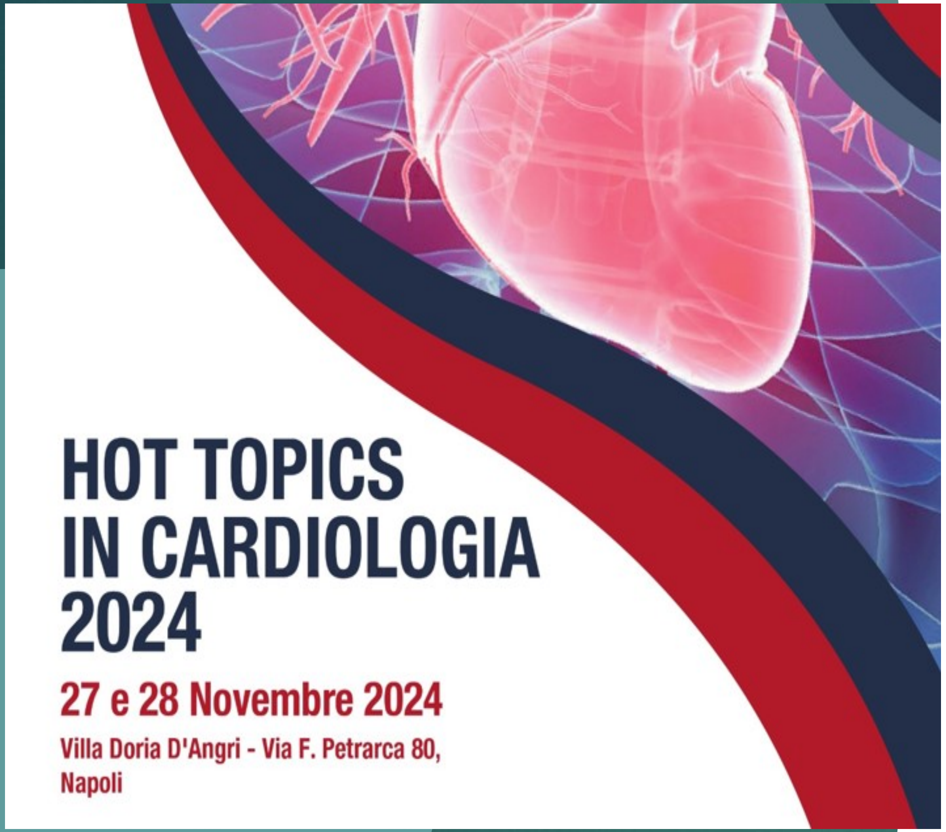

New Insights In Cardiology: Intelligenza Artificiale In Cardiologia

Prof. Giovanni Esposito
Presidente Scuola di Medicina e Chirurgia
Università degli Studi di Napoli "Federico II"
Direttore UOC Cardiologia, AOU "Federico II"
Past President SICI-GISE

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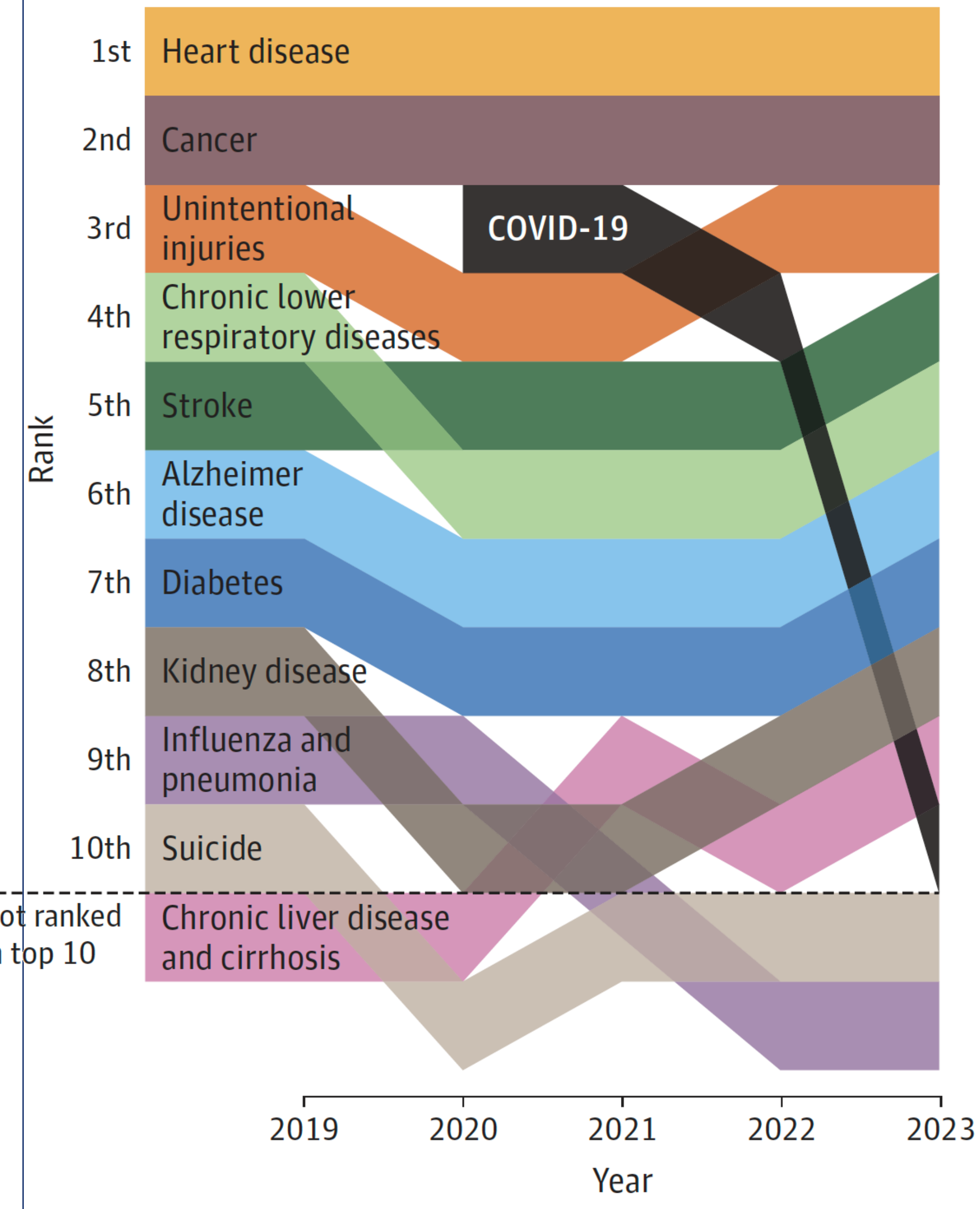
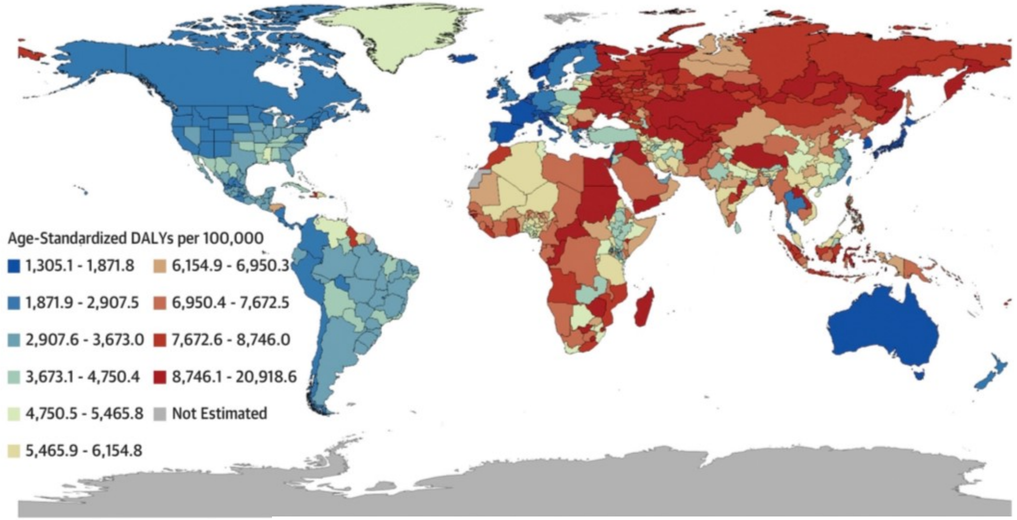
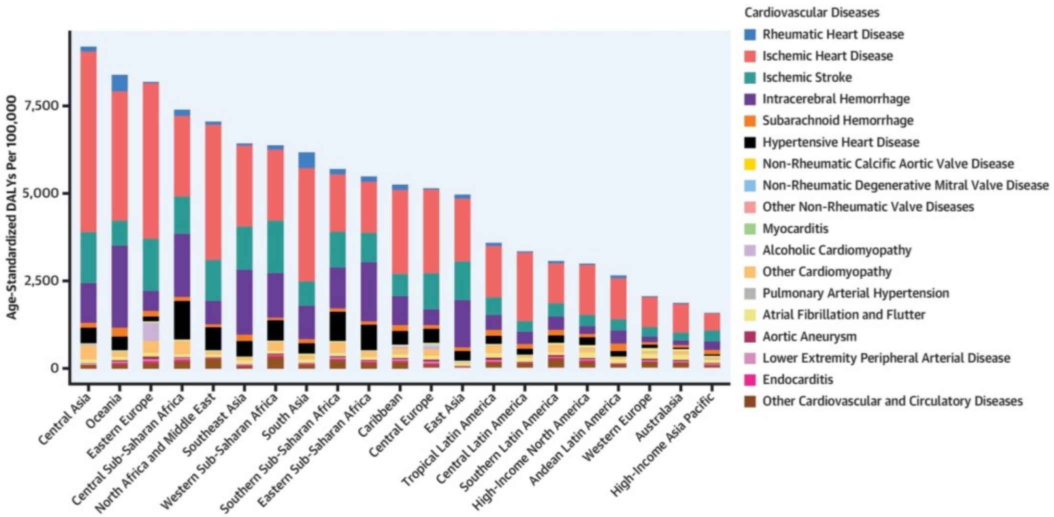
Link
profitable solutions

CAUSES OF DEATH IN US: 2019 - 2023



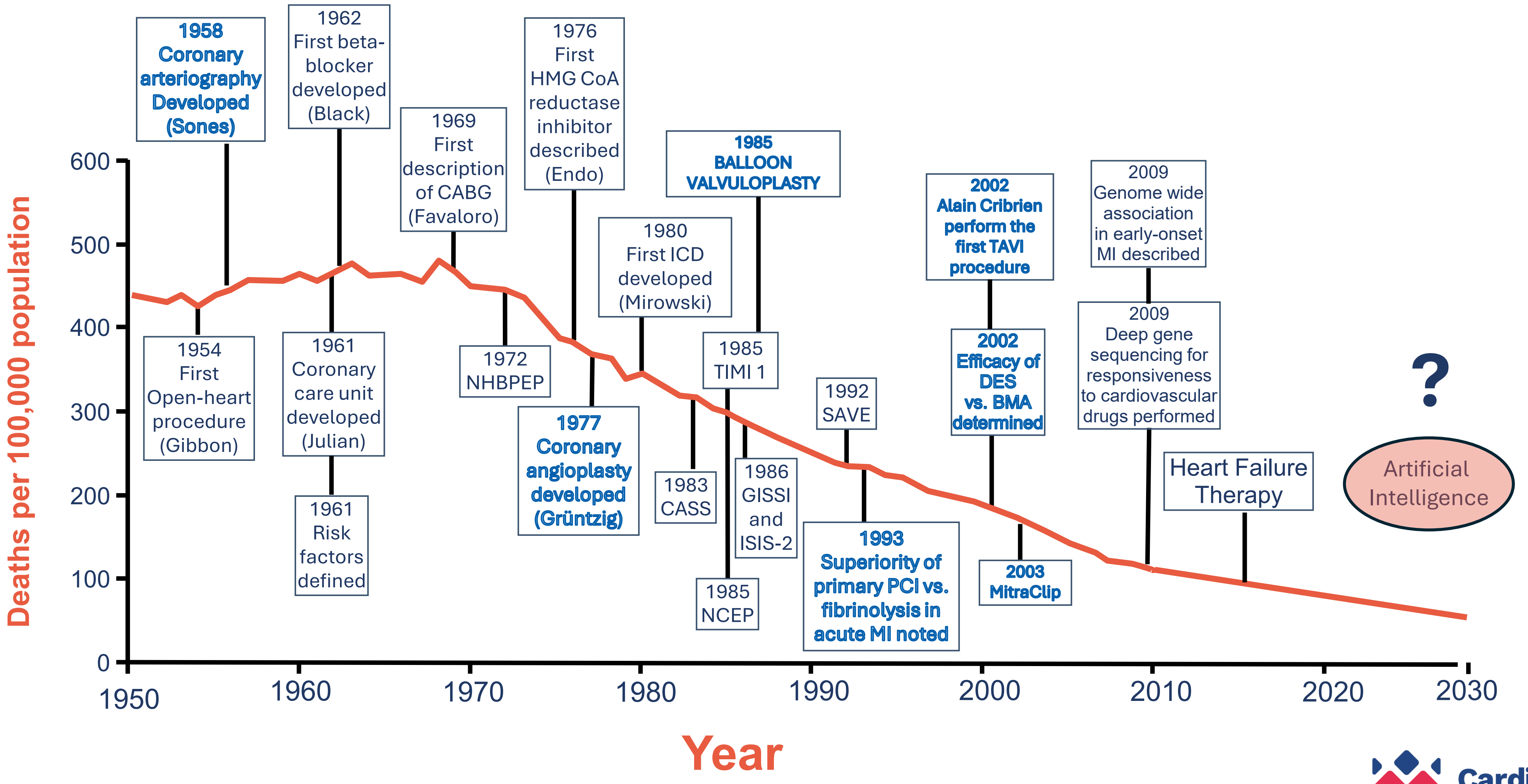
Ahmad F. *JAMA* 2024, in press





Vaduganathan M et al. J Am Coll Cardiol. 2022;80(25):2361-2371.

Decline in Deaths from Cardiovascular Disease in Relation to Scientific Advances



Adapted from Nabel EG and Braunwald E., N Eng J Med 2012;366:54-63

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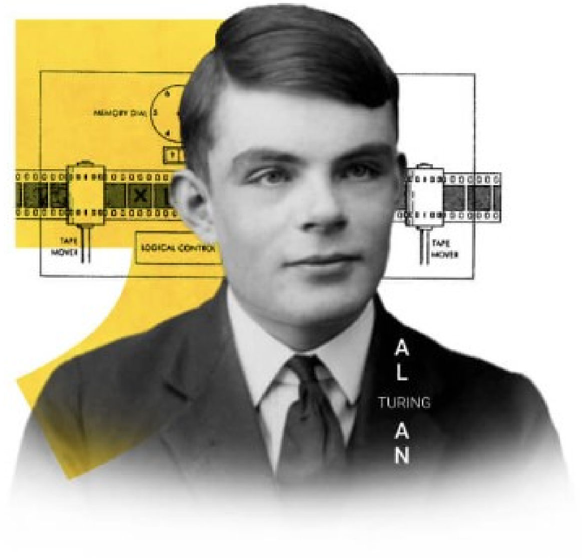
Artificial Intelligence: History and Definition



«A computer would deserve to be called intelligent if it could deceive a human into believing that it was human.
Can machines think?»

Alan Turing, 1950

ARTIFICIAL INTELLIGENCE
is a tool that uses machines to learn and perform complex tasks

MACHINE LEARNING
is an algorithm that can find solutions to problems using the data provided and improve performance by the exposure to more data

DEEP LEARNING
uses convolution neural networks to identify patterns and learn information from vast amounts of data

Di Costanzo A, Spaccarotella CAM, Esposito G, Indolfi. J Clin Med. 2024;13(4):1033.

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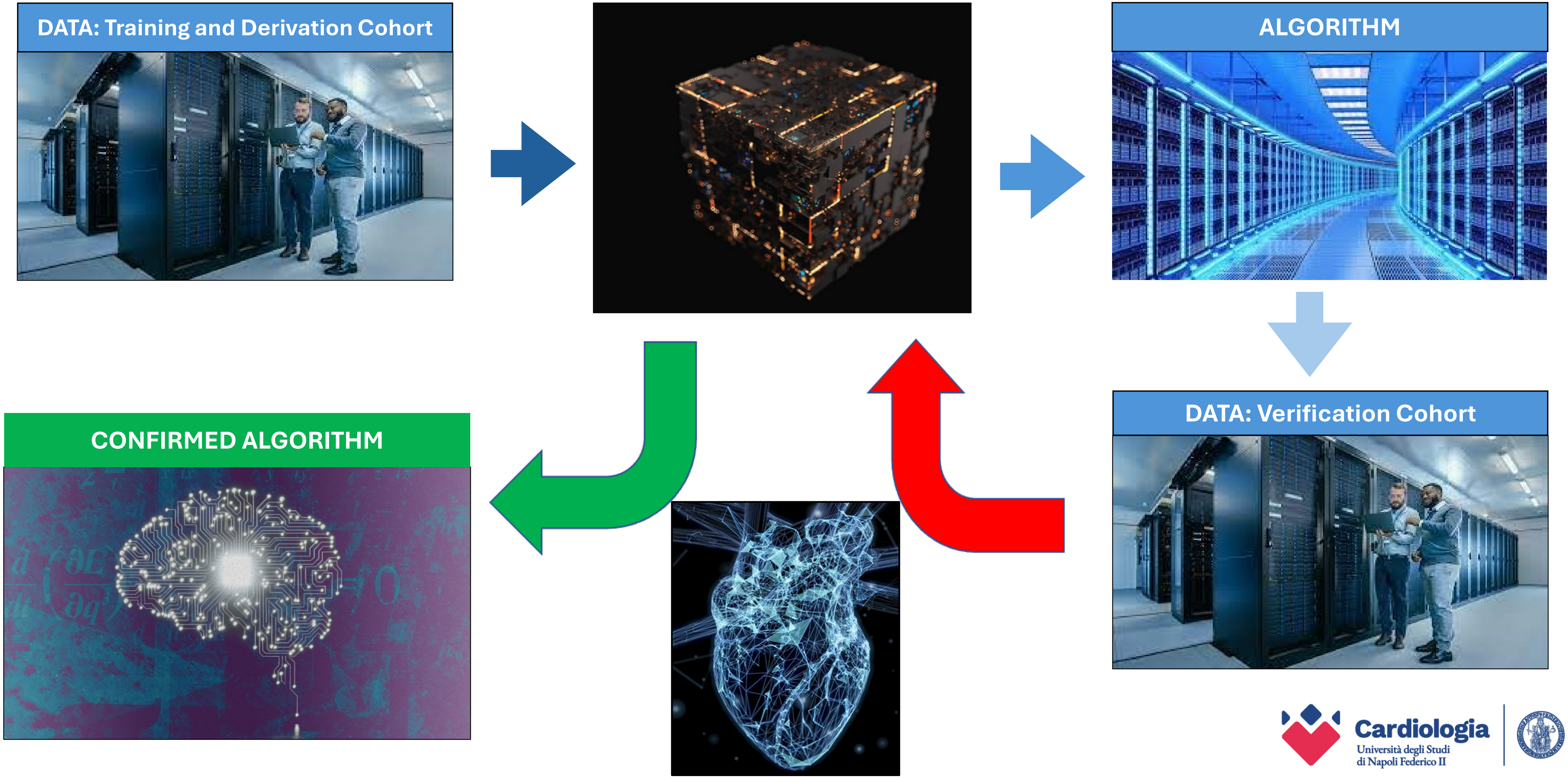
ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING



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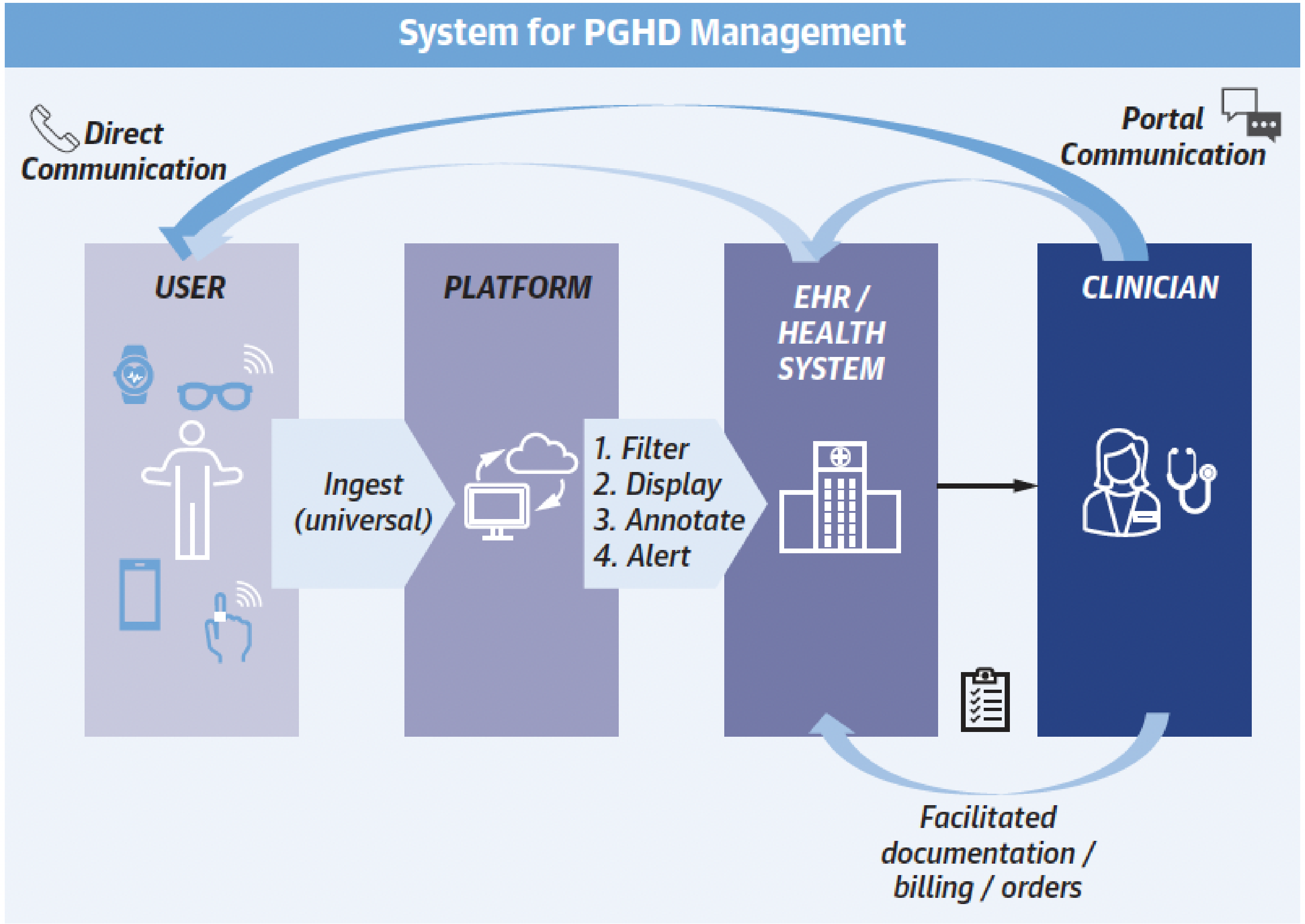
Patient-Generated Health Data (PGHD)

- The efficient application of wearable devices to clinical practice could be facilitated by a **platform** that ingests data from a variety of wearable devices, followed by filtering (identification of clinically true data), display, and annotation, and critical alerting processes.

- The curated data/reports would then be sent to the **electronic health record**.

- Interaction with the data (including ordering and reporting) could remain through the electronic health records to **simplify workflow and minimize the problem of multiple logins**



Varma N et al. J Am Coll Cardiol. 2024;83(5:611-631).

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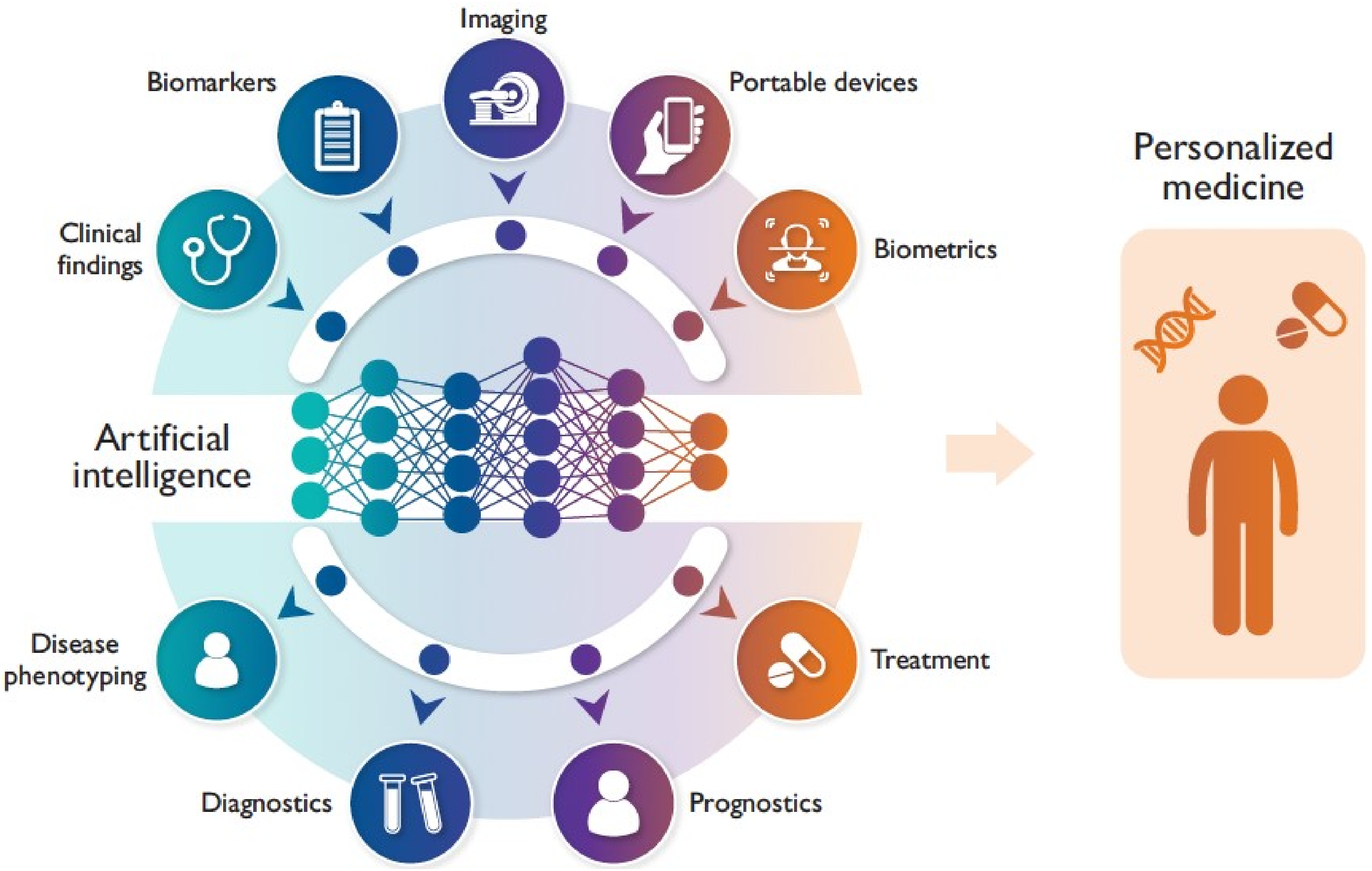
ARTIFICIAL INTELLIGENCE: TO ACHIEVE PERSONALIZED THERAPY IN CARDIOLOGY

- **Clinical information including patient data, laboratory parameters, and results from clinical examination, large-scale data from registries, imaging data, and patient biometrical data can all be processed by artificial intelligence.**

- **Resulting models allow for disease phenotyping, enhance diagnostics, improve prognostication, and facilitate treatment decision-making, thus ultimately contributing to a more personalized therapy of patients with cardiovascular disease.**



Lüscher TF et al. Eur Heart J. Published online August 19, 2024.

