



HeartLung
Technologies



Introducing AutoChamber™ AI

AutoChamber™ is the first FDA-approved AI that received “**Breakthrough**” designation for enabling physicians to detect patients with enlarged cardiac chambers and left ventricular hypertrophy that are invisible to the human eye.

Effective April 1, 2025, Medicare approved reimbursement for AutoChamber™ under HCPCS G0183.

Every year over 10 million chest CT scans are done in the US alone and among them many asymptomatic patients with enlarged heart chambers are missed resulting in late-stage heart failure, atrial fibrillation, stroke, and sudden cardiac death. AutoChamber™ AI can help physicians fill this gap and save many lives from preventable cardiovascular death.

Case Example 1

Developed HF in 11 years

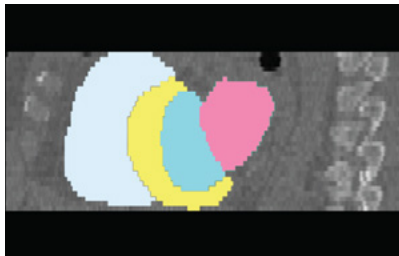
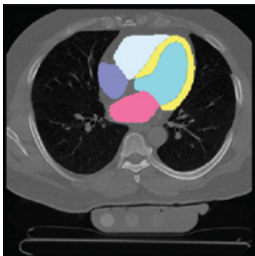
Male, Age: 54

CAC Score: 0

10-year ASCVD Risk: 4.1%

LV Volume: 198.4 cc (**99th percentile**)

Cohort LV Volume: 116.9 ± 24.9 cc



Case Example 2

Developed AF/stroke in 9 years

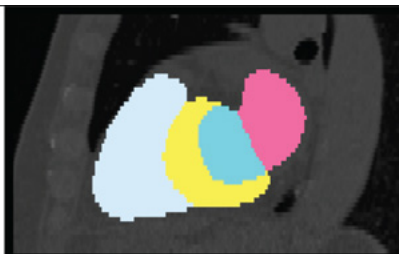
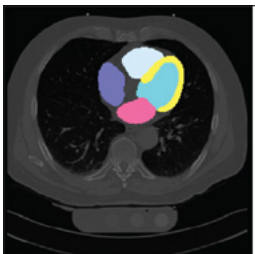
Female, Age: 57

CAC Score: 0

10-year ASCVD Risk: 1.4%

LA Volume: 84.6 cc (**96th percentile**)

Cohort LA Volume: 55.8 ± 14.1 cc



● LA ● LV ● RA ● RV ● LV Mass

These lives could have been saved by AutoChamber™

These two case examples show patients who were deemed low risk because of a Coronary Artery Calcium (CAC) score of 0. Both patients later developed fatal stroke, atrial fibrillation (AF), and heart failure (HF).

AutoChamber™ was run on these patients' scans and found that both cases had enlarged cardiac chambers and were at high risk of heart failure, atrial fibrillation, and stroke. The add-on AutoChamber™ report could have been life-saving.



AutoChamber™ AI provides highly significant added values to CAC scans, CCTA, CPTA, LDCT, and chest diagnostic CT scans.

Your Cardiac Chambers Volumetry Report

This is an opportunistic report generated by AutoChamber™ AI based on CT scans ordered for other reasons

Patient Name: Doe, Jack

ID: 9008

Date of Exam: 7/16/2024

Date of Birth: 1/1/1953

Gender: Male

Clinic
Logo



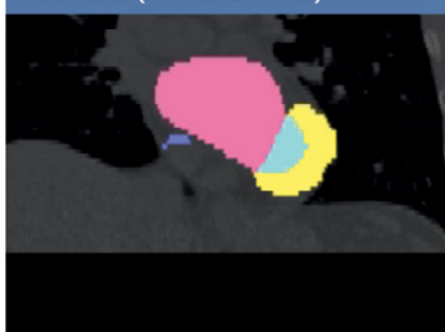
Powered by
HeartLung
Technologies

AutoChamber Volumetry

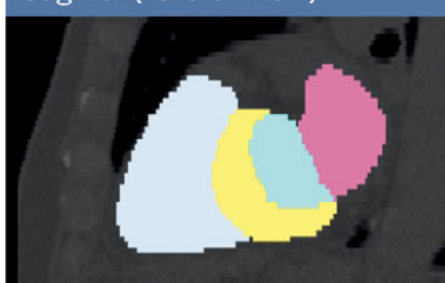
Chamber	Value	Percentile
LA	89.1 cc	96th
LV	121.6 cc	80th
RA	88.7 cc	58th
RV	131.8 cc	65th
LVM	118.5 g	90th
LA/RA	0.90	80th
LV/RV	0.75	74th

Cardiothoracic Ratio: 0.51

Coronal (Frontal View)



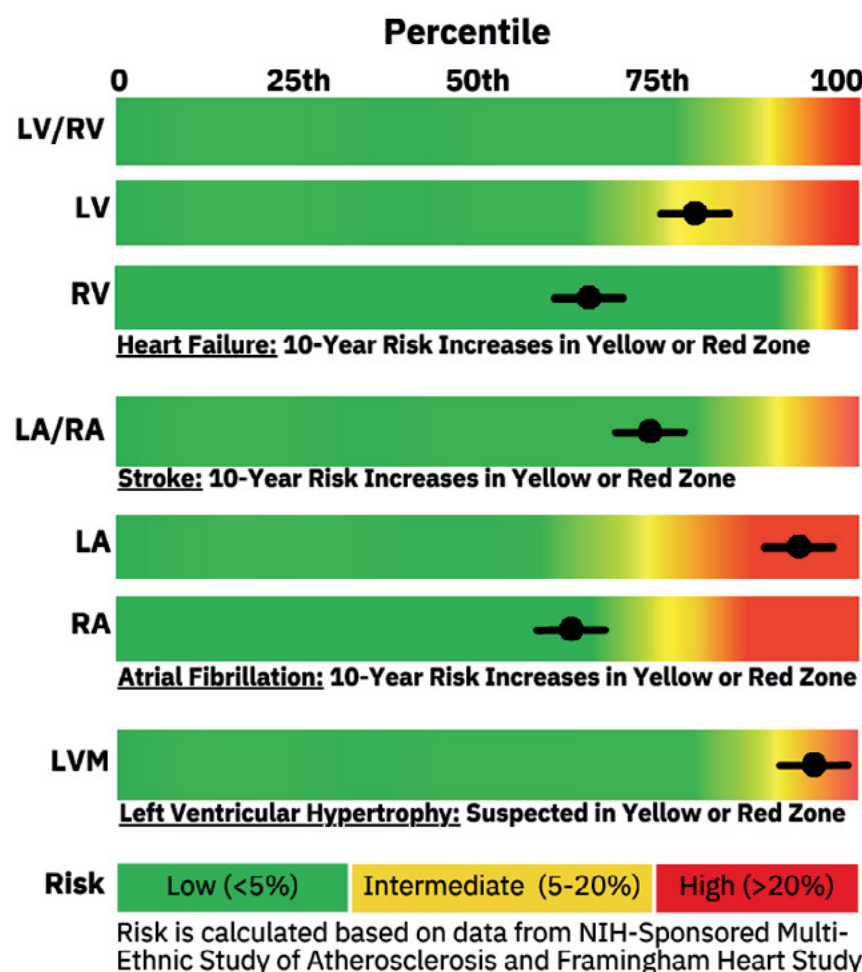
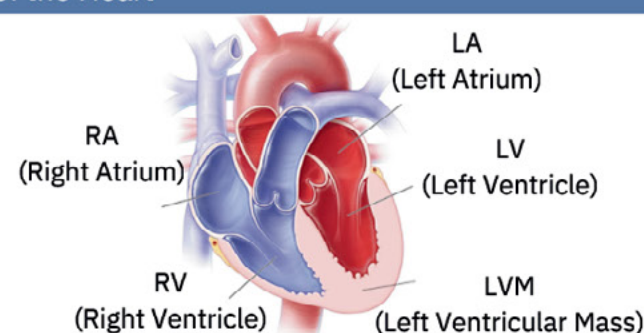
Sagittal (Lateral View)



