Making heart transplants obsolete with small removable pump

December 18 2017

On this 50th anniversary of the first heart transplant, which occurred in December 1967, a University of Houston biomedical engineer is creating a next-generation heart pump for patients suffering with heart failure. Results are so promising that Ralph Metcalfe, professor of mechanical and biomedical engineering, who oversees the research project with William Cohn, director of the Center for Technology and Innovation at the Texas Heart Institute, predicts radical improvement in treatment of failing hearts will happen within a decade.

What sets it apart from other devices is its ability to assist, perhaps temporarily with the potential to remove it, allowing some patients to avoid both heart transplants and life-long use of an LVAD (left ventricular-assist devices) heart pump. "This device, once perfected, can have as much impact on society as the polio vaccine had in the 1950s," said Metcalfe. "Breakthroughs are coming very fast." These new devices in some cases - perhaps most - will be lifelong helpers for the heart. But for some, the device is expected to give the heart enough of a rest that the heart can actually heal, something infrequently heard of in today's state-of-the-art practices. This will not be like the larger and more cumbersome pumps of past decades, but a small device that can be implanted without major surgery. The goal is to develop better, less invasive treatments that can be used early in the course of cardiovascular problems, long before critical stages of heart failure manifest. Potential benefits are enormous.

"If you look at the causes of death in 2015, the most recently reported year, about 23 percent were related to heart disease. Heart failure is a major part of that," Metcalfe said. In the United States, more than 6.5 million people live with varying stages of heart failure.

In Texas Heart Institute laboratories, performance of LVADs depends in great measure on the small impellers mechanical engineering Ph.D. candidate Alex Smith is working to perfect. To maintain ideal speed and pressure, the impellers must maintain a flow that is neither so mild the pump is inefficient nor so forceful that cells become misshapen or otherwise damaged by shear in the blood flow. 3-D printers replicate Smith's designs in about eight hours, a process that used to take a machinist months to craft by hand. "This is a huge advance, hard to overemphasize," said Metcalfe.

A happy anniversary

Those early artificial hearts, medical breakthroughs in the 1960's, were huge and heavy, with only a small part of the mechanism implanted into a patient's chest. The rest of the (often noisy) equipment was left outside of the body, either bedside or on a cart that trailed the patient. Survival was measured in weeks at first, then in months. Today, patients can live up to a decade with their circulatory system at least partially dependent on an implanted mechanical pump with a wearable external battery.

Current artificial heart pumps are not replacements for a biologic heart. Instead, they are assistants that function alongside a weakened heart, helping do the job of pumping blood. These left ventricular-assist devices are implanted close to the patient's own heart. They most often are considered a "bridge-to-transplant" treatment, a way to carry a very sick patient until a suitable donor heart is found.The heavy, bulky equipment that functioned outside a patient's body may be long gone, but the heart pumps now being implanted are still ungainly enough to cause discomfort.

Small miracles

The small device the team is developing fits easily in the palm of a hand. It will be implanted percutaneously, meaning it will be passed through an incision in the skin, most likely into the subclavian vein just beneath the collar bone, then carried to the heart's atrial septum (the wall separating the left and right atria). In contrast, implanting a current heart pump requires a surgeon to make a large incision and open the patient's chest.

Intervening early in the disease process, before the heart is too seriously damaged, allows the best chance for such healing to happen."It's like an athlete whose injury is immediately immobilized on the playing field," Metcalfe explains. "By being immobilized, the injured area heals quicker. We haven't been able to immobilize a living heart, of course. But with this device, many unhealthy hearts may get the rest they need to recover."

If complete healing is accomplished, the LVAD will be removed and the heart left to function on its own, healthy and strong. Those patients could expect full lifespans and enjoy normal lifestyles.

Provided by University of Houston