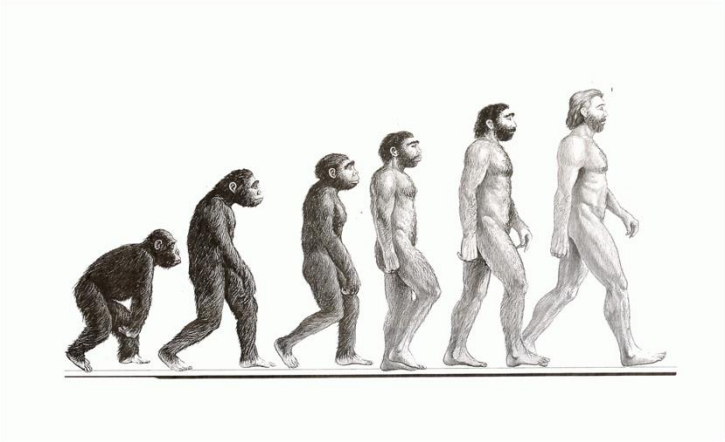
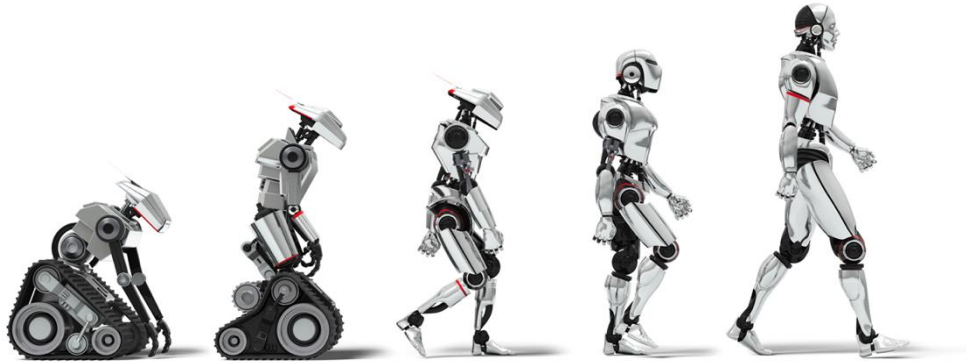
Les big data et leurs algorithmes
peuvent-ils sauver des vies ?

Pierre Taboulet, Saint-Louis-Lariboisière (AP-HP)

www.e-cardiogram.com





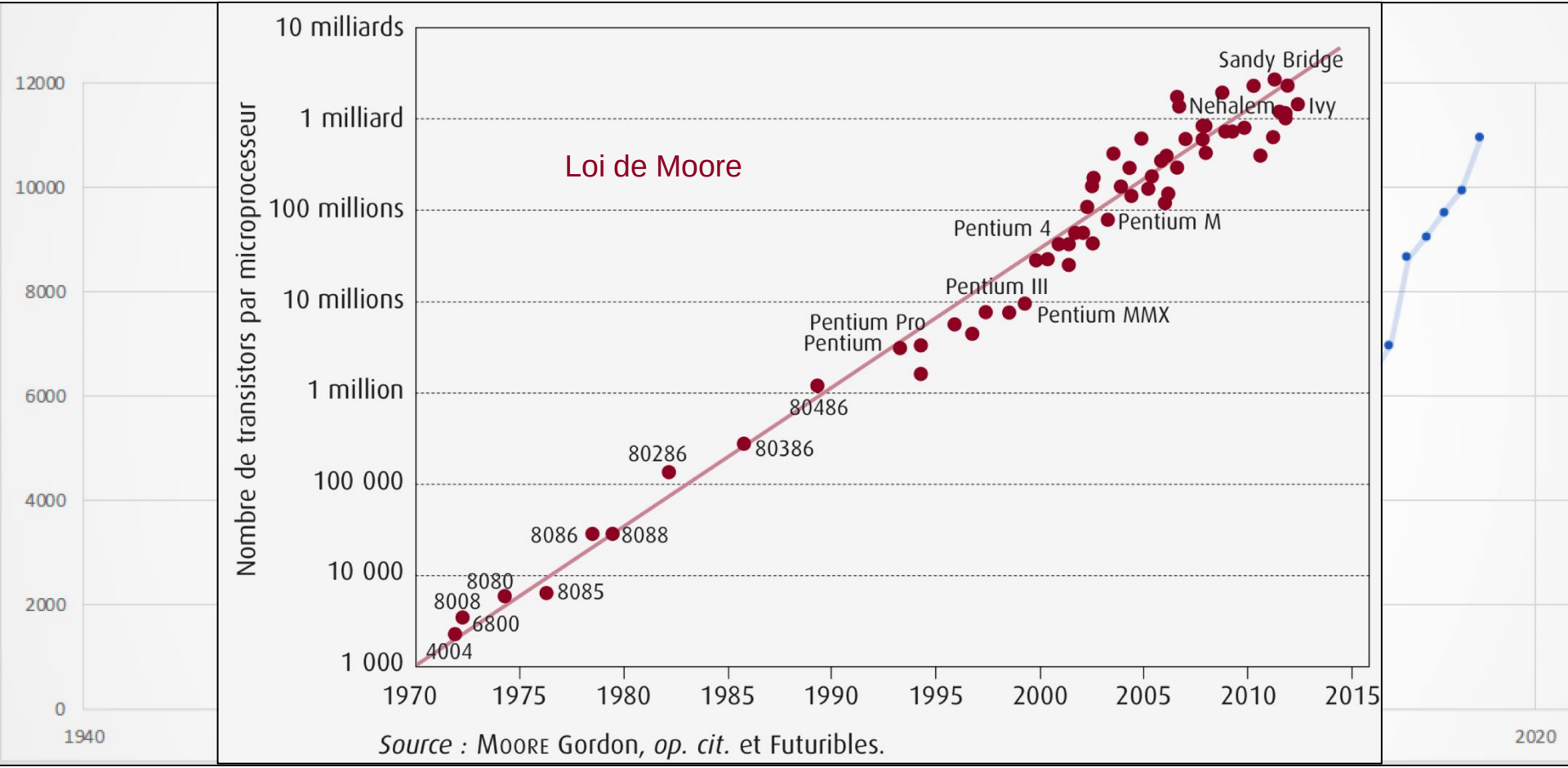
DÉCLARATION DE LIENS D'INTÉRÊT AVEC LA PRÉSENTATION

Intervenant : Pierre TABOULET, Paris

☑ Je déclare les liens d'intérêt suivants :

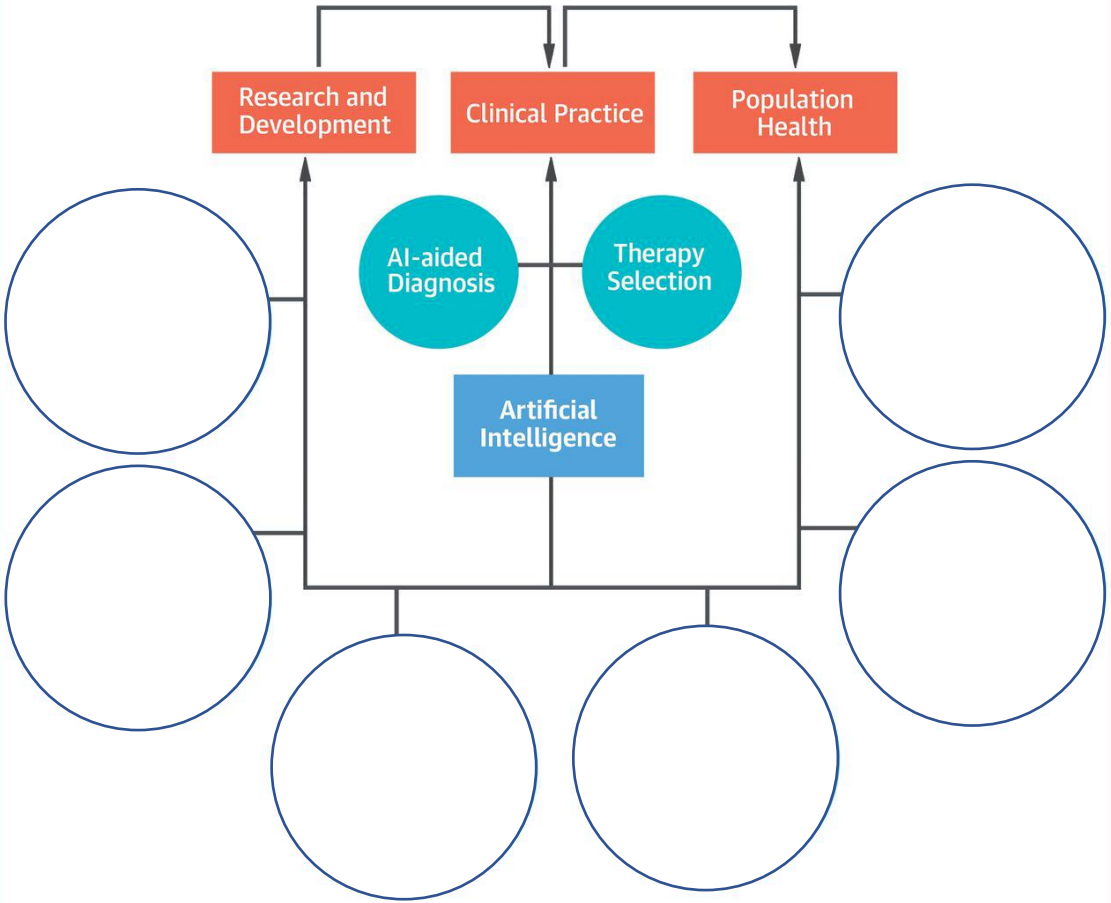
co fondateur : Cardiologs technologies®

« artificial intelligence OR neural network OR Machine learning »



BABYLON TRIAGE AND DIAGNOSTIC SYSTEM

CENTRAL ILLUSTRATION: Role of Artificial Intelligence in Cardiovascular Medicine



Johnson, K.W. et al. J Am Coll Cardiol. 2018;71(23):2668-79.

Cardiologs CE FDA
BIG DATA FOR HEART SCREENING

SYSTÈME NATIONAL DES DONNÉES DE SANTÉ

Méthodologie et technique

Cette rubrique présente des études d'ordre administratif ou technique relatif au traitement des données médicales et médico-économiques. Elle inclut par exemple des études faisant référence à l'optimisation du processus de traitement de données, des procédures techniques, des algorithmes de détection de pathologies ou d'état de santé, des méthodes novatrices d'analyse de données à forte volumétrie, les méthodes d'exploitation du big data, etc.