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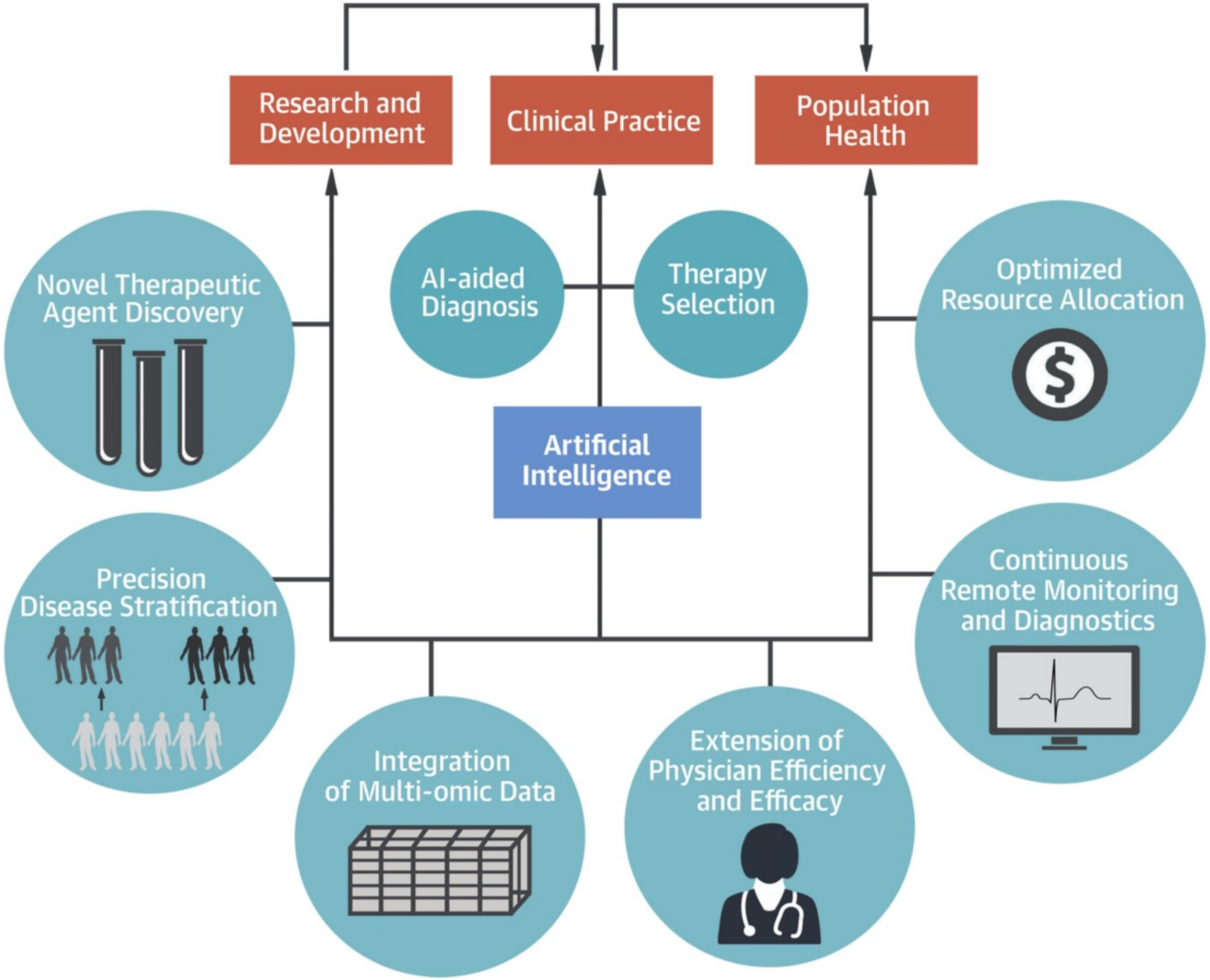
Role of Artificial Intelligence in Cardiovascular Medicine



Johnson KW, et al., J Am Coll Cardiol. 2018;71(23):2668-2679.

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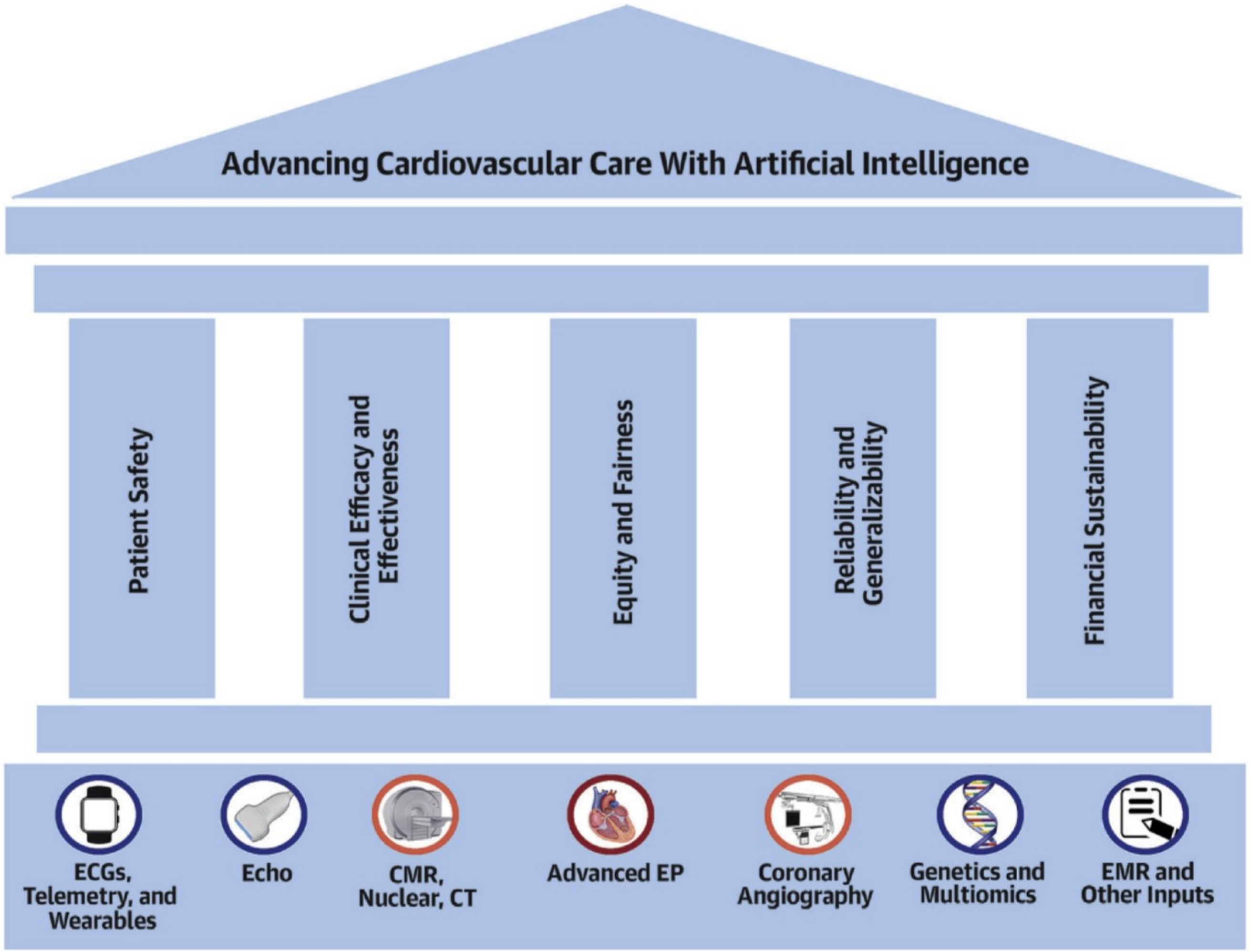
ADVANCING CARDIOVASCULAR CARE WITH ARTIFICIAL INTELLIGENCE



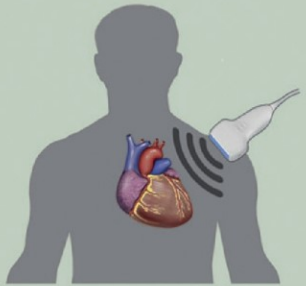
Jain SS et al. J Am Coll Cardiol. 2024;83(24):2487-2496.

CARDIOVASCULAR ARTIFICIAL INTELLIGENCE BY IMAGING MODALITY

Electrocardiograms and Wearables

- Detection of structural heart disease from 12-lead ECG
- Detection of atrial fibrillation wearable smartwatch
- Screening for asymptomatic LV dysfunction (LVEF ≤50%)

Echocardiograms

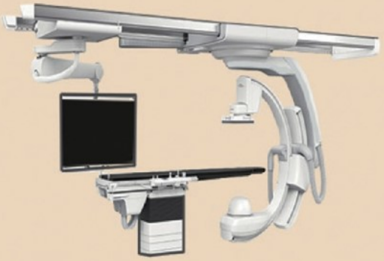


- Cardiologist agreement on LVEF greater with AI vs sonographer
- Diagnosis of HCM and CA from other causes of LVH
- Novice users assisted to quickly and accurately assess LV

MRI, Nuclear, CT

- Auto-assess coronary calcium on all CT scans to find untreated CAD
- Perivascular fat attenuation index on Coronary CTA to predict mortality
- AI-based virtual native enhancement replacing LGE on CMR

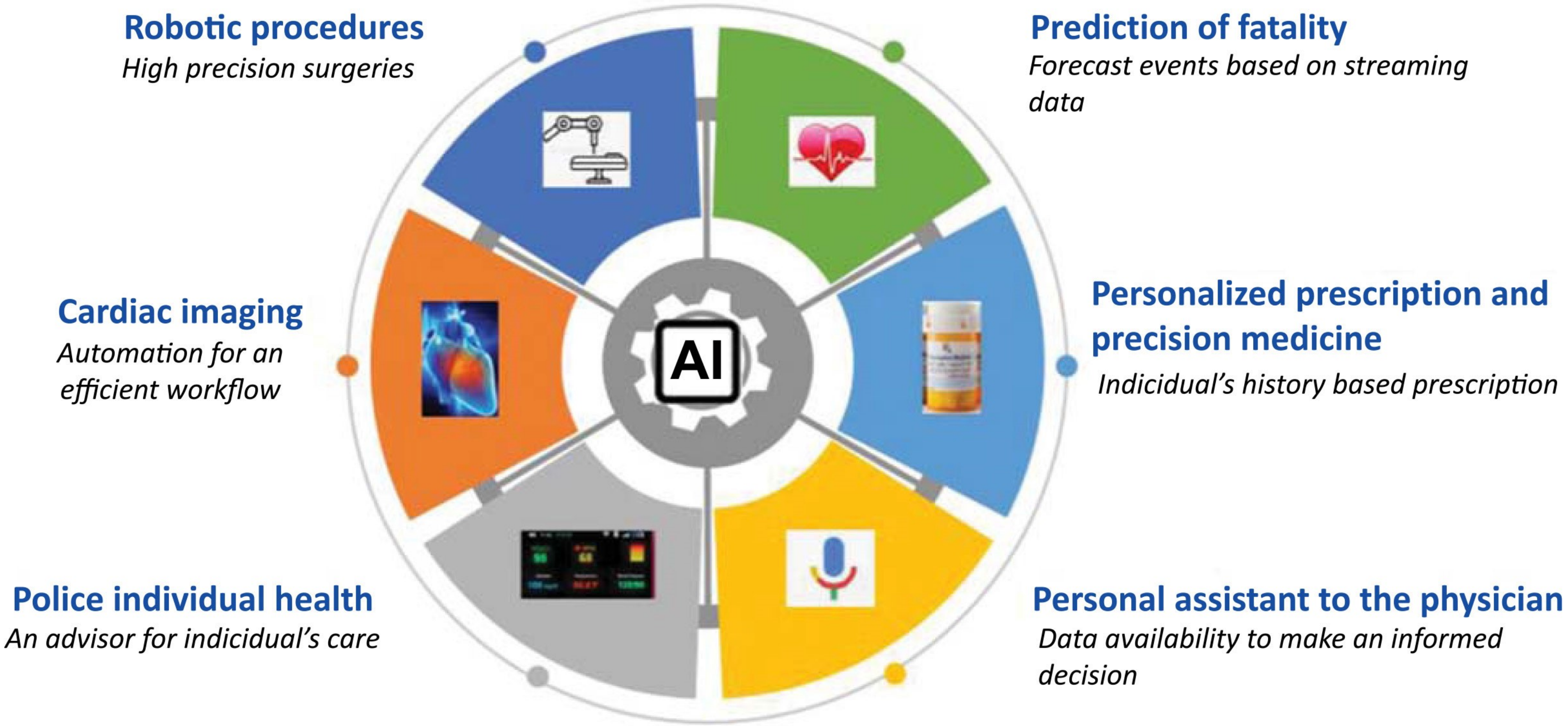
Coronary Angiography



- Automated LVEF calculation without requiring ventriculogram
- Prediction of MACE based on plaque morphology on angiography
- Coronary artery stenosis localization and estimation during LHC

Elias P et al., J Am Coll Cardiol. 2024;83(24):2472-2486.

THE EMERGENCE OF ARTIFICIAL INTELLIGENCE IN CARDIOLOGY: CURRENT AND FUTURE APPLICATIONS



Artificial intelligence and cardiology.

Kulkarni P et al. Curr Cardiol Rev. 2022;18(3):e191121198124.

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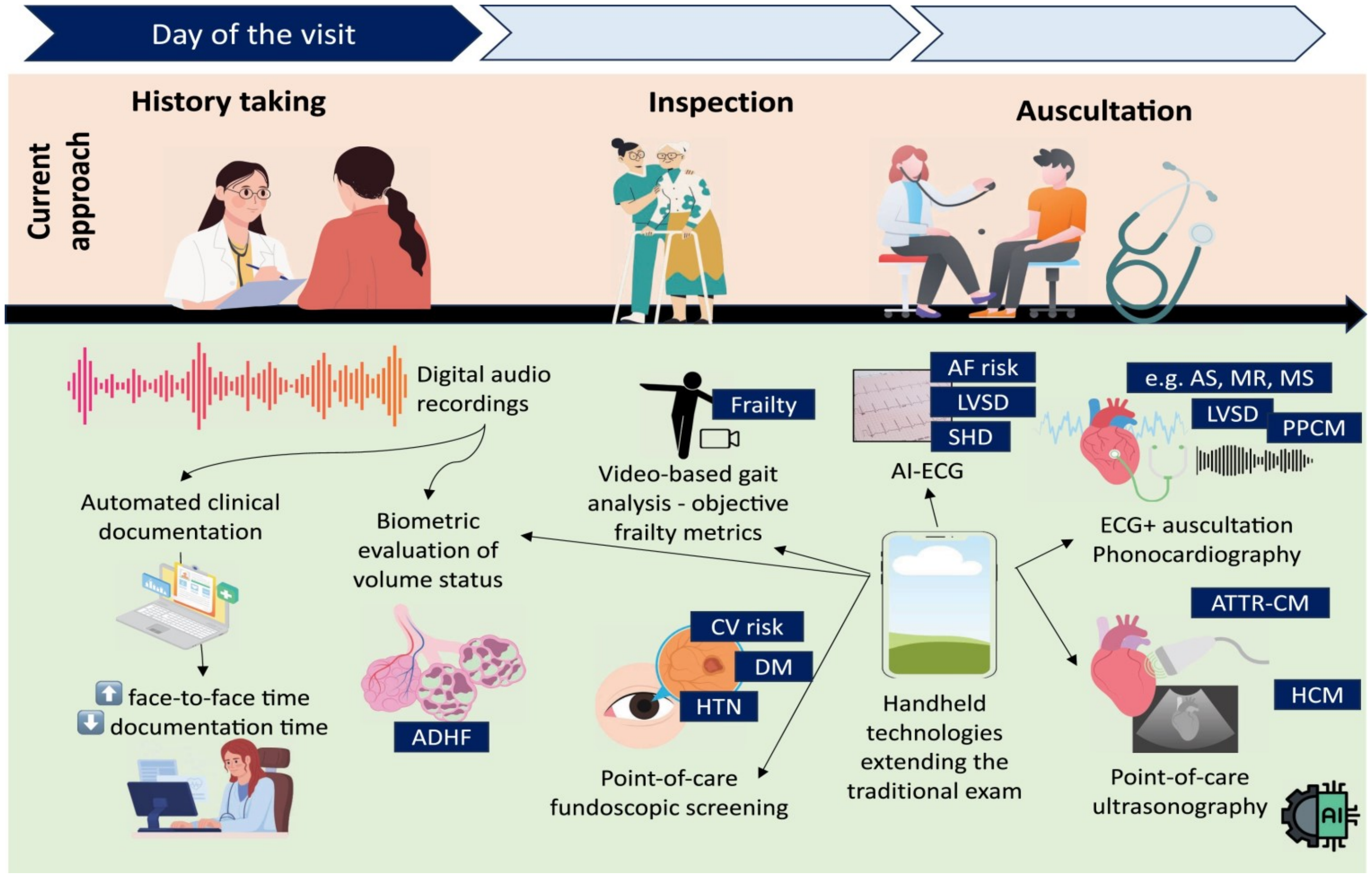
Artificial Intelligence-Enhanced Patient Evaluation-1



Oikonomou EK et al. Eur Heart J. 2024;45(35):3204-3218.

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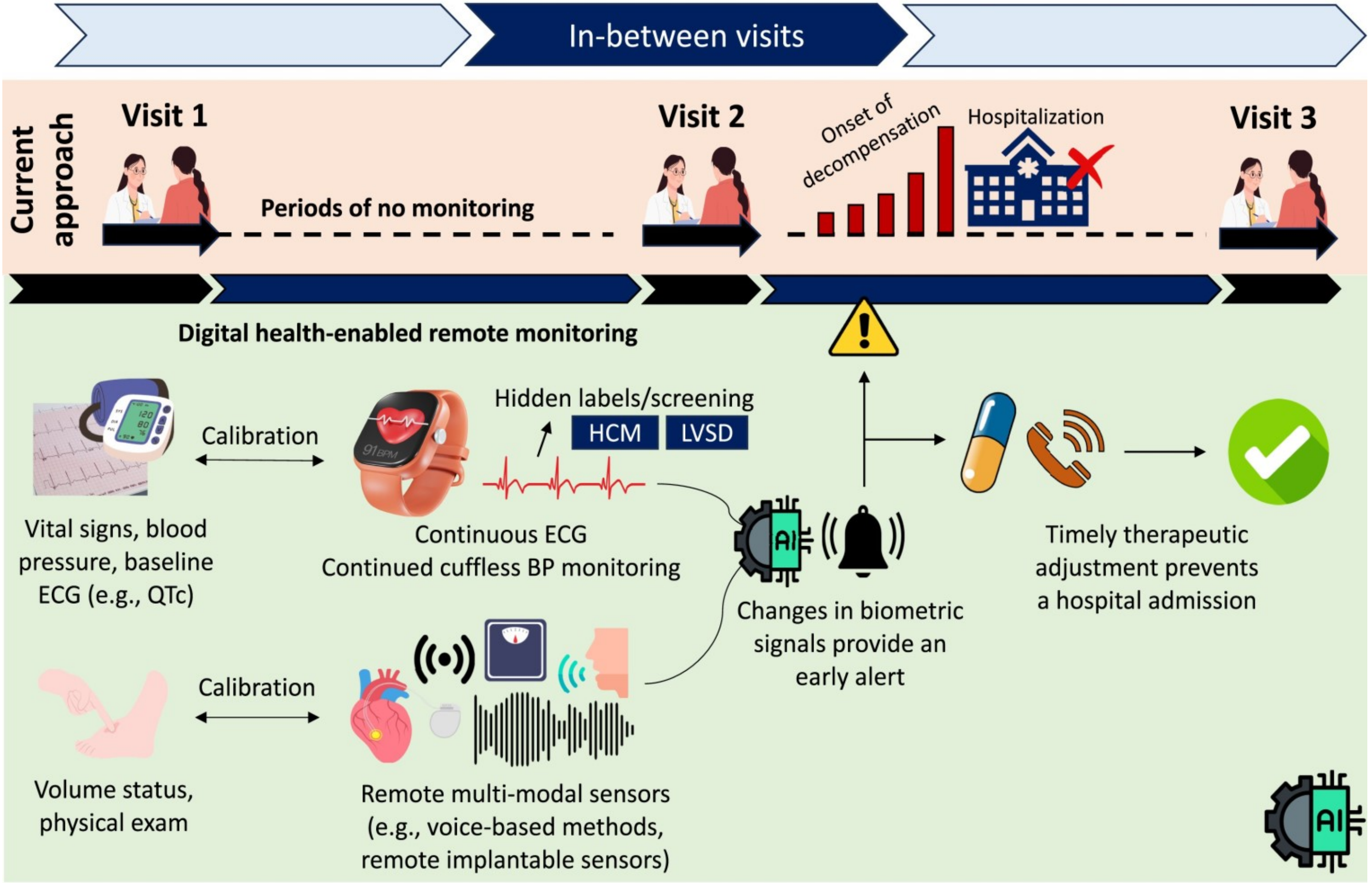
Artificial Intelligence-Enhanced Patient Evaluation-2



Oikonomou EK et al. Eur Heart J. 2024;45(35):3204-3218.

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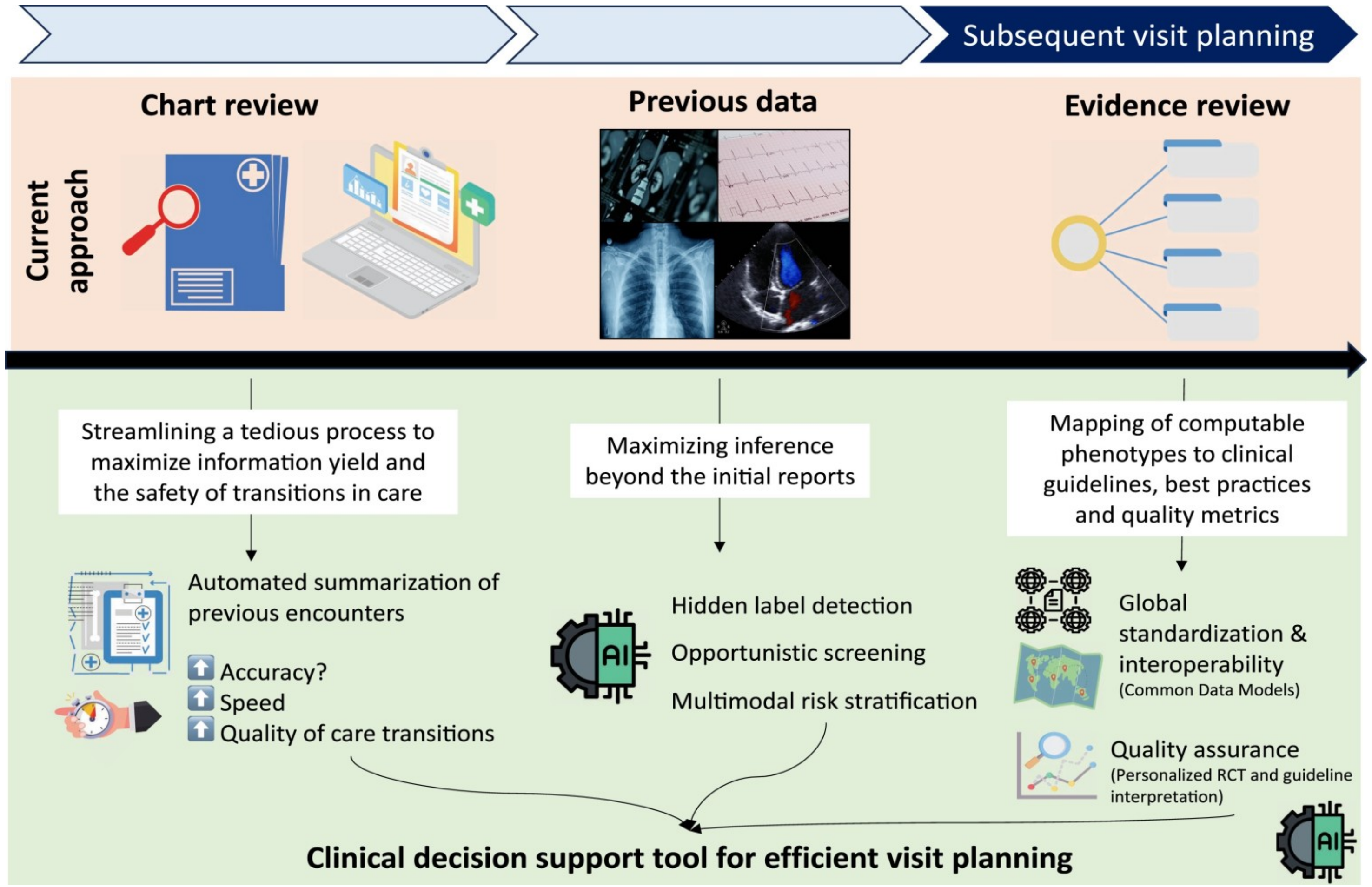
Artificial Intelligence-Enhanced Patient Evaluation-3



Oikonomou EK et al. Eur Heart J. 2024;45(35):3204-3218.

