A Bridge to Lung Transplantation

Gaining patients precious time is only one advantage

In the summer 2003 issue of Medicine at Michigan*, in our cover story "Bioengineering Human Health," we reported on research being done by Robert Bartlett (M.D. 1963) and his colleagues to develop a prototype of an implantable artificial lung then being tested in sheep. Recently, Bartlett's lab received a $5 million grant from the National Institutes of Health to prepare the lung for clinical trial. The following update provides details on the progress and status of this exciting — and future life-saving — technology which is moving ever-closer to human application.*

"A lot of research has been involved with studying the physiology of the heart," Robert Bartlett says, "and then designing a lung device that uses the heart rather than a mechanical pump — that's what we've accomplished in the last five years. Now we need to refine the device into final form." Bartlett, a professor emeritus of surgery, is a pioneer in the development of artificial organs. His laboratory, which has been developing an artificial lung for the last 12 years, has had continuous funding from the NIH since 1971 for the development of artificial organs.

Robert Bartlett holding the artificial lung

Thirty years ago, Bartlett's laboratory developed a temporary artificial lung system known as extracorporeal membrane oxygenation (ECMO) which is used in intensive care units throughout the world to treat patients with acute lung failure, but ECMO is not practical as a bridge to lung transplantation. Currently, there is no mechanical system that can replace lung function well enough and long enough to allow patients months of time while they wait for donor lungs. This device will allow that time.

The implantable artificial lung also will permit conditioning of the patient.

"People with end-stage lung diseases are often debilitated, and this adds to the difficulty of transplantation and recovery. We know they will do better when they finally get the transplant if they can get into good physical shape before the operation," Bartlett says. "An implantable artificial lung would permit a patient to be fairly mobile and to live at home, rather than remaining bedridden in an ICU waiting for surgery, as is often the case."

Another advantage of the implantable lung is that the device can be left in place following transplantation until the transplanted lungs are fully functioning. This will permit accepting lungs for transplantation that would otherwise be declined.

The NIH grant funds research in collaboration with James Grotberg, Ph.D., and Joseph Bull, Ph.D., in the Department of Bioengineering at the U-M College of Engineering. The grant doesn't cover clinical trials, but will fund all steps necessary to get to that point.

"Because these devices are prototypes, we make them one at a time. An important part of our research from this point forward is to have a device that satisfies the FDA and can be reproduced commercially so that it can be made exactly the same every time," explains Bartlett.

There also are some physiology experiments remaining, Bartlett says. In previous testing, the device had fairly constant blood flow, and researchers need to understand the effect of variable blood flow. When blood flow is lower, clotting can become a factor and the correct use of anticoagulants needs to be defined. When blood flow is higher, the heart has to work harder to pump blood through the device. Exercise requires high blood flow, placing corresponding demands on the device to provide oxygen. In both cases, small changes to the prototype device will be necessary to make sure it functions under the same varying conditions as the lungs it will replace.

The U-M team collaborates with the four other laboratories in the world working on implantable lungs — the universities of Maryland, Kentucky, Pittsburgh and Osaka (Japan).

Keith Cook, Ph.D., a U-M research investigator and cardiac physiology expert, is the main bioengineer in this, the final phase of the project. Because the prototype relies on the patient's own heart to pump blood through the device, Cook's understanding of how the right ventricle, which does the pumping, works, fails, handles stress — and how the device will perform according to these variables — is vital to the project's success.

Bartlett's team also includes three Health System physicians: Jonathan Haft (Residency 2001, Fellowship 2005), an adult cardiac surgeon, Ronald Hirschl (M.D. 1983, Residencies 1989 and 1991), a pediatric surgeon, and Andrew Chang, M.D., surgical director of lung transplants. The first clinical trial will be conducted with adult patients.

—Mary Beth Reilly

Editor's note: The device developed by U-M physicians and engineers still needs further testing in animals before any clinical trial involving human participants can take place. At this time, the team is not establishing a list of patients to be considered for the first clinical trial.