hemodynamics in CHD Result In Brief

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Resolution of congenital heart defects

Congenital heart defects (CHDs) cover a wide range of heart defects at birth and affect almost 1 % of the population. Besides poor life expectancy and quality of life for patients, considerable healthcare expenses are also incurred.

Conventionally, severe CHD is treated via high-risk operations on the developed heart in early childhood to restore normal blood circulation, but outcomes are uncertain. No link has been found between genetic mutations and CHD, suggesting that forces causing abnormal blood flow in the foetus are responsible for these heart defects.

The EU-funded project HEMODYNAMICS IN CHD (Mechanical regulation of congenital heart defects) has investigated the in utero forces that remodel the heart and result in CHD.

Relevant heart defects were successfully created in chicken embryos using left atrial ligation (LAL) and right atrial ligation (RAL). Blood flow was thereby disturbed on either the left or right side of the heart at early stages of heart development. Measurements of morphological changes, such as valve size, and haemodynamics were modelled using computational fluid dynamics (CFD) methods.

Using LAL on embryonic day 4, the scientists successfully created an animal model of hypoplastic left heart syndrome. The CHDs created using RAL were part of the first model of its kind to ever be generated to describe defects affecting the right side of the heart.

Analysis showed that disturbed haemodynamic forces did cause abnormal heart morphology. The left atrioventricular valve is very sensitive to wall shear stress (WSS) and a decrease results in a corresponding reduction in orifice size. An increase in WSS results in an increase in valve orifice size. Ventricle development is sensitive to atrial flow and a decrease results in a corresponding decrease in ventricular volume.

Overall, left and right sides respond differently to changes in flow-induced forces. This was expected as the left side, being part of the systemic flow, operates under higher pressure than the right pulmonary system. Of great significance is that WSS abnormalities at the aortic valve result in a defect, but are tolerated at the pulmonary valve.

CFD modelling has provided in-depth information on changes in haemodynamic environments, such as shear stress levels and their effects on heart development. Treatment in the womb could include restoration of forces to prevent development of faulty valves and chambers.

Related information

Report Summary	Final Report Summary - HEMODYNAMICS IN CHD (mechanical regulation of congenital heart defects)

Subjects

Scientific Research

Keywords

Congenital heart defects, blood flow, atrial ligation, shear stress, valve

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