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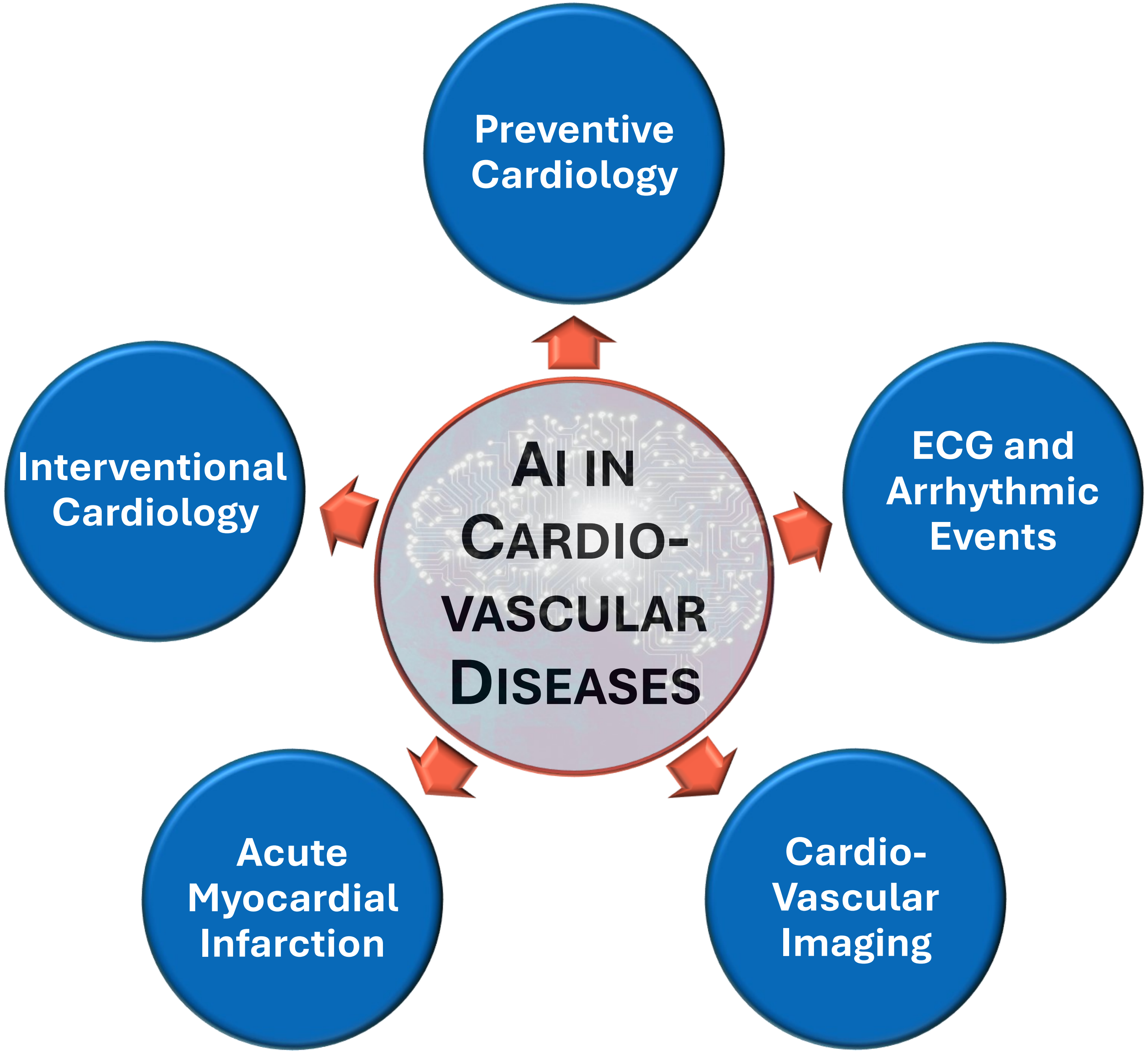

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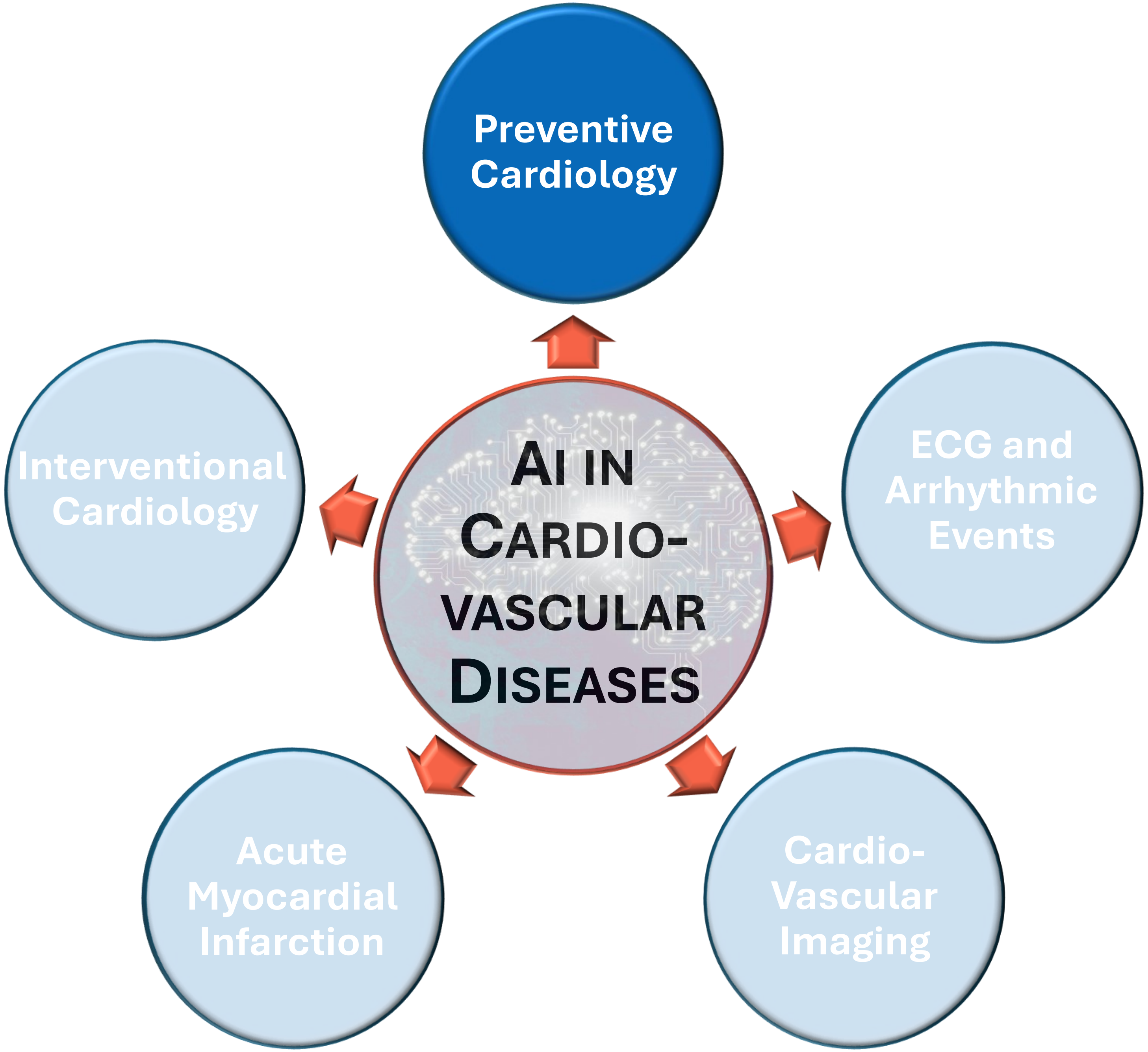

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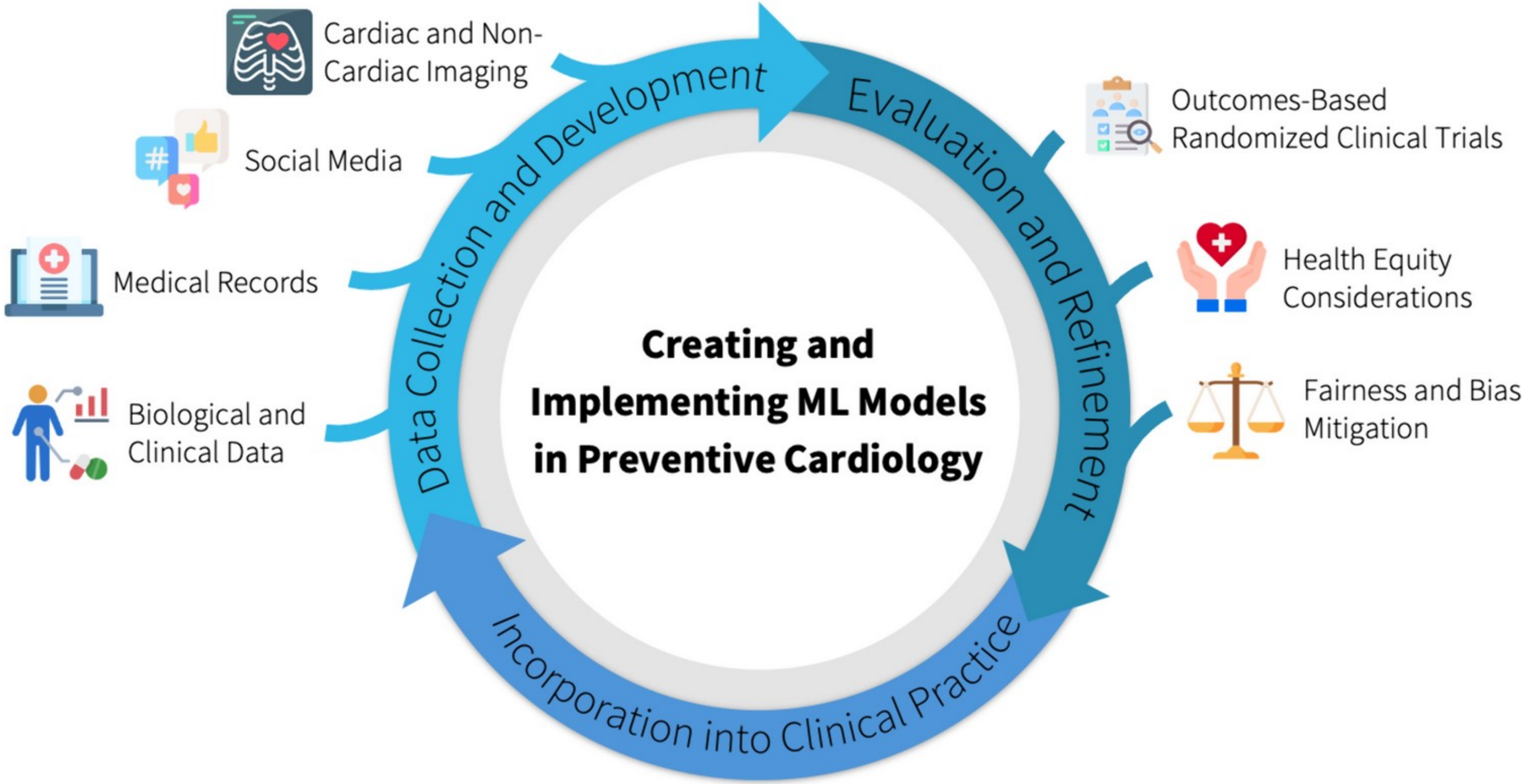
Artificial Intelligence in Preventive Cardiology

- **AI models have shown superior performance in personalized ASCVD risk evaluation compared to traditional risk scores;**

- **These models support automated detection of ASCVD risk markers (including coronary artery calcium, chest X-ray, mammograms, coronary angiography and CT-scans);**

- **Large language models are effective in identifying and addressing gaps and disparities in ASCVD preventive care.**



Parsa S et al., *Curr Atheroscler Rep*. Published online May 23, 2024.

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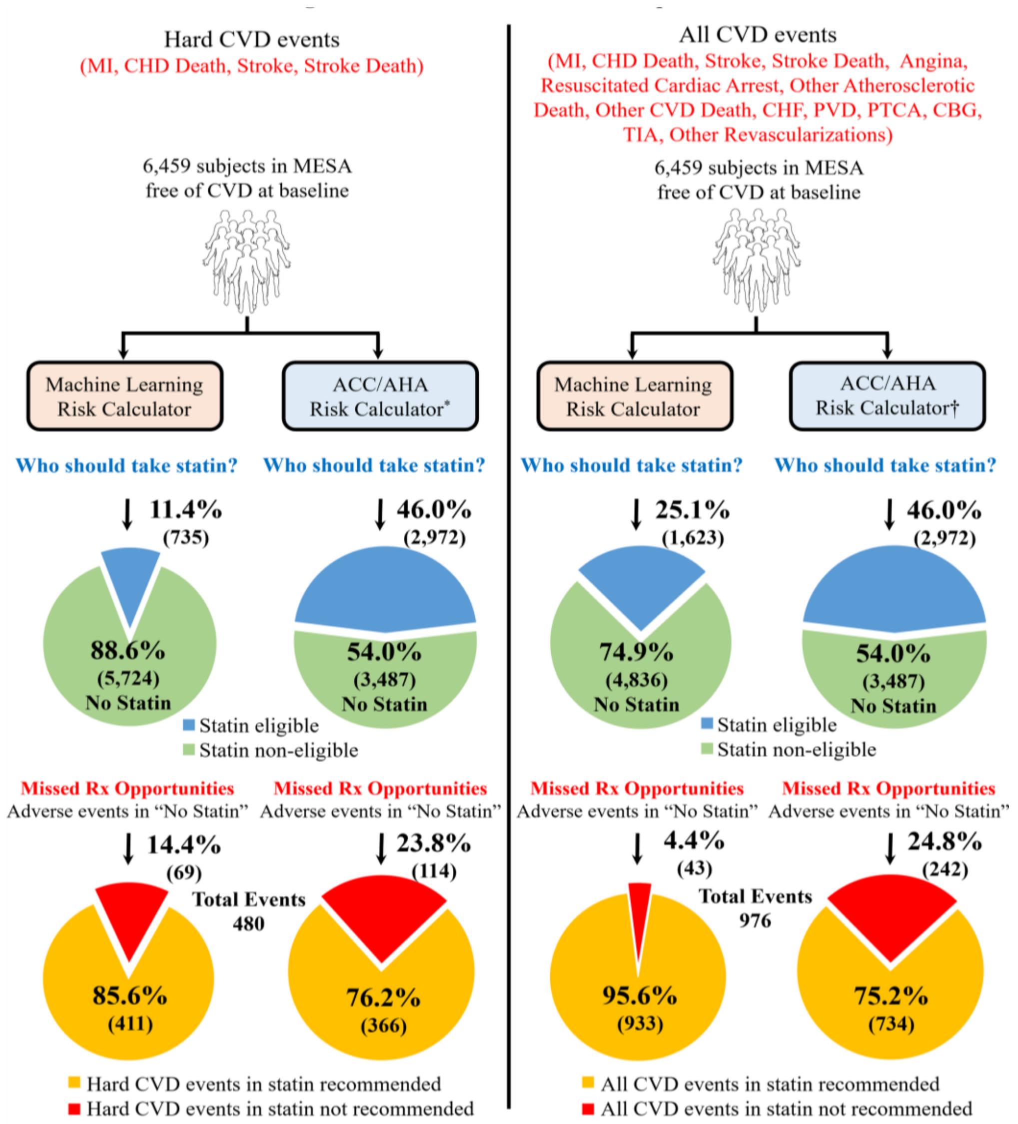
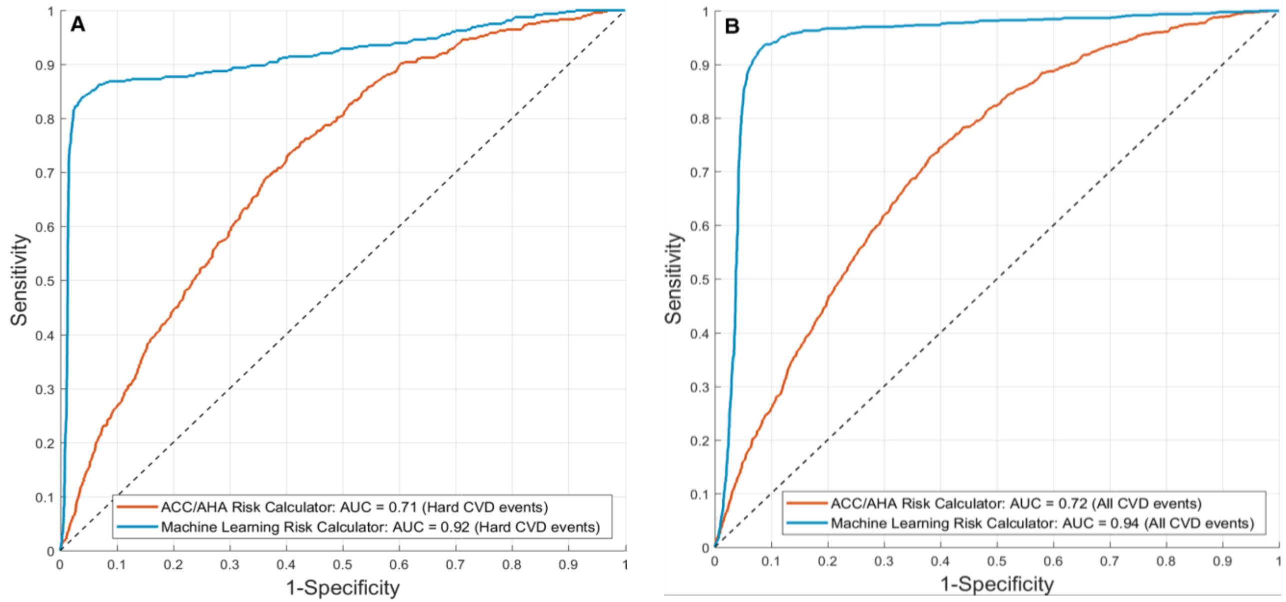
MACHINE LEARNING VS. ACC/AHA RISK CALCULATOR





ML Risk Calculator outperformed the ACC/AHA Risk Calculator:

- **Less drug therapy;**
- **Missing fewer CV events.**

Kakadiaris IA et al., *J Am Heart Assoc*. 2018;7(22):e009476.

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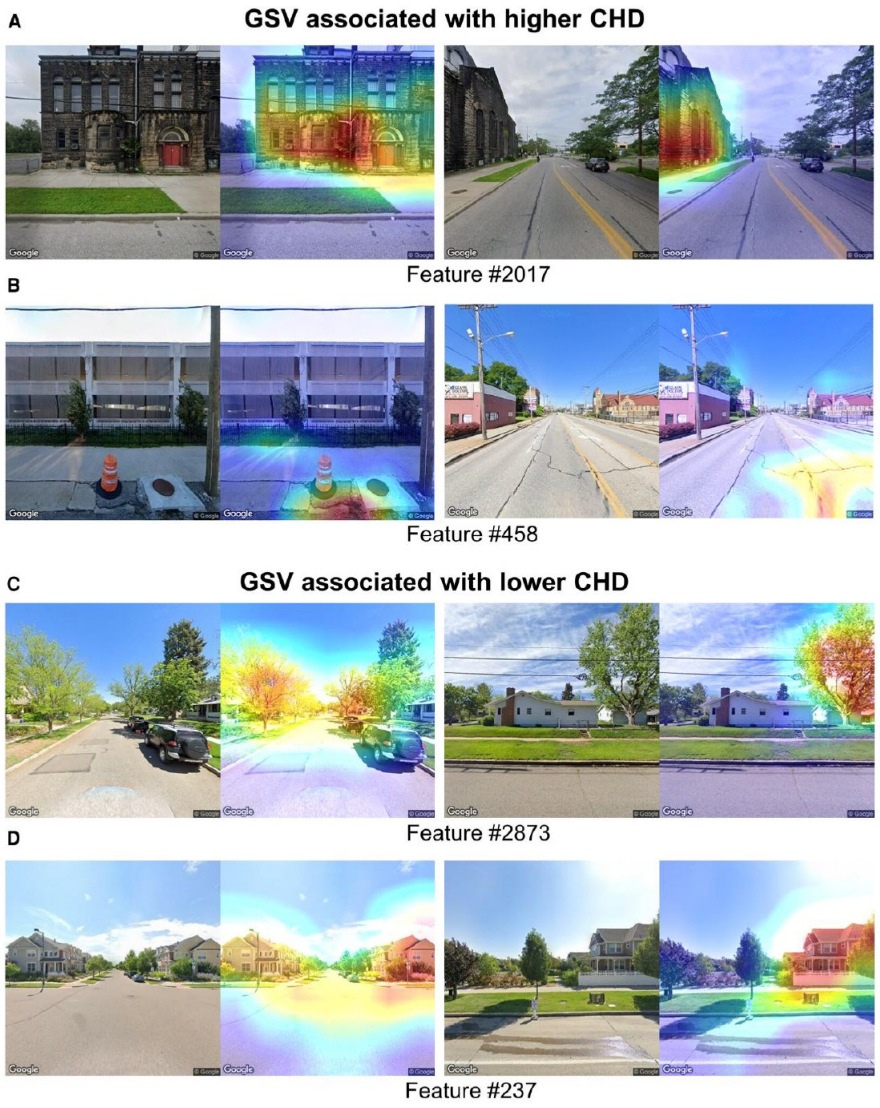
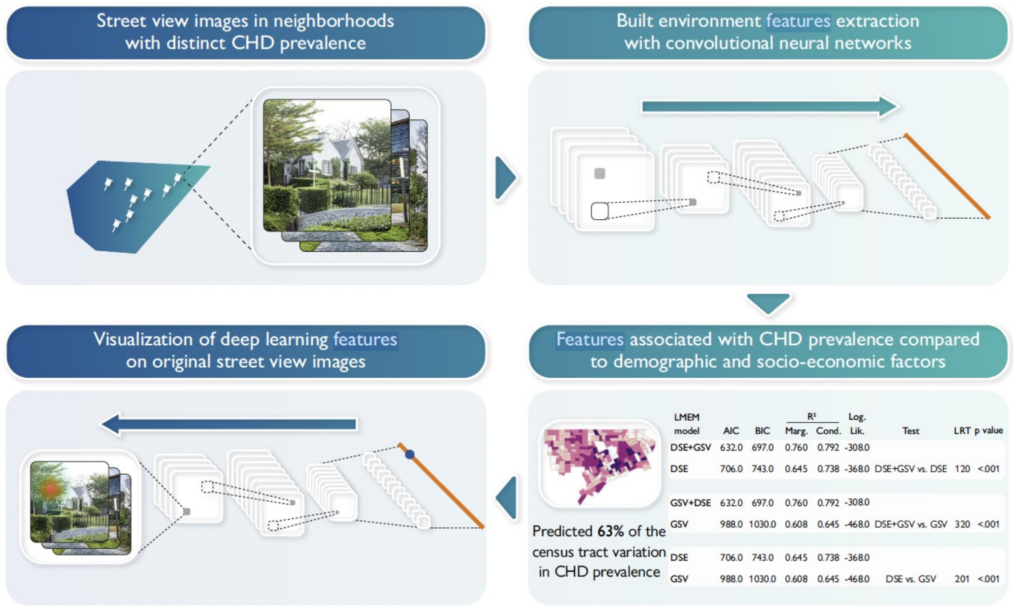
Association between Machine Vision-based Built Environment from Google Street View and Prevalence of Coronary Artery Disease in U.S Cities



- **Neighborhood characteristics derived from Google Street View (GSV) images of 7 U.S. cities (Cleveland, Fremont, Kansas City, Detroit, Bellevue, Brownsville and Denver) were associated with 63% of the variance in prevalence of CAD.**
- **Compared with a model including age, sex, race, income, education, and composite indices for social determinants of health, addition of GSV features enhanced the association with CAD.**



LMEM model	AIC	BIC	R^2 Marg.	R^2 Cond.	Log. Lik.	Test	LRT	p value
DSE+GSV	632.0	697.0	0.760	0.792	-308.0			
DSE	706.0	743.0	0.645	0.738	-368.0	DSE+GSV vs. DSE	120	<.001
GSV+DSE	632.0	697.0	0.760	0.792	-308.0			
GSV	988.0	1030.0	0.608	0.645	-468.0	DSE+GSV vs. GSV	320	<.001
DSE	706.0	743.0	0.645	0.738	-368.0			
GSV	988.0	1030.0	0.608	0.645	-468.0	DSE vs. GSV	201	<.001

Chen Z et al. Eur Heart J. 2024;45(17):1540-1549.