Parcours et offre de soins

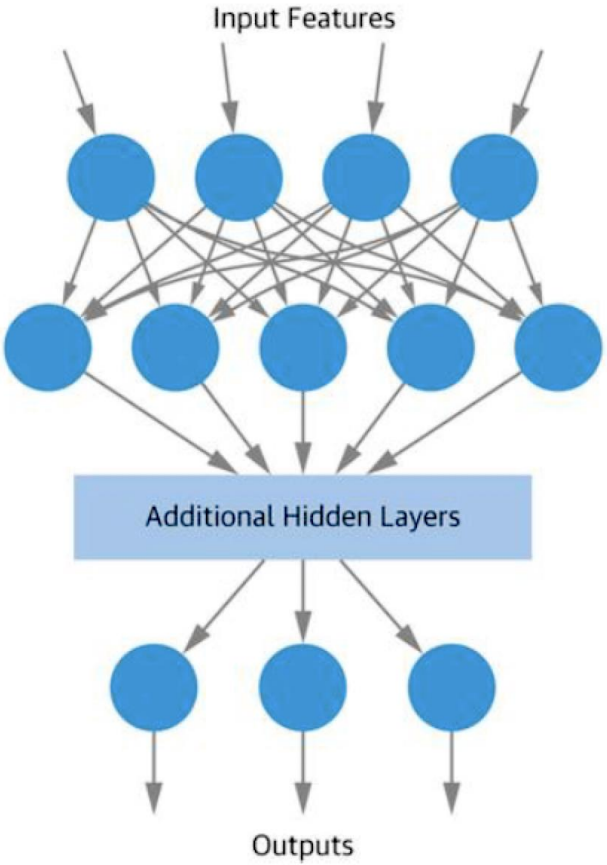
Les études de cette rubrique permettent d'avoir une vision large des soins de ville et hospitaliers pris en charge par l'Assurance maladie et le système de santé.

Médico-économique et sociale

Cette rubrique concerne les études sur la consommation de soins ou des différents types de prestation et leurs coûts (ville, hôpital, indemnités journalières) selon de nombreuses caractéristiques de couverture maladie (CMU-C, ACS, ALD, handicap, invalidité…) en lien avec l'environnement économique et social.

Epidémiologie et vigilance

Cette rubrique propose des études réalisées notamment par des équipes d'épidémiologistes y compris de pharmacovigilance et souvent en lien avec des experts de l'Assurance Maladie. Il s'agit principalement des études réalisées dans le but d'évaluer l'efficacité comparative des produits de santé et/ou les risques qui y sont associés, incluant une description synthétique des pathologies prises en charge par le système de santé.



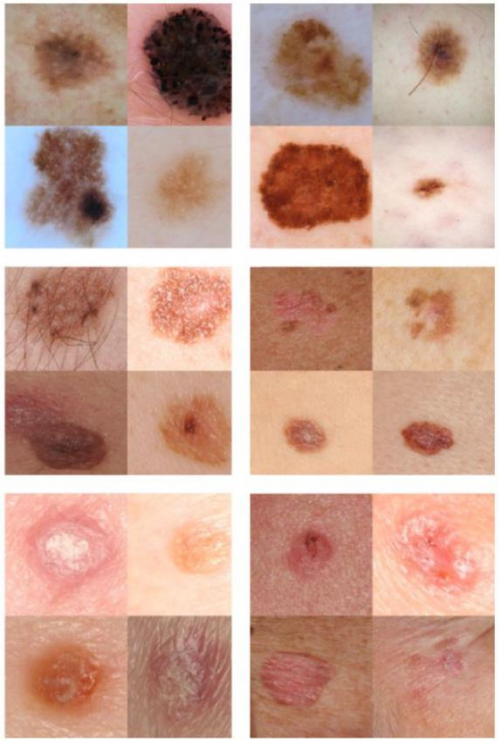
Deep convolutional neural networks « DNN » (réseau de neurones connectés)

- *Imitate the multilayered organization of the visual cortex*
- *Neural networks transform input volumes of data (for example the pixels in an image) on the basis of the weights of each connection, which are determined a priori by training the network with known input and output volumes*

Auspicious machine learning. Nat Biomed Eng

Dermatologist-level classification of skin cancer with deep neural networks

Andre Esteva[1]*, Brett Kuprel[1]*, Roberto A. Novoa[2,3], Justin Ko[2], Susan M. Swetter[2,4], Helen M. Blau[5] & Sebastian Thrun[6]

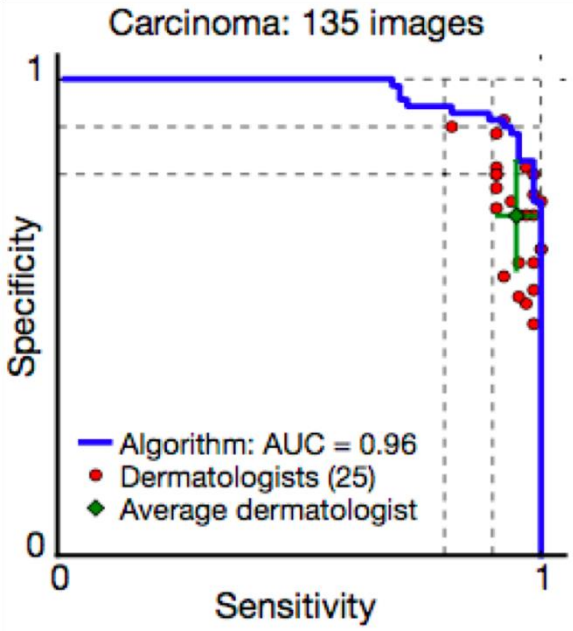


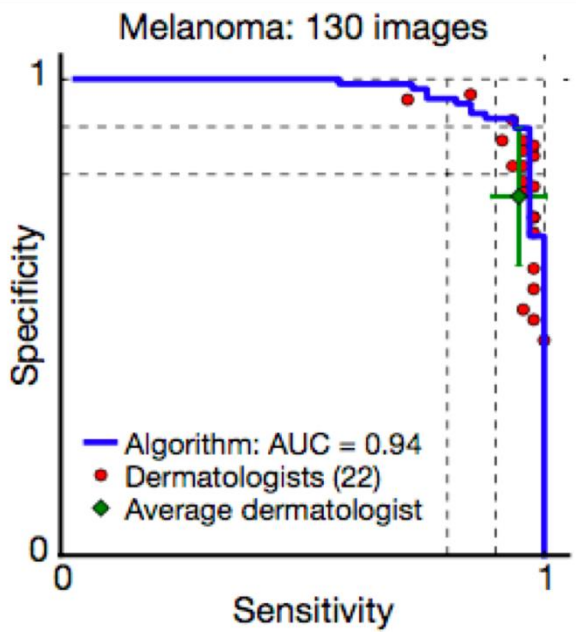
1. Algorithm construction
Dataset of 129,450 clinical images
consisting of 2,032 different diseases.

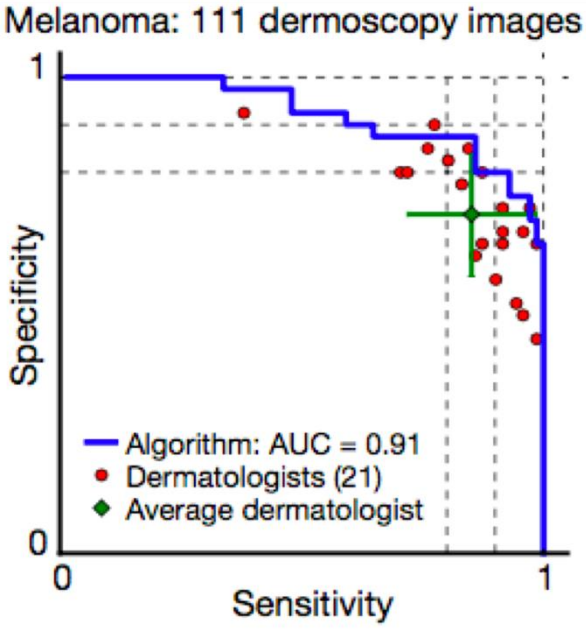
2. Test IA performance against 21 board-certified dermatologists on 376 biopsy-proven clinical images
- keratinocyte carcinomas versus benign seborrheic keratoses;
- malignant melanomas versus benign nevi

Dermatologist-level classification of skin cancer with deep neural networks

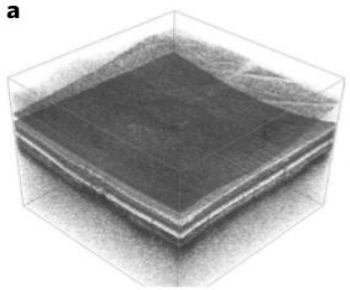
Andre Esteva[1]*, Brett Kuprel[1]*, Roberto A. Novoa[2,3], Justin Ko[2], Susan M. Swetter[2,4], Helen M. Blau[5] & Sebastian Thrun[6]







Clinically applicable deep learning for diagnosis and referral in retinal disease



Digital OCT scan

- De Faw J et al. *Nature Medicine*, 2018
- Data:
  - Training set: 14,884
  - Test set: 997
- Method:
  - 4 diagnosis categories: urgent > semi-urgent > routine > observation only
  - **Such categories directly predicted by the algorithm**, along with 10 pathologies
  - Deep learning against 8 experts
- Reference annotation:
  - examining the subsequent patient clinical records
  - **Such a gold standard can only be obtained retrospectively**
- Results: Deep learning is comparable or better than clinical experts

Aide au diagnostic et imagerie

Cardiologs CE FDA

BIG DATA FOR HEART SCREENING

Chatbots médicaux

- Clustaar
- Khresterion
- Mojotbots.ai
- Synapse medecine
- Wefight

Insurtech

- ADDON-acs
- Alan
- Shift technologies

Handicap

- A.I.Mergence
- Leka
- Panda guide
- Robocath
- Wandercratft
- Yumii

Objets connectés et monitoring

- @-Health
- Auxivia
- BioSerenity
- Bodycap
- D Chronolife
- Data for life
- Diabeloop
- E-vone
- Feetme
- i-Nside
- Ironova
- Life Plus
- Neogia
- NextMind
- Pkvitality
- Plume labs
- Rythm
- Sensome
- WitMonki

Divers

- Babyprogress
- Silkke

Gestion parcours patient et hospitalier

- DeepOR
- Eurekam
- Exelus
- Honestica
- MyDisease2EZ
- Sancare`
- Syadem

Analyse du comportement et prévention

- Ad Scientam
- AImerging Health
- Alantaya
- Angel Assistance
- Bebocap
- Betterise Health Tech
- Biomouv
- Bloomizon
- Cardiologs Technologies
- ExactCure
- Foodvisor
- Implicity
- Kap Code
- Lucine
- Mensia Technologies
- Qalyo
- Smarter time
- Telegrafik

Recherche biologique et pharmaceutique

- Alphanozos
- Carenity
- Dexstr.io
- Iktos
- Inato
- Keen Eye Technologies
- Owkin
- Pixyl
- Qynapse
- SeqOne
- Synsight
- Traaser

bpifrance Le Hub

FRENCH STARTUPS IN

SANTÉ & AI

Ce mapping a été élaboré pour mieux décrypter et visualiser le paysage entrepreneurial français du secteur de l'e-santé en recensant les startups créées après 2010 et utilisant au moins une des technologies suivantes : machine learning / deep learning / systèmes experts. Il n'est pas exhaustif et n'a pas pour objectif de promouvoir des acteurs ou activités spécifiques du secteur.

