



UNIVERSITÉ
CATHOLIQUE
DE LILLE 1875

Intelligence Artificielle en Cardiologie et en imagerie

Effet de mode ou promesse pour l'avenir ?
Alexandre Altes, Sylvestre Marechaux

I have no disclosure of interest

ARTIFICIAL INTELLIGENCE



ARTIFICIAL INTELLIGENCE EVERYWHERE

La big data en santé, une mine d'or de 12 milliards d'euros pour la Grande-Bretagne

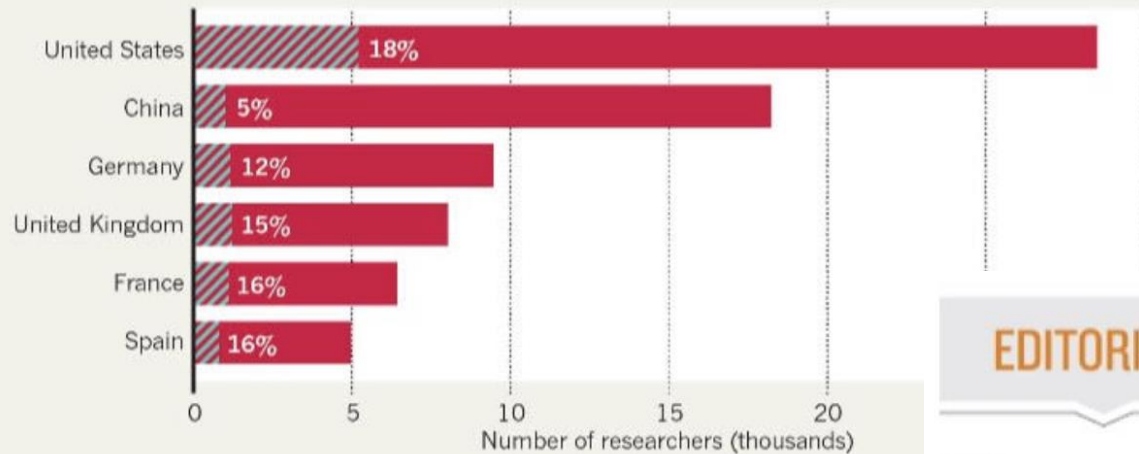
La NHS est assise sur un trésor convoité par l'industrie pharmaceutique.

Slate

AI TALENT CONCENTRATION

China has the second-largest number of researchers who have published AI papers or been issued patents in the past decade. But the proportion of those considered to be in the top 10% of the field is smaller than in other AI-leading nations.

■ Total AI talent ▨ Top AI talent



Nature 2019



China's huge population is helping the nation to make great strides in facial-recognition technology.

ARTIFICIAL INTELLIGENCE

China's ambitious quest to lead the world in AI by 2030

The United States is ahead in terms of high-impact AI papers and people, but for how long?

EDITORIALS

WORK-LIFE BALANCE Just say no to summer-holiday peer review p.417



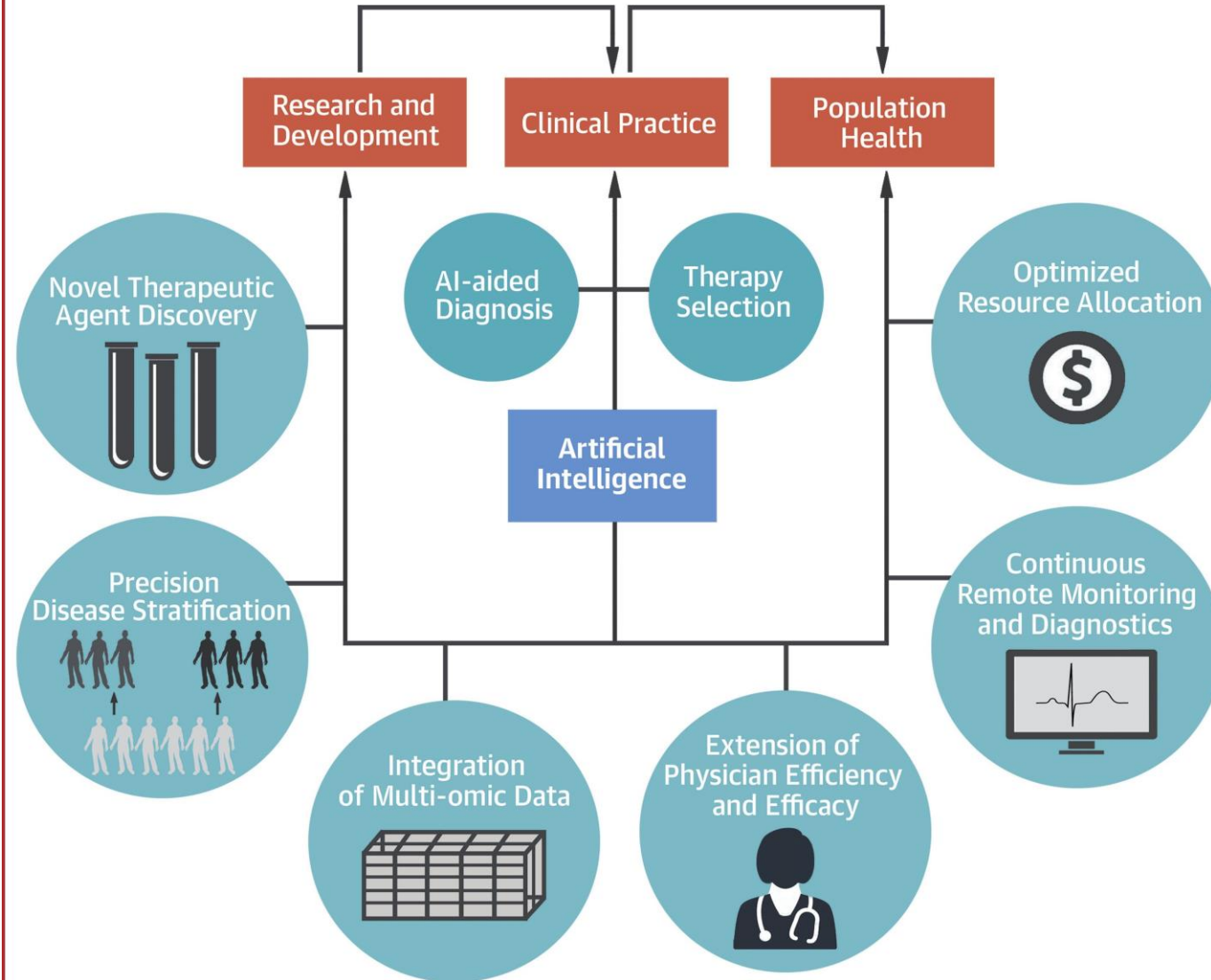
WAR STORIES Nations overstate their contribution to winning p.418

CLIMATE CHANGE July was the hottest month ever recorded on Earth p.420

Protect AI panel from interference

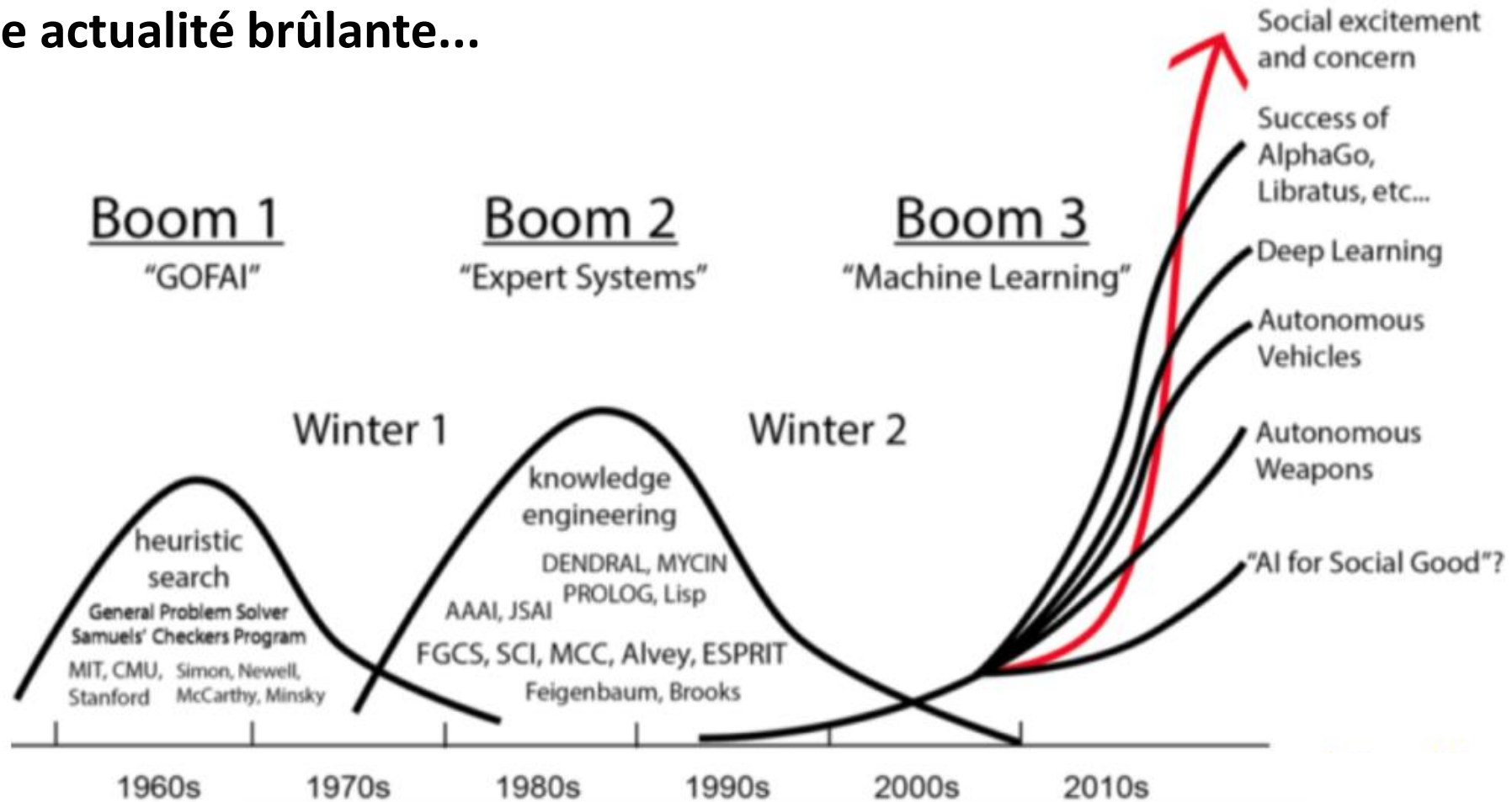
An important effort is under way to establish an international committee to advise on the ethics of artificial intelligence. The group should be supported and shielded from undue influence.

CENTRAL ILLUSTRATION: Role of Artificial Intelligence in Cardiovascular Medicine

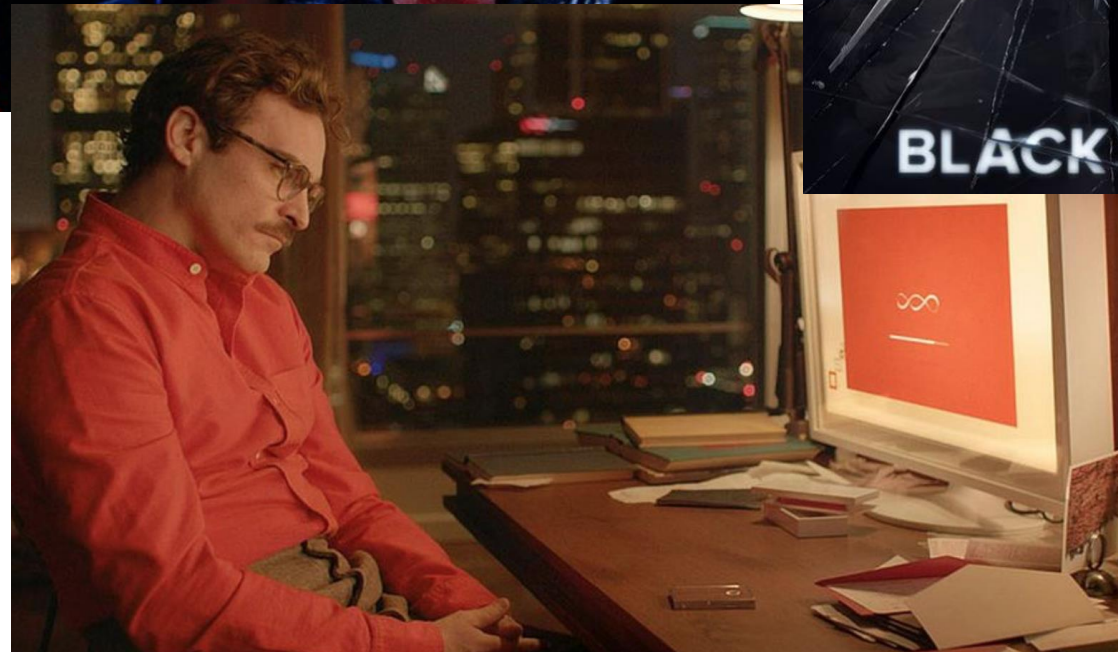
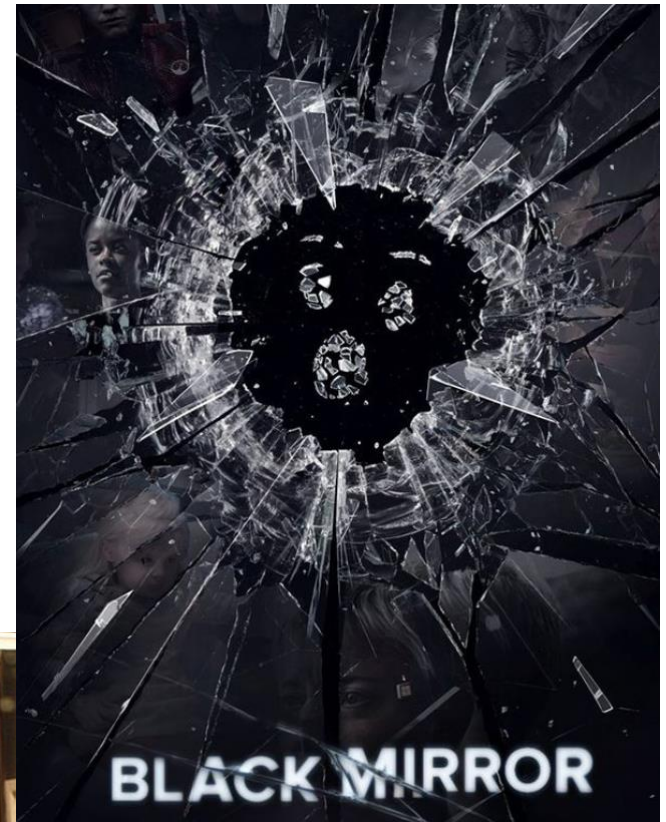


Johnson, K.W. et al. J Am Coll Cardiol. 2018;71(23):2668-79.

