AI and Cardiology

Partho P Sengupta, MD, FACC

Henry Rutgers Professor of Cardiology,
Chief of Cardiology, Rutgers Robert Wood Johnson Medical School & Chief of Cardiac Services, Robert Wood Johnson University Hospital,New Brunswick, NJ

Oct 11th , 2025

Kentucky CHAPTER

RWJBarnabas HEALTH

RUTGERS THE STATE UNIVERSITY OF NEW JERSEY

Disclosures

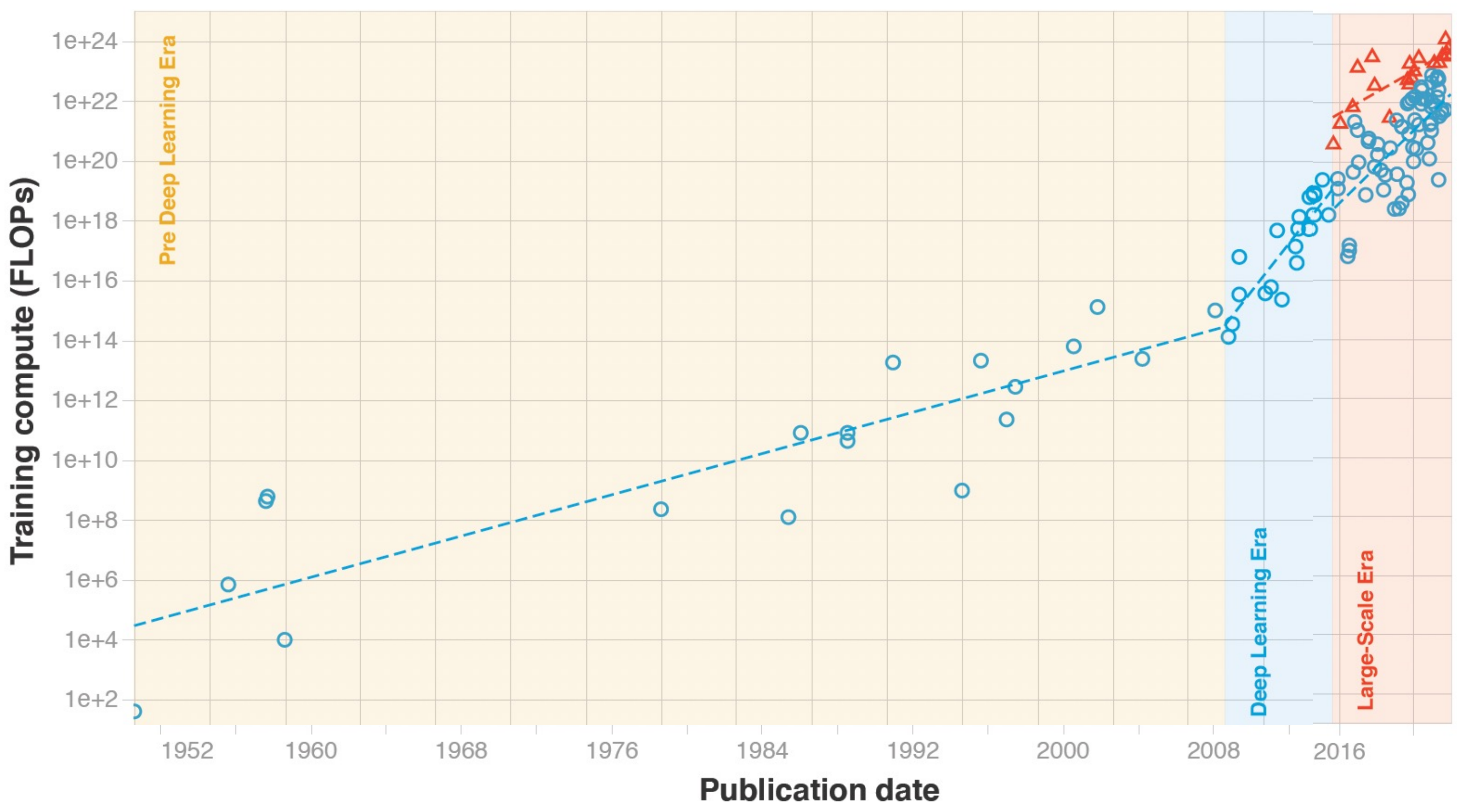
Within the prior 24 months, I have had a financial relationship with
a company producing, marketing, selling, re-selling, or distributing healthcare products used by or on patients:

Nature of Financial Relationship	**Ineligible Company**
Grant/Research Support	HeartSciences, Butterfly Inc., MindMics
Consultant Fees/Honoraria	RCE technologies, HeartSciences
Individual Stock(s)/Stock Options	RCE technologies, HeartSciences

Supported by Grants from NHLBI (1R01HL173998-01A1, 3U01HL088942-17S1, 1P50MD017356-01), & NSF-Bridges in Digital Health

Democratization of AI

Training compute (FLOPs) of milestone Machine Learning systems over time



https://arxiv.org/abs/2202.05924

Artificial Intelligence

The field of study

Machine Learning

The branch of AI that focuses on the autonomous learning of tasks

Deep Learning

The subset of machine learning that uses an artificial neural network architecture to perform complex tasks

Example: CNN

Generative AI

Deep learning that creates data similar to its training set

Example: LLM

"Will AI Displace Cardiology Workforce?"

THE LANCET
Gastroenterology & Hepatology

ARTICLES · Volume 10, Issue 10, P896-903, October 2025

Download Full Issue

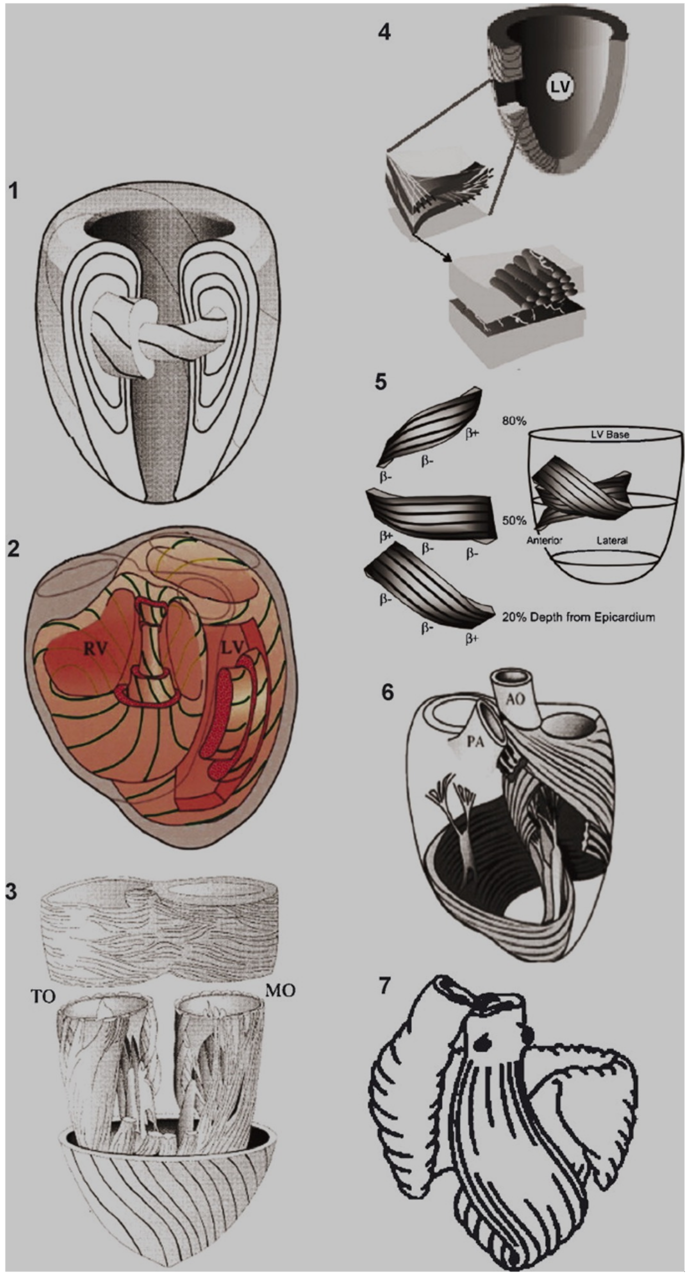
Endoscopist deskilling risk after exposure to artificial intelligence in colonoscopy: a multicentre, observational study

Krzysztof Budzyń, MD [a,b] · Marcin Romańczyk, MD [a,b] · Diana Kitala, PhD [c] · Paweł Kołodziej, MD [d] · Marek Bugajski, MD [e] · Hans O Adami, MD [f,g] · et al. Show more

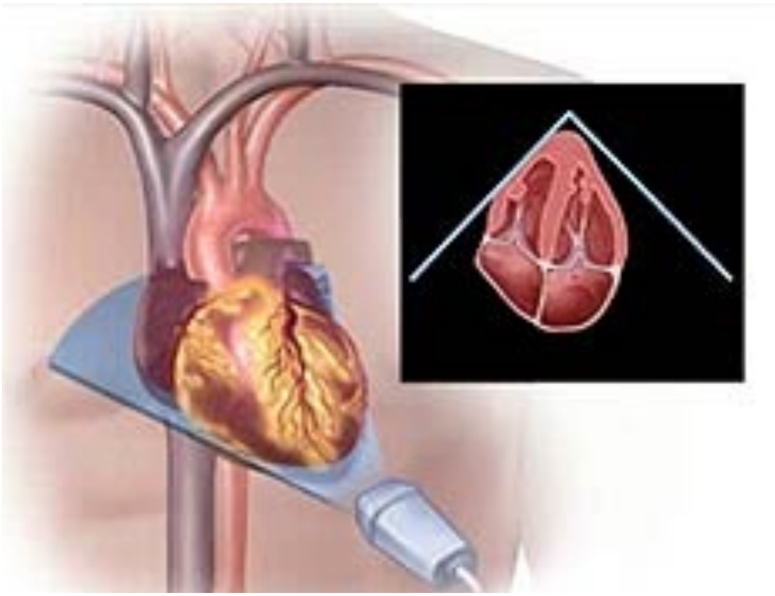
Affiliations & Notes Article Info Linked Articles (3)

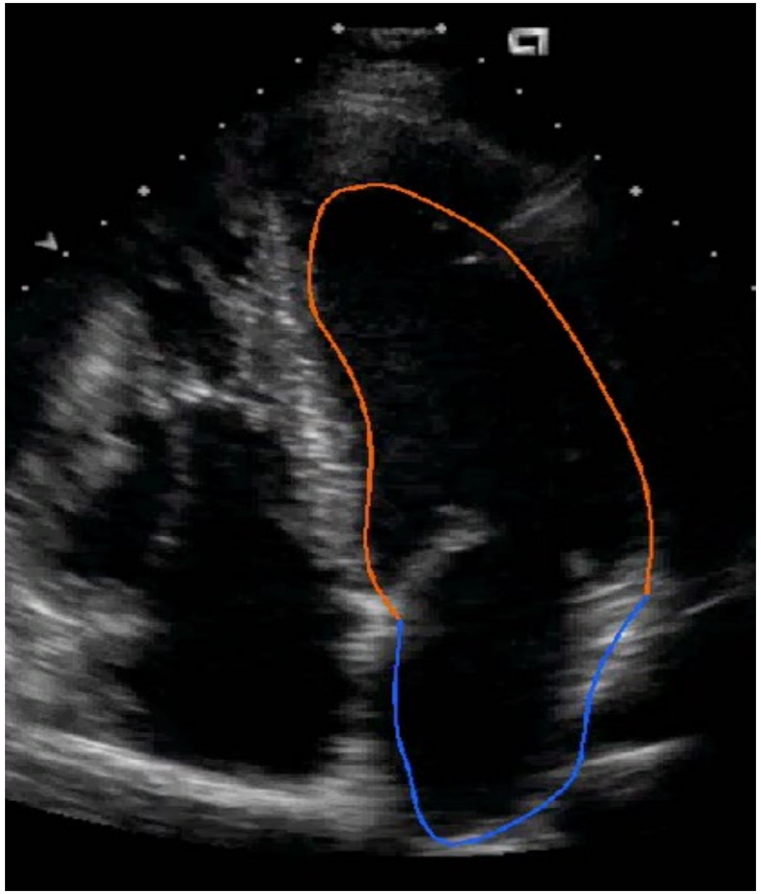
Until 2007 there were 8 different models of heart's function.

Gilbert et al. Eur J Cardiothorac Surg 2007;32:231-49

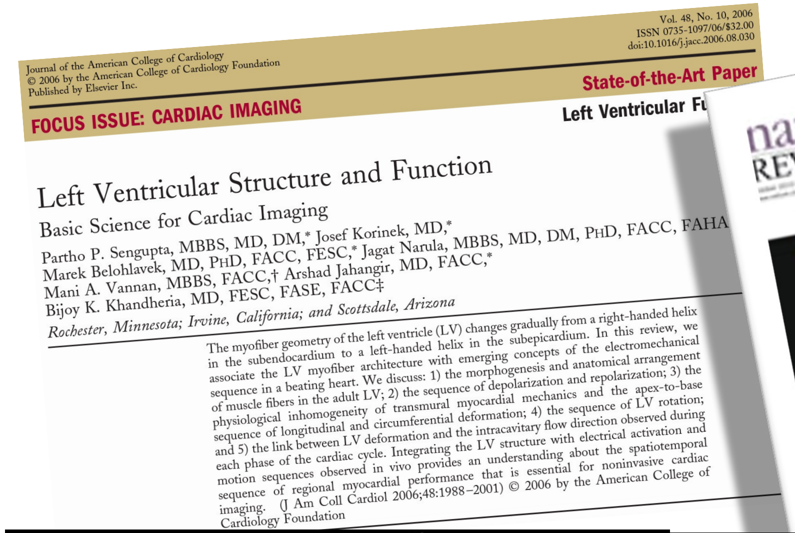


Gilbert et al. Eur J Cardiothorac Surg 2007;32:231-49





Left Ventricular Muscle And Fluid Mechanics


Journal of the American College of Cardiology
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Vol. 48, No. 10, 2006
ISSN 0735-1097/06/$32.00
doi:10.1016/j.jacc.2006.08.030

