Chest Radiography and Mammography-Derived Imaging Biomarkers Enhance Cardiovascular Risk Prediction Beyond ASCVD Risk Score

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Introduction

Cardiovascular disease (CVD) remains underdiagnosed in women in the United States and current risk prediction models underperform in female populations. Emerging deep learning techniques can quantify both breast arterial calcification (BAC) in mammograms and imperceptible features in chest radiographs (CXR) which presents a new possibility for enhanced opportunistic screening for CVD risk prediction. In this study, we evaluate CXR embeddings and BAC quantification as imaging biomarkers to enhance CVD risk prediction

Hypothesis

Automated imaging biomarkers derived independently from routine chest radiographs and mammograms may enhance traditional clinical risk scores for cardiovascular risk stratification.

Methods

We identified a cohort of women who underwent both screening mammography and CXR (frontal and lateral views) (N&#3f9,552) at our institution. The 10-year ASCVD risk score was calculated for patients using electronic health record data. We applied an in-house BAC quantification model to mammograms to extract BAC scores and utilized RAD-DINO to extract embeddings from CXRs. Two XGBoost models were trained on the resultant CXR embeddings to predict 10-year CVD event risk. We then developed a multivariable Cox proportional hazard model incorporating ASCVD score, BAC score, and both CXR-derived risk scores (frontal and lateral) as independent covariates to predict 10-year CVD risk and compare their hazard ratios (HR). Subgroup analysis was performed for patients aged 40-60 years for whom early detection may be most beneficial.

Results

Both BAC and CXR embeddings demonstrated higher HR (BAC: 1.14 [95%CI 1.01-1.28]; CXR Frontal: 4.91 [2.82-8.55]; CXR Lateral: 2.37 [1.27-4.39]) compared to ASCVD score (1.02 [1.01-1.03]), all $p < 0.05$. Kaplan-Meier analysis revealed significantly higher event rates in women with moderate-to-severe BAC versus zero-to-mild BAC ($p < 0.005$). Similarly, CXR

model-positive patients showed increased CVD event rates ($p < 0.005$). While frontal CXR demonstrated higher HR and time-dependent AUCs compared to lateral views (0.68 [0.64-0.71] vs 0.65 [0.62-0.69], respectively), these differences were not significant, and both views independently predicted CVD events, suggesting that either view could be utilized for CVD risk assessment. Our findings were consistent across patients aged 40-60 years, suggesting strong potential for early risk stratification in younger women.

Conclusion

Automated analysis of mammograms and chest radiographs enhances cardiovascular risk prediction in women beyond ASCVD scores, enabling early intervention through existing screening programs.

Figure(s)

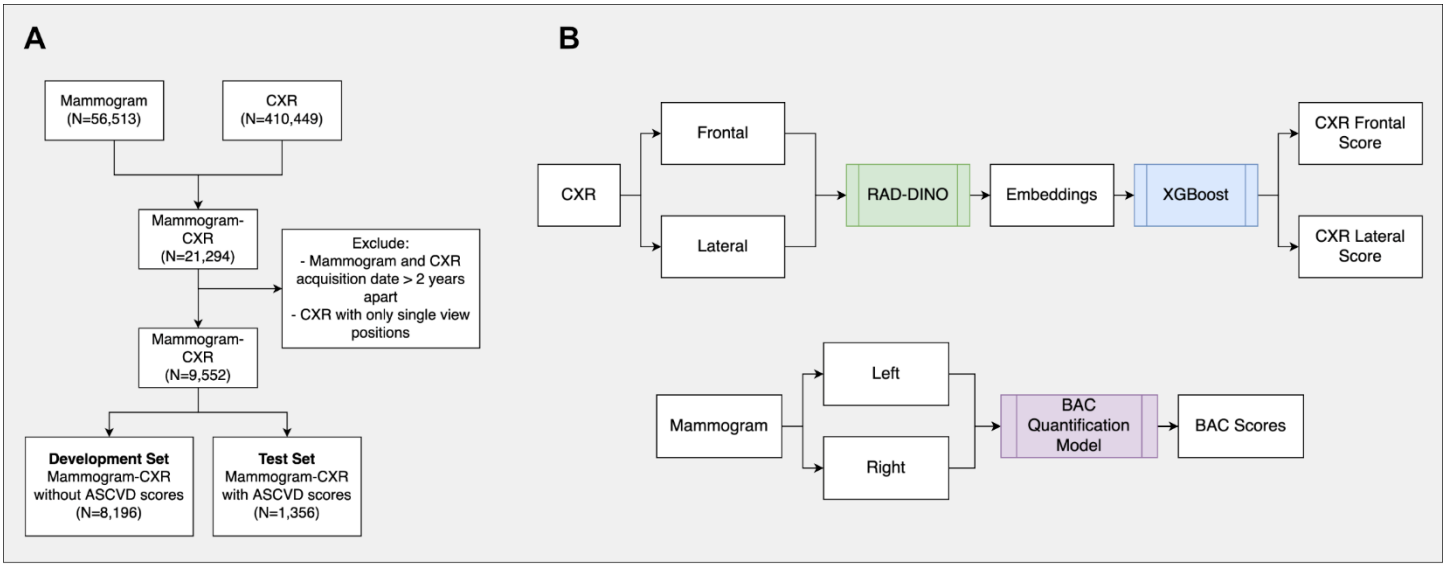

Figure 1. Study Methods. A. Data curation flowchart; B. Workflow to obtain the imaging marker scores. Top: CXR scores from frontal and lateral CXRs: Bottom: breast arterial calcification (BAC) scores from mammograms.