IA : une actualité brûlante...



....mais pas nouvelle !



Intelligence artificielle

- Simulation des capacités humaines comme la **perception, reconnaissance, traduction, dialogue**
- « Aide à la décision »

Machine Learning

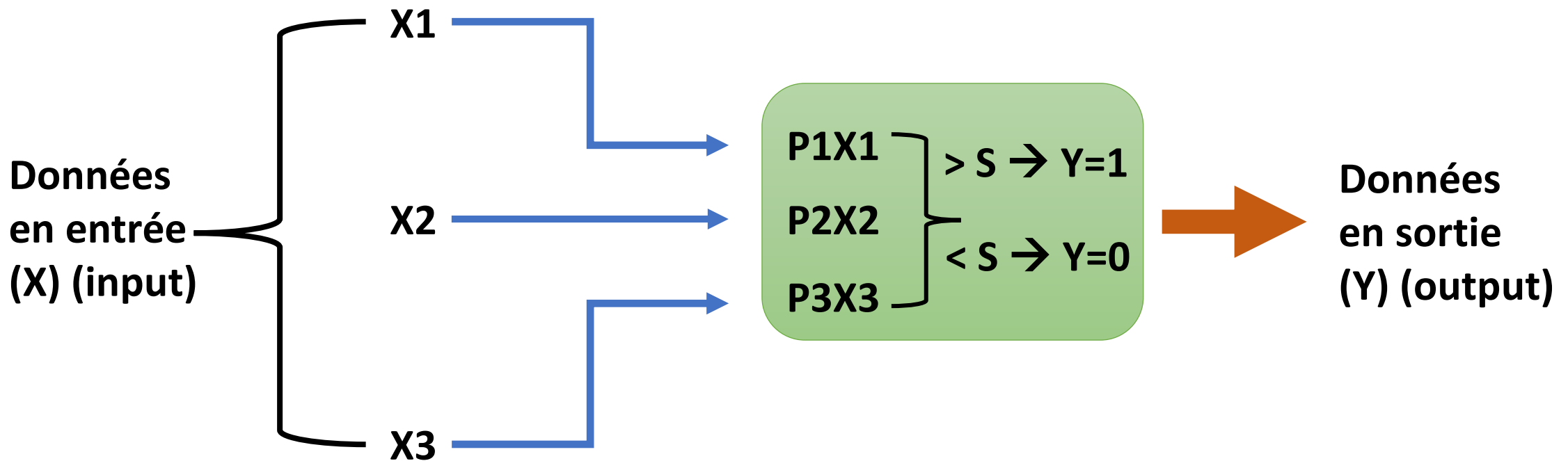
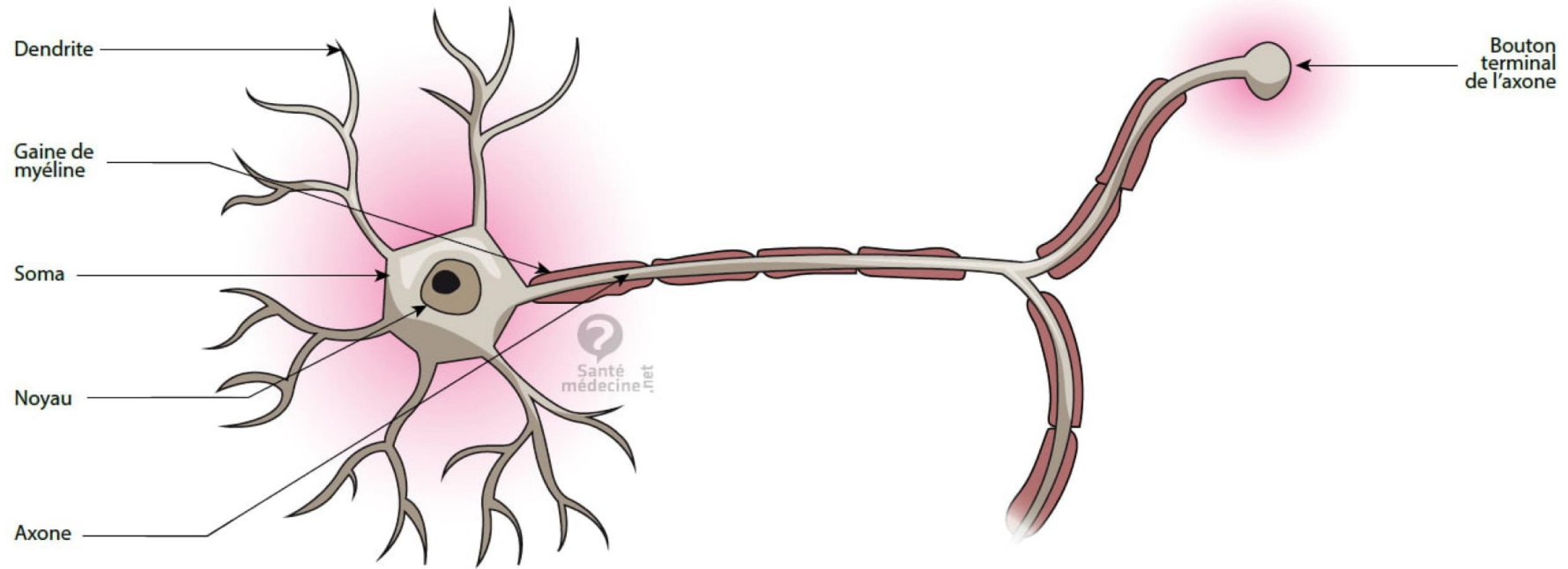
- Apprentissage automatique : traitement de **données** en masse grâce à des **algorithmes**

