

University of Maryland first to use unmanned aircraft to deliver kidney for transplant

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In a first-ever advancement in human medicine and aviation technology, a University of Maryland unmanned aircraft delivered a donor kidney to surgeons at the University of Maryland Medical Center in Baltimore for successful transplantation into a patient with kidney failure. Credit: University of Maryland Medical Center/University of Maryland School of Medicine

In a first-ever advancement in human medicine and aviation technology, a University of Maryland unmanned aircraft has delivered a donor kidney to surgeons at the University of Maryland Medical Center (UMMC) in Baltimore for successful transplantation into a patient with kidney failure. This successful demonstration illustrates the potential of unmanned aircraft systems (UAS) for providing organ deliveries that, in many cases, could be faster, safer, and more widely available than traditional transport methods.

The momentous flight on April 19, 2019 was a collaboration between transplant physicians and researchers at the University of Maryland School of Medicine (UMSOM) in Baltimore; aviation and engineering experts at the University of Maryland (UMD); the University of Maryland Medical Center; and collaborators at the Living Legacy Foundation of Maryland (The LLF).

"This major advance in [human medicine](#) and transplantation exemplifies two key components of our mission: innovation and collaboration," said E. Albert Reece, MD, Ph.D., MBA, Executive Vice President for Medical Affairs, UM Baltimore, and the John Z. and Akiko K. Bowers Distinguished Professor and Dean, University of Maryland School of Medicine. "Innovation is at the heart of our focus on accelerating the pace and scope of discovery, where research can rapidly transform medicine. At the same time, collaboration is the key to our success in providing discovery-based medicine—both in conducting research and in delivering the highest quality [patient care](#)."

The kidney recipient, a 44-year-old woman from Baltimore, who spent eight years on dialysis before undergoing the [transplant procedure](#), said, "This whole thing is amazing. Years ago, this was not something that you would think about," she said. She was discharged from UMMC on Tuesday.

"For more than 25 years, the University of Maryland Medical Center has provided cutting-edge care in [organ transplantation](#)," said Mohan Suntha, MD, MBA, President and CEO of the University of Maryland Medical Center in Baltimore. "Our Transplant Program cares for patients who come from our local community, the state and the nation, many of whom have been turned away at other hospitals, because we have the skill, talent and knowledge to advance even the most complex transplant cases, often times not just improving but saving lives."

Maryland faculty and researchers believe this prototype organ transport blazes a trail for the use of UAS to expand access to donated organs, improving outcomes for more people in need of organ transplants.

"As a result of the outstanding collaboration among surgeons, engineers, the Federal Aviation Administration (FAA), organ procurement specialists, pilots, nurses, and, ultimately, the patient, we were able to make a pioneering breakthrough in transplantation," said Joseph Scalea, MD, assistant professor of surgery at UMSOM, project lead, and one of the surgeons who performed the transplant at UMMC.

Among the many technological firsts of this effort include: a specially designed, high-tech apparatus for maintaining and monitoring a viable human organ; a custom-built UAS with eight rotors and multiple powertrains to ensure consistently reliable performance, even in the case of a possible component failure; the use of a wireless mesh network to control the UAS, monitor aircraft status, and provide communications for the ground crew at multiple locations; and aircraft operating systems that combined best practices from both UAS and organ transport standards.

"We had to create a new system that was still within the regulatory structure of the FAA, but also capable of carrying the additional weight of the organ, cameras, and organ tracking, communications, and safety

systems over an urban, densely populated area—for a longer distance and with more endurance," said Matthew Scassero, MPA, director of UMD's UAS Test Site, part of A. James Clark School of Engineering. "There's a tremendous amount of pressure knowing there's a person waiting for that organ, but it's also a special privilege to be a part of this critical mission."

Prior to this landmark organ delivery flight, the Maryland partners worked together to develop and test the UAS by first successfully transporting saline, blood tubes, and other materials, and then by transporting a healthy, but nonviable, human kidney. These [test flights](#) were preceded in 2016 by the state of Maryland's first civil unmanned aerial delivery of simulated medical cargo, a collaborative effort between UMD's UAS Test Site and the University of Maryland Shore Regional Health in Easton, Maryland, to illustrate how the use of UAS could radically change medical care and impact the lives of real people.

Advancing Transplantation through UAS Transport

Transportation logistics are often the most complicated part of the organ transplant process—and how long an organ remains viable throughout travel is a major issue. Transport methods typically involve expensive chartered flights or rely on variable commercial flights, and occasionally result in an organ left on a plane or other delays that destroy the organ's viability. These current transport methods also don't adequately cover many parts of the country, such as rural or geographically remote areas, which limits access in these areas both to organ donations and organ transplants.

According to the United Network for Organ Sharing, which manages the organ transplant system in the United States, in 2018 there were nearly 114,000 people on waiting lists for an organ transplant; about 1.5 percent of deceased donor organ shipments did not make it to the intended

destination; and nearly four percent of organ shipments had an unanticipated delay of two or more hours.

"There remains a woeful disparity between the number of recipients on the organ transplant waiting list and the total number of transplantable organs. This new technology has the potential to help widen the donor organ pool and access to transplantation," said Scalea. "Delivering an organ from a donor to a patient is a sacred duty with many moving parts. It is critical that we find ways of doing this better."

Beating the organ transplant clock is a key responsibility of U.S. organ procurement organizations, including project collaborator, The LLF. "The University of Maryland UAS project is incredibly important," said Charlie Alexander, Chief Executive Officer of The LLF, noting that the work is at the proof-of-concept stage. "If we can prove that this works, then we can look at much greater distances of unmanned organ transport. This would minimize the need for multiple pilots and flight time and address safety issues we have in our field."

Designing a UAS Organ Delivery System

To create a UAS designed to carry an organ and provide real-time monitoring of its condition, Scalea partnered with several medical technology companies to design and develop the Human Organ Monitoring and Quality Assurance Apparatus for Long-Distance Travel (HOMAL; patent pending). It measures and maintains temperature, barometric pressure, altitude, vibration, and location (via GPS) during transportation and transmits the information to the smartphones of transplant personnel.

The needed unmanned aircraft and operating systems were designed by UMD UAS Test Site engineers to meet the rigid medical, technical, and regulatory demands of carrying a donor organ for human transplantation.

"We built in a lot of redundancies, because we want to do everything possible to protect the payload," said Anthony Pucciarella, director of operations at the UMD UAS Test Site. These safeguards included backup propellers and motors, dual batteries, a backup power distribution board, and a parachute recovery system (in case the entire aircraft fails).

"This history-making flight not only represents a breakthrough from a technological point of view, but provides an exemplary demonstration of how engineering expertise and ingenuity ultimately serve human needs—in this case, the need to improve the reliability and efficiency of organ delivery to hospitals conducting transplant surgery," said Darryll J. Pines, Ph.D., dean of the A. James Clark School of Engineering and Nariman Farvardin Professor of Aerospace Engineering. "As astonishing as this breakthrough is from a purely engineering point of view, there's a larger purpose at stake. It's ultimately not about the technology; it's about enhancing human life."

More information: 1. Scalea et al. Am J Transplant. 2019 Mar;19(3):962-964

2. Scalea et al. IEEE J Transl Eng Health Med. 2018 Nov 6;6:4000107

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