MAYO CLINIC

How to see the future: Detection of silent and future disease – role of artificial intelligence

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Torino, Italy
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NATURAL HISTORY OF DISEASE

Metabolic and physiologic abnormalities

I feel great!

SYMPTOMS + SIGNS

Diagnostic testing
treatment

Develop over **years**

Waiting for signs and symptoms before diagnosing has been done for 2,000 years. **WE CAN DO BETTER.**

IT MAY BE TOO LATE!
First event may be:
Stroke, Heart attack
Sudden death

YOU COULD HAVE HEART DISEASE AND NOT KNOW IT

ASYMPTOMATIC LEFT VENTRICULAR DYSFUNCTION

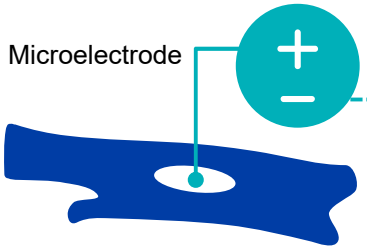
~2%
GLOBAL POPULATION

7M
AMERICAN CITIZENS

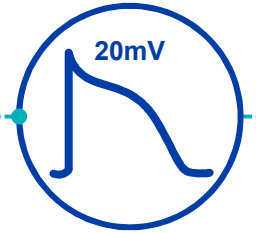
9%
OVER 60 YEARS OLD

TREATMENTS LOWER MORTALITY AND HOSPITALIZATION

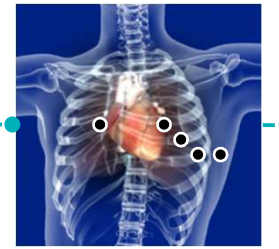
IDENTIFICATION REQUIRES EXPENSIVE, NOT READILY AVAILABLE TESTS



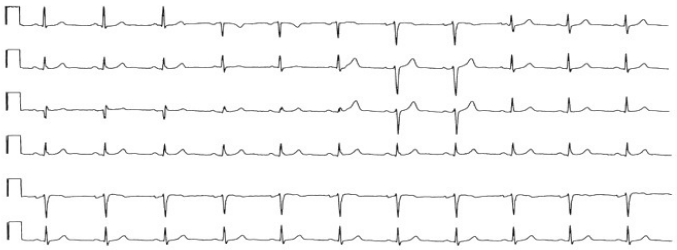
SINGLE
HEART CELL



VOLTAGE OF
SINGLE CELL



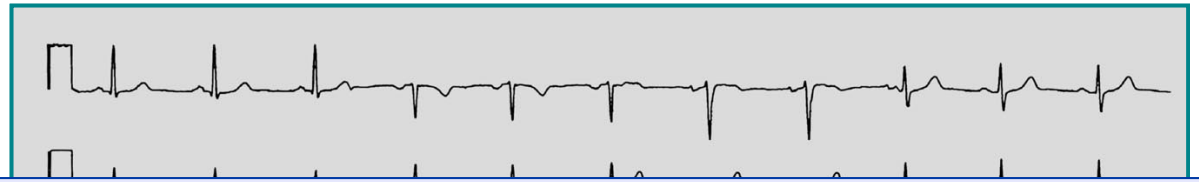
ECG: RECORD
FROM BODY SURFACE



ECG – ELECTROCARDIOGRAM
Widely available, inexpensive, painless test

Is the Ejection Fraction Low?
Weak Heart Pump?

ECG – Electrocardiogram. Painless, Inexpensive, Widely Available



- A clinician cannot assess EF from an ECG
- We hypothesized that a *deep convolutional neural network* could be trained to identify who has a low EF from an ECG
- ECG is a ubiquitous, inexpensive, painless test
- We used the vast Mayo Clinical data vault to build and test an AI network
- Once the network identifies a low EF subject → an echocardiogram can be arranged

BUSINESS DAY

Google's AlphaGo Defeats Chinese Go Master in Win for A.I.

点击查看本文中文版

By PAUL MOZUR MAY 23, 2017

Ke Jie, the world's top Go player, reacting during his match on Tuesday against AlphaGo, artificial intelligence software developed by a Google affiliate. China Stringer Network, via Reuters

RELATED COVERAGE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Master of Go Board Game Is Walloped by Google Computer Program MARCH 9, 2016

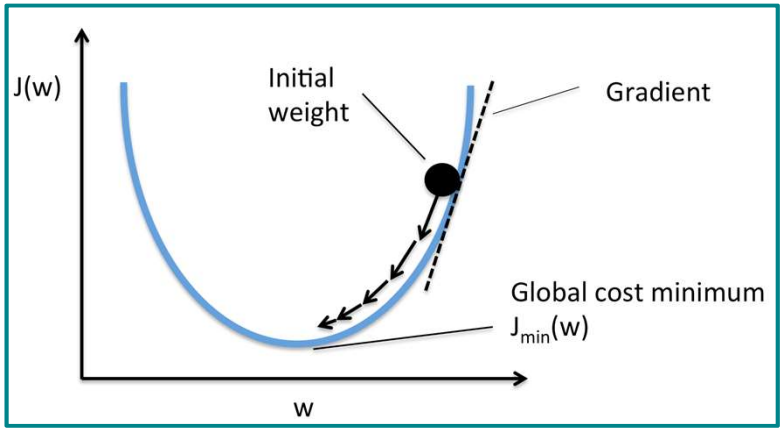
HONG KONG — It isn't looking good for humanity.

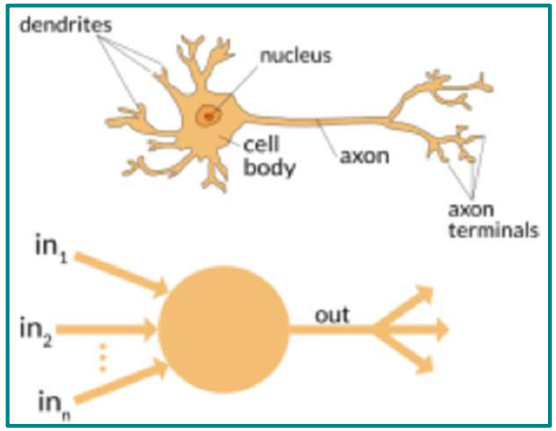
It isn't looking good for humanity.