**Données (E) -> Exécution de tâches (T)
-> Degré de performance (P)**

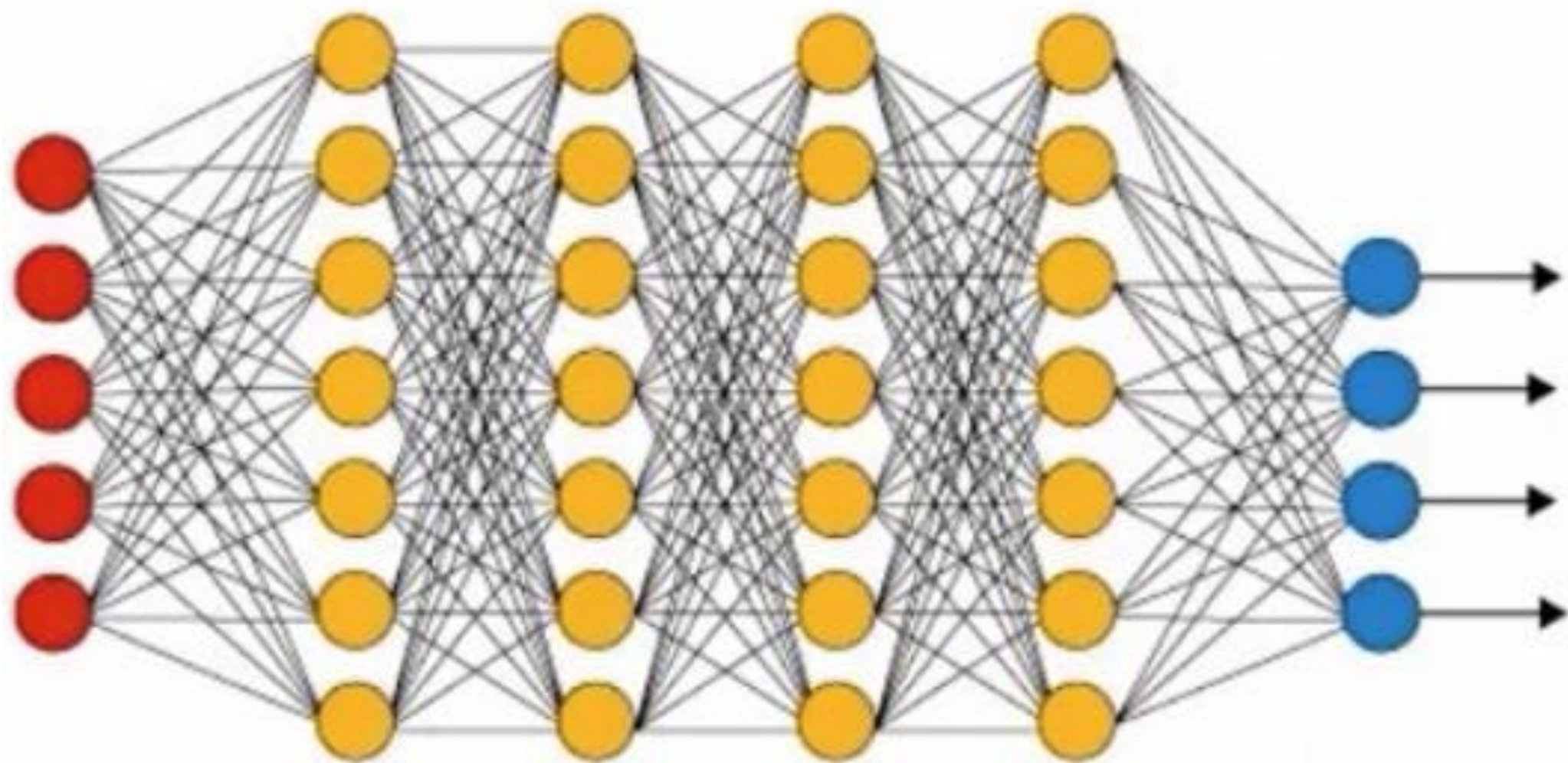
MODELE ++

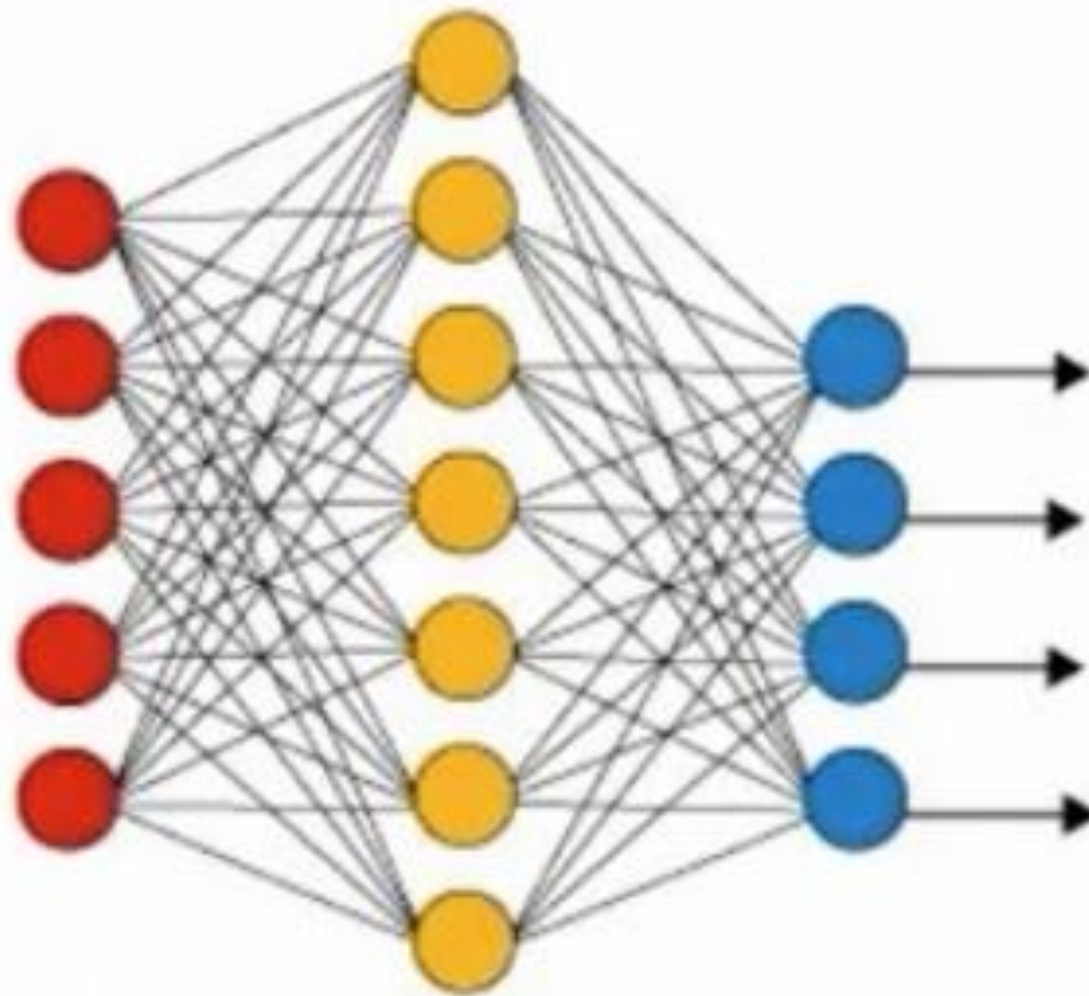
Deep Learning

- Modèles de ML s'appuyant sur les **réseaux neuronaux**



Deep Learning Neural Network

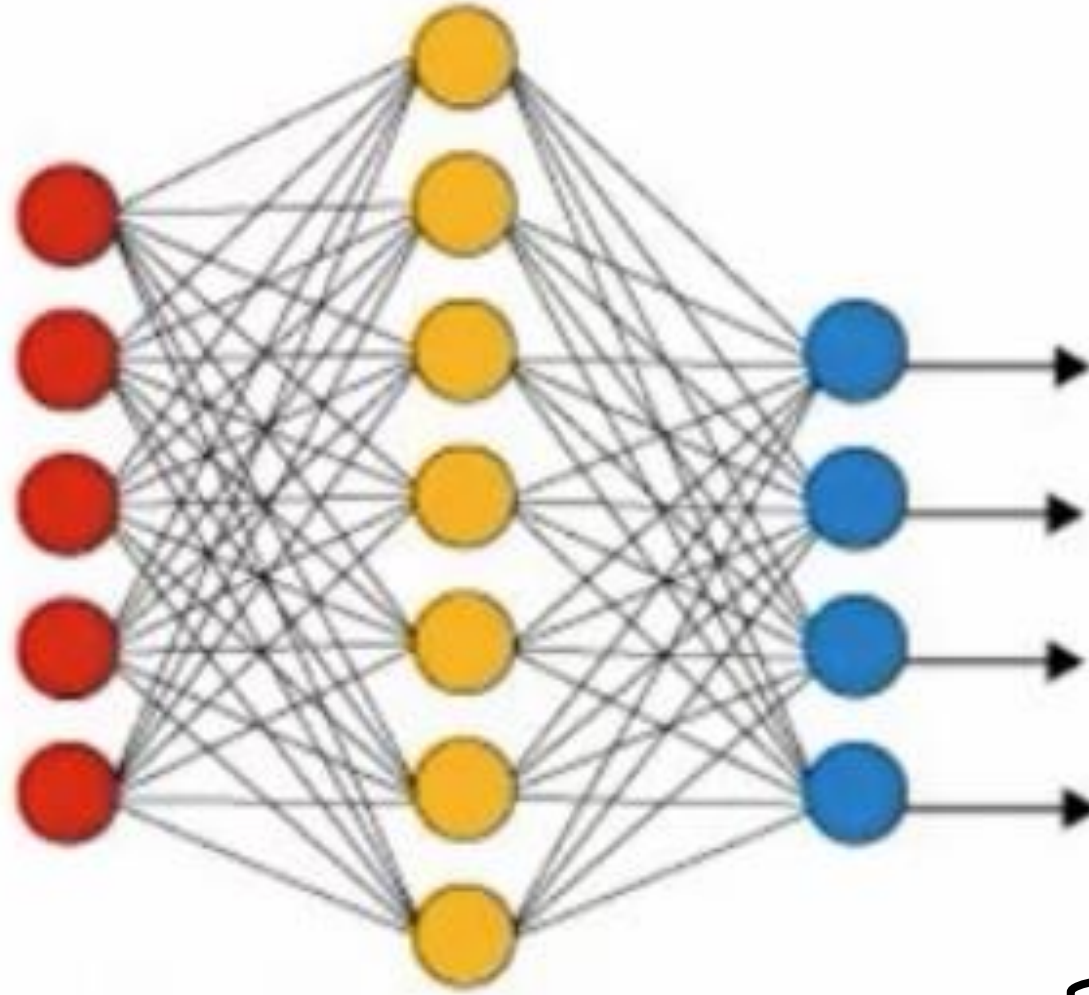




CHIEN

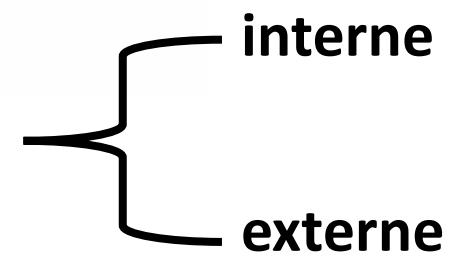
CHAT

Cohorte d'APPRENTISSAGE



CHIEN ✓

Cohorte de VALIDATION



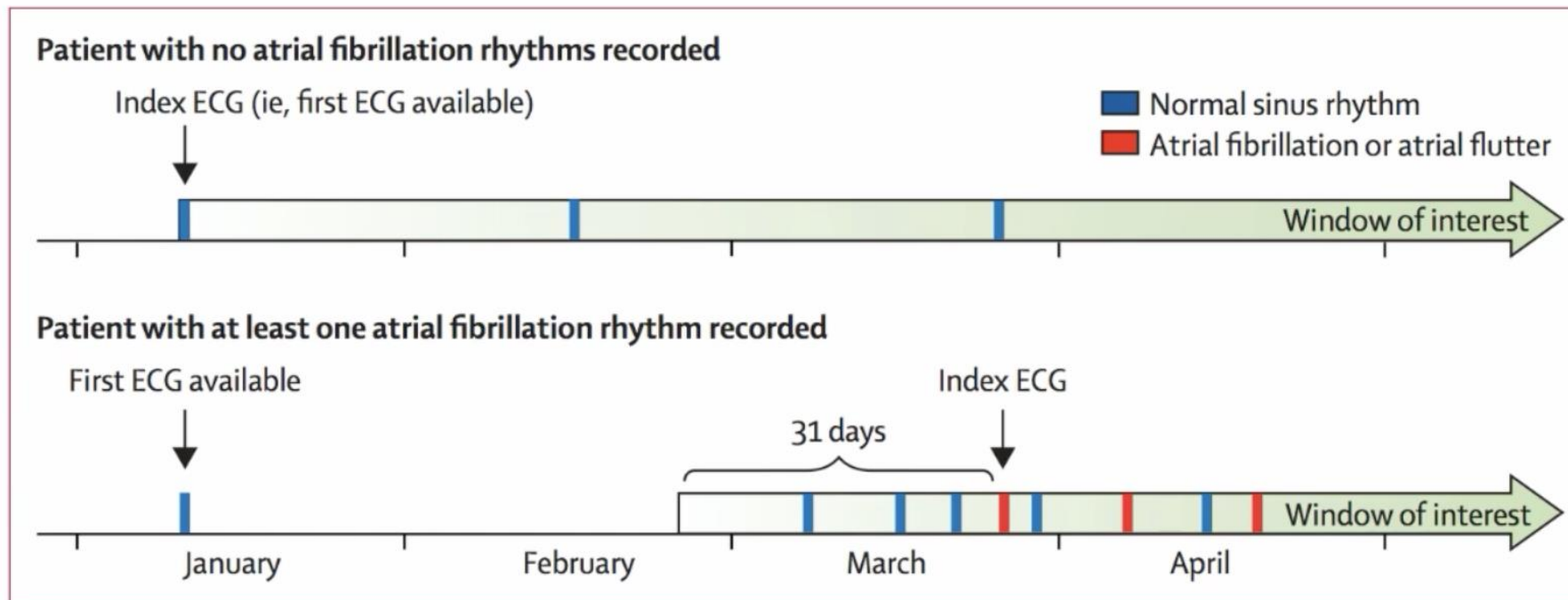


Qualité d'une étude utilisant le ML → dépend de la qualité des données ayant servi à construire le modèle

Cohorte de VALIDATION

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



Détection/prédiction de la FA paroxystique chez les patients en RS

Signes ECG prédictifs de FA

>180 000 patients en RS,
650 000 ECG → NN

Se/Sp 80% pour prédire une FA

Attia et al. Lancet 2019

Cardiologs

A deep neural network for 12-lead electrocardiogram interpretation outperforms a conventional algorithm, and its physician overread, in the diagnosis of atrial fibrillation



Stephen W. Smith ^{a,*.1}, Jeremy Rapin ^{b.2}, Jia Li ^{b.3}, Yann Fleureau ^{b.4}, William Fennell ^{c.5}, Brooks M. Walsh ^{d.6}, Arnaud Rosier ^{e.7}, Laurent Fiorina ^{f.8}, Christophe Gardella ^{b.9}

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}

J Electrocardiol. 2015 Jan-Feb;48(1):29-30. doi: 10.1016/j.jelectrocard.2014.10.008. Epub 2014 Oct 30.

Big data and the electrocardiogram.

Estes EH¹.

ML pour répondre à quelles questions ?

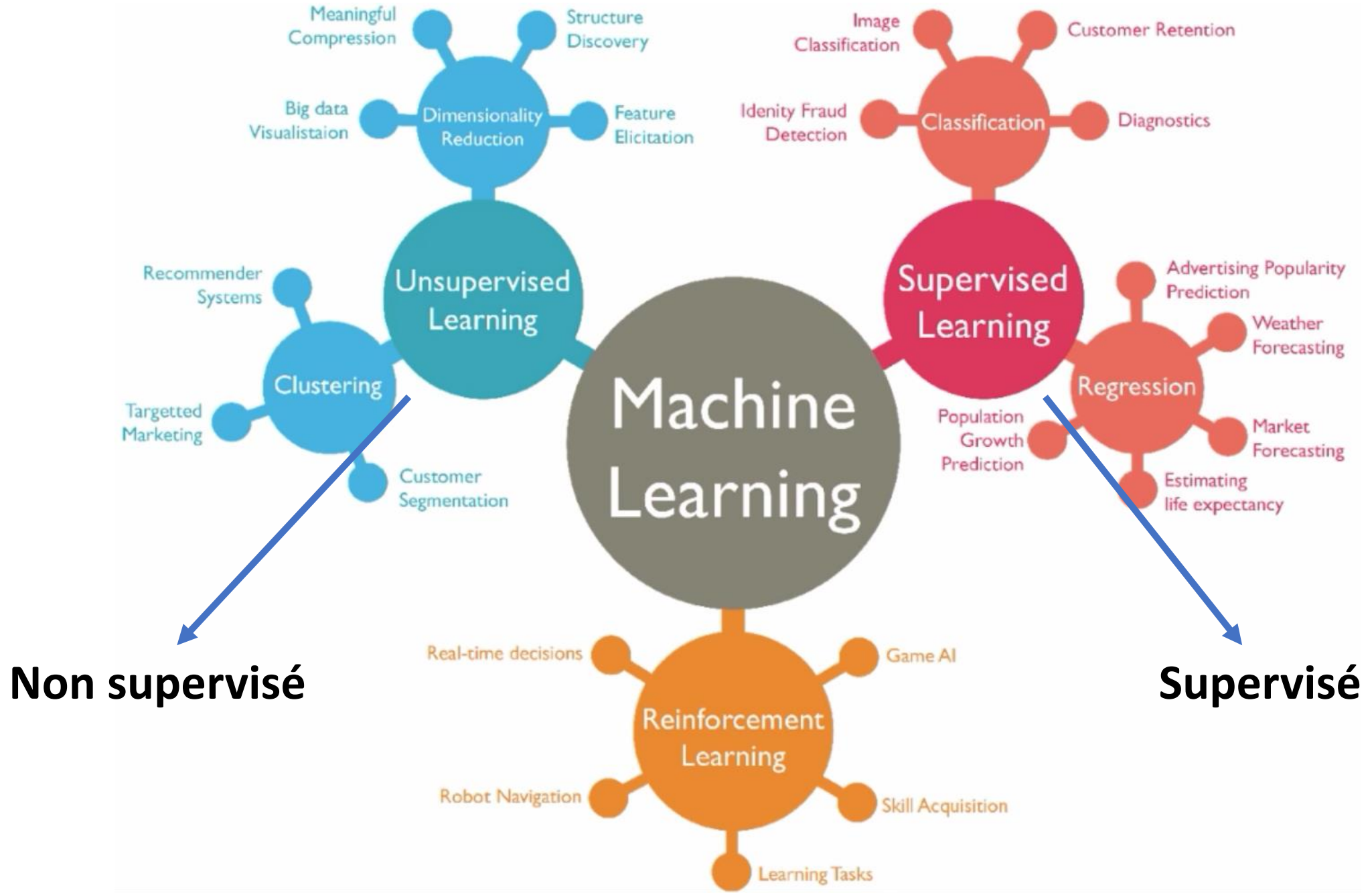
CLASSIFICATION

- **Séparation** des patients d'étude par rapport à une composante (ou objectif) bien précis (ex : répondeurs ou non à une thérapie)

