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Short Report

Comparison of AI-enabled cardiac chambers volumetry based on non-gated chest CT scans with echocardiography: An AI-CVD study within the Multi-Ethnic Study of Atherosclerosis (MESA)

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Each year, approximately 19 million non-gated chest computed tomography (CT) scans are performed in the United States for various clinical indications [1]. The AI-CVD project was established to opportunistically derive actionable information from routine chest CT scans, specifically non-contrast chest CT (NCCT) scans. Among the clinically relevant metrics that can be extracted from NCCT, cardiac chamber volumes are of particular interest [2]. We previously showed that AI-CVD cardiac chamber volumetry in coronary artery calcium (CAC) scans, particularly the left atrium (LA) and left ventricle (LV), predicts future atrial fibrillation (AF) and heart failure (HF) [3–5]. Furthermore, we previously compared AI-CVD chamber volumetry with manual chamber volumetry in cardiac MRI and demonstrate comparable results for predicting HF [6]. In this study, we compared AI-CVD–derived cardiac chamber volumetric measurements from non-gated NCCT with corresponding echocardiographic measurements.

We included 1675 participants from the Multi-Ethnic Study of Atherosclerosis (MESA) who underwent both non-gated, chest NCCT and echocardiography at exam 6 (2016–2018) and provided consent for commercial use of their data (mean age: 73.6 ± 8.4 years; 44.6% male). NCCT-scans were acquired via the established MESA lung protocol (www.mesa-nhlbi.org). Automated AI-CVD cardiac chambers volumetry was performed using AutoChamber™ (HeartLung.AI, Houston, TX), an FDA-approved (K252029) deep learning tool within the AI-CVD platform that segments all four cardiac chambers and left ventricular mass. For each participant, LA, LV, right atrial (RA), and right ventricular (RV) volumes and LV mass were automatically calculated by summing segmented cross-sectional areas on soft tissue kernel images, multiplied by slice thickness, and indexed to body surface area to derive volume indices like LAVI, and LVVI. Echocardiography protocols have been reported [7] and involved two-dimensional imaging performed by sonographers trained and certified by the Northwestern University Echocardiography Core Laboratory (NUECL) using a standardized protocol. De-identified studies were analyzed at the NUECL using GE EchoPAC software, with cardiologist review for quality assurance. LV volumes at end-diastole and ejection fraction were derived using the biplane Simpson's method from apical 2- and 4-chamber views, excluding papillary muscles and trabeculae. LA volume was measured at end-systole, excluding pulmonary veins and the appendage. As with NCCT, volumes were indexed to body surface area.

Among the 1675 participants, 158 had baseline (MESA Exam 6) AF and 37 had HF, of whom 9 had an ejection fraction <40%. Over a median follow-up of 2.6 years, 16 HF events occurred (3.94 incidence per 1000-person-years), while over a median of 1.6 years, 49 new AF events were observed (6.78 incidence per 1000-person-years). Mean LVVI was 53.0 ± 12.1 mL/m^2 on NCCT compared with 41.0 ± 8.8 mL/m^2 on echocardiography (Fig. 1-Panel a). Similarly, mean LAVI was higher on NCCT (36.2 ± 13.3 mL/m^2) than on echocardiography (28.2 ± 9.2 mL/m^2) (Fig. 1-Panel b). Echocardiography's lower volumes reflect its known underestimation of chamber size compared with CT [8], due to lower spatial resolution, geometric assumptions, and difficulty delineating the endocardial border in poor acoustic windows or marked trabeculation [8].

Participants with baseline HF demonstrated higher LVVI values on both NCCT and echocardiography, consistent with prior literature, particularly in HF with reduced ejection fraction [9]. NCCT-based LVVI demonstrated comparable discrimination for baseline HF (AUC 0.76 [0.66–0.85] vs. 0.70 [0.61–0.80], p = 0.12) (Fig. 1-Panel c). For AF, LAVI was higher among affected individuals on both NCCT and echocardiography, with NCCT-based LAVI showing significantly higher discrimination (AUC 0.77 [0.73–0.81] vs. 0.72 [0.67–0.76], p = 0.01) (Fig. 1-Panel d).