The Mathematics of AI – Gradient Decent
Training a Computer the way an Infant Learns

$$\hat{f}_{w,b}(x) = Wx + b$$

The learning step:
In each step we will update the weights against the direction of gradient of the loss function until we are close enough to its minimum

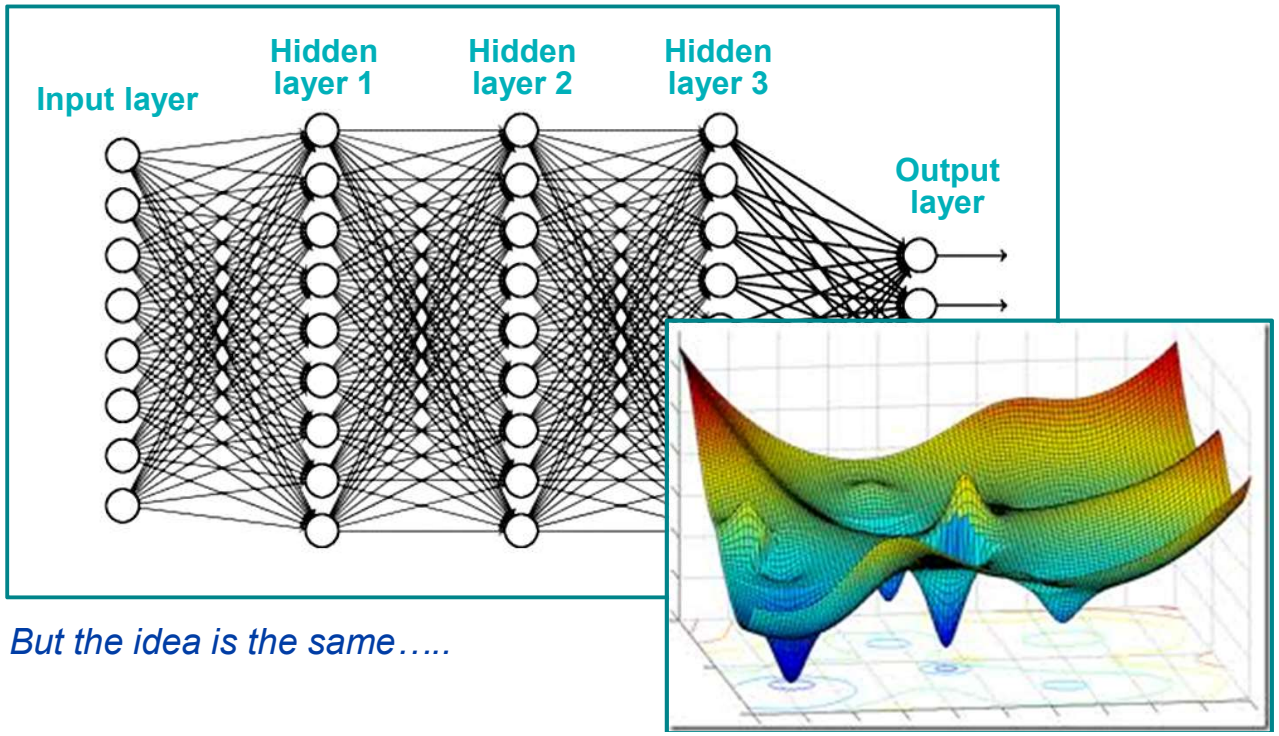




For Linear Regression there is also a closed form solution…

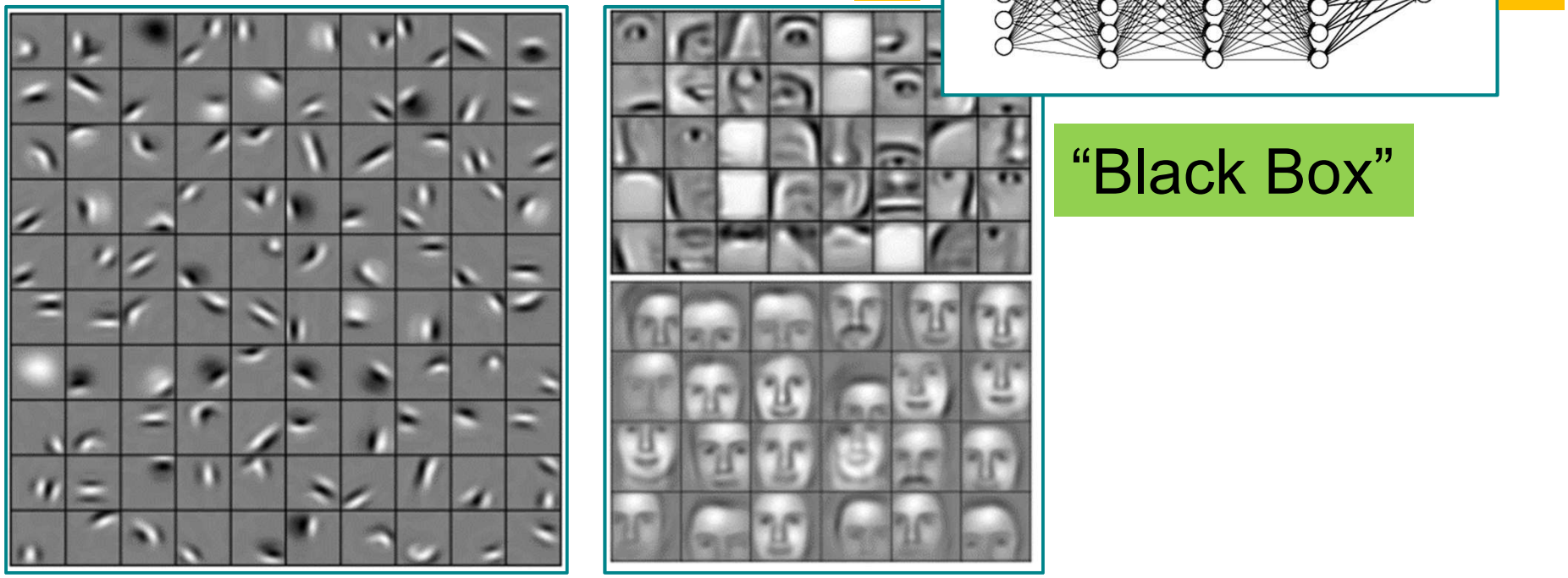
The Mathematics of AI – Neural Networks

When the function is not a simple linear relation between X and Y we build
A deeper network and add non-linear functions to find f(x)