FOCUS ISSUE: CARDIAC IMAGING

State-of-the-Art Paper

Left Ventricular Fu

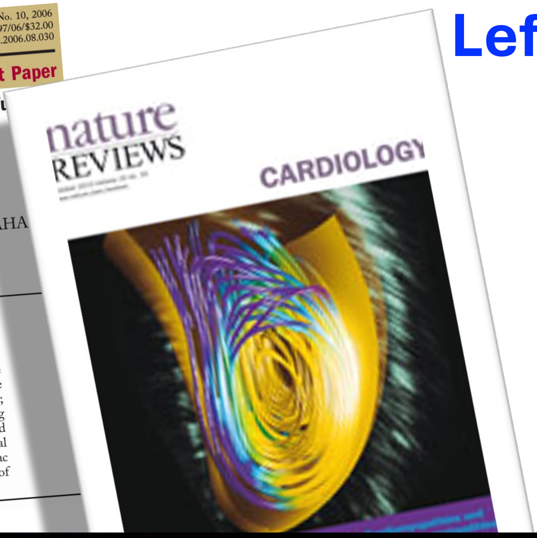
Left Ventricular Structure and Function

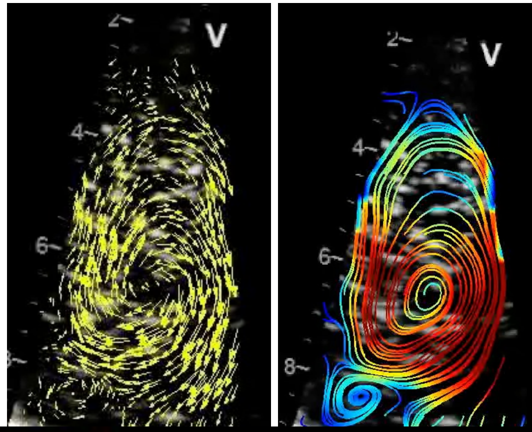
Basic Science for Cardiac Imaging

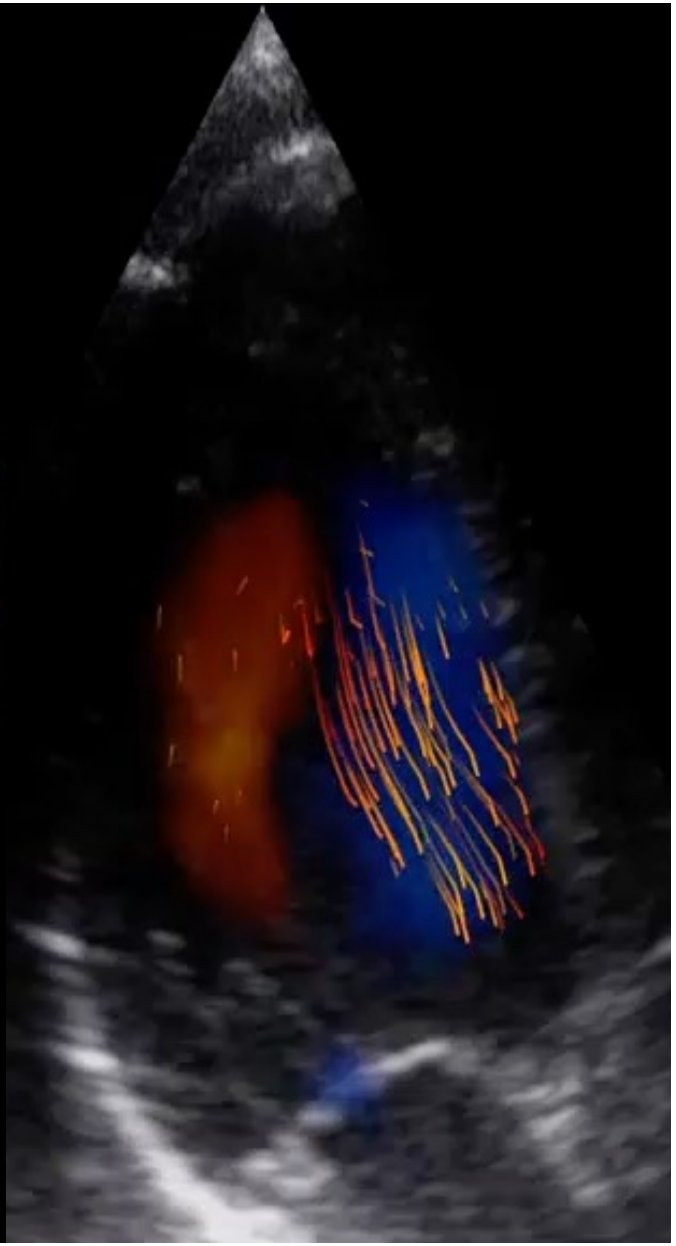
Partho P. Sengupta, MBBS, MD, DM,* Josef Korinek, MD,* Marek Belohlavek, MD, PhD, FACC, FESC,* Jagat Narula, MBBS, MD, DM, PhD, FACC, FAHA Mani A. Vannan, MBBS, FACC,† Arshad Jahangir, MD, FACC,* Bijoy K. Khandheria, MD, FESC, FASE, FACC‡

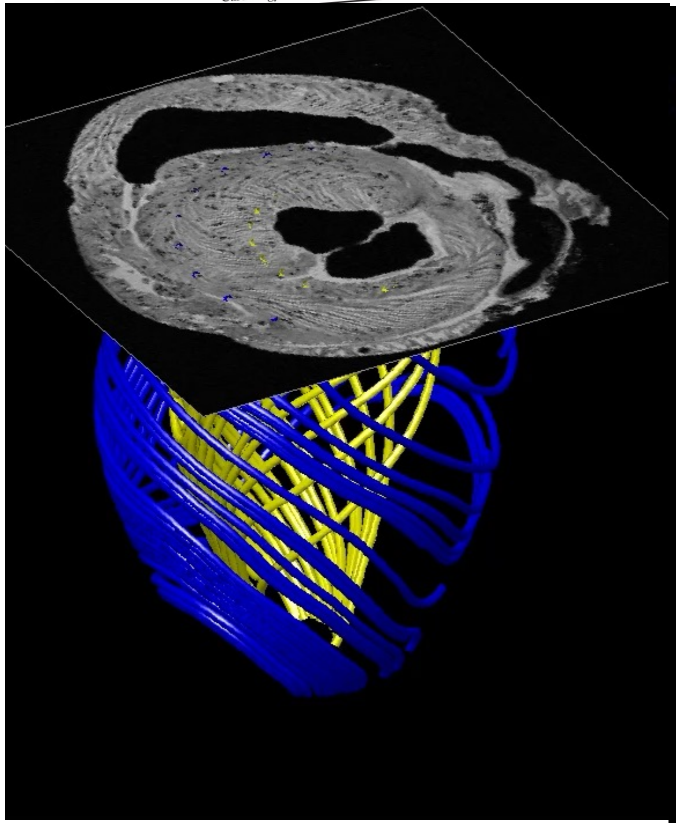
Rochester, Minnesota; Irvine, California; and Scottsdale, Arizona

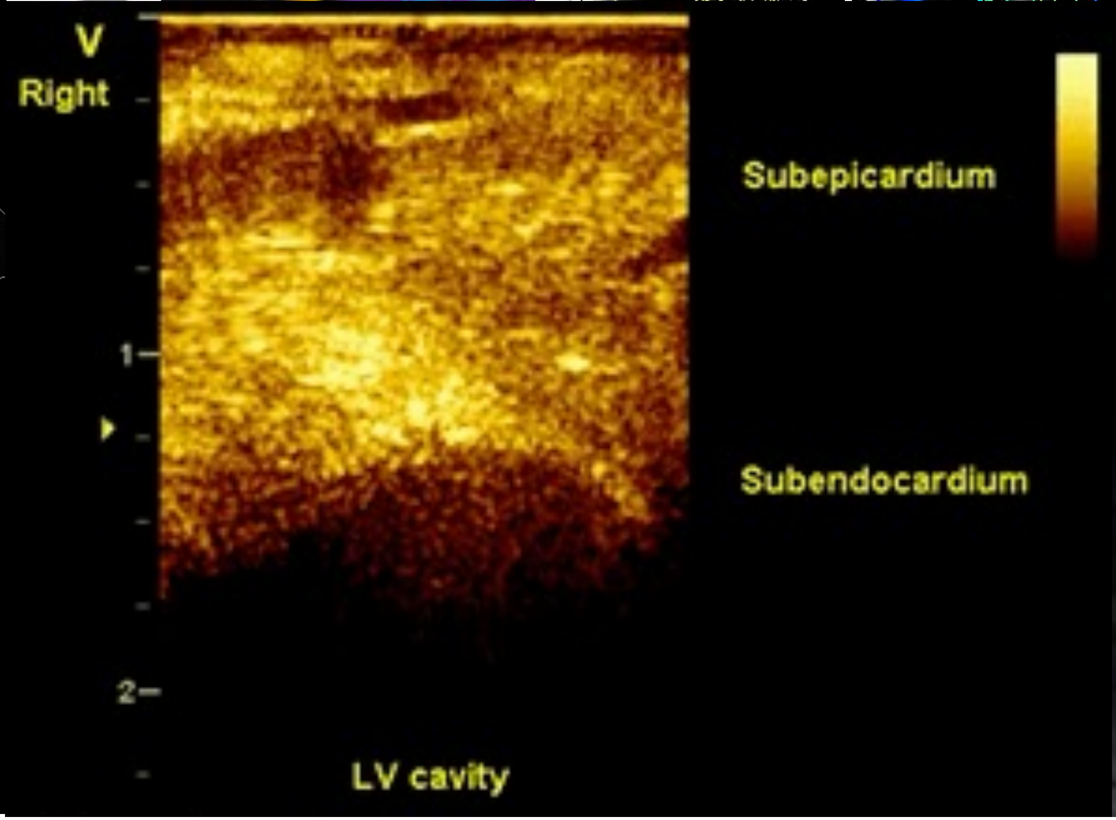
The myofiber geometry of the left ventricle (LV) changes gradually from a right-handed helix in the subendocardium to a left-handed helix in the subepicardium. In this review, we associate the LV myofiber architecture with emerging concepts of the electromechanical sequence in a beating heart. We discuss: 1) the morphogenesis and anatomical arrangement of muscle fibers in the adult LV; 2) the sequence of depolarization and repolarization; 3) the physiological inhomogeneity of transmural myocardial mechanics and the apex-to-base sequence of longitudinal and circumferential deformation; 4) the sequence of LV rotation; and 5) the link between LV deformation and the intracavitary flow direction observed during each phase of the cardiac cycle. Integrating the LV structure with electrical activation and motion sequences observed in vivo provides an understanding about the spatiotemporal sequence of regional myocardial performance that is essential for noninvasive cardiac imaging. (J Am Coll Cardiol 2006;48:1988–2001) © 2006 by the American College of Cardiology Foundation







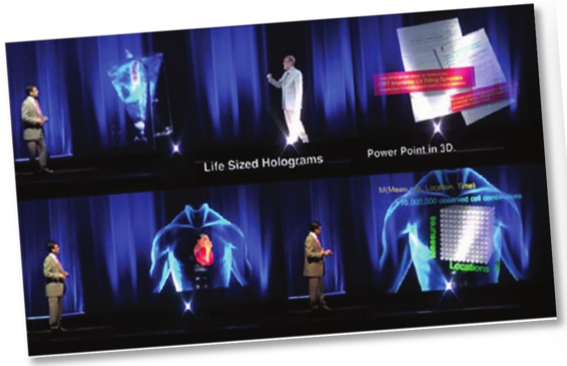


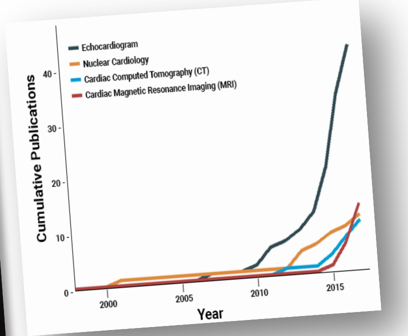


JACC Cardiovascular Imaging

Intelligent Platforms for Disease Assessment

Novel Approaches in Functional Echocardiography





Machine Learning for Data-Driven Discovery

The Rise and Relevance*

Predicting Preclinical Heart Failure Progression

The Rise of Machine-Learning for Population Health*

Enforcing Quality in Strain Imaging Through AI-Powered Surveillance*

Building Trust in AI

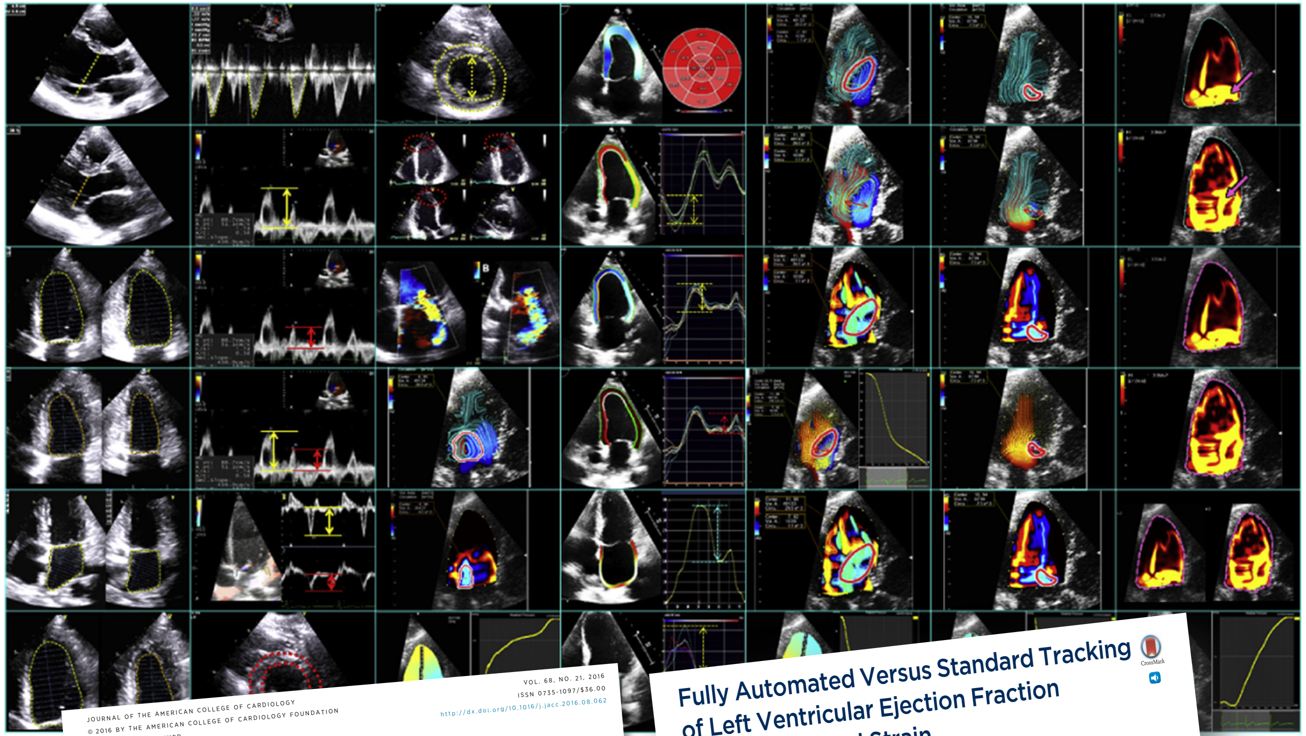
Opportunities and Challenges for Cardiac Imaging

Automated Interpretation of Myocardial Perfusion Images

Tell Me AI Where to Look*

Imaging With Deep Learning

Sharpening the Cutting Edge



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http://dx.doi.org/10.1016/j.jacc.2016.08.062

Machine-Learning Algorithms to Automate Morphological and Functional Assessments in 2D Echocardiography

Sukrit Narula, BS,[a] Khader Shameer, PhD,[b] Alaa Mabrouk Salem Omar, MD, PhD,[a,c] Joel T. Dudley, PhD,[b] Partho P. Sengupta, MD, DM[a]

ABSTRACT

BACKGROUND Machine-learning models may aid cardiac phenotypic recognition by using features of cardiac tissue deformation.

OBJECTIVES This study investigated the diagnostic value of a machine-learning framework that incorporates speckle-tracking echocardiographic data for automated discrimination of hypertrophic cardiomyopathy (HCM) from physiological hypertrophy seen in athletes (ATH).

METHODS Expert-annotated speckle-tracking echocardiographic datasets obtained from 77 ATH and 62 HCM patients were used for developing an automated system. An ensemble machine-learning model with 3 different machine-learning algorithms (support vector machines, random forests, and artificial neural networks) was developed and a majority voting method was used for conclusive predictions with further *K*-fold cross-validation.

RESULTS Feature selection using an information gain (IG) algorithm revealed that volume was the best predictor for differentiating between HCM ands. ATH (IG = 0.24) followed by mid-left ventricular segmental (IG = 0.134) and average longitudinal strain (IG = 0.131). The ensemble machine-learning model showed increased sensitivity and specificity compared with early-to-late diastolic transmitral velocity ratio ($p < 0.01$), average early diastolic tissue velocity (e′) ($p < 0.01$), and strain ($p = 0.04$). Because ATH were younger, adjusted analysis was undertaken in younger HCM patients and compared with ATH with left ventricular wall thickness >13 mm. In this subgroup analysis, the automated model continued to show equal sensitivity, but increased specificity relative to early-to-late diastolic transmitral velocity ratio, e′, and strain.

CONCLUSIONS Our results suggested that machine-learning algorithms can assist in the discrimination of physiological versus pathological patterns of hypertrophic remodeling. This effort represents a step toward the development of a real-time, machine-learning–based system for automated interpretation of echocardiographic images, which may help novice readers with limited experience. (J Am Coll Cardiol 2016;68:2287–95) © 2016 by the American College of Cardiology Foundation.