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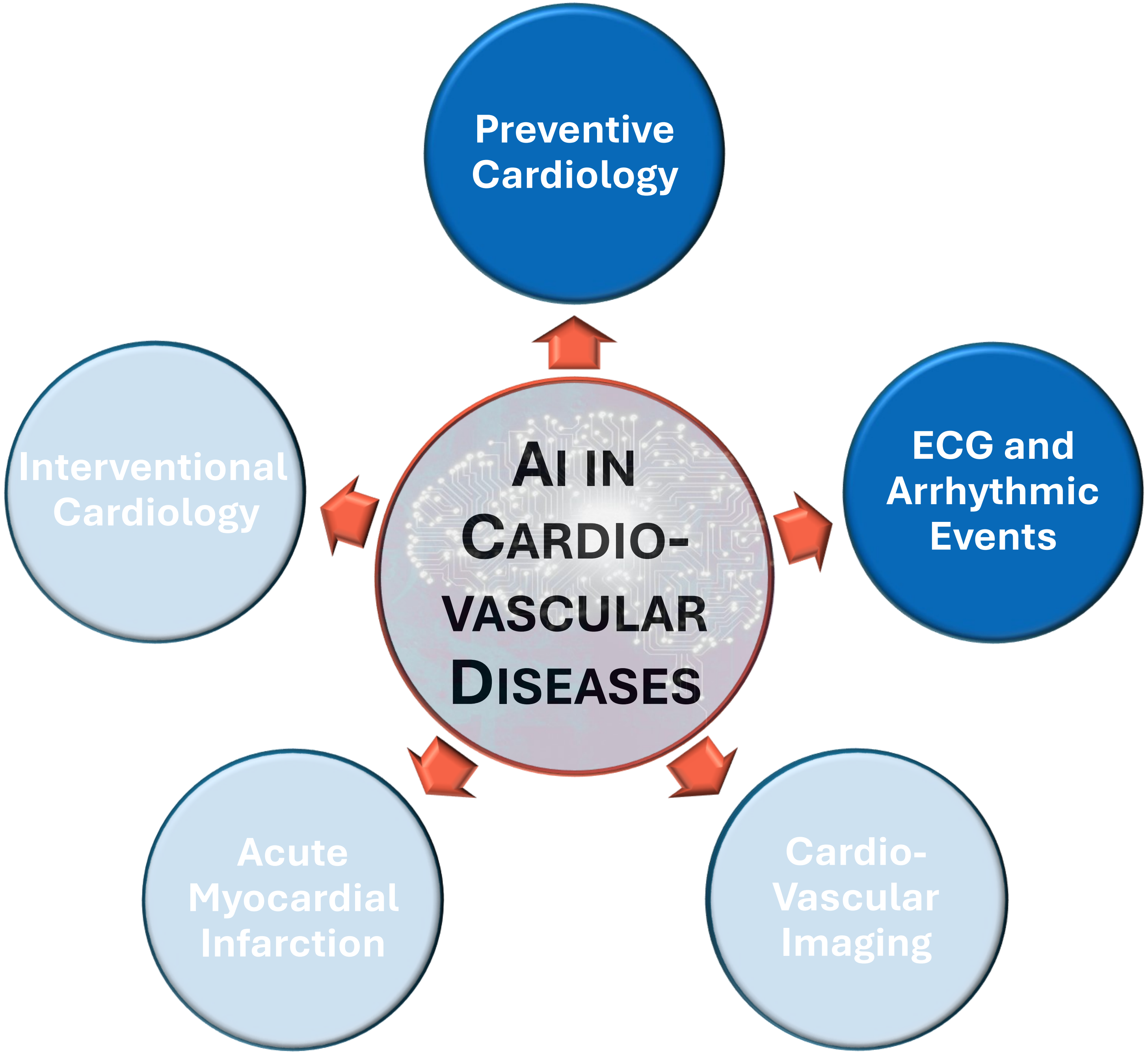
Preventive Cardiology
Interventional Cardiology
AI IN CARDIO-VASCULAR DISEASES
ECG and Arrhythmic Events
Acute Myocardial Infarction
Cardio-Vascular Imaging
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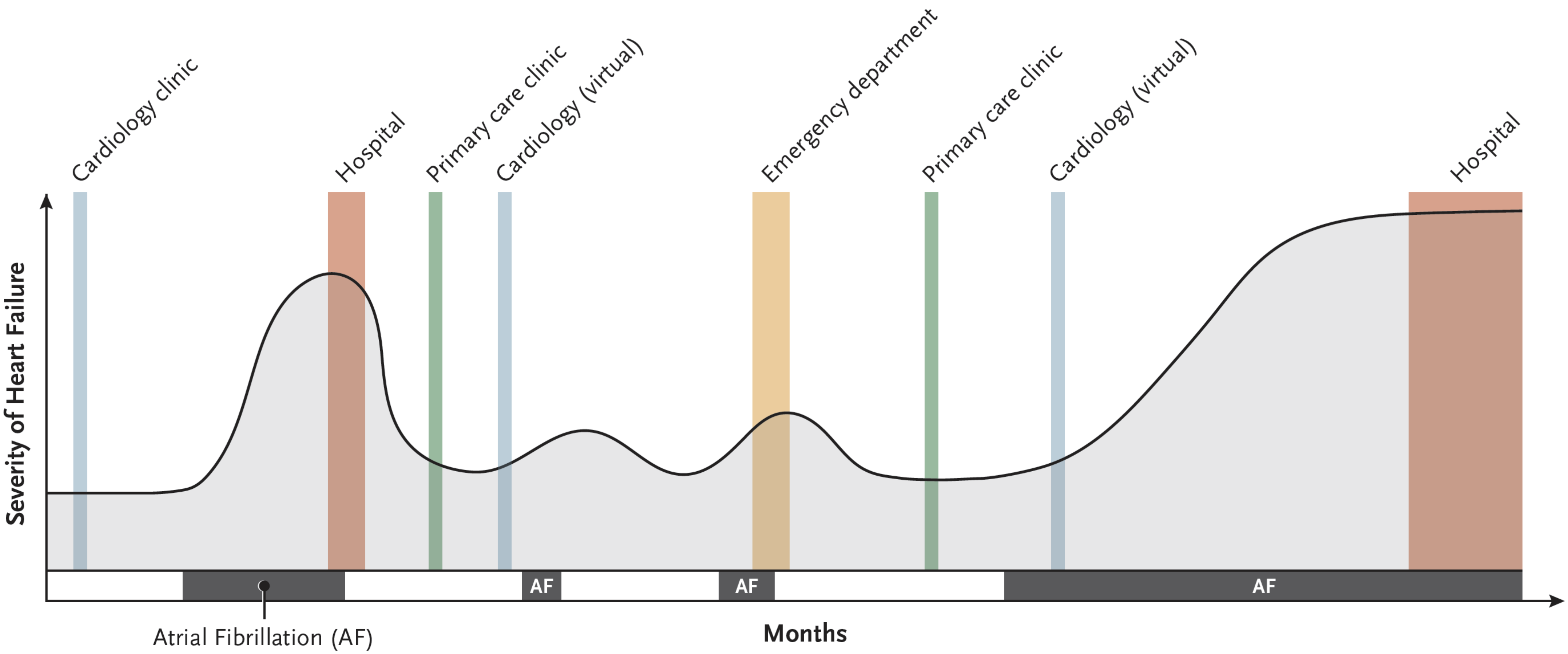
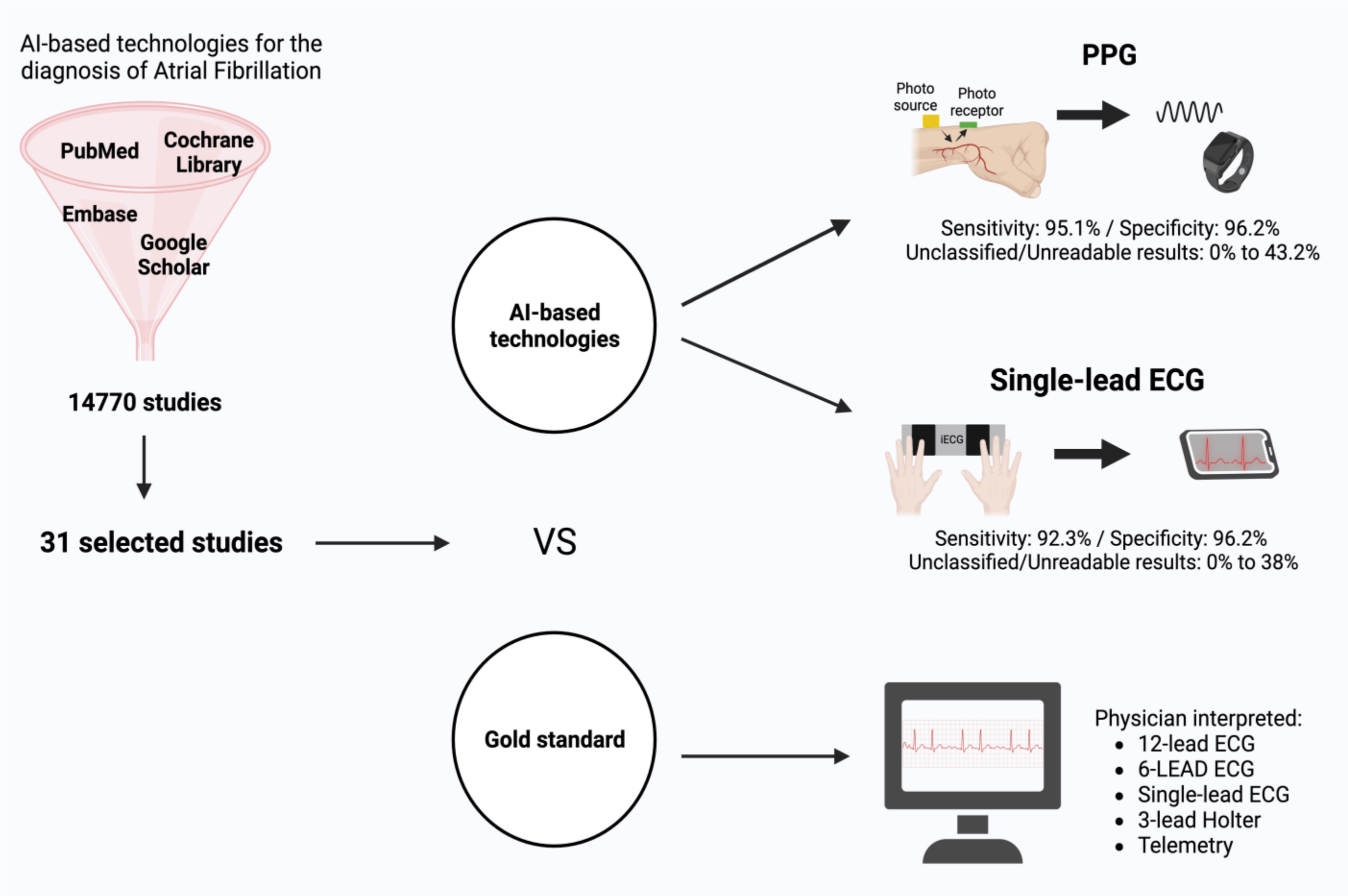
Gaps in Care of a Patient with Paroxysmal Atrial Fibrillation and Heart Failure in a Traditional Episodic Care Model

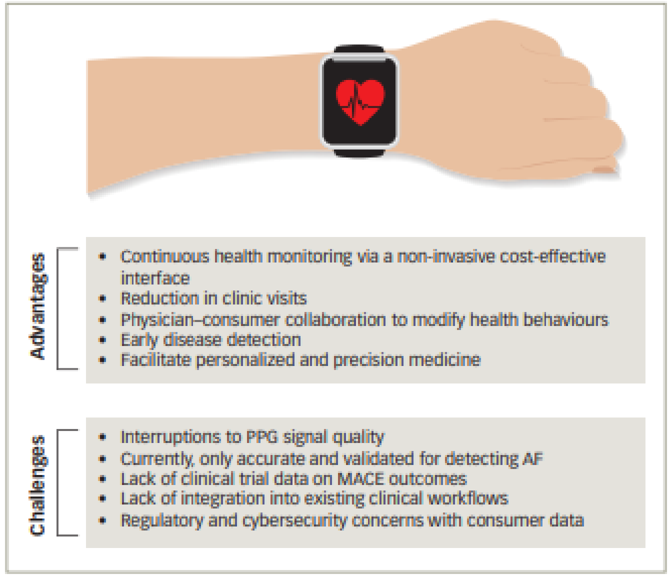


Spatz ES. et al. N Engl J Med 2024;390:346-56.

AI-BASED VS. TRADITIONAL TOOLS FOR AF DIAGNOSIS



AI-based methods for the diagnosis of atrial fibrillation have high sensitivity and specificity for the detection of AF.



Manetas-Stavrakakis N et al., *J Clin Med*. 2023;12(20):6576.

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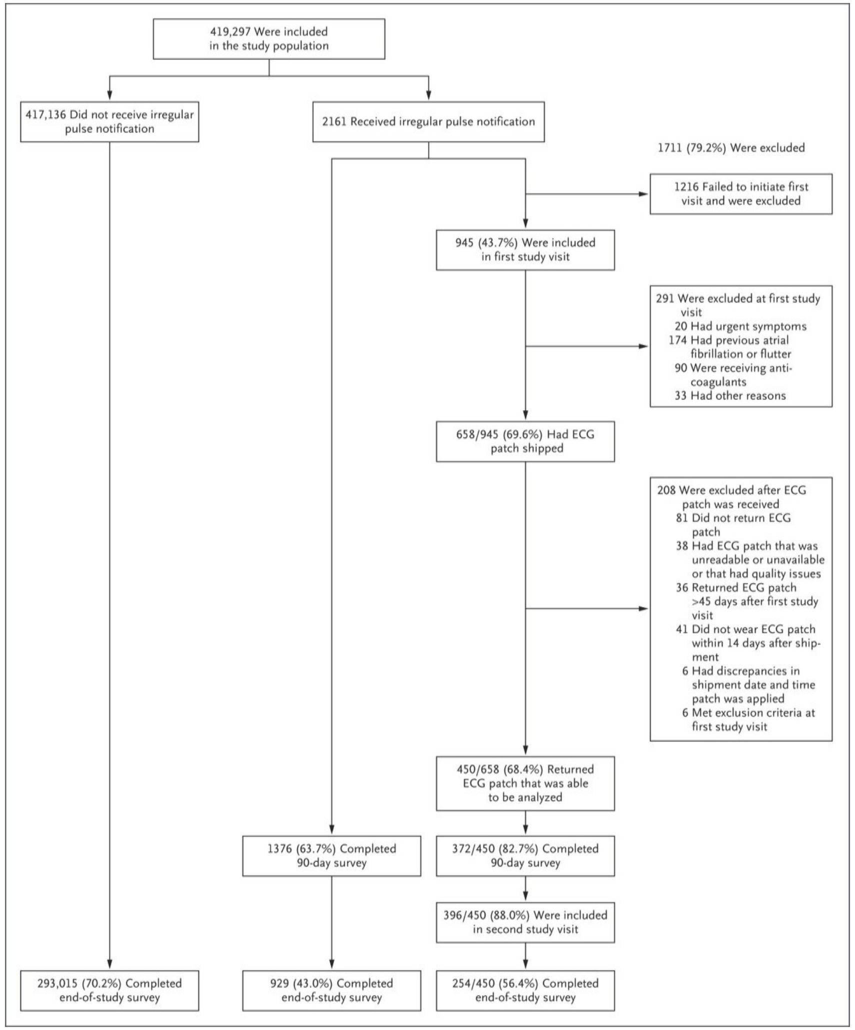
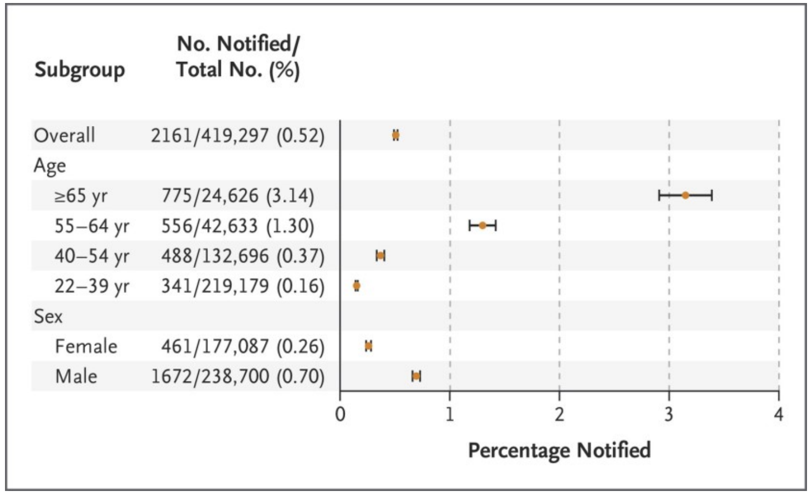
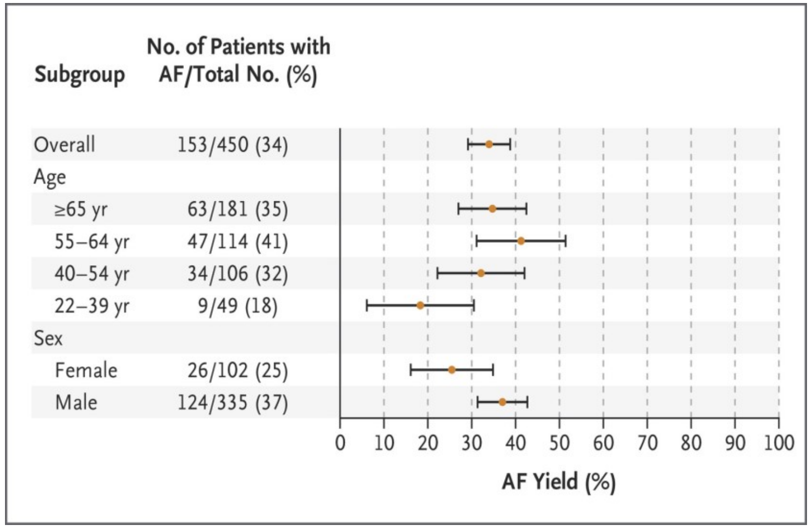
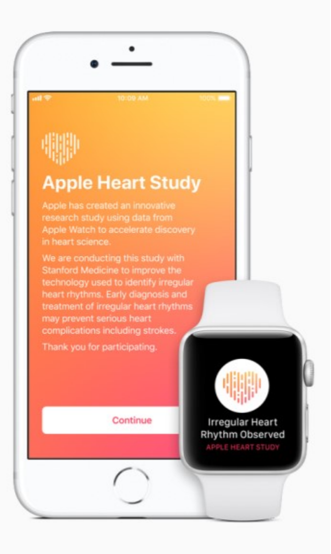
Wearable Devices for AF Diagnosis: the APPLE HEART Study









Variable	Notification Subgroup (N=929)	Non-notification Subgroup (N=293,015)
New diagnosis — no. (%)		
Atrial fibrillation	404 (43)	3070 (1.0)
Stroke	7 (0.8)	321 (0.1)
TIA	12 (1.3)	498 (0.2)
Heart failure	30 (3.2)	648 (0.2)
Myocardial infarction	10 (1.1)	574 (0.2)
Major bleeding	7 (0.8)	842 (0.3)
Medication use — no. (%)*		
Warfarin	20 (2.2)	265 (0.1)
Direct oral anticoagulant	202 (22)	996 (0.3)
Aspirin	338 (36)	40,774 (14)

Perez MV et al., *N Engl J Med*. 2019;381(20):1909-1917.

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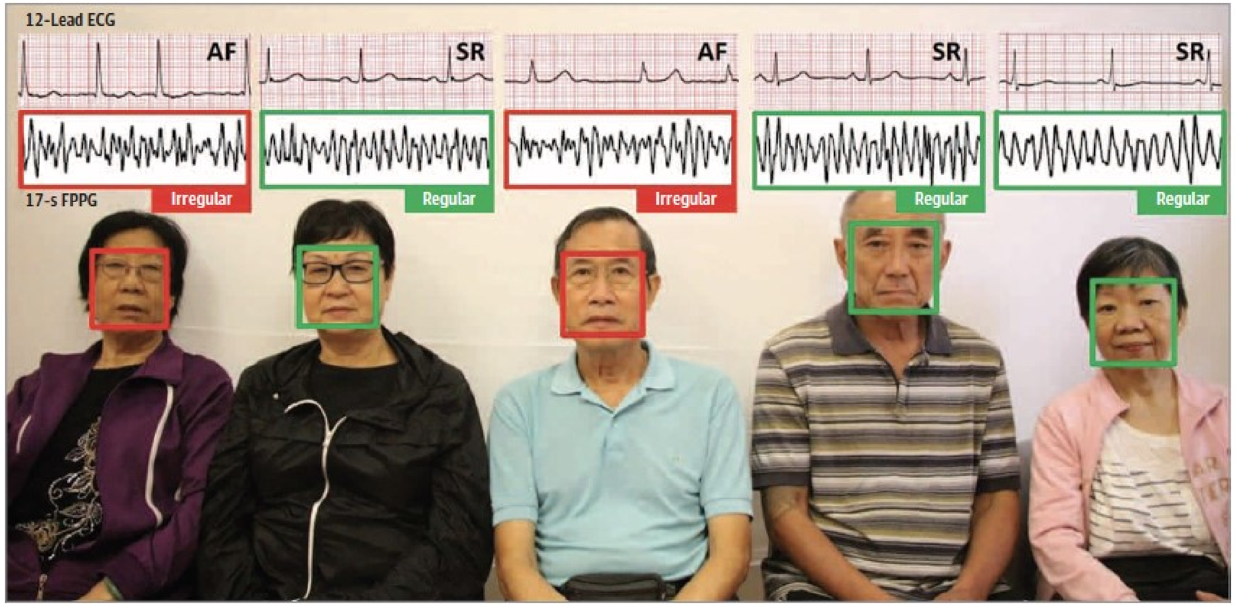
Contact Free Detection of AF from Video with Deep-Learning

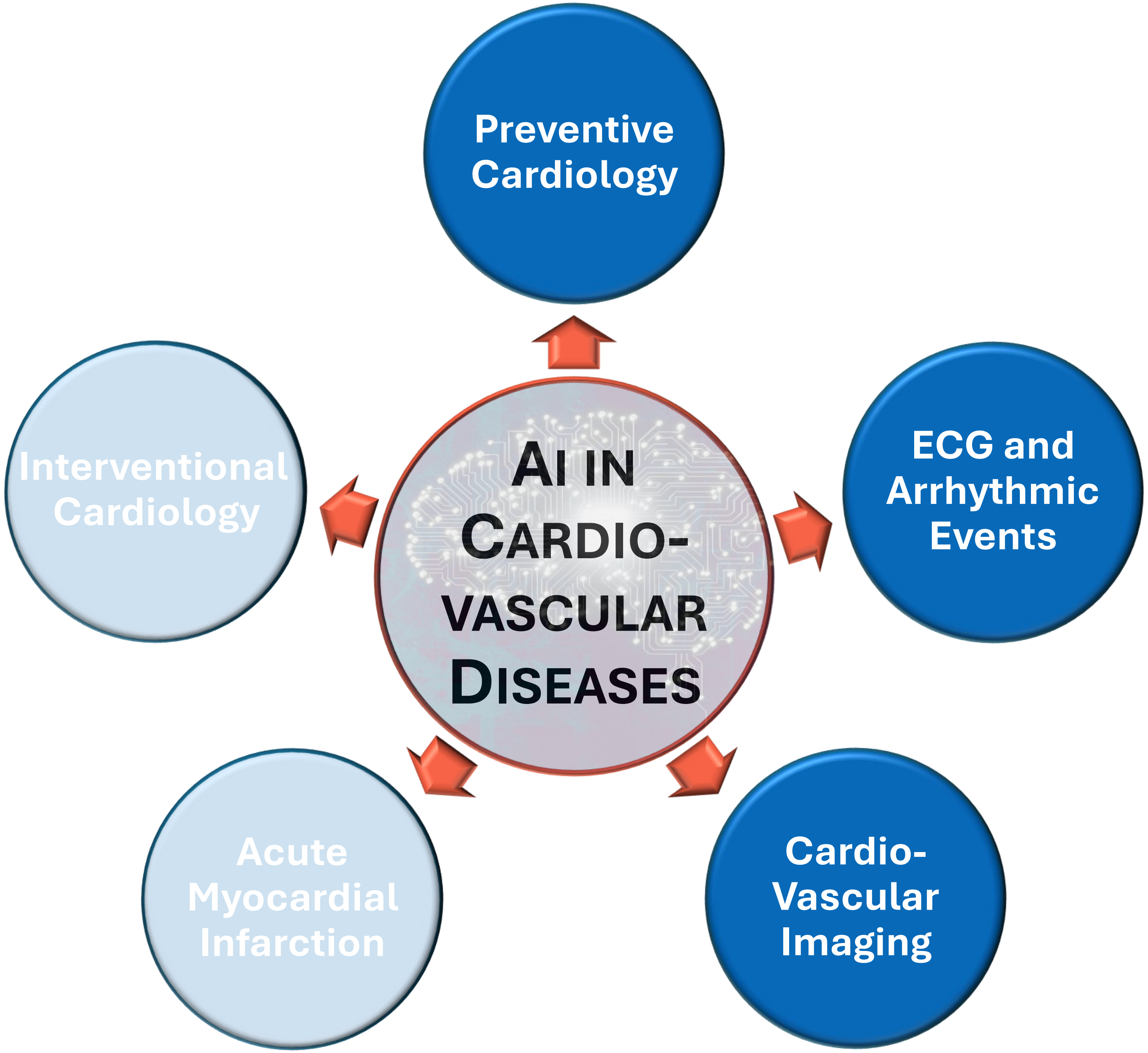


- 20 patients with permanent AF and 24 control individuals in sinus rhythm were recruited;
- Analysis of facial photo-plethysmographic (FPPG) signals from multiple patients concurrently using a single digital camera and a pretrained deep convolutional neural network;
- Pulse irregularity in >50% FPPG segments for each patient was considered positive for AF;
- 64 videos were recorded, each capturing 5 patients simultaneously in 32 different heart-rhythm permutations based on a 5-participant binary (AF/SR) matrix;
- Each patient appeared in 7 videos and 320 individual FPPG signals were analyzed.

Diagnostic Accuracy of Facial Photoplethysmographic in Detecting Atrial Fibrillation

	12-Lead ECG		
Variable	AF Present	AF Absent	Total
FPPG, No. (%)[a]			
Positive	150 (46.9)	3 (0.9)	153
Negative	10 (3.1)	157 (49.1)	167
Total No.	160	160	320

Yan BP et sl., *JAMA Cardiol*. 2020;5(1):105-107.