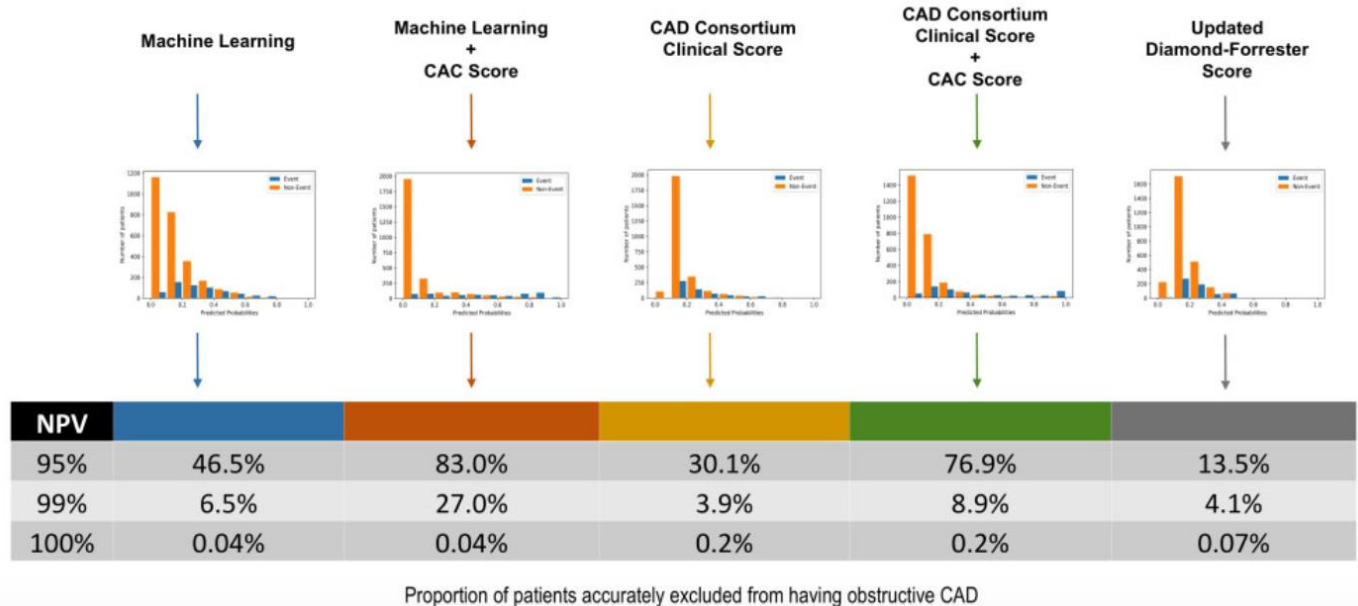
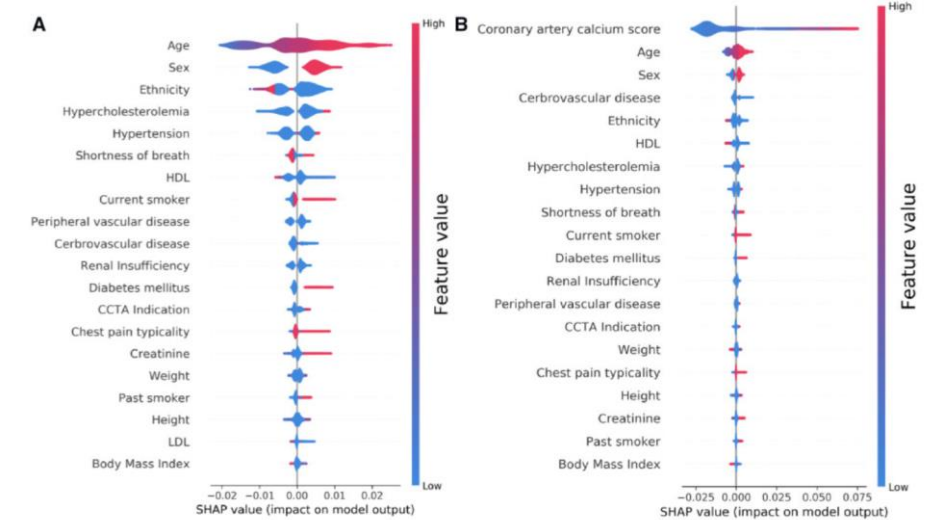
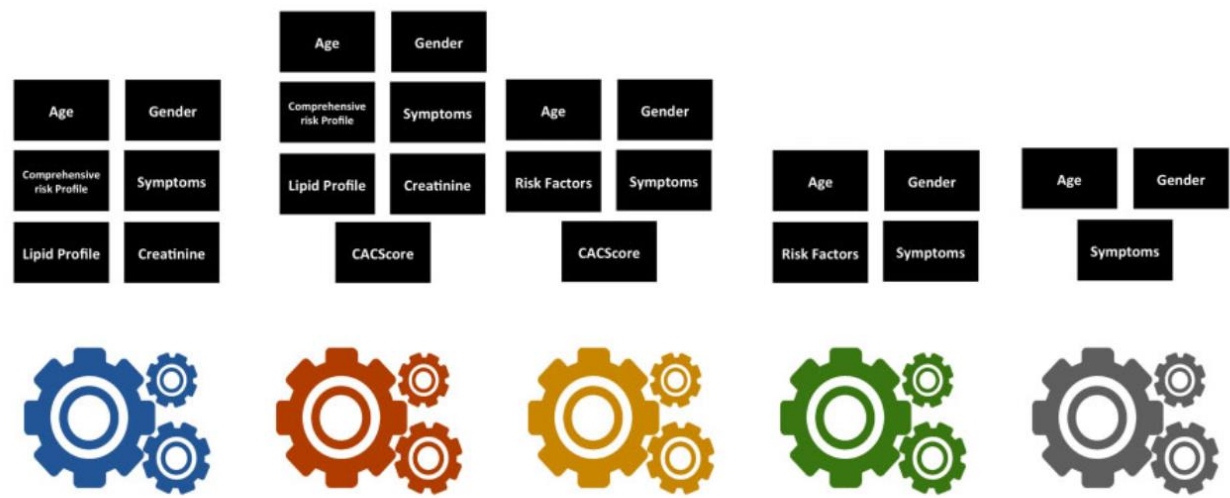
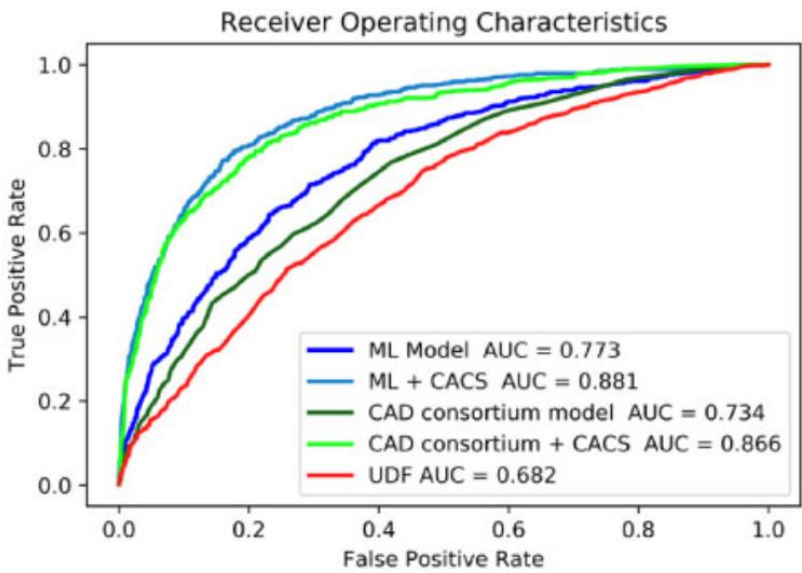
REGRESSION

- **Prédiction** d'une variable indépendante (outcome, ex = survie) par rapport à une ou plusieurs variables dépendantes

Ce qui n'est pas différent de la statistique conventionnelle...c'est la méthode qui change !

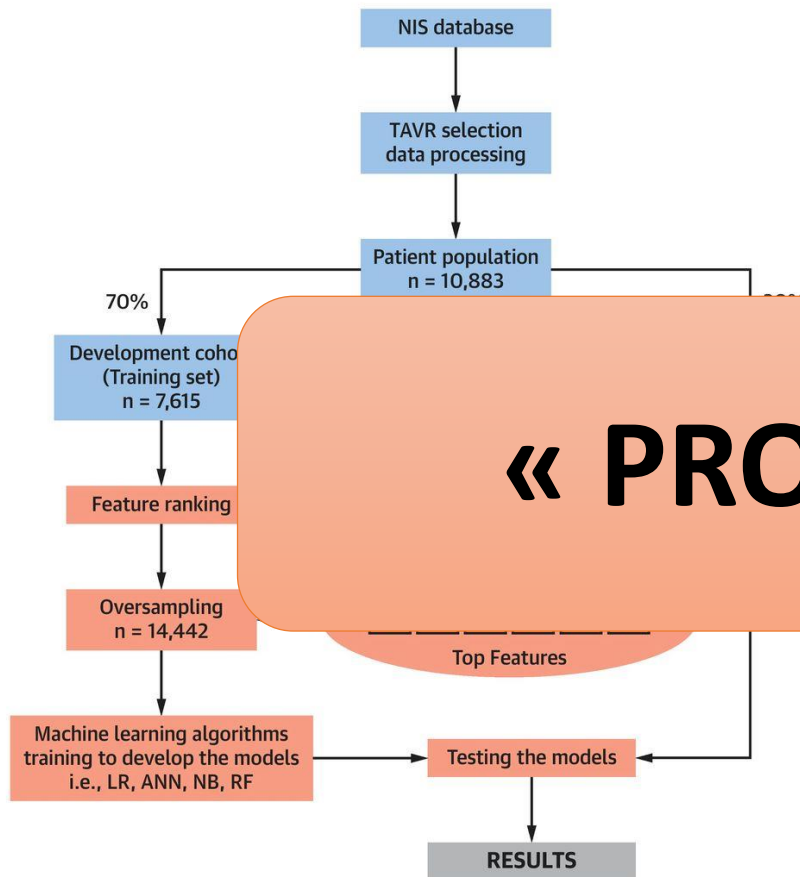


Un des rôles du ML → PREDICTION D'OUTCOME



→ Prédiction CAD (sur coroscan) à partir d'un modèle ML clinique (+score calcique coronaire) *Aref et al. EHJ 2019*

CENTRAL ILLUSTRATION: Overview of the Methods Used for Data Extraction, Training, and Testing



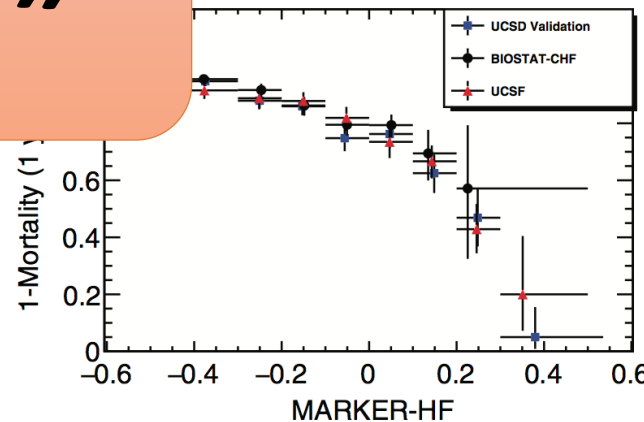
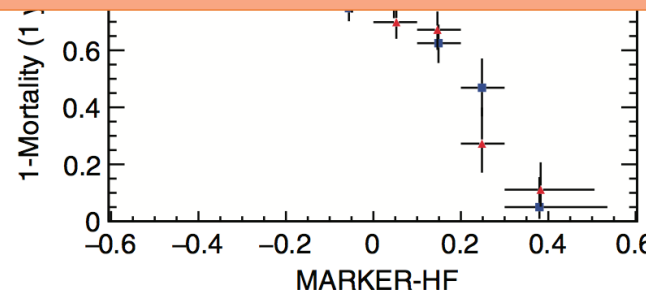
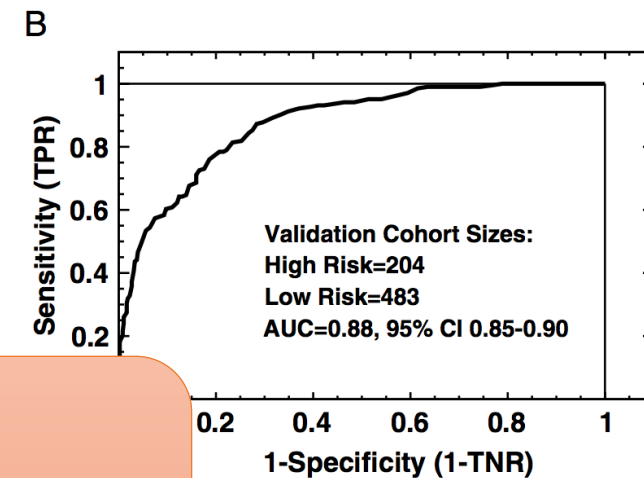
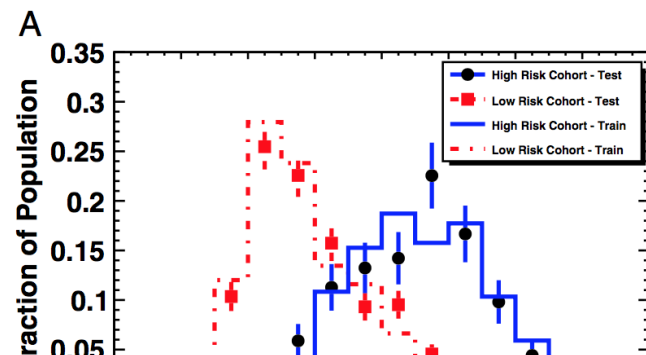
Hernandez-Suarez, D.F. et al. J Am Coll Cardiol Interv. 2019;12(14):1328-38.

>10 000 patients (2012-2015)

AUC 0.92 (0.89-0.95)

➔ Prédiction mortalité intra-hospitalière post-TAVI

Hernandez-Suarez D.F. et al. JACC Interv 2019



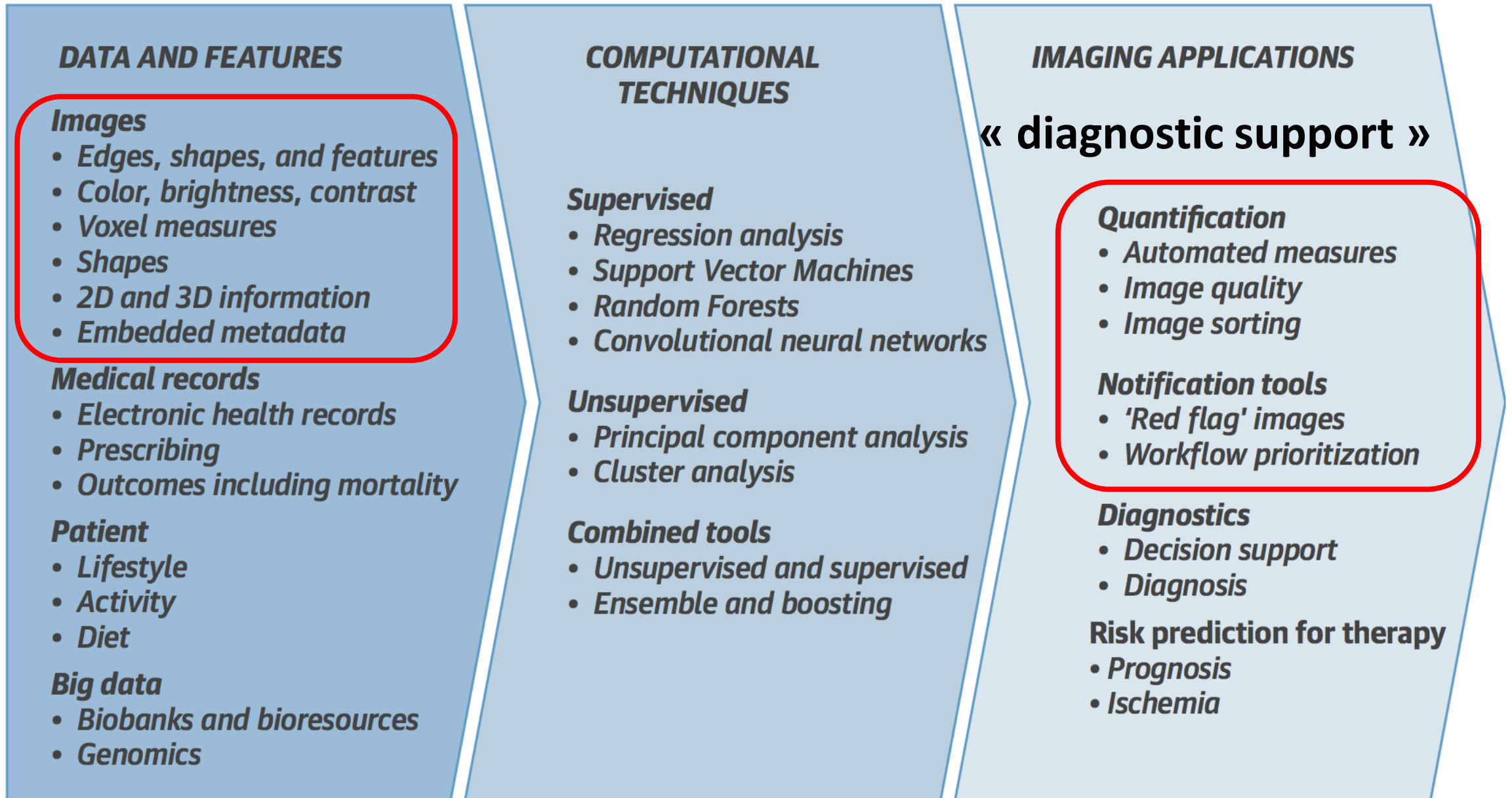
6000 patients (Europe, US)

