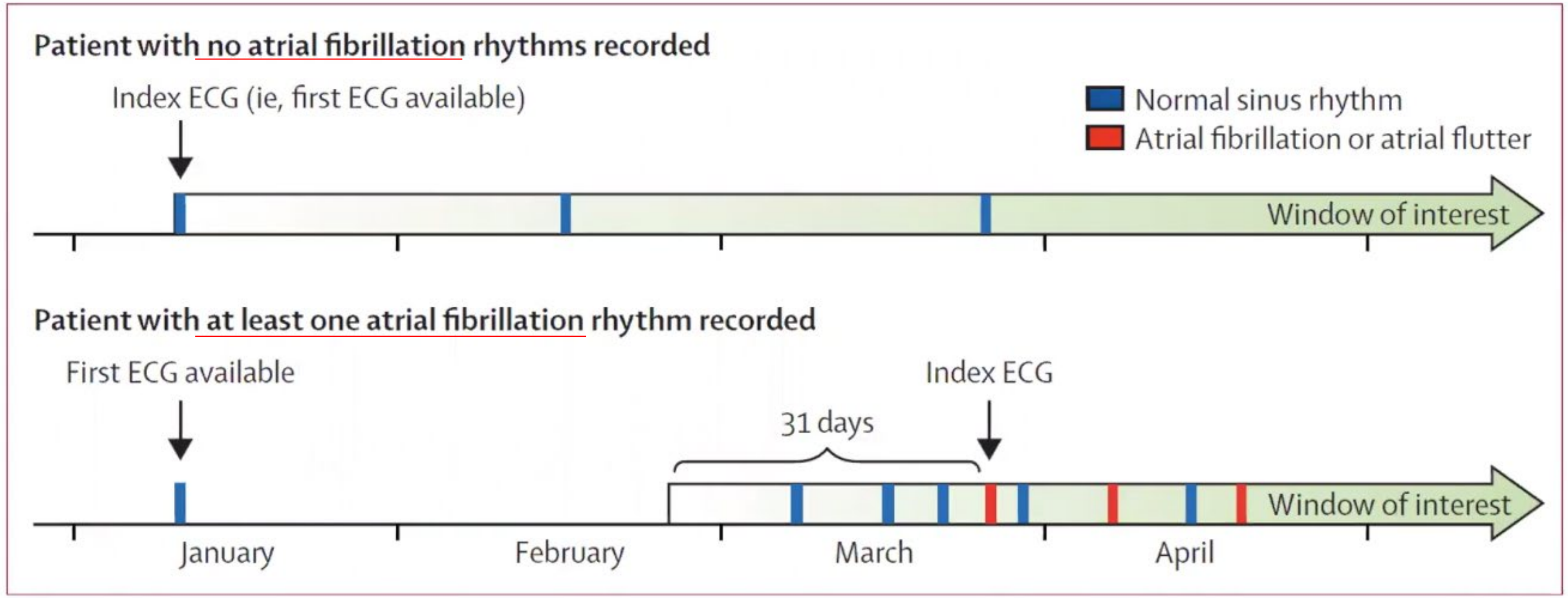
Can AI Identify if SILENT AF IS PRESENT?

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

ATRIAL FIBRILLATION RISK **CNN →** to assess presence of silent AF during NSR

NETWORK only given NSR EKG, from 2 POPULATIONS: **AF and No AF**

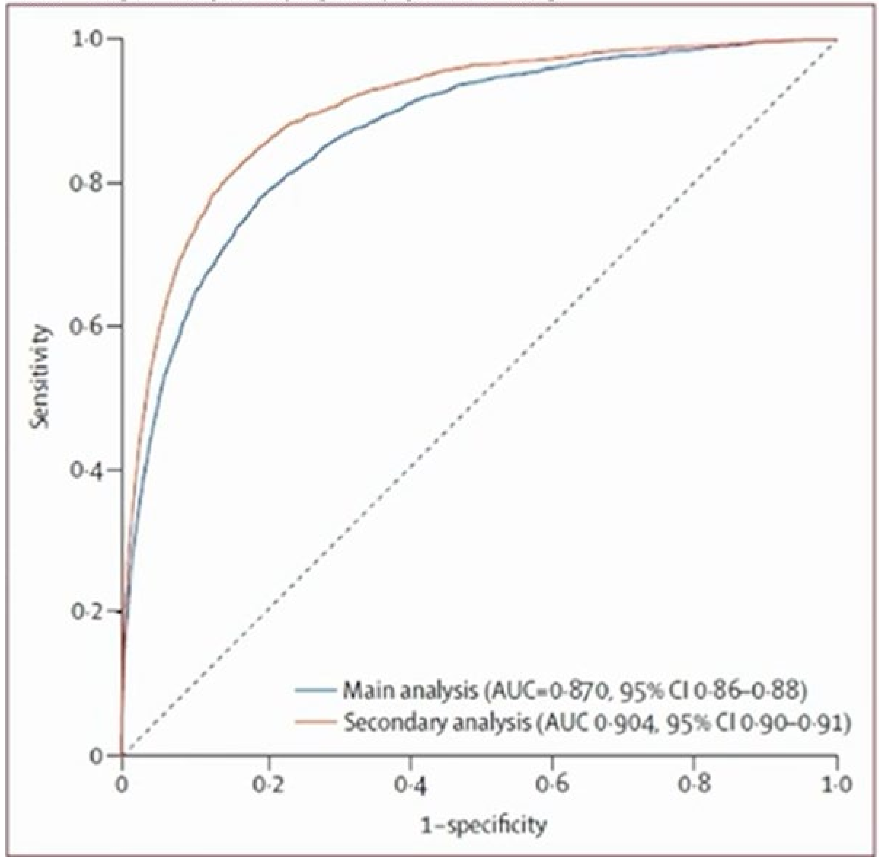


- **AI-EKG acquired during NSR permits identification of individuals with AF**
- **AI-EKG is strongly predictive of concurrent AF within 30 days of EKG during SR**
- **High degree of accuracy**

Attia Z.I et al. Lancet 2019; 394: 861–67

ATRIAL FIBRILLATION RISK: from an EKG recorded during Normal Sinus Rhythm → 'AF IS PRESENT ANOTHER TIMES'

AF risk from a Sinus rh EKG



AREA UNDER THE CURVE OF AF

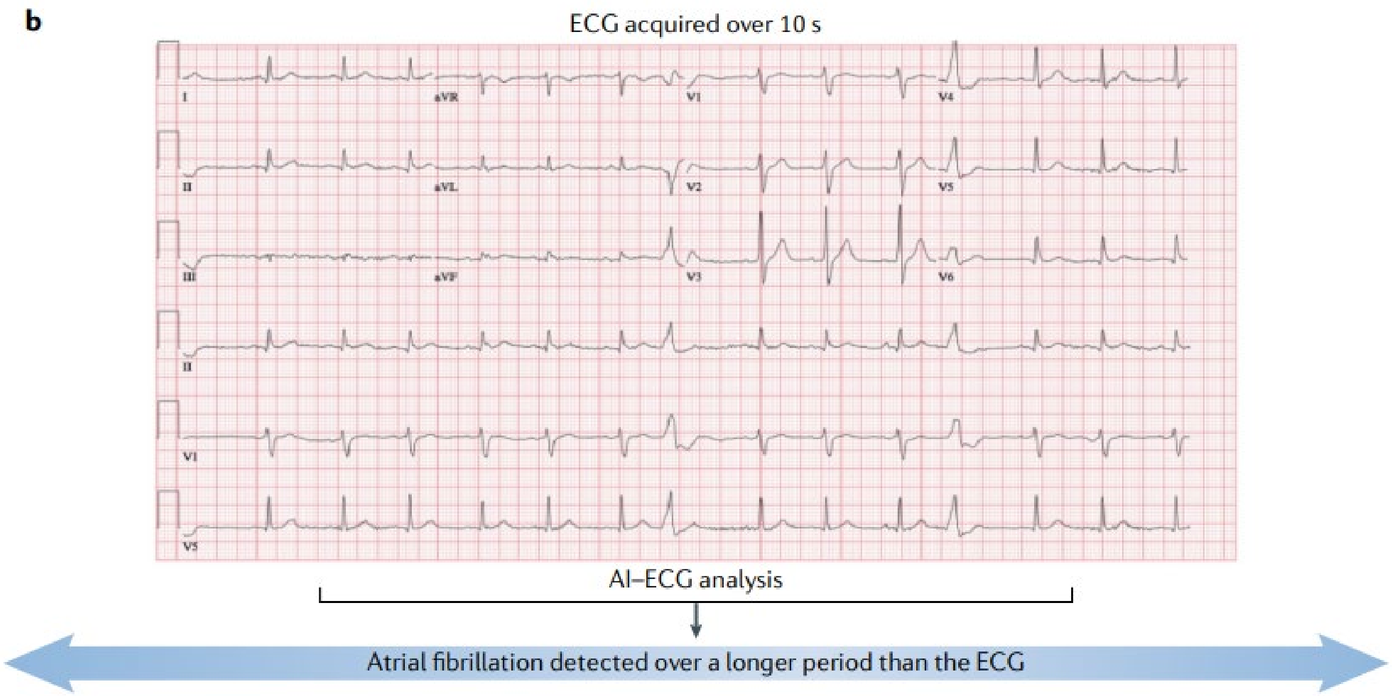
AUC – 0.90
PERFECT – 1.0

- **AI-EKG is strongly predictive of concurrent AF within 30 days of EKG during SR**

Attia Z.I et al. Lancet 2019; 394: 861–67

AI EKG – SINUS RHYTHM but AF IS PRESENT ANOTHER TIMES

AI converts a 10sec EKG into an 'extended' monitor to screen for <u>SILENT AF</u>



