# Using PIV for left ventricular flow analysis

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## Introduction

The flow in the left ventricle of the heart is of great interest to a number of research areas like embryonal development and congenital defects, diagnostics of abnormal muscle activity, influence of prosthetic valve orientation and geometry on its function and optimization of new valve designs.

### *Objectives*

To analyse the flow in a left ventricle model by means of an experimentally validated 3D computational model.

## Methods

### *Computational*

A 3D computational model of the ventricle was developed using a finite element method to solve the instationary Navier-Stokel equations using an arbitrary Lagrange-Euler method. Mesh deformation is prescribed to mimic the wall movements in the experiments.

### *Experimental*

A transparent EPDM rubber model of the ventricle based on MRI images was mounted in a plexiglass box (fig 1). The model was deformed by changing external pressure by motion of a piston. The flow is visualised using Particle Image Velocimetry. A Carbomedics prosthetic valve (fig2) was tested in the "natural" orientation, and rotated over $90^o$.

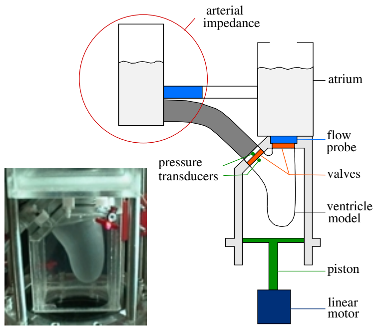


**Fig. 1:** *Experimental setup*

**Fig2:** *Carbomedics prosthetic valve*

The flow is seeded with light-reflecting particles. Using a pulsed laser sheet for illumination only particles in the sheet will be visible. Two cameras under a different angle see different displacements of particles which can be used to reconstruct the out of plane displacement component (fig 3).

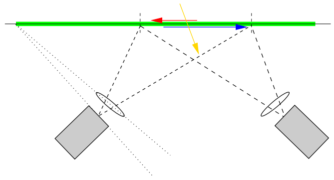

**Fig 3:** *Two cameras focused at light a sheet (green) through wich a particle moves (yellow). The displacement recorded by the right camera is red, the other blue.*

## Results

### *Computational*

The computational model shows the development of a jet with a vortex on either side during filling (fig 4).

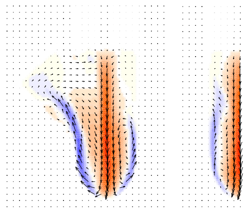

**Fig4:** *Computational results*

### *Experimental*

Physiologically relevant pressures and valve flows were realised. Visualisations were performed without the rubber model ventricle. The flow downstream the mitral valve (fig 5) is greatly disturbed by the leaflets when looking in a plane perpendicular to the axes of the leaflets while in the other direction a jet with two vortices on each side develops during filling.

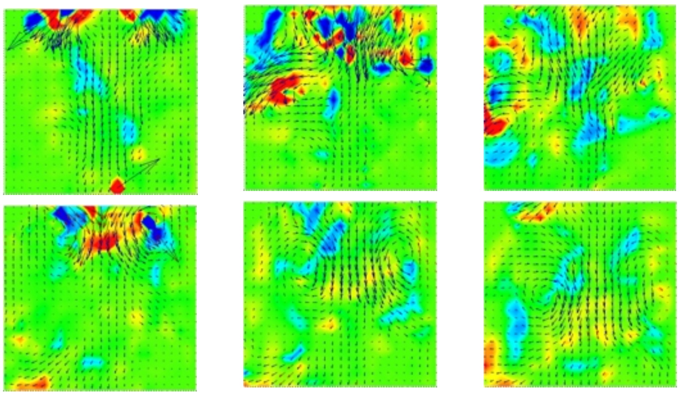

**Fig 5:** *Experimental results. Time increases from left to right. The mitral valve is located at the top in the center. The upper row shows the flow downstream the mitral valve with axes perpendicular to the light sheet, the lower with axes aligned with the light sheet. The background color is the out of plane component of the velocity.*

## Conclusion and Discussion

The experiments show that mitral valve orientation is important for the flow pattern in the ventricle. Computations with valve geometry and orientation will be done as well as quantitative PIV measurements using a rubber model ventricle.