Fully Automated Versus Standard Tracking of Left Ventricular Ejection Fraction and Longitudinal Strain

The FAST-EFs Multicenter Study

Christian Knackstedt, MD,* Sebastiaan C.A.M. Bekkers, MD, PhD,* Georg Schummers,† Marcus Schreckenberg,† Denisa Muraru, MD, PhD,‡ Luigi P. Badano, MD, PhD,‡ Andreas Franke, MD,§ Chirag Bavishi, MD, MPH,‖ Alaa Mabrouk Salem Omar, MD, PhD,‖ Partho P. Sengupta, MD, DM‖

ABSTRACT

BACKGROUND Echocardiographic determination of ejection fraction (EF) by manual tracing of endocardial borders is time consuming and operator dependent, whereas visual assessment is inherently subjective.

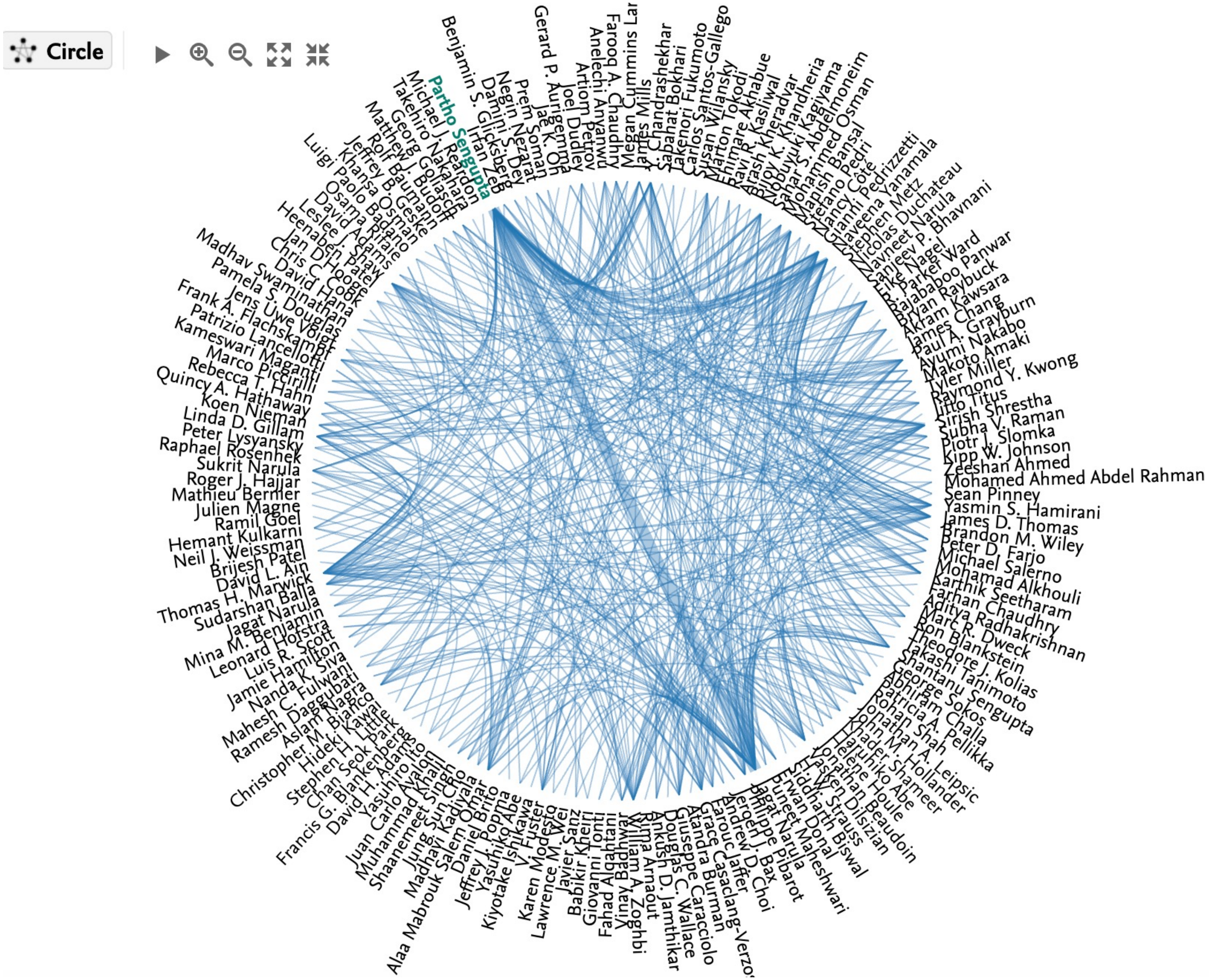
OBJECTIVES This study tested the hypothesis that a novel, fully automated software using machine learning-enabled image analysis will provide rapid, reproducible measurements of left ventricular volumes and EF, as well as average biplane longitudinal strain (LS).

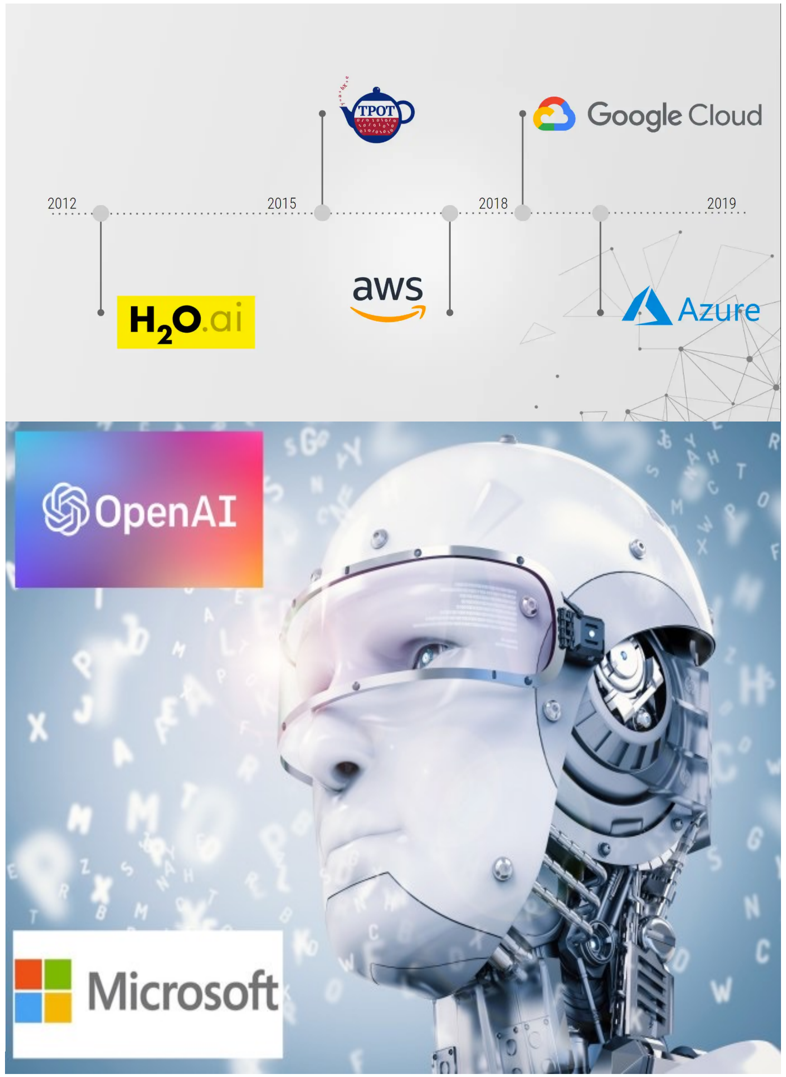
METHODS For a total of 255 patients in sinus rhythm, apical 4- and 2-chamber views were collected from 4 centers that assessed EF using both visual estimation and manual tracing (biplane Simpson's method). In addition, datasets were saved in a centralized database, and machine learning-enabled software (AutoLV, TomTec-Arena 1.2, TomTec Imaging Systems, Unterschleissheim, Germany) was applied for fully automated EF and LS measurements. A reference center reanalyzed all datasets (by visual estimation and manual tracking), along with manual LS determinations.

RESULTS AutoLV measurements were feasible in 98% of studies, and the average analysis time was 8 ± 1 s/patient. Interclass correlation coefficients and Bland-Altman analysis revealed good agreements among automated EF, local center manual tracking, and reference center manual tracking, but not for visual EF assessments. Similarly, automated and manual LS measurements obtained at the reference center showed good agreement. Intraobserver variability was higher for visual EF than for manual EF or manual LS, whereas interobserver variability was higher for both visual and manual EF, but not different for LS. Automated EF and LS had no variability.

CONCLUSIONS Fully automated analysis of echocardiography images provides rapid and reproducible assessment of left ventricular EF and LS. (J Am Coll Cardiol 2015;66:1456–66) © 2015 by the American College of Cardiology Foundation.

Automated Machine Learning





Circulation

EDITORIAL

Learning About Machine Learning to Create a Self-Driving Echocardiographic Laboratory

Technical Considerations

Article, see p 1623

Jan D'hooge, PhD
Alan G. Fraser, BSc, MBChB

Circulation

EDITORIAL

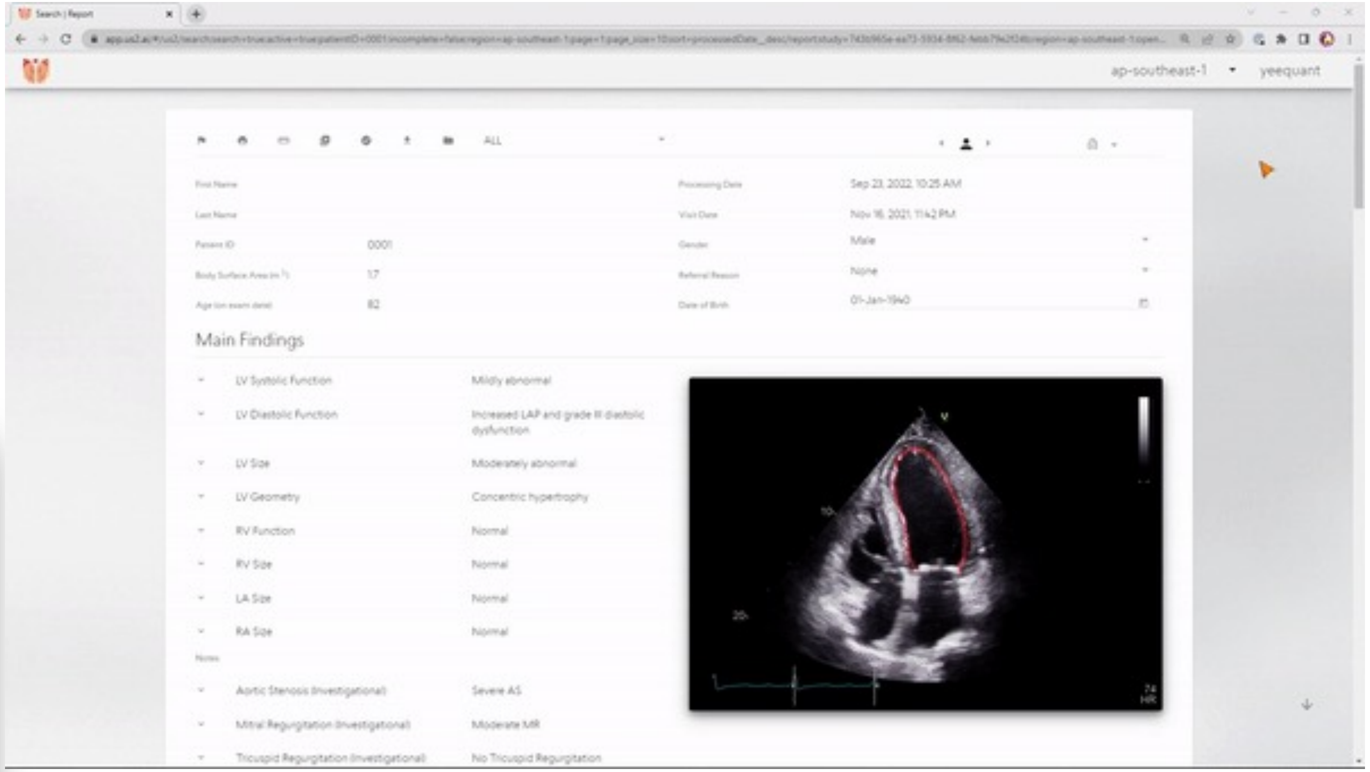
Will Artificial Intelligence Replace the Human Echocardiographer?

Clinical Considerations

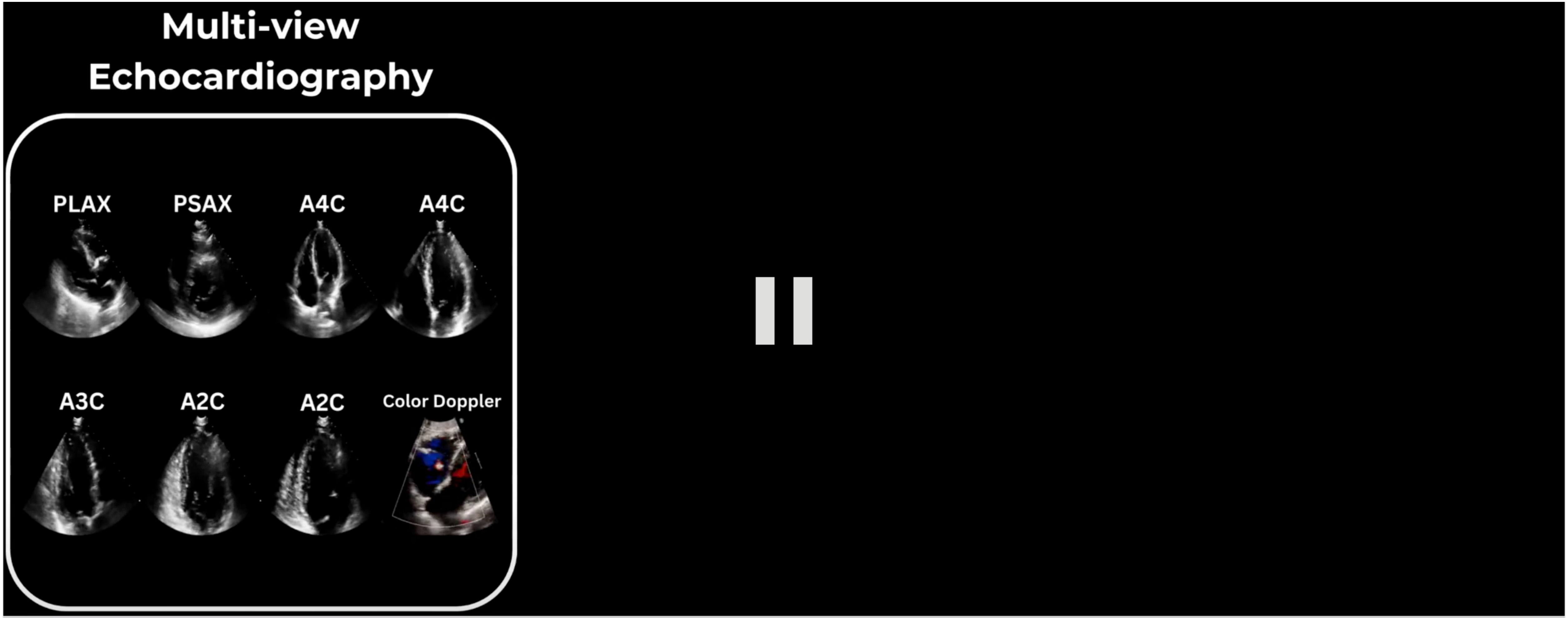
Article, see p XXX

Partho P. Sengupta, MD, DM
Donald A. Adjeroh, PhD

An older population with an increased prevalence of cardiovascular disease and an aging workforce are engendering a state of healthcare crisis in cardiology.[1] Most cardiologists now face an unprecedented time crunch as they