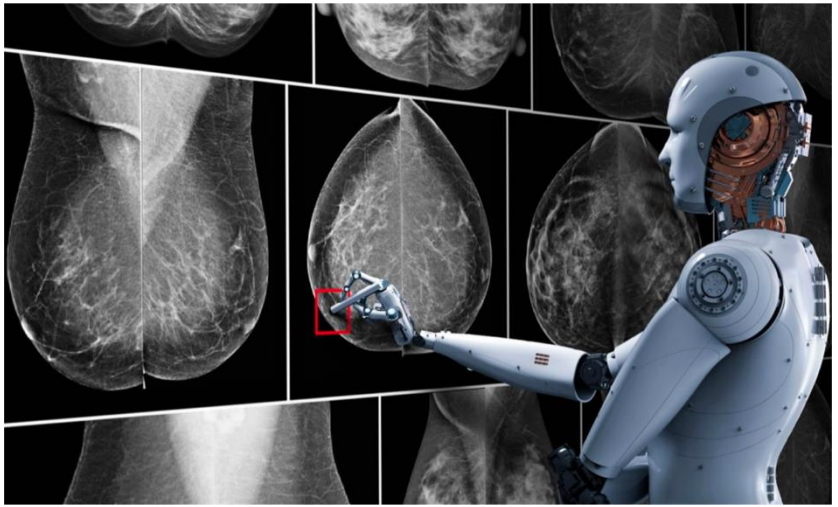
Direction des Filières Industrielles

Mars 2018

A.I. Improves Breast Cancer Diagnoses

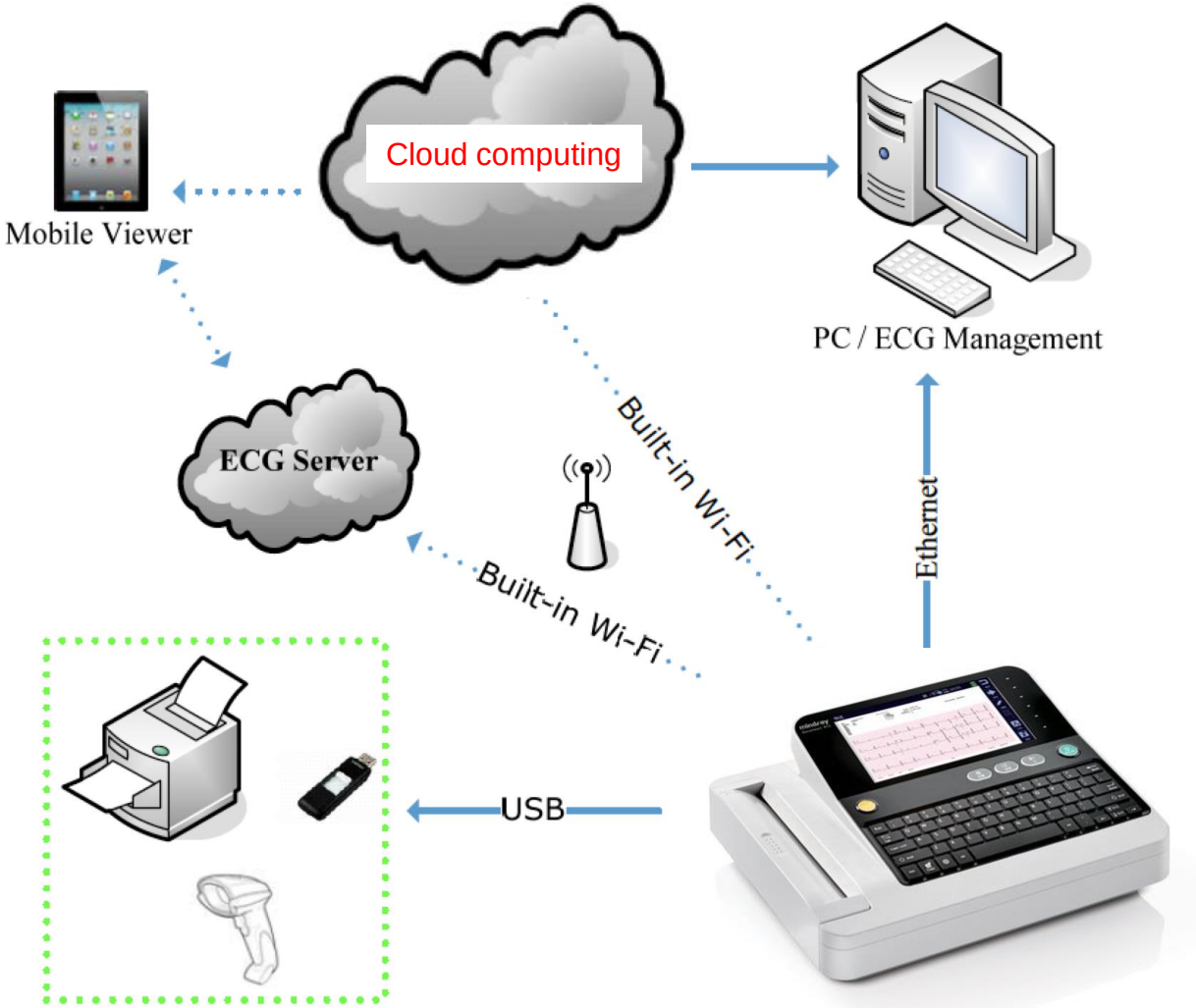
by factoring out False Positives

- Breast cancer, mammogram, false positives problematic
- Therapixel : French start-up
- AI algorithms to reduce the number of patients who undergo biopsies when no cancer is present.
- 10,000 standard mammograms
- Therapixel reduced significantly the number of false positives (win “ The Digital Mammography Challenge”)



“Algorithms can now achieve better detection rates than radiologists”

Cardiologs



Local Analysis Program

Cardiologs
BIG DATA FOR HEART SCREENING

Improved interpretation of atrial dysrhythmias by a new neural network ECG interpretation algorithm

Stephen W. Smith*, Jeremy Rapin$, Jia Li$, Brooks M. Walsh+, Arnaud Rosier#$, Laurent Fiorina#, Kenneth W. Dodd*, Pierre Taboulet#$.
*Department of Emergency Medicine Hennepin County Medical Center ❖ Minneapolis, Minnesota
*Hennepin County Medical Center, +Bridgeport Hospital, CT; #Various institutions in France; $Cardiologs

Objectives

We sought to assess both (1) the accuracy of a new neural network ECG Algorithm (CardioLogs®) in the interpretation of atrial dysrhythmias, and (2) the effect of incorrect automated interpretation on the accuracy of medical doctors (MD) overread.

Methods

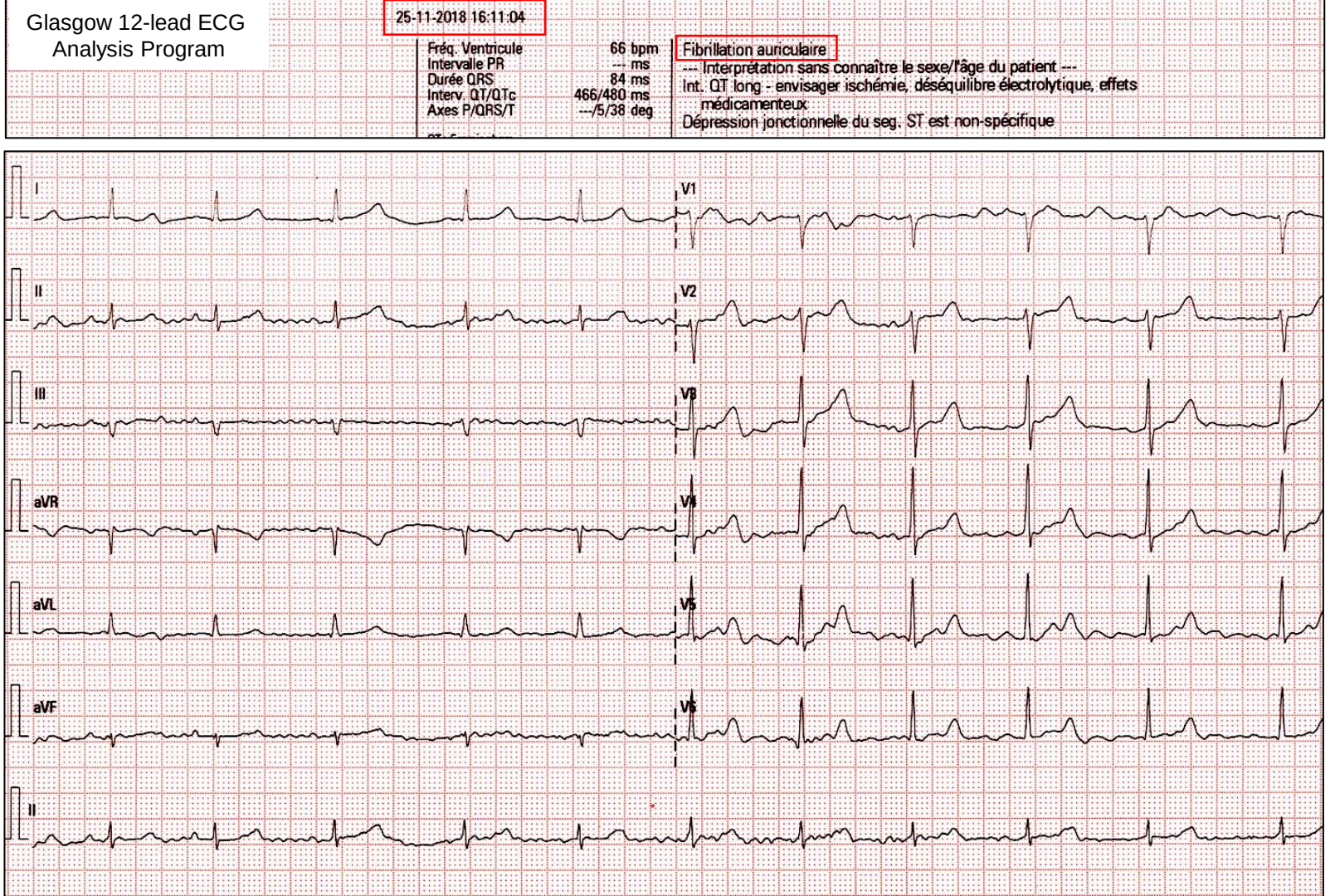
Consecutive 500 ECGs with suspected AF-AT-AFL by any algorithm were interpreted by