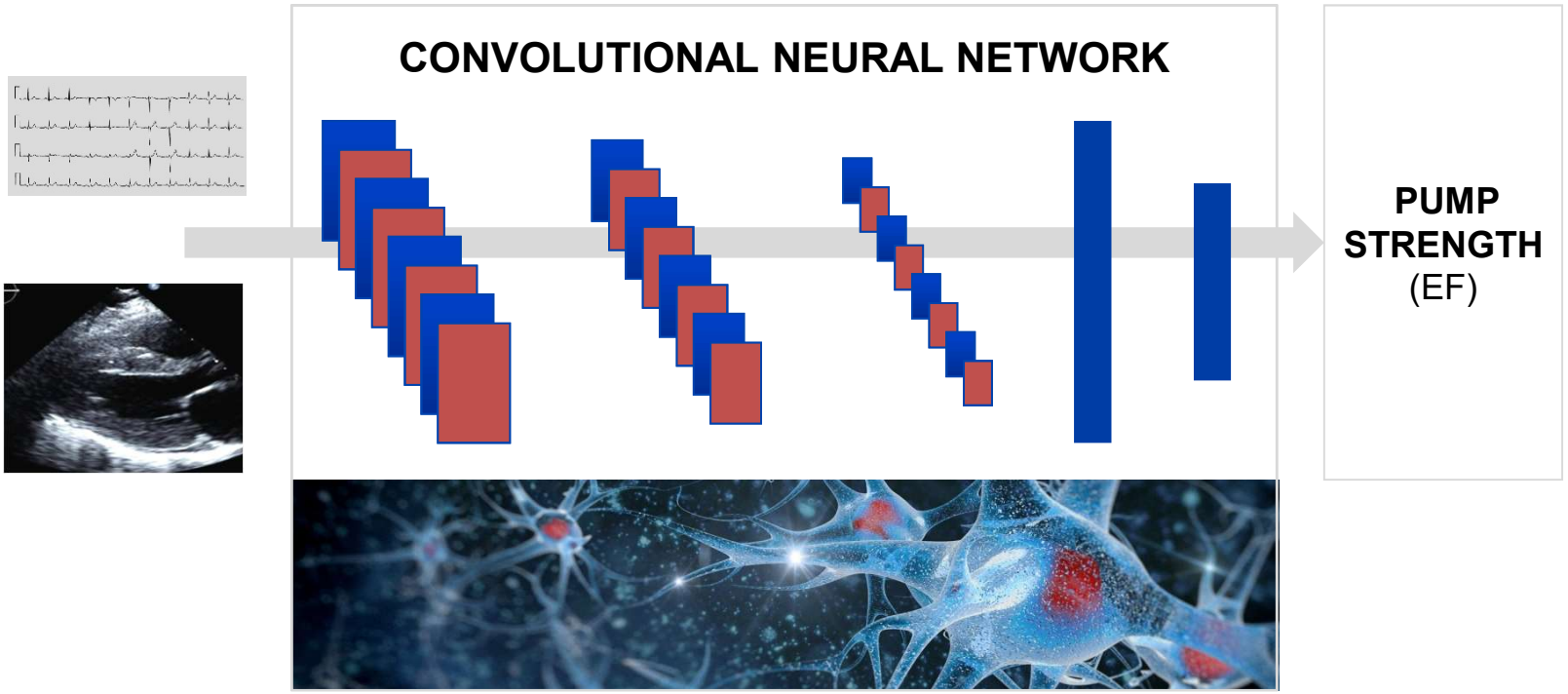


But the idea is the same…..

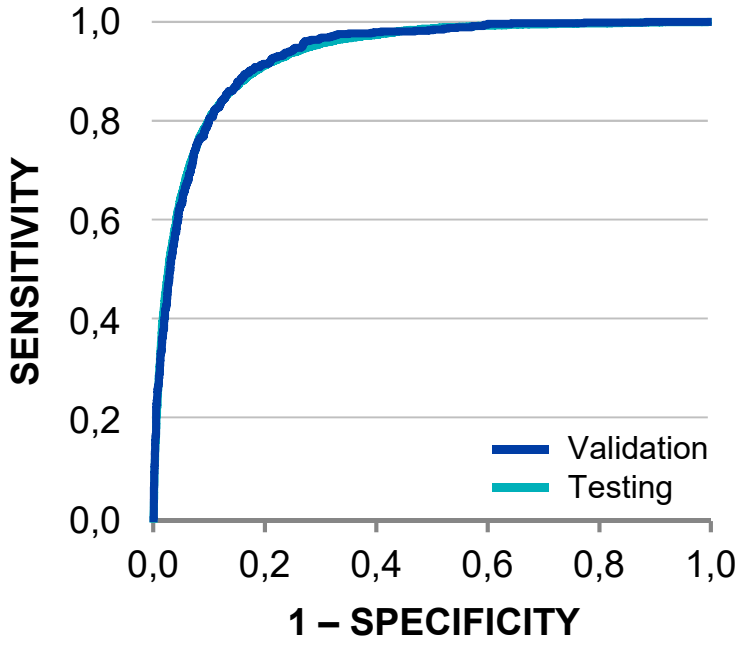
Convolutional Neural Networks
Feature Hierarchy Example:



ROBUST DIGITAL WAREHOUSE OF MEDICAL INFORMATION



TEST PERFORMANCE
RECEIVER OPERATING CHARACTERSITICS



AREA UNDER CURVE OF EF

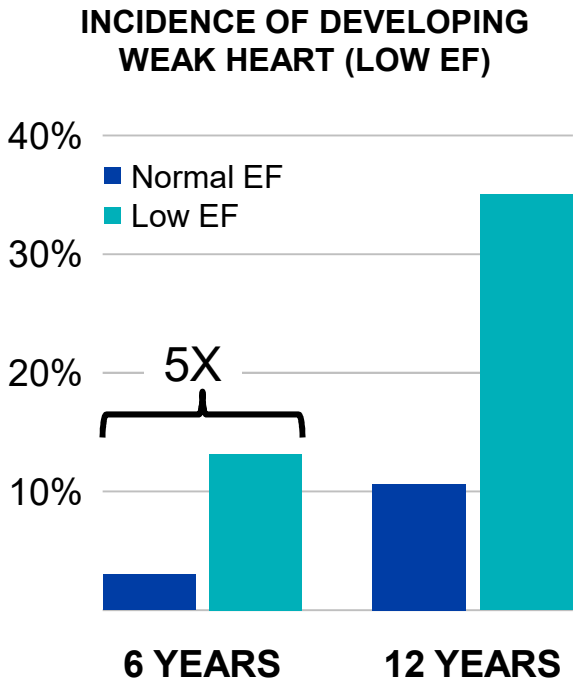
AI ECG = 0.93
PERFECT = 1.0

FAVORABLY COMPARES WITH OTHER TESTS

(PAP SMEAR = 0.7, MAMMOGRAM = 0.85)