US2AI, courtesy Yoram Hummel



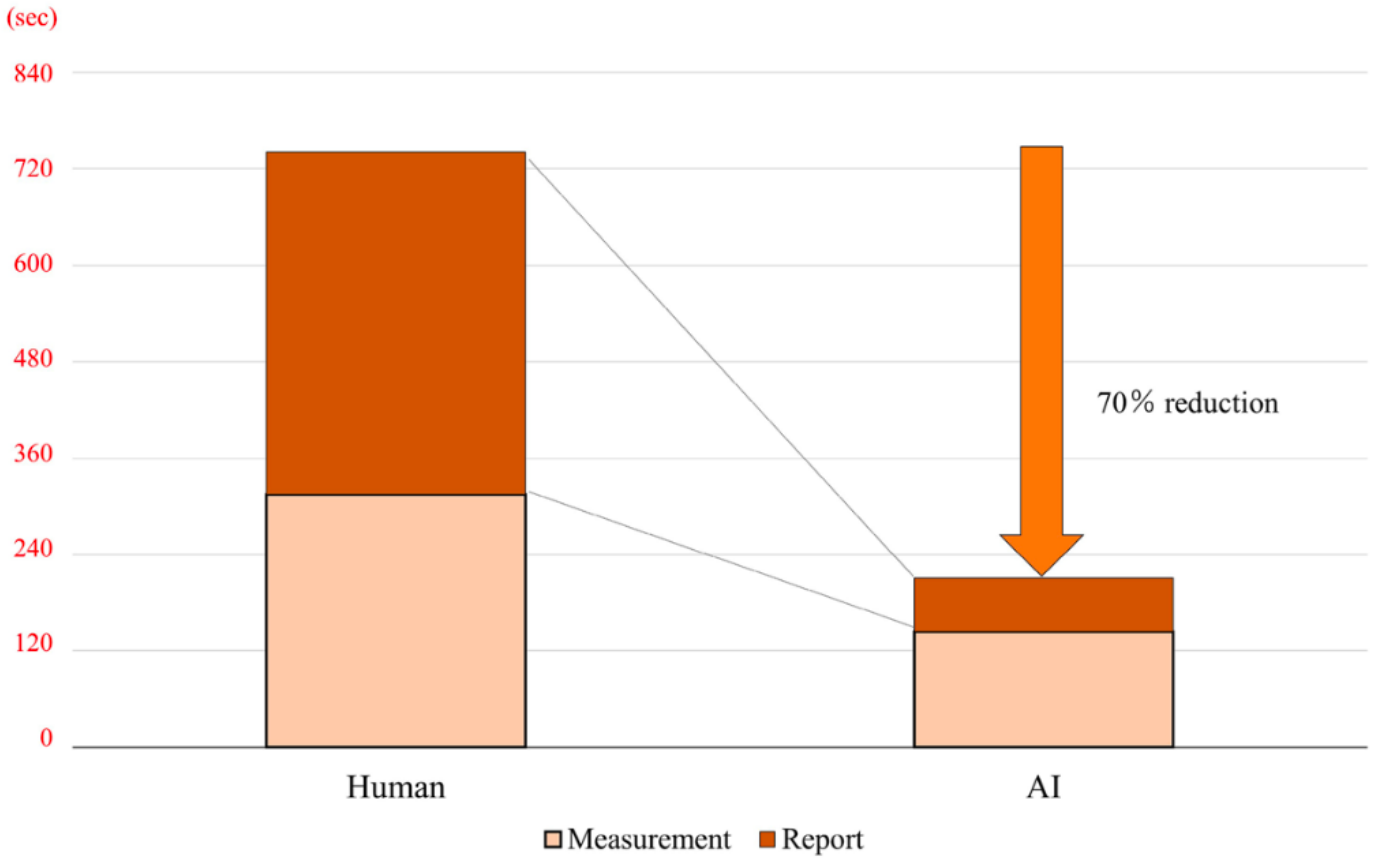
https://www.cards-lab.org/panecho

Journal of Echocardiography
https://doi.org/10.1007/s12574-023-00636-6

ORIGINAL INVESTIGATION

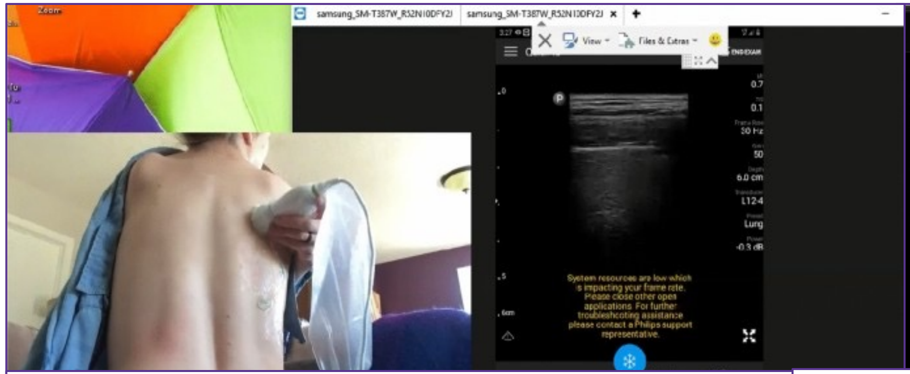
Reducing echocardiographic examination time through routine use of fully automated software: a comparative study of measurement and report creation time

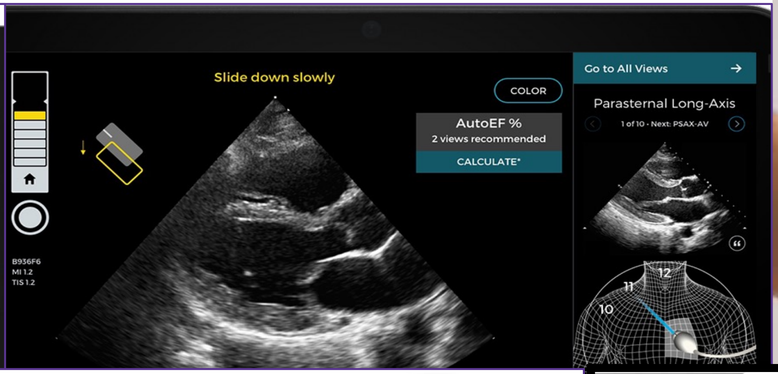
Yukina Hirata[1] · Yuka Nomura[1] · Yoshihito Saijo[2] · Masataka Sata[2] · Kenya Kusunose[2,3]

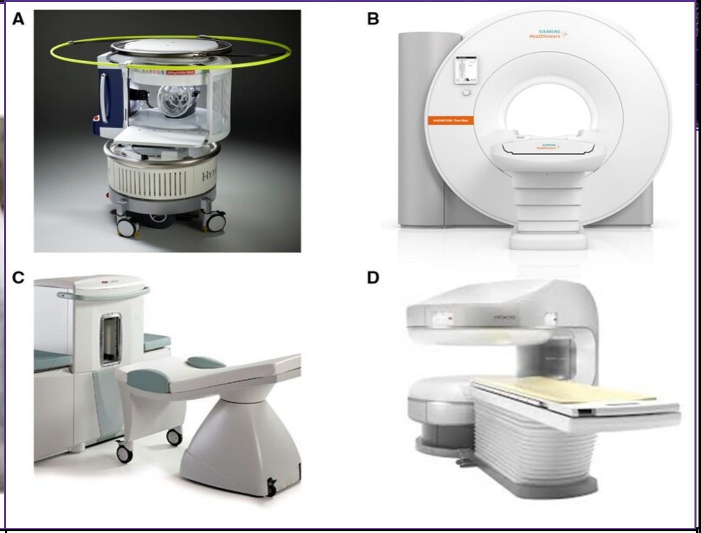


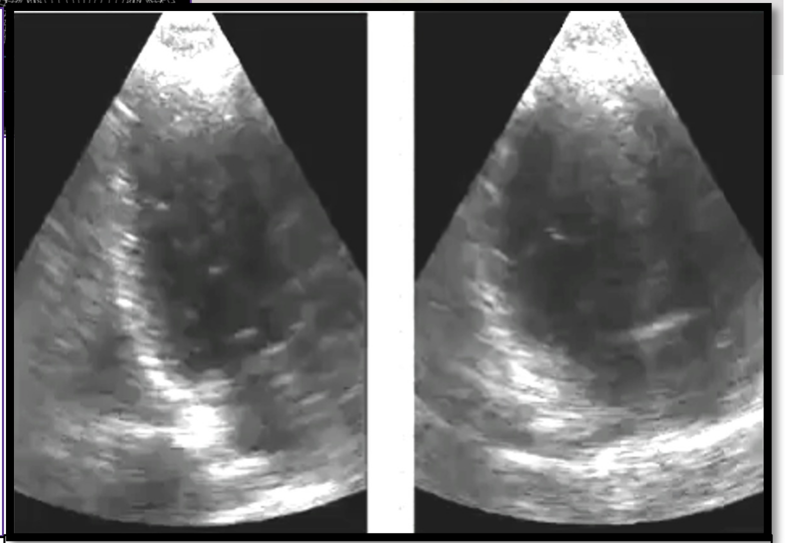
AI-driven Autonomous Imaging, Miniaturized/ Portable Devices

Self Scanning	Wearable Ultrasound









Portable CT	Portable MRI	Fully Automated Imaging

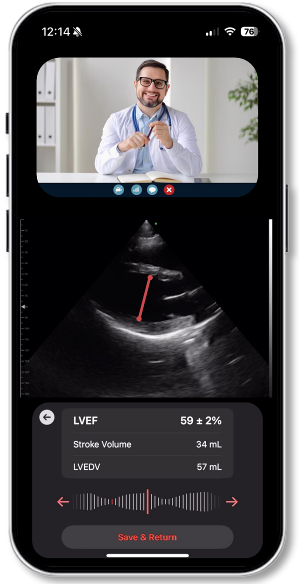
Autonomous Ultrasound Scanner

Cynova

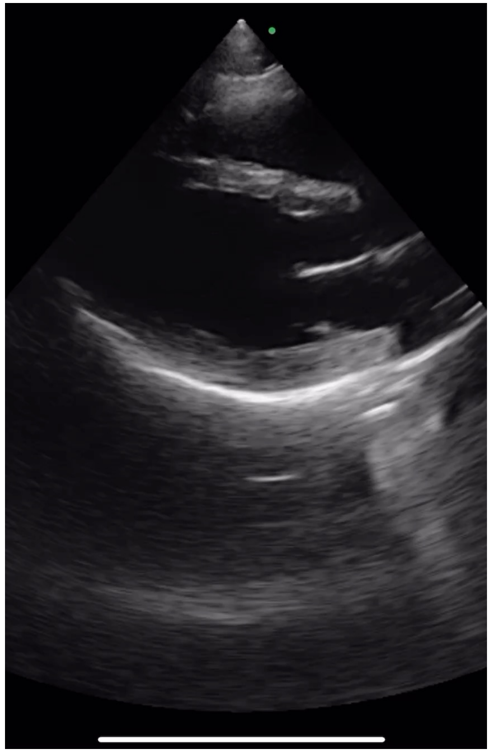
Hands-free

+

AI-powered



Ultrasound System



🔧 Easy setup with nurses or family members

📊 Simplified workflow with reduced clinical overhead

📡 Access anytime, anywhere

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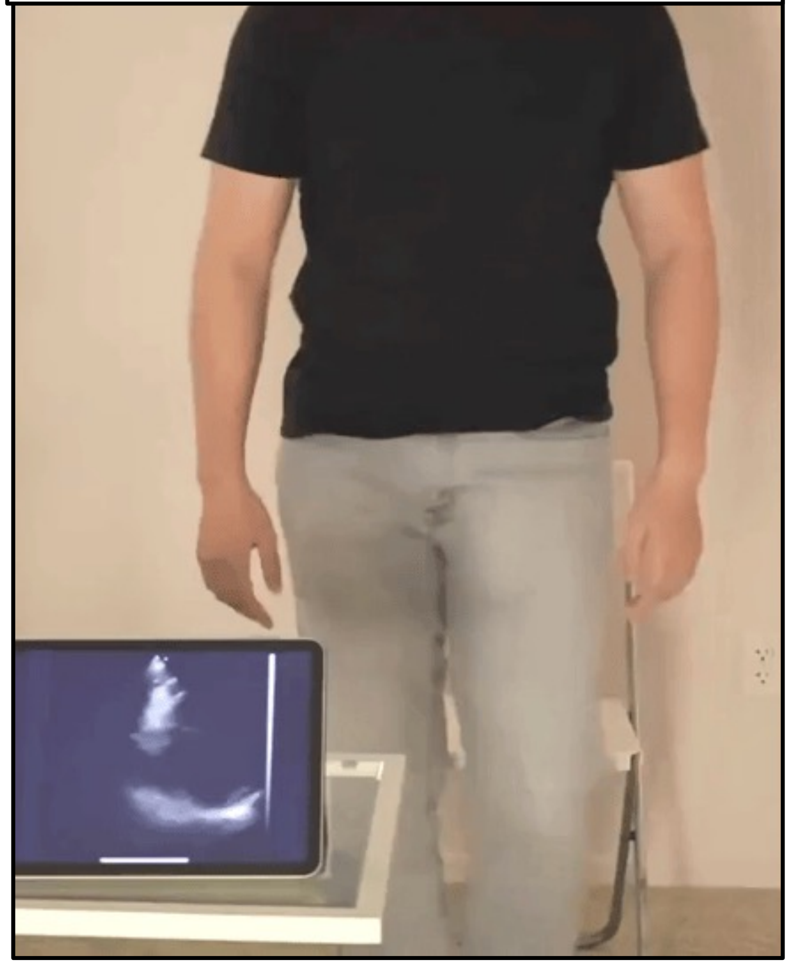
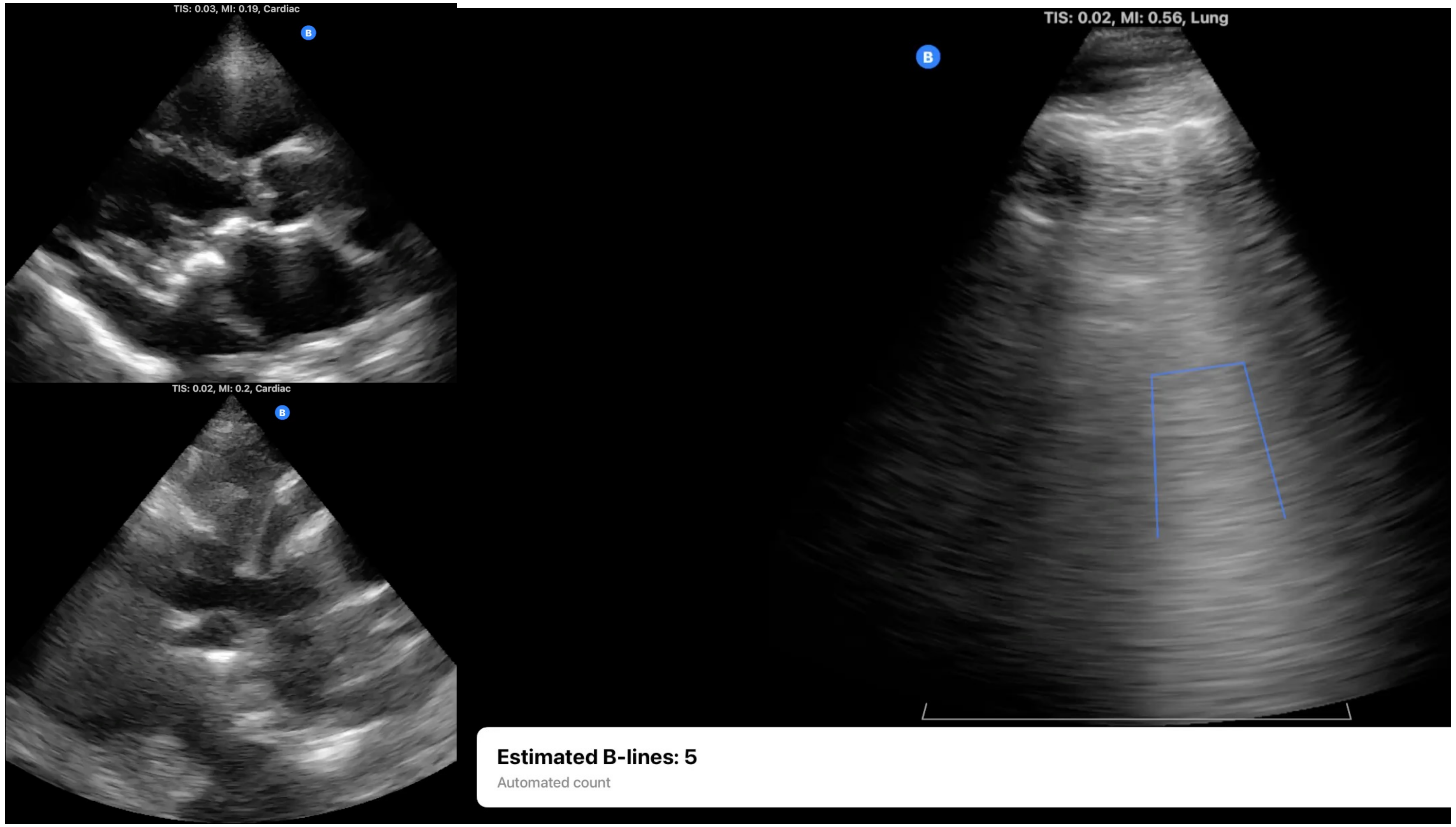
A wearable cardiac ultrasound imager