Screening
Diagnosing
Monitoring

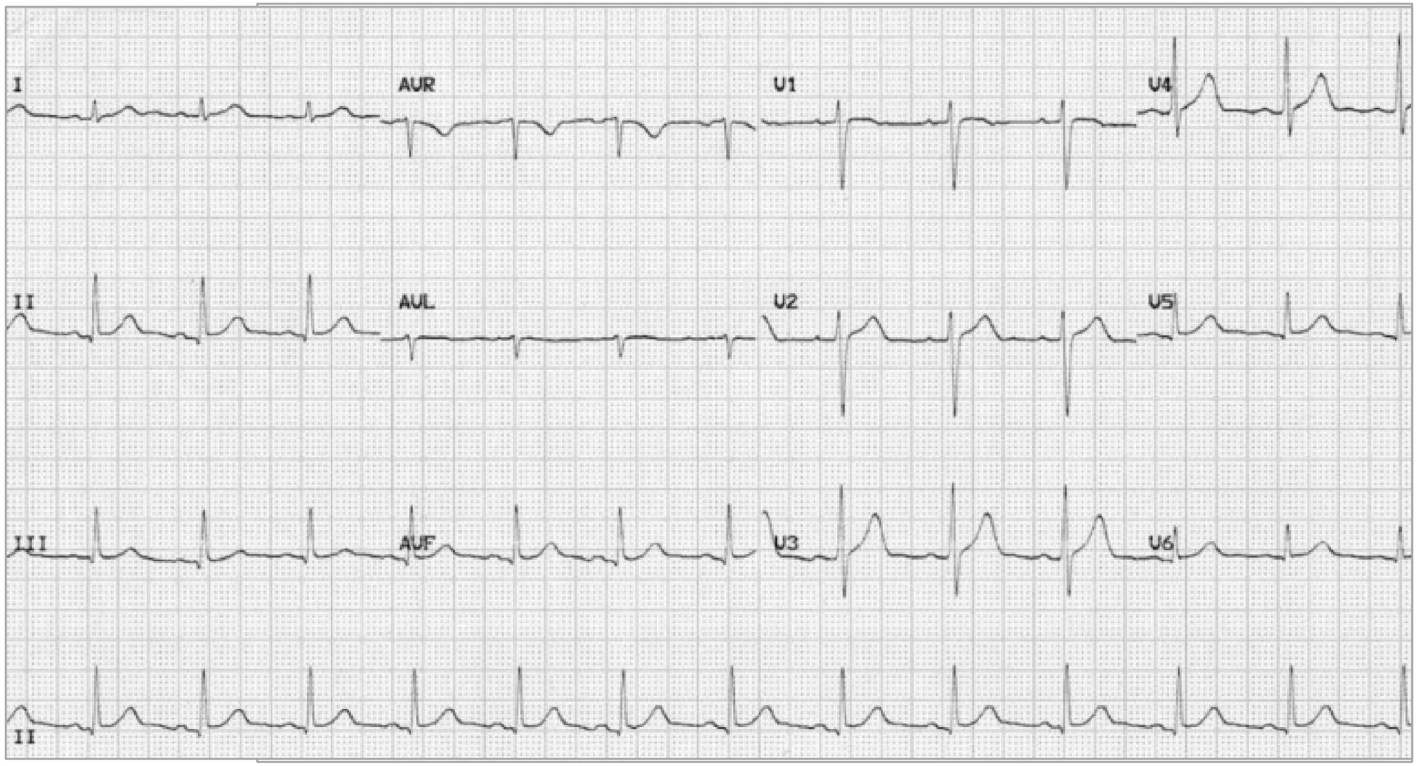
SILENT AF DETECTION in SR

Stored EKG can be used as a "Holter" monitor

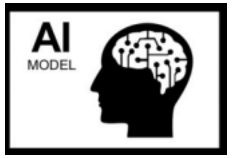
The AI-EKG AF probability progressively increases with time prior to the first AF episode

Nat Rev Cardiol. 2021 Jul;18(7):465-478. doi: 10.1038/s41569-020-00503-2

Case - 68Y M Retired MD, Hx T2DM, CKD



AI reading



Probability of AF 90%

Holter:
AF dx within 1 week

OAC

Future: Stroke prevention?

→ Prospective trial designed to **detect silent AF – high risk pts are in focus**

Lancet 2022; 400: 1206–12
Nat Rev Cardiol. 2021 Jul;18(7):465-478. doi: 10.1038/s41569-020-00503-2
THE Lancet Volume 400, Issue 10359, https://doi.org/10.1016/S0140-6736(22)01637-3

AI-guided screening was associated with increased detection of atrial fibrillation (high-risk group)

Case - 68Y M Retired MD, Hx T2DM, CKD

AI-EHR identification of high risk pts

AI-EKG **Silent AF?**
YES

→ Prospective trial designed to **detect silent AF – high risk pts are in focus**

→ **AI-guided targeted screening** approach (AI-EKG AF in SR? Y**+** → NLP OAC? Y**+** → 30d monitor)

Beagle study   Batch Enrollment of and AI-Guided Intervention to Lower Neurologic event with Undiagnosed AF

CLINICAL UTILITY

Retrospective - *AI-EKG* for Silent AF + Massive digital chart review
***Prospective* Remote digital monitor enrollment to confirm AF**

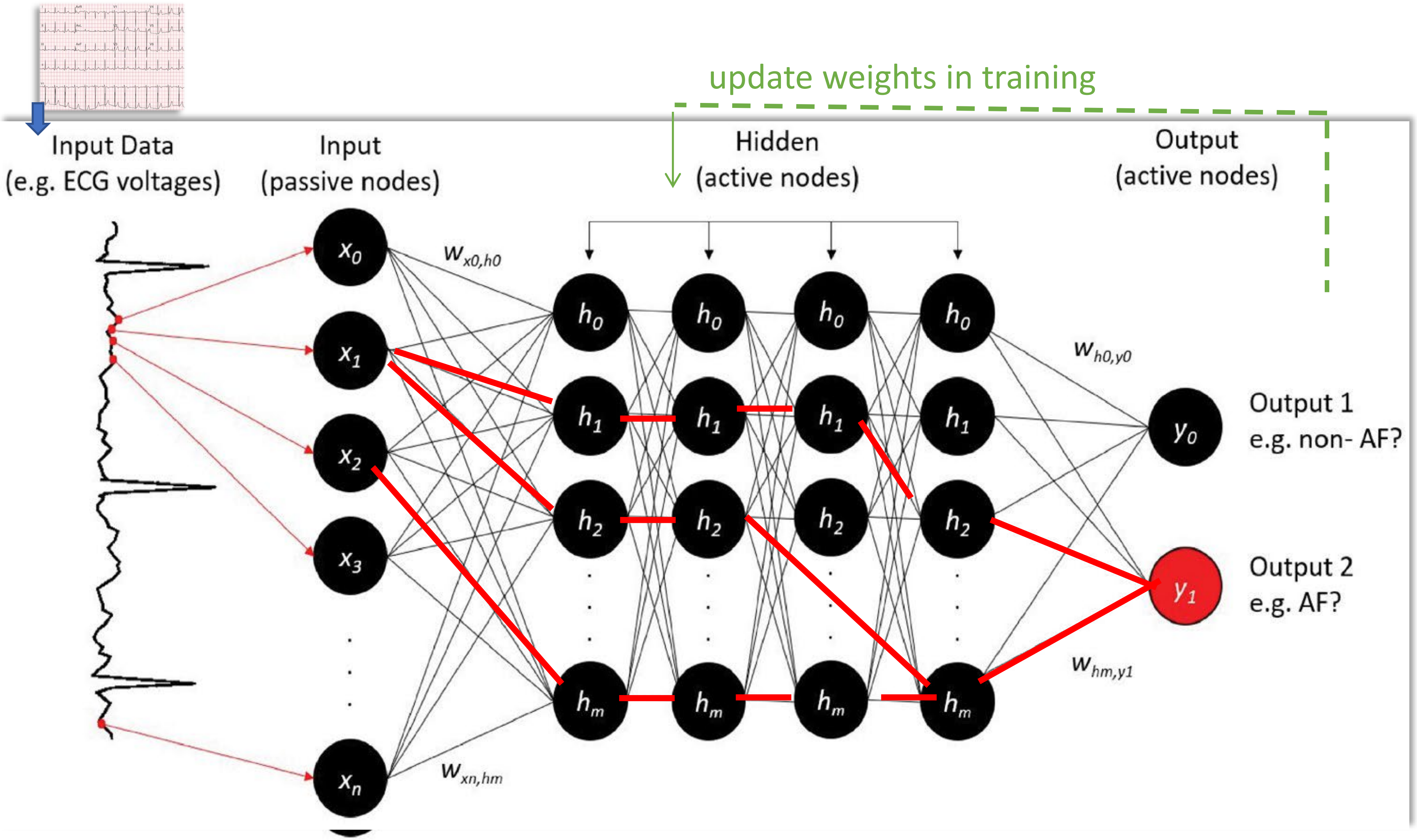
Arrhythmia & Electrophysiology Review 2023;12:e12
https://doi.org/10.1016/S0140-6736(22)01637-3
Lancet 2022; 400: 1206–12; escardio.org

…insight to CNN training

METHODOLOGY

Neural network design to classify 'AF' from the EKG

Continuous analog ekg voltage points are fed to 'input neurons



Supervised learning (i.e.CNN)

