The Sound of Atherosclerosis: Voice Signal Characteristics are Independently Associated with Coronary Artery Disease

Elad Maor M.D. Ph.D1, Jaskanwal D, Sara MBChB1, Diana M. Orbelo, PhD2, Lilach O, Lerman MD PhD3, Yoram Levanon, PhD, Noa Silberklang, Yotam Luz, PhD, Daniella Perry, PhD, Amir Lerman MD1
(1) Division of Cardiovascular Diseases, (2) Department of Otorhinolaryngology, (3) Division of Nephrology and Hypertension (4) Beyond Verbal Communications

Mayo Clinic, Rochester, MN

Background

Diagnosis of CAD is challenging: There is still a need for simple non-invasive tests to facilitate screening and improve the accuracy of the cardiovascular risk estimation models by incorporating additional markers of cardiovascular disease.

Voice – a novel diagnostic approach:
Voice signal characteristics have been suggested to be associated with a number of different pathological entities. As a systemic inflammatory process, coronary atherosclerosis is associated with multiple pathologic processes such as chronic kidney disease, cerebrovascular disease and vascular dementia, retinopathy and peripheral artery disease. We therefore hypothesized that this process might also involve the anatomic structures association with voice production.

Study Aim

Identify association between voice characteristics and CAD among patients presenting for evaluation of myocardial ischemia by coronary angiogram.

Methods

Study population
150 patients, including 120 patients who presented for coronary angiography, 21 apparently healthy control volunteers and 9 control subjects who were referred to non-cardiac procedures. Study protocol was approved by the institutional review board (#IRB 14-000058), and all patients provided informed consent for participation.

Voice characteristics
Patients were asked to speak aloud a predetermined amount of text into a recording device. Voice was recorded, stored online and analyzed for each participant: R from the voice [MFCCs] were used in order to extract information – the participant was asked to read a prespecified text, R separate baseline voice recordings were documented and analyzed for each participant: R

Results

Presence of CAD, defined as angiographically determined stenosis of any degree present in at least one of seven pre-determined coronary vessels documented as present or absent (binary variable).

Multivariate analysis

OD | 95% CI | P
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Age | 1.073 | 1.021-1.128 | 0.006
Gender | 2.362 | 0.819-6.811 | 0.132
Feature 15 | 1.915 | 0.850-4.265 | 0.134
Recording 2 – Positive experience | Age | 1.091 | 1.026-1.159 | 0.005
Recording 3 – Negative experience | Feature 15 | 0.044 | 0.212-0.549 | 0.034
Voice analysis example: CAD vs. Control

The red line for the CAD patient and green line for the control subject present the power spectrum density (PSD) of their speech frequencies expressed in the R3 recordings. The values were calculated by averaging over time the instantaneous PSD values calculated using Fourier transform on 25ms frames with 10ms shift.

Conclusions

• This is the first study to describe an association between voice characteristics and CAD: we identified thirteen voice features that were associated with CAD.
• The strongest association between voice and CAD was observed when patients were requested to record their voice while describing a negative experience (R3 recording).
• The association was found to be independent of age, gender and other traditional cardiovascular risk factors that are used in the Framingham risk score.

References
1. Levani, Y., & Lossos-Shifrin, L. Method and system for diagnosing pathological phenomenon using a voice signal. (Google Patents, 2008).