Développement d'un score (PAD, creat, BUN, Hb, plq, GB, albumine, IDGR)

➔ Prédiction mortalité à 1 an dans l'HF

Adler et al. Eur J HF 2019

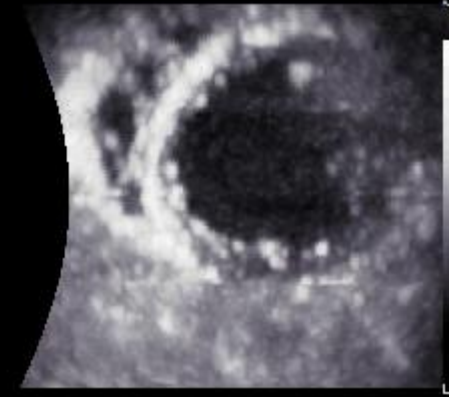
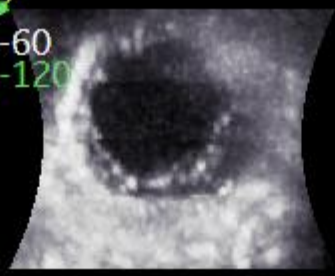
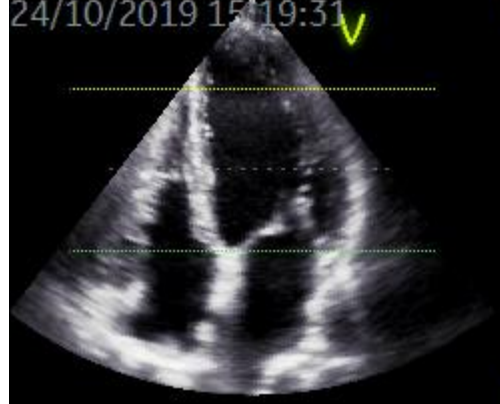
« PROOF-OF-CONCEPT »



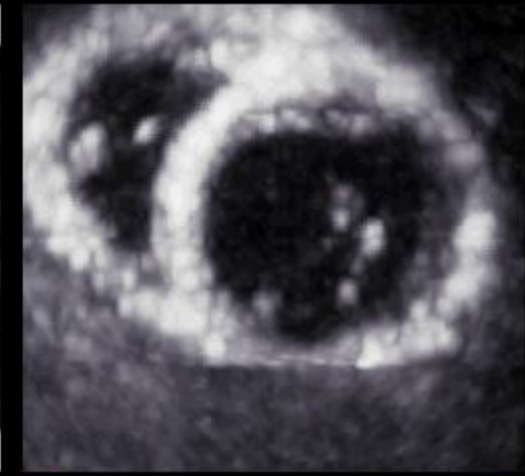
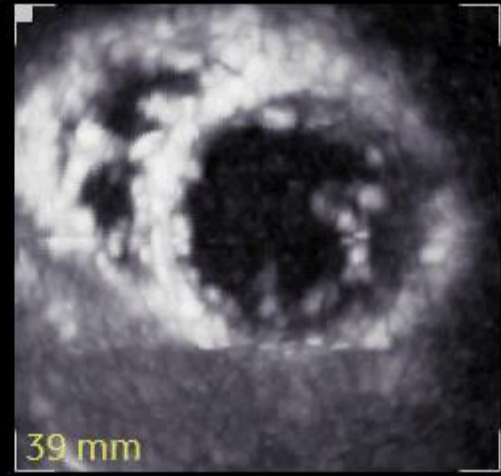
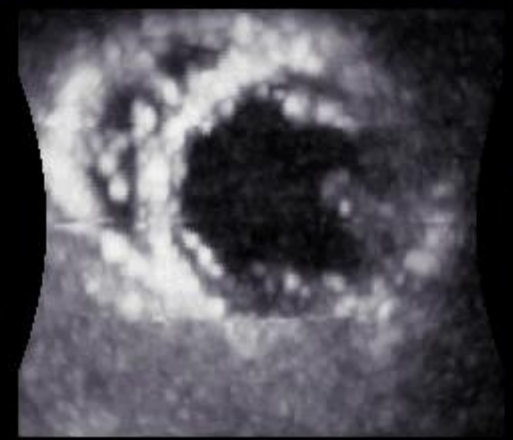
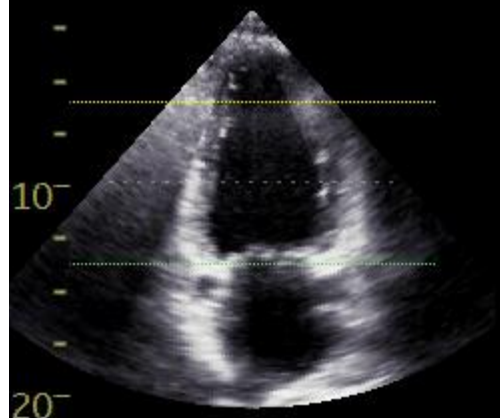
24/10/2019 15:19:31 ✓



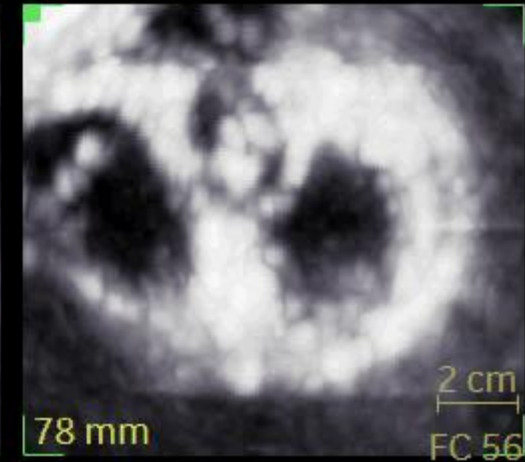
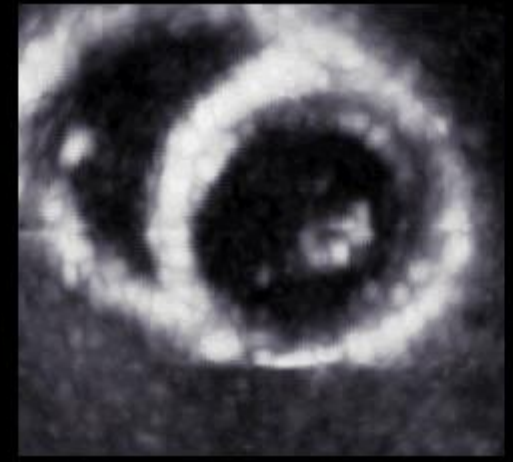
A1: -60
A2: -120



0 mm



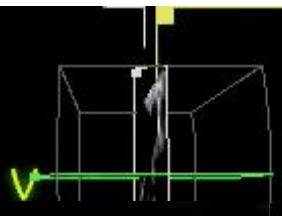
39 mm



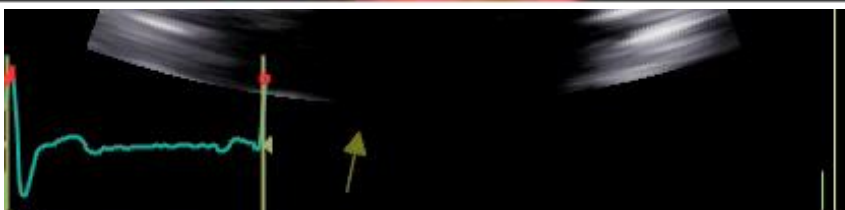
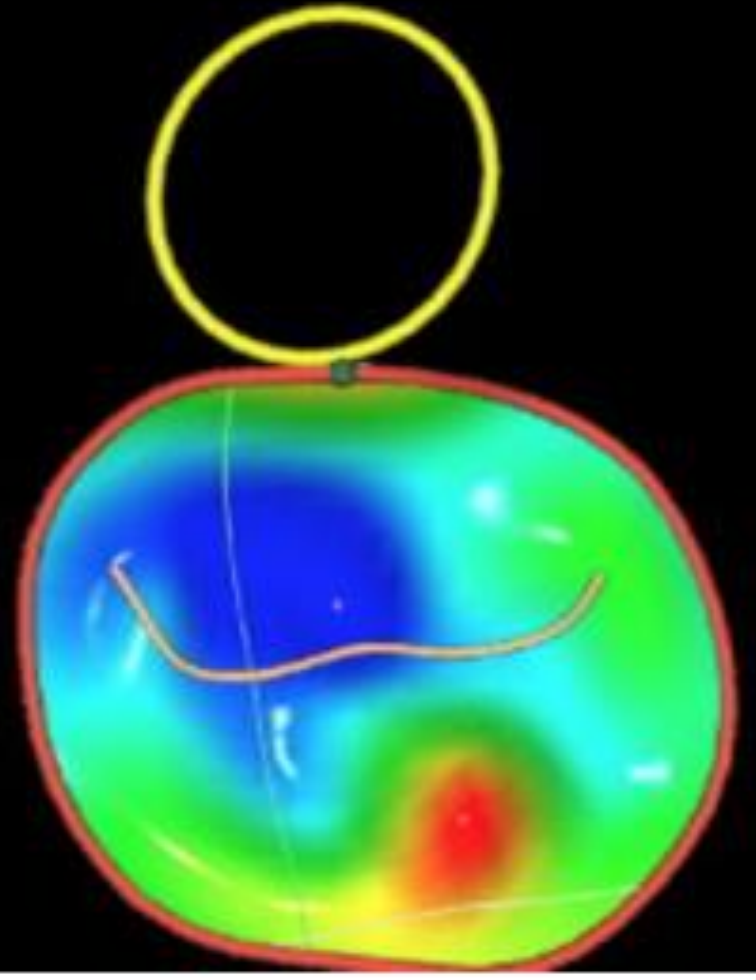
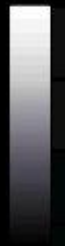
78 mm