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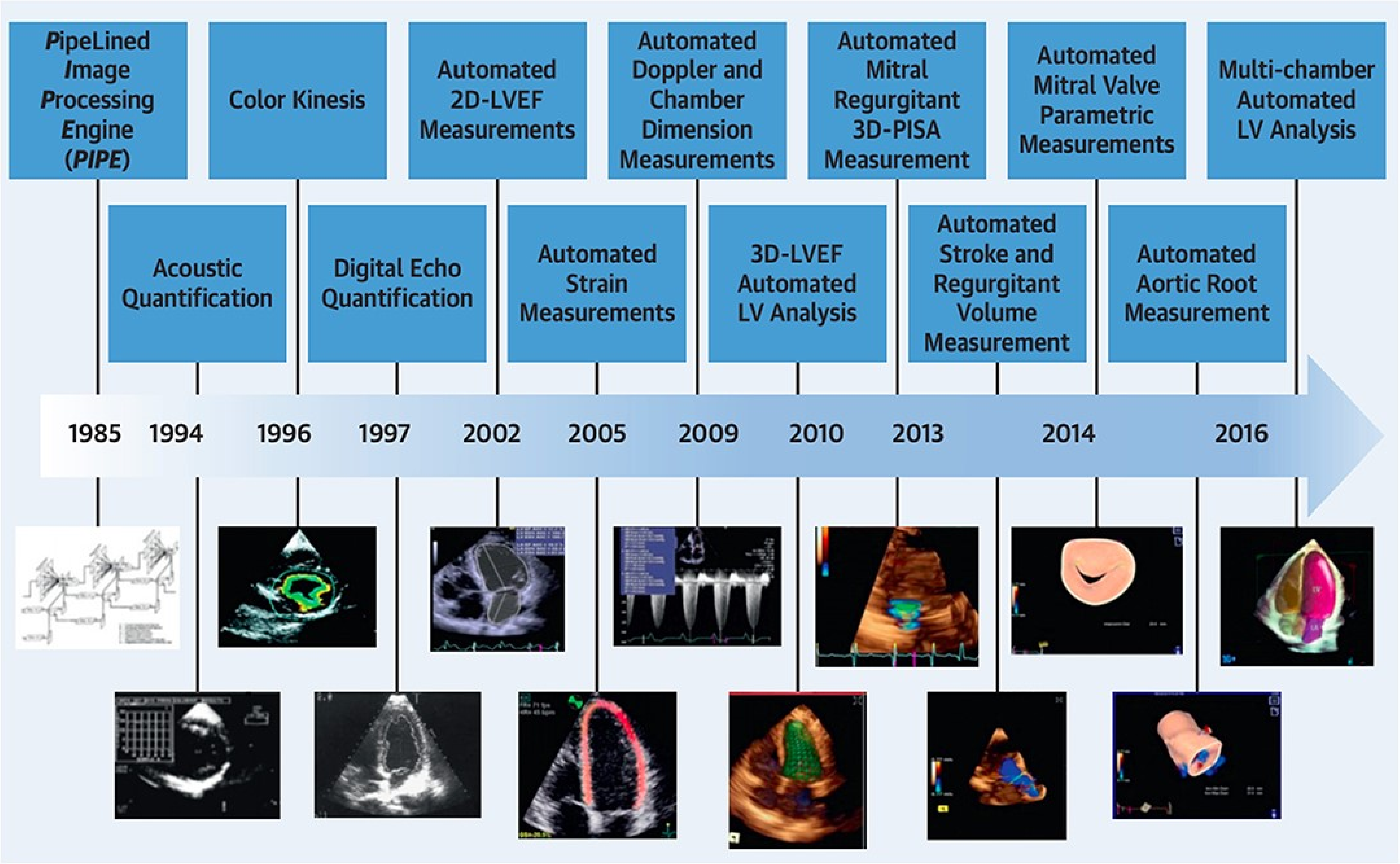
Temporal Progression in Automated Quantification in Echocardiography



Seetharam K et al., *Front Cardiovasc Med*. 2020;7:618849. Published 2020 Dec 23.

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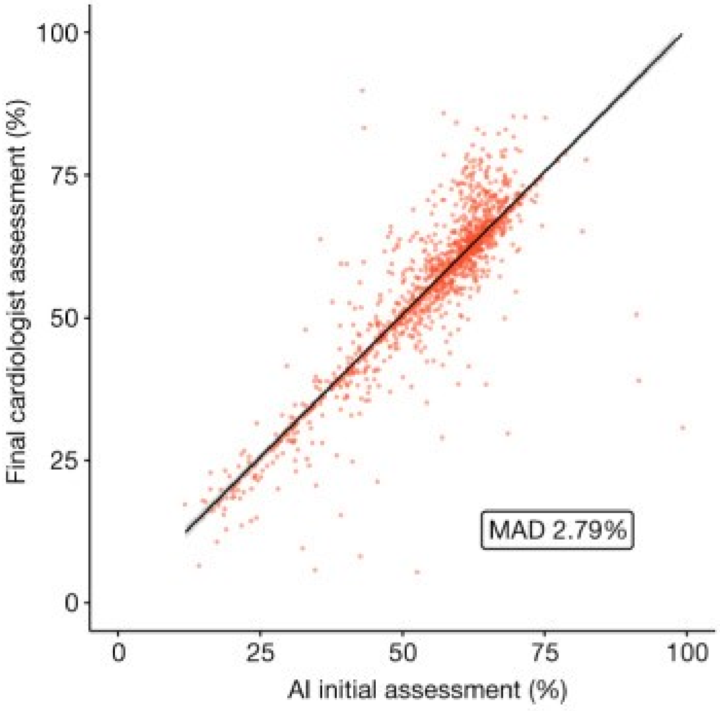
AI IN ECHOCARDIOGRAPHY

- AI-guided workflow for the initial assessment of cardiac function in echocardiography was non-inferior and even superior to the initial assessment by the sonographer.
- Cardiologists required less time, substantially changed the initial assessment less frequently and were more consistent with previous clinical assessments by the cardiologist when using an AI-guided workflow.



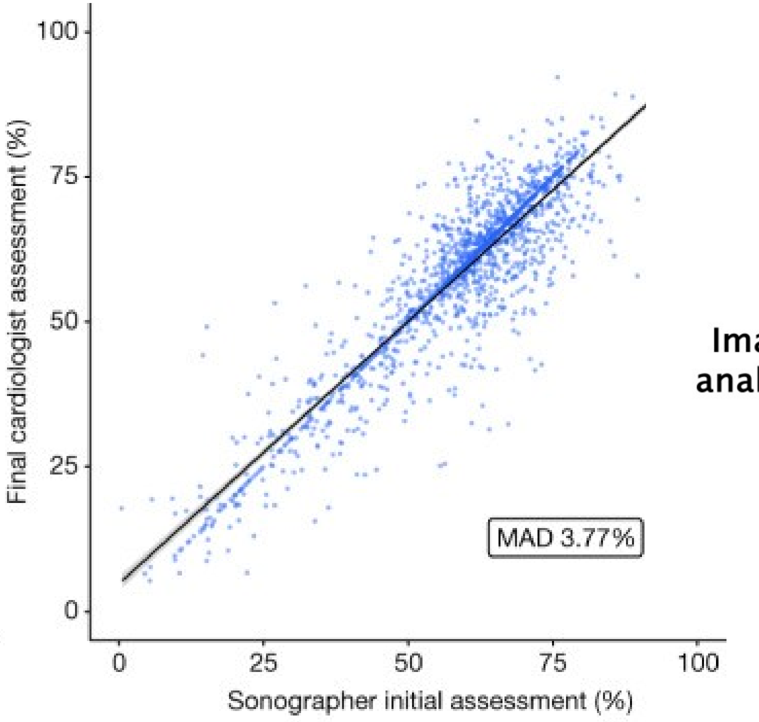


Image acquisition

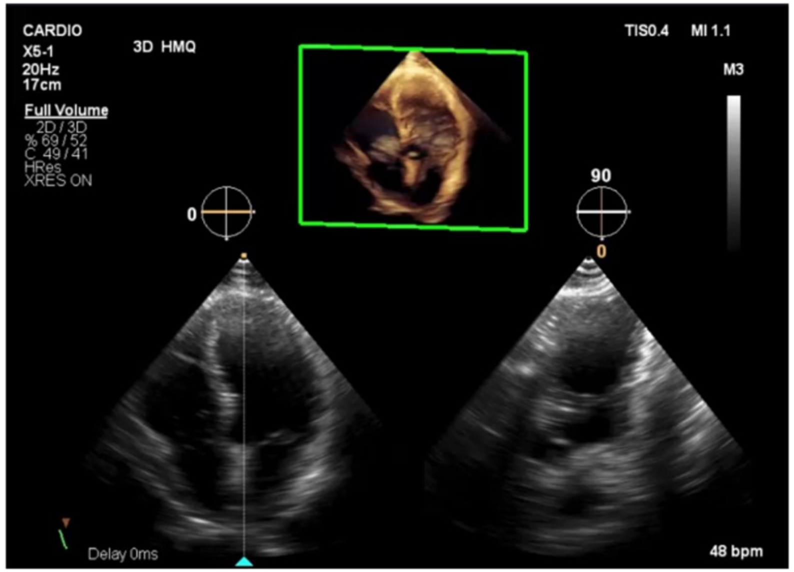
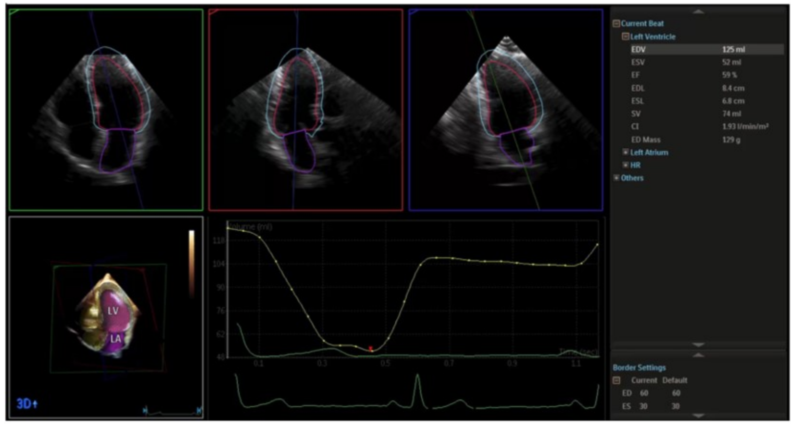


Image analysis



He B et al., *Nature*. 2023;616(7957):520-524.

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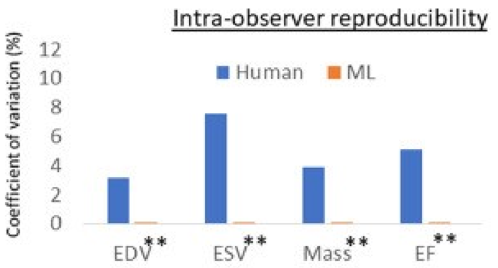
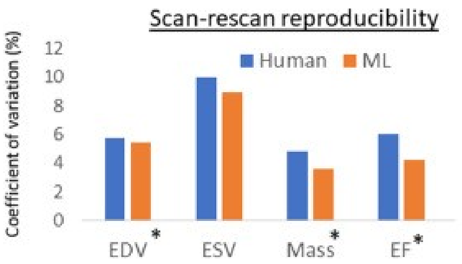
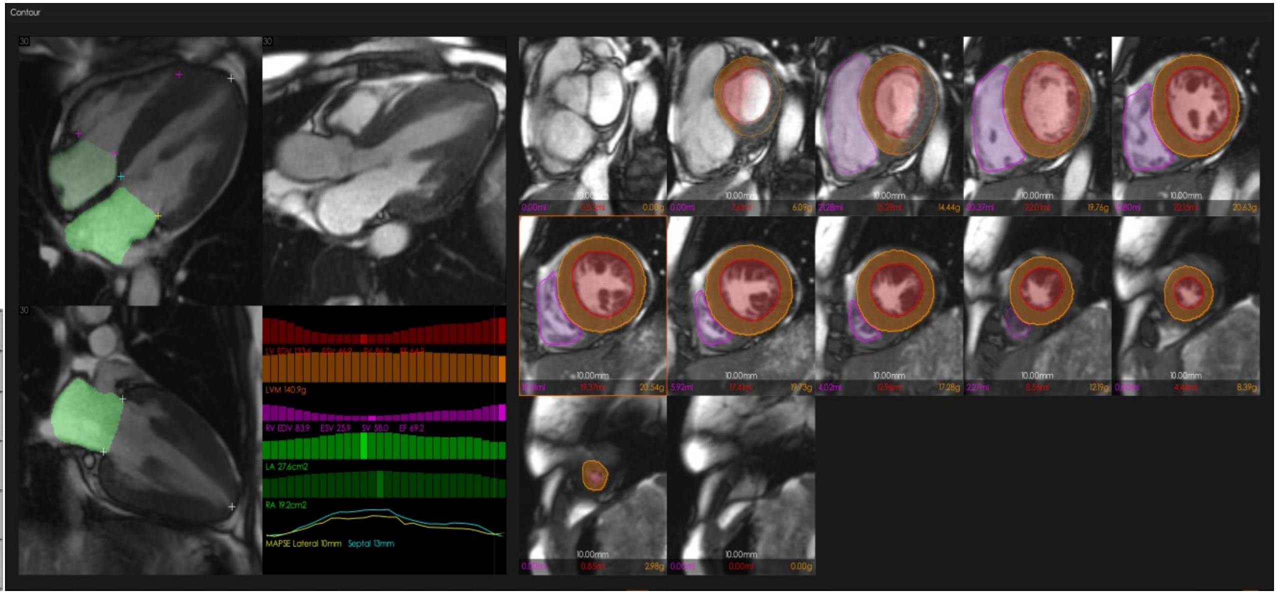
AI in Cardiac Magnetic Resonance

- AI-guided analysis was **quickly** than human;
- Machine analysis had **superior precision** with more repeatability;
- This translates to a 46% reduction in required trial sample size using an LVEF endpoint.





	Intra-observer Reproducibility (%)			Scan-rescan Reproducibility (%)		
	Human	Machine		Human	Machine	
EDV	3.2 (2.6 – 3.8)	0	P<0.001**	5.7 (4.8 – 6.4)	5.4 (4.3 – 6.8)	P=0.04*
ESV	7.6 (6.3—9.1)	0	P<0.001**	10 (8.1 – 11.9)	8.9 (7.6—10.3)	P=0.10
EF	5.1 (3.7-6.4)	0	P<0.001**	6 (5.1-7.0)	4.2 (3.5 – 5.0)	P<0.01*
LVM	3.9 (3.4—4.4)	0	P<0.001**	4.8 (4.1 – 5.6)	3.6 (2.9 – 4.3)	P<0.01*



Davies RH et al., *J Cardiovasc Magn Reson*. 2022;24(1):16. Published 2022 Mar 10.

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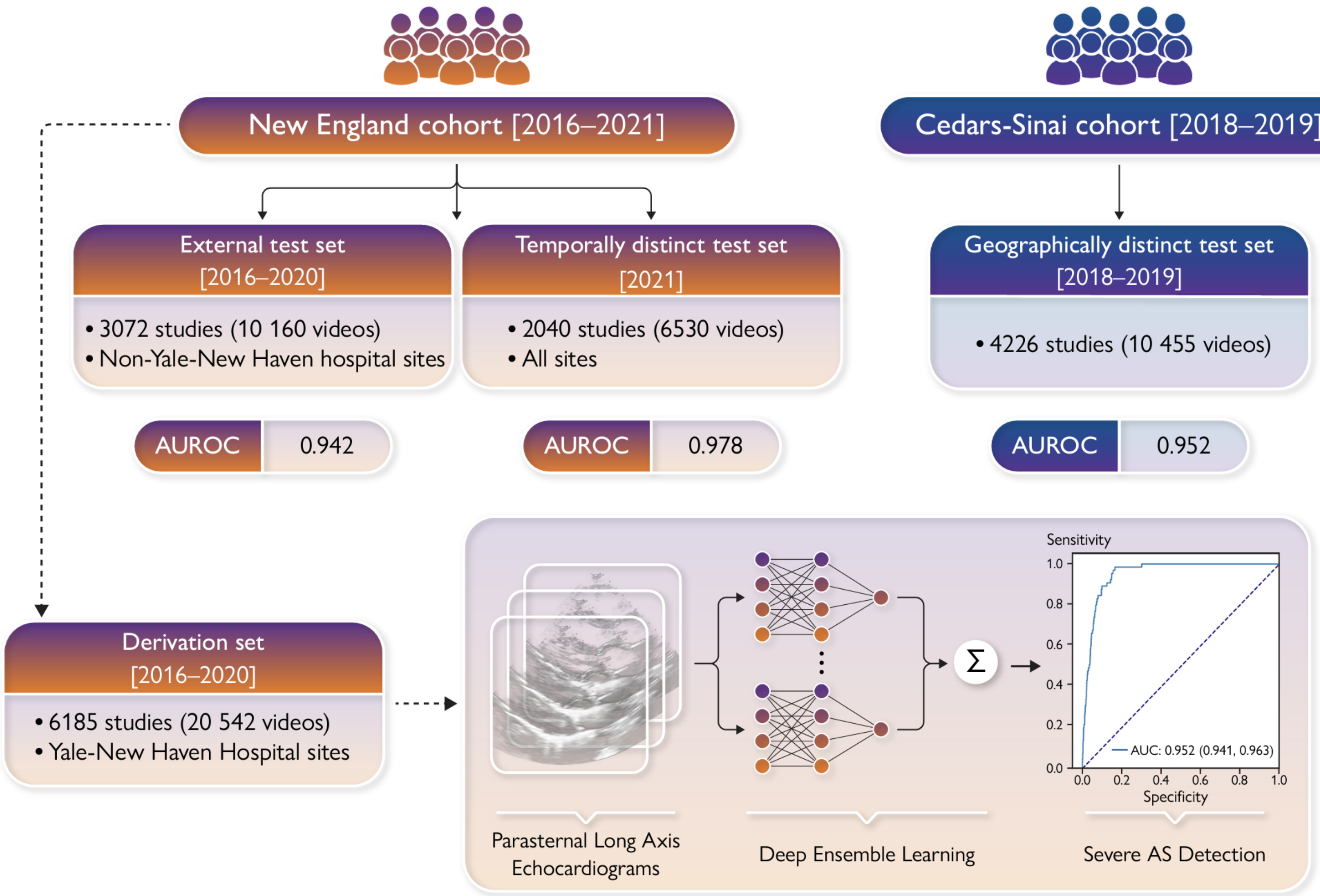
AI IN AORTIC STENOSIS EVALUATION



- **Using self-supervised pretraining and ensemble learning, a deep learning model was trained to detect severe AS using single-view echocardiography without Doppler imaging.**
- **The model maintained high performance in multiple geographically and temporally distinct cohorts.**
- **This automated method to detect severe AS using a single TTE view may have relevant implications for point-of-care ultrasound screening by individuals with minimal training in limited resource settings.**

Holste G et al., *Eur Heart J*. 2023;44(43):4592-4604.

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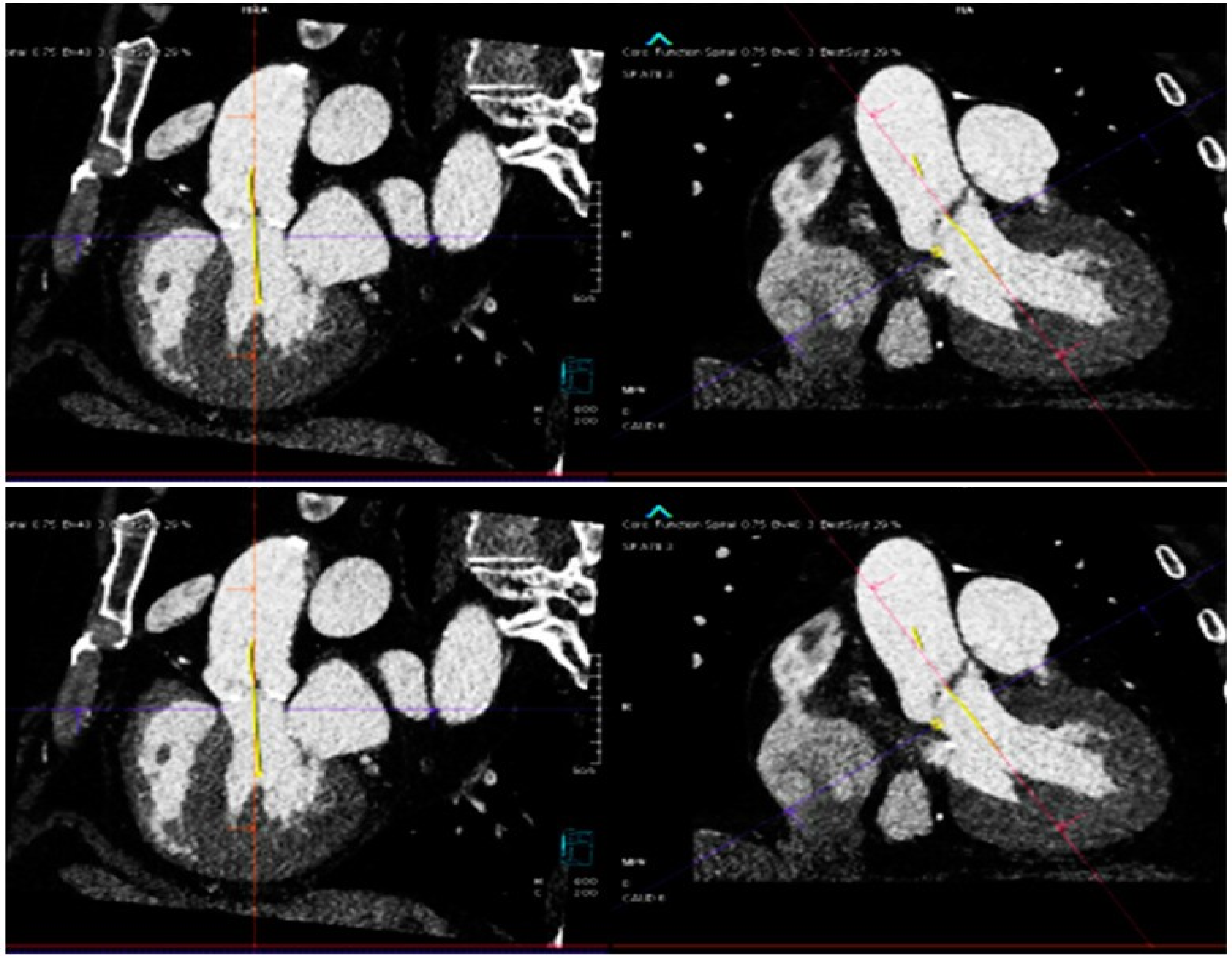
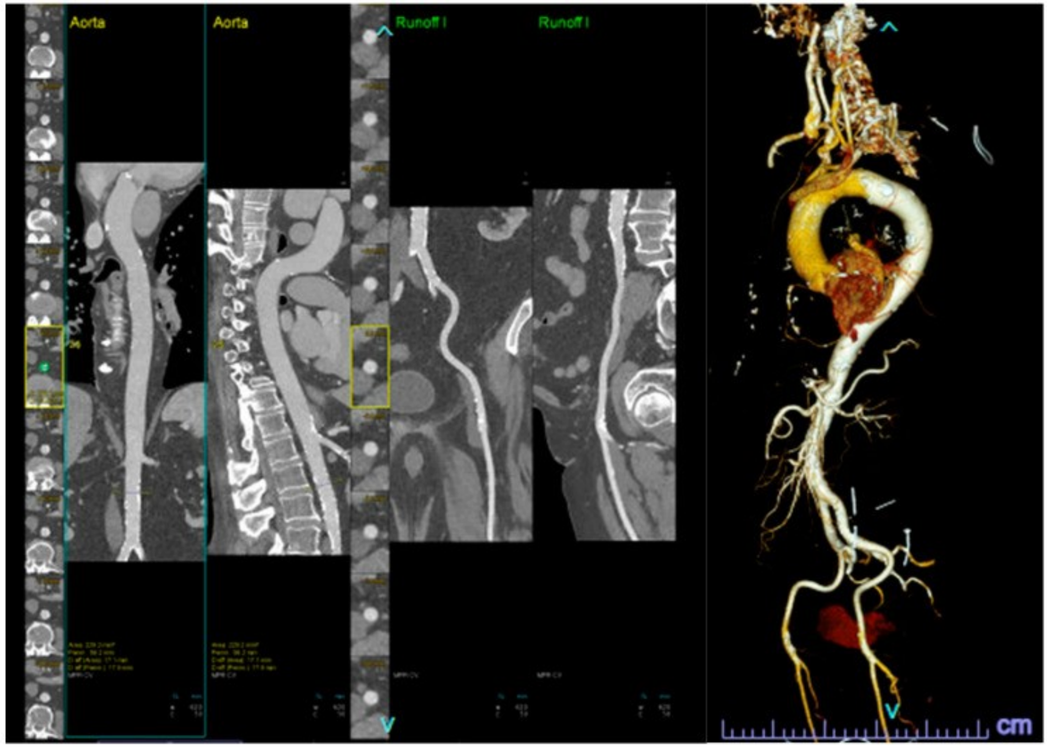
AI in pre-TAVR Planning: CT-scan

Automatic Determination of Aortic Valve Annular Plane



Automatic Evaluation of Vascular Access



Benjamin MM et al., *Diagnostics (Basel)*. 2024;14(3):261. Published 2024 Jan 25.