Axial (Transverse View)



Chambers of the Heart



Recommendations

The results of your cardiac chambers volumetry indicate that you have a **high risk of future cardiovascular disease**. Consultation with your care provider is recommended.

Detect Hidden Heart Disease

Catch What A Calcium Score Can't!

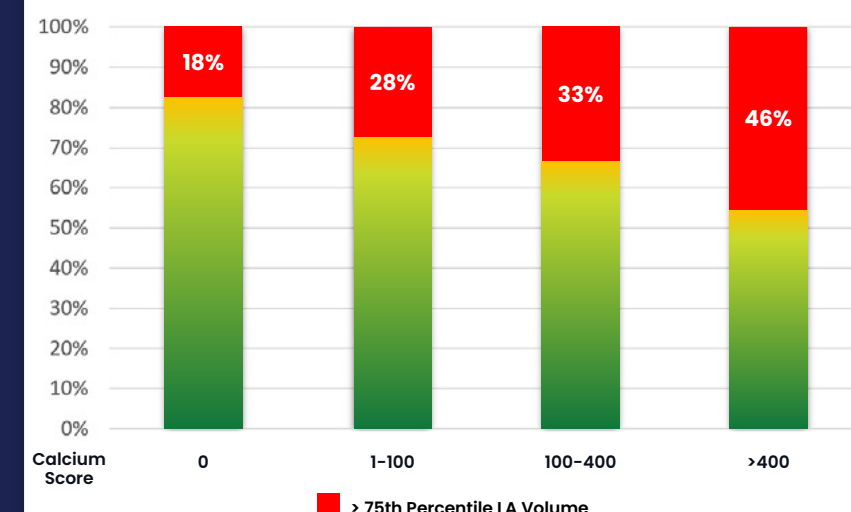
This graph shows a significant percentage of people who are classified as low risk based on coronary artery calcium (CAC) scores of zero or below 100 have an enlarged left atrium (LA) that puts them at a high risk of atrial fibrillation (AF) and stroke.

Similar results were found for enlarged left ventricle (LV) putting patients at a high risk of heart failure (HF).

References:

- Naghavi M, Reeves AP, Atlas KC, Zhang C, Li D, Atlas T, Henschke CI, Wong ND, Roy SK, Budoff MJ, Yankelevitz DF. AI-Enabled CT Cardiac Chamber Volumetry Predicts Atrial Fibrillation and Stroke Comparable to MRI. JACC Adv. 2024 Nov 15;3(11):101300.
- Naghavi M, Reeves A, Budoff M, Li D, Atlas K, Zhang C, Atlas T, Roy SK, Henschke CI, Wong ND, Defilippi C, Levy D, Yankelevitz DF. AI-enabled cardiac chambers volumetry in coronary artery calcium scans (AI-CACTM) predicts heart failure and outperforms NT-proBNP: The multi-ethnic study of Atherosclerosis. J Cardiovasc Comput Tomogr. 2024 Jul-Aug;18(4):392-400.
- Naghavi M, Yankelevitz D, Reeves AP, Budoff MJ, Li D, Atlas K, Zhang C, Atlas TL, Lirette S, Wasserthal J, Roy SK, Henschke C, Wong ND, Defilippi C, Heckbert SR, Greenland P. AI-enabled left atrial volumetry in coronary artery calcium scans (AI-CACTM) predicts atrial fibrillation as early as one year, improves CHARGE-AF, and outperforms NT-proBNP: The multi-ethnic study of atherosclerosis. J Cardiovasc Comput Tomogr. 2024;18(4):383-391.
- Naghavi M, Reeves, A.P., Atlas, K., Zhang, C., Atlas, T., Henschke, C., Yankelevitz, D., Budoff, M., Li, D., Roy, S., Nasir, K., Molloy, S., Fayad, Z., McConnell, M., Kakadiaris, I., Maron, D., Narula, J., Williams, K., Shah, P., Levy, D., Wong, N. Artificial intelligence applied to coronary artery calcium scans (AI-CAC) significantly improves cardiovascular events prediction. npj Digit. Med. 7, 309 (2024).