Attia … Friedman Nature Medicine Jan 2019

LONG-TERM OUTCOME OF PATIENTS WITH A “FALSE POSITIVE” AI ECG

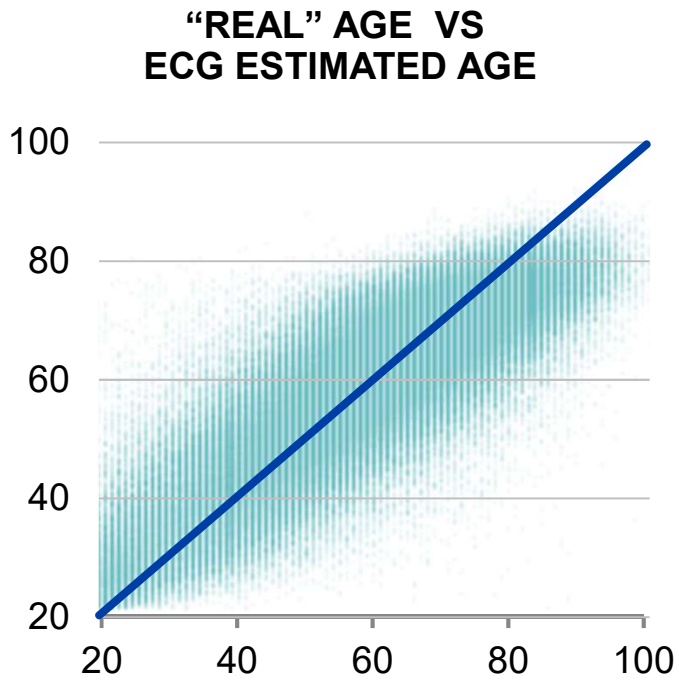


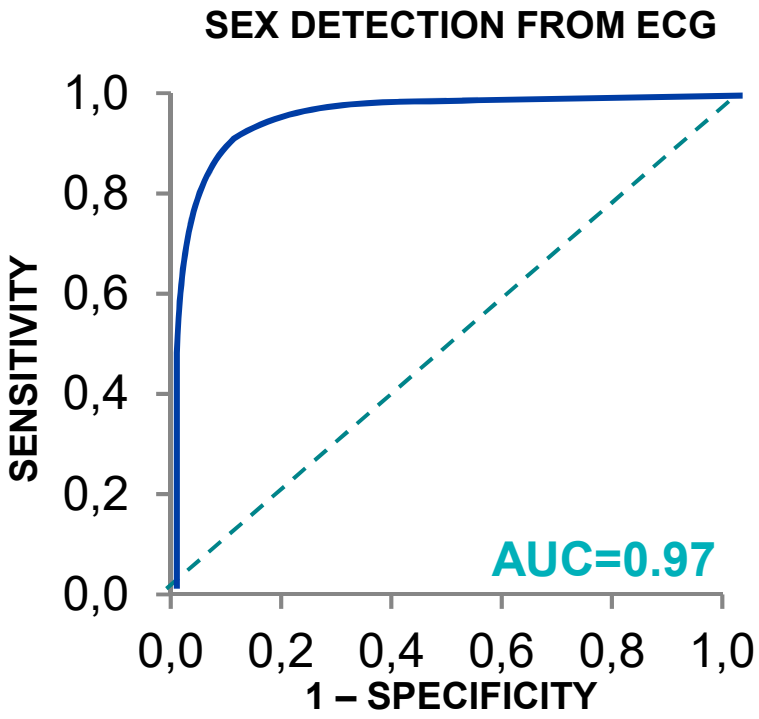
PREDICT DISEASE
BEFORE IT BECOMES MANIFEST

HIGH RISK
ARRANGE FOLLOW UP IMAGING STUDIES

WHAT IF WE TELL THE COMPUTER THE AGE AND GENDER, **NO DOES IT HELP?**

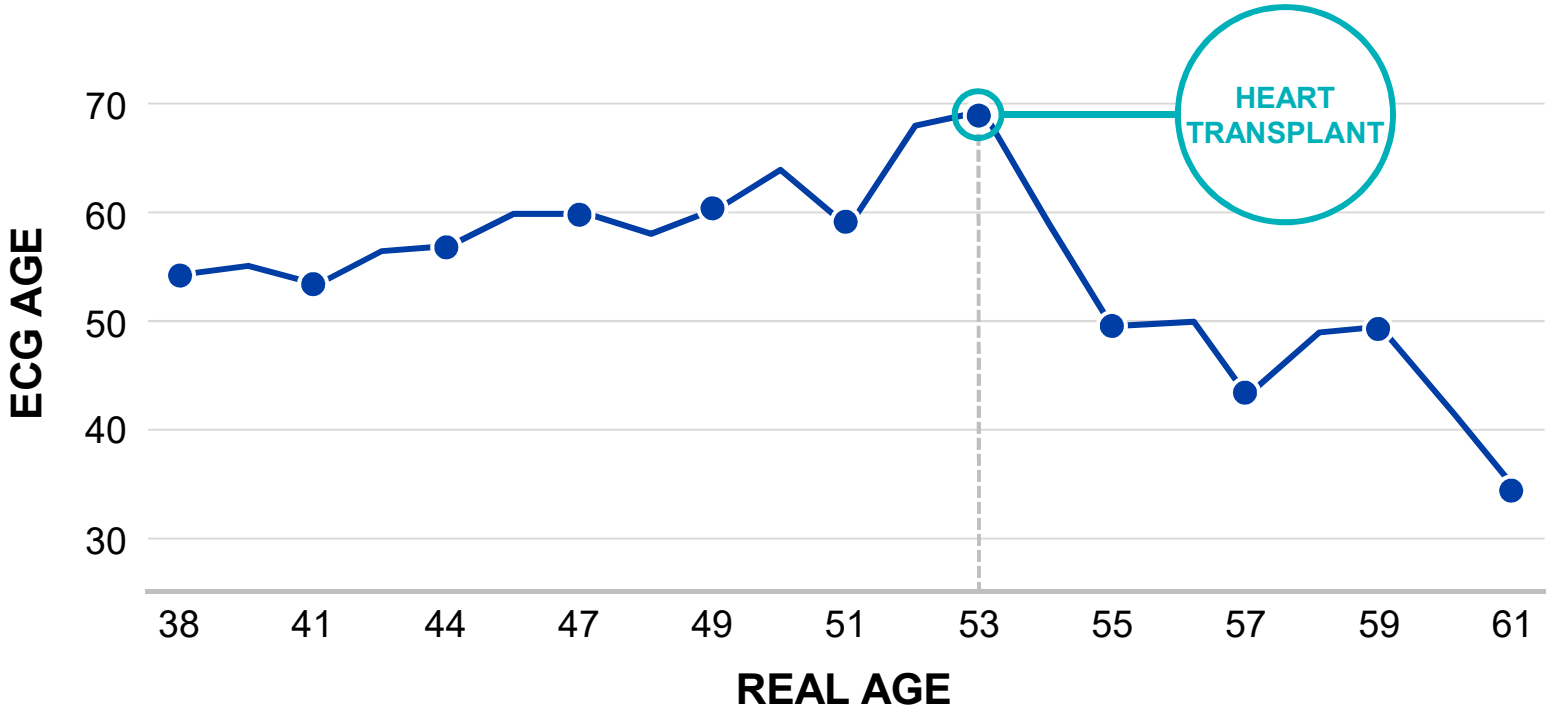
AGE AND SEX FROM ECG





Attia…Kapa Circ AE 2019 in press

PROGRESSION OF ECG AGE IN A PATIENT WITH MULTIPLE ECGS

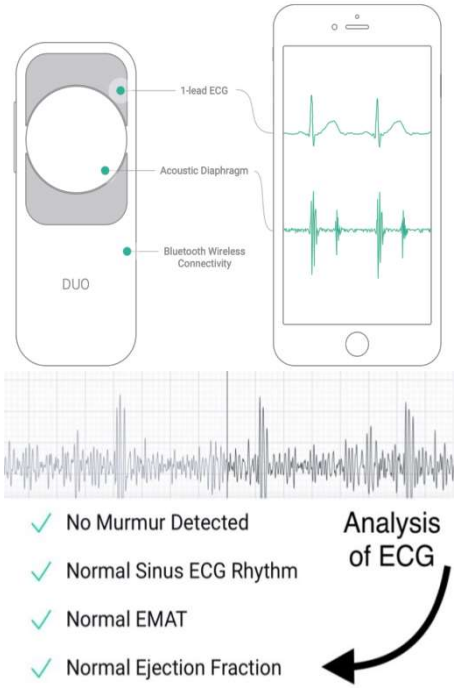


ECG ON A STETHOSCOPE “EXPERT IN YOUR POCKET”

