Virtual heart sheds new light on heart defect

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(Medical Xpress)—A virtual heart, developed at The University of Manchester, is revealing new information about one of the world's most common heart conditions.

Researchers at the School of Physics and Astronomy used cutting edge technology to build an advanced computational model of an anatomically correct sheep's heart. It was made by taking a series of very thin slices of the heart, imaging them in 2D and then using a computer programme to render them into a 3D model.

The reconstruction includes details of the complex fibre structure of the tissue, and the segmentation of the upper chambers of the heart into known distinctive atrial regions. Single-cell models that take into account information about the electrical activity in different atrial parts of regions the heart were then incorporated into the model. The virtual heart was then used to investigate the condition atrial fibrillation (AF).

Professor Henggui Zhang led the research and explains why they wanted to study AF: "Atrial fibrillation (AF) affects approximately 1.5% of the world's population. In the UK more than 500,000 patients have been diagnosed with the condition which causes an irregular heart rate. It is also known to increase the risk and severity of stroke. Despite its prevalence very little is known about what causes AF. We hoped our model would allow us to understand the mechanisms of this condition to ultimately help create better treatments."

AF occurs when abnormal electrical impulses suddenly start firing in the

upper chambers of the heart. These impulses override the heart's natural pacemaker, which can no longer control the rhythm of the heart. This desynchronises the heart muscle contraction and reduces the heart's efficiency and performance.

Professor Zhang and his team focussed on the pulmonary vein which is a common area that initially triggers AF. They simulated erratic electrical waves passing through the vein and the surrounding atrial tissue, and then studied the impact this had on the rest of the heart.

What they found was that regional differences in the electrical activity across the tissue of the heart, known as electrical heterogeneity, is key to the initiation of AF. The largest electrical difference was between the pulmonary vein and the left atrium which may go some way to explaining why the pulmonary vein region is a common source of irregular heartbeats.

The scientists also identified that the fibre structure of the heart plays an important role in the development of AF. There were directional variations in the conduction of electrical waves along and across the fibres, this is known as anisotropy. The fibre structure in the left atrium is much more organised compared with the complex structures of the pulmonary vein region. The sudden variation in conduction at the junction between the left atrium and the pulmonary vein regions appeared to contribute to the development of AF.

Professor Zhang says: "This study has for the first time identified the individual role of electrical heterogeneity and fibre structure in the initiation and development of AF. It has not previously been possible to study the contribution of the two separately but using our computational model we've been able to clearly see that both electrical heterogeneity and fibre structure need to be taken into consideration when treatment strategies for AF are being devised."

The next step for Professor Zhang and his team will be to find a way to target the electrical conduction in specific regions of the heart to better protect against AF. They also want to use their virtual heart to gain a deeper understands of AF and to apply their findings to the development of more effective treatments.

Professor Zhang concludes: "We're really excited about the potential that our virtual heart opens up for research into this incredibly complex organ. By bringing together physics and biology we hope to unlock some of the unanswered questions about atrial fibrillation – a condition which is only going to become more common as people live longer."

More information: The paper "A novel computation sheep atria model for the study of atrial fibrillation" will be published online in the Royal Society's independent journal, *Interface Focus*, on Wednesday 16 January 2013.

Provided by University of Manchester