Background: Concealed left ventricular hypertrophy (LVH) is a prevalent condition that is correlated with a substantial risk of cardiovascular events and mortality, especially in the young to middle-aged adults. Early identification of LVH is warranted.

Methods: PO-631-06

ARTIFICIAL INTELLIGENCE-ENABLED MODEL FOR EARLY DETECTION OF LEFT VENTRICULAR HYPERTROPHY AND MORTALITY PREDICTION IN YOUNG TO MIDDLE-AGED ADULTS

Chih-Min Liu MD; Ming-En Hsieh; Yu-Feng Hu PhD; Tzu-Yin Wei; I-Chien Wu; Pei-Fen Chen; Yenn-Jiang Lin MD, PhD; Satoshi Higa MD, PhD, FHRS and Shih-Ann Chen MD

Background: Concealed left ventricular hypertrophy (LVH) is a prevalent condition that is correlated with a substantial risk of cardiovascular events and mortality, especially in the young to middle-aged adults. Early identification of LVH is warranted.

Objective: In this work, we aimed to develop an AI-enabled model for early detection and risk stratification of LVH using 12-lead electrocardiograms (ECGs).

Methods: By deep learning techniques on the ECG recordings from 28,745 patients (20-60 years old), the AI model was developed to detect verified LVH from transthoracic echocardiography and evaluated on an independent cohort. The LVH diagnoses were further correlated with future cardiovascular and all-cause mortality.

Results: The area under the curve (AUC) of the AI model in diagnosing LVH was 0.89 (sensitivity: 90.3%, specificity: 69.3%), which was significantly better than that of the cardiologists’ diagnosis (AUC: 0.64). In the second independent cohort, the diagnostic performance of the AI model was consistent (AUC: 0.86; sensitivity: 85.4%, specificity: 67.0%). After a follow-up of 6 years, AI-predicted LVH was independently associated with higher cardiovascular or all-cause mortality (hazard ratio: 1.91 and 1.54, respectively) (Figure 1). The predictive power of the AI model for mortality was consistently valid among patients with different ages, sexes, and comorbidities, including hypertension, diabetes mellitus, stroke, heart failure, and myocardial infarction.

Last, we also validated the model in the international independent cohort from Japan (AUC:0.83).

Conclusion: The AI model improved the detection of LVH and mortality prediction in the young to middle-aged population and represented an attractive tool for risk stratification. Early identification by the AI model gives every chance for timely treatment to reverse adverse outcomes.

PO-631-07

A NOVEL METHOD FOR EXPLAINABLE DEEP NEURAL NETWORK-BASED INTERPRETATION OF ELECTROCARDIOGRAMS USING VARIATIONAL AUTO-ENCODERS: THE FACTORECG

Rutger van de Leur; Max Bos MSc; Rutger J. Hassink MD; Pieter A. Doevendans; Deepak Gupta and Rene Van Es PhD

Background: Deep neural networks (DNNs) show excellent performance in interpreting electrocardiograms (ECGs), even for novel applications such as detection of reduced ejection fraction (EF). Despite these promising developments, clinical implementation is hampered by the ‘black box’ nature of most algorithms and the lack of adequate explainability techniques. Especially, currently employed heatmap-based methods have shown to be inaccurate.

Objective: We aimed to develop a novel method, based on a variational auto-encoder (VAE), to identify the underlying factors of variation in the ECG and use them to develop an inherently explainable pipeline for automatic ECG interpretation.

Methods: We designed a β-VAE, that used the power of DNNs to learn to summarize the ECG in only 21 continuous factors (the “FactorECG”) by training on a database with 1.1 million ECG recordings (https://decoder.ecgx.ai). These factors are explainable through visualizations on both the model- and individual patient-level and are subsequently used in common and interpretable statistical methods. The predictive performance of the novel explainable DNN is compared to state-of-the-art ‘black box’ DNNs in three tasks: a conventional ECG interpretation task, detection of reduced EF and prediction of one-year mortality.

Results: The explainable DNN was able to compress the ECG into 21 generative ECG factors, which are associated with physiologically valid underlying anatomical and (patho)physiological factors. When applying the novel pipeline to the three tasks, the explainable DNN performed on par with the ‘black box’ DNNs in conventional ECG interpretation (AUC 0.94 vs 0.96), detection of reduced EF (AUC 0.90 vs 0.91) and prediction of one-year mortality (AUC 0.76 vs 0.75), while also providing explainability on which ECG features were important for prediction or diagnosis, in contrast to the ‘black box’ DNN (Figure 1).

Conclusion: Future studies should employ DNNs that are explainable by design to gain confidence in artificial intelligence and make it possible to identify biased models to facilitate better clinical implementation.
REAL-TIME INTERACTIVE 3D SIMULATION OF TEMPORARY CARDIAC PACING

Vassilios Hurmusiadis BENG, MA, DPhil

Background: In response to the COVID19 pandemic the UK NHS confirmed that more than 4,000 retired healthcare workers had signed up to help battle the outbreak. At the same time large numbers of doctors and nurses of all specialties were being diverted to Intensive Care Unit (ICU) management. Evidently there was a sharp increase in demand for rapid clinical training. Temporary Cardiac Pacing (TCP) is one of the critical interventions in ICU patients with acute respiratory distress syndrome. It is an intervention that helps the heartbeat get back to normal rhythm. Traditionally training for TCP takes place on the patient.

Objective: In order to address the increased need for rapid training, we set out to adapt our heart simulator for ICU procedure training and provide a simulation-bases eTraining solution for TCP.

Methods: We developed an application for TCP eTraining, accessible on tablets and smart phones. The app is based on our validated electromechanical simulation model of the heart and realtime interactive 3D simulation technology. The app content consists of a virtual heart in various arrhythmic states. A simulated interactive pacemaker is connected to the heart model and is capable of generating realtime changes in pacing location, rate, voltage, sensitivity and mode. Real-time ECG signals are being recorded on the virtual heart and are used to monitor the effect of the pacemaker. Self-study tutorials introduce the procedure and tests allow trainees to assess their learning outcomes.

Results: The app has received CPD accreditation in the UK and has so far been used at the University of Oxford, University of Leeds and Middlesex University. All trainees, medical students and trainee nurses followed the self-study tutorials and took the MCQ and interactive test which are embedded within the TCP app. Development was based on Unity 3D and was made available on iOS, Android, macOS, Windows and WebGL platforms.

Conclusion: This project allowed us to meet an urgent training need and at the same time expand our expertise and market scope into clinical training. The impact on clinical training was high and the societal benefit came from better and quicker trained staff. The project was funded by an Innovate UK grant.