ICU
MANAGEMENT & PRACTICE

3D-printed Splint Saves Infant's Life

Half a millennium after Johannes Gutenberg printed the bible, researchers printed a 3D splint that saved the life of an infant born with severe tracheobronchomalacia, a birth defect that causes the airway to collapse.

While similar surgeries have been preformed using tissue donations and windpipes created from stem cells, this is the first time 3D printing has been used to treat tracheobronchomalacia—at least in a human.

Matthew Wheeler, a University of Illinois Professor of Animal Sciences and member of the Regenerative Biology and Tissue Engineering research theme at the Institute for Genomic Biology (IGB), worked with a team of five researchers to test 3D-printed, bioresorbable airway splints in porcine, or pig, animal models with severe, life-threatening tracheobronchomalacia.

"If the promise of tissue engineering is going to be realized, our translational research must be 'translated' from our laboratory and experimental surgery suite to the hospital and clinic," Wheeler said. "The large-animal model is the roadway to take this device from the bench top to the bedside."

For more than 40 years, pigs have served as medical research models because their physiology is very similar to humans. In addition to tracheobronchomalacia, pigs have been biomedical models for muscular dystrophy, diabetes, and other diseases. The team chose to use two-month-old pigs for this study because their tracheas have similar biomechanical and anatomical properties to a growing human trachea.

"Essentially, all our breakthroughs in human clinical medicine have been initially tested or perfected in animal models," Wheeler said. "Through the use of animal models, scientists and doctors are able to perfect techniques, drugs, and materials without risking human lives."

First, Wheeler sent a CT scan of a pig's trachea to Scott Hollister, a professor of biomedical engineering at the University of Michigan. Hollister used the CT scan and a 3D CAD program to design and print the splints. These devices were made from an FDA-approved material called polycaprolactone or PCL, which Wheeler has used in more than 100 large-animal procedures.

Next, Wheeler developed a strategy to implement the device and U-M associate professor of pediatric otolaryngology Glenn Green carried out the surgical procedure. After the splint was placed, the pigs' tracheobronchomalacia symptoms disappeared.

"All of our work is physician inspired," Wheeler said. "Babies suffering from tracheobronchomalacia were brought to ear, nose and throat surgeons, but they didn't have any treatment options. They turned to us to engineer a cure."

Kaiba (KEYE'-buh) Gionfriddo was six weeks old when he suddenly stopped breathing and turned blue at a restaurant with his parents. As a result of severe tracheobronchomalacia, his heart would often stop beating, and despite the aid of a mechanical ventilator, he had to be resuscitated daily by doctors.

April and Bryan Gionfriddo believed their son's chance of survival was slim until Marc Nelson, a doctor at Akron Children's Hospital in Ohio, mentioned researchers from the University of Michigan were testing airway splints similar to those used in Wheeler's study.

After obtaining emergency clearance from the Food and Drug Administration, Hollister and Green used computer-guided lasers to print, stack, and fuse thin layers of plastic to make up Kaiba's splint.

The splint was sewn around Kaiba's airway to expand his collapsed bronchus and provide support for tissue growth. A slit in the side of the splint allows it to expand as Kaiba's airway grows. In about three years, after Kaiba's trachea has reconstructed itself, his body will reabsorb the splint as the PCL degrades.

Soon Kaiba's tracheotomy tube will be removed after a year without any breathing crises. His success story provides hope for other children born with this disorder, an estimated 1 in 2,100 births.

"It's not very rare," Wheeler said. "It's really not. I think it's very rewarding to all of us to know that we are contributing to helping treat or even cure this disease."

More data from Wheeler's large animal trials will be essential to show the long-term viability of this procedure before it can be used to save the lives of other children born with this disorder. In future trials, Wheeler plans to add stem cells to the splint in order to accelerate healing.

This translational research was conducted at the IGB, a research facility at the U of I that promotes multi-disciplinary collaboration. The institute is considered by many to be the Midwest region's center for large-animal biomedical models.

"We have a reputation for being excellent in this area," Wheeler said. "We would like to capitalize on the expertise and the facilities that we have here to continue to conduct life-saving research. I'm hoping that this story will encourage more people come to us and say 'Hey, we'd like to develop this model.'"

Source: University of Illinois at Urbana-Champaign

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