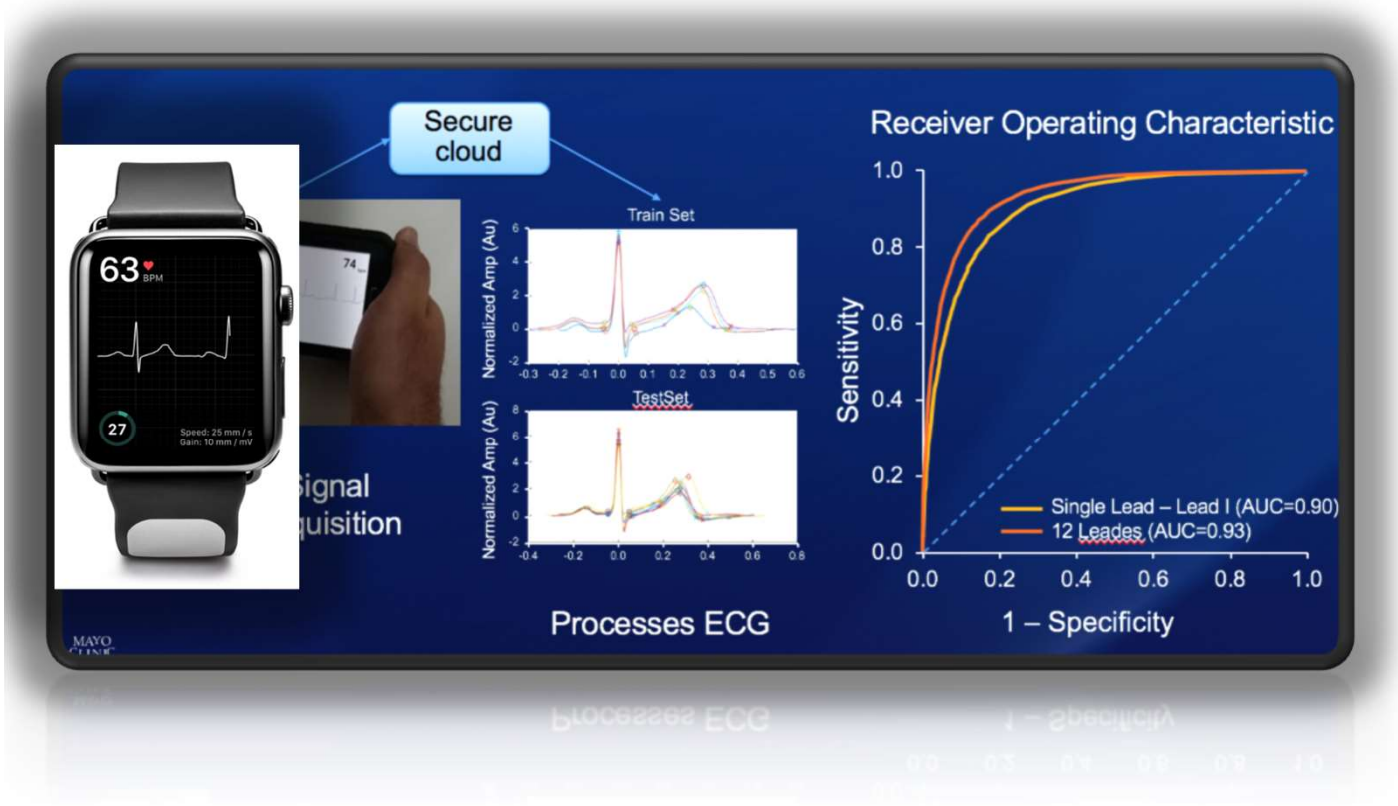
AI
Screens for EF

15 seconds

Study in progress



Smartphone enabled, massively scalable, point of care technology!

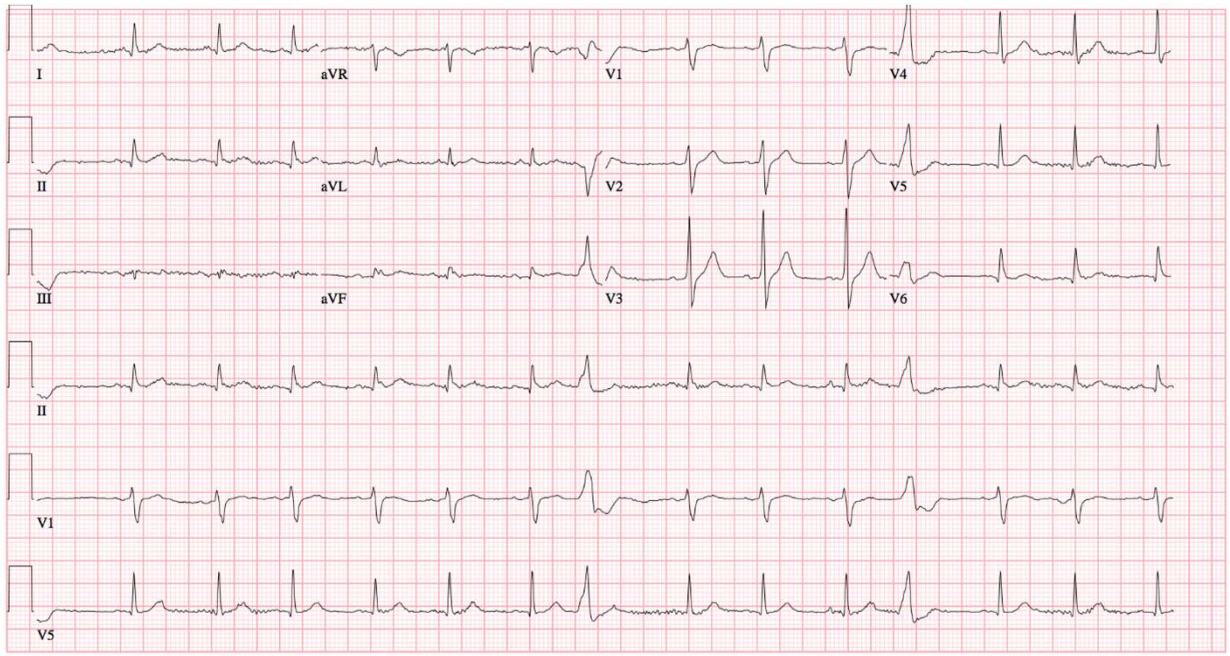


SMART PHONE ELECTRODES

Adapted from Yasin, Attia…Friedman J Electrocardiography 2017

SKIP

72 year man presents with embolic stroke of uncertain source (cryptogenic stroke). Aspirin or Oral Anticoagulant?