Cumulative incidence curves by tertiles demonstrated substantial overlap between NCCT- and echocardiography-derived LVVI for HF, with the highest tertile of each showing incidence rates of 9.9 and 8.1 per 1000-person-years, respectively (Fig. 1-Panel e). Similarly, for LAVI and AF, the highest tertile of NCCT-scan and echocardiography demonstrated 45.9 and 38.6 incidence per 1000-person-years (Fig. 1-Panel e). For HF prediction, NCCT-derived LVVI (combined with age and sex in a Cox proportional hazard model) demonstrated a C-index of 0.82, compared with 0.79 for the echocardiography-based model (similarly combined with age and sex). The 95% confidence interval for the difference in C-indices (CT minus echocardiography) was −0.06 to 0.07, with a two-sided p-value of 0.36. For AF, the NCCT-derived LAVI model (combined with age and sex) yielded a C-index of 0.73, compared with 0.73 (combined with age and sex) for the echocardiography-based model. The difference in C-indices was negligible (95% CI: −0.04 to 0.05; two-sided p = 0.66), suggesting comparable discriminative performance between modalities (Table 1).

To our knowledge, this is the first study comparing AI-derived chamber volumetry from non-gated NCCT with echocardiography. Our findings show that NCCT-based AI-derived cardiac chambers volumetry and echocardiography provide similar discrimination of prevalent and incident HF and AF. Recently, the American Heart Association suggested that non-gated NCCT scans have the potential to become a cornerstone of clinical practice by improving cardiovascular disease risk prediction and reaching a broader, more diverse population through opportunistic AI tools, particularly among patients who have traditionally been identified only by coronary artery calcium (CAC) scanning [1]. However, our findings suggest that this potential extends beyond CAC, as AI-based analysis of NCCT can identify a comparable range of high-risk patients to those previously detectable only through echocardiography. Although non-gated acquisitions do not allow determination of the cardiac cycle phase at which chamber volumes are captured, we have previously demonstrated that non-gated NCCT provides non-inferior predictive performance compared with ECG-gated scans for both HF and AF [10]. Importantly, NCCT-derived measures are not intended to replace echocardiography but rather to serve as an opportunistic screening and triage tool in patients already undergoing NCCT for other indications. Further studies with longer follow-up, broader age ranges, larger sample sizes and cross cardiac cycle comparisons are needed to validate these findings.

In summary, AI-enabled opportunistic assessment of cardiac chamber volumes from non-gated NCCT demonstrates comparable performance to echocardiography for cardiovascular risk assessment, while offering practical advantages by eliminating the need for contrast agents, ECG-gating, and specialized operator expertise. Larger observational studies, clinical trials, and cost-effectiveness analyses are warranted to further evaluate NCCT-based AI-enabled screening as a tool for the primary prevention of cardiovascular disease.

Declarations

Funding disclosures

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Availability of data and materials

MESA data are available upon approval of a manuscript proposal and completion of a Data and Materials Transfer agreement.