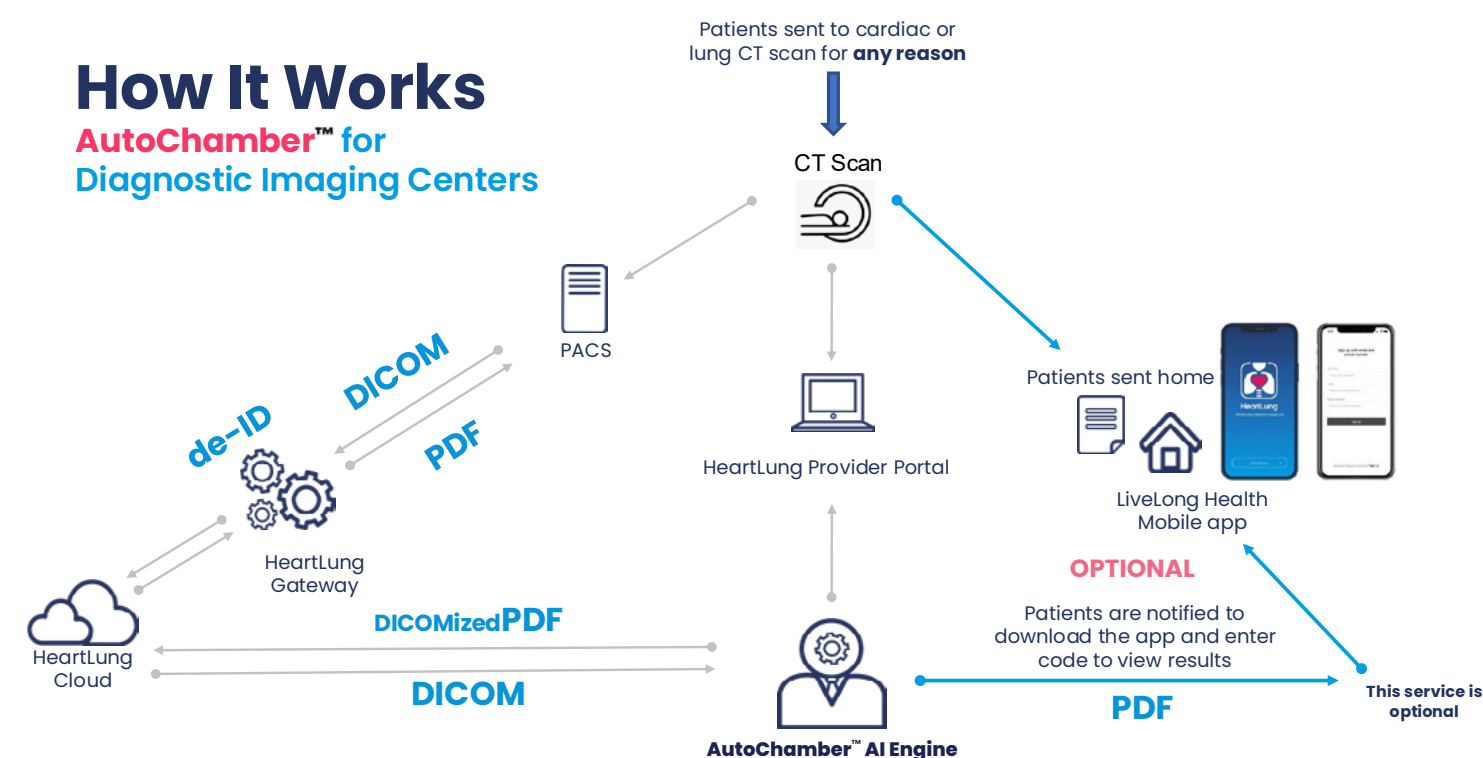
Enlarged Left Atrium (LA) by Calcium Score Categories



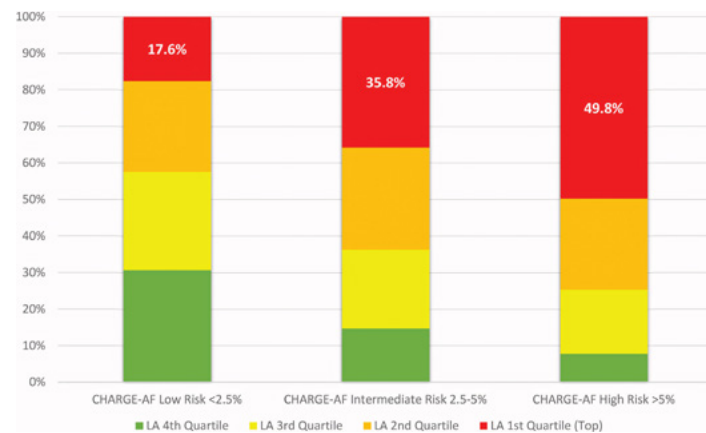
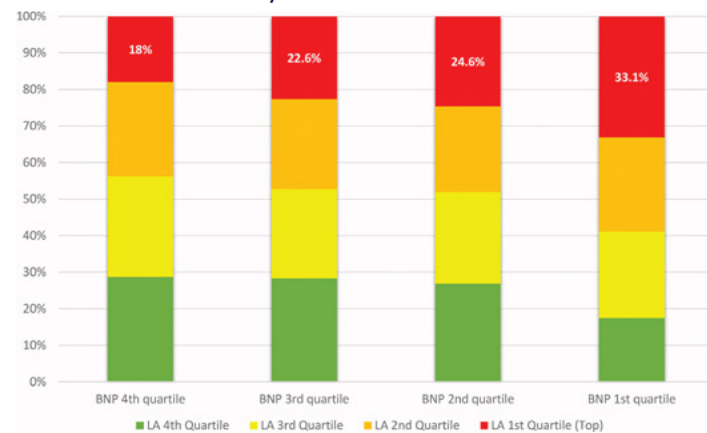
Simple & Easy Workflow Integration

How It Works

AutoChamber™ for
Diagnostic Imaging Centers



AutoChamber™ LV Quartiles by 5-year CHARGE-AF Risk

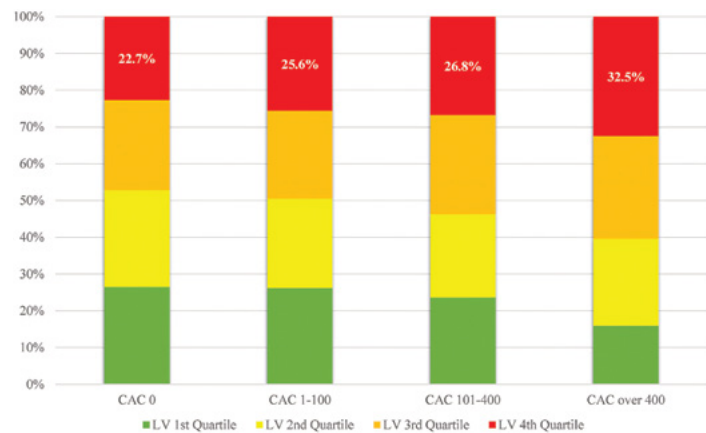
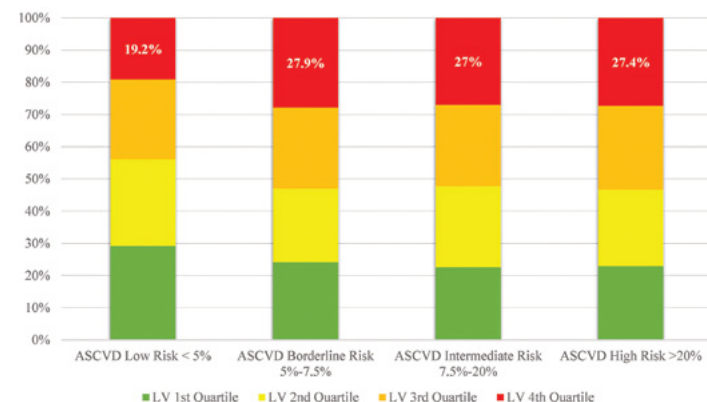
4 Quartile Distribution of AutoChamber™
LA by NT-ProBNP Quartiles

- Distribution of AI-CAC LA Volume by CAC Categories, NT-proBNP Quartiles, and CHARGE-AF Risk Score Quartiles.
(A) Quartiles of AI-CAC LA volume by 5-year CHARGE-AF risk categories. (B) Quartiles of AI-CAC LA volume by NT-proBNP quartiles.