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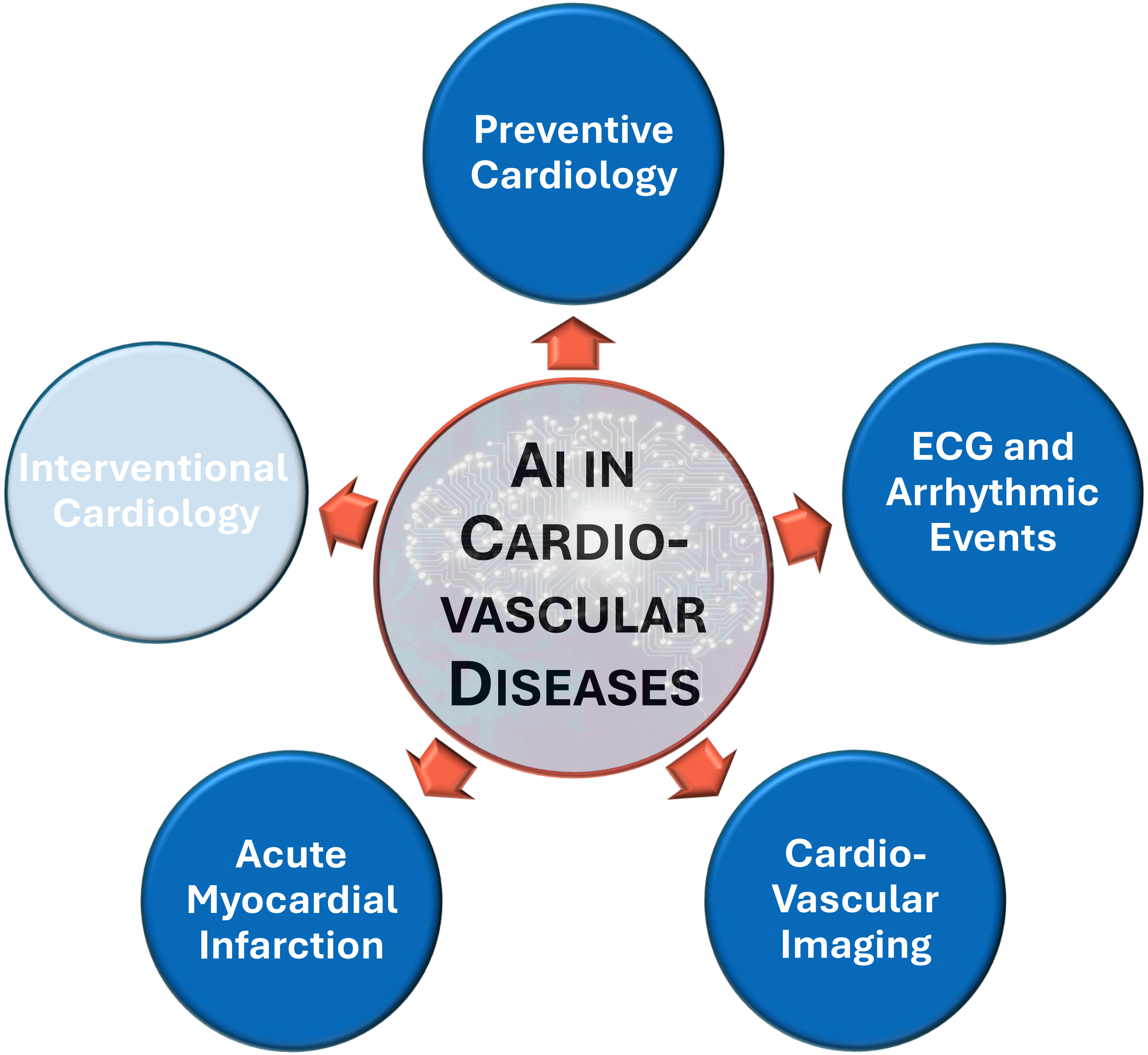

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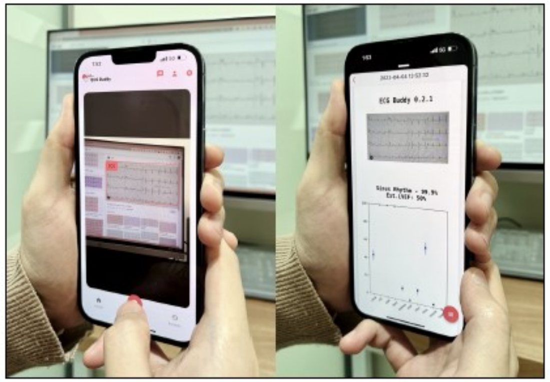
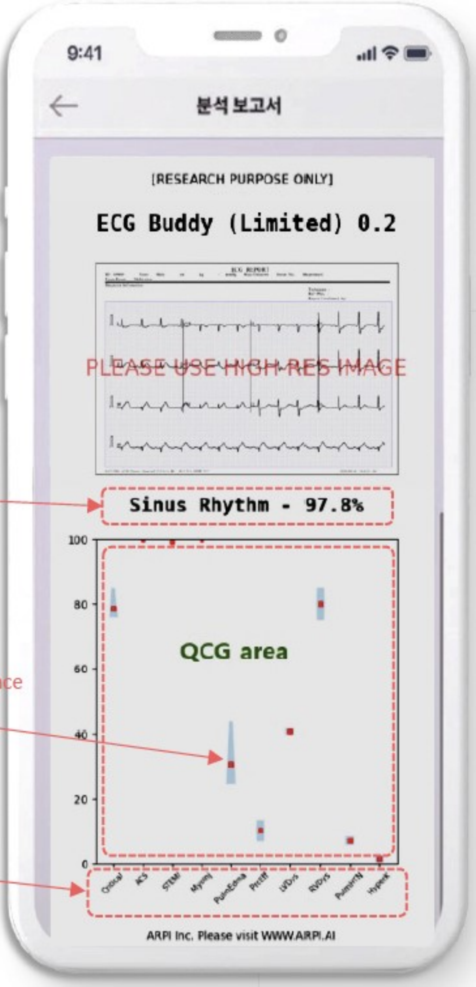
DIAGNOSTIC PERFORMANCE OF STEMI ON ECG: ECG BUDDY

®





35 Rhythms

QCG™ scores and confidence intervals

Biomarkers

QCG™ Score Category

1. Critical condition	→ Needs of critical care
2. Acute Coronary Syndrome 3. ST-elevation Myocardial Infarction 4. Miocardial Injury	→ Cardiac Ischemia
5. Pulmonary Edema 6. Large Pericardial Effusion 7. Left Ventricular Dysfunction 8. Right Ventricular Dysfunction 9. Pulmonary Hypertension	→ Heart Function
10. Severe Hyperkalemia	→ Electrolytes

Interpretation and suggestions

Sinus Rhythm - 99.7%.
Assign the patient to critical care zone.

This looks like a definite STEMI. Call Cath. Lab., right now.

RV dysfunction is very likely. **LV dysfunction** (LVEF<40%) and pulmonary edema is suspected. Check echocardiography.

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AI-POWERED RAPID IDENTIFICATION OF STEMI: THE ARISE TRIAL

NEJM AI

NEJM AI 2024; 1 (7)
DOI: 10.1056/AIoa2400190

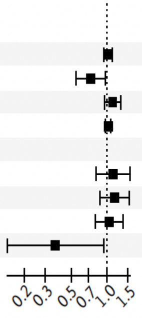
ORIGINAL ARTICLE

Artificial Intelligence–Powered Rapid Identification of ST-Elevation Myocardial Infarction via Electrocardiogram (ARISE) — A Pragmatic Randomized Controlled Trial

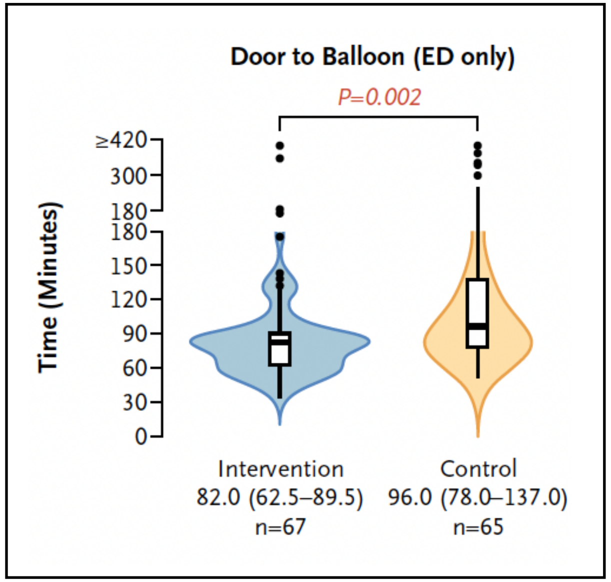
Chin Lin, Ph.D.,[1,2,3,4] Wei-Ting Liu, M.D.,[5] Chiao-Hsiang Chang, M.D.,[5] Chiao-Chin Lee, M.D.,[5] Shi-Chue Hsing, M.D.,[5] Wen-Hui Fang, M.D.,[2,6] Dung-Jang Tsai, Ph.D.,[1,2,7] Kai-Chieh Chen, M.S.,[8] Chun-Ho Lee, M.S.,[3] Cheng-Chung Cheng, M.D.,[5] Yi-Jen Hung, M.D.,[9] Shih-Hua Lin, M.D.,[10] Chien-Sung Tsai, M.D.,[11] and Chin-Sheng Lin, M.D., Ph.D.[1,5]

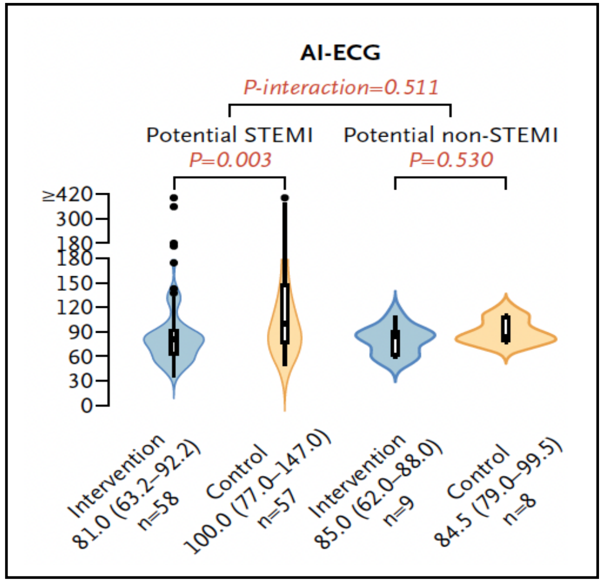
Received: February 21, 2024; Revised: April 7, 2024; Accepted: April 30, 2024; Published: June 27, 2024

	Intervention Event/n (%)	Control Event/n (%)	Odds Ratio (95% CI)	P Value
All–Cause Mortality	1153/21,612 (5.3%)	1127/21,622 (5.2%)	1.02 (0.94, 1.12)	0.568
Cardiac Death	85/21,612 (0.4%)	116/21,622 (0.5%)	0.73 (0.55, 0.97)	0.029
Low Ejection Fraction	340/21,612 (1.6%)	304/21,622 (1.4%)	1.12 (0.96, 1.31)	0.151
Hospitalization for ED Patients	4781/13,606 (35.1%)	4721/13,688 (34.5%)	1.03 (0.98, 1.08)	0.261
STEMI–Related Diagnoses				
STEMI with occluded vessel(s)	77/21,612 (0.4%)	68/21,622 (0.3%)	1.13 (0.82, 1.57)	0.453
Urgent coronary angiography	100/21,612 (0.5%)	86/21,622 (0.4%)	1.16 (0.87, 1.55)	0.303
All STEMIs	107/21,612 (0.5%)	102/21,622 (0.5%)	1.05 (0.80, 1.38)	0.726
STEMI without coronary angiography for AI–potential STEMI	7/108 (6.5%)	16/101 (15.8%)	0.37 (0.14, 0.94)	0.036



In patients with STEMI, AI-ECG-assisted triage of STEMI decreased the door-to-balloon time, the ECG-to-balloon time and cardiac death. No differences were found regarding new-onset heart failure with reduced ejection fraction.





Chin L et al. NEJM AI. 2024;1(7).

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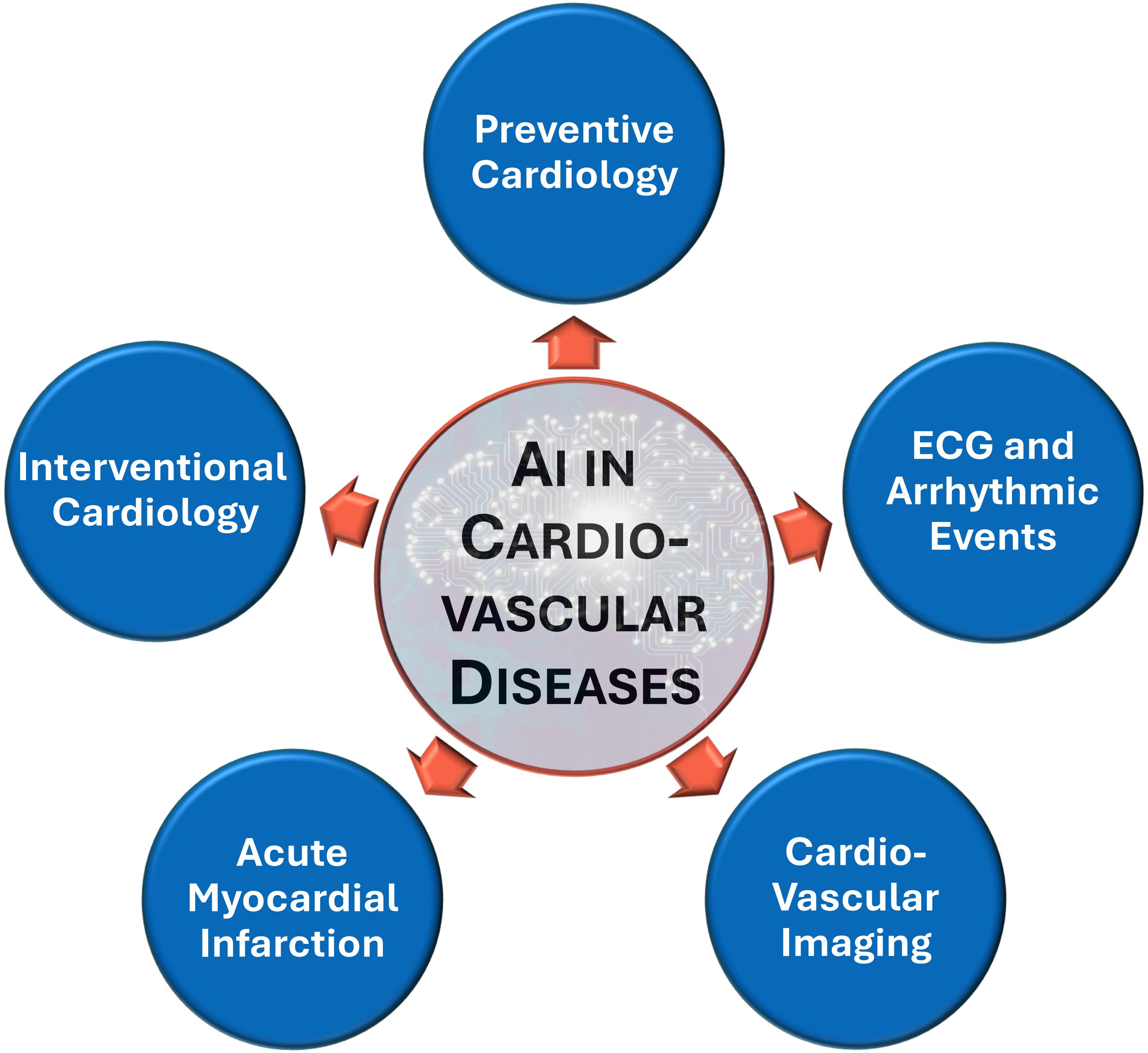

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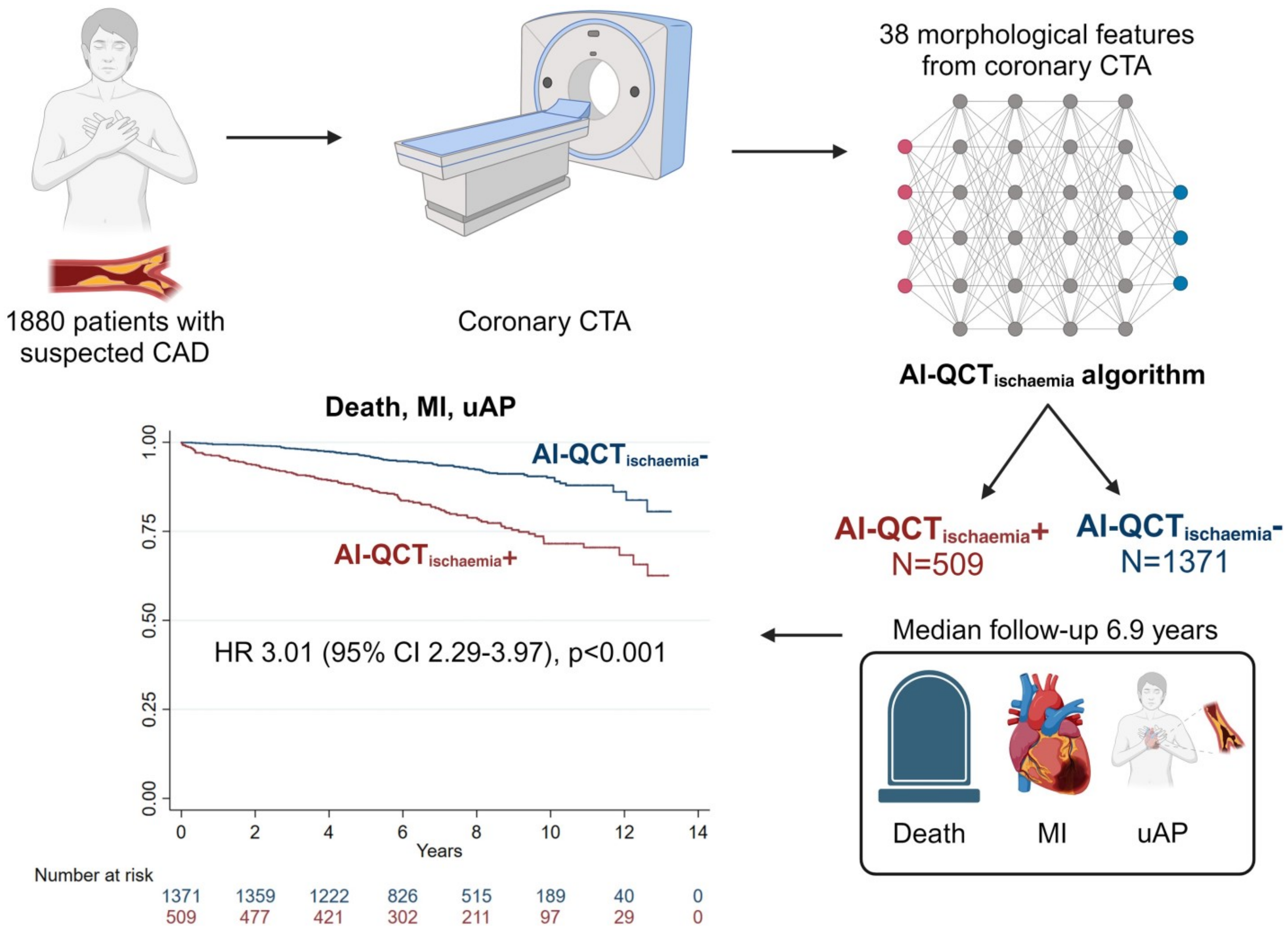
ANATOMICAL ASSESSMENT: CORONARY-CT



- **Amongst patients with suspected CAD, an abnormal AI-QCT ischaemia (a novel artificial intelligence-guided quantitative computed tomography ischaemia algorithm) result was associated with a two-fold increased adjusted rate of long-term death, MI, or unstable angine.**

- **AI-QCT ischaemia may be useful to improve risk stratification, especially amongst patients with no/non-obstructive CAD on coronary CTA.**

Bär S et al. Eur Heart J Cardiovasc Imaging. 2024;25(5):657-667.

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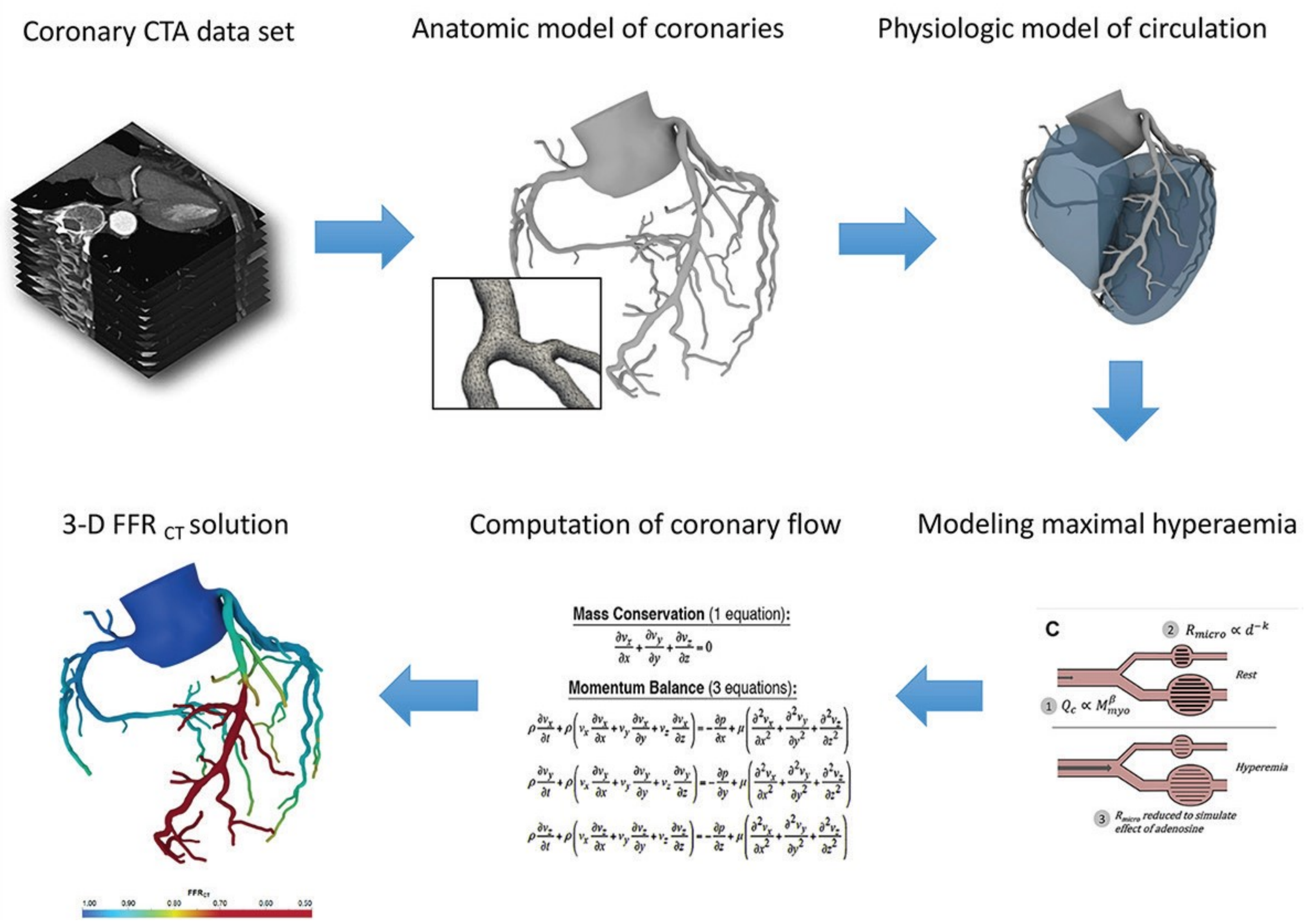
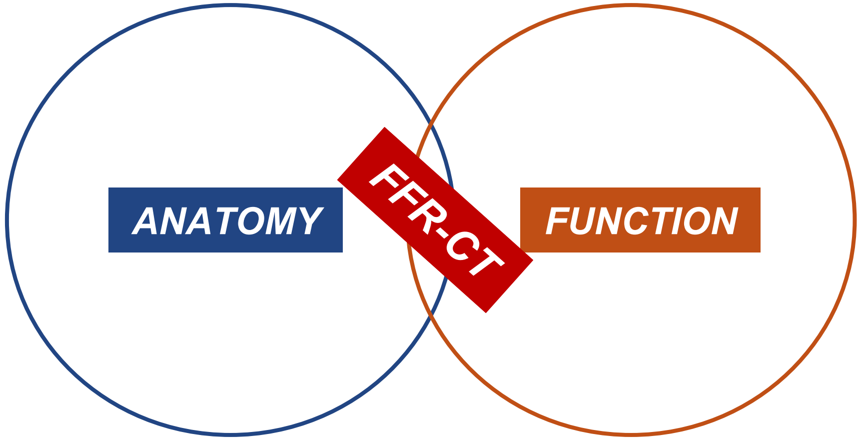
FUNCTIONAL ASSESSMENT: FFR-CT

THE (RE-(EVOLUTION) OF CCTA



- Computational Fluid Dynamics (CFD) and machine learning (AI)
- From typical CTA datasets
- No additional radiation
- No change in imaging protocol
- No additional medications



From Gabara L. and Curzen N, Expert Analysis ACC. 2019.