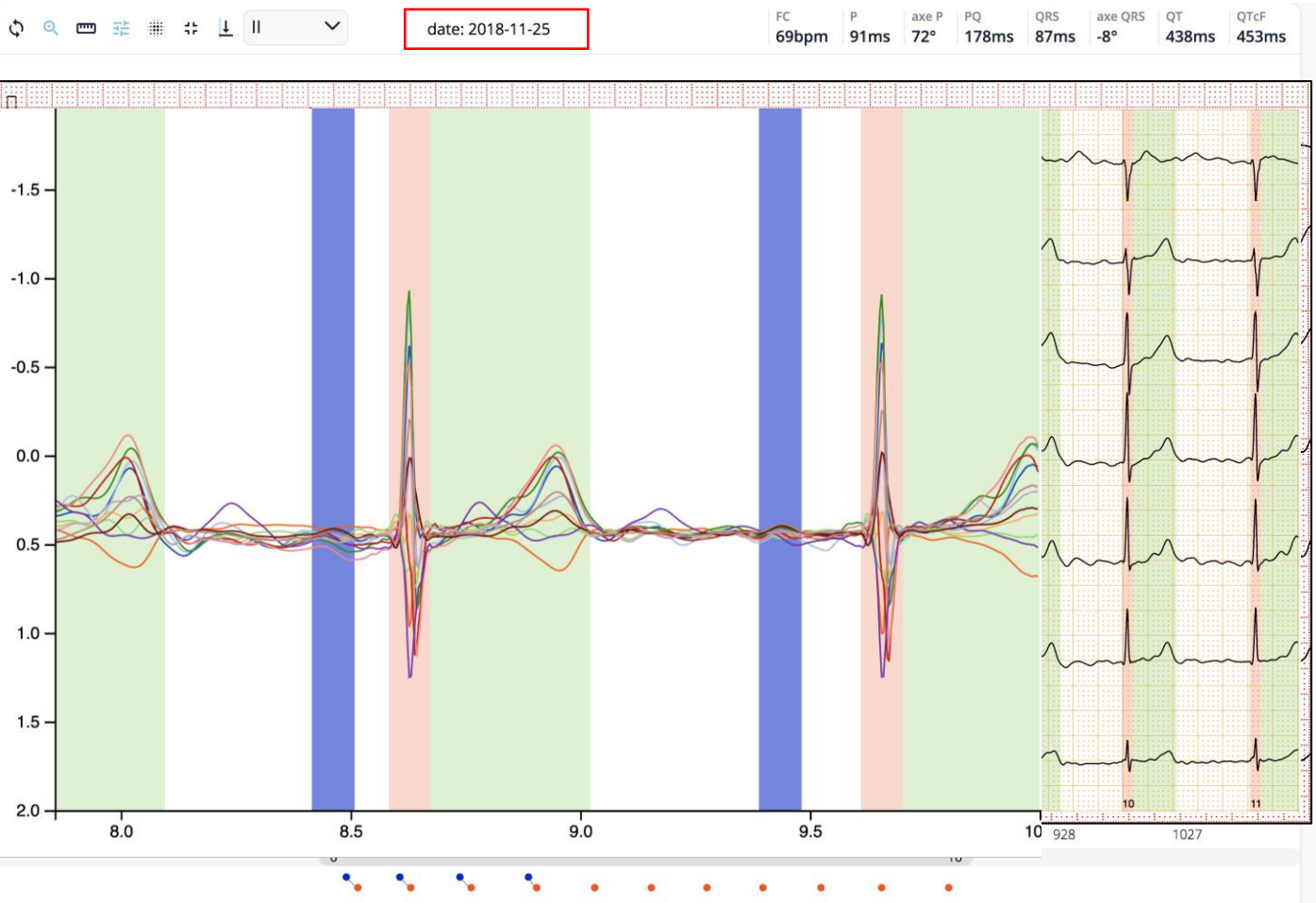
a) Veritas®-Alg
b) Physicians (ED or C), who overread V-Alg
c) CardioLogs®-Alg

Group/utility	Sensitivity	P-value	Specificity	P-value	Accuracy	P-value
Cardiologs	97.5%		73.0%		**92.6%**	
Veritas	96.0%	0.23	16.0%	<0.0001	**80.0%**	<0.0001
Veritas + MD	96.0%	0.23	65.0%	0.22	**89.8%**	0.11

« Incorrect ADs significantly reduce the reader's diagnostic accuracy » Bond RR et al J Electrocardiol. 2018 (51)

Glasgow 12-lead ECG Analysis Program





Commencer votre diagnostic

Cardiologs

sauvegarder annuler

ECGPredict - 2.0.0
Nov 26, 2018

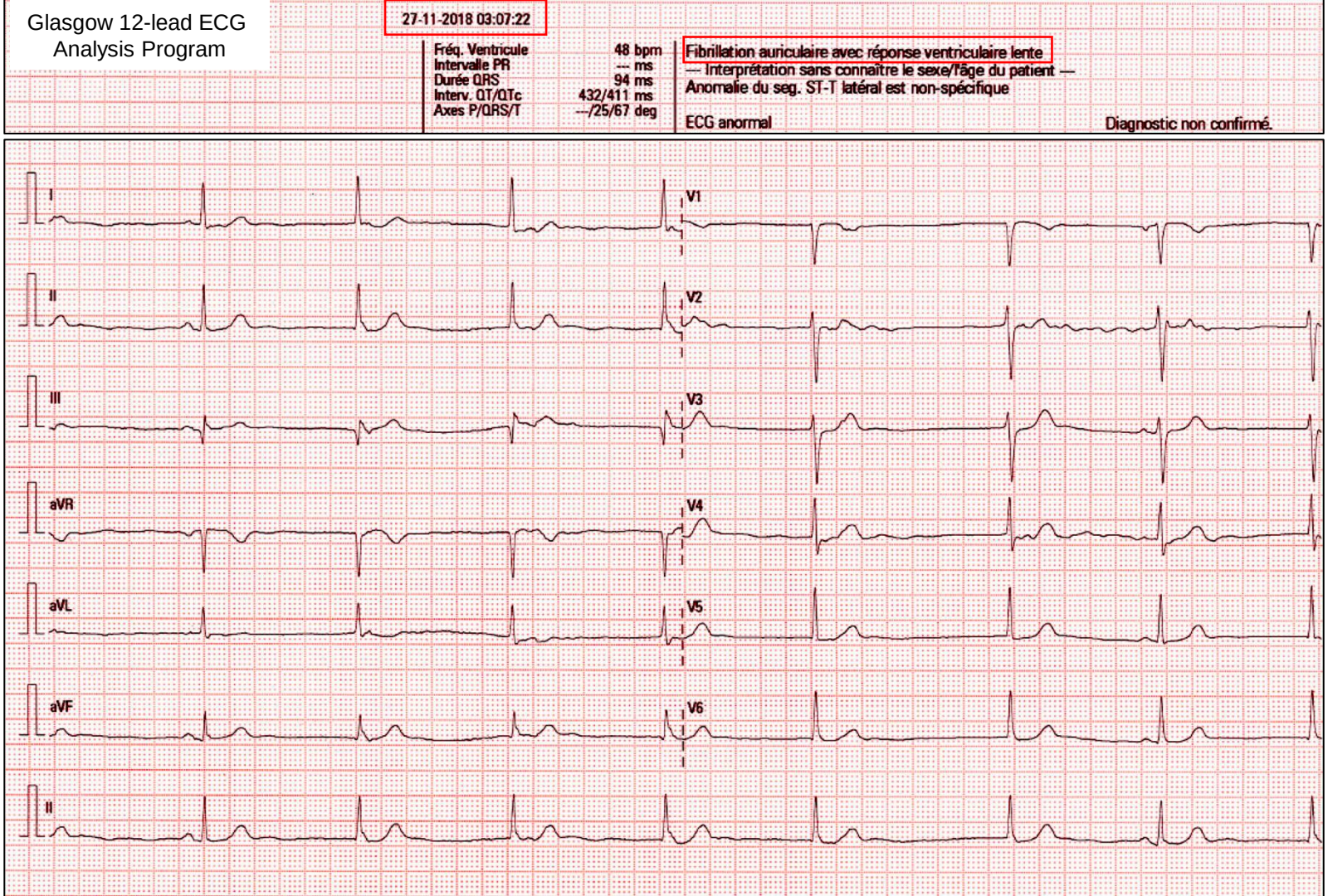
Rythme sinusal

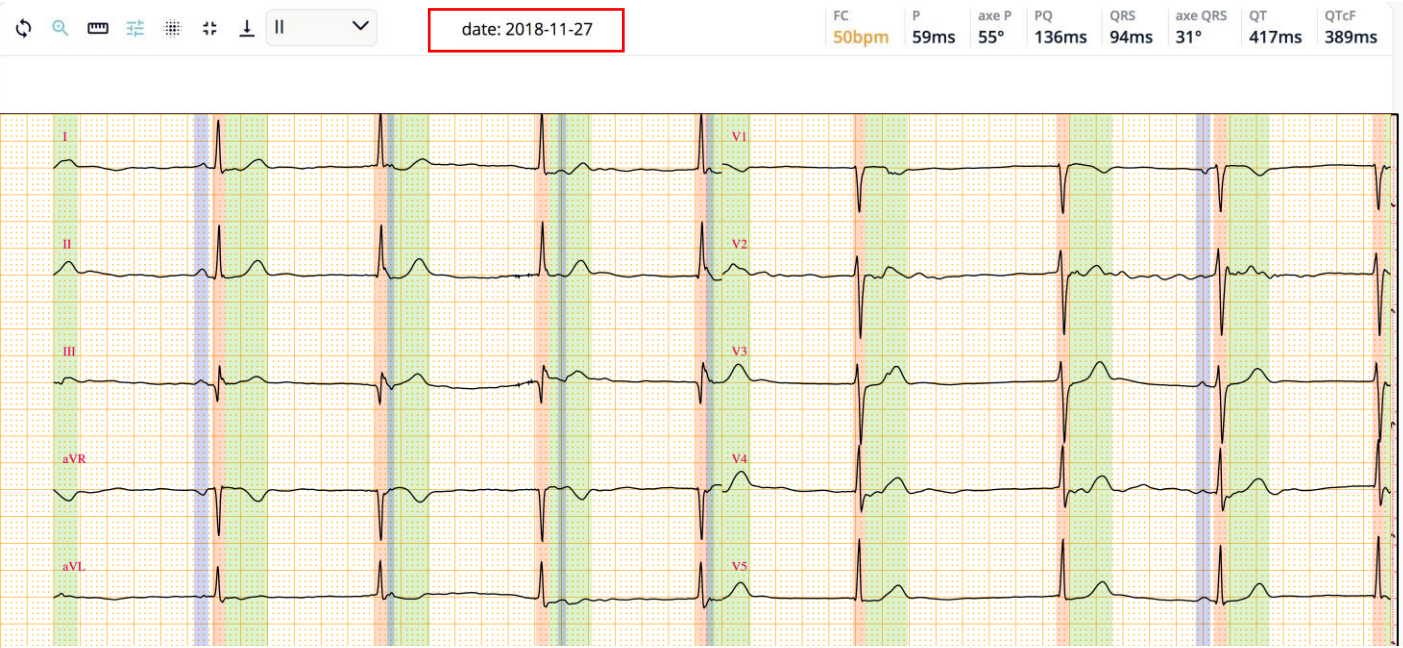
Intervalle QTc borderline (430 - 470 ms)

MR2018112516103786_25112018161104....

