Screening for Aortic Dissection on CT Angiography Using a Convolutional Neural Network

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Introduction

Aortic dissection is a condition in which the aortal wall tears, causing blood to flow through the torn region as the middle and inner layers of the wall separate. This condition can be fatal if not recognized and treated immediately. The ideal imaging technique for identification of aortic dissection is computed tomography angiography (CTA) of the aorta. A fast method of screening chest CT studies for this pathology could assist with efficient patient triage and diagnosis.

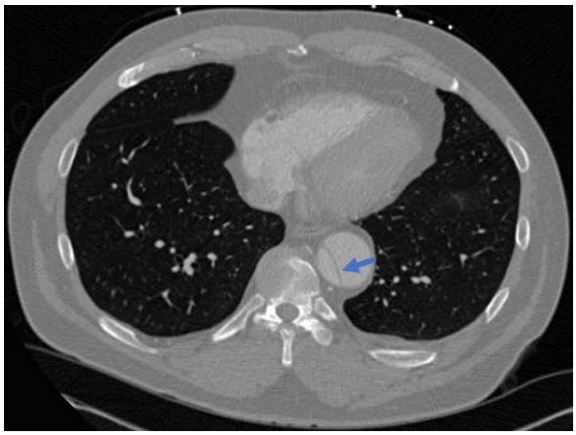

Figure 1: A thoracic CTA image showing an aortic dissection (blue arrow) within the aorta.

Hypothesis

We hypothesized that by training a convolutional neural network (CNN) on CTA data, an aortic dissection detector could be created from an existing database without requiring annotations. Since chest CTA series consist of many 2D slices, and because aortic dissections are typically visible across many image slices, we hypothesized that by applying a 2D image classification model to each slice individually, we could calculate a “positive fraction” and this fraction would be a strong predictor of a patient having aortic dissection.

Methods

A set of studies either positive or negative for aortic dissection were obtained from our database. Studies were passed through a pipeline to extract a single optimal CTA series from each study. A jpeg file was created for every slice in each CTA series. For the positive data, the set of jpeg images was then manually reviewed and any image not showing aortic dissection was removed. In total, 57,074 axial CTA images (20,887 positive) were created from 475 patients. When

entering the model, data was cropped from 512x512 to keep only the centermost 256x256 pixels, as the aorta was always within this window. A CNN consisting of five layers (each containing convolution, maxpooling, and dropout functions) and softmax activation was used. After training, the model was applied to a unique test dataset of 50 positive and 50 negative CTA series. Each image slice of a test series was classified, and the fraction of total slices positive for aortic dissection was used as a metric for whether the series was classified as positive or negative overall.

Results

Within the test dataset, we achieved an AUC of 0.938. The ideal positive fraction cutoff along the ROC curve was 0.25, corresponding to a sensitivity of 90.0% and specificity of 86.0%. The mean time for each series to be loaded and pass through the model was approximately 11 seconds and depended largely on the number of slices in the series.

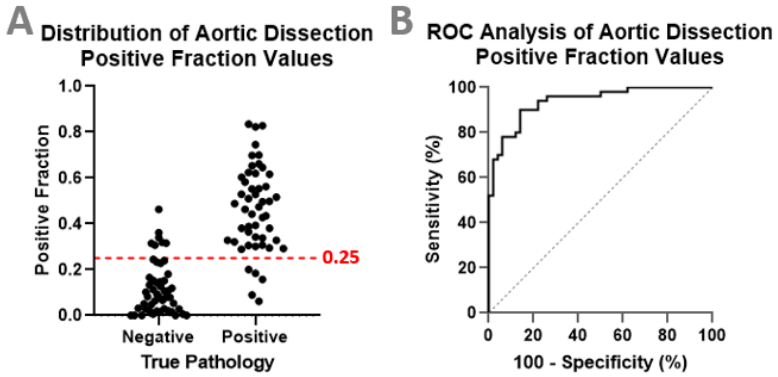

Figure 2: A) The distribution of positive fraction values calculated from the test dataset. B) Receiver-operator curve analysis for the data in (A).

Conclusion

A convolutional neural network was used to stratify patients with aortic dissection by applying a 2D model on each slice of 3D CTA data. This model did not require reader annotations to create. The model is currently being wired into our system workflow.

Statement of Impact

Our institution receives over 100,000 chest CT studies per year, many of which contain a CTA series. This workflow provides a simple and lightweight method of screening CT studies for aortic dissection, allowing for more efficient triage and diagnosis of patients. We are also currently working to add other pathologies such as aortic aneurysm and aortic rupture into this same model.

Keywords

aortic dissection, CTA, convolutional neural network, machine learning