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Researchers creating next generation prosthetic heart valves

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Researchers in the School of Biomedical Engineering and the Department of Mechanical Engineering at Colorado State University are working on developing replacement heart valves that will be superior to current mechanical and tissue-based heart valves and reduce patients' need for medication to prevent blood clots.

Supported by a five-year, $1.8 million grant from the National Institutes of Health, Assistant Professor and Principal Investigator Lakshmi Prasad Dasi leads a research team creating revolutionary heart valves that incorporate state-of-the-art engineering and design. The result will be a new family of heart valves made from synthetic materials addressing the problems associated with both mechanical and bioprosthetic or tissue-based valves.

"All present-day replacement heart valves suffer from significant drawbacks," explained Dasi, whose expertise is in heart-valve engineering and cardiovascular biomechanics. "Patients who receive mechanical heart valves must remain on lifelong medication to prevent blood clotting. On the other hand, bioprosthestic valves, usually made from tissue from cows or pigs, are prone to hardening over time and don't last more than 10 to 15 years. The valves to be developed in this project will be made from synthetic flexible materials containing hyaluronan, a molecule found in any soft tissue, with a structure optimized for superior performance over a much longer period of time."

Co-investigators on the project are Susan James, head of the Department

of Mechanical Engineering and an expert in polymer synthesis, and associate professor Ketul C. Popat, an expert in bio-compatibility and surface nano-engineering. Together with Dasi, they invented the novel technology that is at the heart of this project.

"We acknowledge that much of the groundwork for this project would not have been possible without the tools developed under my National Scientist Development Grant focused on heart valve disease, from the American Heart Association, and Dr. James's proof-of-concept award from the Colorado Office of Economic Development and International Trade," Dasi said.

The engineering team is also working with Dr. Christopher Orton, a veterinary cardiothoracic surgeon and head of the Department of Clinical Sciences in the College of Veterinary Medicine and Biomedical Sciences at CSU, who will implant prototype valves in pigs and sheep as part of the pre-clinical evaluation.

"In addition to superior performance when implanted in patients, the next generation synthetic material heart valves will allow for easy automated manufacturing, as opposed to the laborious process currently used to manufacture tissue valves," Dasi said. "This would enhance the consistency while reducing cost of the device, which will become increasingly important in the coming years as demand grows for a replacement valve that will last a lifetime without the need for continuous anti-clotting medication. Currently, over 290,000 heart valve procedures are performed annually worldwide, and that number is estimated to triple to over 850,000 by 2050, an expansion rate of 10 percent to 12 percent per year."

In addition to heart valves, the team hopes their innovative strategy to reduce the need for anti-clotting medication will find applications in any medical devices where manmade surfaces come in contact with blood

flow, such as implanted stents, ventricular assist devices, extra-corporeal circuits, and heart-lung and dialysis machines.

"Further, our goal is to translate this new paradigm to also engineer next-generation minimally invasive heart valves," Dasi added.

Research on developing the new and improved heart valves began last month in the new Suzanne and Walter Scott, Jr. Bioengineering Building on the CSU campus.

"All of our labs are next to each other," Popat said. "The advantages of being co-located for us as researchers—as well as for the graduate and undergraduate students who are learning some very practical aspects of applied science – are already obvious."

Provided by Colorado State University