Training to diagnose a known endpoint

- Match input to known output labels (dx, rx)

y0; incorrect, no AF

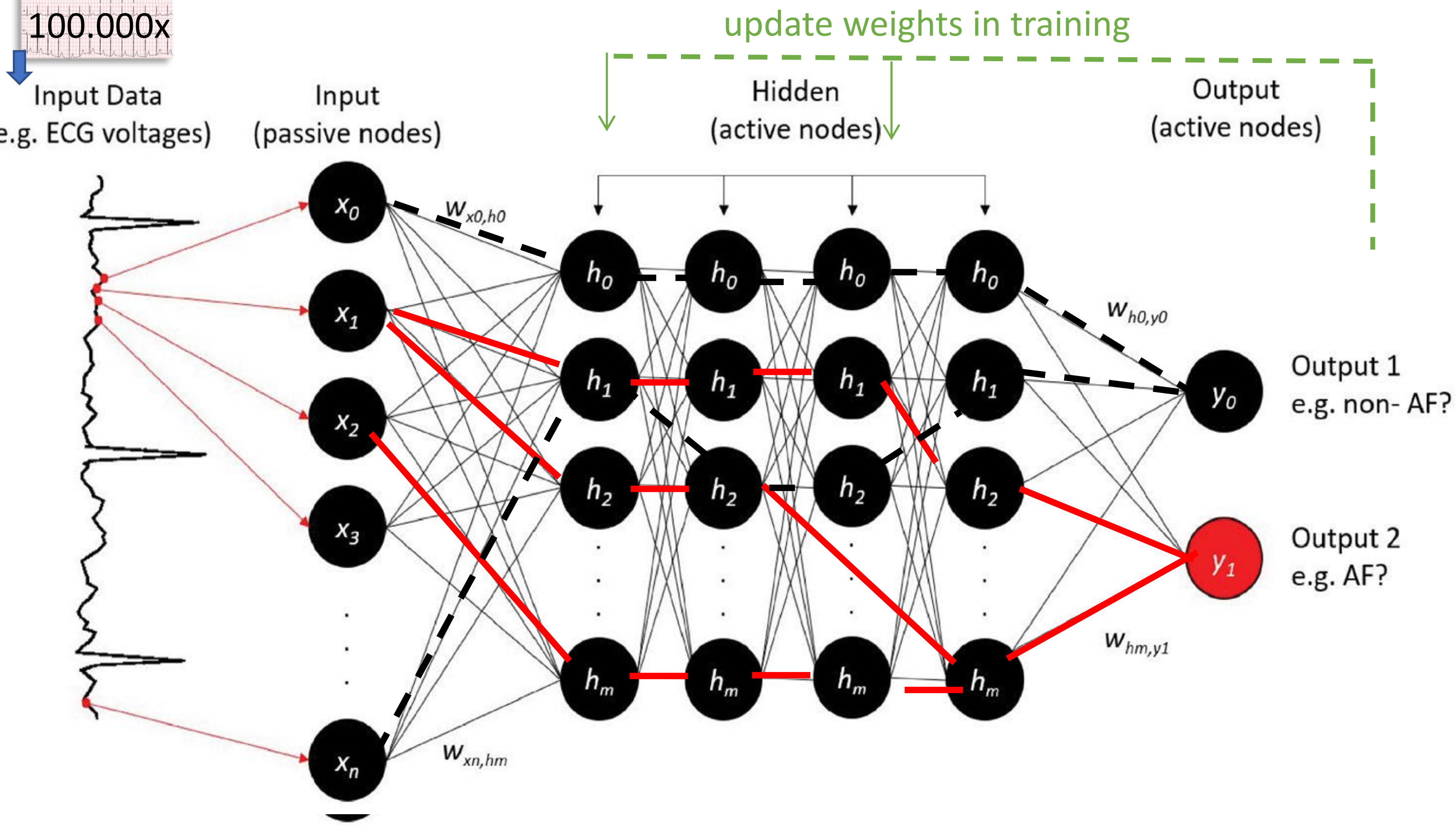
y1; correct AF

EHJ, https://doi.org/10.1093/eurheartj/ehz056

Neural network design to classify AF from the EKG

Repeat 100.000x

Continuous ekg voltage points are fed to 'input neurons



y0; incorrect, no AF

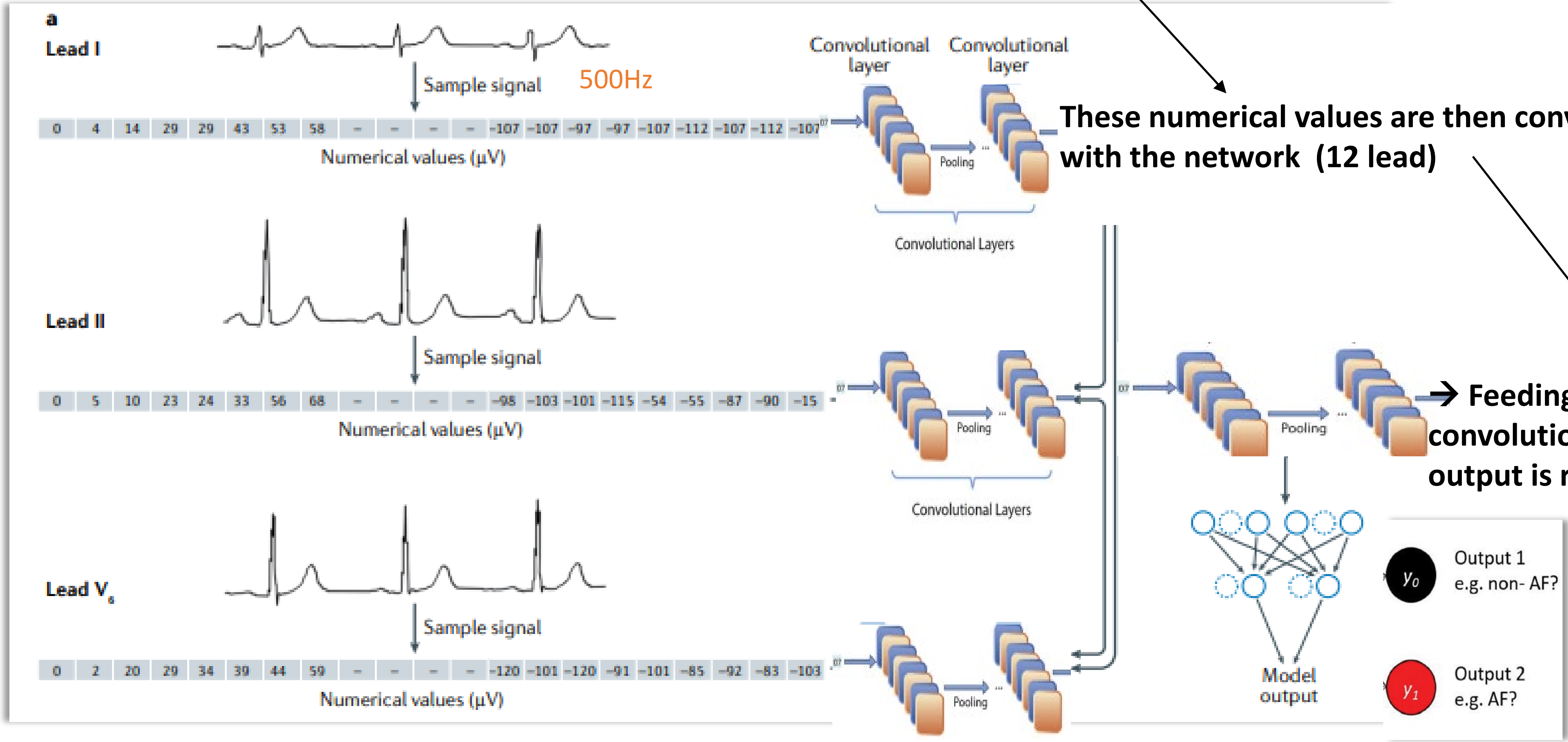
y1; correct AF

EHJ, https://doi.org/10.1093/eurheartj/ehz056

Development of a CNN using the 12-EKG and application to detect silent AF

The analogue EKG signal is converted to a digital recording → numerical values corresponding to the amplitude of the signal

These numerical values are then convolved with the network (12 lead)



→ Feeding sequential layers of convolutions until the final model output is reached

Nat Rev Cardiol. 2021 Jul;18(7):465-478. doi: 10.1038/s41569-020-00503-2

…CASES

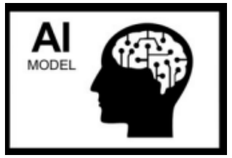
…Cases

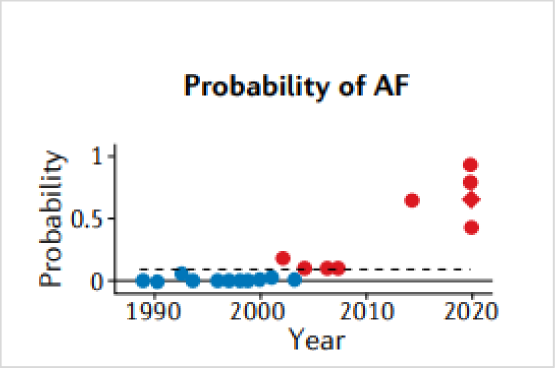
Artificial Intelligence-Enabled ECG to Identify Silent Atrial Fibrillation in Embolic Stroke of Unknown Source

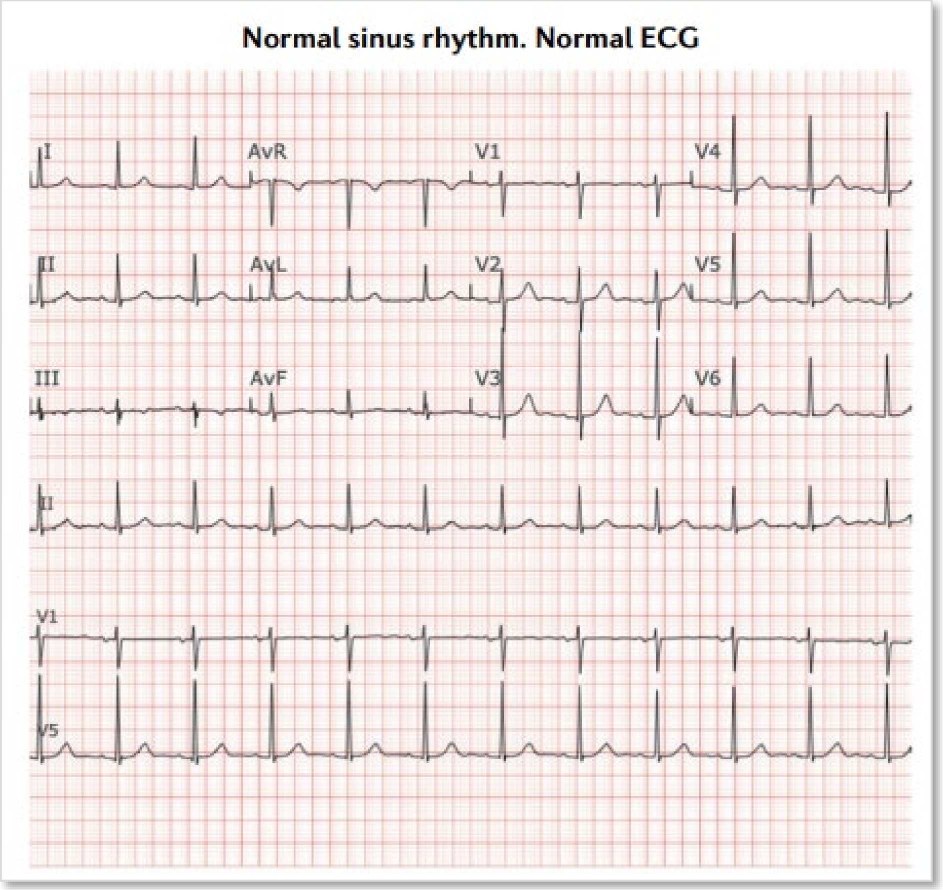
Positive - to predict Silent AF detection