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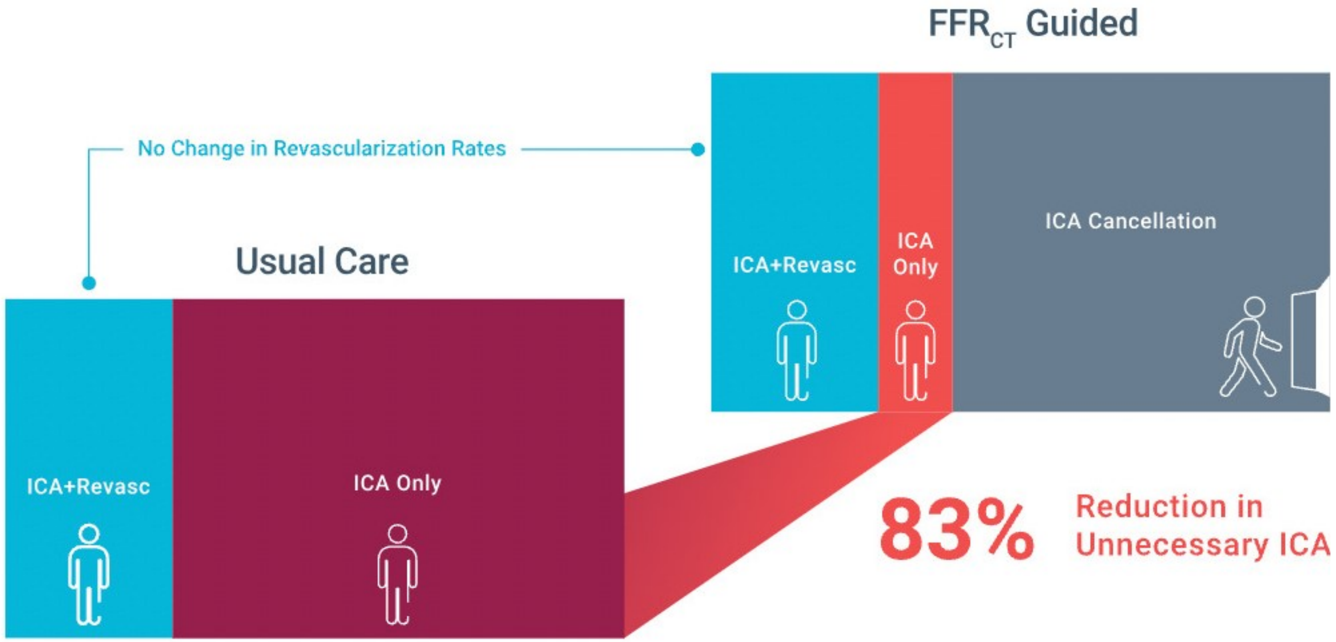
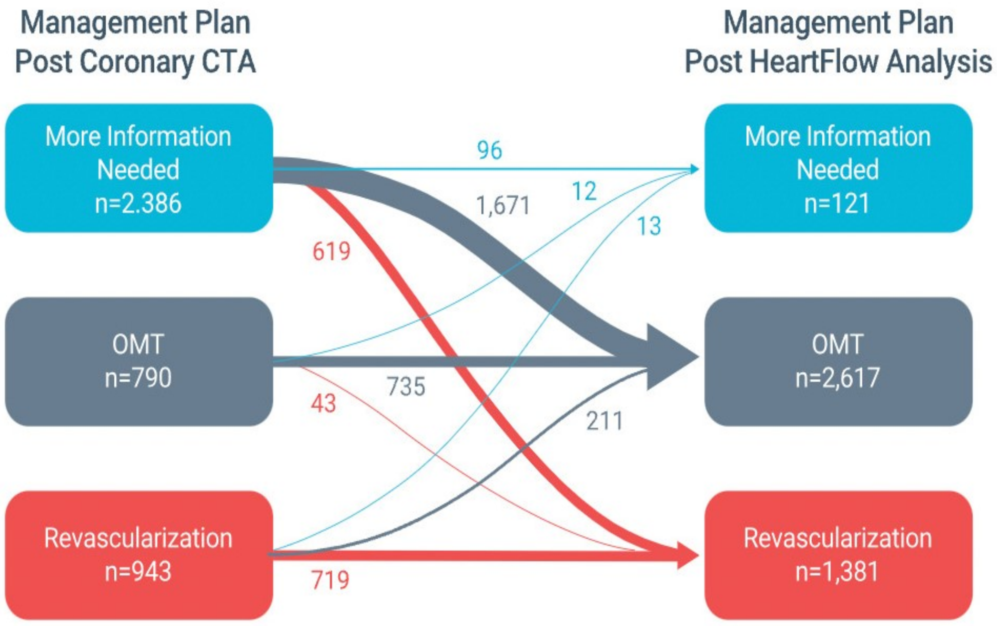
FFR-CT

ADVANCE Registry: Clinical Efficacy and Impact on Clinical Decision Making

Reduction of unnecessary ICAs with no reduction in revascularization rates



Management plan change post CCTA & FFR-CT Analysis



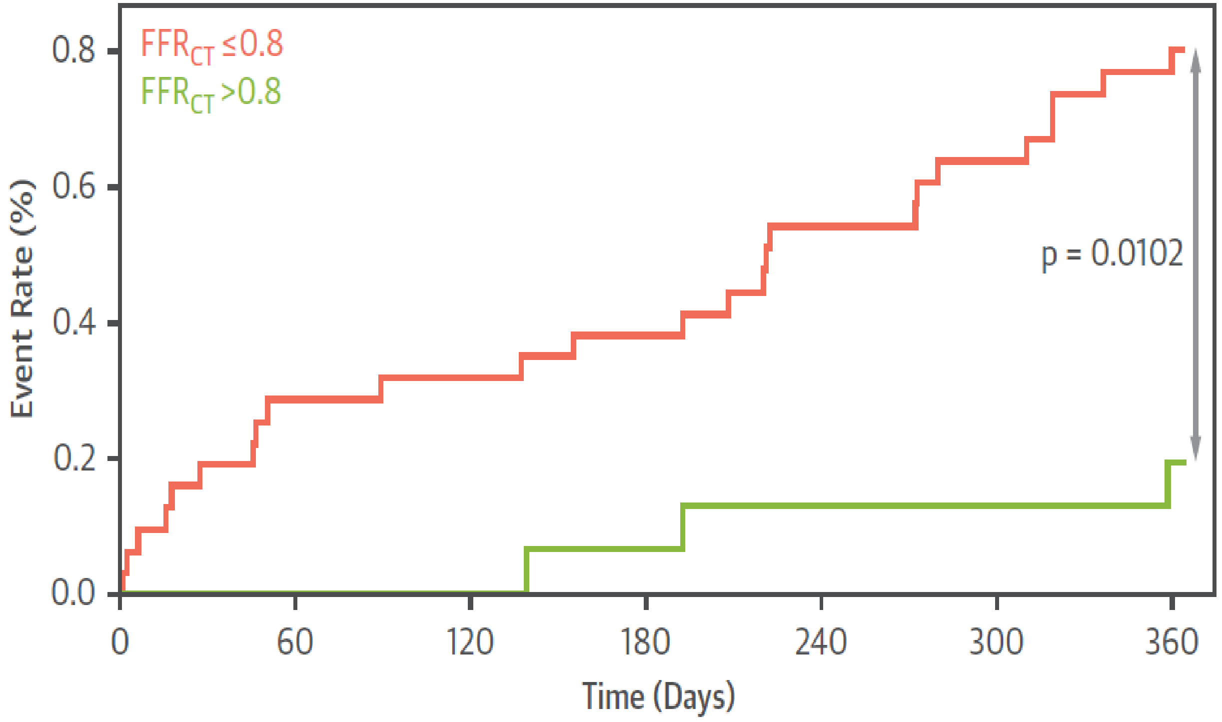
66.9% of patients were re-classified!

Fairbairn TA et al. *Eur Heart J*. 2018;39(41):3701-3711.

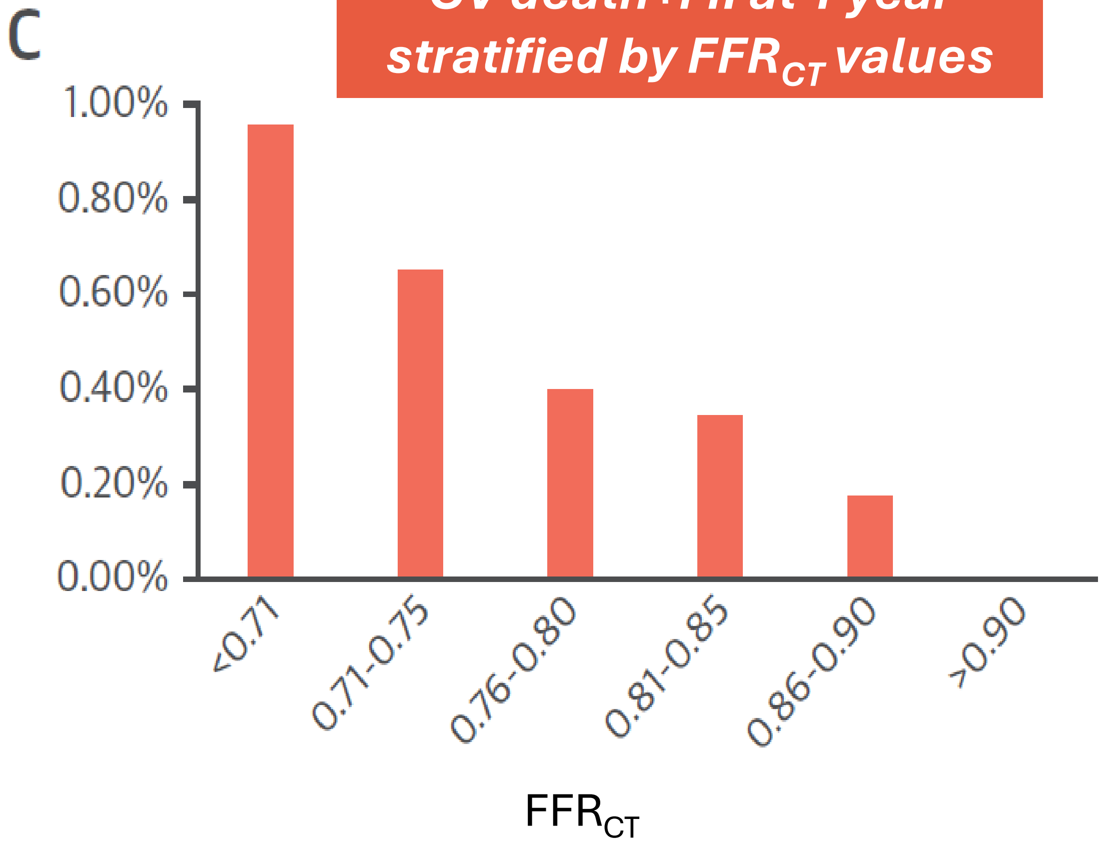
FFR-CT

ADVANCE Registry: Impact on Outcomes

CV death+MI stratified by FFR_{CT} > 0.80 vs ≤ 0.80



CV death+MI at 1 year stratified by FFR_{CT} values



Patel MR et al. *JACC Cardiovasc Imaging*. 2020;13(1 Pt 1):97-105.

FFR-CT

PRECISE TRIAL: A RANDOMIZED CONTROLLED TRIAL EVALUATING 2,013 PATIENTS WITH CHEST PAIN

Non-acute CP or equiv patients; No history of CAD or CAD testing <1 year
Recommended for non-emergent NI test or ICA: N=2100

Randomization stratified by preferred first test
if usual care and PROMISE risk score.

R

Usual care evaluation
Strategy selected by site clinician

Functional testing OR Direct to cath

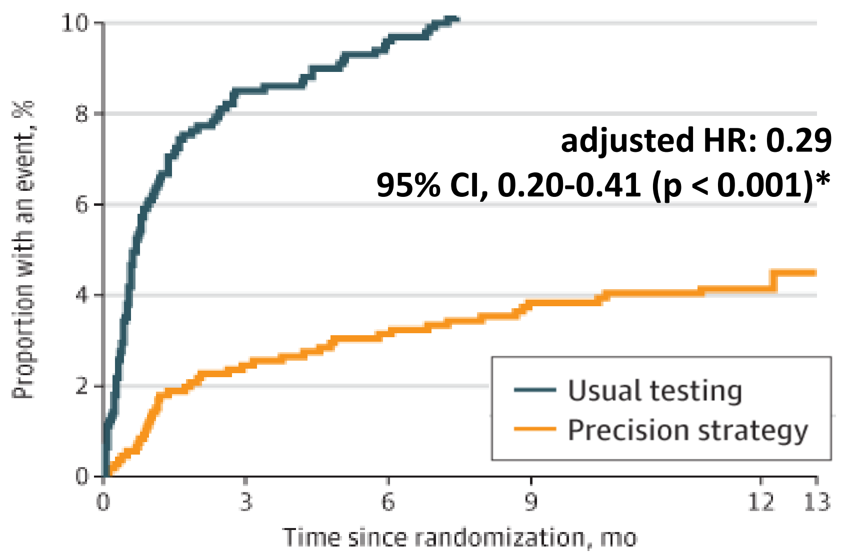
Precision evaluation
Strategy assigned by PROMISE risk strata

Guideline rec medical management wo planned testing

cCTA +/- FFR_{CT}

Composite Primary Endpoint: Effective CP Evaluation at 12 months
MACE (death/MI), Cath w/o obs CAD (stenosis≥50%, FFR≤0.80, iFR≤0.89)
Secondary Endpoints
Hierarchical analysis of primary endpoint; Resource use; QOL; Death/MI/CV hospitalizations; Preventive med use; Primary at 24 mo; Radiation; Cath efficiency; Co-Primary endpoints of DECISION

Primary Composite Endpoint (MACE+ICA without obstructive CAD)



***This difference is due to a lower rate of catheterization without obstructive CAD in PS, with no statistically significant difference in the safety components of death, death or non fatal MI and nonfatal MI.**

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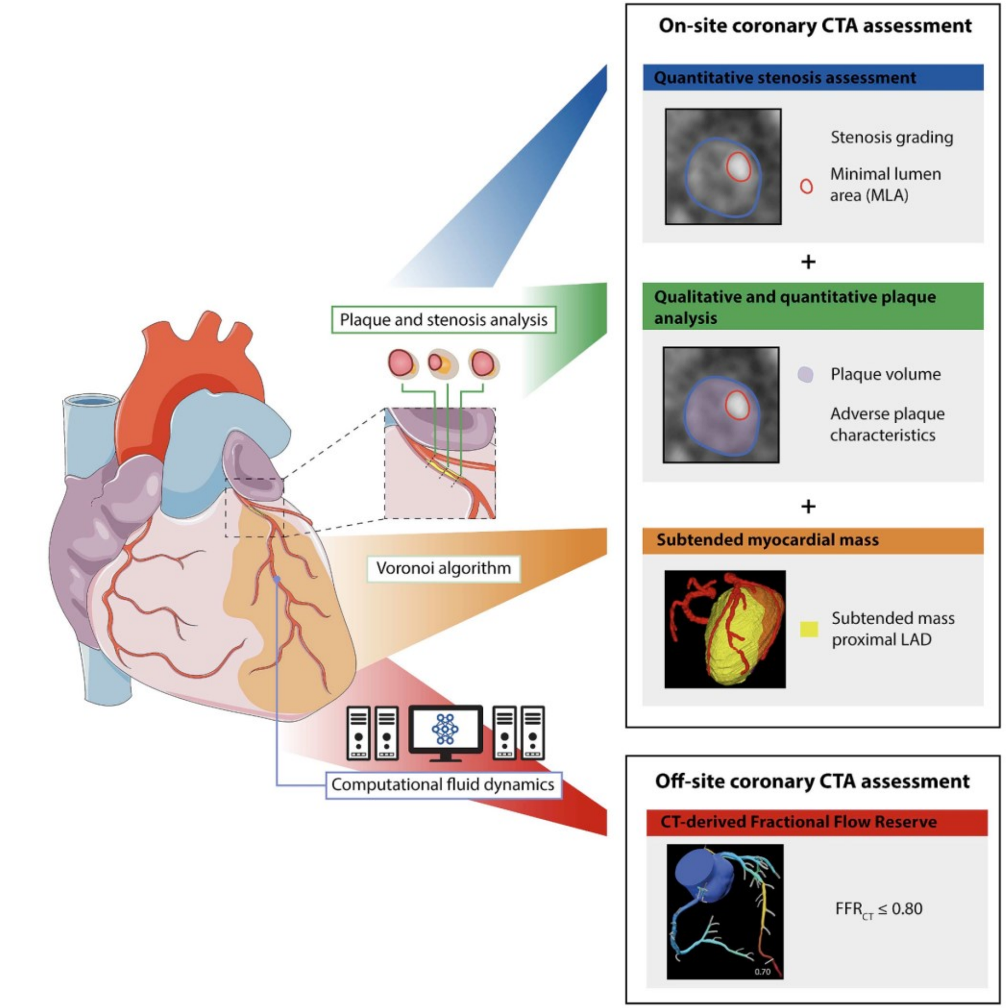
Douglas PS et al. *JAMA Cardiol*. 2023;8(10):904-914.

FFR-CT

2024 ESC Guidelines on Chronic Coronary Syndromes



Vrints C et al. Eur Heart J. 2024.

Bom et al. Journal of Cardiovascular Computed Tomography 2021; 15:37–45

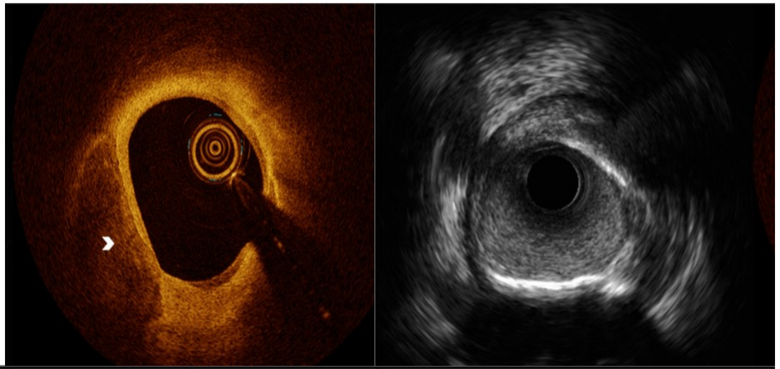
The use of one or more of the following test results is recommended to identify individuals at high risk of adverse events: • CCTA: o left main disease with ≥50% stenosis, three-vessel disease with ≥70 stenosis, or two-vessel disease with ≥70% stenosis, including the proximal LAD or one-vessel disease of the proximal LAD with ≥70% stenosis and FFR-CT ≤0.8.	**I**	**B**

Recommendation Table 13 — Recommendations for selection of initial diagnostic tests in individuals with suspected chronic coronary syndrome (see also Evidence Table 13)

In patients with a known intermediate coronary artery stenosis[d] in a proximal or mid coronary segment on CCTA, CT-based FFR may be considered.	**IIb**	**B**

Intravascular Imaging: OCT vs. IVUS

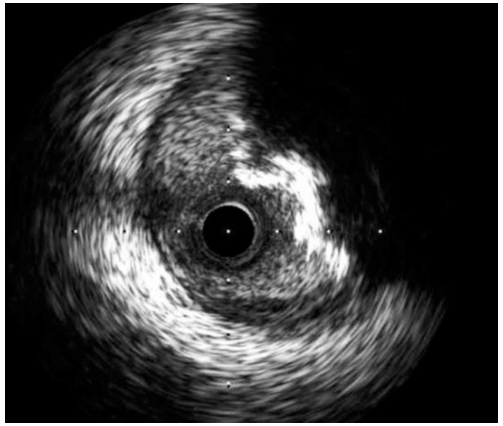
OCT: An optical imaging modality that uses near-infrared light for high-resolution imaging of vessel anatomy, tissue microstructure and stents.

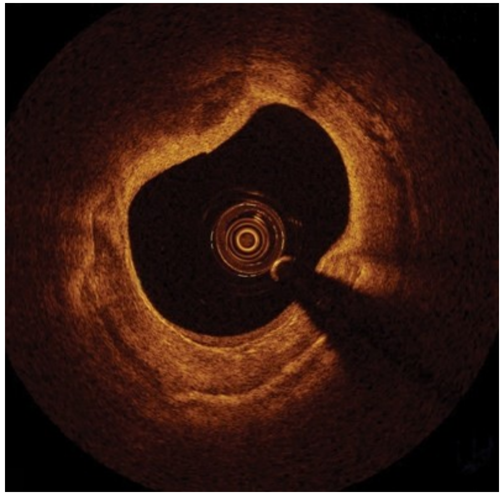


	OCT	IVUS
Resolution	15 μm	150 μm
Penetration	2 mm	10 mm
Field of View	10 mm	10 mm
Frame Rate	100 FPS	15-30 FPS
Pullback Speed	75 mm/sec	0.5/1.0 mm/sec
Catheter Size	Sub 3F	3.2 F

IVUS: An ultrasound imaging modality with high depth of penetration with more visibility of all three arterial layers and more appropriately true vessel size enabling larger-sized stent implantation.

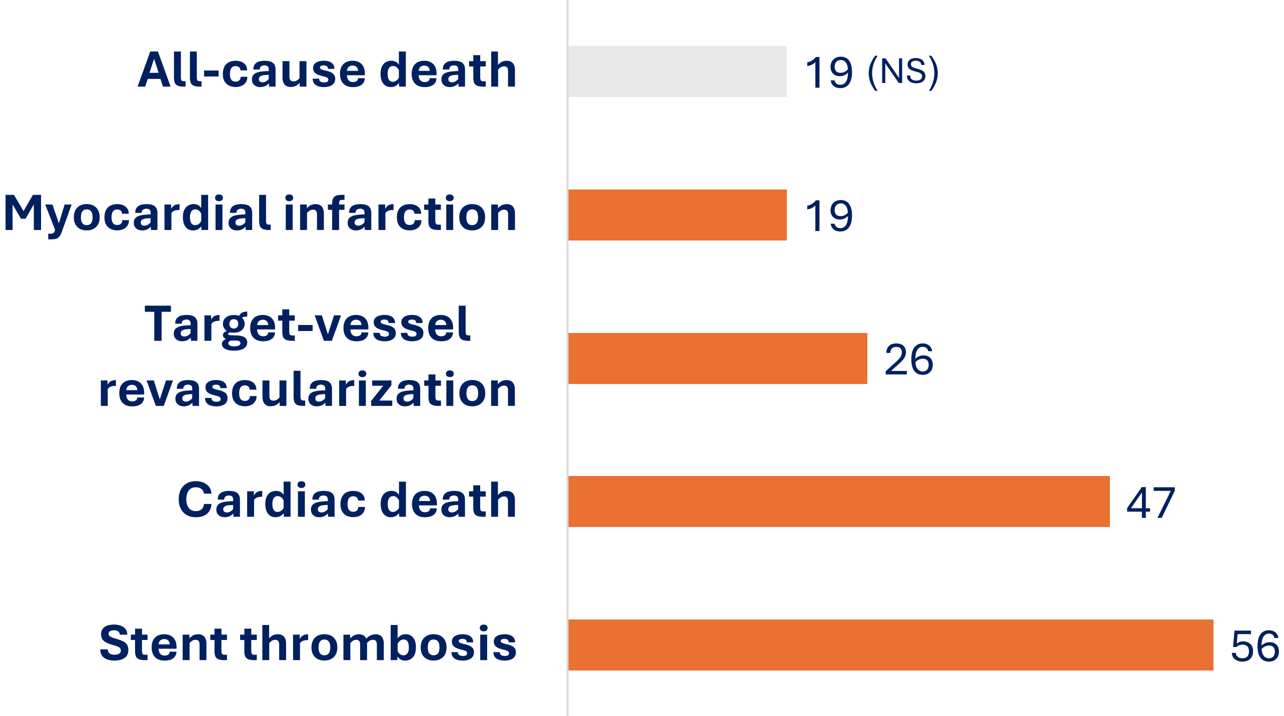
Imaging-Guided PCI: Meta-Analysis





Relative Risk Reductions with Imaging-guided Vs. Angiography-guided PCI

20 randomized controlled trials (N=11,698)



Khan et al. BMJ 2023;383:e077848

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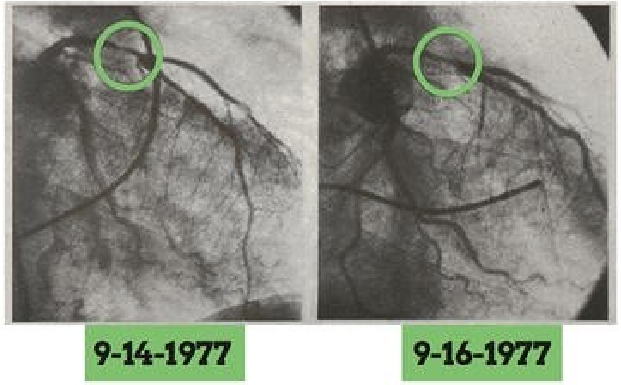
AI-DRIVEN INTRAVASCULAR IMAGING ALLOWS FOR AUTOMATED IN-DEPTH ASSESSMENT OF THE INTRACORONARY ANATOMY

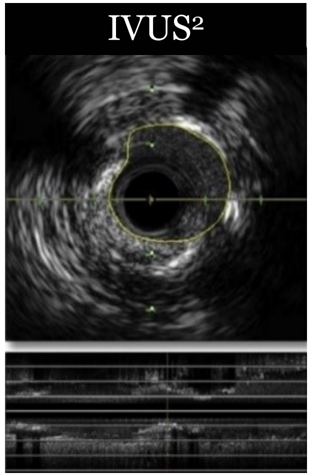
Timeline
(1977- Present)

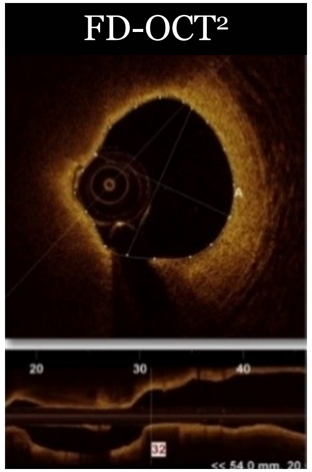
CORONARY ANGIOGRAPHY

1977: Andreas Gruentzig first PCI angiography[1]



INTRAVASCULAR IMAGING





AI-DRIVEN PCI GUIDANCE

1.Retrieved on Sept 2021 from: https://www.pcronline.com/About-PCR/40-years-angioplasty/Timeline/First-PTCA.
2.Kubo, T. et al. (2013). OCT compared with IVUS in a coronary lesion assessment. JACC: Cardiovascular Imaging, 6(10), 1095-1104.

