INFLUENCE OF HEMODIALYSIS ASSOCIATED CARDIOVASCULAR ABNORMALITIES ON PULSE WAVE ANALYSIS: MODELING-BASED APPROACH

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OBJECTIVES

Pulse wave analysis (PWA) performed on a recorded pulse wave shape in peripheral arteries is a well-established tool for non-invasive cardiovascular system status assessment. However, due to many abnormalities, such as fluid overload, changed blood rheology and arteriovenous fistula, it is unclear how reliable is PWA for patients on hemodialysis (HD).

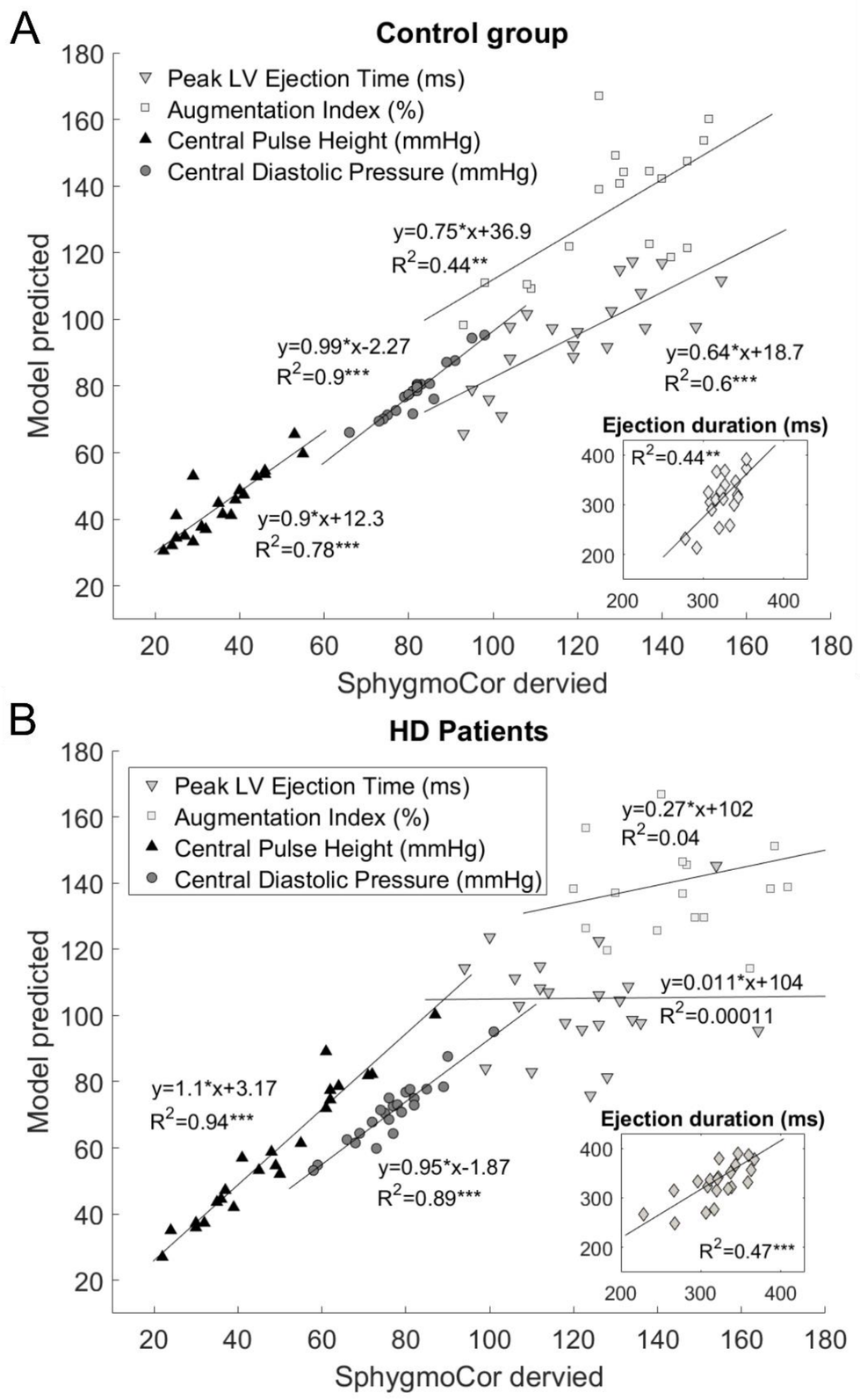

Figure 1. Correlation of selected model-predicted and SphygmoCor derived pressure waveform characteristics for (A) control subjects and (B) hemodialysis patients. Shown are linear regression equations together with coefficients of determination (R^2). Correlations were tested using Pearson's linear correlation coefficient.

