Particle Image Velocimetry Reveals the Velocity Distribution in the Embryonic Chicken Heart

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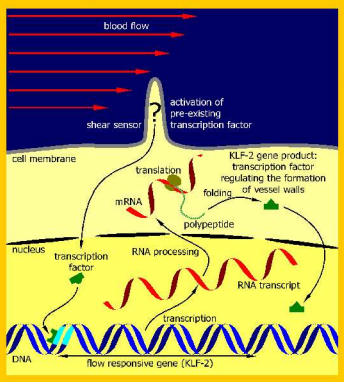
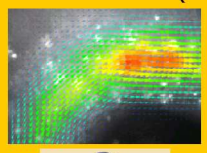
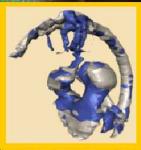
1. Motivation

How does blood flow interact with cardiovascular development?



cause: blood flow (PIV)

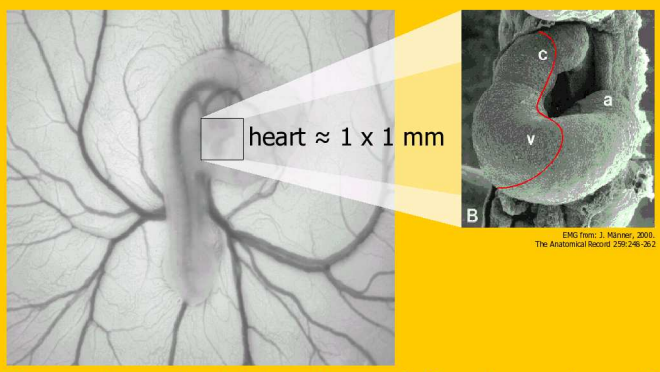




effect: gene expression (mRNA visualization)

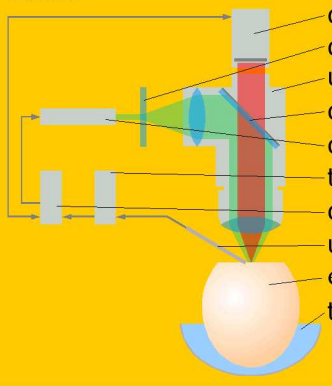
The comparison of blood velocity distributions (cause) and gene expression patterns (effect) helps to clarify the relationship between fluid forces (wall shear stress) and shear stress responsive gene controlled heart development.

2. Experimental Set-Up

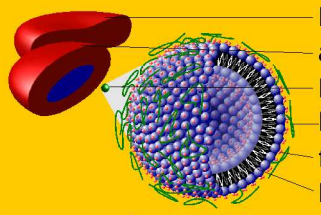


EMG from: J. Männer, 2000. The Anatomical Record 259:248-262

The embryonic chicken heart (after three days of incubation) serves as a model for the human heart.

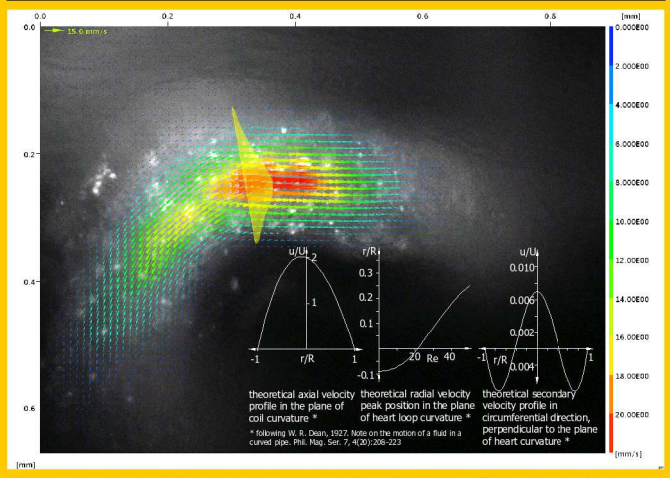


The image acquisition is synchronized to the cardiac cycle of the embryo by means of an ultrasound Doppler velocimeter. In this way, measurements can be repeated at identical flow conditions to enable ensemble correlation.



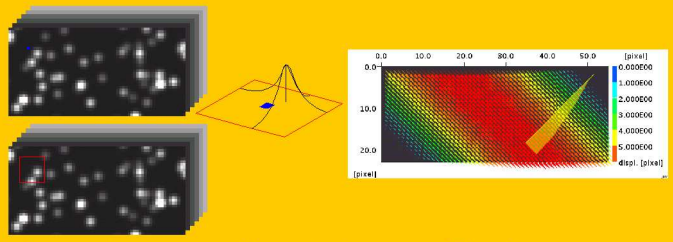
Long circulating (due to polyethylene glycol – PEG – coating) liposomes are utilized as tracer particles.

3. Results



Due to the asymmetric velocity profile, the inner curvature wall is exposed to higher shear stress.

4. Work in Progress



1. Ensemble correlation of a single pixel position (≈ 10^2 images) with an extended search area.

2. One correlation function for every pixel position (size of the search area) is obtained.

3. The result is one time averaged velocity field with a resolution of one pixel (here shown for synthetic images).

For the accurate determination of the wall shear stress, single pixel ensemble correlation can increase the spatial resolution to one pixel.

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