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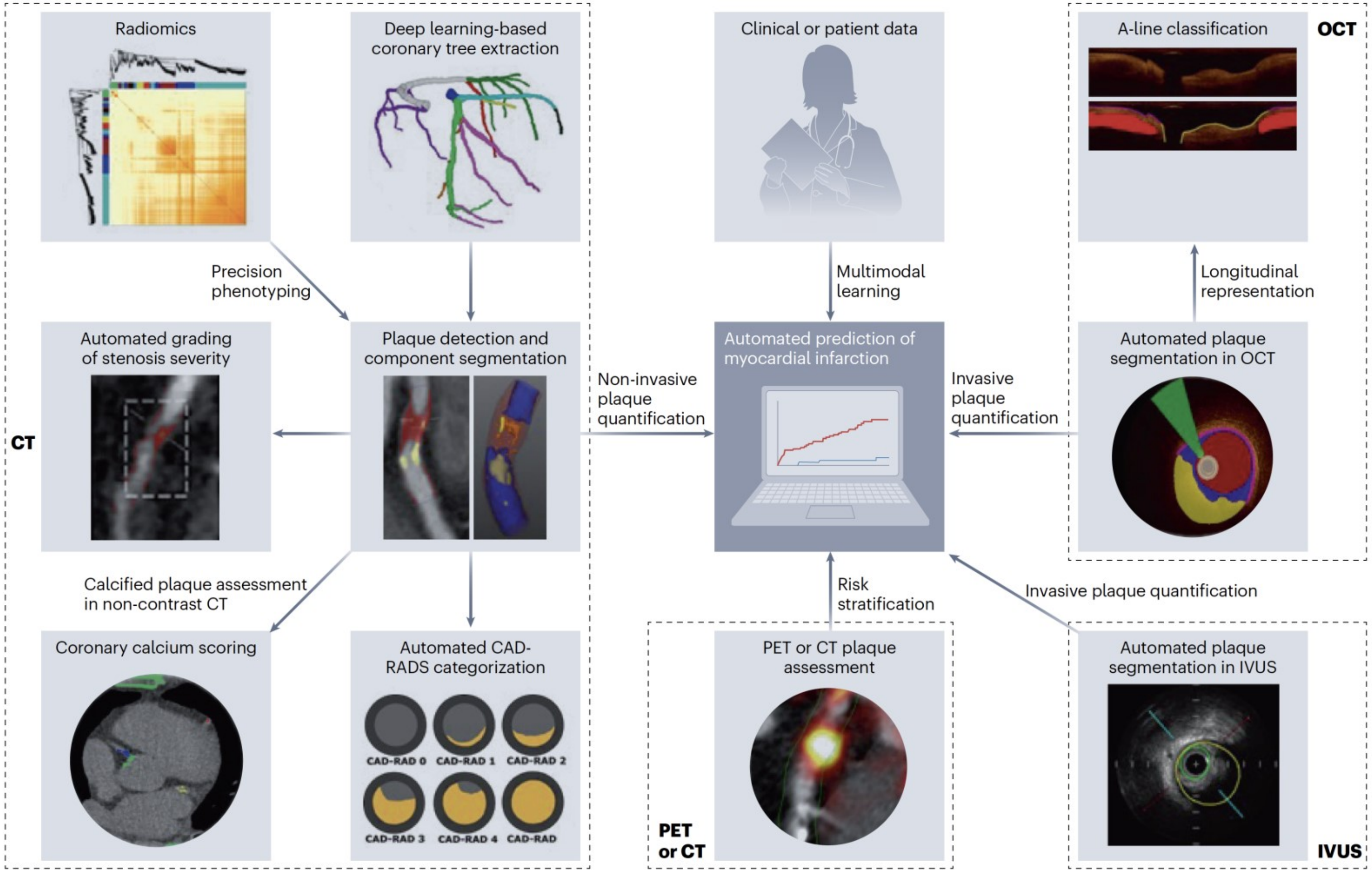
THE INTERACTION BETWEEN TASKS SUPPORTED BY AI TOOLS FOR THE ASSESSMENT OF VULNERABLE PLAQUES IN CORONARY ARTERIES

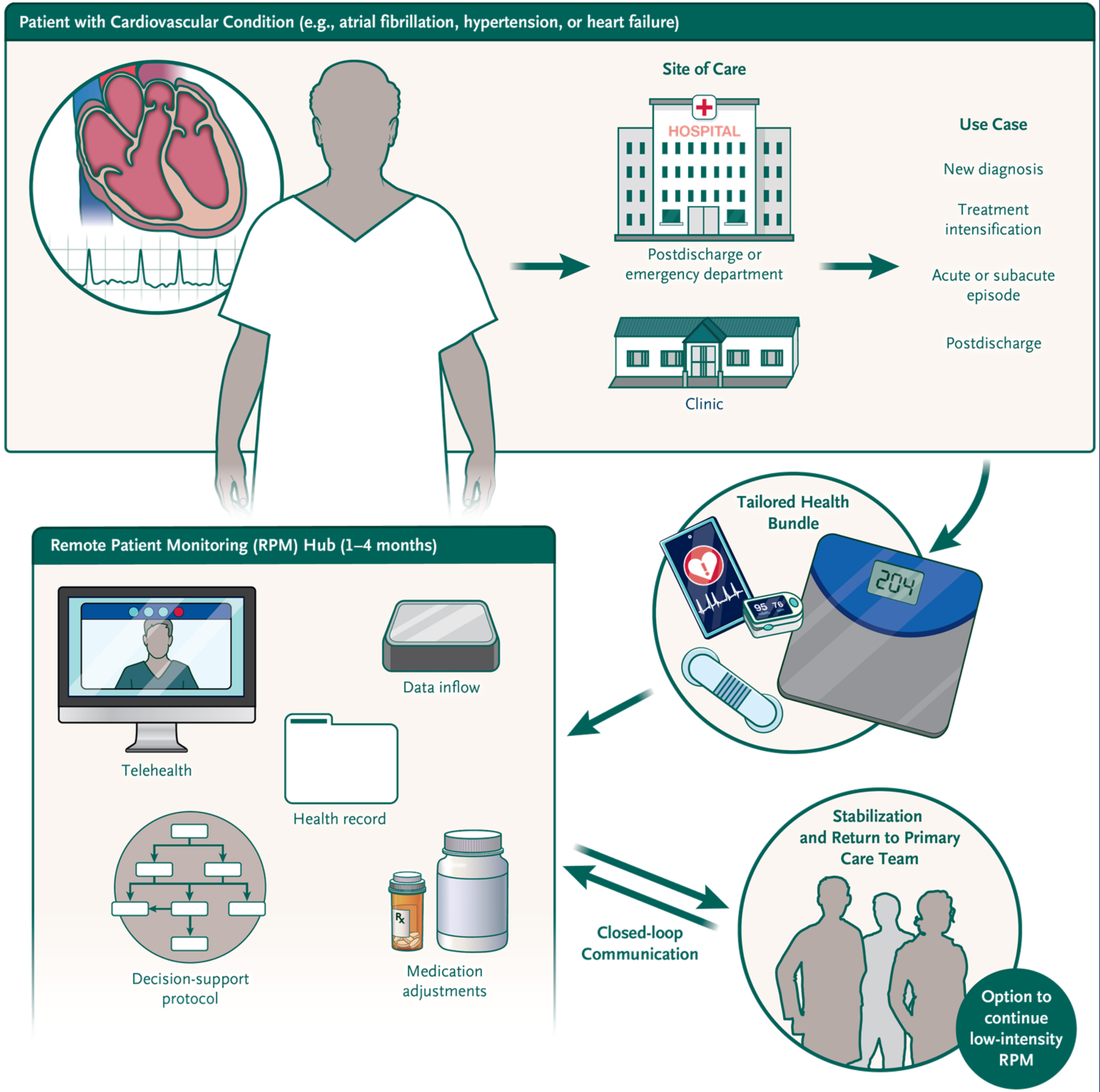


Föllmer B et al. Nat Rev Cardiol. 2024;21(1):51-64.

Hub Model for Remote Patient Monitoring

Spatz ES. et al. N Engl J Med 2024;390:346-56.

Cardiovascular conditions may require a period of intensive monitoring and medication adjustment. In this model of remote patient monitoring (RPM), a digital health bundle with remote management through a centralized hub may be prescribed.



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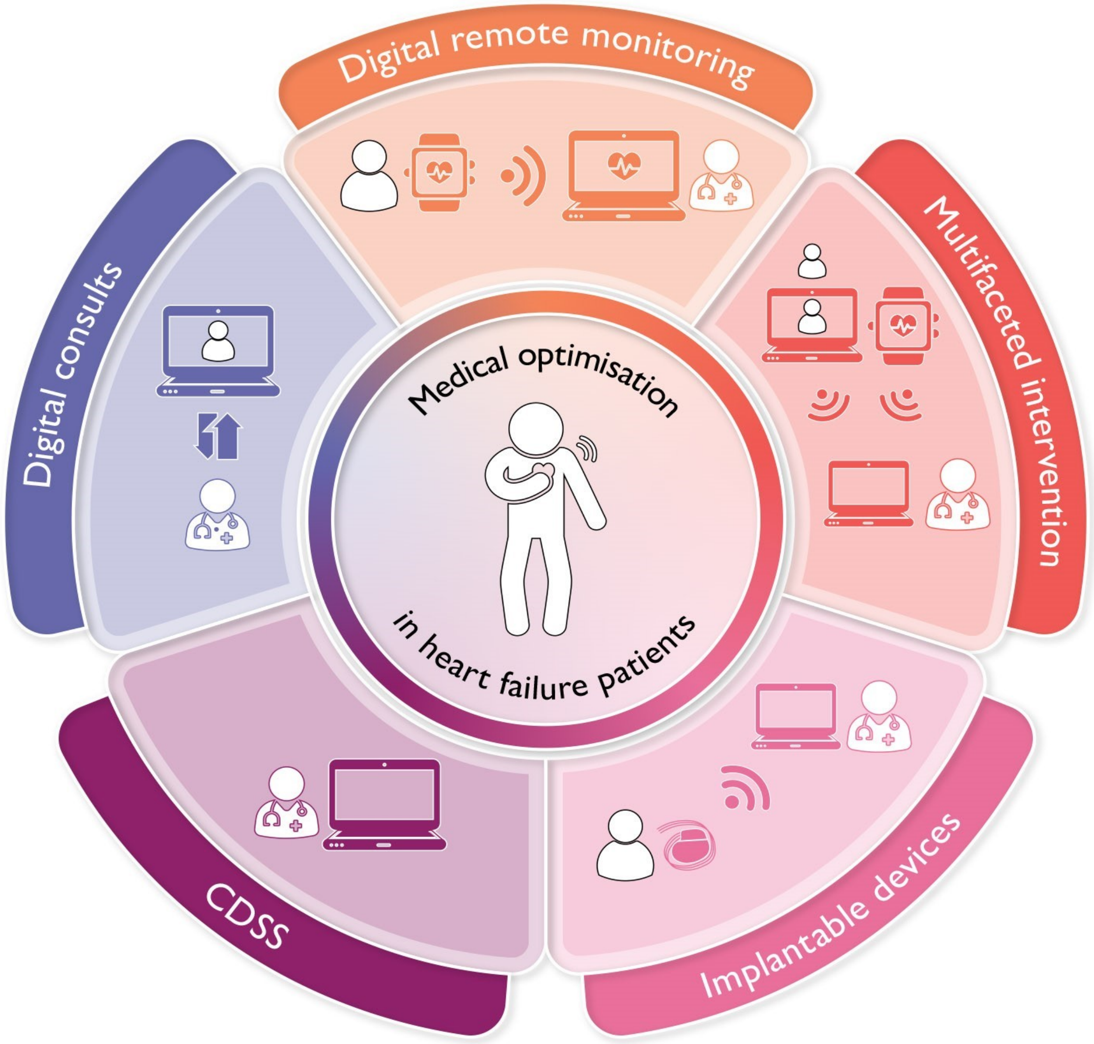
Digital Solutions to Optimize Guideline-Directed Medical Therapy Prescription Rates in Patients with Heart Failure

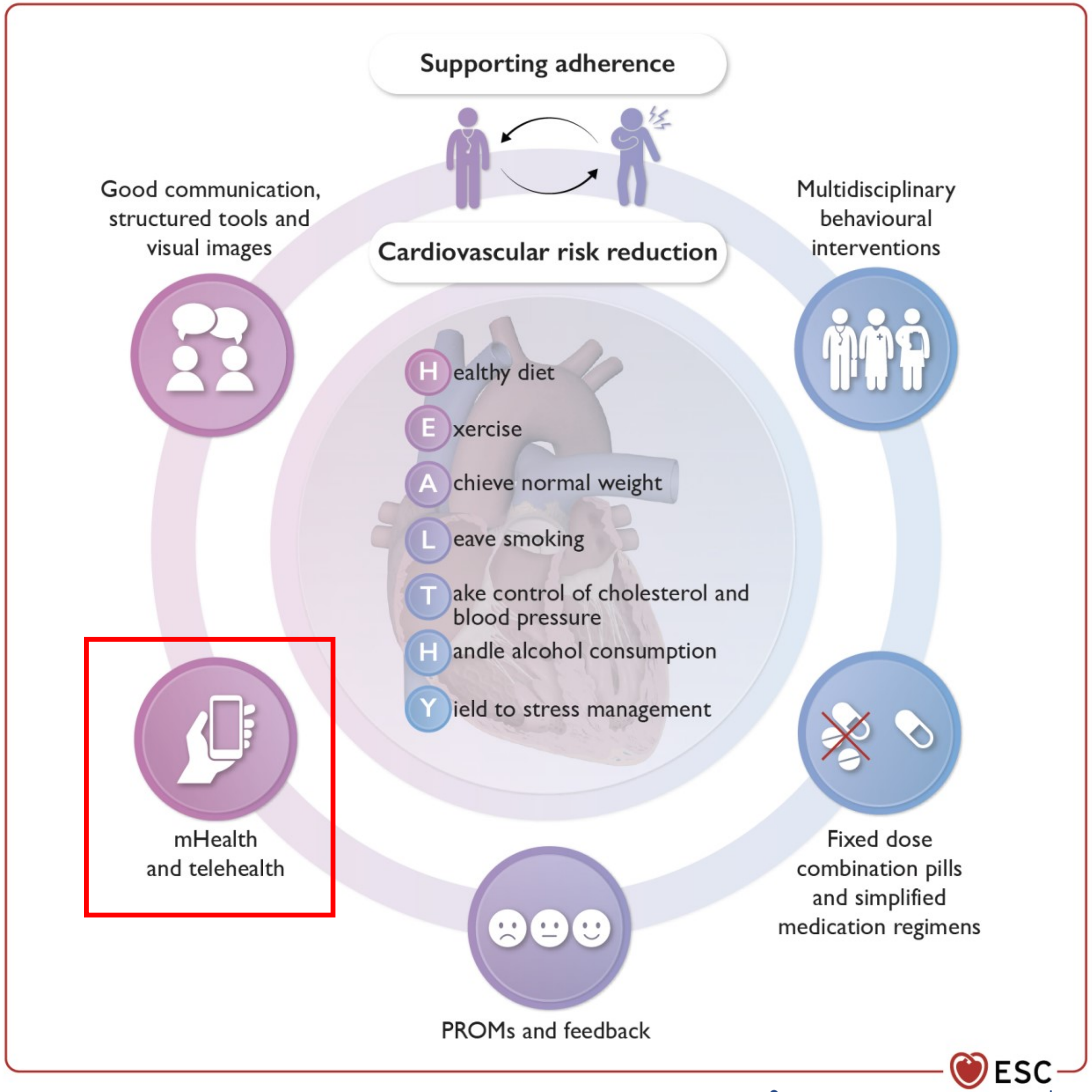


Schuuring MJ. Eur Heart J Digit Health. 2024;5(6):670-682.

Chronic Coronary Syndromes: Long-Term Follow-up

Recommendations	Class[a]	Level[b]
Mobile health interventions (e.g. using text messages, apps, wearable devices) are recommended to improve patient adherence to healthy lifestyles and medical therapy.	I	A

Vrints C et al. Eur Heart J. 2024.



Vrints C et al. Eur Heart J. 2024.

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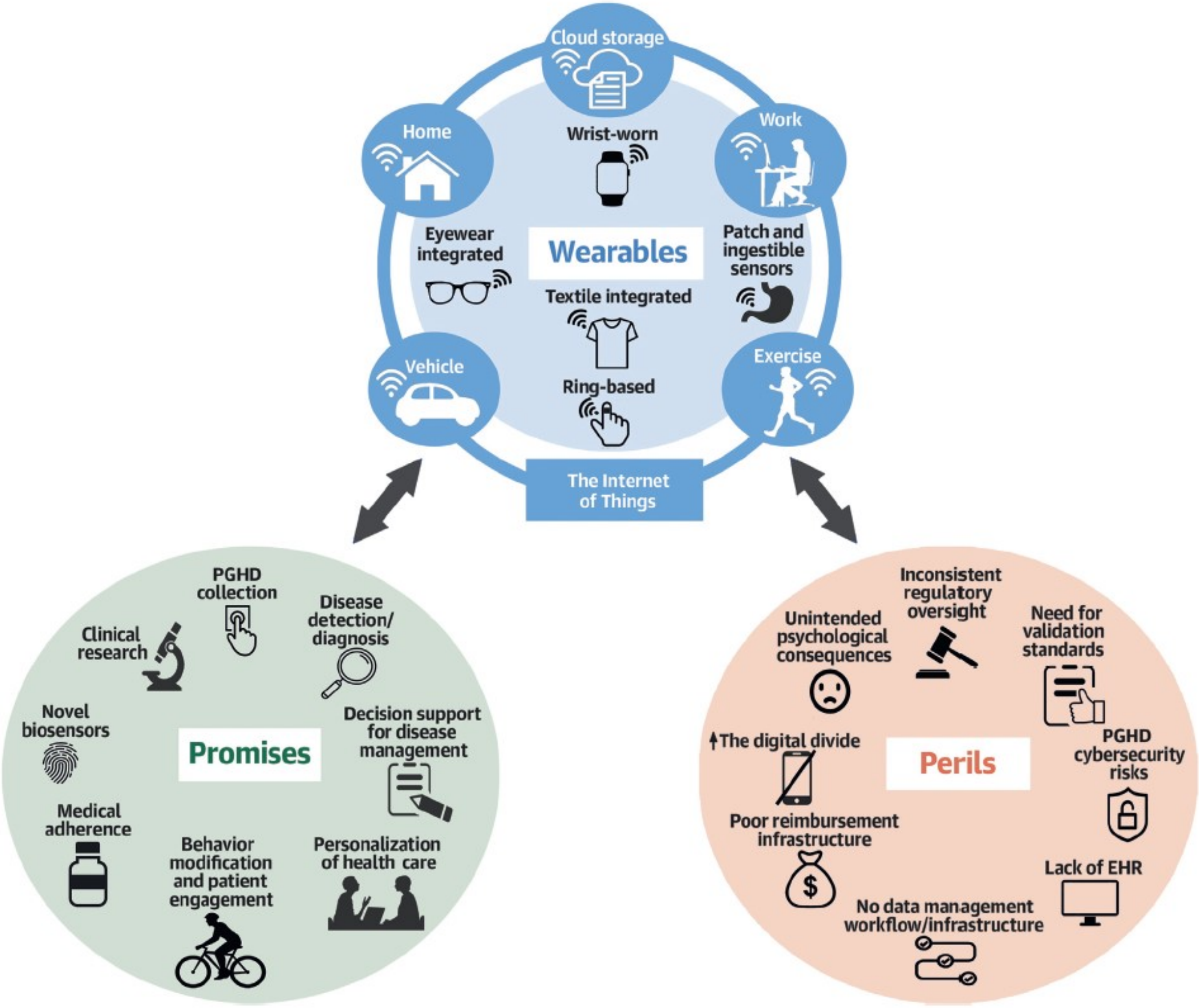
THE PROMISES AND PERILS OF MOBILE TECHNOLOGIES IN CARDIOVASCULAR CARE



Varma N et al. J Am Coll Cardiol. 2024;83(5:611-631).

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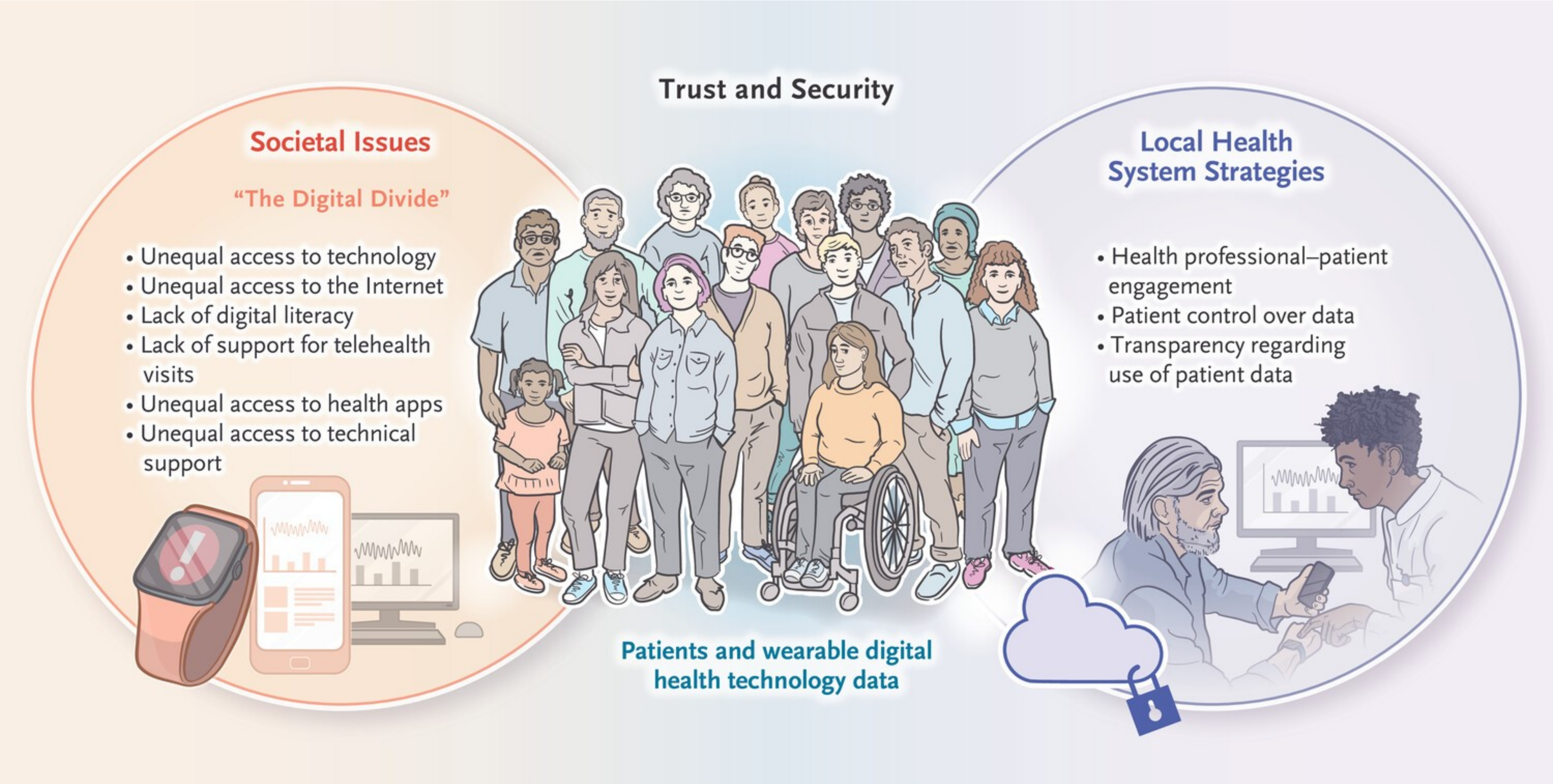
WEARABLE DIGITAL HEALTH TECHNOLOGIES: TRUST AND SECURITY



Patients' trust and security must be addressed to ensure that they are willing to share the data from their wearable DHTs. Societal issues that must be addressed to facilitate trust are listed, along with local health system strategies that are essential for trust and security.

Ginsburg SG et al., *N Engl J Med 2024;390:1118-27*

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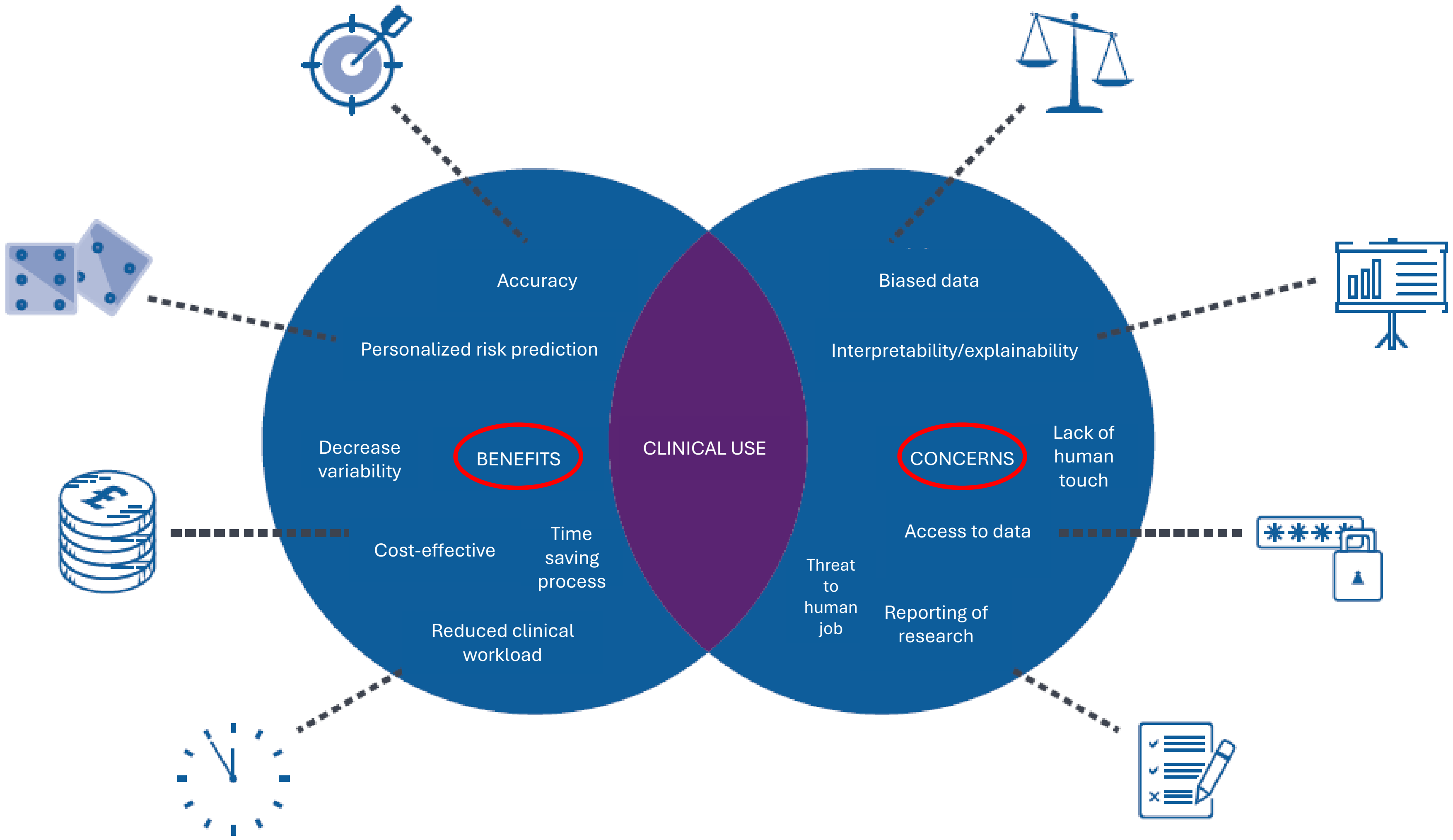
AI IN CARDIOVASCULAR DISEASES: BENEFITS AND CONCERNS



Shipley E et al., Arrhythm Electrophysiol Rev. 2022;11:e03.

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"How can you think about that with everything that's going on in the field of A.I.?"