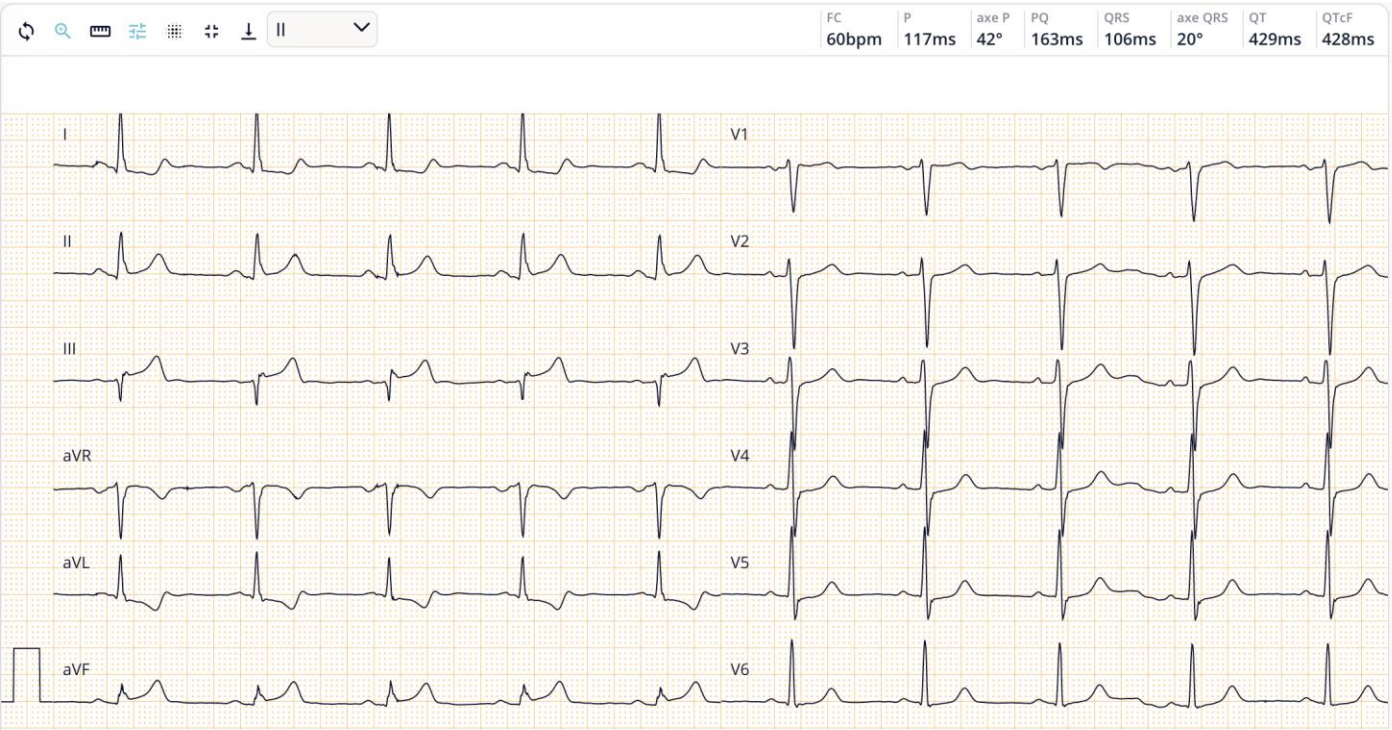
nozYzM0D

Glasgow 12-lead ECG Analysis Program





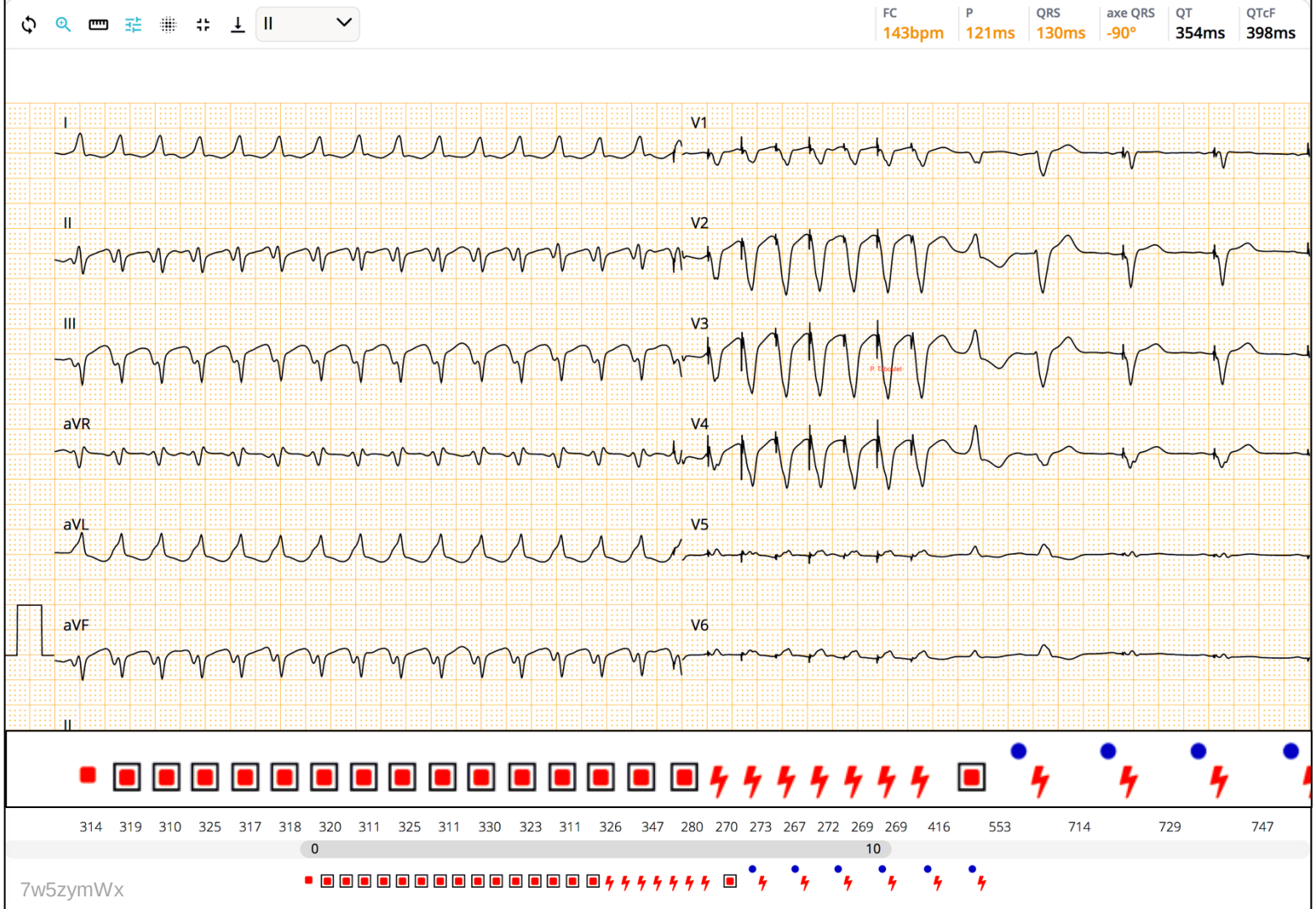
Rythme sinusal 0.492
Rythme d'échappement jonctionnel 0.655
BAV2 - Bloc AV 2e degré Mobitz 1 0.054
BAV3 - Bloc AV 3e degré (complet) 0.081
X - Tracé de mauvaise qualité/artefacts/parasites 0.055
QRS - Complexe(s) d'échappement jonctionnel 0.182
Dysfonction sinusale, BSA ou arrêt sinusal 0.591
BAV - Bloc AV de 2e, 3e ou haut degré 0.315



- Rythme sinusal 0.995
- QRS anormaux non spécifiques 0.327
- Cor - Probable infarctus avec sus-décalage de ST (SCA ST+) 0.936
- Onde T+ ample, ischémie myocardique possible 0.128
- Anomalie non spécifique de l'onde T 0.081

vx0j5WAo

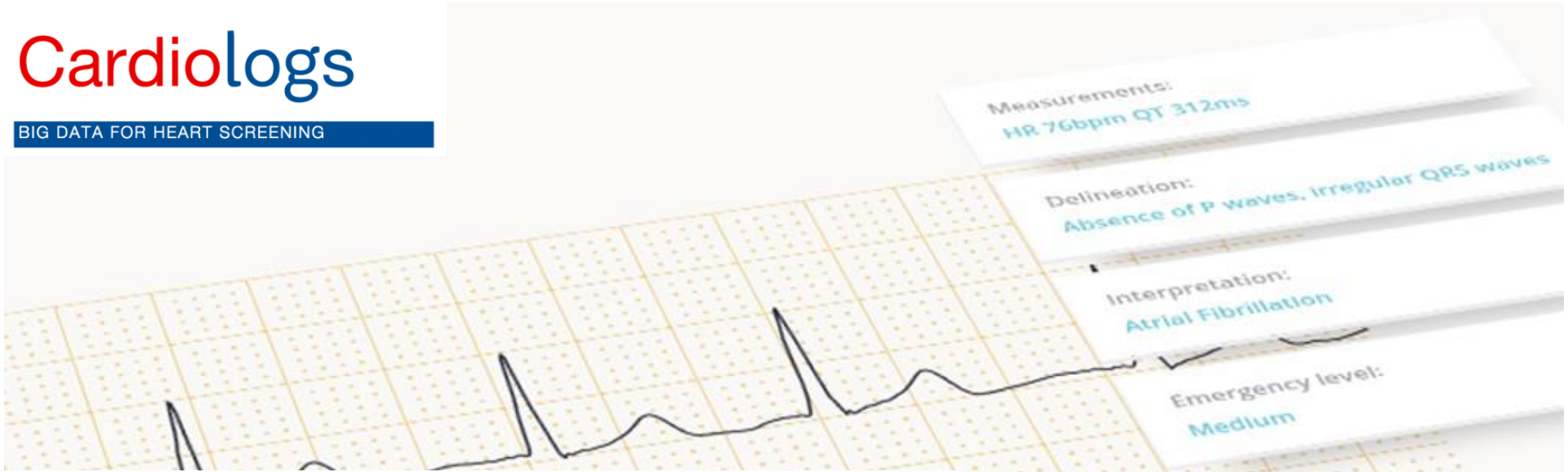

date: 2017-12-18
FC 70bpm
P 122ms
axe P 45°
PQ 184ms
QRS 97ms
axe QRS 23°
QT 404ms
QTcF 428ms
Smith 3 15
V1
V2
V3
V4
V5
V6
II
II
1 2 3 4 5 6 7 8 9 10 11 12
864 868 845 838 808 795 836 907 911 945 974
0 10
test algo 201806 - 0.1
Sep 10, 2018
Rythme sinusal
QRS anormaux non spécifiques
K - Hyperkaliémie probable
Repolarisation variante de la normale (précoce...)


FC
143bpm
P
121ms
QRS
130ms
axe QRS
-90°
QT
354ms
QTcF
398ms
I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6
II
314 319 310 325 317 318 320 311 325 311 330 323 311 326 347 280 270 273 267 272 269 269 416 553 714 729 747
0
10

7w5zymWx

Cardiologs

BIG DATA FOR HEART SCREENING



ELSEVIER

Journal of Electrocardiology

Available online 16 November 2018

In Press, Accepted Manuscript

A deep neural network learning algorithm outperforms a conventional algorithm for emergency department electrocardiogram interpretation

Stephen W. Smith MD [a, b], Brooks Walsh MD [c], Ken Grauer MD [d], Kyuhyun Wang MD [f], Jeremy Rapin Ph.D. [h], Jia Li [h], William Fennell M.D. [e], Pierre Taboulet M.D. [h, g]