POCUS-CARE Trial: A Step-Wedge Cluster Randomized Trial



Outcome	POCUS	Control	p-value
Cumulative LOS in each arm (days)	713	959	0.008**
Cumulative total direct hospitalization cost for each arm ($ all patients)	2,442,945	3,194,482	0.020**

Maganti K, Yanamala N, Sengupta PP et al, JAMA Network 2025

The Need

Projected Burden of CV Disease and Workforce Shortage

35.6 million CV deaths by 2050

Total CV deaths ↑ **73.4%**

Age-standardised CV mortality rates ↓ **30.5%**

ESC European Society of Cardiology
European Journal of Preventive Cardiology (2024) **00**, 1–15
https://doi.org/10.1093/eurjpc/zwae281
FULL RESEARCH PAPER
Cardiovascular disease

Global burden of cardiovascular diseases: projections from 2025 to 2050

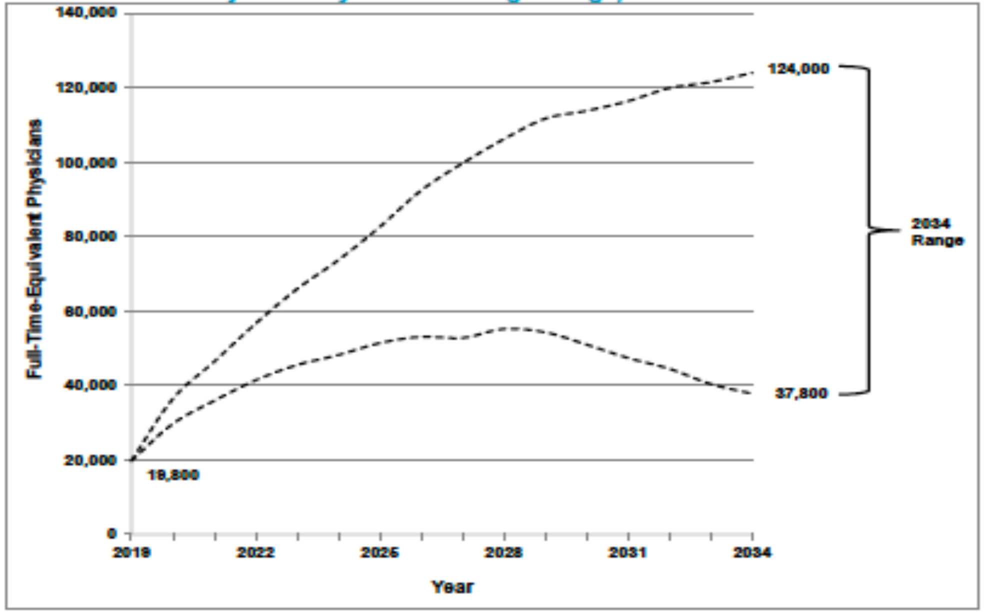
World Health Organization

10 million
more health workers
are needed by 2030, primarily in low and lower-middle income countries

The Complexities of Physician Supply and Demand: Projections From 2019 to 2034

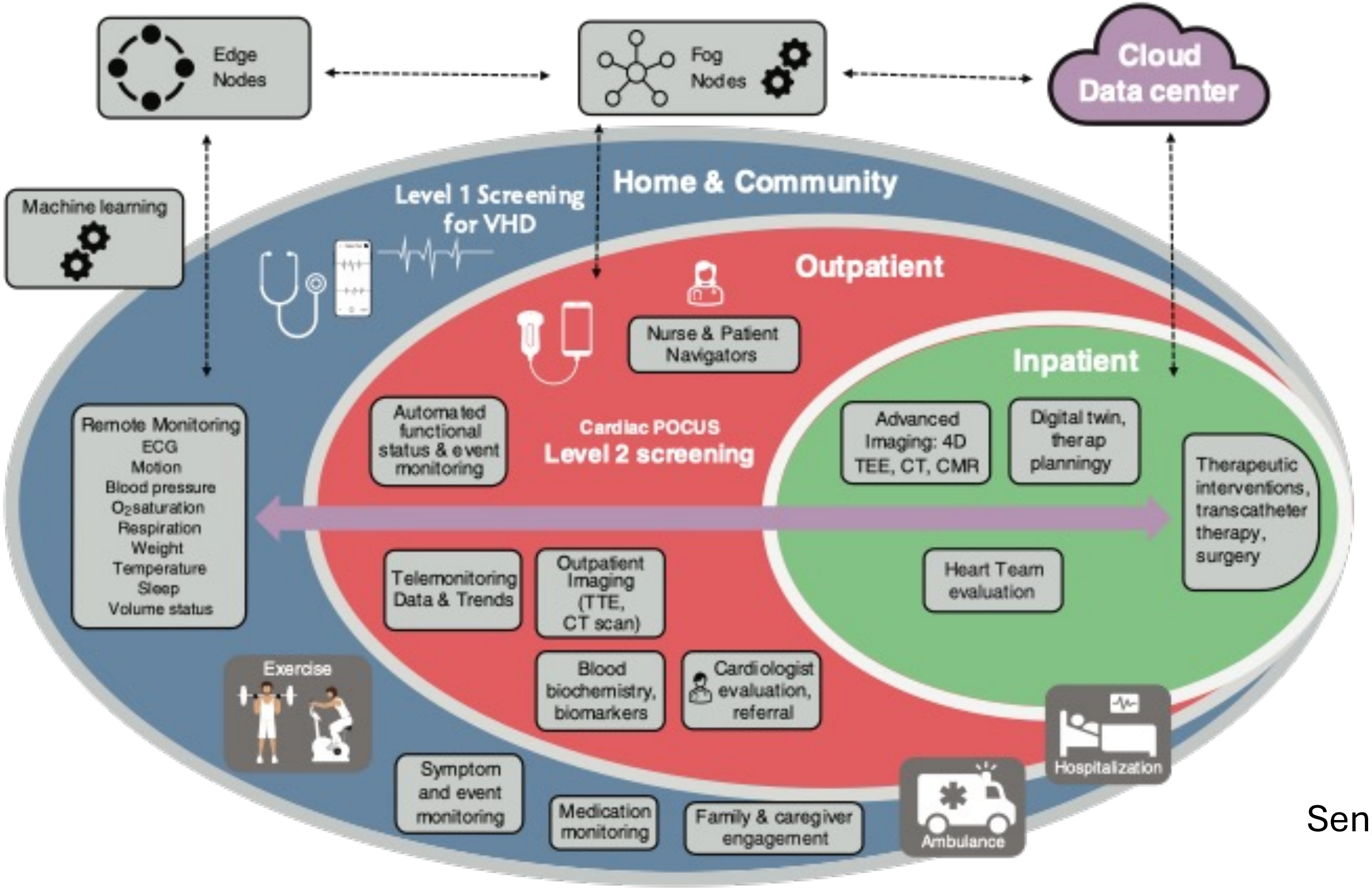
AAMC

Exhibit 2: Total Projected Physician Shortage Range, 2019-2034



The Need

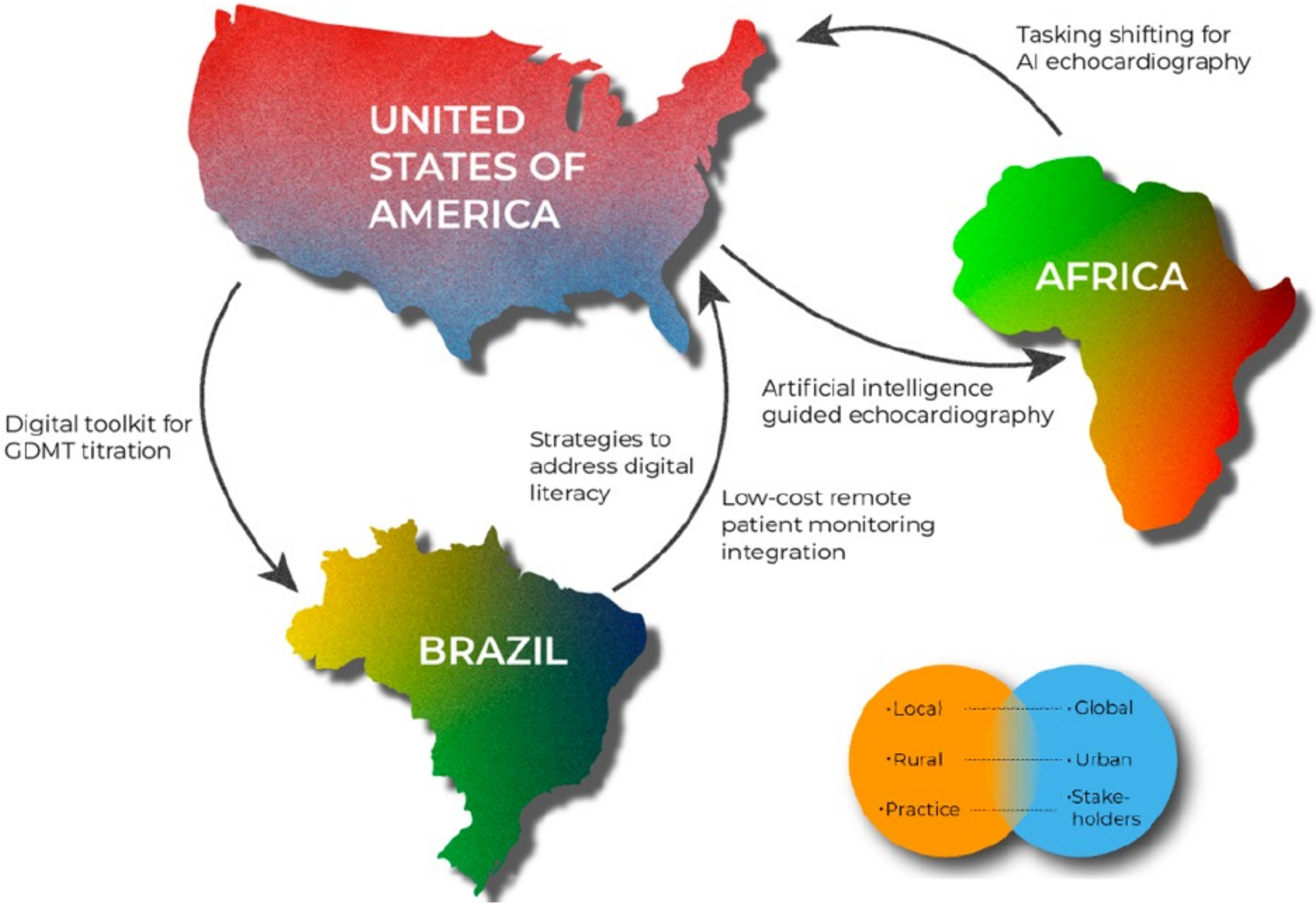
AI Can Advance Access For Screening and Early Detection of Heart Disease



Sengupta PP et al, Lancet 2023

The Need

AI Can Advance Global Cardiovascular Health Equity



Medical imaging clinic in Juana Vicente, Dominican Republic. US probe (left) is connected to a laptop computer, powered by an external battery (orange cord) because of absent electricity.

Prediction # 1. A new era of "Augmented Imaging"— physicians using AI to boost efficiency, reduce burnout, and rediscover joy in medicine, enhancing both clinical care and their own professional fulfillment.

JACC Journals › JACC: Imaging › Archives › Just Accepted

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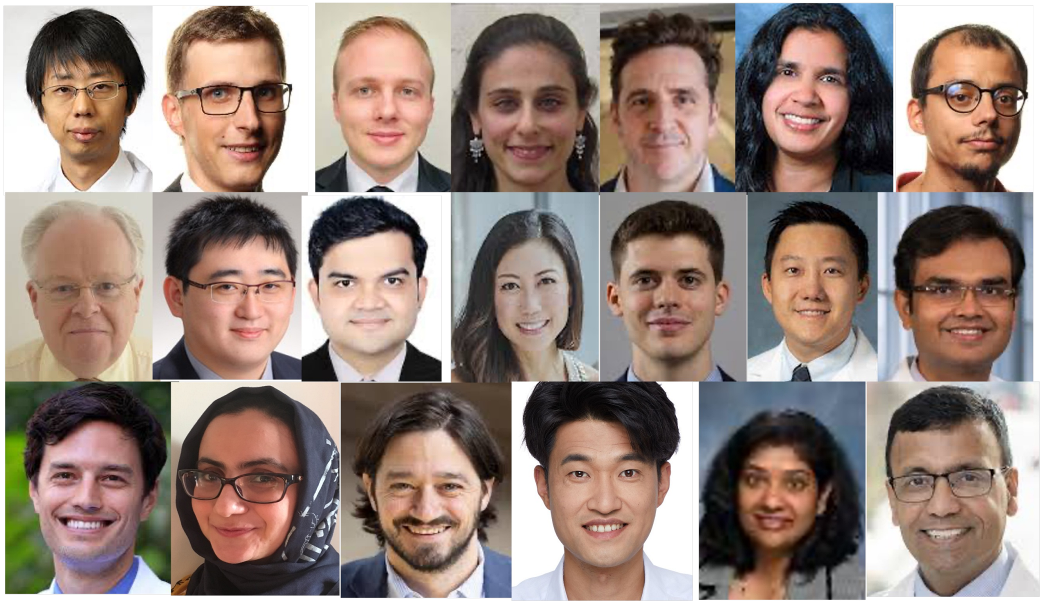
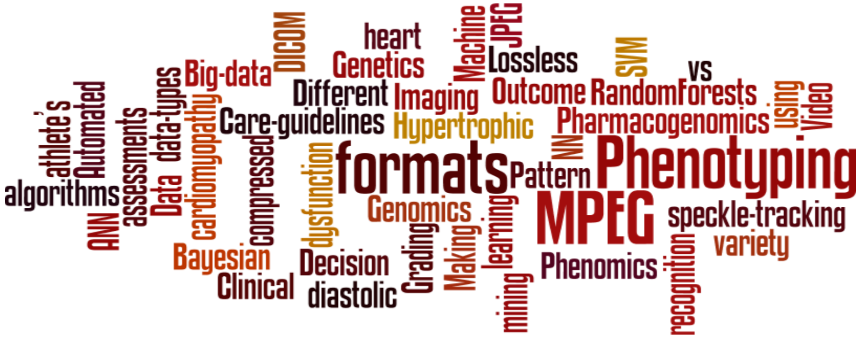
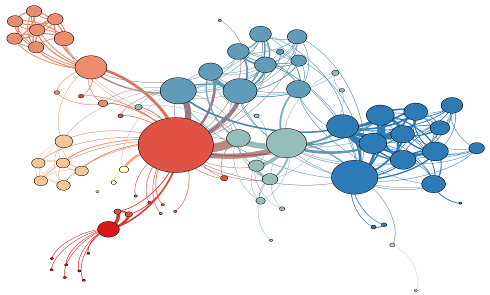
PRIME 2.0: An Update to The Proposed Requirements for Cardiovascular Imaging-Related Machine Learning Evaluation Checklist



