Hemodynamic effects of hypertension and type 2 diabetes

insights through a 4D flow MRI-based personalized cardiovascular model

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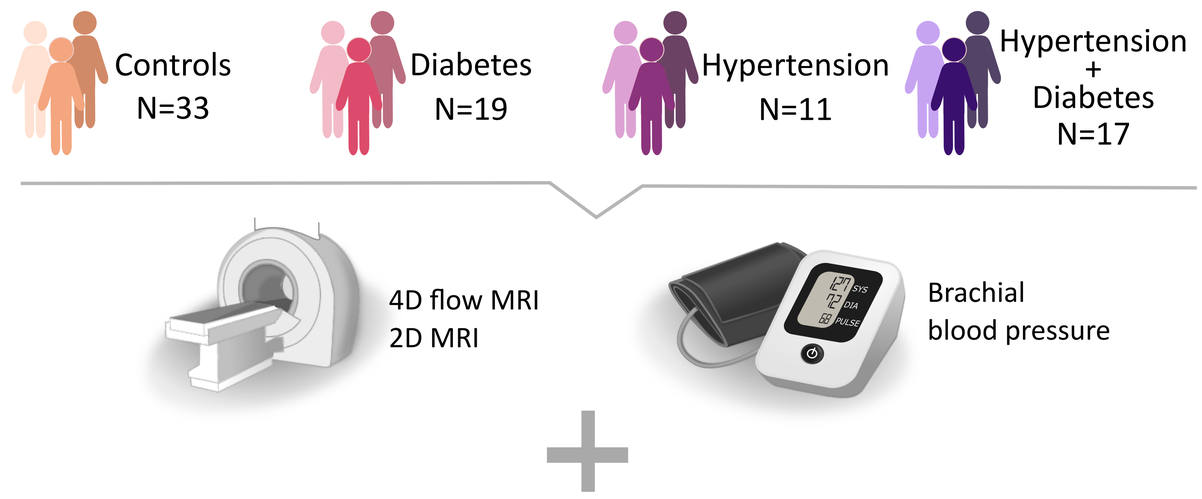
Introduction

- Hypertension (HT) and type 2 diabetes (T2D) are risk factors for cardiovascular diseases such as coronary artery disease and stroke [1,2].
- The link between these diseases and diabetes and hypertension can be understood through changes in the regulation of blood flow and blood pressure - the hemodynamic mechanisms.
- We combine mechanistic models [3] with four-dimensional magnetic resonance imaging (4D flow MRI) to further elucide the hemodynamic mechanisms in hypertension and T2D.

Method

1 Hemodynamic measurements

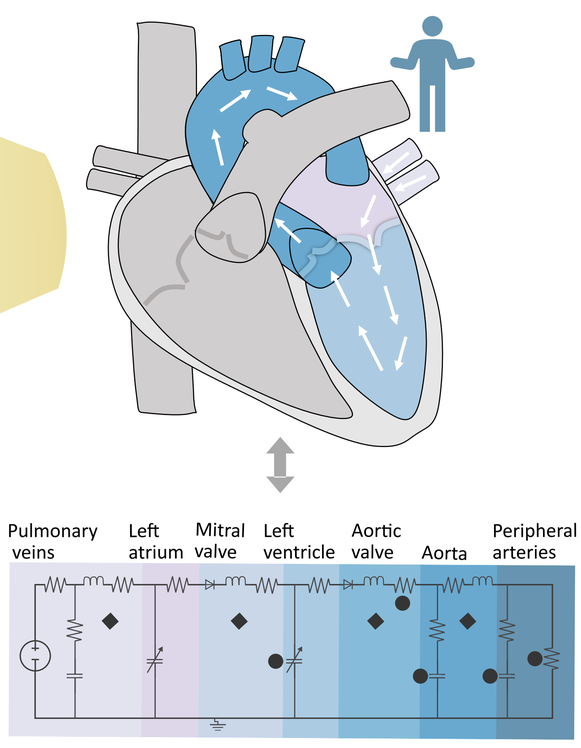
N = 80 subjects from SCAPIS Linköping [4,5] were included.



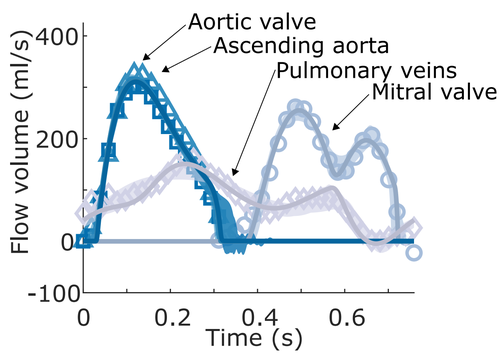
2 Subject-specific cardiovascular models

For all 80 subjects, the model can describe estimation data of 5 data-based variables, systolic and diastolic blood pressure, and blood flow volume in four locations in the heart.