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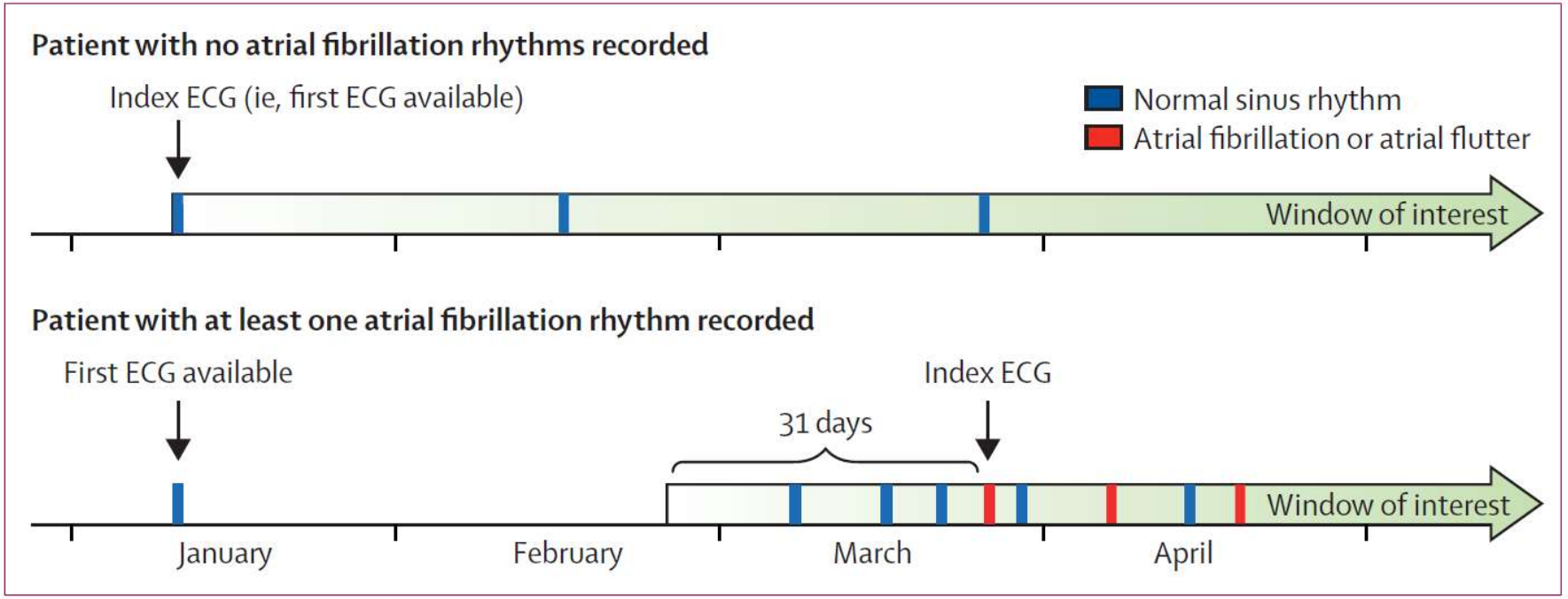
ATRIAL FIBRILLATION RISK: defining populations

Network only given NSR ECGs, but from 2 populations: AF and No AF



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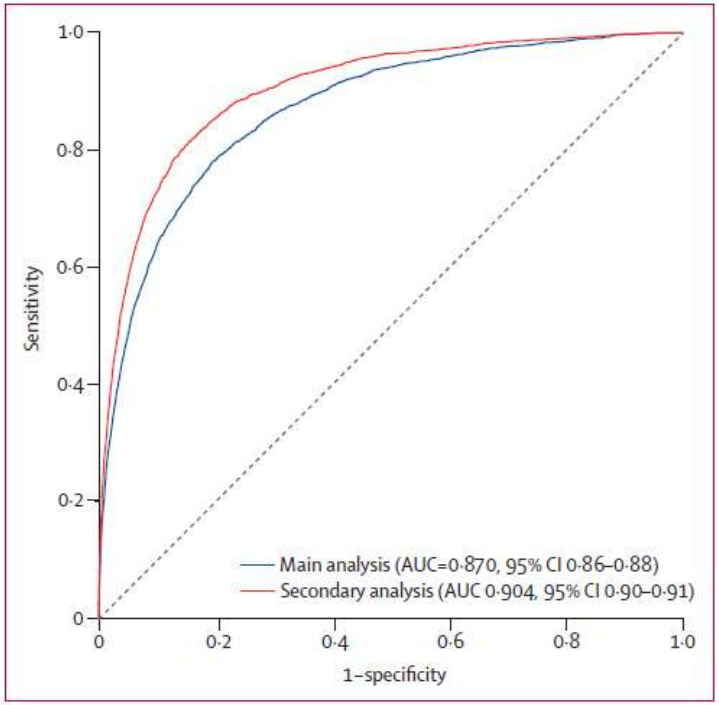
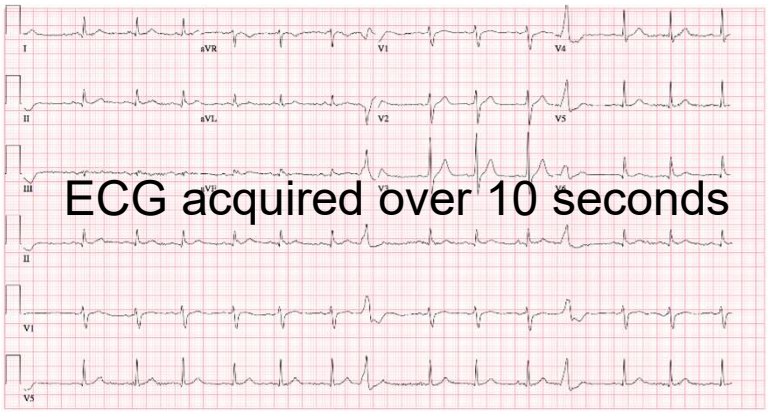
Attia…Friedman: Lancet Aug 2019

ATRIAL FIBRILLATION RISK: from an ECG recorded during Normal Sinus Rhythm



	AUC	Sensitivity	Specificity
Primary	0.87	79·0%	79·5%
Secondary	0.90	82·3%	83·4%

AI converts a 10 second ECG into an extended Holter to screen for atrial fibrillation!