Hx embolic stroke - undetermined source- ESUS

- increased probability of silent atrial fibrillation (red dots)
- predated the clinical documentation AF





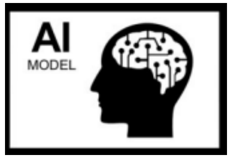


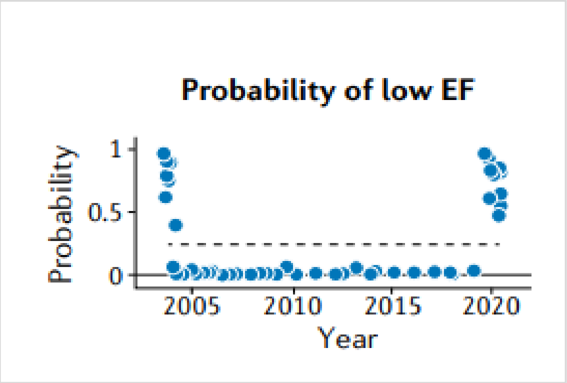
Nat Rev Cardiol. 2021 Jul;18(7):465-478. doi: 10.1038/s41569-020-00503-2

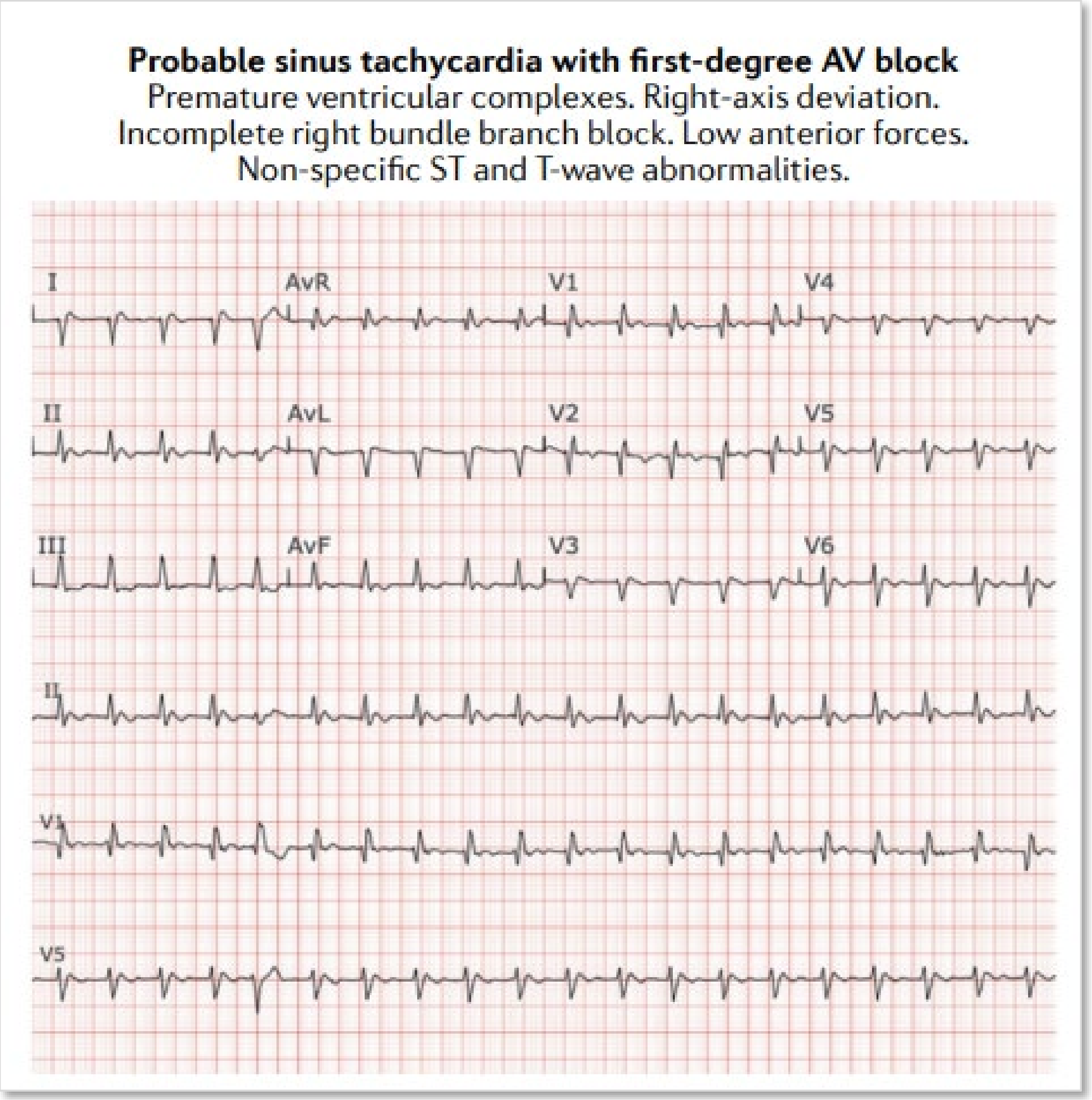
…Cases

Hx of heart transplantation in 2005 and graft rejection with LVSD in 2020.

AI–EKG reported
a high probability of low ejection fraction (EF) x2
correlating with the graft rejection

