This company is bioengineering pig kidneys and livers for possible transplant into humans

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In an Minnesota lab, clear containers hold pig kidneys and livers that scientists hope will someday be transplantable in humans.

Miromatrix Medical, a biomedical firm based in the Twin Cities suburb of Eden Prairie, is exploring the scientific area known as xenotransplantation.

Xenotransplantation is a blanket term for a wide range of biomedical procedures aimed at increasing the options, and shortening the waitlist, for people in need of donated organs. The U.S. Food and Drug Administration defines it as any procedure involving the transfer of cells, tissues or organs from a nonhuman animal source into humans.

Nearly 100,000 Americans are waiting for a kidney and about 23,000 patients receive transplants each year, said Claire Johnson, program manager for the National Kidney Foundation's Minnesota operations. The technologies underway at Miromatrix and its competitors are aimed at creating new sources of implantable organs.

"The implications could be enormous for eliminating the waitlist," Johnson said. "It would be transformative."

A high-profile case earlier this year shed light on both the promise and continued challenges of xenotransplantation. A genetically modified pig heart was transplanted into 57-year-old David Bennett at the University of Maryland Medical Center. Although he died two months later, researchers viewed the procedure as a success because Bennett's body did not reject the organ.

Miromatrix Chief Executive Jeff Ross said that—unlike the Maryland case—their system removes all pig cells, including any viruses, from the organs in a process known as "decellularizing."

"We start with that pig organ, but we're removing all the cells. … We call them 'bioengineered organs,' " Ross said, adding that Miromatrix's competitors are using genetically modified pig organs.

Xenotransplant research stretches back decades, with pig organs having proved to be the best animal source for transplantation as they are roughly the same size as human organs.

There are two primary concerns in this field: immunosuppression and the possible transmission of animal viruses. To address the immunity concern, drugs are given to lower a patient's natural immune response in hopes the body won't attack the transplanted organ.

Ross believes his company's approach eliminates the viral risk because its pig organs will have human cells, meaning that standard immunology transplant protocols could be used.

To decellularize an organ, Miromatrix injects a chemical that dissolves the pig cell membranes. "We essentially use a detergent," Ross said.

The scaffold of the organ is essentially unchanged, he said. Miromatrix then recellularizes the organ with human cells from organs not placed for transplants.

Dr. Allan Kirk, a kidney transplant surgeon with Durham, N.C.-based Duke Health who has worked on xenotransplant research since the early 1990s, said genetically modified organs are ready for clinical trials but the outlook is less certain for the Miromatrix approach.

"There are a lot of people that have been working on decellularized organs. … That is way less developed than the approach of genetically modifying pigs," he said. Most research on decellularized organs is being done at universities and private labs. Miromatrix is the only company trying to commercialize it.

"It's not the same as a xenotransplant, but it's not the same as a [human-to-human] allotransplant either. It's something in between," Kirk said of

the company's work.

Miromatrix's technology was developed at the University of Minnesota. Dr. Christopher McGregor, a professor of surgery at the university's medical school with a research background in xenotransplantation, agrees that Miromatrix's approach faces more challenges in the short term.

"It is innovative and in the long term has potential. … There's a lot of work yet to be done before it's ready for prime time," said McGregor, who is part of the university's porcine transplantation program that's working towards its own clinical trials for pig organ transplants.

Ross, Miromatrix's CEO, points to the company's previous developments as reason for optimism. The company has already used its decellularization process for two products cleared by the U.S. Food and Drug Administration (FDA). Miromesh is a biological mesh that can be used in hernia repair procedures, and Miroderm can be used for wound treatment. Both products are derived from decellularized pig livers.

In 2019, Miromatrix spun off a new company, Plymouth-based Reprise Biomedical, which now markets Miromesh and Miroderm.

"We have thousands of patients who have been implanted with the matrix with no immune-related issues," Ross said. The "matrix" refers to the protein matrix that surrounds the cells.

The company still has a long road to getting FDA approval for its kidneys and livers. Miromatrix has yet to say when it hopes to begin clinical trials for implanting the organs into humans. It plans to submit its pre-investigational new drug application to the FDA in 2023.

The company will, however, start clinical trials of its external liver assist

device in 2023. The external liver device is essentially a one-time liver dialysis that integrates a bioengineered pig liver with an existing pump system already in use at most hospital ICUs, Ross said. A patient's blood passes through the bioengineered liver and then returns to the patient.

Miromatrix went public in June 2021, raising about $44.6 million. But like many companies that went public last year, its stock is now trading significantly lower from where it debuted.

Medtech giant Baxter International and dialysis service provider DaVita Inc. own nearly one-fifth of Miromatrix.

The University or Maryland case renewed interest in animal organ transplants. After the patient's death, doctors discovered that the heart contained a porcine virus, though it's unclear whether that contributed to the man's heart failure.

"This is an inflection point for the xenotransplant field," said Kirk, the surgeon from Duke Health. "I would say that there are more things unsolved than there are things that are solved."

That doesn't mean the Maryland case wasn't encouraging, Kirk and McGregor said.

"I thought that it was a landmark case," McGregor said. It offers "the beginning of a road of making xenotransplantation a potential treatment for patients with end-stage organ disease."