2 cm
FC 56

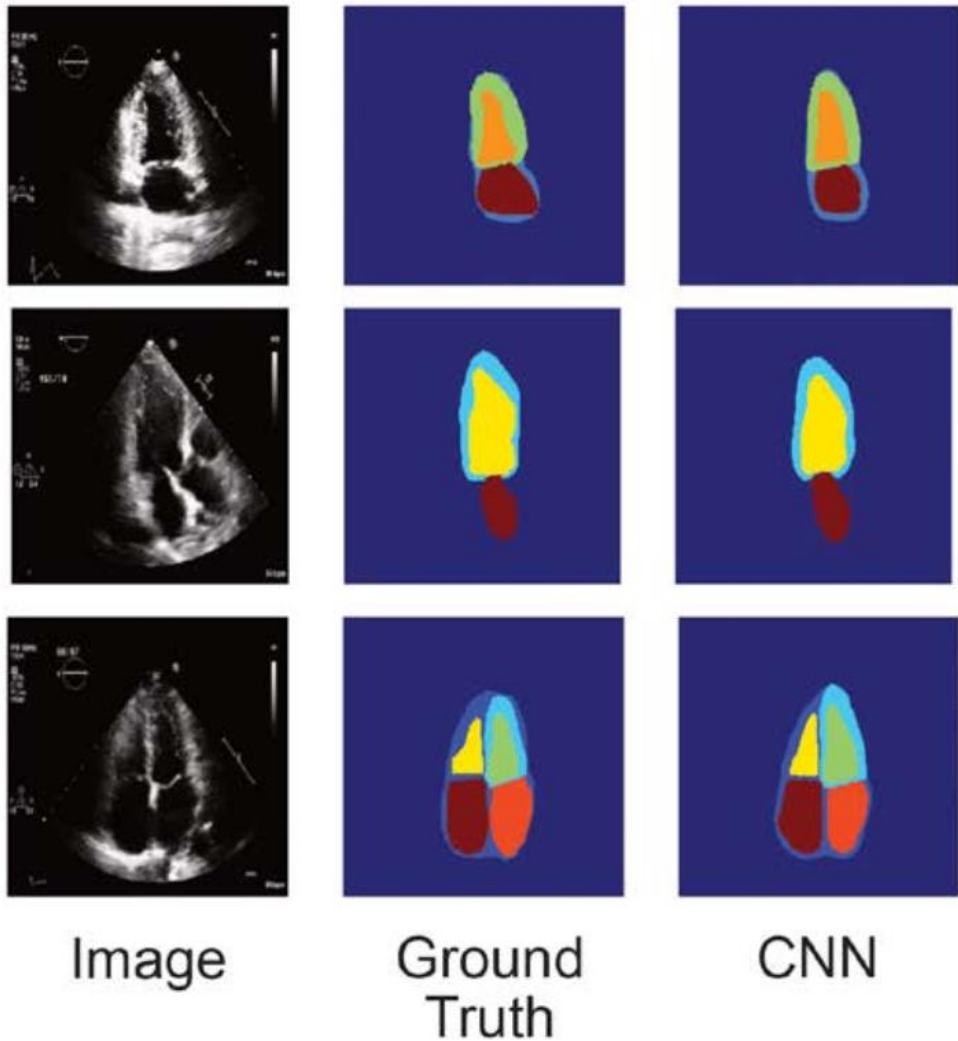
24/10/2019 15:30:28



Soft



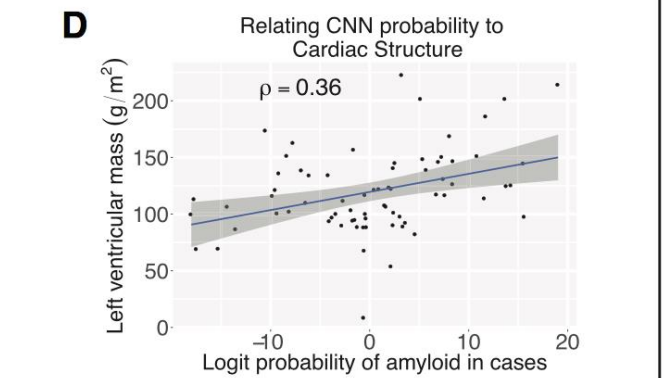
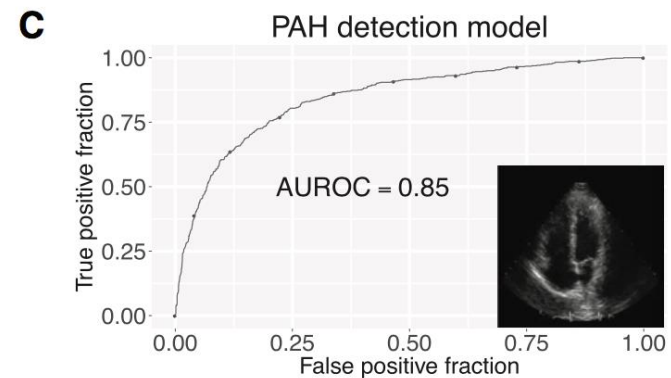
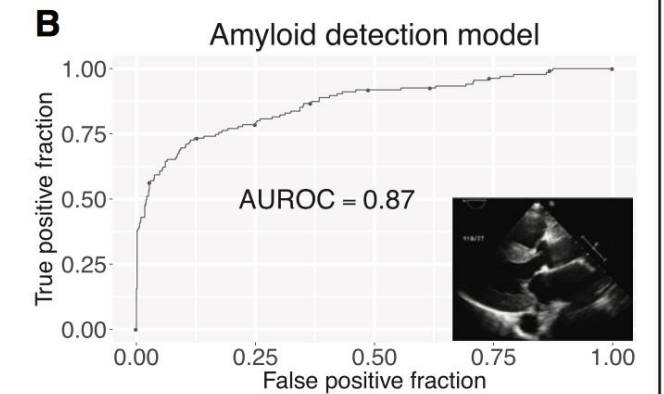
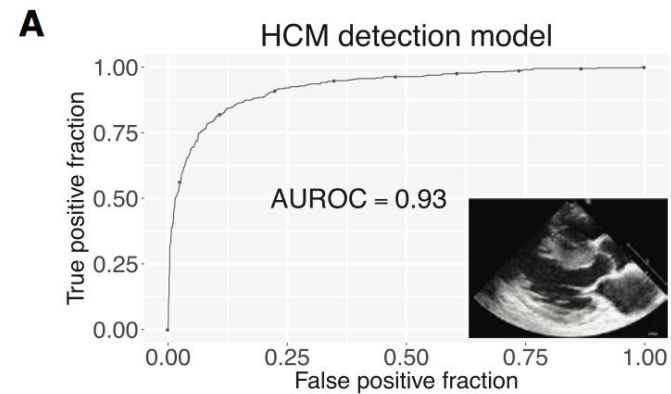
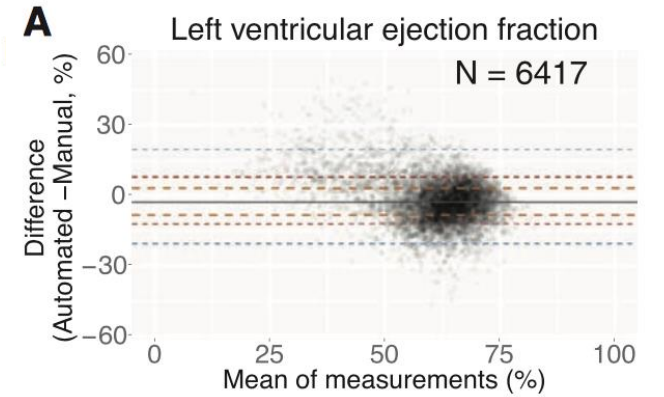
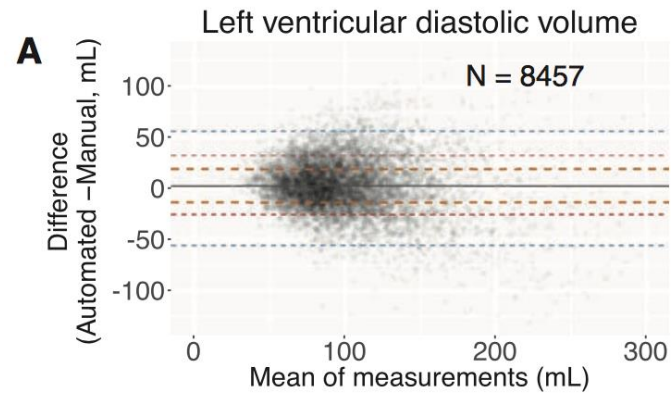
2 cm
FC 55

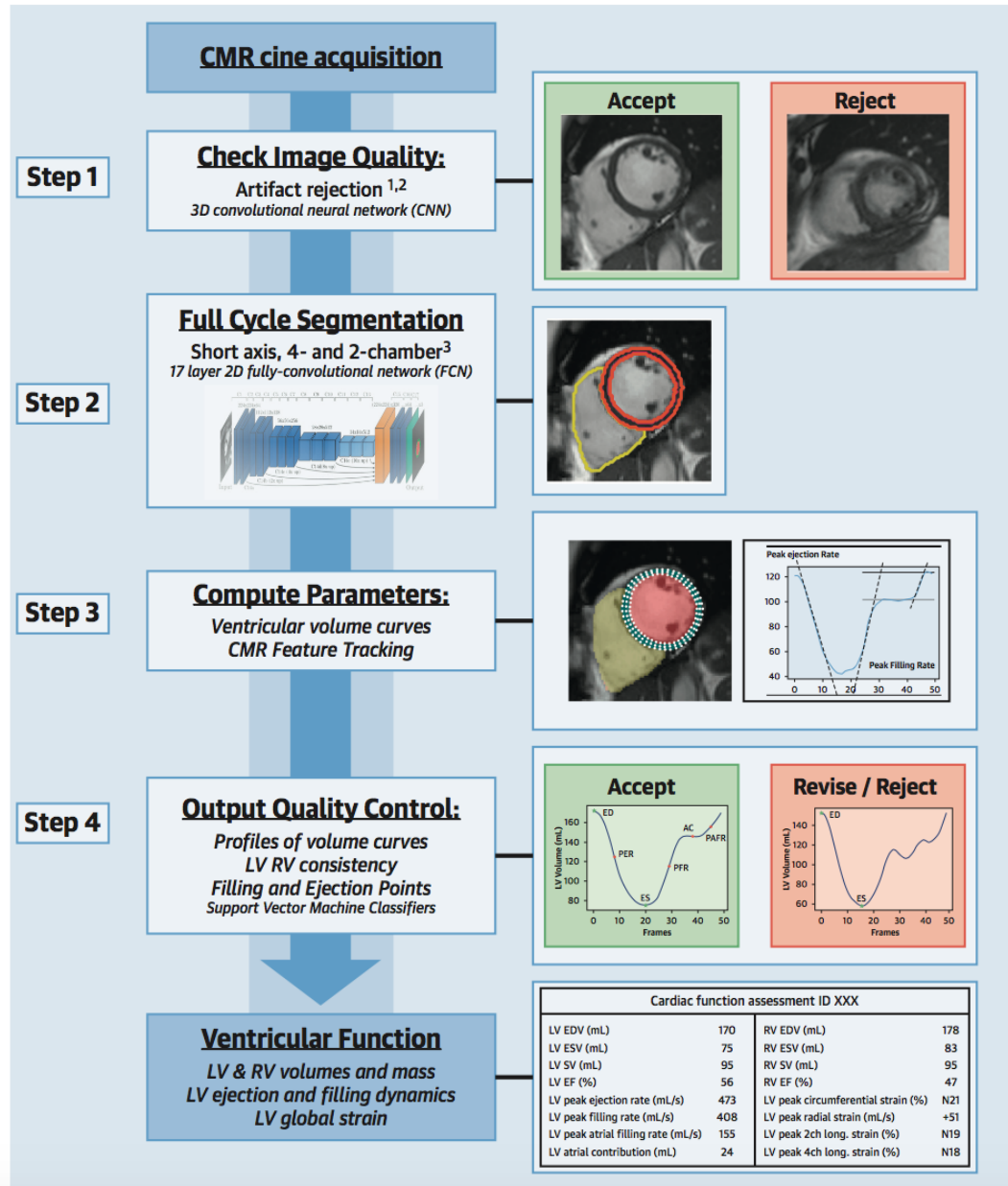


Image

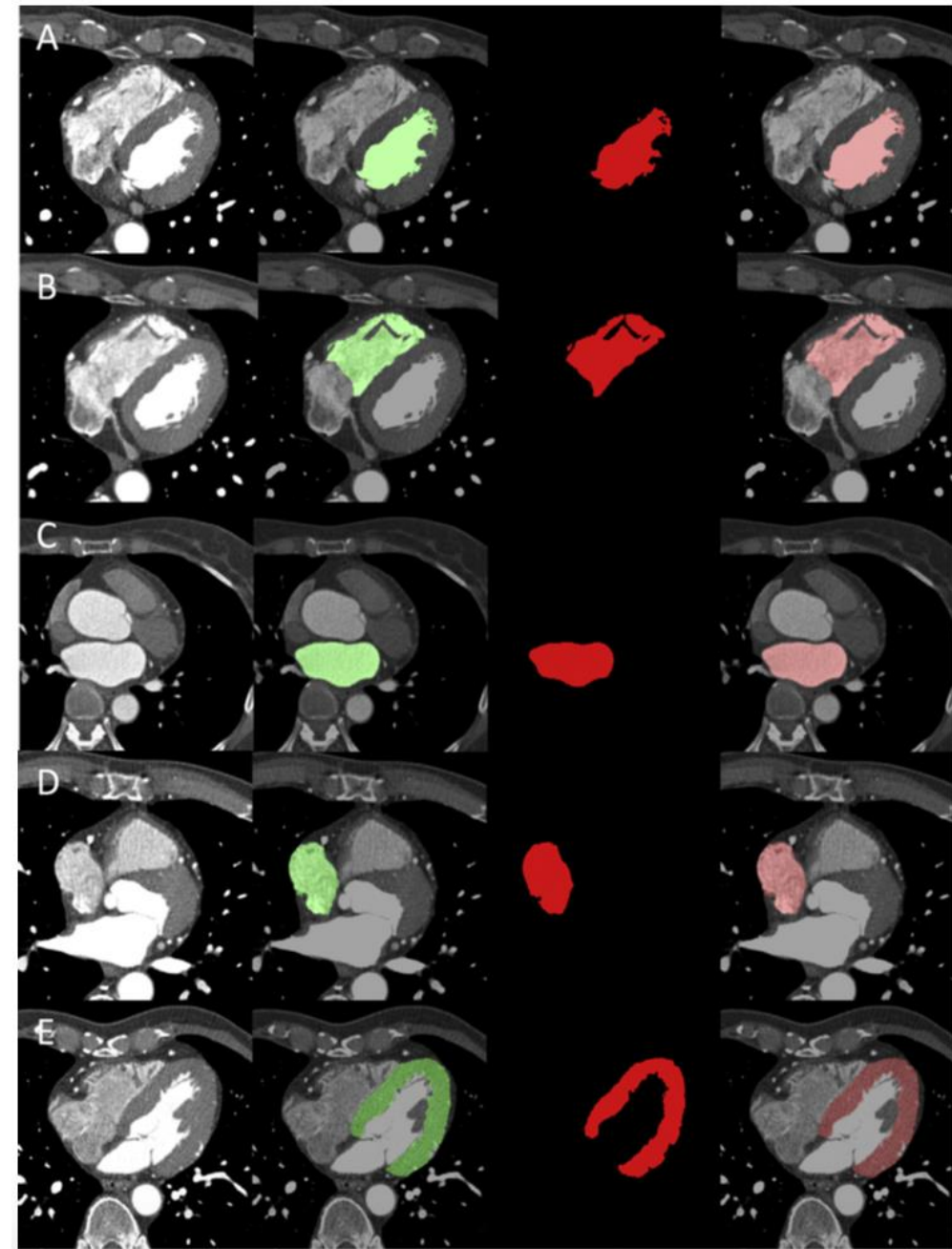
Ground Truth

CNN





Ruijsink et al. JACC Img 2019



Baskaran et al JACC Img 2019

Will Artificial Intelligence Replace the Human Echocardiographer?