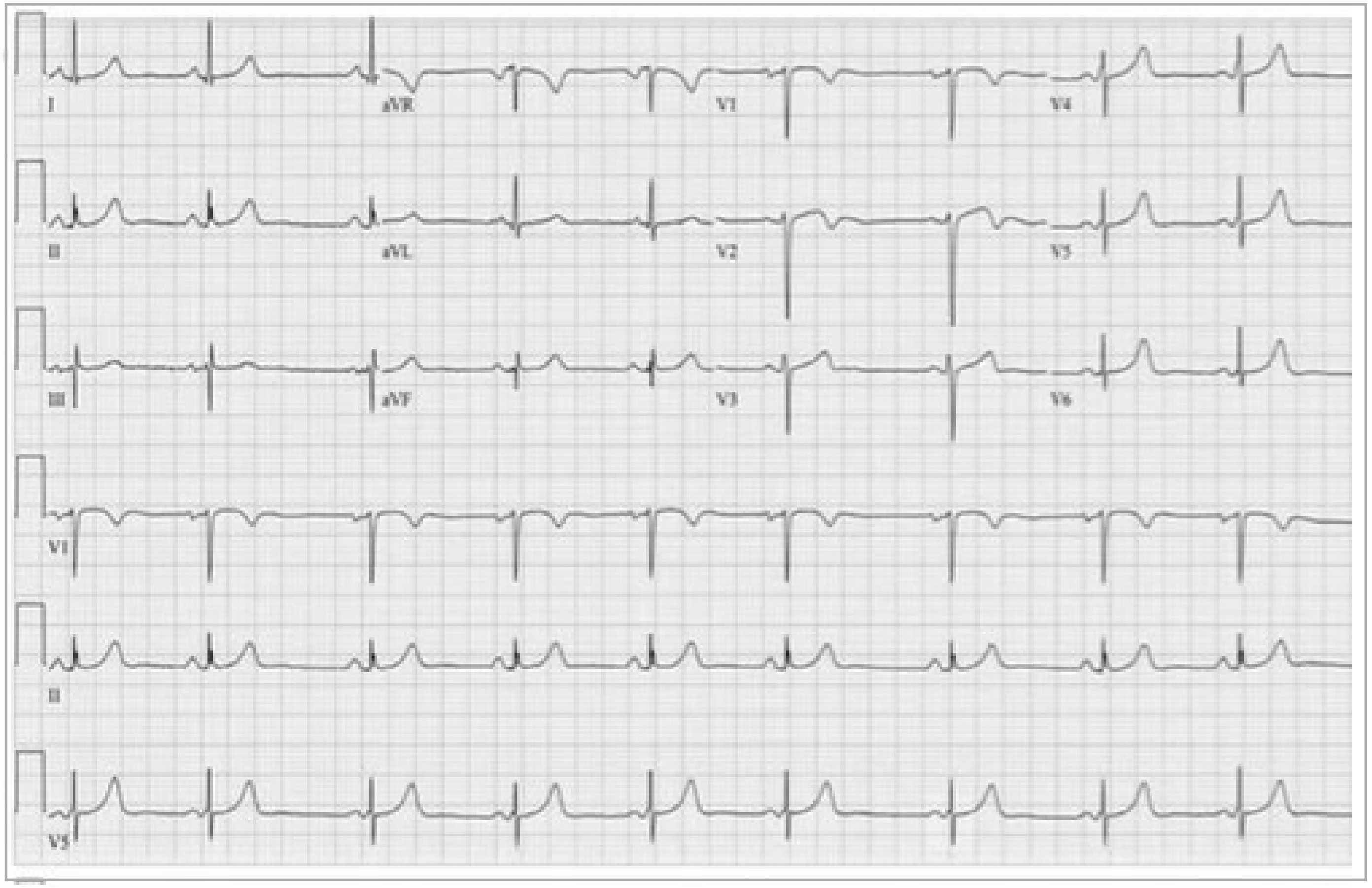






Nat Rev Cardiol. 2021 Jul;18(7):465-478. doi: 10.1038/s41569-020-00503-2

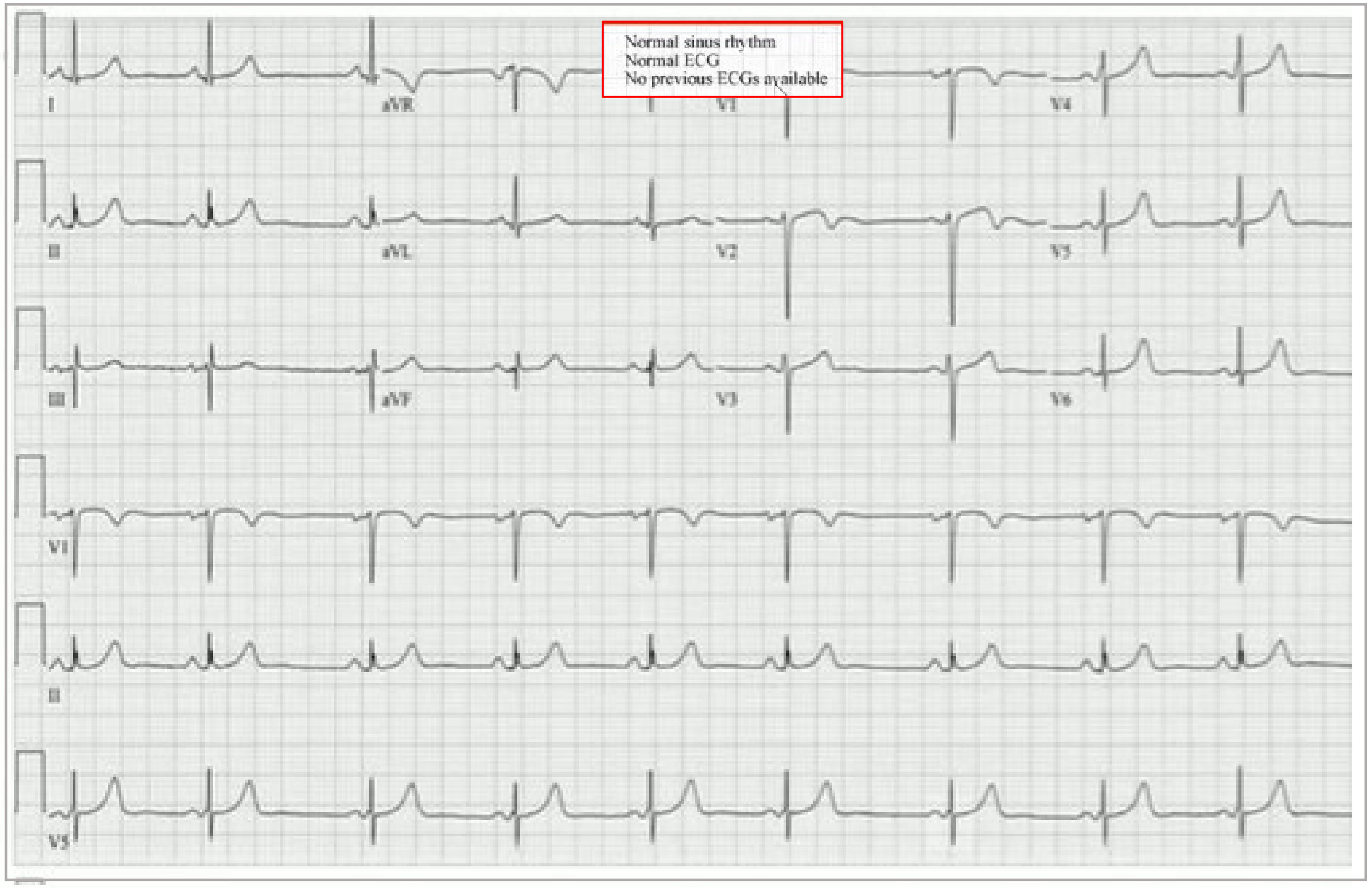
26y F No history / No history provided



What do you think about this EKG?

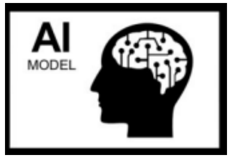
Nat Rev Cardiol. 2021 Jul;18(7):465-478. doi: 10.1038/s41569-020-00503-2