Prediction # 2 A New Taxonomy of Disease Classification

Clinical + **Cardiac Diagnostic data** + **Biochemical, Genomics**

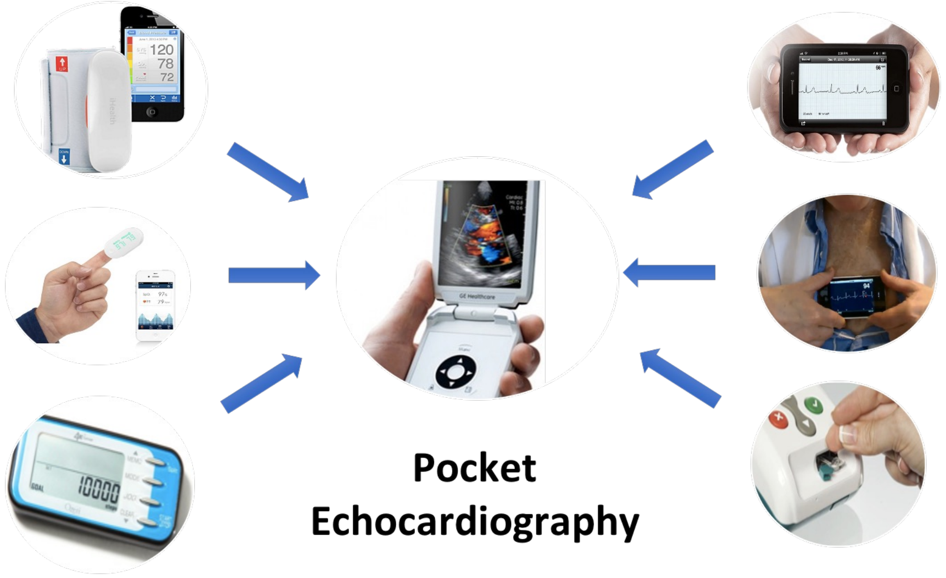




Blood pressure iBP

Oxymetry iO2

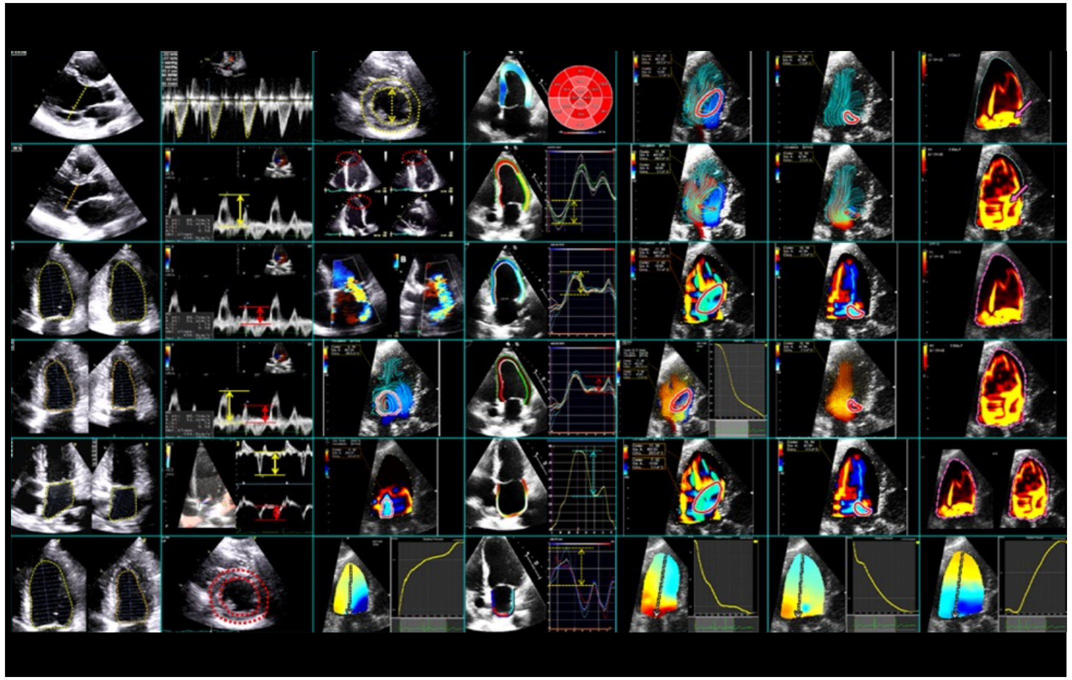
Activity Monitor 6 MWT



Pocket Echocardiography

iECG

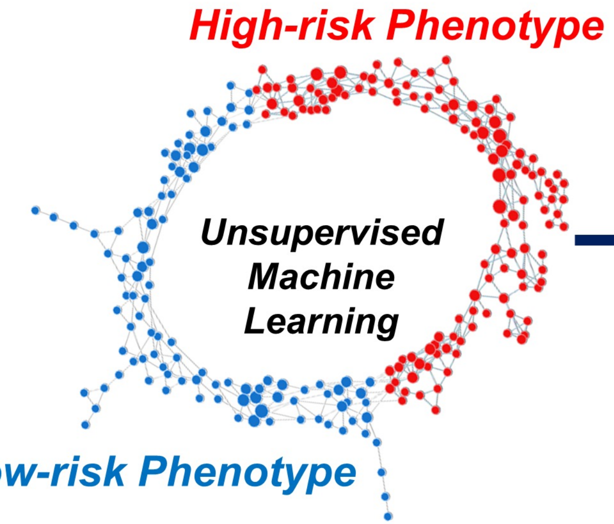
Point-of-Care BNP



Deep Learning for Assessing Diastolic Dysfunction in HFpEF

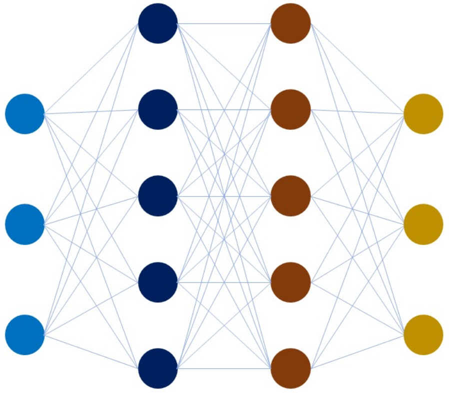
Ambarish Pandey, MD

Similarity Clustering

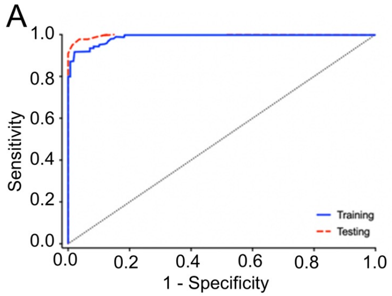


Supervised Classifier

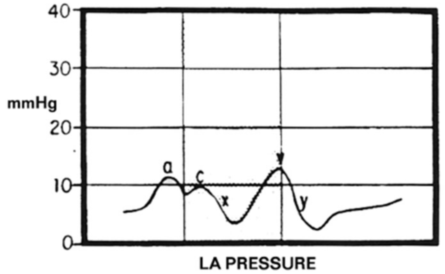
Training Set



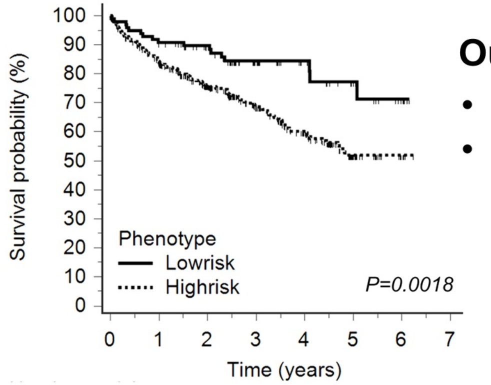
Deep Learning Model



Model Evaluation

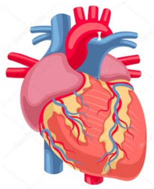


Hemodynamic Validation
Invasive cohort
(N = 83)



Outcome Validation

- TOPCAT (N = 518)
- External Validation (N = 219)

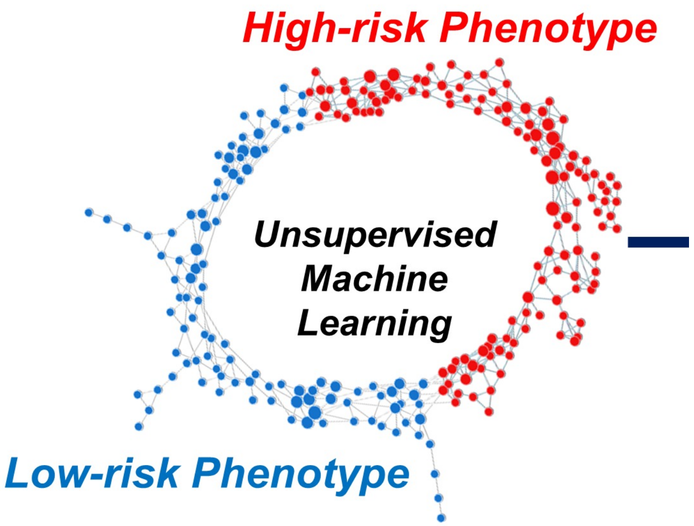


Cardiac Biomarkers

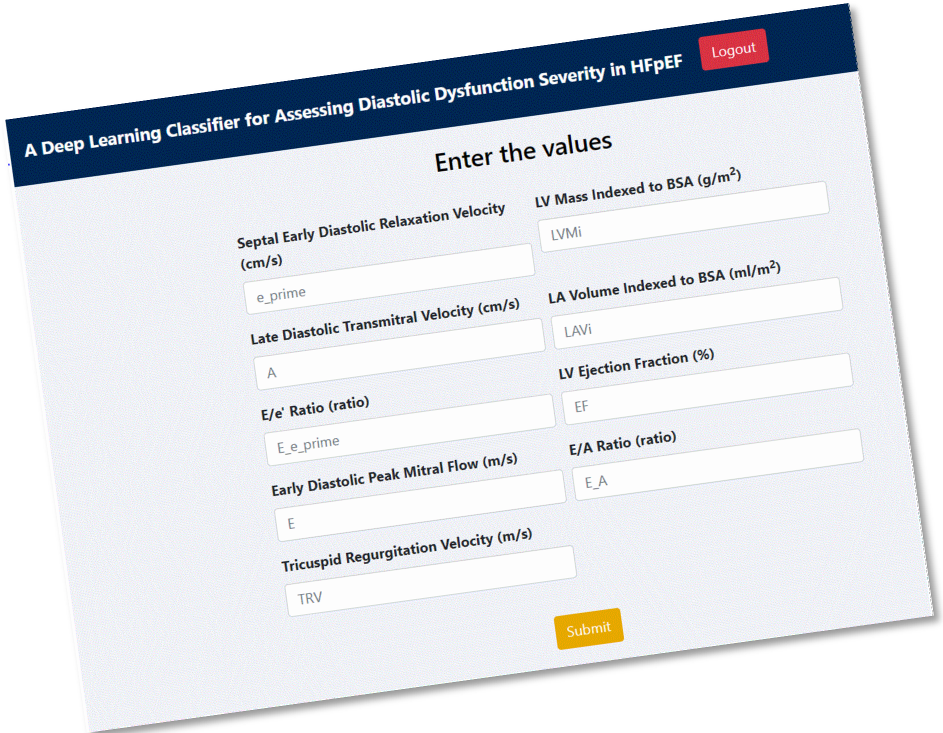
Exercise Performance

- NEAT (N = 110)
- RELAX (N = 216)

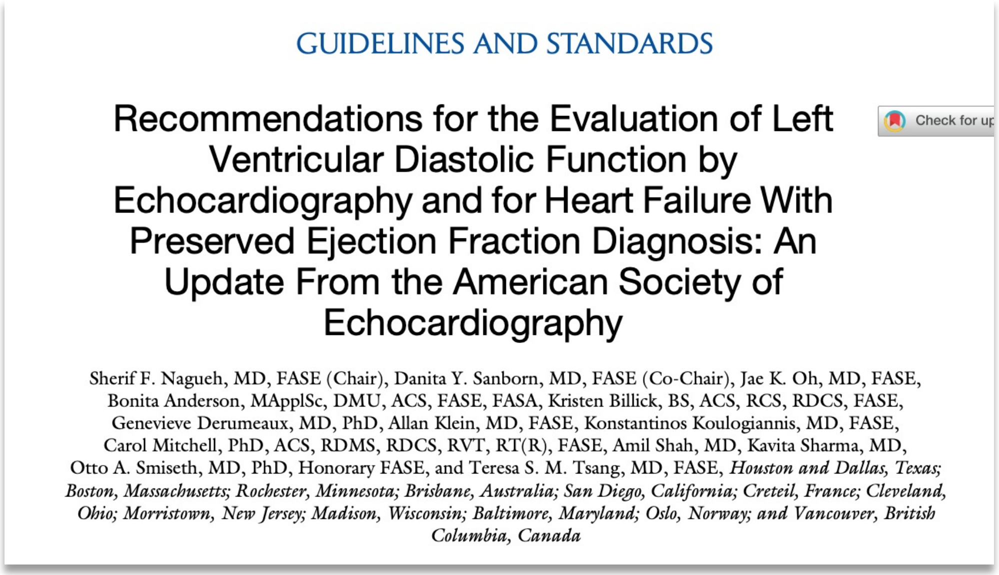
J Am Coll Cardiol Img 2021, 14: 1887–1900



J Am Coll Cardiol Img 2021, 14: 1887–1900



https://wvu-model.herokuapp.com



GUIDELINES AND STANDARDS

Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography and for Heart Failure With Preserved Ejection Fraction Diagnosis: An Update From the American Society of Echocardiography

Sherif F. Nagueh, MD, FASE (Chair), Danita Y. Sanborn, MD, FASE (Co-Chair), Jae K. Oh, MD, FASE, Bonita Anderson, MApplSc, DMU, ACS, FASE, FASA, Kristen Billick, BS, ACS, RCS, RDCS, FASE, Genevieve Derumeaux, MD, PhD, Allan Klein, MD, FASE, Konstantinos Koulogiannis, MD, FASE, Carol Mitchell, PhD, ACS, RDMS, RDCS, RVT, RT(R), FASE, Amil Shah, MD, Kavita Sharma, MD, Otto A. Smiseth, MD, PhD, Honorary FASE, and Teresa S. M. Tsang, MD, FASE, *Houston and Dallas, Texas; Boston, Massachusetts; Rochester, Minnesota; Brisbane, Australia; San Diego, California; Creteil, France; Cleveland, Ohio; Morristown, New Jersey; Madison, Wisconsin; Baltimore, Maryland; Oslo, Norway; and Vancouver, British Columbia, Canada*

“ Machine learning models based on clinical outcomes offer a more evidence-based approach to optimizing the classification of diastolic function with both reduction of “indeterminate’’ cases and improvement of the clinical relevance of diastolic function classification.”

Prediction #3 A New Taxonomy of Measurements

Ultrasonic Texture Features for Assessing Cardiac Remodeling and Dysfunction

Quincy A. Hathaway, PhD,[a,*] Naveena Yanamala, PhD,[b,*] Nanda K. Siva, BS,[a] Donald Adjeroh, PhD,[c]
John M. Hollander, PhD,[d] Partho P. Sengupta, MD, DM[b]

ABSTRACT

BACKGROUND Changes in cardiac size, myocardial mass, cardiomyocyte appearance, and, ultimately, the function of the entire organ are interrelated features of cardiac remodeling that profoundly affect patient outcomes.