Take Home Point

AutoChamber™ detects a significant portion of high-risk patients who are wrongly classified as low-risk by existing standards such as CHARGE-AF, BNP, CAC score and ASCVD score.

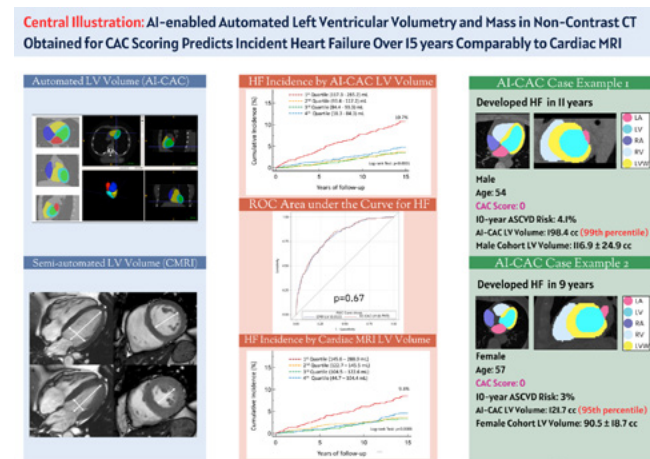
AutoChamber™ LV Volume by CAC Categories

AutoChamber™ LV Volume by ASCVD Pooled
Cohort Equation Risk Categories

- Quartiles of AI-CAC Left Ventricle (LV) Volume by coronary artery calcium (CAC) and ASCVD Pooled Cohorts Equation Categories.



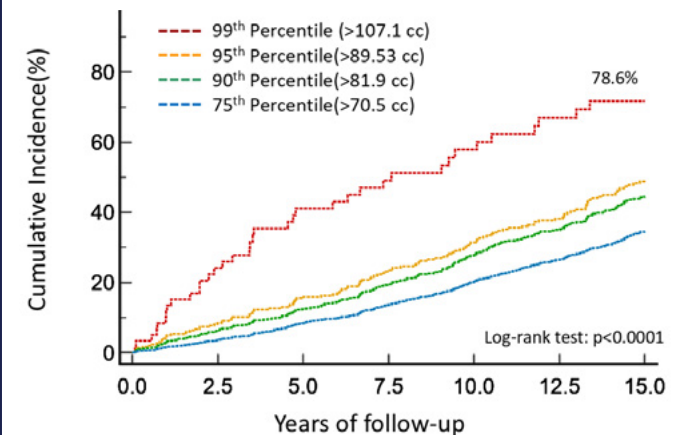
- Naghavi M, Reeves A, Budoff M, Li D, Atlas K, Zhang C, Atlas T, Roy SK, Henschke CI, Wong ND, DeFilippi C, Levy D, Yankelevitz DF. AI-enabled cardiac chambers volumetry in coronary artery calcium scans (AI-CAC™) predicts heart failure and outperforms NT-proBNP: The multi-ethnic study of Atherosclerosis. J Cardiovasc Comput Tomogr. 2024 Jul-Aug;18(4):392–400.



- AutoChamber AI applied opportunistically to existing CAC scans predicted future heart failure similarly to a cardiac MRI, which is much more expensive and time-consuming.



- Naghavi M, Yankelevitz D, Reeves AP, Budoff MJ, Li D, Atlas K, Zhang C, Atlas TL, Lirette S, Wasserthal J, Roy SK, Henschke C, Wong ND, DeFilippi C, Heckbert SR, Greenland P. AI-enabled left atrial volumetry in coronary artery calcium scans (AI-CAC™) predicts atrial fibrillation as early as one year, improves CHARGE-AF, and outperforms NT-proBNP: The multi-ethnic study of atherosclerosis. J Cardiovasc Comput Tomogr. 2024 Jul-Aug;18(4):383–391.



- Cumulative incidence of atrial fibrillation (AF) in the top quartile of AI-CAC left atrial (LA) volume (adjusted by BSA).

Comparing Incident Heart Failure Associated with Enlarged Cardiac Chambers versus Diabetes: An AI-CVD Study within the Multi-Ethnic Study of Atherosclerosis (MESA)

Morteza Naghavi, Seyed Reza Mirjalili, Kyle Atlas, Anthony P. Reeves, Chenyu Zhang, Jakob Wasserthal, Amir Azimi, Thomas Atlas, Claudia I. Henschke, David F. Yankelevitz, Javier J. Zulueta, Jeffrey Mechanick, Andrea Branch, Ning Ma, Rowena Yip, Wenjun Fan, Sion K. Roy, Khurram Nasir, Sabee Molloy, Zahi Fayad, Michael V. McConnell, Ioannis A. Kakadiaris, George Abela, Rozemarijn Vliegenthart, David J. Maron, Jagat Narula, Kim Williams, Prediman K. Shah, Matthew J. Budoff, Daniel Levy, Roxana Mehran, Robert A.Kloner, Nathan D. Wong.

Abstract

Background and aims:

Type 2 diabetes mellitus (T2DM) is classified as Stage A (at risk) heart failure (HF). We previously showed that artificial intelligence (AI)-detected enlarged cardiac chambers particularly left atrium (LA), left ventricle (LV) and increased LV mass in coronary artery calcium (CAC) scans were strongly associated with HF. In this study, we compare the incidence of HF in individuals with enlarged chambers vs. T2DM.

Methods:

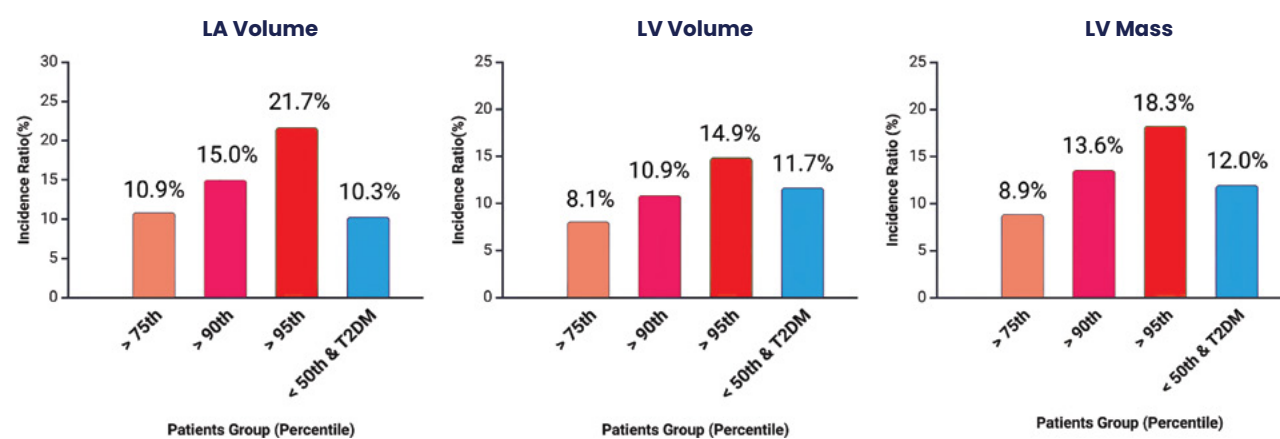
AI-enabled cardiac chambers volumetry was applied to baseline CAC-scans of 5789 MESA participants aged 45–84 (47.7% male, 12.5% T2DM). LA, LV, and LV mass percentiles were indexed by body surface area. We used Cox regression and Kaplan-Meier with log-rank tests to evaluate HF incidence over 19 years. Enlarged chambers were defined as ≥ 95 th percentile.