Atrial fibrillation detected over weeks

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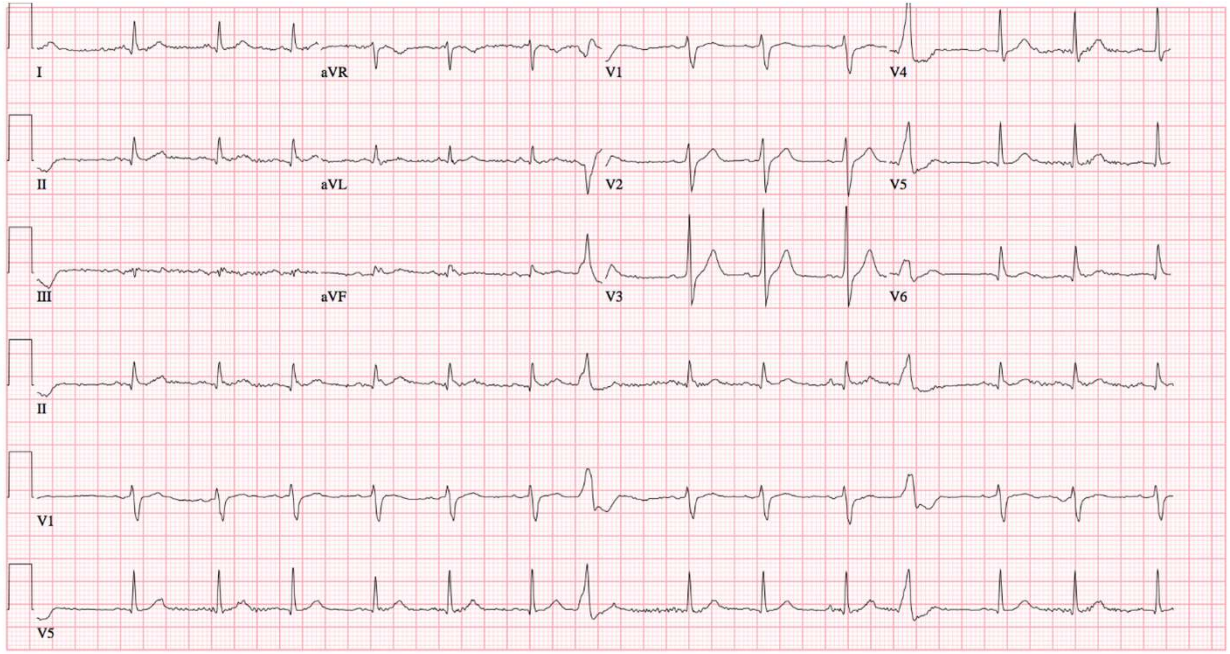
72 year man presents with embolic stroke of uncertain source (cryptogenic stroke). Aspirin or **Oral Anticoagulant**?

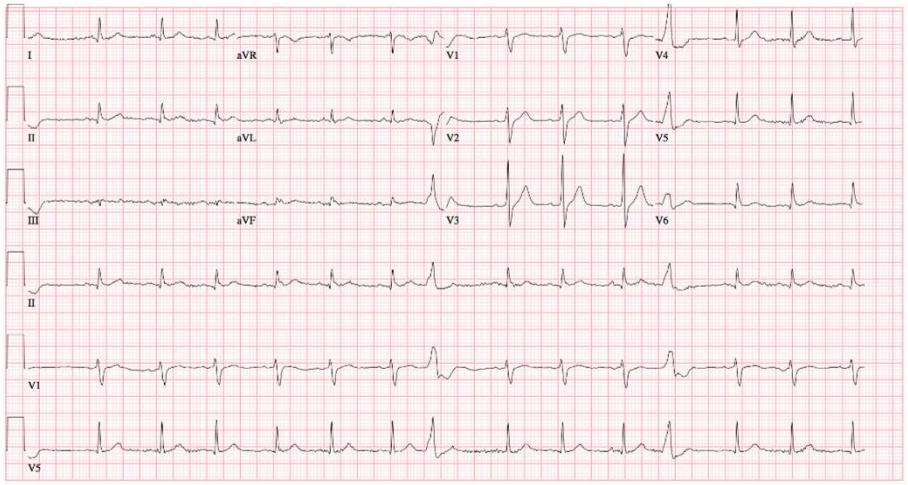


This patient had AF Yesterday

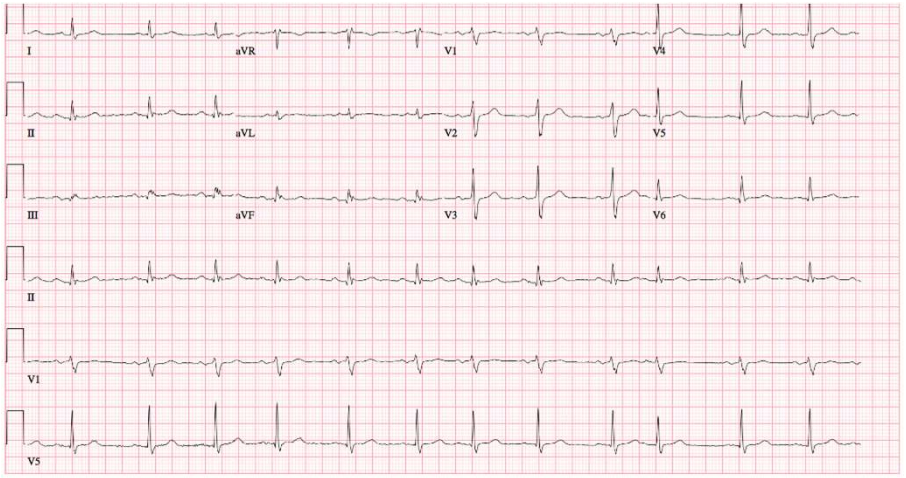
(documented, and +AI ECG for AF)

What is inside of the AI black box?

How does the magic happen?

