

# AN IN VIVO METHOD FOR MEASURING VESSEL WALL MOTION AND CYCLIC STRAIN USING MAGNETIC RESONANCE IMAGING

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**Abstract** — The measurement of vessel wall motion and cyclic strain has important applications in physiology and disease research, the design of intravascular devices, and cardiovascular treatment planning. However, present methods for measuring wall motion and strain have limitations. We developed a method to measure vessel wall velocity using phase contrast (cinePC) magnetic resonance imaging (MRI) techniques. These data are then used to calculate the cyclic strain in the wall. This method was evaluated using a pulsatile flow rig with a simulated vessel fabricated from polyvinyl alcohol cryogel (PVA). Although further development and validation are required, this method has promise for measuring vessel motion and cyclic strain *in vivo*.

**Keywords** — Magnetic resonance imaging, vessel strain, wall motion

## I. INTRODUCTION

Prior attempts to measure vessel wall motion *in vivo* focused on tracking the luminal boundary over the cardiac cycle. This approach is problematic since out-of-plane motions can yield the false impression of in-plane deformation. Prior studies to track myocardial strain, using methods such as Fourier tracking [1], are not directly applicable to measuring vessel wall cyclic strain as they assume that the imaging spatial resolution is small compared to the size of the object and the heterogeneity of the strain field being studied. A new approach is to measure the actual velocity of the vessel wall and calculate the cyclic strain directly from the velocity. We have used cinePC MRI to measure vessel wall velocity data and calculate the cyclic strain in the vessel wall.

## II. METHODS

A model vessel was fabricated using PVA. The manufacturing process and material properties are detailed in [2]. This tube was then connected to a water-filled flow rig and computer-controlled pump which provided a sinusoidal waveform. CinePC MRI was used to obtain time-resolved velocity data in axial slices through the vessel. Using Matlab (MathWorks, Inc.), the vessel was manually segmented for each time frame, and the velocity components were averaged

through the thickness of the wall for 200 segments around the vessel. The strain rate was calculated using a small strain approximation from the vessel wall velocity field and assuming a constant strain rate throughout the time of each image frame.

## III. RESULTS

The magnitude image for one time frame is shown in Figure 1. The average circumferential strain over the pulse cycle is shown in Figure 2. This was obtained by averaging the strain along the circumference of the wall.



Figure 1

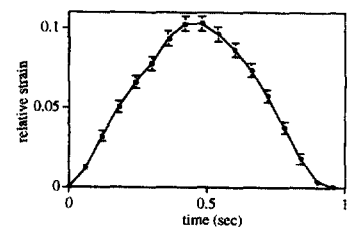


Figure 2

## IV. DISCUSSION AND CONCLUSIONS

This study measured the average strain throughout the wall thickness. As techniques and resolution improve, it will be desirable to improve the segmentation of vessel wall and incorporate particle tracking to allow for more accurate vessel strain measurements. It is possible to calculate vessel wall strain from cinePC MR data. Although the technique will need validation, this appears to be a viable method to use for *in vivo* quantification of vessel wall motion and strain.

The authors thank Rebecca Fahrig for her help with scanning.

## REFERENCES

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