Results:

In non-T2DM individuals, enlarged LA (HR:5.0 [3.4–7.4]), LV (HR:5.5 [3.7–8.3]), and LV mass (HR:5.4 [3.7–7.9]) were independently associated with HF after full adjustment. Non-T2DM individuals with enlarged LA had higher HF incidence than those with T2DM and normal LA volume (21.7% vs. 10.3%, $P=0.001$); similar findings were observed for LV mass (18.3% vs. 12.0%, $P=0.04$). Those with both T2DM and enlarged chambers had higher HF risk compared to either condition alone; except for LA where the risk was not significantly different from having an enlarged LA alone.

Conclusion:

Enlarged LA, LV, and LV mass without T2DM exhibited a greater risk of incident HF than T2DM with normal chambers. Adding cardiac chambers volume and mass to HF staging should be investigated.



ORIGINAL RESEARCH

EMERGING TECHNOLOGIES AND INNOVATIONS

AI-Enabled CT Cardiac Chamber Volumetry Predicts Atrial Fibrillation and Stroke Comparable to MRI

Morteza Naghavi, MD,¹ Anthony P. Reeves, PhD,² Kyle C. Atlas, MS,³ Chenyu Zhang, MS,⁴ Dong Li, PhD,⁵ Thomas Atlas, MD,⁶ Claudia I. Henschke, MD,⁷ Nathan D. Wong, PhD,⁸ Sion K. Roy, MD,⁹ Matthew J. Budoff, MD,¹⁰ David F. Yankelevitz, MD¹

ABSTRACT

BACKGROUND AI-CAC provides more actionable information than the Agatston coronary artery calcium (CAC) score. We have recently shown in the MESA (Multi-Ethnic Study of Atherosclerosis) that AI-CAC automated left atrial (LA) volumetry enabled prediction of atrial fibrillation (AF) as early as 1 year.

OBJECTIVES In this study, the authors evaluated the performance of AI-CAC LA volumetry versus LA measured by human experts using cardiac magnetic resonance imaging (CMRI) for predicting incident AF and stroke and compared them with Cohorts for Heart and Aging Research in Genomic Epidemiology model for atrial fibrillation (CHARGE-AF) risk score, Agatston score, and N-terminal pro b-type natriuretic peptide (NT-proBNP).

METHODS We used 15-year outcomes data from 3,552 asymptomatic individuals (52.2% women, age 61.7 ± 10.2 years) who underwent both CAC scans and CMRI in the MESA baseline examination. CMRI LA volume was previously measured by human experts. Data on NT-proBNP, CHARGE-AF risk score, and the Agatston score were obtained from MESA. Discrimination was assessed using the time-dependent area under the curve.

RESULTS Over 15 years follow-up, 562 cases of AF and 140 cases of stroke accrued. The area under the curve for AI-CAC versus CMRI volumetry for AF (0.802 vs 0.798) and stroke (0.762 vs 0.751) were not significantly different. AI-CAC LA significantly improved the continuous net reclassification index for prediction of 5-year AF when added to CHARGE-AF risk score (0.23), NT-proBNP (0.37, 0.37), and Agatston score (0.44) (P for all <0.0001).

CONCLUSIONS AI-CAC automated LA volumetry and CMRI LA volume measured by human experts similarly predicted incident AF and stroke over 15 years. Further studies to investigate the clinical utility of AI-CAC for AF and stroke prediction are warranted. (JACC Adv. 2024;3:101300) © 2024 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (<https://creativecommons.org/licenses/by-nc-nd/4.0/>).

From the ¹HeartLung.AI, Houston, Texas, USA; ²Department of Electrical and Computer Engineering, Cornell University, New York, USA; ³Division of Cardiology, The Lundquist Institute, Torrance, California, USA; ⁴Department of Radiology, Tustin Tele-radiology, Tustin, California, USA; ⁵Department of Radiology, Mount Sinai Hospital, New York, New York, USA; and the ⁶Heart Disease Prevention Program, Division of Cardiology, University of California, Irvine, California, USA. The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the [Author Center](#).

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- Naghavi, M, Reeves, A, Atlas, K. et al. AI-Enabled CT Cardiac Chamber Volumetry Predicts Atrial Fibrillation and Stroke Comparable to MRI. JACC Adv. 2024 Nov, 3 (11).

JACC: ADVANCES

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VOL. 3, NO. 11, 2024

EDITORIAL COMMENT

New Frontiers for Predicting Atrial Fibrillation and Stroke AI-Based Left Atrial Volumetry

Carlotta Onnis, MD,^{1,2} Marly van Assen, PhD³

Atrial fibrillation (AF), the most common cardiac arrhythmia, has a global prevalence estimated to be 59 million individuals in 2019.¹ However, the true prevalence is estimated to be even higher, due to the number of undiagnosed patients, representing 11% to 23% of patients with AF.² AF is a tremendous burden on patients and health care systems not only because of its prevalence and associated costs but also because it increases the risk of stroke 5-fold, a major contributor to cardiovascular mortality.³ Timely detection of AF, potentially in asymptomatic patients, could contribute to a decrease time-to-treatment and reduce AF-associated complications. Hence, many risk prediction scores have been developed to evaluate the future risk of occurrence of AF and stroke. For example, the revised Framingham stroke risk score for 10-year stroke prediction and the atherosclerotic cardiovascular disease pooled cohort equation for 10-year prediction of a first atherosclerotic cardiovascular disease event, including stroke.⁴ Other nontraditional risk factors, such as coronary artery calcium (CAC) score, have been assessed for their additive value to these risk scores. With regard to AF, widely used methods to predict risk of new-onset AF include the CHARGE-AF (Cohorts for Heart and Aging Research in Genomic Epidemiology AF) risk score and left atrial size. The former is a 5-year AF risk predictor that uses age, race, medical history, and vital signs as variables, and it has shown significant discrimination for AF incidence with a uniform prediction window.^{5,6} The latter, particularly atrial volume, has been extensively studied as a marker of increased risk of AF, and left atrial enlargement correlates with increased levels of N-terminal pro b-type natriuretic peptide (NT-pro-BNP).^{7,8} Traditionally, left atrial volume is measured with cardiac MR (CMR), which can be a costly and time-consuming imaging technique, or with echocardiography, which is a highly operator-dependent modality. Atrial size measurement on computed tomography (CT) scans has been evaluated as a possible alternative. Reference values of left atrial volume have been determined for electrocardiogram-gated contrast-enhanced CT, but studies have also focused on noncontrast measures, including cardiac chambers' volumetry, quantified on non-contrast electrocardiogram-gated scans, such as CAC scans.^{9,10} The benefit of using CAC scans is its wide availability and low radiation dose. CAC scans are used as a screening tool for coronary artery disease, and there has been a notable increase in its use in recent years in the United States and worldwide.¹¹ Thus, noncontrast measurements, such as left atrial volumetry, may improve its prognostic value beyond prediction of coronary artery disease, and may provide additional information about patients' cardiac health, without the need for additional tests. As artificial intelligence (AI) increasingly reshapes medical practice with excellent capabilities for segmentation, new algorithms have been developed and applied for AF detection.¹² The novelty of this study by Naghavi et al¹³ in this issue of JACC: Advances relies on the application of AI in CAC scans to measure left atrial volume, predict future AF and stroke, and overcome the challenges of CMR-based left atrial size quantification.