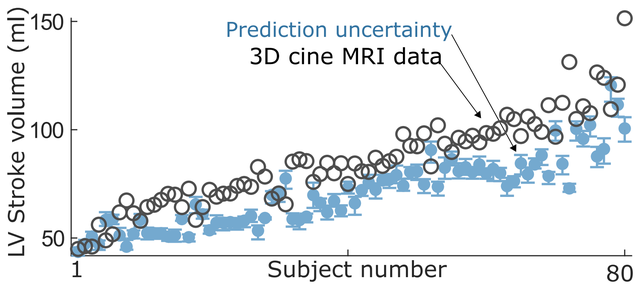
The cardiovascular model:



Model training - simulation (—) vs estimation data (o) for one of the subjects:



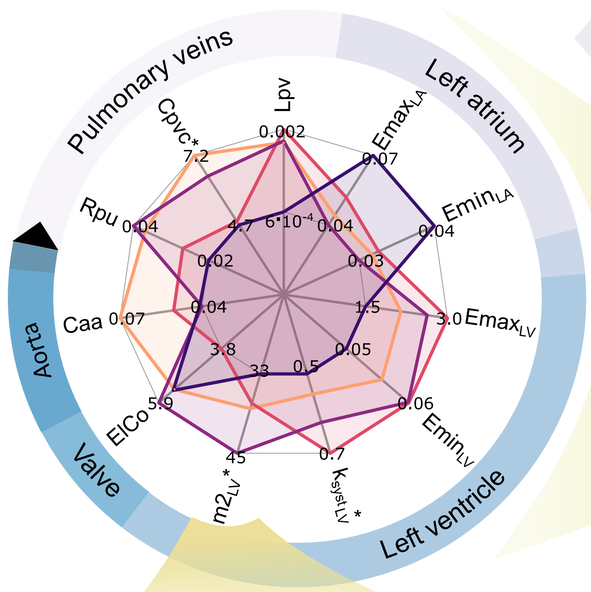
Model comparison - prediction vs data not used in model training:



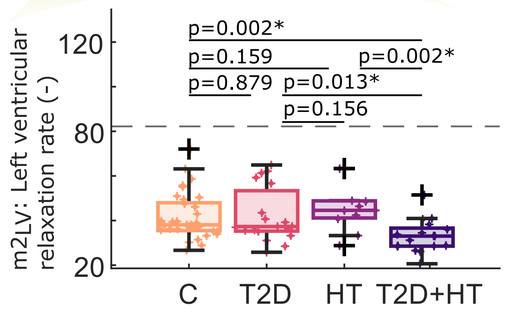
Results

3 Differences in hemodynamic function

Median values of the hemodynamic parameters that differ most between any of the four groups.

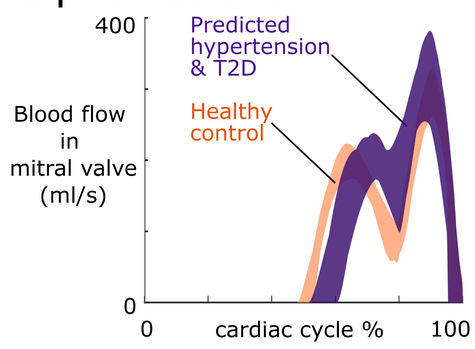


The left ventricular relaxation rate (m2LV) is lower in subjects with both T2D and HT compared to controls, T2D, and HT alone.

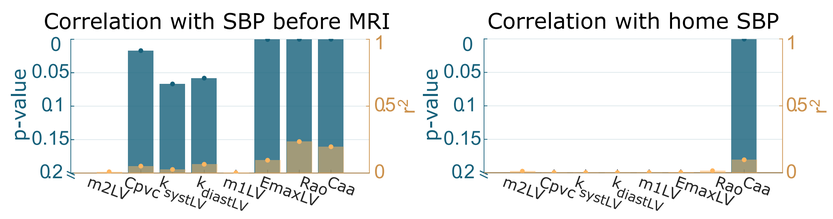


4 Patient-specific predictions

Based on the hemodynamic differences, the model can make new patient-specific predictions of reduced ventricular relaxation rate in a healthy control.

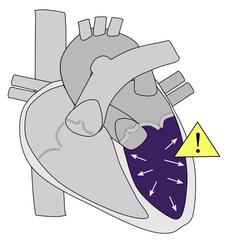


5 Correlation with other hemodynamics



Conclusions

- Combining the cardiovascular model and MR imaging data demonstrated that the hemodynamic mechanisms in hypertension and T2D are complex, subject-specific, and dependent on concurrent hemodynamics.
- Subjects with both T2D and hypertension have slower left ventricular relaxation, indicating diastolic dysfunction, compared to controls and subjects with only T2D or hypertension.
- A comprehensive and subject-specific analysis is needed to fully understand the hemodynamic mechanisms, including a gradual change of a combination of several subject-specific hemodynamic parameters such as aortic stiffness, heart rate, and ventricular contraction and relaxation
- The use of the subject-specific model to predict patient specific disease progression is a first step towards a use in patient-specific analysis and treatment planning to prevent cardiovascular events.



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Region Östergötland

CMIV
Center for Medical Image Science and Visualization

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[5] Edin C et al. (2022). Front Cardiovasc Med.

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