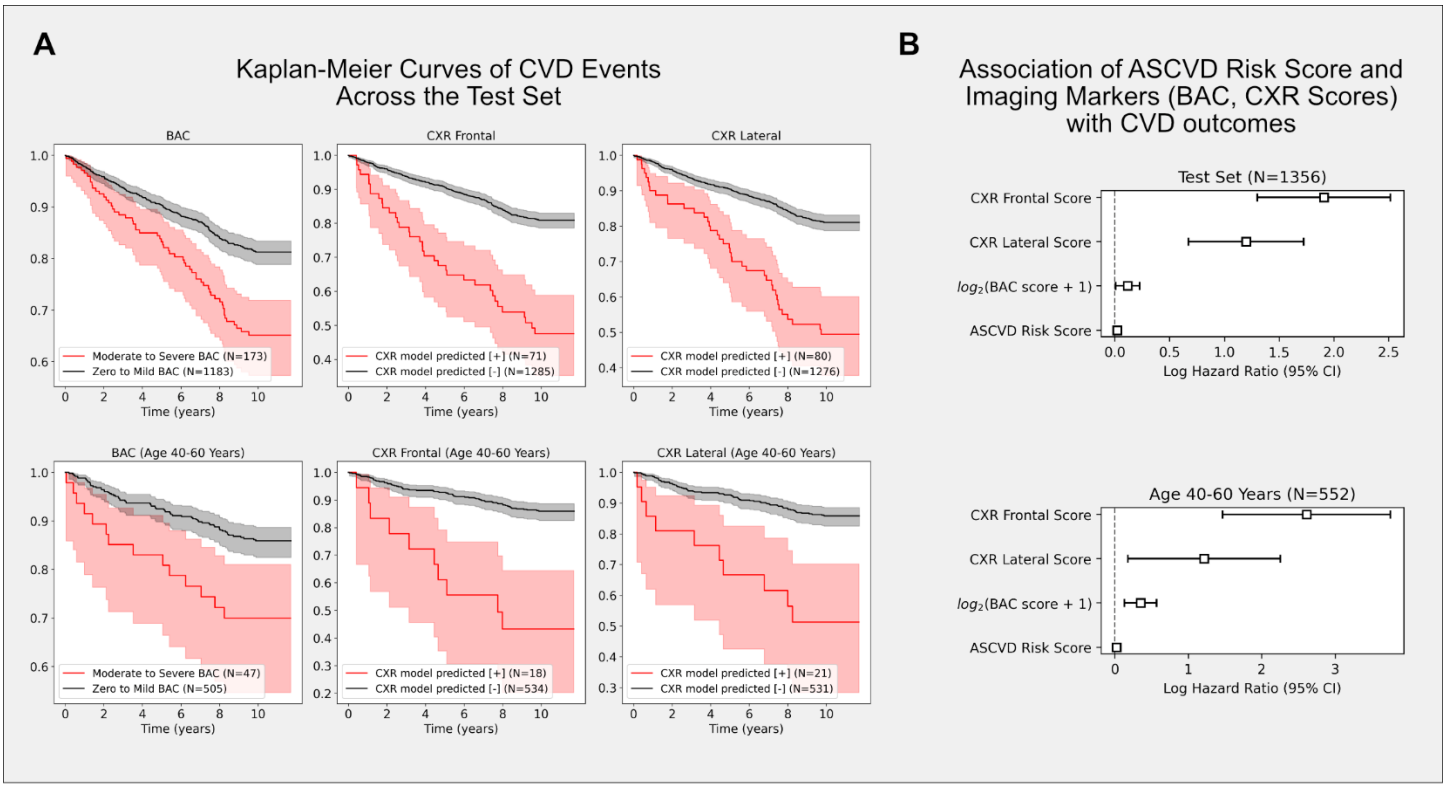

Figure 2. Study Results A. Kaplan-Meier curves of patients with CVD events from the time of mammograms, grouped by BAC, and CXR binary prediction. Top: all patients in the test set; Bottom: patients aged 40-60 years in the test set; B. Log Hazard Ratios of multivariable Cox Proportional Hazards models which includes the 10-year ASCVD risk score as the clinical marker, and CXR scores and BAC scores as imaging markers. Top: run on all patients in the test set; Bottom: run on patients aged 40-60 years in the test set.

Keywords

Applications; Artificial Intelligence/Machine Learning; Imaging Research