Can Laser Doppler Vibrometer detect carotid stenosis from skin vibrations? Hydraulic bench tests on patient-specific model.

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Background

Within the H2020 CARDIS project, we explore the use of a laser Doppler vibrometer (LDV) [1] to detect asymptomatic carotid stenosis from measurement of skin vibrations on the neck of affected patients. We hypothesise that flow instabilities induced by the stenosis will propagate as mechanical waves through soft tissues of the neck. We here report measurements on an experimental model to assess the ability of LDV to detect stenosis-induced vibrations.

Methods

A compliant carotid bifurcation with internal carotid artery (ICA) 76% area-stenosis model was surrounded by hydrogel and a skin-like layer to mimic neck's skin and soft tissues. Measurements were acquired (20KHz) at physiological flows (water) through the artery [2][3], at several distances downstream from the stenosis. Intra-arterial pressure measurements were performed at the same location for reference (Fig1A). To assess in which frequency range the Fast Fourier Transform spectra of the signals are most sensitive to changes in flow rate, we constructed a univariate linear model in SPSS for the integral of the normalized spectra (8K, Hann, 50%-overlap, LabChart), where inflow was used as covariate and the frequency range as fixed factor.

Results

The spectrograms (Fig1B) showed that the LDV was able to detect flow-induced instabilities in the 0-500Hz range. The sensitivity was highest between 50-150Hz for both LDV and pressure.

Conclusion

The LDV was able to detect stenosis-related flow features with a sensitivity comparable to the intra-arterial manometer, proving the potential of the technique for stenosis diagnosis by detecting neck skin vibrations. In-vivo validation is in progress.

[1] Li Y et al, Optics Express 26(3): 3638-3645, 2018.

[2] Likittanasombut P, J Neuroimaging 16: 34-38, 2006.

[3] Groen HC, J Biomech 43: 2332-2338, 2010.