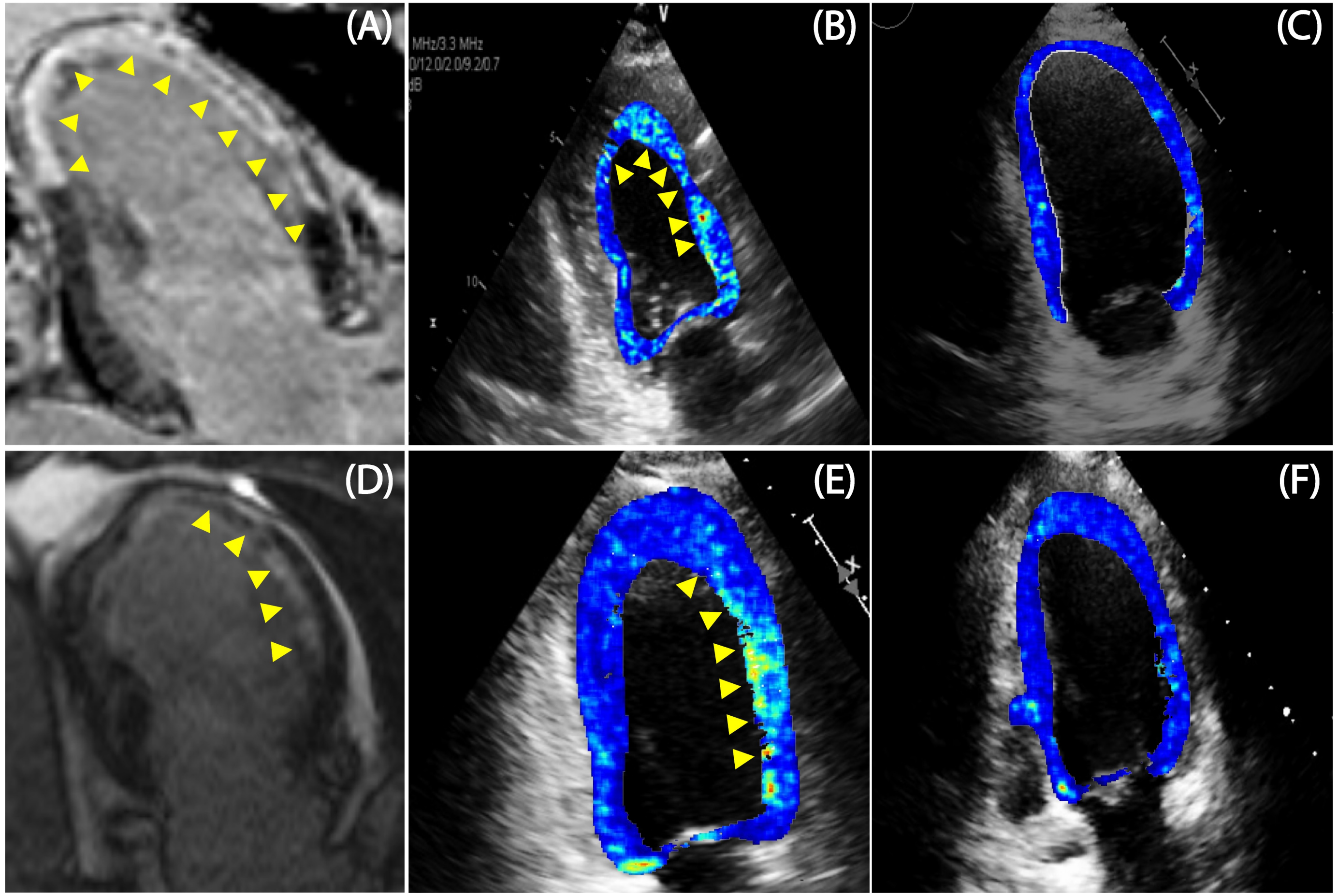
OBJECTIVES This study proposes that the application of radiomics for extracting cardiac ultrasonic textural features (ultrasomics) can aid rapid, automated assessment of left ventricular (LV) structure and function without requiring manual measurements.

METHODS This study developed machine-learning models using cardiac ultrasound images from 1,915 subjects in 3 clinical cohorts: 1) an expert-annotated cardiac point-of-care-ultrasound (POCUS) registry (n = 943, 80% training/testing and 20% internal validation); 2) a prospective POCUS cohort for external validation (n = 275); and 3) a prospective external validation on high-end ultrasound systems (n = 484). In a type 2 diabetes murine model, echocardiography of wild-type (n = 10) and Leptr$^{-/-}$ (n = 8) mice were assessed longitudinally at 3 and 25 weeks, and ultrasomics features were correlated with histopathological features of hypertrophy.

RESULTS The ultrasomics model predicted LV remodeling in the POCUS and high-end ultrasound external validation studies (area under the curve: 0.78 [95% CI: 0.68-0.88] and 0.79 [95% CI: 0.73-0.86], respectively). Similarly, the ultrasomics model predicted LV remodeling was significantly associated with major adverse cardiovascular events in both cohorts ($P < 0.0001$ and $P = 0.0008$, respectively). Moreover, on multivariate analysis, the ultrasomics probability score was an independent echocardiographic predictor of major adverse cardiovascular events in the high-end ultrasound cohort (HR: 8.53; 95% CI: 4.75-32.1; $P = 0.0003$). In the murine model, cardiomyocyte hypertrophy positively correlated with 2 ultrasomics biomarkers (R^2 = 0.57 and 0.52, $Q < 0.05$).

CONCLUSIONS Cardiac ultrasomics-based biomarkers may aid development of machine-learning models that provide an expert-level assessment of LV structure and function. (J Am Coll Cardiol 2022;80:2187-2201) © 2022 by the American College of Cardiology Foundation.

Ultrasomic Texture Analysis for Predicting Acute MI



Jamthikar A, Sengupta PP et al JACC Cardiovascular Imaging 2025

Ultrasonic Texture Features for Assessing Cardiac Remodeling and Dysfunction

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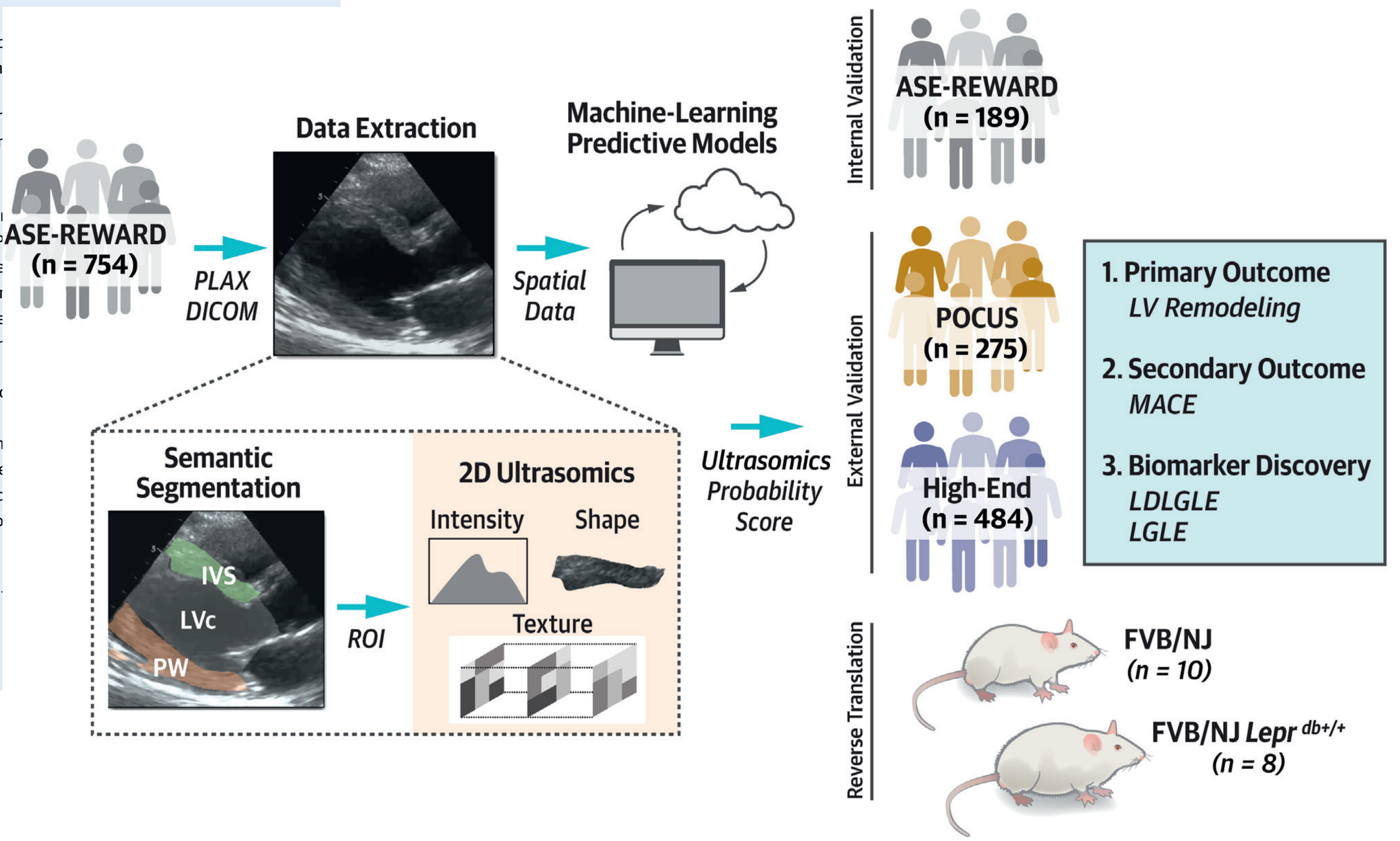
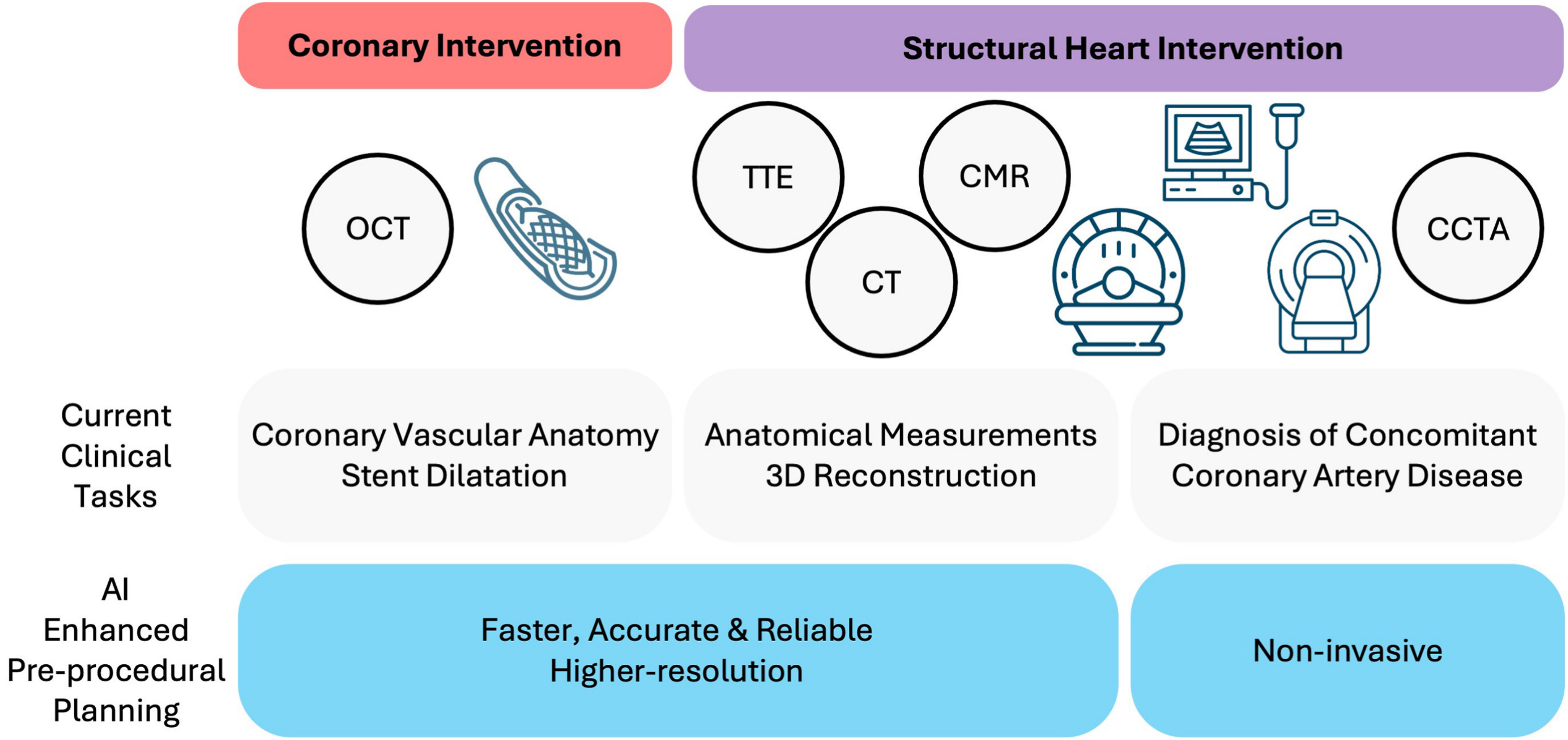
American College of Cardiology Foundation.

CENTRAL ILLUSTRATION Ultrasomics Biomarkers for Predicting Cardiac Outcomes



Hathaway QA, et al. J Am Coll Cardiol. 2022;80(23):2187-2201.