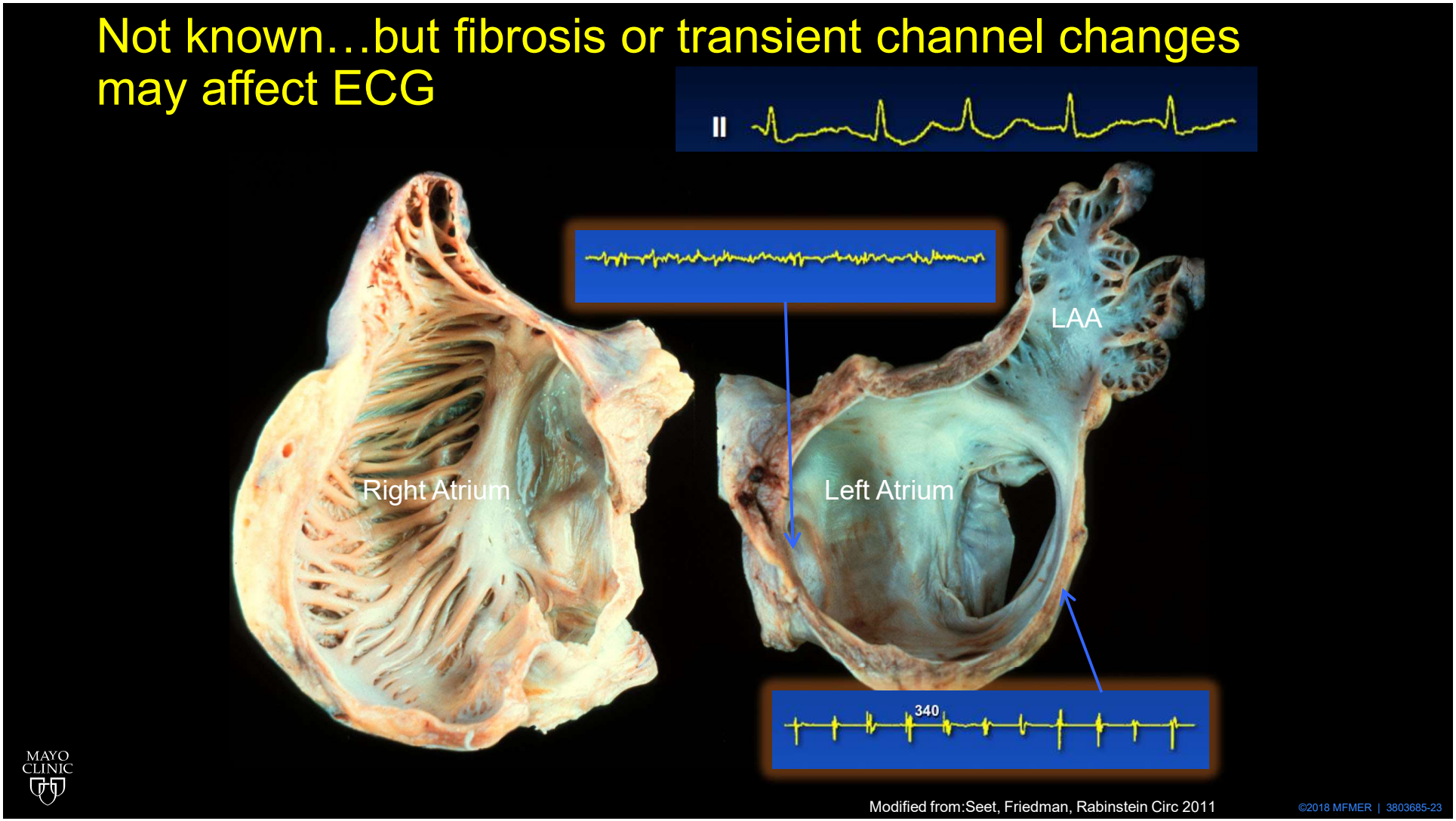


+AI ECG for AF



- AI ECG for AF

Not known…but fibrosis or transient channel changes may affect ECG



Modified from:Seet, Friedman, Rabinstein Circ 2011

Moving Fast

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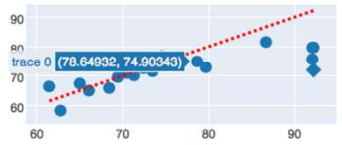
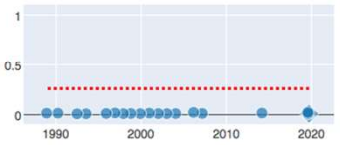
AI report for patient with the number : 01-[redacted]

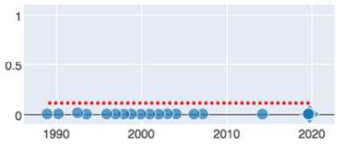
ECG Age



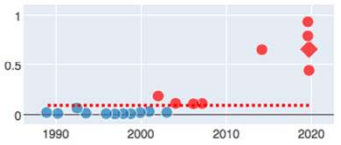
Probabilty of Low EF



Probabilty of HCM

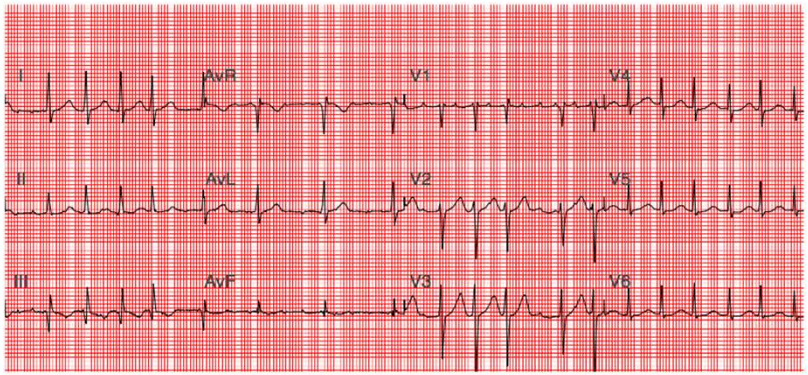


Probabilty of AF/silent AF



Complete ECG | Median Beats

Atrial flutter with variable A-V block Nonspecific ST and T wave abnormality



Results

Compare ECGs | Print Report | Download Results

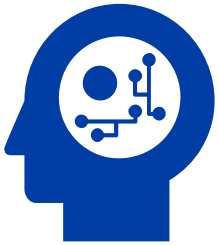
ECG Date	Main Rhythm	Heart Rate	QT/QTc	Real Age	ECG Age	P of Male (%)	P of Low EF (%)	P of AF (%)	P of HCM (%)
09/19/2019 5:38 AM	Atrial flutter	116	326/453	92.202739726	72.0	17.42%	0.59%	65.63%	0.01%
09/18/2019 8:03 PM	Sinus tachycardia	109	356/477	92.2	79.7	16.35%	0.93%	43.52%	0.01%
07/31/2019 8:35 AM	Normal sinus rhythm	79	426/488	92.0712328767	79.7	7.77%	0.39%	92.94%	0.03%
07/30/2019 6:50 AM	Sinus rhythm	92	398/492	92.0684931507	75.7	7.55%	1.87%	78.84%	0.22%
03/10/2014 5:37 PM	Normal sinus rhythm	69	434/465	86.6712328767	81.5	1.04%	1.11%	65.15%	0.10%
03/08/2007 9:08 AM	Normal sinus rhythm	63	456/466	79.6657534247	72.9	0.57%	0.75%	10.56%	0.18%
03/01/2006 9:25 AM	Normal sinus rhythm	69	436/463	78.6493150685	74.9	2.94%	1.77%	10.28%	0.08%

Moving Fast: Integrated Team and an Infrastructure

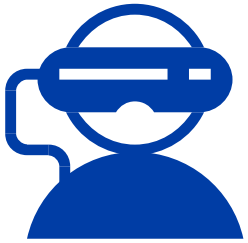
- Create multidisciplinary teams (collaborations)
- Build technical infrastructure:
- From Publication to Clinical use: 6 months
- Over 10,000 pts screened with AI today

CARDIOVASCULAR INNOVATION

NEW: VICE CHAIR FOR INNOVATION



AI

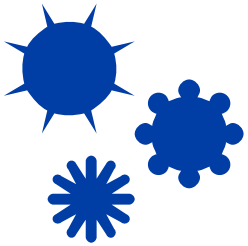


VIRTUAL REALITY

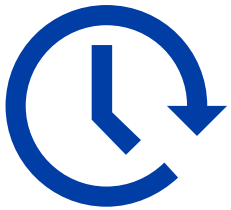
DEVICES

MEDICATIONS AND BIOLOGICALS

CONCLUSIONS



DETECTS
“OCCULT”
DISEASE



PREDICTS
FUTURE
DISEASE

SMARTPHONE
AI MASSIVELY
SCALABLE

WE ARE
DRIVING
INNOVATION

MAYO CLINIC

MAYO CLINIC

Mayo Clinic Department of Cardiovascular Medicine

Current Applications and Future of

ARTIFICIAL INTELLIGENCE

in Cardiology

THANK YOU

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