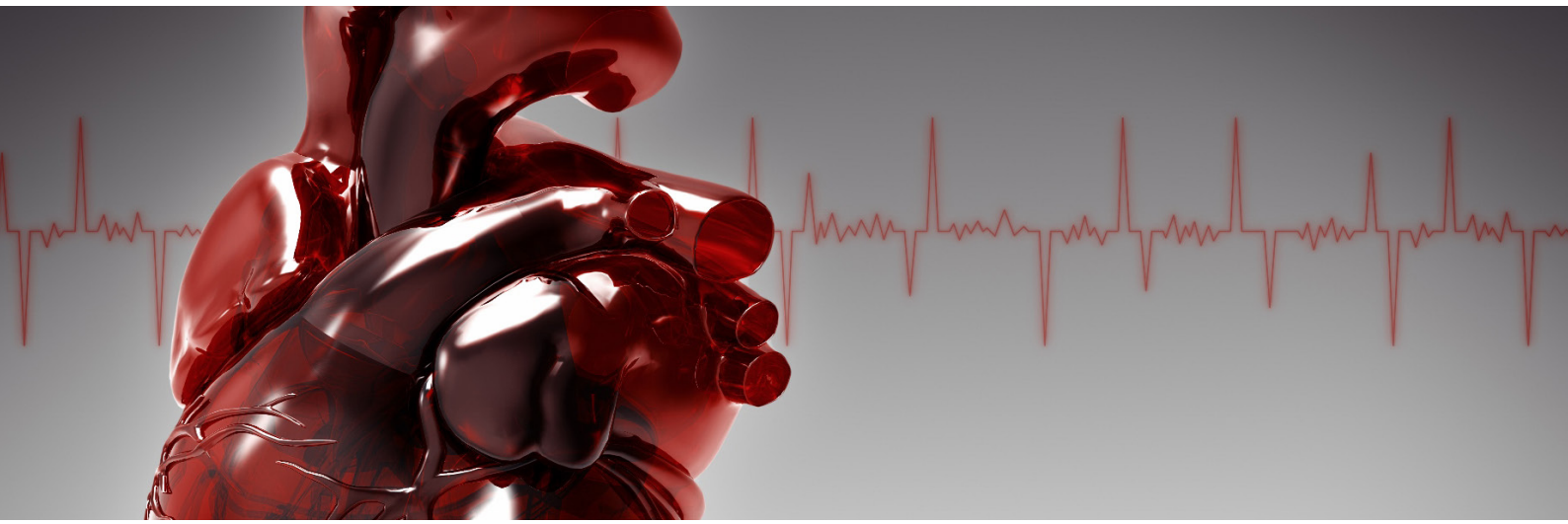
Using HPC to deal with matters of the heart

Hartree Centre
Science & Technology Facilities Council



A collaborative research project is using the STFC Hartree Centre's supercomputers to develop new methods of blood pump simulation, which could assist in the improvement of devices that prolong lives of people with heart disease.

Challenge

Heart and circulatory system diseases were the second most common cause of death in the UK, with around 155,000 people losing their lives in 2014*. With too few donors available, Ventricular Assist Devices (VADs), such as blood pumps, are increasingly used to manage heart conditions because they can prolong the life of the patient while they wait for a donor. In order to develop these devices, detailed analysis of blood flow around the body is required.

Blood flows in complex patterns are highly turbulent, making it difficult to simulate, and VADs need to operate under complex conditions and varying pressures. This means that a computational model which integrates the flow of blood through a pump requires large computing resources.

Solution

A research consortium including the Science and Technology Facilities Council (STFC), FH Aachen University of Applied Sciences, Jülich Research Centre and EDF R&D was set up to investigate the suitability of high performance computing (HPC) techniques to speed up the modelling process. The aim was to assess the accuracy of existing technique and increase confidence in computational approaches in the design of complex medical devices. This was done in the framework of the US Food and Drug Administration (FDA) Computational Round Robin #2.

To achieve a numerical blood flow analysis of a centrifugal blood pump, the research team used computational fluid dynamics combined with high performance computing, which enables calculations to be carried out faster and more accurately. In this case, one simulation involved 76 million elements or "computational cells" just to describe a pump's dimensions. To carry out this research, the team used 4 million hours of computing time on supercomputers at the Hartree Centre and Forschungzentrum Jülich.

Benefits

Computational fluid dynamics research which could improve the accuracy of VADs is essential to ensuring that the quality of these devices continues to improve, prolonging and even saving lives. The research results showed that the simulation was capable of scaling up to the high performance infrastructure which enables faster calculations, and proving that HPC is a suitable and useful method for future work. The team has also secured funding to develop the project further, which will involve assessing an existing mathematical model called large eddy simulation (LES) as a turbulence model for blood flow.

*British Heart Foundation: *Cardiovascular Disease Statistics 2015*

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