# Computer simulations of blood flow through mechanical heart valves could pave the way for more individualized prosthetic

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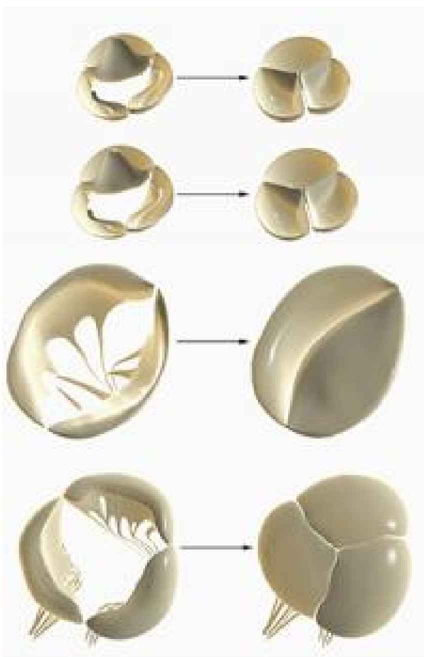

Four types of heart valves in open (left) and shut (right) positions. Diseased valves can be replaced with prosthetic ones but they can lead to complications. Credit: MedicalRF.com/Corbis

Every year, over 300,000 heart valve replacement operations are performed worldwide. Diseased valves are often replaced with mechanical heart valves (MHVs), which cannot yet be designed to suit each patient's specific needs. Complications such as blood clots can occur, which can require patients to take blood-thinning medication.

To investigate why such complications occur, Vinh-Tan Nguyen at A*STAR's Institute of High Performance Computing, Singapore, together with scientists at the National University of Singapore and institutions across the USA, have developed a new computer model to simulate the dynamics of blood flow through MHVs.

"The current practice for heart valve replacement in patients is a one-size-fits-all approach where a patient is implanted with the best-fit valve available on the market," explains Nguyen. "The valves are well designed for general physiological conditions, but may not be suitable for each individual's particular heart condition."

The researchers focused on the blood flow dynamics in a prosthetic valve known as a bileaflet MHV. This type of MHV contains two mobile leaflets, or gates, which are held in place by hinges. The leaflets open and close in response to blood flow pressures through the valve. Little is known about the effect that the hinged leaflets have on blood dynamics, although such designs are suspected of causing blood clots.

The computer model developed by Nguyen and his team simulates pressure flows through bileaflet MHVs by representing blood vessels as a computational mesh, where calculations are performed for individual blocks of the mesh. Their crucial advance was in enabling this mesh to move and evolve in response to the leaflet movements.

The researchers validated their computer model through laboratory experiments with a full 3D reproduction of the heart's circulation system . Particle imaging equipment allowed them to visualize the fluid dynamics under different scenarios including pulsatile flow, which follows the pattern of a typical cardiac cycle.

"We obtained good agreement between our computer simulations and the experiments in terms of the magnitude and velocity of blood flow through the leaflets," states Nguyen. The researchers also found that leaflet hinges might play a vital role in clotting, because individual hinges have different tolerances that can disrupt normal blood flow and cause stress in the vein walls.

This research is a first crucial step in understanding the impact of MHVs on blood flow. "Ultimately we hope to provide doctors with a tool to evaluate blood flow dynamics and other related aspects in patients with newly implanted valves," says Nguyen.

**More information:** Nguyen, V.-T., Kuan, Y. H., Chen, P.-Y., Ge, L., Sotiropoulos, F. et al. Experimentally validated hemodynamics simulations of mechanical heart valves in three dimensions. *Cardiovascular Engineering and Technology* 3, 88–100 (2012). rd.springer.com/article/10.1007/s13239-011-0077-z

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