METHODS

Peripheral pressure profiles of 20 healthy volunteers (10 females, age 40.9 +/- 10.3 years, weight 79.2 +/- 21.3 kg) and 23 stable prevalence HD patients (14 females, age 64.8 +/- 13.3 years, weight 70.1 +/- 15.4 kg, median dialysis vintage 9.6 (1.3 – 29.8) years) were recorded and analyzed using applanation tonometry (SphygmoCor, AtCor Medical, Australia). Patient-specific stroke volumes were additionally measured using impedance cardiography (PhysioFlow, Manatec Biomedical, France).

Recorded peripheral pressure profiles were used to estimate five patient-specific parameters of physiology-based mathematical model of blood flow in the system of fifty-five compliant and tapering arterial segments, i.e. elasticity of arterial wall, compliances and resistances of capillary bed, moment of peak left ventricular (LV) ejection and stroke volume.

RESULTS

- In both control and HD group statistically significant correlations were found between model estimated and SphygmoCor derived heart ejection duration and central systolic/diastolic pressures, Fig. 1.
- Correlations between model predicted and SphygmoCor derived augmentation index and peak LV ejection time were found only in the control group, compare Fig. 1.
- Correlation between model predicted and measured stroke volume was found in both cohorts.
- There was a high agreement between the simulated and recorded peripheral pulse profiles in both groups (average R^2 of 0.94 and 0.92 for control and HD group, respectively), Figs. 2A and 3A.
- Model predicted central systolic and diastolic pressures were on average higher and lower, respectively, by about 5 mmHg compared to those derived by SphygmoCor, Figs. 2B and 3B, as described previously [1,2].

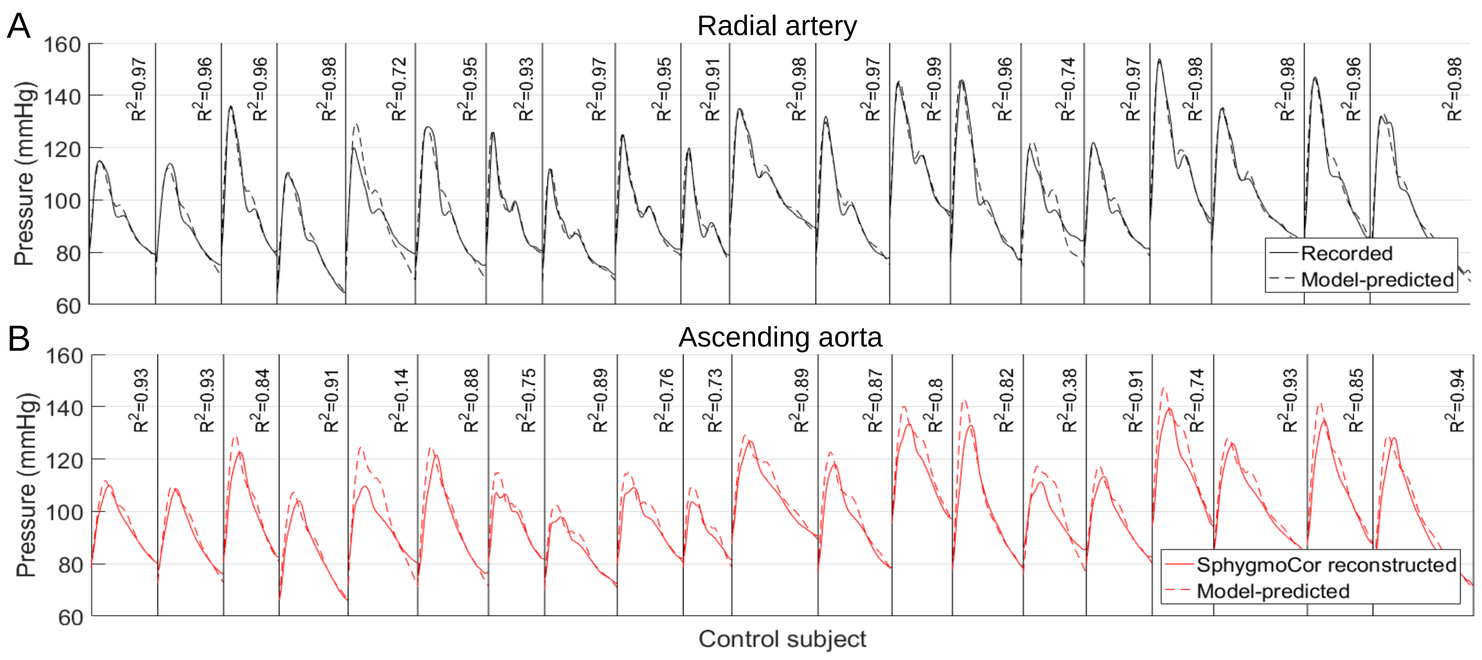

Figure 2. Comparison of SphygmoCor derived (solid lines) and model-predicted (dashed lines) pressure waveforms in (A) radial artery and (B) ascending aorta for control subjects. R^2 is coefficient of determination.