26y F



- Computer reading: Normal
- Human reading:
  ~ minor abnormality

AI reading

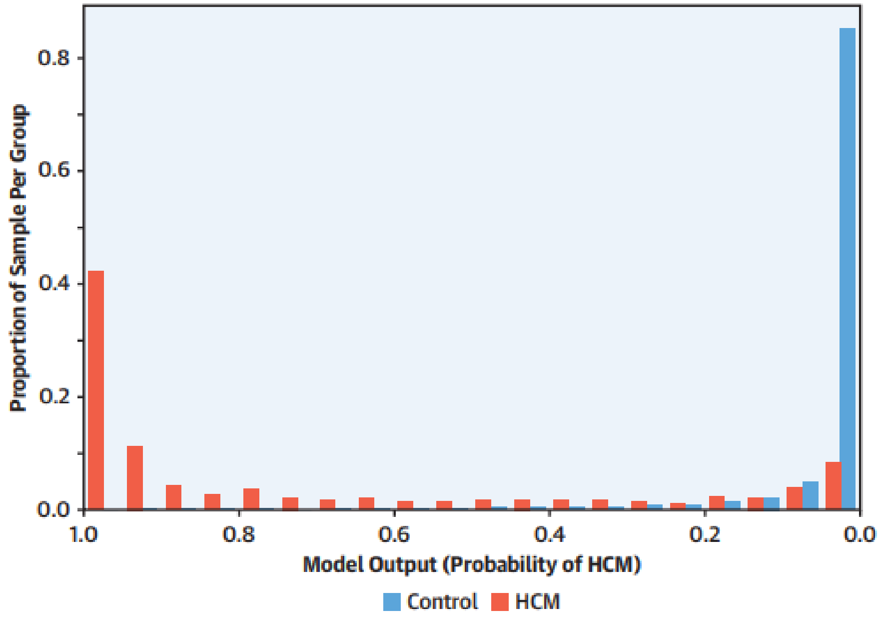


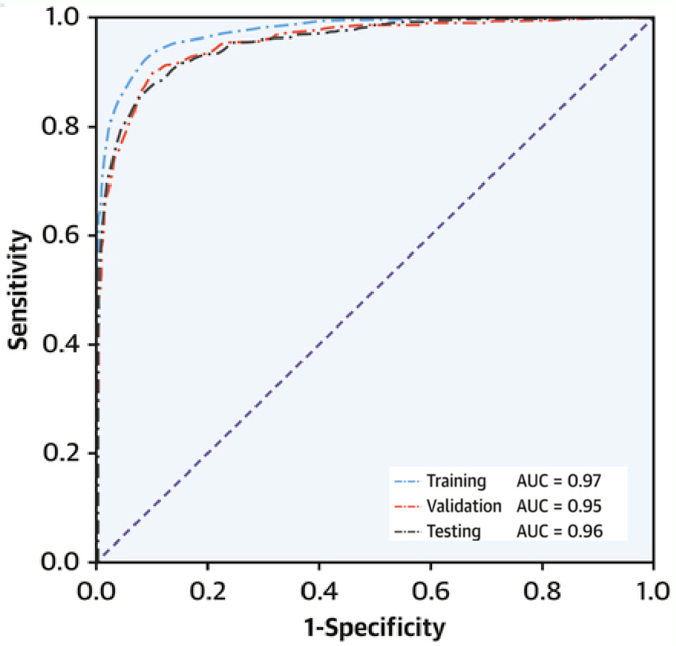
Probability of HCM 72.6%

Echo: HCM

doi:10.1093/eurheartj/ehab649

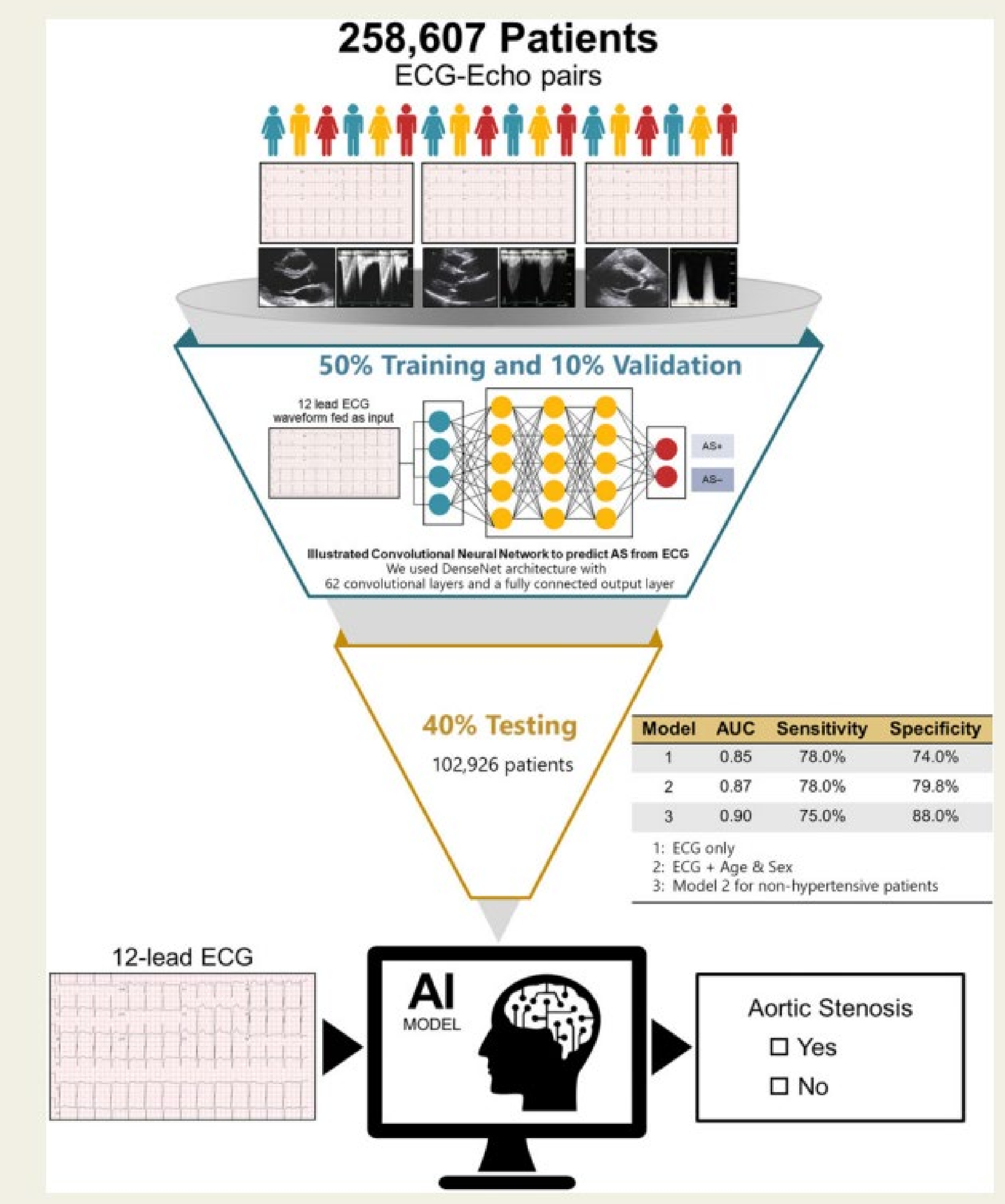
HCM: MODEL PERFORMANCE





HCM- Int J Cardiol. 2021 Oct 1;340:42-47. doi: 10.1016/j.ijcard.2021.08.026

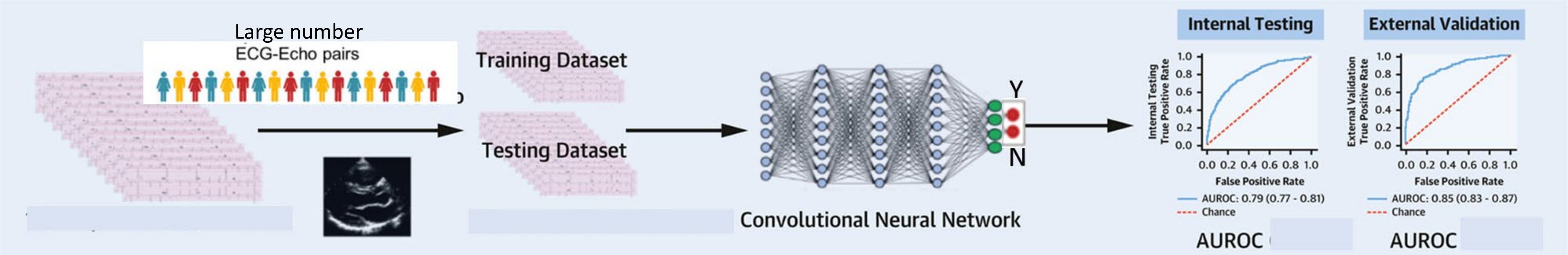
AORTIC STENOSIS



European Heart Journal (2020) **42**, 2885–2896
doi:10.1093/eurheartj/ehab153

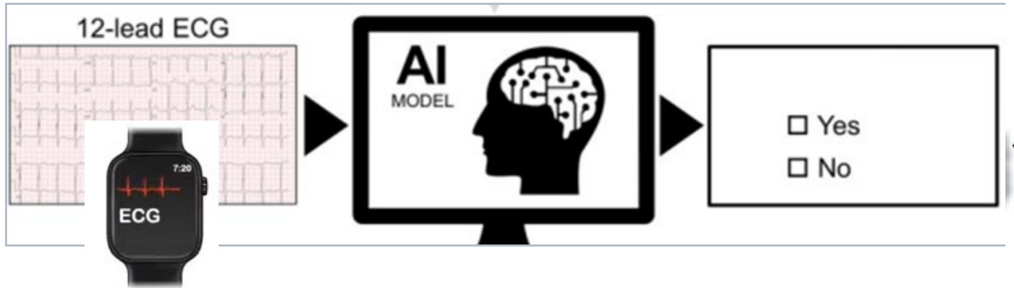
OVERVIEW

AI-EKG OVERVIEW



AI-EKG MODEL TRAINING

Internal data	External data
Train, Train → Validate, Validate, Test	Validate, Test



- Current Rhythm
- AF in NSR
- Low Ejection Fraction
- Valvular Diseases
- Channelopathies
- Hypertrophic Cardiomyopathy

- **Gender and Age / Physiologic Age**
- **HFpEF**
- **PVC→ CMP; SCD**
- **QT, Arrhythmia dx,**
- **Acute MI**
- **Amyloid**
- **Hyperkalemia**
- **AAD titration**
- **Others, PAH, Liver cirrhosis, Frailty, Anemia COVID, OSA etc)**

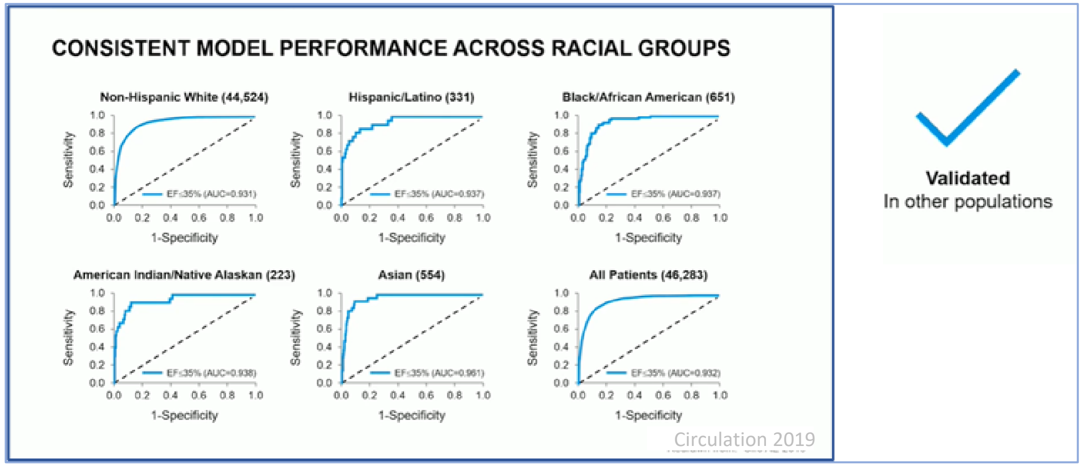
Outcome:
Occult disease presence
Prognostic – Predictive on impending disease

WHAT can the MACHINE SEE, HUMAN CANNOT

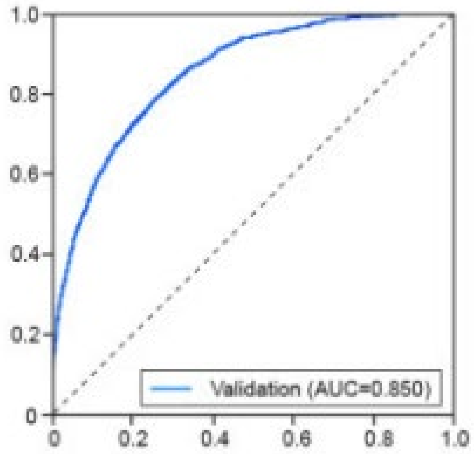
Lampert et al JACC: CLINICAL ELECTROPHYSIOLOGY VOL. - , NO. - , 2023 Electrocardiogram screening for aortic valve stenosis using artificial intelligence | European Heart Journal | Oxford Academic (oup.com)

AI-EKG OVERVIEW -- PERFORMANCE

DETECTION OF LOW EJECTION FRACTION- 12 LEAD

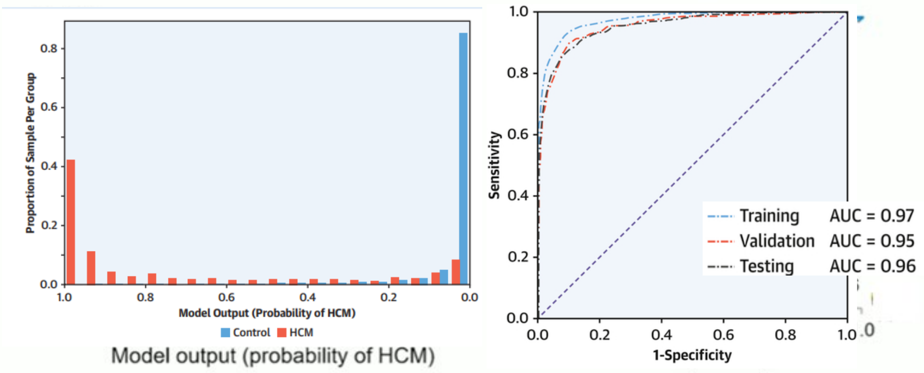


AORTIC STENOSIS PERFORMANCE



Eur Heart J. 2021 Aug 7;42(30):2885-2896. doi: 10.1093/eurheartj/ehab153.

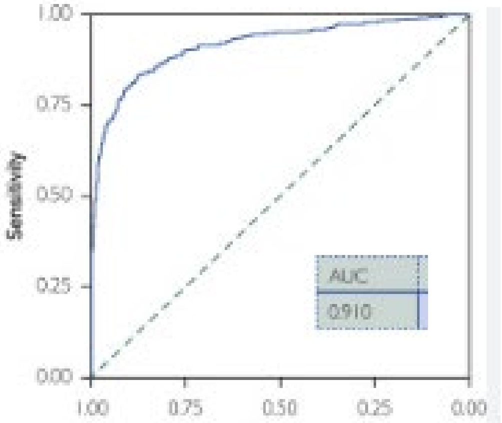
HCM: MODEL PERFORMANCE



HCM- Int J Cardiol. 2021 Oct 1;340:42-47. doi: 10.1016/j.ijcard.2021.08.026

Amyloidosis PERFORMANCE

Model Performance



Mayo Clin Proc. 2021 Nov;96(11):2768-2778. doi: 10.1016/j.mayocp.2021.04.023

MULTIPLE RELEVANCE - RICH PIPELINE OF AI TOOLS

CONSISTENT FINDINGS
AI-EKG find Occult disease
AI EKF Predicts disease before clinically detected

Prediction - recurrent pattern

- LVD
- AF
- AS
- Amyloid
- Liver cirrhosis

NEW EFFECTIVE DRUG TREATMENT AVAILABLE

- LVD
- HYPERTROPHIC CMP
- AMYLOID HEART DISEASE
- PULMONARY HTN

UNDERDIAGNOSED – MORBITITY IMPLICATION

- LVD
- HYPERTROPHIC CMP
- EPISODIC AF
- OTHERS..