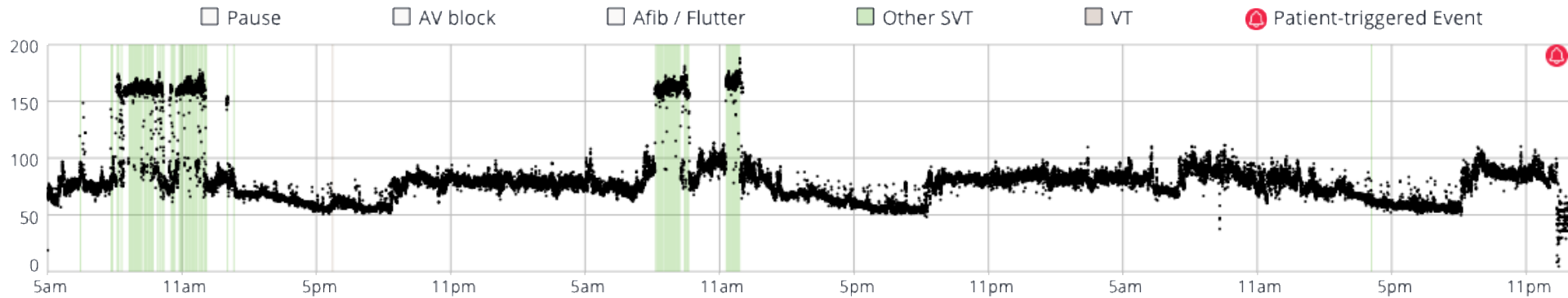
Recherchons des bases de données

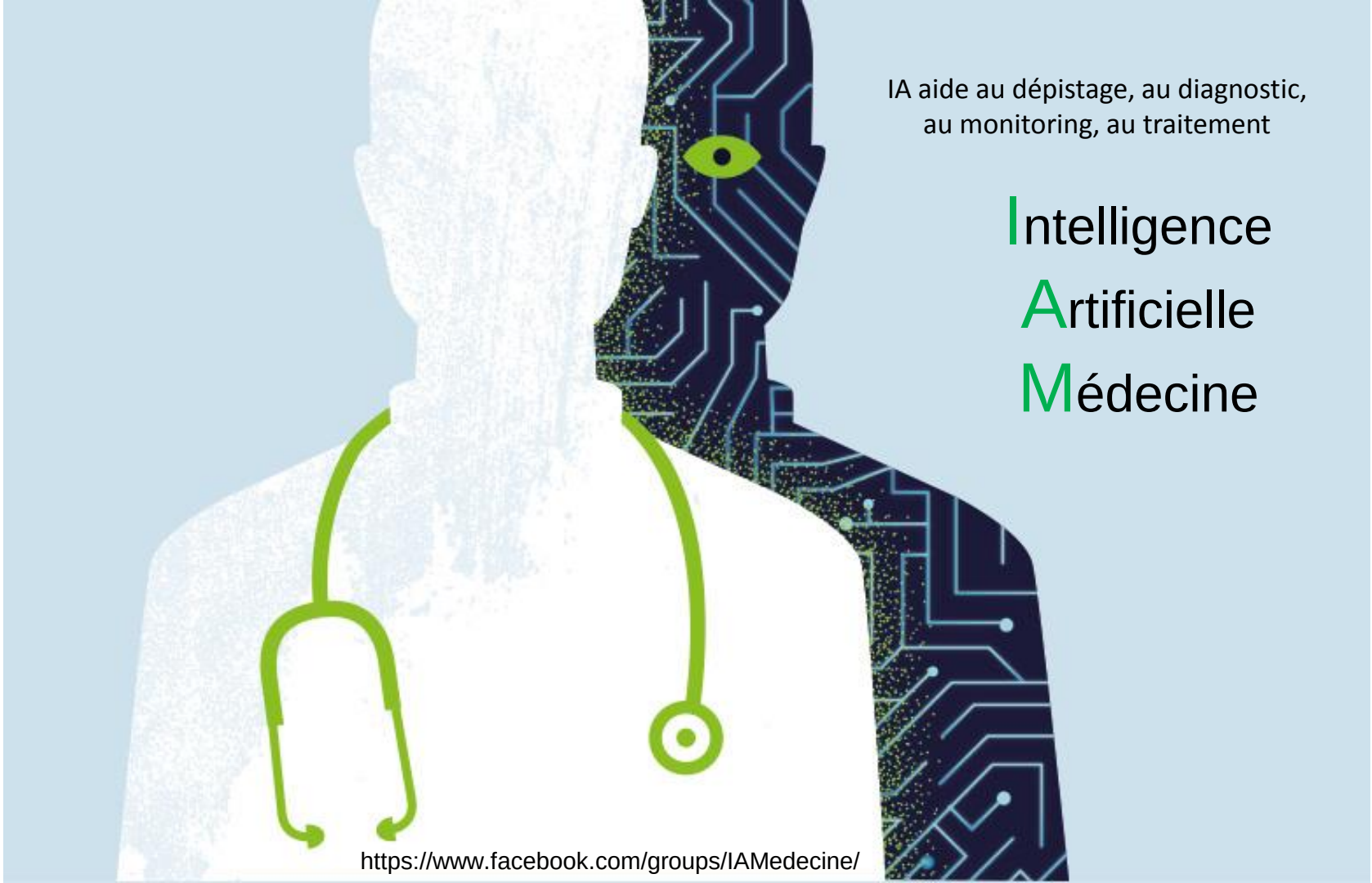
Prolonged or long-term Holter-ECG

(FDA approval)

Cardiologs

BIG DATA FOR HEART SCREENING



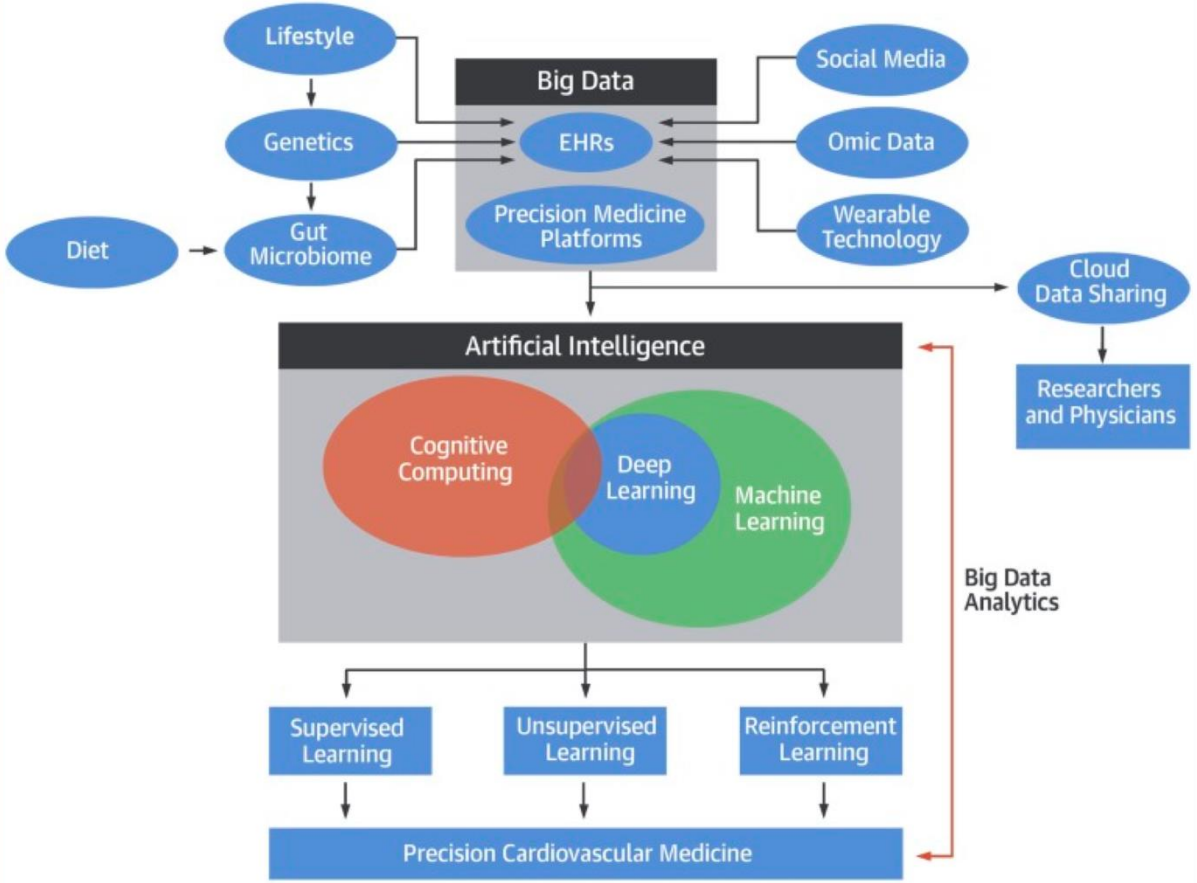


IA aide au dépistage, au diagnostic,
au monitoring, au traitement

Intelligence
Artificielle
Médecine

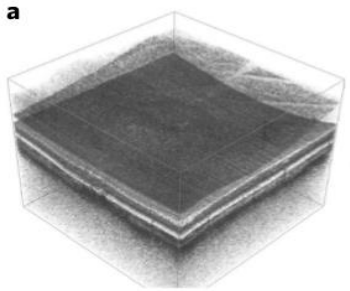
https://www.facebook.com/groups/IAMedecine/

CENTRAL ILLUSTRATION: Artificial Intelligence in Precision Cardiovascular Medicine



Krittanawong, C. et al. J Am Coll Cardiol. 2017;69(21):2657-64.

Clinically applicable deep learning for diagnosis and referral in retinal disease



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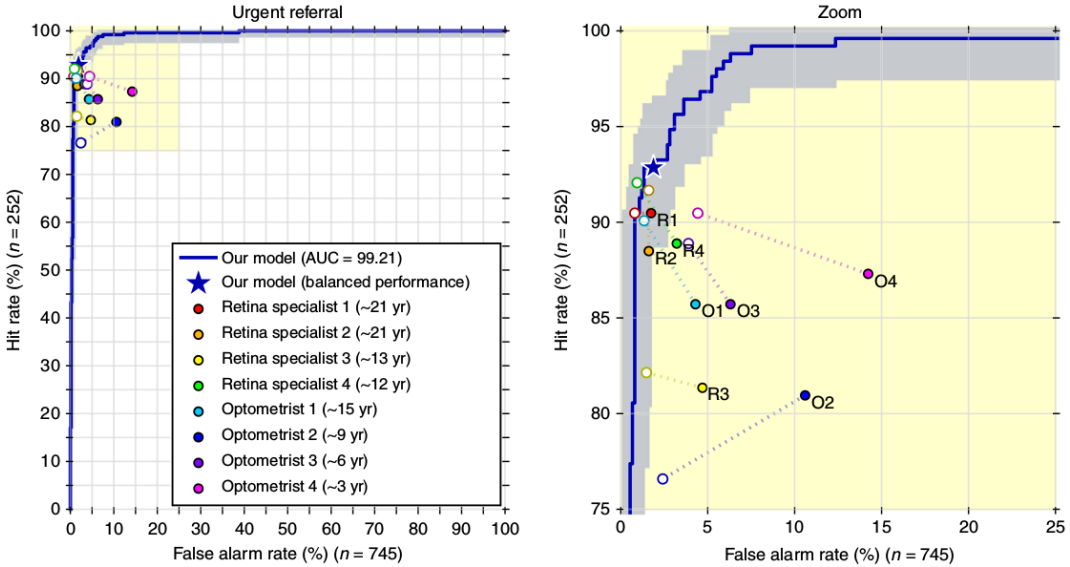
- Results: Deep learning is comparable or better than clinical experts

Clinically applicable deep learning for diagnosis and referral in retinal disease