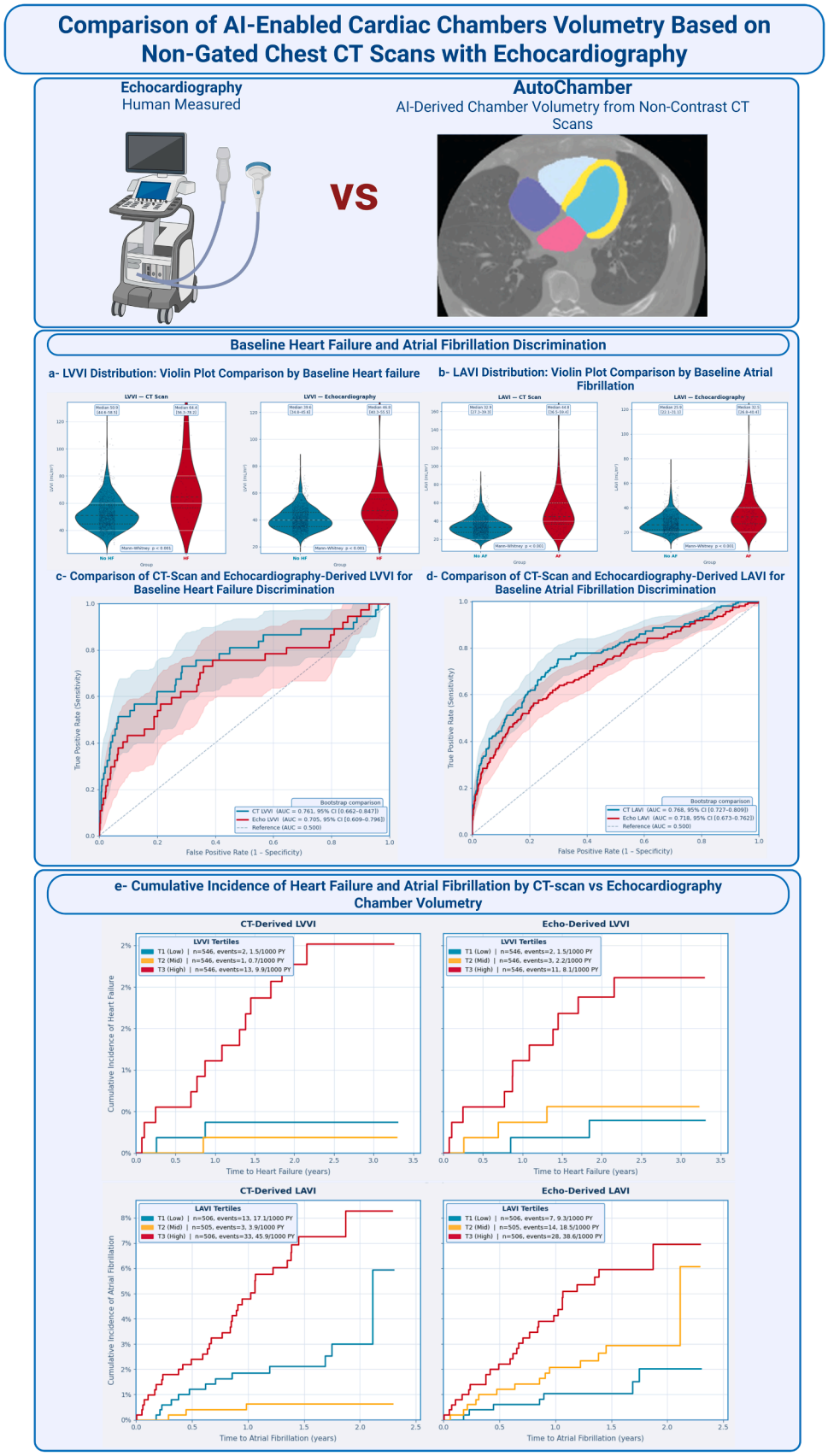


Fig. 1. Comparison of AI-enabled cardiac chambers volumetry based on non-gated chest CT scans with echocardiography.

Table 1
Comparative analysis of AI-based chamber volumetry from non-gated lung CT and manual echocardiography for the prediction of atrial fibrillation and heart failure.