SCREEINING DISEASES

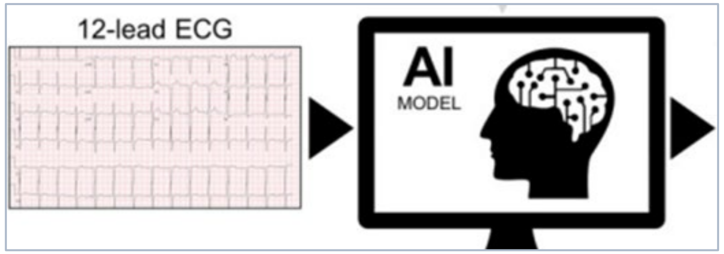
PREVALENT DISEASES

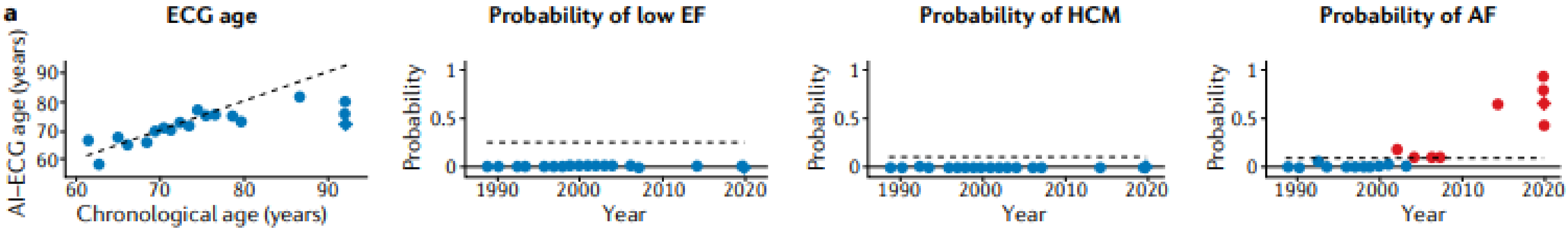
- LVD (AUC 0.93)
- AS (AUC 0.85)

RARE DISEASES

- HCM (AUC 0.96)
- AMYLOID HEART (0.91)
- Peripart CMP (0.87-.92)

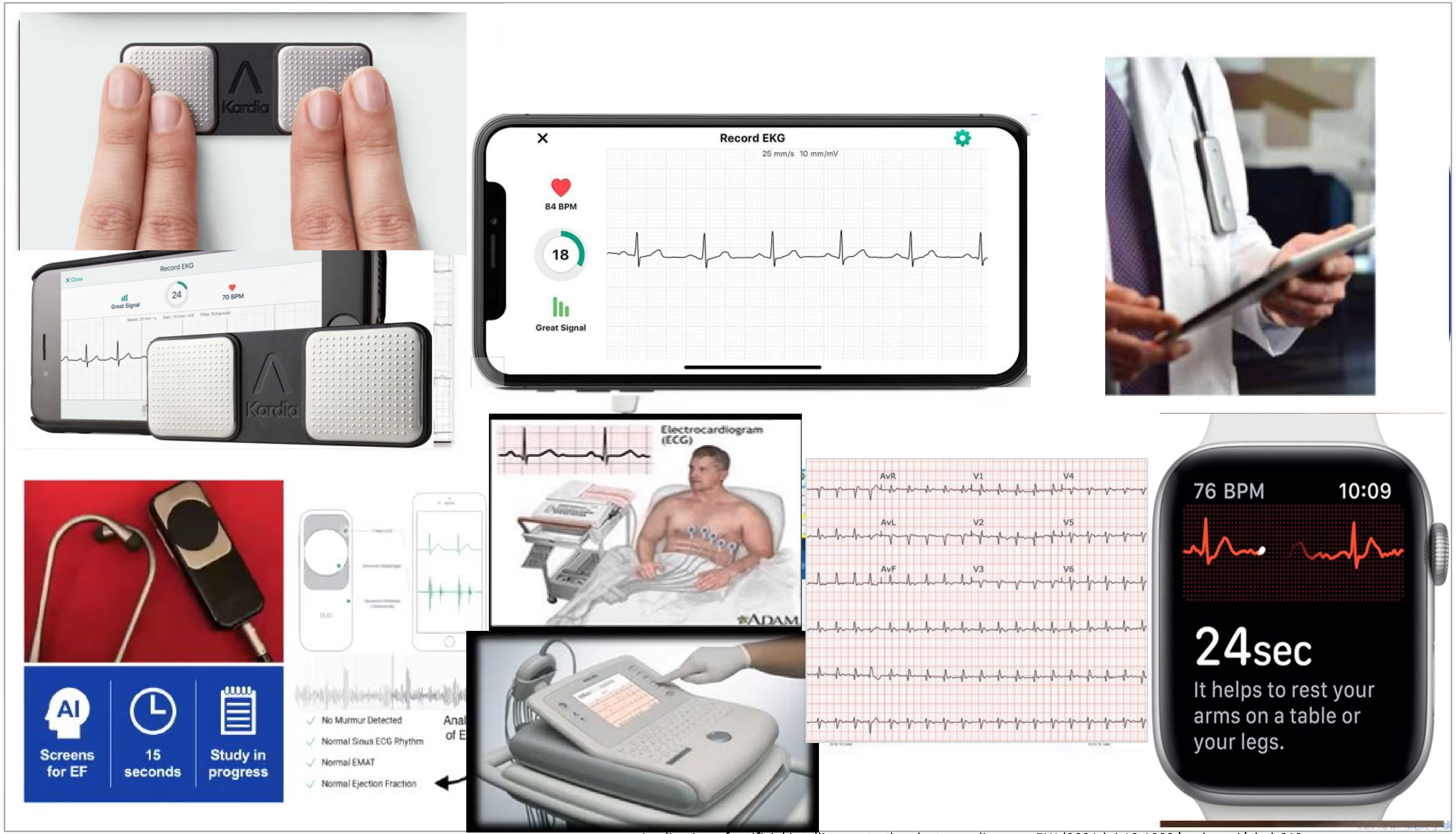
MULTIPLE SIMULTANEOUS ALGORITHMS





https://doi.org/10.1038/nature01096

MULTIPLE WAYS TO GET SIGNALS



Application of artificial intelligence to the electrocardiogram, EHJ (2021doi:10.1093/eurheartj/ehab649

MULTIPLE CHALLENGES

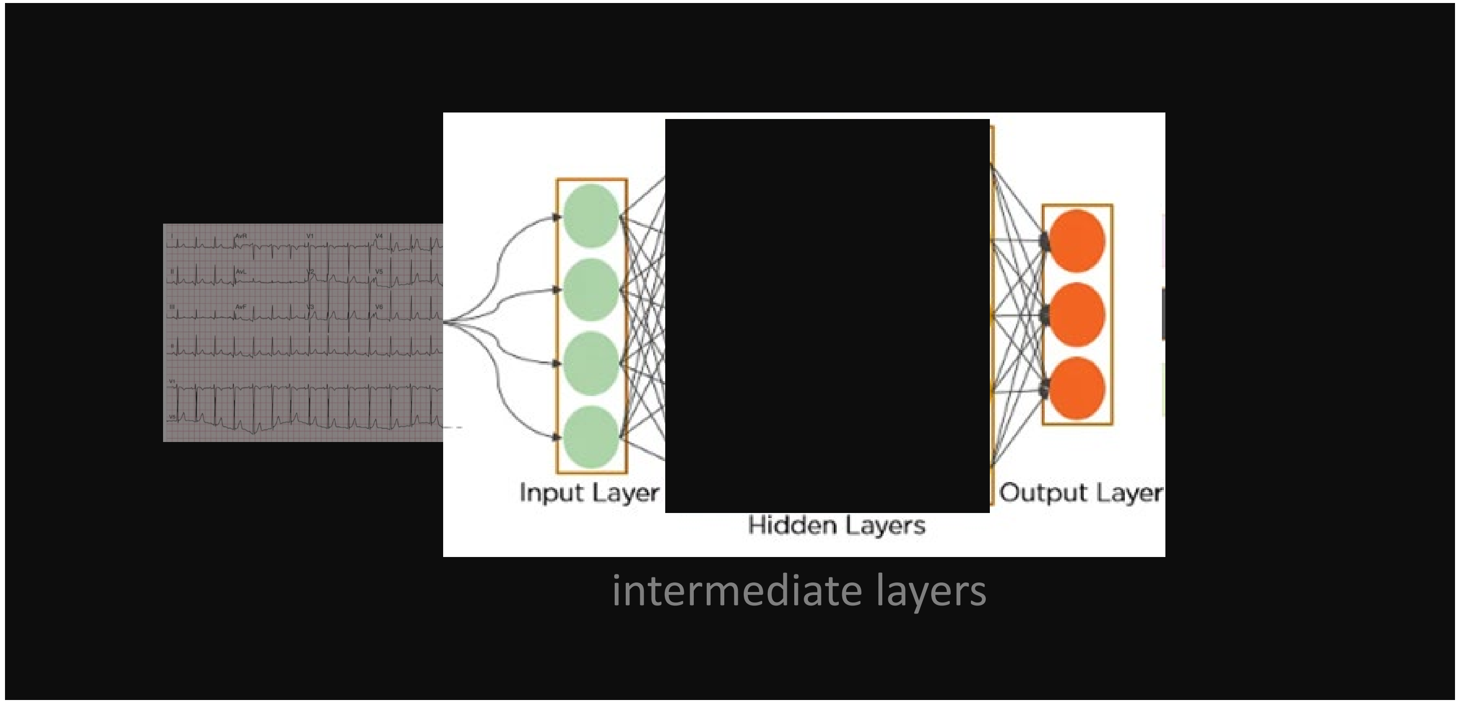
- Barriers of AI-EKG (Barriers to AI-EKG Adoption: Algorithm generalizability, implementation, utility)
- Data label accuracy: robustness of data labels used for training and testing
- Risk of bias: cohort creation and controls, formulating q, poor input data
- Overfitting/lack of generalizability
- Data privacy, (sharing) Regulations, Replicability, Standardization
- Transparency. Trust and *many more*..
- **Explainability**

What does the Machine see in the EKG?