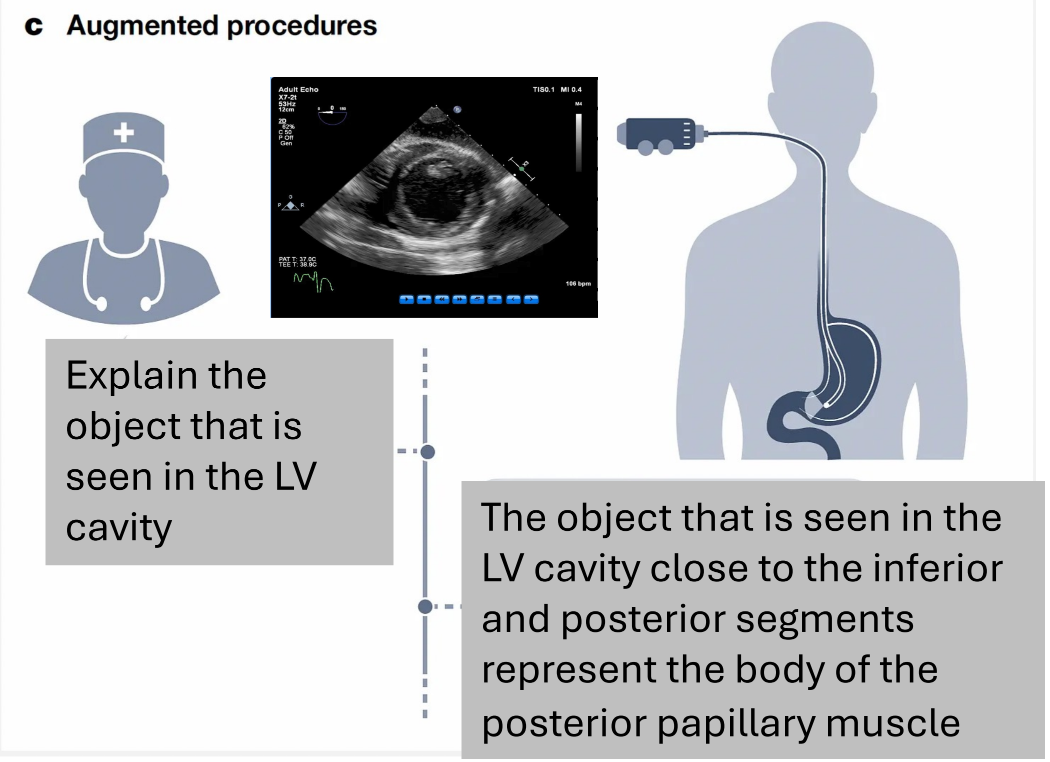
Aminorroaya et al. Journal of the Society for Cardiovascular Angiography & Interventions, Volume 4, Issue 3, 102562

Prediction # 4 Emergence of Robotics + AI

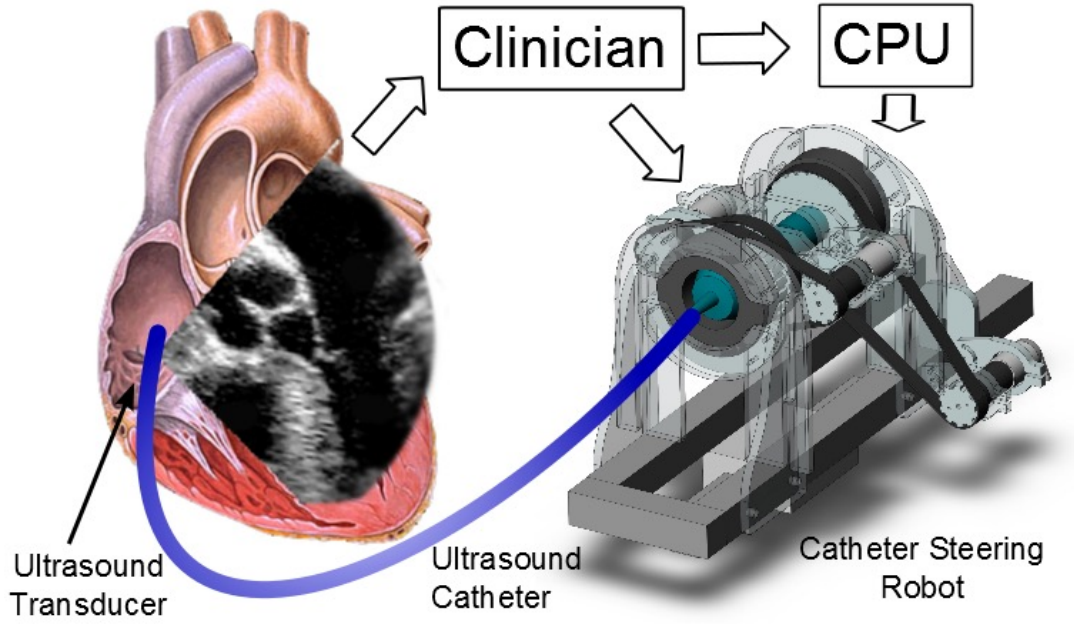
922 IEEE TRANSACTIONS ON MEDICAL ROBOTICS AND BIONICS, VOL. 4, NO. 4, NOVEMBER 2022

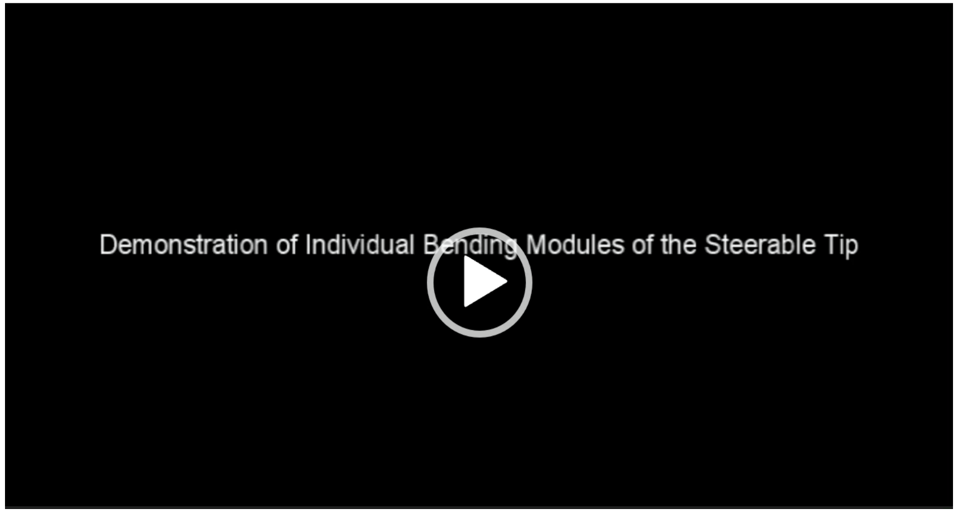
Toward the Design and Development of a Robotic Transcatheter Delivery System for Mitral Valve Implant

Namrata U. Nayar, *Graduate Student Member, IEEE*, Ronghuai Qi, and Jaydev P. Desai, *Fellow, IEEE*



Nature **volume 616**, pages259–265 (2023





Prediction # 5 Newer Therapies and Interventions

3D-printed tissue
Gene Therapies
Cell therapies
Nanoparticles
Nanorobotics

Prediction #4 New uses in Cardiovascular Therapies

Cardiac Surgery 1953

Cardiac Transplant 1967

Minimally Invasive Cardiac Surgery 1990s

2025

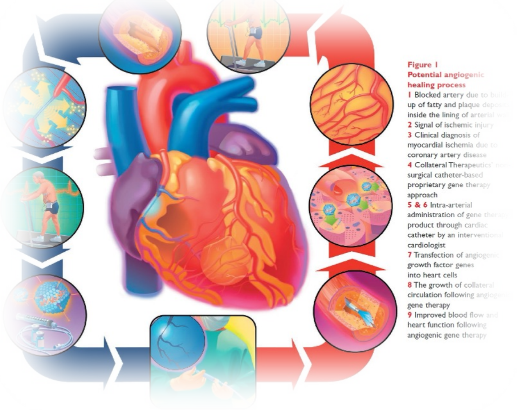
Cardiac Cath 1927

Drugs CCU 1962

Invasive Cardiology 1977

Structural Heart Interventions 2002

2030



https://www.linkedin.com/posts/samerjoudi_artificialintelligence-agenticai-activity-7288646925984190464-ewiH

nature

https://doi.org/10.1038/s41586-025-09442-9

Accelerated Article Preview

The Virtual Lab of AI agents designs new SARS-CoV-2 nanobodies

On the morning of April 26, Tsinghua University held an inauguration ceremony for Tsinghua AI Agent Hospital and the 2025 Tsinghua Medicine Townhall Meeting at the Main Building Reception Hall. Tsinghua President Li Luming and Vice President Wang Hongwei attended the event.

Digital Twin: Synthetic Generation of Echo from Surface ECG

nature cardiovascular research

Article

https://doi.org/10.1038/s44161-025-00629-

Synthetic generation of cardiac tissue motion from surface electrocardiograms

Received: 18 September 2024

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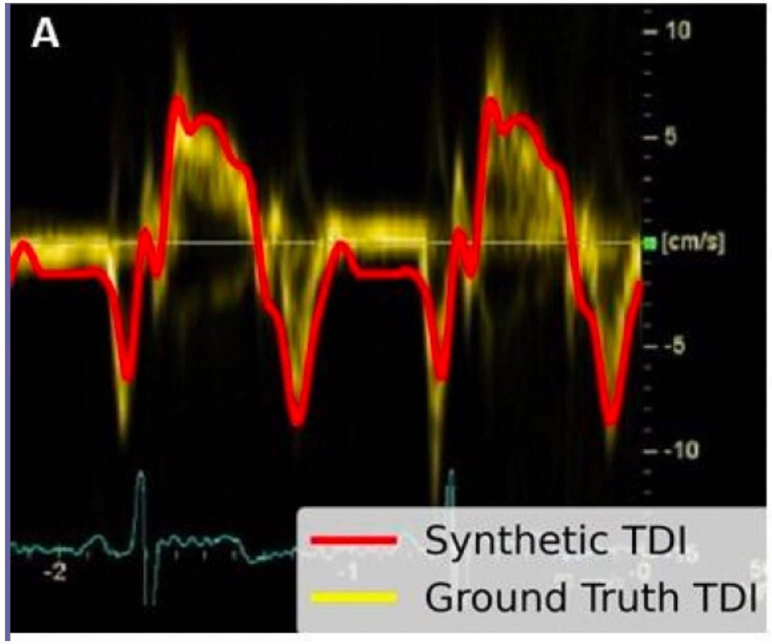
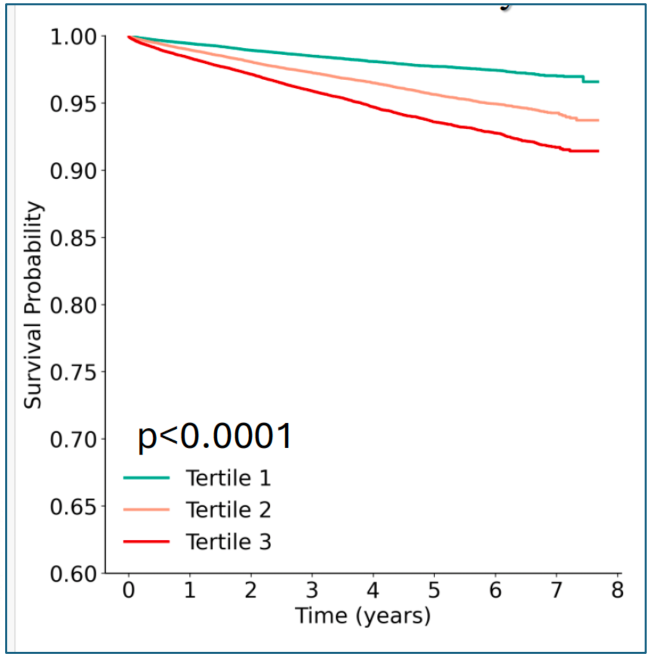
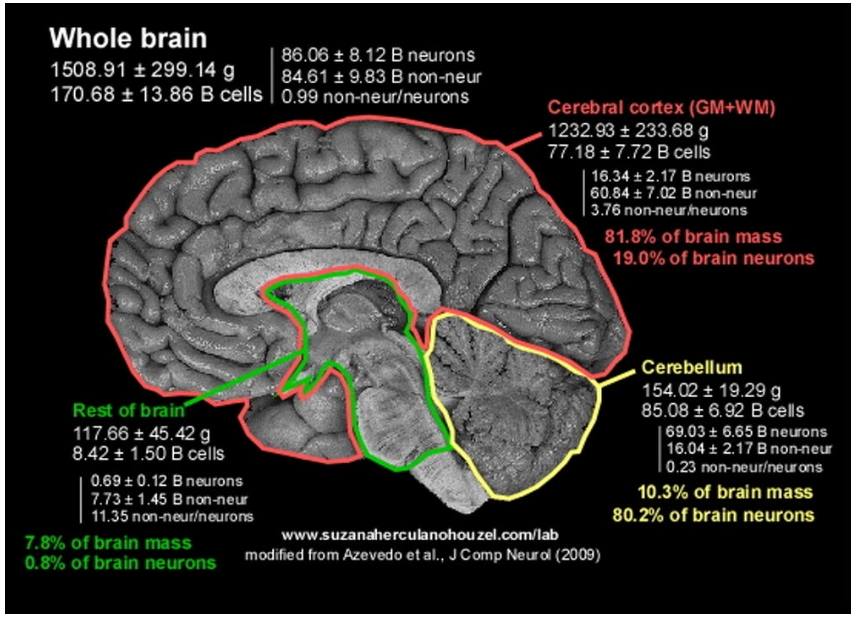
Published online: 14 April 2025

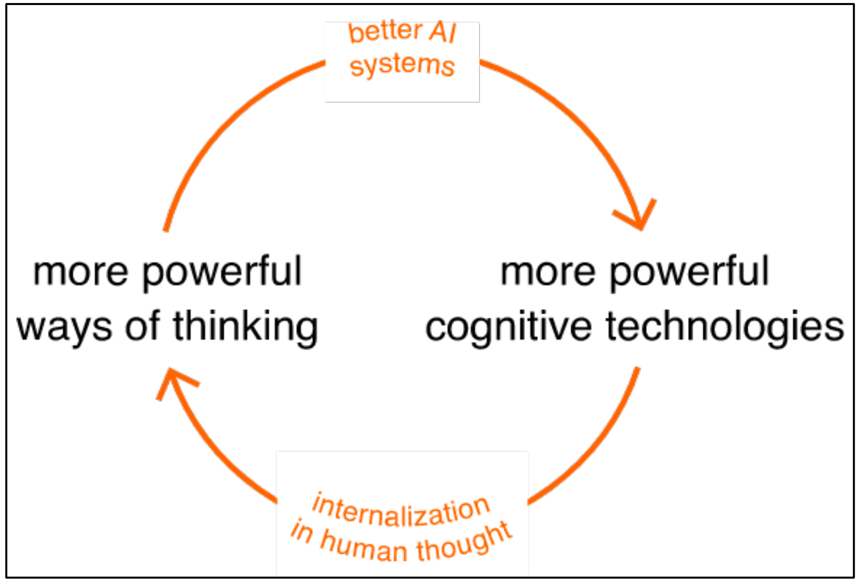
Aditya Radhakrishnan[1,2,4], Naveena Yanamala[2,3,4], Ankush Jamthikar[3], Yanting Wang[3], Sasha-Ann East[3], Yasmin Hamirani[3], Kameswari Maganti[3] & Partho P. Sengupta[3]



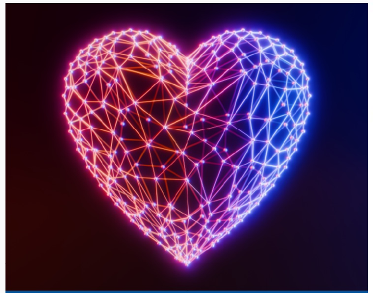


AI in Cardiology





- We don’t have the luxury of making 230 million years of mistakes and random variations to produce an intelligent machine **–AI should not replace critical thinking**
- “AI operates on a radically shorter time scale, with fewer degrees of freedom, takes a much more direct route to our objective.”
  –Use AI for low-caliber activities
- “AI bundles the objective facts from a data perspective” **–AI should not endanger empathy and morality in medicine**



Read more

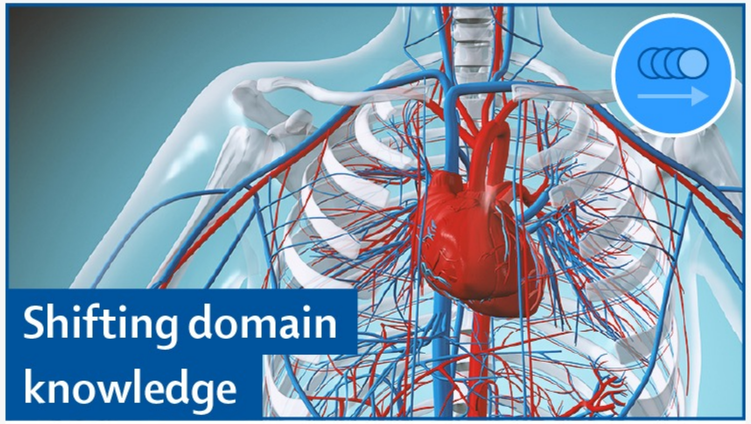
Lancet Digital Health: Artificial intelligence and digital innovations in cardiovascular care

Artifical Intelligence and Digital Innovations in Cardiovascular Care 1

Challenges for augmenting intelligence in cardiac imaging

Partho P Sengupta, Damini Dey, Rhodri H Davies, Nicolas Duchateau, Naveena Yanamala

Barriers to the clinical implementation of AI technology



New Generation of Leaders

ASE Young Investigator Award Nominations & Winners

Josef Korinek
2006

Mac Eleid
2008

Nupoor Narula
2010

Mayank Kansal
2010

Sukrit Narula
2015

Sanjeev Bhavnani
2015

Ines Sheriffi
2016

Marton Tokodi
2018

Nobuyuki Kagiyama
2019

Ambarish Pandey
2020

Quincy Hathaway
2021

Rohan Shah
2022

A Radhakrishnnan
2024

Innovation & Strength-based Leadership

Center for innovation

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