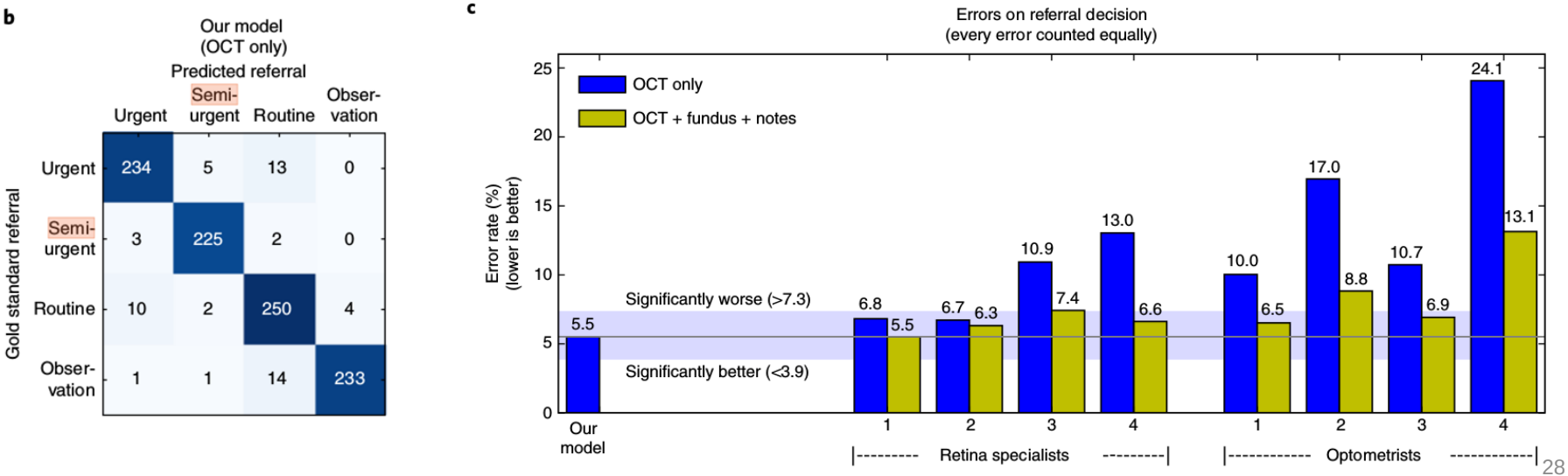
Detection of urgent cases
Binary classification

Filled markers: OCT only
Open markers: OCT + fundus image + summary note



Clinically applicable deep learning for diagnosis and referral in retinal disease

Classification of referrals



AI Improves Breast Cancer Diagnoses by Factoring Out False Positives

- Breast cancer, mammogram, false positives problematic
- Therapixel : French start-up
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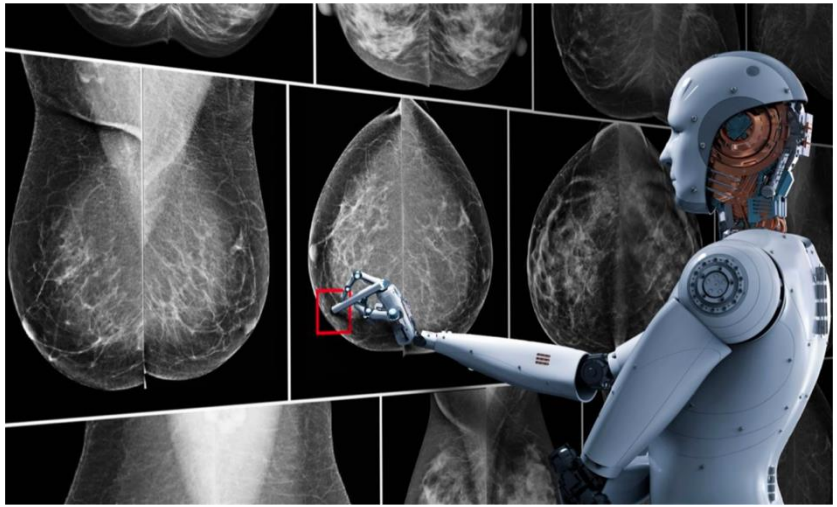
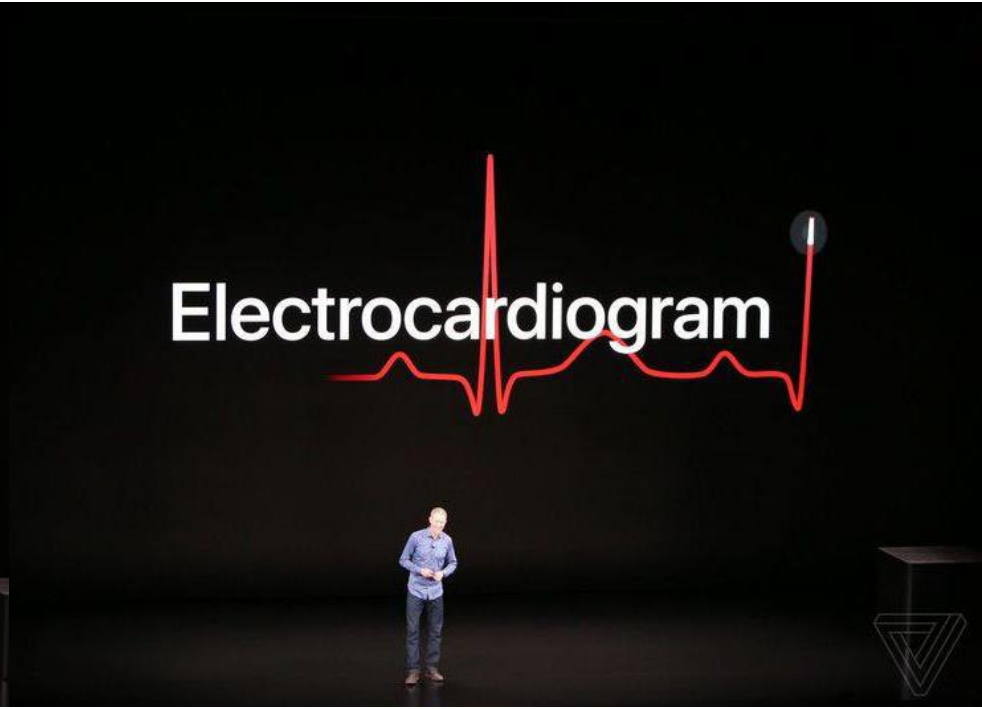


“Algorithms can now achieve better detection rates than radiologists”



JAMA Cardiology | Original Investigation

Passive Detection of Atrial Fibrillation Using a Commercially Available Smartwatch

When GAFA meet JAMA

Geoffrey H. Tison, MD, MPH; José M. Sanchez, MD; Brandon Ballinger, BS; Avesh Singh, MS; Jeffrey E. Olgin, MD; Mark J. Pletcher, MD, MPH; Eric Vittinghoff, PhD; Emily S. Lee, BA; Shannon M. Fan, BA; Rachel A. Gladstone, BA; Carlos Mikell, BS; Nimit Sohoni, BS; Johnson Hsieh, MS; Gregory M. Marcus, MD, MAS

Journal of Electrocardiology
Available online 16 November 2018
In Press, Accepted Manuscript

A deep neural network learning algorithm outperforms a conventional algorithm for emergency department electrocardiogram interpretation

Stephen W. Smith MD [a, b], Brooks Walsh MD [c], Ken Grauer MD [d], Kyuhyun Wang MD [f], Jeremy Rapin Ph.D. [h], Jia Li [h], William Fennell M.D. [e], Pierre Taboulet M.D. [h, g]

Table 7. Diagnostic Performance of Cardiologs® vs. Veritas® for identifying an ECG with at least one major abnormality, among the 914 cases that did not require tiebreaking.

Major Abnormalities	Cardiologs®, % (95% CI)	Veritas®, % (95% CI)	p-value
Sensitivity	98.0 (95.6-99.1)	96.6 (93.8-98.1)	0.22
Specificity	96.6 (94.9-97.8)	88.6 (85.8-90.8)	<0.0001
PPV	93.2 (89.8-95.5)	79.9 (75.5-83.8)	<0.0001
NPV	99.0 (97.9-99.5)	98.2 (96.7-99.0)	0.24
Accuracy	97.0 (95.7-98.0)	91.1 (89.1-92.8)	<0.0001

Table 8c. Positive Predictive Value (True positives by the algorithm divided by all positives for that algorithm)

	Cardiologs®		Veritas®		P
	Number	%, 95% CI	Number	%, 95% CI	P
All abnormalities	448/527	85.0% (81.7-87.8)	420/671	62.6% (58.9-66.2)	< 0.0001
Major abnormalities	297/347	85.6% (81.5-88.9)	283/439	64.5% (59.9-68.8)	< 0.0001
Emergency abnormalities	20/28	71.4% (52.9-84.7)	17/33	51.5% (35.2-67.5)	0.1126

Abstract

Background

Cardiologs® has developed the first electrocardiogram (ECG) algorithm that uses a deep neural network (DNN) for full 12-lead ECG analysis, including rhythm, QRS and ST-T-U waves. We compared the accuracy of the first version of Cardiologs® DNN algorithm to the Mortara/Veritas® conventional algorithm in emergency department (ED) ECGs.

Methods

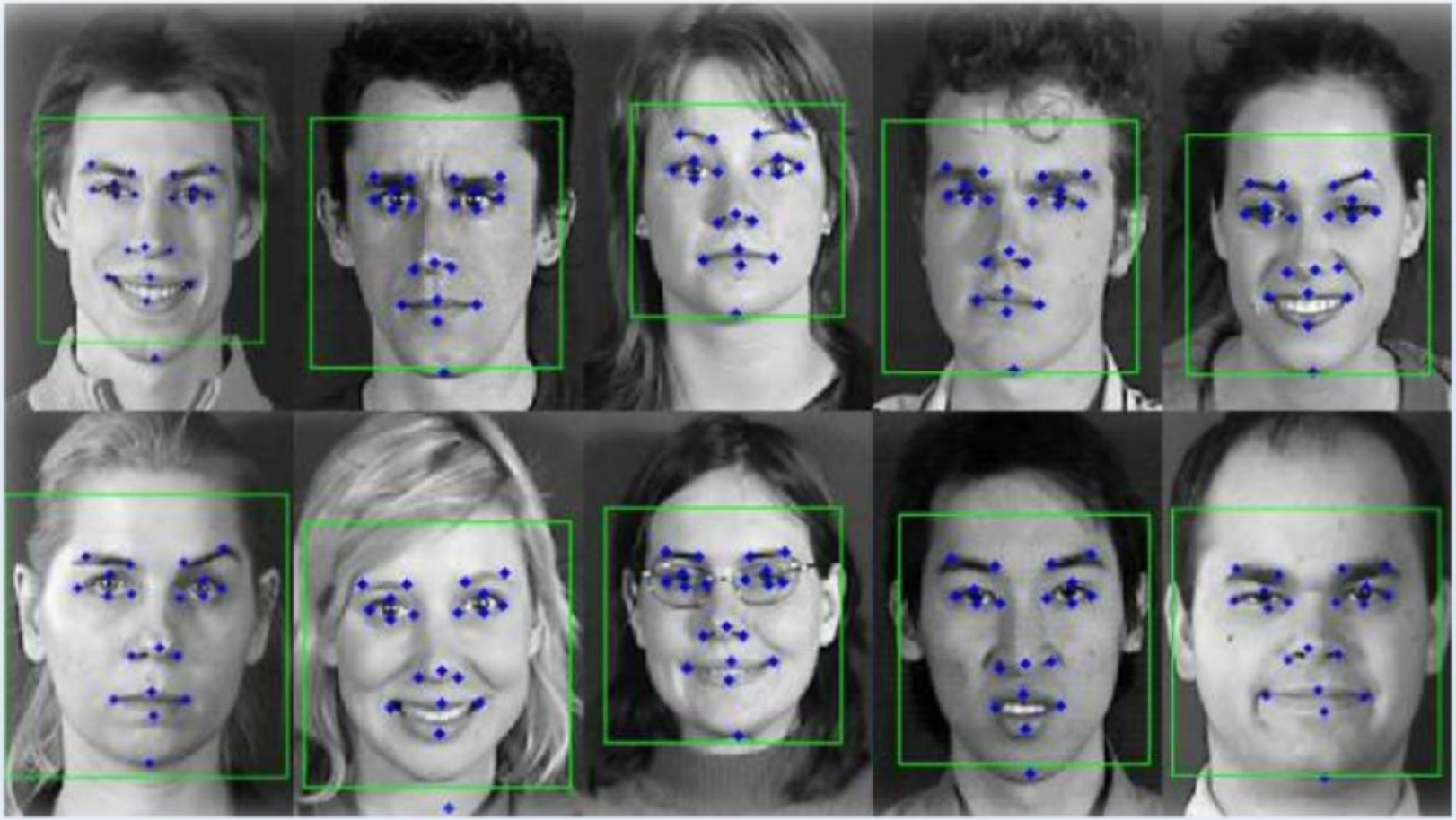
Individual ECG diagnoses were prospectively mapped to one of 16 pre-specified groups of ECG diagnoses, which were further classified as “major” ECG abnormality or not. Automated interpretations were compared to blinded experts'. The primary outcome was the performance of the algorithms in finding at least one “major” abnormality. The secondary outcome was the proportion of all ECGs for which all groups were identified, with no false negative or false positive groups (“accurate ECG interpretation”). Additionally, we measured sensitivity and positive predictive value (PPV) for any abnormal group.