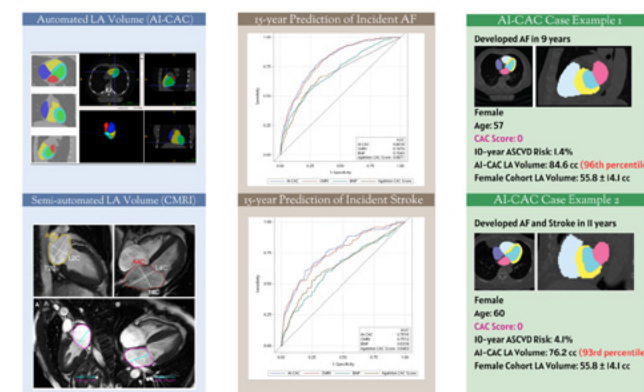
From the ¹Department of Radiology, Azienda Ospedaliera Universitaria (A.O.U.), Cagliari, Italy; and the ²Transnational Laboratory for Cardio-thoracic Imaging and Artificial Intelligence, Department of Radiology and Imaging Sciences, Emory University, Atlanta, Georgia, USA. The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the [Author Center](#).

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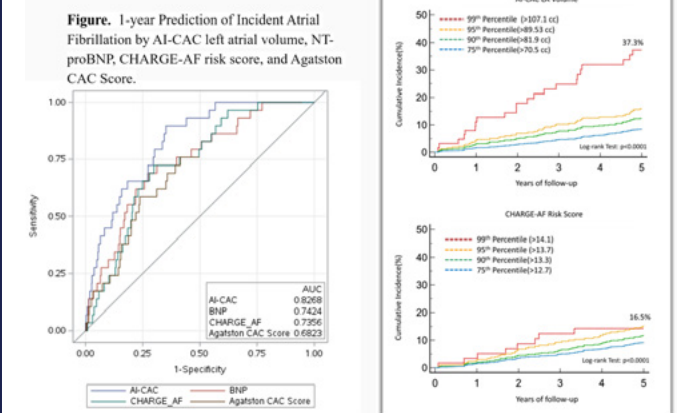
<https://doi.org/10.1016/j.jaccadv.2024.101299>

- Onnis, C, van Assen, M. New Frontiers for Predicting Atrial Fibrillation and Stroke: AI-Based Left Atrial Volumetry. JACC Adv. 2024 Nov, 3 (11).

Central Illustration: AI-enabled Cardiac Chambers Volumetry in CT Scans Predicts Atrial Fibrillation and Stroke Comparably to MRI and Outperforms NT-proBNP and Agatston CAC Score Over 15 years



- Central illustration: AI-enabled left cardiac chambers volumetry in CT scans predicts atrial fibrillation and stroke comparably to MRI and outperforms NT-proBNP and agatston CAC score over 15 years.



- 1-year prediction of incident atrial fibrillation by AI-CAC left atrial volume, NT-proBNP, CHARGE-AF risk score, and Agatston CAC score.

Direct and Indirect Revenue Opportunities for Providers

Imaging Centers

Direct Revenue

Hospitals

Indirect Revenue

AutoChamber Cash Flow Analysis		
Assumptions:		
AutoChamber HCPCS G0183 Reimbursement	\$88	
HeartLung Fee per AutoChamber Report	\$30	
Net Direct Revenue per AutoChamber Report	\$58	
Percentage of High Risk for Heart Failure in Routine Chest CT Scans	5%	
Downstream Revenue for Workup of High Risk for Heart Failure	\$1,000	
Percentage of Heart Failure	0.5%	
Lifetime Cost per Heart Failure Patient	\$109,541	
Direct Revenue		
Chest CT Scans per Day		100
Yearly Gross Direct Revenue from HCPCS G0183		\$2,117,000
Indirect Revenue		
Annual Expected Revenue for High Risk Patients		\$1,825,000
Indirect Health Savings over 10 Years		
91 Patients Saved per year (0.5%)		\$13,290,950

Provider Q&A

- **Is AutoChamber™ reimbursed? If yes, what CPT code?**

Yes, AutoChamber™ is reimbursable under the new category 3 HCPCS code G0183, with a reimbursement rate of \$88.06. This code was released by CMS on April 1st, 2025, following HeartLung's application for AutoChamber™ reimbursement as an FDA-designated **"Breakthrough"** medical device.

"New HCPCS Code Describing Software that Reports the Volume of Cardiac Chambers and Left Ventricular Wall Mass, Effective April 1, 2025. CMS is establishing a new HCPCS code, G0183, to describe a software that utilizes data from previously obtained CT scans to report the volume of cardiac chambers and left ventricular wall mass. Table 8 attachment A lists the long descriptor, status indicator, and APC assignment for HCPCS code G0183. For information on OPPS status indicators, please refer to OPPS Addendum D1 of the CY 2025 OPPS/ASC final rule for the latest definitions. This code, along with its short descriptor, status indicator, and payment rate, is also listed in the April 2025 update of the OPPS Addendum B." <https://www.cms.gov/medicare/coding-billing/healthcare-common-procedure-system>

Because AutoChamber™ uses existing CT images with no need for additional scans, radiation exposure, or patient scheduling, it's a seamless, no-brainer add-on to your current workflow. It not only enhances patient care but also creates a new revenue stream with minimal operational changes.