Lack of transparency

BLACK BOX

humans cannot understand how the network makes its decisions



EXPLAINABILITY

uncovering the underlying rules

2023 Deep Learning to Predict PVC Cardiomyopathy, modified

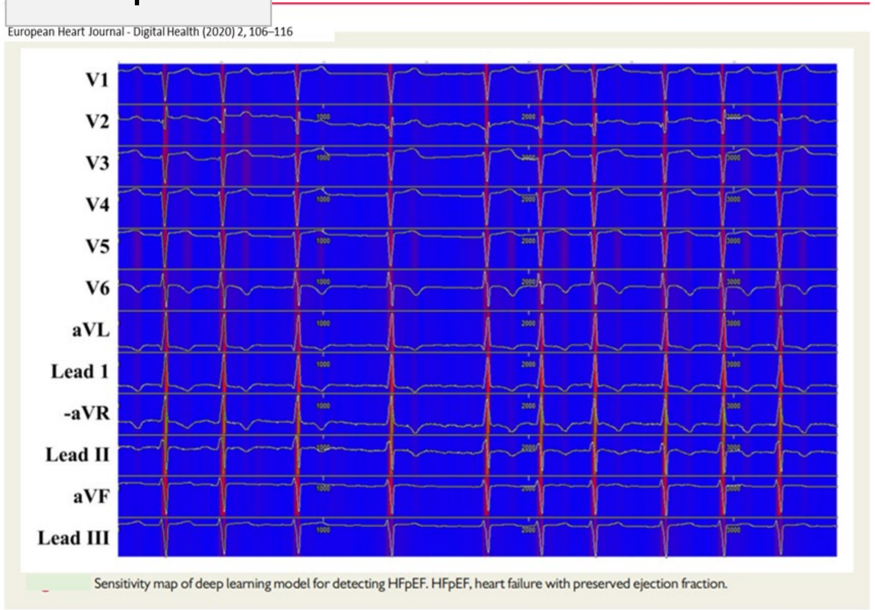
What does the Machine see in the EKG?

→ Other techniques

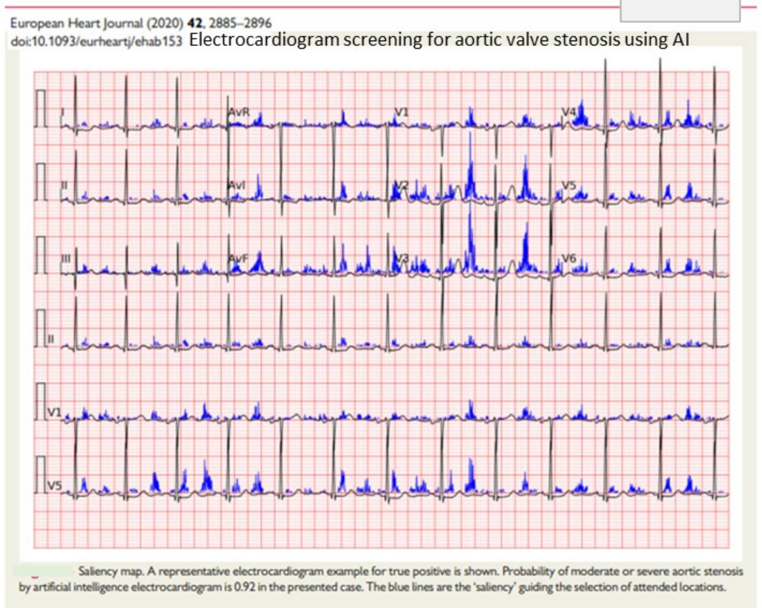
→ SALIENCY MAPS

highlight the portions of the EKG that contributed to the model's output in selected samples.

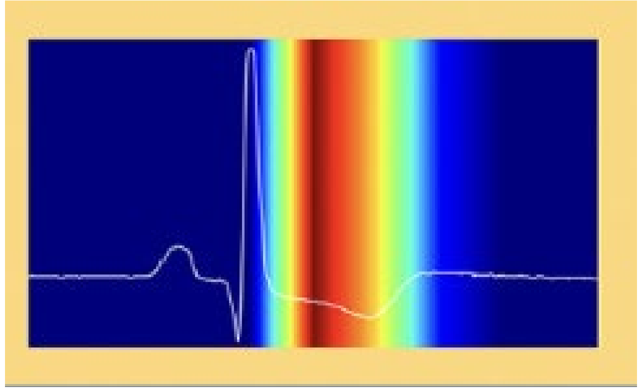
LVD pEF

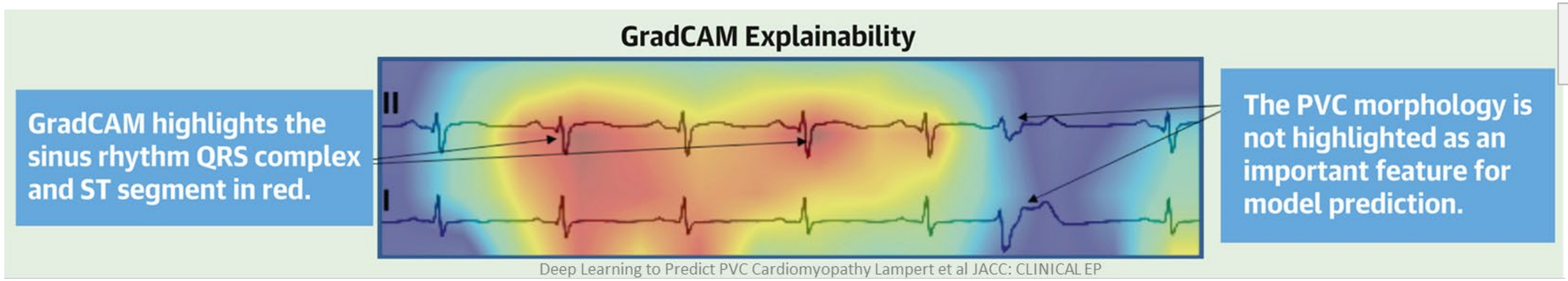


AS



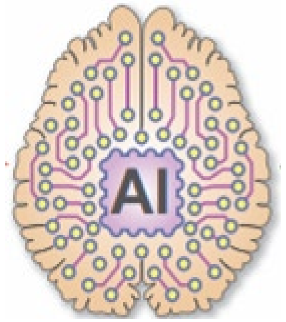
HCM - Single lead





PVCs

AI-EKG – **SUMMARY**



AI has the potential to completely change the way physicians use EKG

POTENTIALLY: Powerful, non-invasive Biomarker -- Digital assistant tool

- **Identify occult diseases**
- **Predict impending diseases**
- **Screening**
- **Monitoring**
- **Deep phenotyping**
- **Identify At-Risk Phenotypes**
- **Age and sex determination**
- **AI-EKG guided management**
  - TBDetermined: direct rx based on EKG
  - tailor triage, work flow, investigations,
  - more precise and earlier treatment,
  - Personalized treatment selection, monitoring

CLINICAL UTILITY

PREDICT DETECT

MASSIVELY SCALABLE

TRANSATE TO PRACTICE DRIVES INOOVATIONS

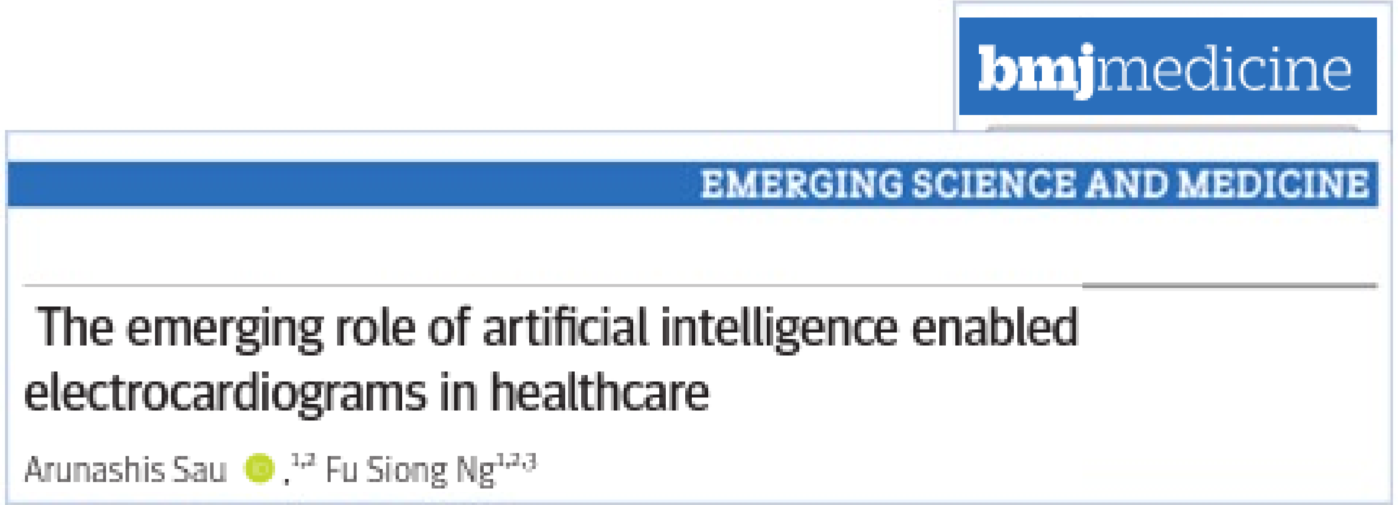
- Is **massively scalable**
- Require testing, vetting and validation
- Can improve resource utilization
- Deployable across many form factors

Further innovations // **Translate to Practice**

Can be run from a smart phone - Widely available, **inexpensive**, test, **Massively scalable**

Shutterstock

AI-EKG - The Present Situation - 2023


bmjmedicine

EMERGING SCIENCE AND MEDICINE

The emerging role of artificial intelligence enabled electrocardiograms in healthcare

Arunashis Sau [1,2], Fu Siong Ng [1,2,3]

- AI enabled EKG is **Not** currently ready for clinical use

- AI has the potential to completely change the way physicians use electrocardiograms
- It **could transform clinical care** of patients with cardiovascular disease, promoting early detection, prediction and tailored therapy

- **Advancements should be made with caution because of several potential pitfalls** with the rapid growth of artificial intelligence enabled electrocardiogram applications
- Great care must be taken to ensure the **implementation** of AI enabled EKG is done **safely and ethically**

BMJMED 2023;2:e000193. doi:10.1136/ bmjmed-2022-000193

The Present Situation of AI-EKG?

BE SMART

WATCH and WAIT

Advancements should be made with caution -- potential pitfalls with the rapid growth of AI enabled EKG applications

→ Multiple center collaboration is being deployed..

BMJMED 2023;2:e000193. doi:10.1136/ bmjmed-2022-000193

QUESTIONS

THANK YOU!