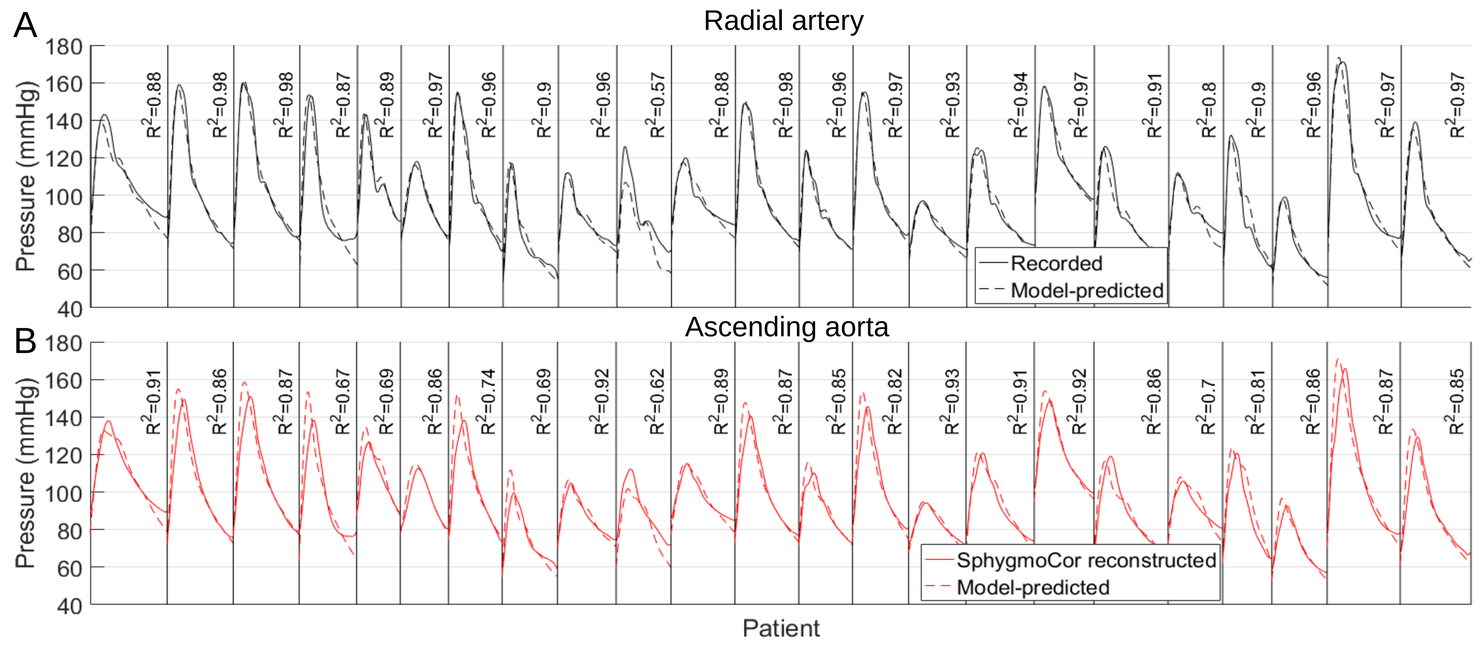

Figure 3. Comparison of SphygmoCor derived (solid lines) and model-predicted (dashed lines) pressure waveforms in (A) radial artery and (B) ascending aorta for HD patients. R^2 is coefficient of determination.

CONCLUSIONS

Good agreement between modeling and PWA results in healthy cohort indicates that for general population PWA agrees with the standard physiological assumptions about pulse wave propagation. However, lack of correlation between model-predicted and SphygmoCor derived augmentation index indicates that the cardio-vascular system abnormalities may have a significant impact on PWA. Having established patient-specific modeling framework we can further investigate how various changes in cardio-vascular system affect PWA.

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DOI: 10.3252/pso.eu.54ERA.2017
ePosters supported by F. Hoffmann- La Roche Ltd.
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