- **How does my PACS connect to AutoChamber™ AI cloud?**

Your PACS can easily connect to AutoChamber™ cloud through a direct link using your unique AE title generated by HeartLung; or via a HeartLung Gateway installed and no hardware installation is required. The scanned CT images are sent from your PACS to AutoChamber™ AI cloud where the report is created and sent back to you, and is also accessible on HeartLung's Provider & Patient Portal. <https://provider.heartlung.ai>

Provider Q&A

- **Do I need a physician's order to add an AutoChamber™ AI report to a thoracic or abdominal CT scan?**

AutoChamber™ is designed as an opportunistic add-on service that can be applied to existing CT scans. Because it uses images that are already acquired for other medically necessary reasons, a separate physician order specifically for AutoChamber™ is not required. Nonetheless, since referring physicians are responsible for treating patients with enlarged chambers, we strongly recommend informing and engaging all referring physicians.

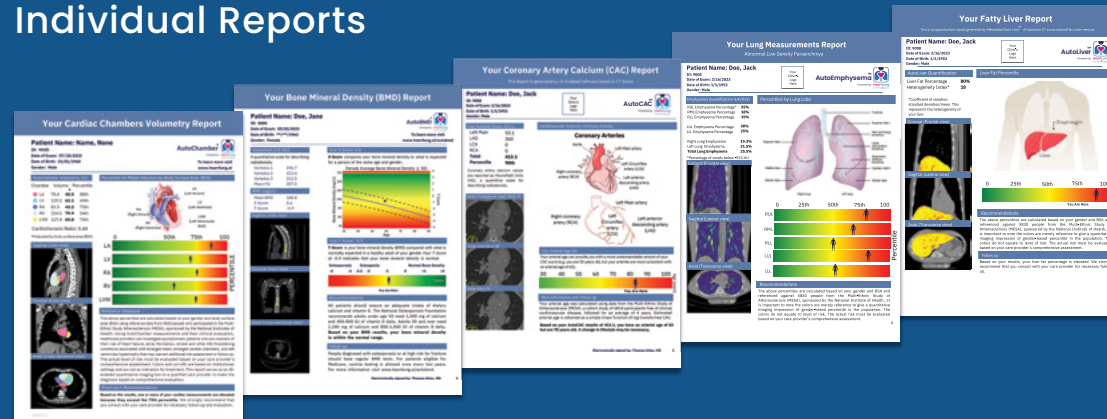
- **Which image series should I send to AutoChamber™ AI Cloud?**

Only send one axial series to AutoChamber™ AI cloud. For example, the axial series used for coronary artery calcium scoring or lung cancer screening would work. The AutoChamber™ AI module works based on intensity (Hounsfield Units), so please send images generated using the standard convolution kernel without any modifications or reconstructions.

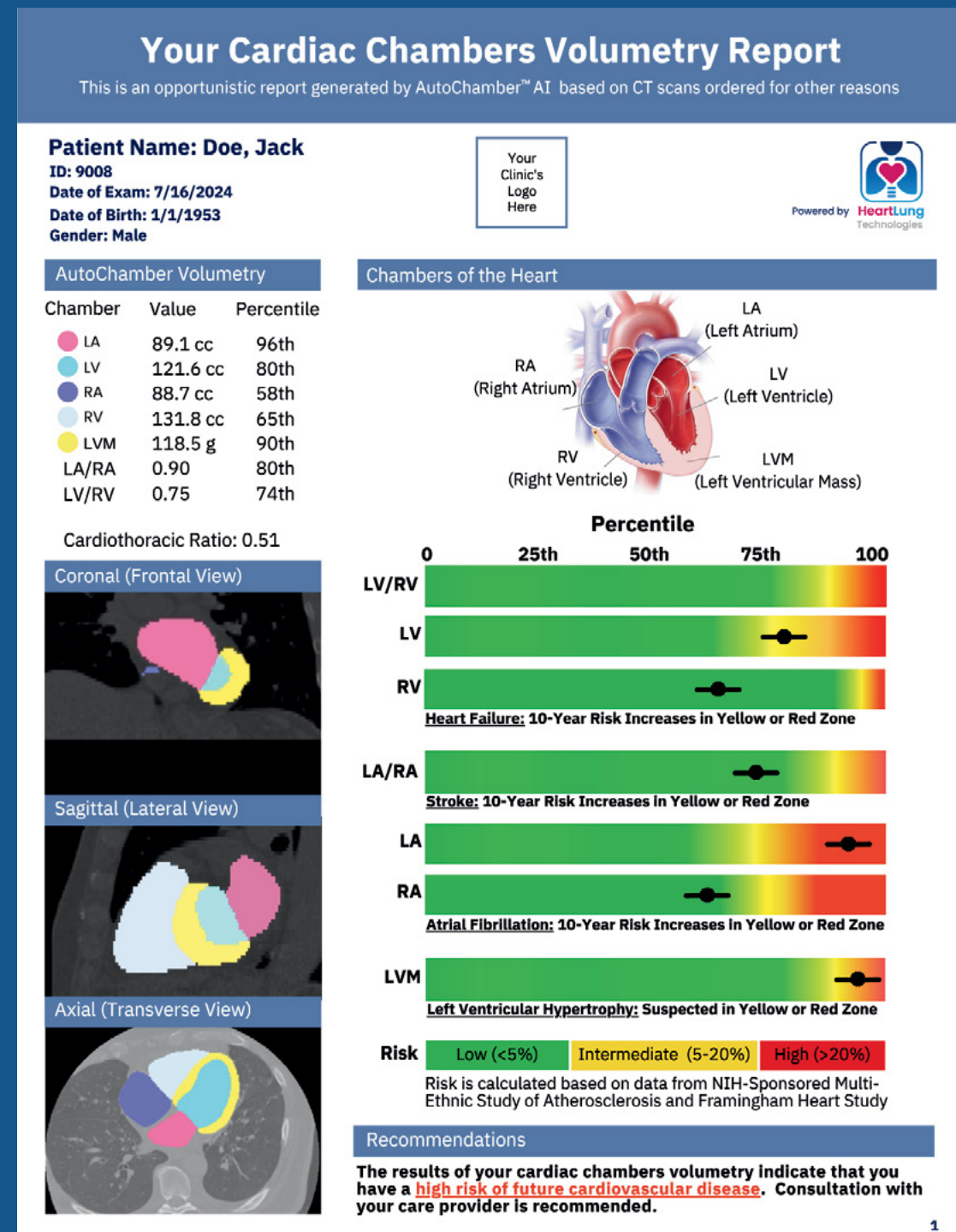
- **How do I start a free trial?**

Simply create an account at <https://provider.heartlung.ai> and send your first set of DICOM images using the unique AE title that our system generates for your center. You will be contacted within 24 hours for verification and testing the setup.

