Detection Of Aortic Valve Stenosis Using A Convolutional Neural Network

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Introduction

- Aortic stenosis (AS) is one of the most common valvular heart diseases affecting adults.
- Severe AS patients are at risk for heart failure and sudden cardiac death, the only available treatment is valve replacement.
- Although the diagnosis of AS is commonly established by echocardiography, patients with moderate to severe AS remain asymptomatic and AS may not be suspected clinically and echocardiography may not be readily available in many parts of the world.
- Due to the lack of inexpensive, widely available screening tests, most patients with AS are diagnosed after they develop symptoms, a stage that may be associated with a poor prognosis.
- The electrocardiogram (ECG) is an inexpensive, rapid, widely available test that is routinely performed to evaluate patients with cardiac and non-cardiac complaints.
- We hypothesized that by applying AI in the form of a convolutional neural network (CNN) to the ECG it could be used to detect early AS, identifying people who could then undergo additional testing. This would be a major advance in the diagnosis of AS.

Objective

Detection of Aortic stenosis from 12 lead ECG alone, Using a deep learning algorithm.

Figure 1 – AS pathophysiological mechanism

Methods

- We trained a convolutional neural network (Figure 3) to detect AS of at least moderate-severe in severity, using a 12 lead ECG.
- Included were all the patients who had an echocardiogram performed from Jan-2016 to Jun-2018 and an ECG performed within 180 days prior to the echocardiogram.
- Data was extracted using the Unified Data Platform (UDP, Mayo Clinic, Rochester).
- The model was trained on 24,579 patients, an optimal model was selected using a validation data set of 3,982 patients and the model was then tested on a third independent dataset of 9,345 patients.
- Patients with cardiac surgery or prosthetic valve prior to the echo used for analysis were excluded.
- As the severity level is subjective, due to Inter-observer variability, and in this proof of concept we were developing a binary classifier, we excluded patients with diagnosis of mild to moderate AS.

Figure 2 – Cohort selection

Figure 3 – CNN Architecture

Results

- Of 37,906 patients, 17,530 patients (46%) were females; of which 1,092 (2.8%) patients with 2,028 ECGs had moderately severe to severe AS and were labeled as "AS positive".
- The area under the Receiver operating characteristic curve (AUC) of the classifier was 0.83 (Figure 4). The sensitivity, specificity and accuracy were 71.48%, 74.38% and 77.74%, respectively.

Figure 4 – AUC results

Conclusion

- This proof of concept suggests that severe AS can be detected using a 12 lead ECG processed using deep learning algorithm.
- The ECG, a ubiquitous, low cost test, may serve as a powerful tool to screen for asymptomatic aortic stenosis in the community.
- Developing this model further will lead to early diagnosis of other valvular diseases using a simple bedside ECG.

References

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