Amniotic stem cells show promise in helping to repair cardiac birth defects

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Researchers at the University of Michigan Department of Surgery have begun testing an alternative to embryonic stem cells that could one day regenerate muscle tissue for babies with congenital heart defects. A research-in-progress report on this new approach, which uses amniotic stem cells, was presented today at the 2013 Clinical Congress of the American College of Surgeons. Although this research is still in an early phase, this new approach has the potential to one day help thousands of babies born each year with congenital heart defects.

Typically, a pregnant woman can have a fetal ultrasound performed to find out the sex of her baby between 18 and 20 weeks gestation. But each year during pregnancy or after birth, 40,000 women also find out that their babies have birth defects in their hearts, according to the Centers for Disease Control and Prevention.*

Babies with congenital heart defects often go through multiple heart operations or even a transplant before their first birthday. But Shaun Kunisaki, MD, a pediatric surgeon and assistant professor of surgery at the University of Michigan, and his surgical team are testing a new method of regenerating defective heart tissue so that one day these multiple operations may no longer be necessary.

"We know that the baby's heart cells are functioning, but the muscle has developed abnormally," lead study author Dr. Kunisaki said. "We have to find the right source of new cells to replace the damaged cells or generate new tissue to augment the damaged heart."

Stem Cell Shortfalls

Until now embryonic stem cells have shown potential to morph into various types of organ tissues, but the ethics surrounding the process of having to destroy the embryo to achieve this outcome has drawn controversy.

Stem cells from bone marrow have also seemed promising, but such cells are obviously hard to obtain from a fetus. Furthermore, getting bone marrow from a donor brings about the same risk as having a heart transplant—having to suppress the newborn infant's immune system so that its body doesn't reject the foreign cells. "Also, bone marrow cells are not made to function like heart muscle cells, but rather to protect against inflammation," Dr. Kunisaki explained.

Cardiac stem cells, which are in the heart, have also been considered, but the heart contains a very limited number of these stem cells.

Amniotic stem cells, however, contain the same genetic makeup as the fetus. Therefore, this approach eliminates the possibility of the newborn infant's body rejecting the cells. And these cells are easily obtainable from amniocentesis, a standard prenatal genetic test in which fluid is extracted from the amniotic sac.

Morphing into heart muscle cells

Beginning in the last quarter of 2011, Dr. Kunisaki and his team obtained amniotic fluid samples from eight pregnant women. They extracted a type of cell called mesenchymal stromal cells, which are the most common type of cell in amniotic fluid.

The next step was to transform those cells into induced pluripotent stem

cells with the exact genetic makeup of the fetus. This step involved genetically reprogramming the cells to be, similar to embryonic stem cells, flexible enough to morph into any cell in the human body—such as the heart muscle.

"Once you have true stem cells, then you can expose these cells in a culture condition, which favors transformation into a heart cell," Dr. Kunisaki reported.

After three weeks in a culture, Dr. Kunisaki and his team observed the amniotic stem cells transform into heart muscle cells. The team confirmed that the cells were indeed heart cells with an antibody test, which has signature proteins that only bind to certain types of cells—in this case, the newly grown heart cells. "And you could see these cells beating in the culture dish," he added.

Next steps and ultimate goals

In the future, Dr. Kunisaki envisions being able to deliver amniotic stem cells to babies with congenital heart defects soon after delivery. The cells would then begin to regenerate damaged tissue into a healthy heart or could serve to augment heart operations. This treatment could help newborn infants stay alive without a transplant.

"Babies have to rely on mom and the placenta for everything. After they're born, they have to rely on their own hearts to function," Dr. Kunisaki explained. "The ideal situation is to have heart stem cells available when they are born. We diagnose heart defects at about 20 weeks gestation. That timeframe gives five months or so to generate heart cells to use at birth."

The researchers' laboratory process of transforming amniotic fluid cells into beating heart cells took just under 12 weeks. The next step is to

move the study to a mouse model, which Dr. Kunisaki estimates will begin in 2014. The ultimate step will be testing the procedure on an actual baby.

"Pregnancy is supposed to be a time to celebrate and welcome a new family member into the world. One of the hardest parts of my job as a surgeon is telling a family that their baby has a heart defect," Dr. Kunisaki said. "Instead, these families have to talk about unforeseen circumstances, such as how to care for a seriously ill child after birth. Often there are not many comforting answers, but our goal is to offer more options."

More information: * Centers for Disease Control and Prevention. Congenital Heart Defects – Data and Statistics. Available at: www.cdc.gov/ncbddd/heartdefects/data.html. Accessed September 6, 2013.

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