Detection of Hypertrophic Cardiomyopathy Using a Convolutional Neural Network-Enabled 12-Lead Electrocardiogram

Wein-Yin Ko, MS, MEng1; Konstantinos C. Siotis, MD,1 Zach I. Atta, MS EE1; Rieky E. Garter, PhD2; Suraj Kapa, MD1; Steve R. Ommen, MD1; Steven J. Denham3; Michael J. Ackerman, MD, PhD1; Bernard J. Gerbarg, MB, CB DPhil1; Adelaide M. Amrutha Olcson, MD, MOH1; Jeffrey J. Geske, MD1; Samuel J. Avisonthaim, MD1; Rick A. Nishimura, MD1; Paul A. Friedman, MD1; Peter A. Noseworthy, PhD1

Department of Cardiovascular Medicine, Mayo Clinic, Rochester, MN; Health Sciences Research, Mayo Clinic College of Medicine, Jacksonville, FL; Information Technology, Mayo Clinic, Rochester, MN

Abstract

Background: Hypertrophic cardiomyopathy (HCM) is one of the leading causes of sudden cardiac death in adolescents and young adults. We aimed to develop an artificial intelligence (AI) approach for the detection of HCM based on the 12-lead ECG.

Methods: We trained and validated a convolutional neural network (CNN) using digital 12-lead ECGs from 2,448 patients with verified HCM diagnosis and 51,153 non-HCM age- and sex-matched control subjects. The ability of the CNN to detect HCM was then tested on a different dataset of 612 HCM and 12,788 non-HCM subjects.

Results: In the combined datasets, mean age was 54.8±15.9 years for the HCM group and 57.5±16.5 years for the control group. After training and validation, the area under the curve (AUC) of the CNN in the validation dataset was 0.95 (95% CI 0.94-0.97) at the optimal probability threshold of 11% for having HCM. When applying this probability threshold in the test dataset, the CNN’s AUC was 0.96 (95% CI 0.95-0.96) with sensitivity 87% and specificity 91% (Figure 2). Positive predictive value was 31% and negative predictive value was 99%.

Among the controls with false positive detections, 31% satisfied the LVH ECG criteria. In a model developed and tested only on a single ECG lead (lead I), the AUC was 0.91 (95% CI 0.85-0.95), sensitivity was 83% and specificity was 81%.

Conclusions

In this study, we report the first AI-based CNN for detection of HCM based on the 12-lead ECG. The network demonstrates high discriminatory ability in distinguishing HCM cases from non-HCM controls with an AUC of 0.96. The network is associated with an extremely low false negative rate across a range of HOM probability thresholds. The model performance was superior in our youngest age cohort (<40 years) in this study which suggests that it may perform well as a screening tool in young adults. Furthermore, in the subgroup of subjects with ECG criteria of LVH, model prediction was superior to the overall population with AUC of 0.95 (95% CI 0.94-0.97), suggesting that the model is a valuable in distinguishing HCM from other causes of LVH. Similar performance was demonstrated among subjects with ECGs that had been considered completely normal by standard interpretation.

© 2019 Mayo Foundation for Medical Education and Research