Individual Reports

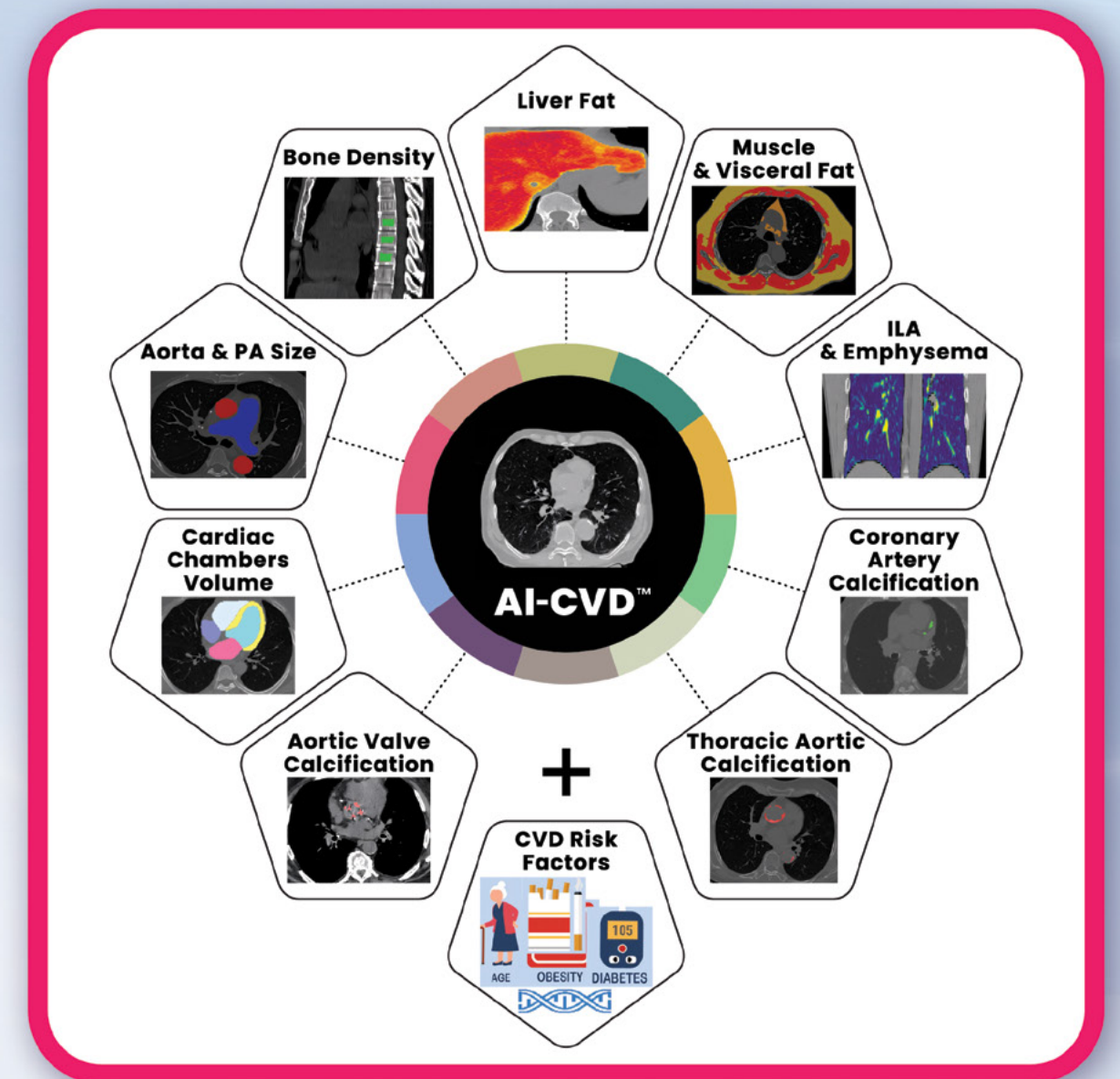


Summary Report



AI-CVD™

CT-BASED AI SOLUTIONS ENABLING EARLY DETECTION AND PREVENTION OF CARDIOVASCULAR DISEASE



To learn more about **AI-CVD™**, which includes **AutoChamber™** Reports, scan the QR code or visit: <https://heartlung.ai/aicvd>

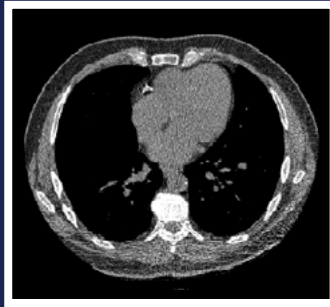


Before AutoChamber™

Coronary Artery
Calcium Scan



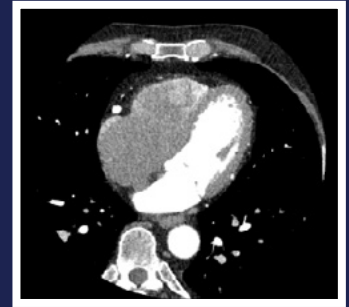
LDCT Lung Cancer
Screening Scan



Lung
Diagnostic Scan

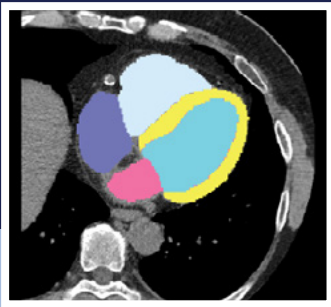


Coronary CT
Angiography Scan

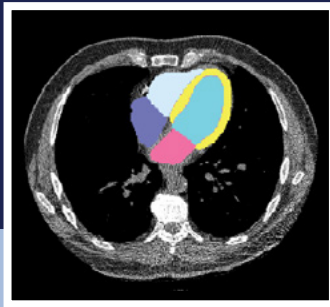


After AutoChamber™

Coronary Artery
Calcium Scan



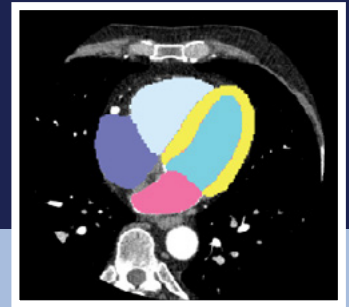
LDCT Lung Cancer
Screening Scan



Lung
Diagnostic Scan



Coronary CT
Angiography Scan



Benefits of AutoChamber™

Opportunistic Value Generator

AutoChamber™ enables your imaging center to find life-threatening conditions in asymptomatic patients and generate revenue.

Simple and Easy Workflow Integration

Your practice can install the HeartLung gateway and receive AutoChamber™ reports directly in your PACS. Your patients can access the report from HeartLung's web portal and mobile app.

No Capital Investment Needed

Any diagnostic imaging center from anywhere in the world can sign up and start adding AutoChamber™ reports to any chest CT scans.

Rapid AI Turnaround Within Minutes

Receive rapid results within minutes of sending your scan to AutoChamber™ AI cloud. No training or learning curve is needed and no calibration phantom.



HeartLung Technologies Co.

2450 Holcombe Blvd, TMC Innovations
Houston, TX 77021
(310) 510-6004
www.HeartLung.ai
contact@heartlung.ai

HeartLung's AutoChamber™ is the first FDA-
approved AI with "**Breakthrough**" designation
enabling opportunistic screening and detection
of hidden heart disease in CT Scans