Clinical Considerations

Sengputa et al. Circulation 2018

ever, it is still a long journey ahead. In the current time, the best use of the technology would be to free up time for physicians from repetitive low-level and uneventful activities like measurements, data preparation, standardization, and quality control to more direct time spent in higher calibers of interpretation, patient care, and medical decision making. This will perhaps allow

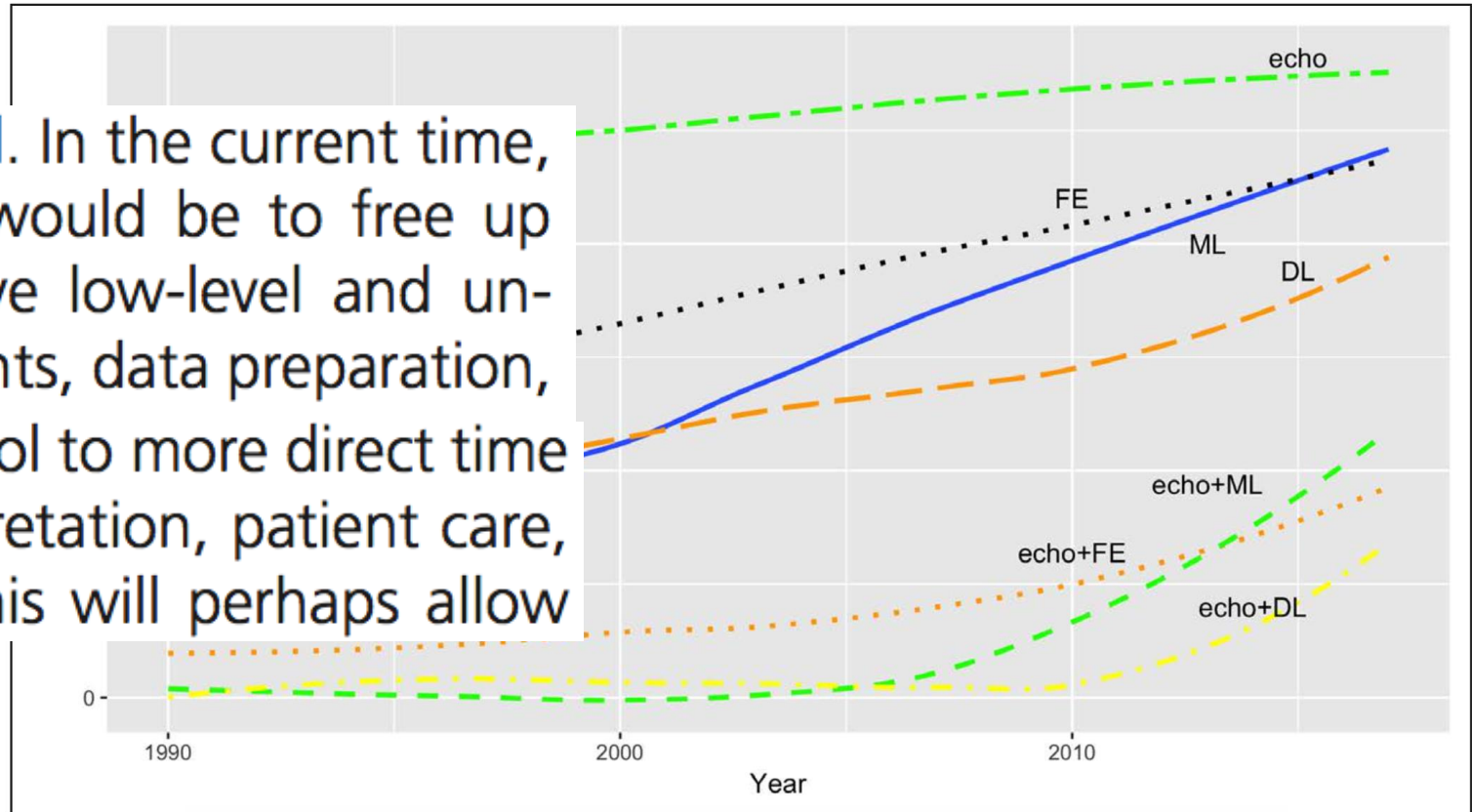
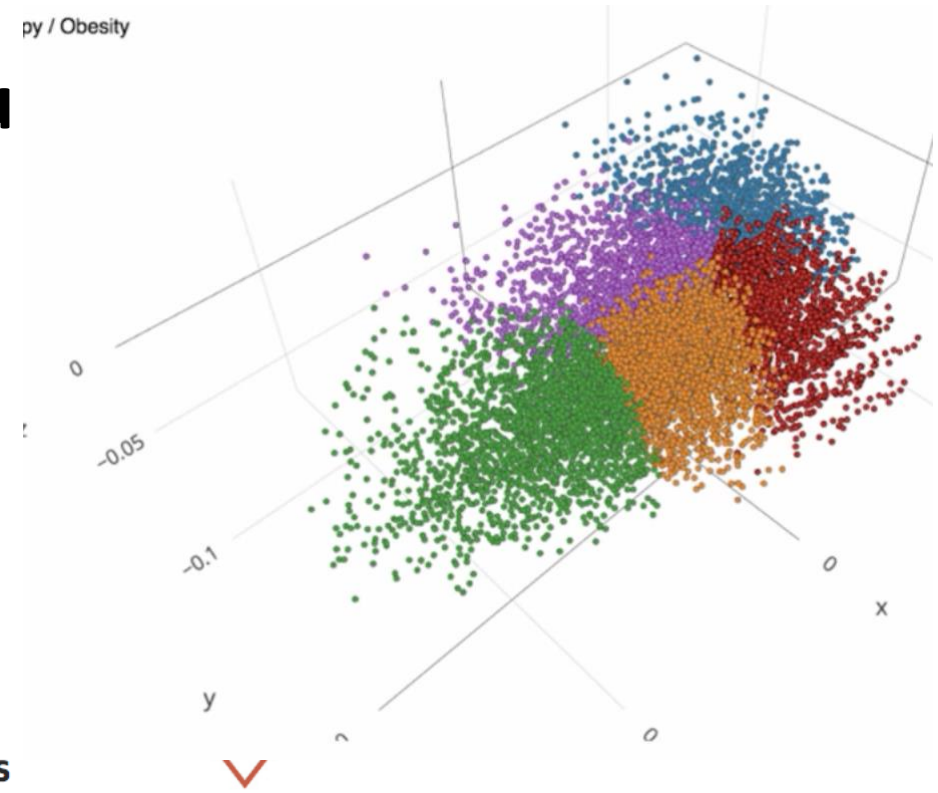


Figure. Trends in artificial intelligence techniques in echocardiography based on publications in PubMed.

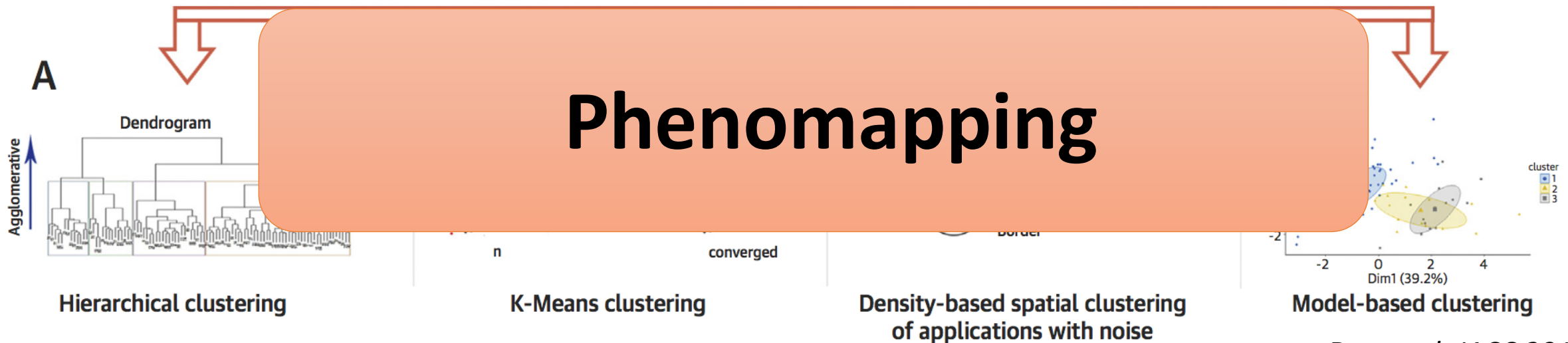
Apprentissage non supervisé : exemple du « CLUSTERING »

- Détection de « **patterns** » initialement inconnus à partir de données complexes (sd cliniques hétérogènes par ex)
- Objectif : **discriminer et classifier** les patients en « groupes homogènes »



Clustering algorithms

Phenomapping



Heart Failure

Phenomapping for Novel Classification of Heart Failure With Preserved Ejection Fraction

Sanjiv J. Shah, MD; Daniel H. Katz, MD; Senthil Selvaraj, MD, MA; Michael A. Burke, MD; Clyde W. Yancy, MD, MSc; Mihai Gheorghiade, MD; Robert O. Bonow, MD; Chiang-Ching Huang, PhD; Rahul C. Deo, MD, PhD

HFpEF pheno-groups: clinical

Pheno-group #1

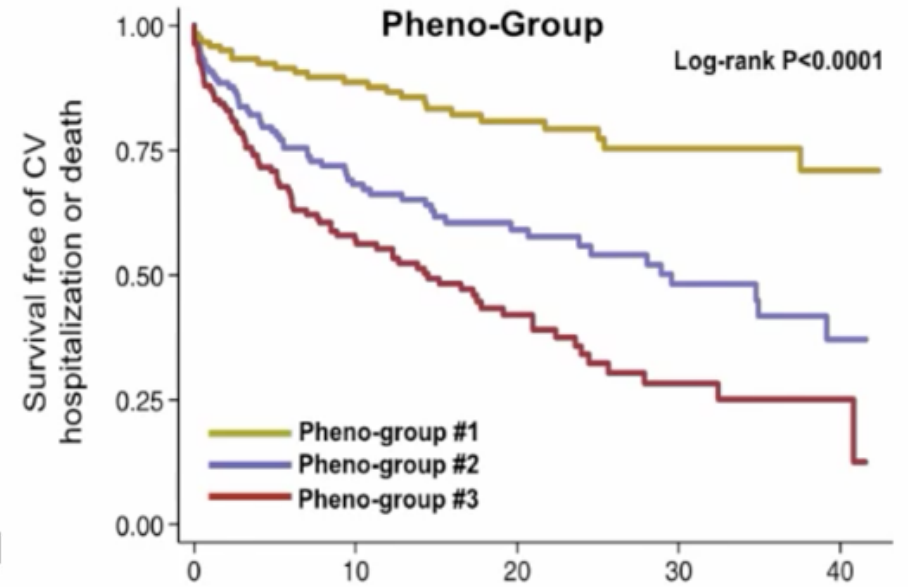
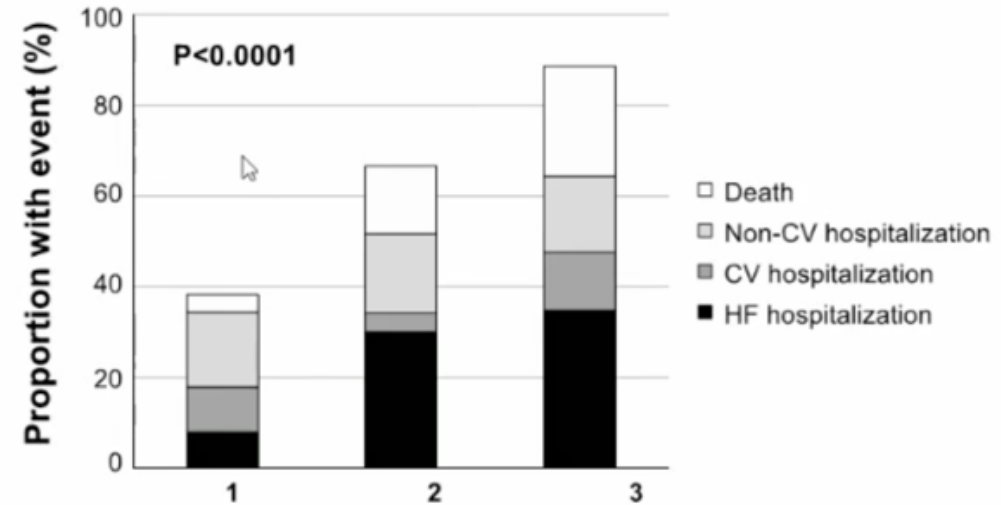
- Youngest
- Least comorbidities (except 51% obese)
- Lowest BNP (median 72 pg/ml)

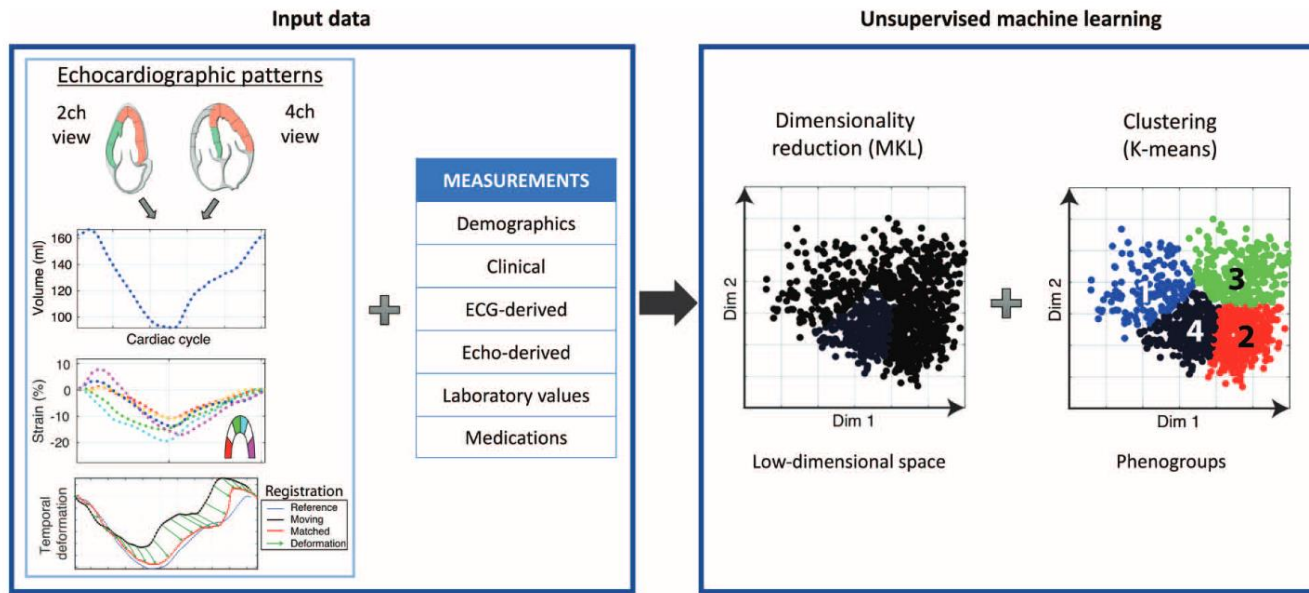
Pheno-group #2

- Highest BMI (mean 37 kg/m²)
- Highest fasting glucose
- Most diabetes
- Most sleep apnea
- Most anti-HTN medications
- Mid-range BNP (median 188 pg/ml)