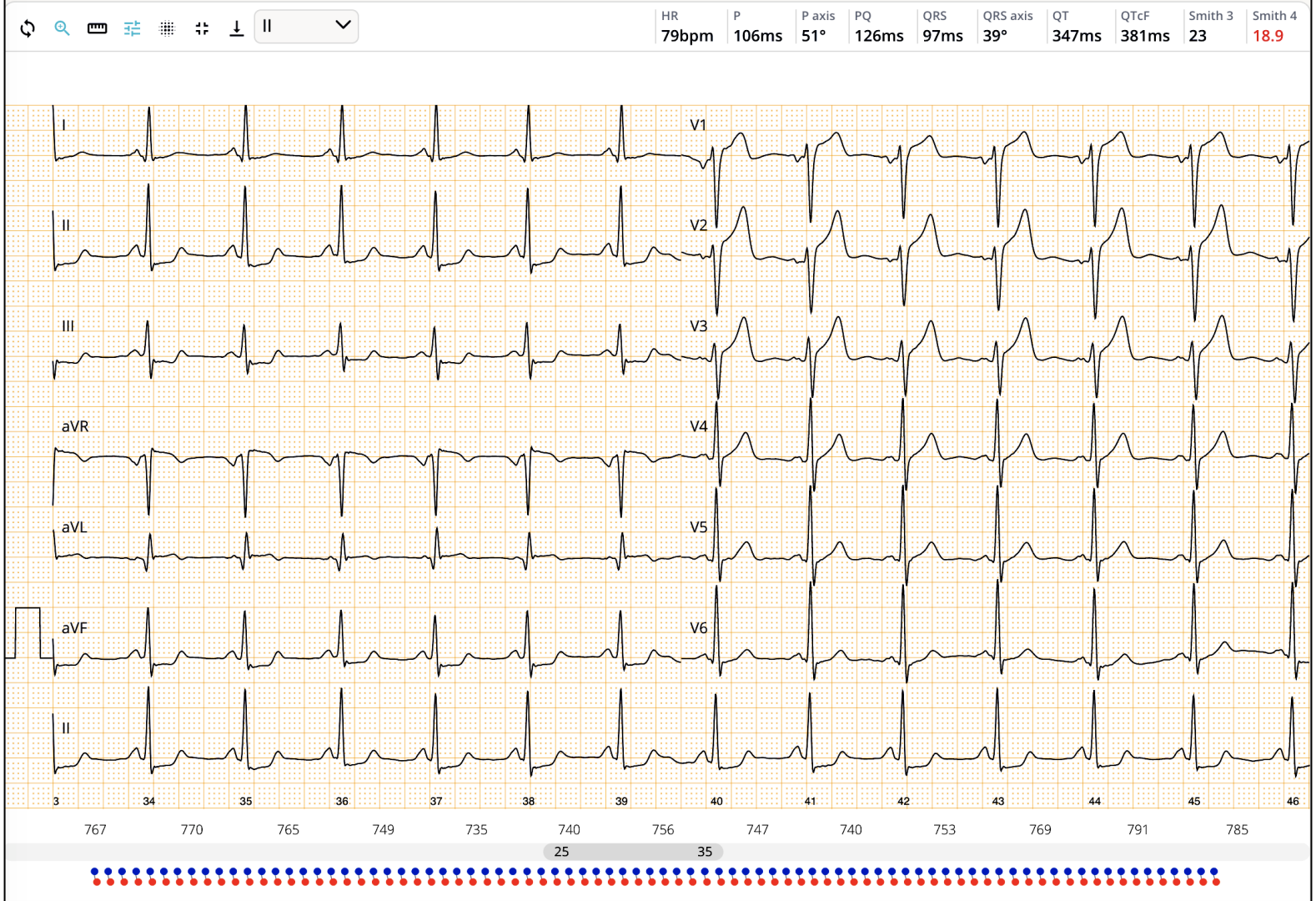
Results

Cardiologs® vs. Veritas® accuracy for finding a major abnormality was 92.2% vs. 87.2% (p<0.0001), with comparable sensitivity (88.7% vs. 92.0%, p=0.086), improved specificity (94.0% vs. 84.7%, p<0.0001) and improved positive predictive value (PPV 88.2% vs. 75.4%, p<0.0001). Cardiologs® had accurate ECG interpretation for 72.0% (95% CI: 69.6–74.2) of ECGs vs. 59.8% (57.3–62.3) for Veritas® (P<0.0001). Sensitivity for any abnormal group for Cardiologs® and Veritas®, respectively, was 69.6% (95CI 66.7–72.3) vs. 68.3% (95CI 65.3–71.1) (NS). Positive Predictive Value was 74.0% (71.1–76.7) for Cardiologs® vs. 56.5% (53.7–59.3) for Veritas® (P<0.0001).

Conclusion

Cardiologs' DNN was more accurate and specific in identifying ECGs with at least one major abnormal group. It had a significantly higher rate of accurate ECG interpretation, with similar sensitivity and higher PPV.




HR 79bpm
P 106ms
P axis 51°
PQ 126ms
QRS 97ms
QRS axis 39°
QT 347ms
QTcF 381ms
Smith 3 23
Smith 4 18.9
I
II
III
aVR
aVL
aVF
II
V1
V2
V3
V4
V5
V6
3 34 35 36 37 38 39 40 41 42 43 44 45 46
767 770 765 749 735 740 756 747 740 753 769 791 785
25 35

Commencer votre diagnostic

Cardiologs

sauvegarder annuler

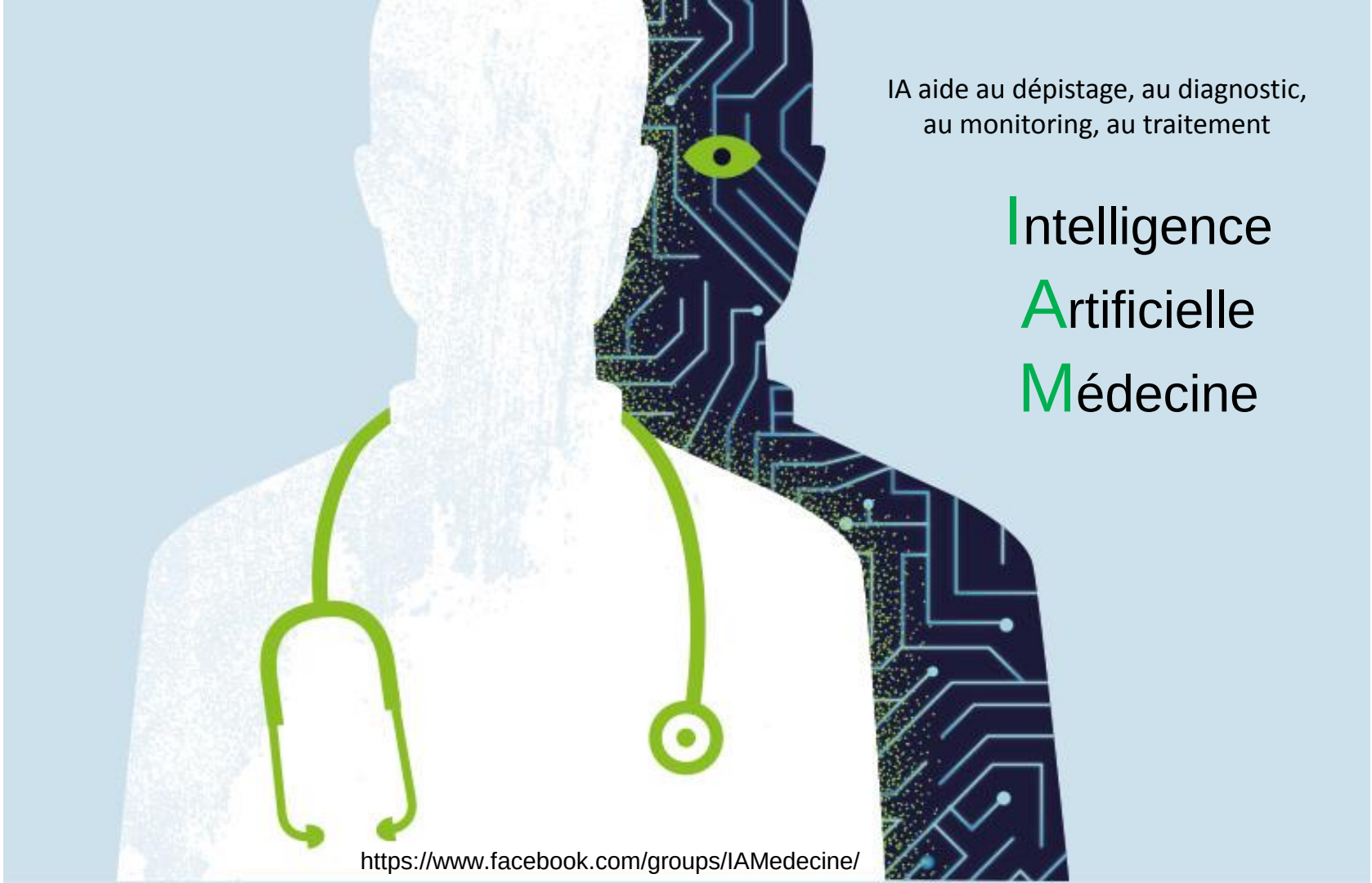
ECGPredict - 2.0.0
Sep 27, 2018

Dysfonction sinusale, BSA ou arrêt sinusal

Rythme d'échappement jonctionnel

Intervalle QTc borderline (430 - 470 ms)

MR2018050111135274_01052018111442....



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au monitoring, au traitement

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