If you wonder why your heart is on the left: it may just be a question of going with the flow

Posted on Tuesday 8th July 2008

Researchers at the University of Birmingham have developed a mathematical model that helps explain why our heart develops on the left side of our body and the liver on the right.

Writing in the Journal of the Royal Society Interface the team from the University's School of Mathematics used fluid mechanics to show exactly how tiny structures called cilia control the flow of fluid around the newly fertilised embryo.

This flow from right to left they create is linked to the embryo losing its left/right symmetry, something that is crucial in the development of all vertebrates. Vertebrates don't develop symmetrically, for example the heart develops on the left side of the chest and the liver on the right side of the abdomen.

This symmetry-breaking is necessary for survival and healthy development.

The research was supported by the Wellcome Trust and the Medical Research Council.

The Birmingham team's model shows how a simple mathematical formula can give an excellent estimate of the flow produced by each individual cilium. This formula also shows that cilia need to be tilted at angle of 35 degrees facing the posterior of the embryo to produce the maximum flow rate. The formula is supported by other groups' experimental observations of zebrafish and mouse embryos.

Dr David Smith MRC Training Fellow comments: "Although these cilia on the embryo are tiny they appear to play a key role in the early development of the body.

We have been able to develop a simple mathematical model, which demonstrates how the whirling motion of the cilia, directs fluid around a small structure on the surface of the embryo. This occurs because of a subtle interaction between the cilium and the cell surface it projects from – a feature that had not previously been modelled.

There are only around 50 microscopic cilia that develop on each embryo around eight days after fertilisation. Our model fits very well with what has been observed on mouse embryos where most of the individual cilia sit an angle of between 27 and 40 degrees. In many ways it is remarkable to think how such a subtle phenomenon can play such a crucial role in how the structure of our body and internal organs develop."

The Birmingham team are now working with researchers from the University's Medical School to see whether similar models can be used to explain how cilia operate elsewhere in the body.

Professor John Blake adds: "We are now looking at whether we can use similar techniques to understand exactly how sperm are able to swim so effectively. Cilia actually play a key role in transport through the body, for example sweeping fluid and foreign particles out of the lungs, so understanding exactly how they operate has a wide relevance."

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NOTES TO EDITORS

The full title of the paper is: Fluid mechanics of nodal flow due to embryonic primary cilia it is published in the Journal of the Royal Society Interfac

The research team is made up of Professor John Blake, Dr David Smith (MRC Training Fellow), and Dr Eamonn Gaffney - now at the University of Oxford.