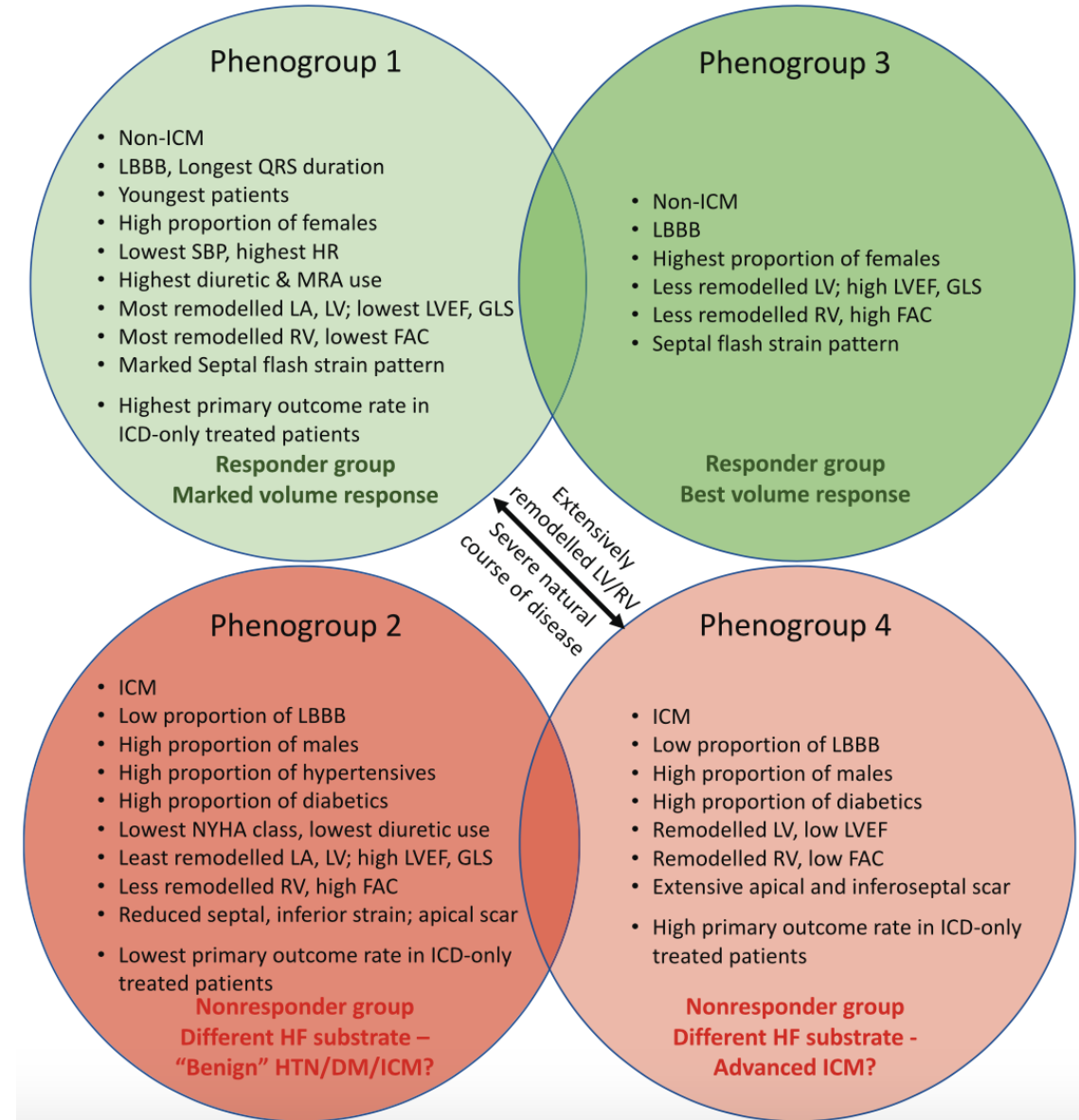
Pheno-group #3

- Oldest
- Lowest BMI
- Worst renal function (53% with CKD)
- Most electrical remodeling, AF
- Highest BNP (median 607 pg/ml)





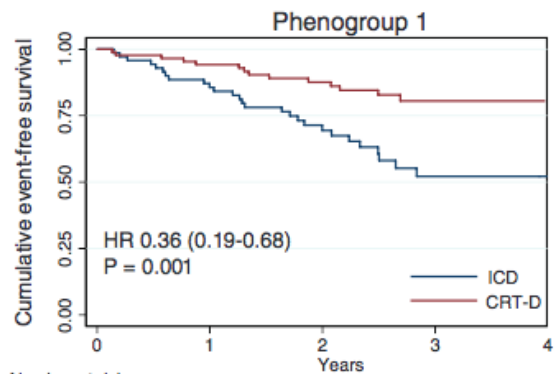
Interpretable machine learning



Machine learning-based phenogrouping in heart failure to identify responders to cardiac resynchronization therapy

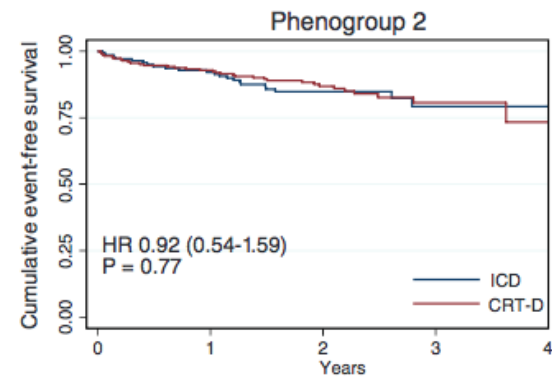
Maja Cikes^{1†}, Sergio Sanchez-Martinez^{2†}, Brian Claggett³, Nicolas Duchateau⁴, Gemma Piella², Constantine Butakoff², Anne Catherine Pouleur⁵, Dorit Knappe⁶, Tor Biering-Sørensen^{3,7}, Valentina Kutyifa⁸, Arthur Moss⁸, Kenneth Stein⁹, Scott D. Solomon^{3*†}, and Bart Bijnens^{2,10†}

Cikes et al. Eur J HF 2016



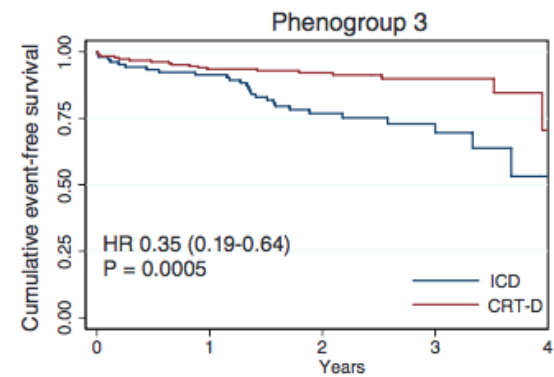
Number at risk

ICD	71	66	59	49	35	24	14	3	1
CRT-D	86	84	80	69	60	48	19	4	1



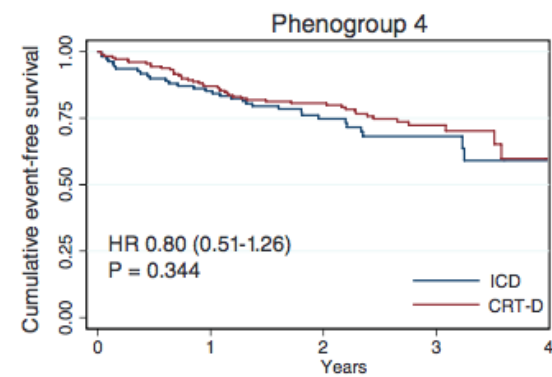
Number at risk

ICD	143	132	126	95	66	40	21	12	6
CRT-D	227	212	207	167	111	57	38	15	9



Number at risk

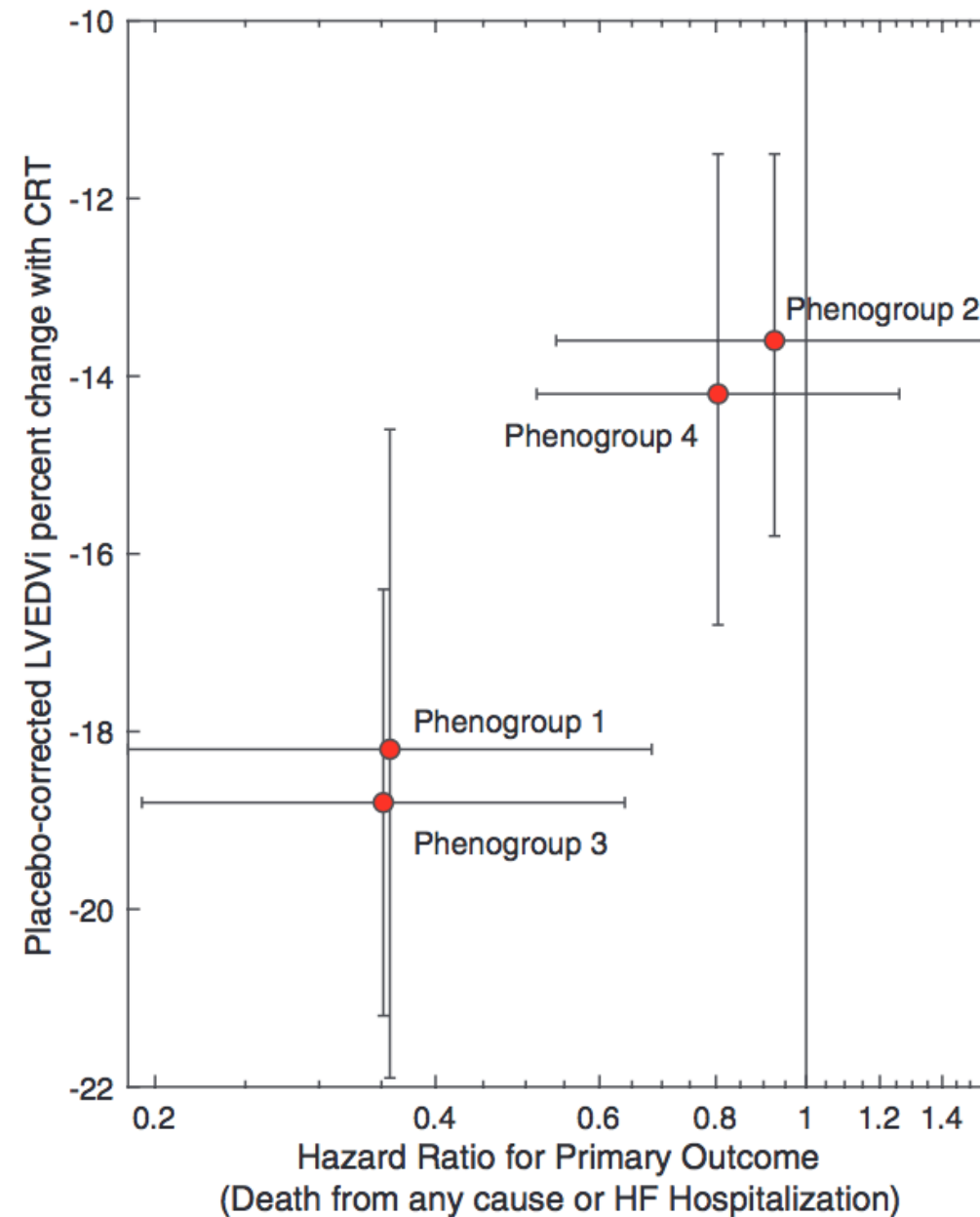
ICD	105	96	94	74	51	34	22	6	4
CRT-D	186	178	173	147	111	67	40	17	5



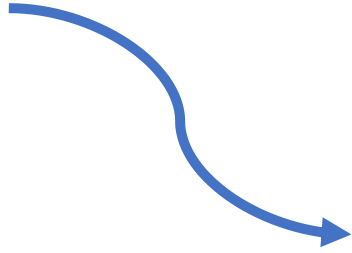
Number at risk

ICD	110	97	90	79	55	37	20	9	4
CRT-D	178	168	153	135	111	71	36	14	8

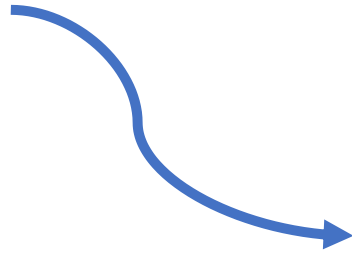
	Phenogroup 1 (N=157)	Phenogroup 2 (N=370)	Phenogroup 3 (N=291)	Phenogroup 4 (N=288)
Primary Outcome				
Participants with event, n (%)	41 (26.11%)	55 (14.86%)	45 (15.46%)	79 (27.43%)
Event rate per 100 person -years	11.9 (8.8 - 16.2)	7.4 (5.7 - 9.6)	7.2 (5.4 - 9.6)	12.8 (10.3 - 16.0)



Experimental Medicine



« Evidence-Based Medicine »



« Tailored Medicine »

ML pour « dépasser les essais randomisés ? »

Bientôt dans les prochaines « guidelines »...

Recommendations	Class ^a	Level ^b
The use of the ML model « xxx » available on xxxx.com is recommended in order to establish diagnosis and provide targeted therapies when appropriate	I	C

Great expectations...

Despite over 40 years of research, the role of artificial intelligence and machine learning (ML) for clinical applications remains in evolution.¹ Experimentation with arbitrary ML methods for medical data analysis can be useful in a theoretical sense, but in general ML methods should be used only when they are superior to existing solutions, not merely for the sake of it.² In fact, there are many cases where ML performs no better than logistic regression.³

Finally, readers should remember that critical appreciation of research papers is vital, especially for topics subject to hype. Statistical significance does not guarantee clinical pertinence (26). Excellent results

sledgehammer cracking a nut. For ML to reach its full potential, there is a need to create a new generation of clinical databases, using dynamic and continuous parameters. We already have the tools,

Baladron et al. JACC Interv 2019

Machine Learning Is No Magic

A Plea for Critical Appraisal During Periods of Hype*

Modine et al. JACC Interv 2019

In the meantime, more effort should be made by

independent studies with different cohorts and be

...still a long way to go

Des challenges à relever

- Validation **prospective**, par des **RCTs**, des modèles de ML pour répondre à des questions cliniques sujettes à controverses
- Repenser la **médecine préventive** : « prévenir c'est guérir », toujours vrai grâce au ML ?
- Dimension **éthique +++** en termes de **responsabilité**, de **protection** des données
- **Education** des patients...et des médecins : sortir du concept de « black box »
- Evolution du **rôle du professionnel de santé**.





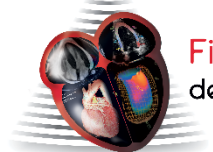
Merci de votre attention !

GHICL – heart valve center, echocardiography laboratories, cardiology department



Dr Alexandre Altes
Dr Ludovic Appert
Dr Camille Binda
Dr Anne-Laure Castel
Dr François Delelis
Dr Caroline Le Goffic
Dr Tiphaine Leblon
Dr Blandine Leman
Pr Sylvestre Marechaux
Dr Wassima Marsou
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Fatih Bouguermou, IDE

The echocardiography laboratory of the GHICL is certified « advanced echo lab » by the European Association for Cardiovascular Imaging (EACVI) until 2023 <https://www.esccardio.org/Education/Career-Development/Accreditation/EACVI-Laboratory-accreditation/Accredited-Laboratories>



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EACVI
European Association of
Cardiovascular Imaging