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Towards a Convenient, Non-Imaging Device for Abdominal Aortic Aneurysm Screening and Surveillance

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***Abstract*—A model was built to predict aortic diameter via arterial waveform features from abdominal aortic aneurysm (AAA) and control patients. The correlation coefficient between the predicted and directly measured diameters was 0.63.**

***Clinical Relevance*— A convenient, non-imaging device based on arterial waveform analysis may help improve AAA detection.**

An abdominal aortic aneurysm (AAA) carries increasing risk of rupture with growing diameter. This condition is often asymptomatic, so screening and surveillance are essential. Ultrasound is employed for such monitoring at high accuracy. However, imaging methods require an expert-operator and are expensive, and AAA is considerably under-detected at present [1] and may become even more under-detected in the future as its prevalence increases with aging. Our goal is to establish a device that is convenient in use and cost for AAA monitoring. We hypothesize that arterial waveforms, which can be obtained with such a device, constitute a non-imaging solution for indicating AAA size. Here, we tested this hypothesis by leveraging an existing, anonymized AAA patient database [2].

The database included carotid and femoral artery tonometry waveforms, distance between the carotid and femoral arteries (D), arm cuff blood pressure (BP) values, and abdominal aortic diameter via imaging from 50 AAA and 50 control patients. The AAA patients were old (75±10 years) and mostly male (90%) and many had comorbidities (e.g., hypertension) and were on medications (e.g., beta-blockers). The control patients had similar attributes.

As shown in Figure 1, we extracted three features of AAA size from the measurements based on physiology. One feature was the ratio of carotid-femoral pulse wave velocity (PWV) to the product of diastolic BP and age. PWV decreases with increasing AAA size per the Moens-Korteweg equation but also decreases with decreasing BP and age [2]. PWV (=D/PTT) was detected at the level of diastolic BP via the foot-to-foot time delay between the carotid and femoral waveforms. The second feature was an index obtained from two lines optimally fitted to the carotid waveform upstroke (CUI). CUI is based on the presence of an early, negative wave reflection in AAA and may increase with increasing AAA size. The third feature was the carotid waveform inflection point area ratio (IPA), which is the diastolic area (after the dicrotic notch) divided by the systolic area. IPA is likewise based on the presence of an early, negative wave reflection in AAA and may increase with increasing AAA size. We also considered subject features including demographics (e.g., age, gender) and clinical information.

We built a linear regression model to predict the abdominal aortic diameter from the features. We selected the features and determined the model coefficients using stepwise regression with the measured abdominal aortic diameter as the dependent variable. We applied leave-one-out cross validation to compare the predicted and reference diameters. For comparison, we likewise built and tested a baseline model in which the waveform features were excluded as input.

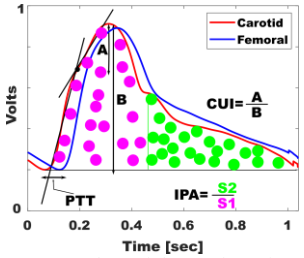

Figure 1: Extracted arterial waveform features.

Figure 2 shows the predicted abdominal aortic diameter of the two models versus the reference diameter. The PWV and IPA features were found to be important. These results show that arterial waveform analysis can indeed indicate AAA size.

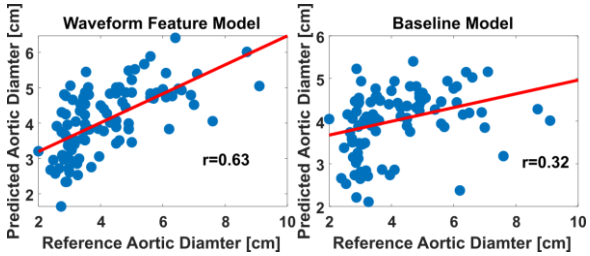

Figure 2: Model-predicted versus reference aortic diameter.

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