Designing Convolutional Neural Networks to Predict Sudden Cardiac Arrest

Anojan Selvalingam
Mahmood I. Alhusseini
Albert J. Rogers
David E. Krummen
Firas AbuZaid
Junaid A.B. Zaman
Tina Baykaner
Paul Clopton
Peter Bailis
Matei Zaharia
Sanjiv M. Narayan

Introduction: Neural networks have not been designed to classify monophasic action potential (MAP) signals that could predict risk for sudden cardiac death or sudden cardiac arrest (SCA). The objective of this study was to develop and compare competing convolutional deep neural networks (CNN) trained on ventricular MAPs, which may alter with pathological remodeling from coronary disease (CAD) and left ventricular (LV) dysfunction, to predict SCA.

Methods: In 26 patients with CAD and LV ejection fraction ≤ 40%, MAPs were recorded at 1 kHz in right (RV) and left (LV) ventricles at EP study. CNNs were iteratively developed in Keras (Python), trained to adjudicated, appropriate ICD therapy (labeled 0/1) at 752±493 days. The network was trained and validated on 3580 MAPs (complete dataset).

Result: Patients had age 62.0±18.7 Y, LVEF 28.0±8.3%. Fig. A shows optimal final CNN with 3 convolutional (blue) and 2 recurrent (gray, ‘LSTM’) neural layers. Training was performed using k-cross validation (CV) with k = 7. Fig. B shows that the CNN training accuracy of this design converged to 100%. In independent validation sets, CNN predicted SCA with accuracies up to 78% depending on clinical features of training and validation cohorts.

Conclusion: We developed deep CNN which, using ventricular action potentials, may for the first time predict SCA at 2-3 year follow-up. These data form the basis for future studies of alternative learning models and additional electrophysiological features to predict SCA.