A Multi-layer CNN using the ECG, Age and Sex Predicts Ventricular Arrhythmias in the General Population

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Background: Life-threatening ventricular arrhythmias (LTVA) prediction in individuals without cardiovascular disease remains a major challenge. We tested the performance of a multi-layer convolutional neural network (CNN) on ECG signals, including additional information (sex and gender) to predict LTVA.

Methods: We split 51,608 individuals from the UK Biobank study into training (90%) and internal test (10%) sets. In the training set, we trained a multi-layer CNN using 15-second ECGs at rest from lead I, age and gender as input. The output was the probability of LTVA within a 10-year follow-up. The CNN model consisted of a four-layer CNN (128, 128, 256 and 256 channels, kernel sizes of 3, groups of 1) and a single attention layer. Age and gender were included in the final layer. Performance was then tested in an external cohort of 32,209 individuals from UK Biobank (3.4-year follow-up) with 10-second ECGs.

Results: In the internal test cohort, 22 subjects had an LTVA, and the area under the curve (AUC) of the CNN was 0.760, with a specificity of 0.526 for a sensitivity of 0.750. In the external test cohort (60 LTVA events), the CNN's prediction led to an AUC of 0.699, and a specificity of 0.551 for a sensitivity of 0.750. We set a threshold at the CNN's prediction value maximising the sum of specificity and sensitivity above median values. Survival analyses showed a hazard ratio (HR) of 8.383 ($P = 1.3 \times 10^{-7}$) for individuals with a CNN's prediction value > threshold, versus those with a CNN's prediction value < threshold.

Conclusions: A multi-layer CNN model using 10-second ECG data from lead I, together with information on age and gender, can stratify individuals at risk of LTVA. Our findings support the potential utility of wearables for accessible screening in the general population.