Skin no barrier for cardiac charger

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Heart-failure patients may someday get a life-saving charge from technology developed by students at Rice University.

A team of seniors designed and built a transcutaneous energy-transfer (TET) unit to power a minimally invasive ventricular assist device (VAD) being created by a Houston company. The VAD is a tiny pump inserted into the aorta via a catheter that helps increase blood flow and heal patients with heart failure.

Rice tCoil – Michael Torre, Erin Watson, Tyler Young, Trevor Mitcham, Hana Wang and Alex Dobranich – made a complementary device that sits a centimeter under the skin and feeds power to the VAD. The challenge presented to the seniors, who were required to complete a capstone design project by Rice's George R. Brown School of Engineering, was to charge the unit wirelessly.

“A lot of people need heart transplants, but there aren’t enough hearts available,” Young said. “One alternative is to have a heart pump implanted, but that carries risks. It’s very invasive surgery, and afterward you have to have wire leads running out of your body” to a battery pack.

The portal through the skin to a power supply can become infected, he said. But the problem is avoidable by sending power to the VAD without wires. The students’ prototype consists of a small coil and a battery that would be inserted one centimeter under the skin at the patient’s waist and wired to the VAD. The patient would also wear a belt-mounted external battery and coil to generate alternating magnetic fields and induce alternating current in the subcutaneous coil. The coils charge the battery, which can operate the pump for more than three hours.

“The patient can take the belt off for a short time, to take a shower, for instance,” Young said. “The pump will work safely off the coils or on the internal battery alone, but obviously it’s best when they’re both working.”

The team demonstrated tCoil at the Engineering Design Showcase that was part of Rice’s recent UnConvention open house. The students put the internal and external coils on either side of a baggie containing lunchmeat to simulate power transfer through the skin. The internal unit was wired to a demonstration pump that clearly pushed red-colored water through a sleeve inside a tank.

The student project was in response to a request from Rice alum Michael Cuchiara, director of research and development at Procyrion, developer of the pump.

“I mentored two senior design teams while I did my Ph.D. in bioengineering at Rice and helped bring a project to Maria Oden (a professor in the practice of engineering and director of the Oshman Engineering Design Kitchen at Rice) for a different client company in

2009," Cuchiara said. "For this project, until recently, our company's expertise was not heavy in electrical engineering design, and I knew Maria could put together a good team."

He said the students, who were mentored by Oden and Gary Woods, a Rice professor in the practice of computer technology and electrical and computer engineering, came through for him. "The Rice team brought us a quick, capital- and resource-efficient proof-of-concept system to show we can power our device through TET," Cuchiara said. "There's was no reason to think we couldn't – but until you do it, you don't have it."

The project is far from complete, Young said. "Erin will work on it this summer, but at some point Procyrion will take it over and continue development," he said. "The next steps will be to miniaturize it and put it in biocompatible casing. Once that's done, it can be implanted for large animal testing." Ideally, he said, the long process of approval by the Food and Drug Administration will follow.

But team members will graduate with the satisfaction of a job well done and two awards: for Best Interdisciplinary Design Project at the Design Showcase and for best medical and rehabilitation technology at the third annual Rice Undergraduate Elevator Pitch Competition last November.

Cuchiara said TET will make ventricular assist available to an ever broader set of patients. "The concept that you can induce a current in another coil without connecting them electrically has been around since Tesla," he said. "And VADs have been around for more than 10 years. But before, they were offered to people who were on their deathbeds. Now that we're able to take the risk (of passing a wire through the skin) out of the equation, we're starting to talk about bringing VADs to people who aren't that sick and can just use a little bit of support."