Validation of a Deep Learning-enabled Electrocardiogram Algorithm to Detect and Predict Cardiac Contractile Dysfunction in the Community

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Background

- Left ventricular systolic dysfunction (LVSD) is common; approximately **2%** of the **general population** and nearly **10%** of **elderly patients** have significant LVSD that has not been diagnosed.
- LVSD is associated with increased **morbidity, mortality and heart failure** but is underdiagnosed.
- Early detection is essential given the known benefits of medical interventions on prevention of progression to symptomatic heart failure and survival.
- Screening for LVSD has centered around either B-type natriuretic peptide (BNP) or imaging that have clear limitations.

Aim

To validate a deep learning algorithm designed to detect LVSD, with a 12-lead electrocardiogram (ECG).

Deep Learning Algorithm

Methods

- In a prospective, randomly-selected cohort (stratified to 7% of residents within each sex and age stratum), residents aged 45 years or older underwent clinical evaluation, medical record abstraction, ECG, baseline echocardiography and follow-up via linkage of routine echocardiograms.
- Those with history of heart failure at baseline were excluded.
- The primary outcome** was the ECG algorithm ability to identify subjects with a low LVEF at baseline (i.e. $\leq 50\%$, $\leq 40\%$ and $\leq 35\%$) in people without clinical history of heart failure.
- The secondary outcome** was to assess the association between a positive ECG screen and a clinically meaningful decrease in LVEF (LVEF of $\leq 35\%$ or absolute change of $\leq 20\%$) over time, among those with normal LVEF ($\geq 50\%$) at baseline.

- Diagnostic performance was summarized with AUC of ROC, sensitivity and specificity).
- Kaplan-Meier curves and Cox proportional hazard models adjusted for risk factors.

Results

- We included 1737 subjects (52% women), mean age $\pm$ SD 61.70 $\pm$ 10.4 years.
- The prevalence of low LVEF at baseline was 5% for $\leq 50\%$, 1.7% for $\leq 40\%$ and 1.0% for $\leq 35\%$, respectively.
- The network yielded excellent diagnostic performance (**see Figure 1**).
- Among those with LVEF $\geq 50\%$ (n=1639), after a median follow-up of 18.5 $\pm$ 4.4 years, 108(6.6%) had a clinically meaningful drop in LVEF.

Among those with LVEF $\geq 50\%$ (n=1639):

- A positive ECG screen but normal LVEF were at higher risk of suffering a clinically meaningful drop in EF **HR=2.49 (95%CI 1.57-3.96, p<.0001)** when compared to those deemed negative (**see Figure 2**).
- The risk increased when assessing shorter follow-up intervals, **HR=3.24** (95%CI 1.91-5.48, p<0.0001) at **15 years**, **HR=3.78** (95%CI 1.97-7.28, p<0.0001) at **10 years** and **HR=7.93** (95%CI 2.20-27.42, p=0.001) at **5 years** (**see Table**).
- These results were only slightly attenuated after adjusting for age, sex, and traditional risk factors (**see Table**).

Figure 1

Figure 2

	HR	95%CI	p-value
Complete follow-up			
Unadjusted	2.49	1.57-3.96	<.0001
Age and sex adjusted	1.89	1.18-3.02	0.007
Multivariate model	1.73	1.07-2.78	0.02
15-years follow-up			
Unadjusted	3.24	1.91-5.48	<.0001
Age and sex	2.35	1.37-4.03	0.001
Multivariate model	2.09	1.21-3.63	0.008
10-years follow-up			
Unadjusted	3.78	1.97-7.28	<.0001
Age and sex	2.70	1.38-5.30	0.003
Multivariate model	2.45	1.24-4.85	0.01
5-years follow-up			
Unadjusted	7.93	2.20-27.42	0.001
Age and sex	4.44	1.22-16.19	0.02
Multivariate model	3.62	0.98-13.32	0.05
Multivariate model: adjusted for age,sex, body mass index, history of diabetes, hypertension and coronary artery disease.			

Conclusions

- A deep learning-enabled ECG algorithm detected low LVEF with excellent accuracy in an unselected community population and predicted future LV dysfunction.
- Applying artificial intelligence to the ECG - a ubiquitous, low cost test - permits the ECG to serve as a powerful tool to screen for LVSD and furthermore to identify individuals at increased risk for its development in the future.

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