Chamber Heart Failure	Echocardiography C-Index	Non-Gated CT scan C-Index	Two-Sided p value	95% Confidence Interval of Difference*	Lower bound of 95% CI of Difference
Left Ventricular Volume Index	0.79 (0.70–0.91)	0.82 (0.67–0.93)	0.36	(−0.06, 0.07)	−0.06
Left Atrial Volume Index	0.79 (0.39–0.90)	0.82 (0.19–0.913)	0.29	(−0.61, 0.07)	−0.61
Left Ventricular Mass Index	0.77 (0.67–0.90)	0.83 (0.20–0.93)	0.35	(−0.59, 0.09)	−0.59
Left-to-Right Ventricular Volume Ratio	0.78 (0.68–0.90)	0.81 (0.71–0.92)	0.43	(−0.05, 0.10)	−0.05
Left-to-Right Atrial Volume Ratio	0.77 (0.68–0.89)	0.78 (0.68–0.90)	0.45	(−0.01, 0.03)	−0.01
Atrial Fibrillation					
Left Atrial Volume Index	0.73 (0.66–0.79)	0.73 (0.66–0.81)	0.66	(−0.04, 0.05)	−0.04
Right Atrial Volume Index	0.67 (0.61–0.77)	0.70 (0.64–0.79)	0.20	(−0.01, 0.07)	−0.01
Left-to-Right Atrial Volume Ratio	0.72 (0.65–0.78)	0.68 (0.62–0.77)	0.18	(−0.07, 0.01)	−0.07
Left Atrial-to-Ventricular Volume Ratio	0.71 (0.64–0.77)	0.70 (0.63–0.78)	0.81	(−0.04, 0.03)	−0.04

* Difference: Non-gated CT - Echocardiogram.

CRediT authorship contribution statement

Seyed Reza Mirjalili: Writing – review & editing, Writing – original draft, Conceptualization. **Kyle Atlas:** Writing – review & editing. **Anthony P. Reeves:** Writing – review & editing. **Chenyu Zhang:** Writing – review & editing. **Jakob Wasserthal:** Writing – review & editing. **Amir Azimi:** Writing – review & editing. **Ali Hashemi:** Writing – review & editing. **Mohammadhossein Mozafarybazargany:** Writing – review & editing. **Amir Ghaffari Jolfayi:** Writing – review & editing. **Thomas Atlas:** Writing – review & editing. **Claudia I. Henschke:** Writing – review & editing. **David F. Yankelevitz:** Writing – review & editing. **Javier J. Zulueta:** Writing – review & editing. **Wenjun Fan:** Writing – review & editing. **Jeffrey I. Mechanick:** Writing – review & editing. **Andrea D. Branch:** Writing – review & editing. **Khurram Nasir:** Writing – review & editing. **Zahi Fayad:** Writing – review & editing. **Michael V. McConnell:** Writing – review & editing. **Jamal S. Rana:** Writing – review & editing. **Rozemarijn Vliegenthart:** Writing – review & editing. **David J. Maron:** Writing – review & editing. **Jagat Narula:** Writing – review & editing. **Matthew J. Budoff:** Writing – review & editing. **Roxana Mehran:** Writing – review & editing. **Kim A. Williams Sr.:** Writing – review & editing. **Prediman K. Shah:** Writing – review & editing. **Oren Mechanic:** Writing – review & editing. **Arthur S. Agatston:** Writing – review & editing. **Robert A. Kloner:** Writing – review & editing. **Nathan D. Wong:** Writing – review & editing. **Morteza Naghavi:** Writing – review & editing, Conceptualization.

Declaration of competing interest

Several members of the writing group are inventors of the AI tool mentioned in this paper. M.N. is the founder of HeartLung.AI. A.P.R., T. A., D.F.Y., N.D.W., and D.L. are advisors to HeartLung.AI. C.Z. is a software engineer for HeartLung.AI. K.A. is a graduate research associate of HeartLung.AI. S.RM, and A.A, A.H, and MM are research fellows for HeartLung.AI. M.V.M is Chief Health Officer for Toku, Inc. and advisor for Porter Health. D.J.M. reports research funding from Cleerly, Inc. and consultant fees from Heartflow. The remaining authors declare no competing interests.

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