Umbilical cord blood may help build new heart valves

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Children with heart defects may someday receive perfectly-matched new heart valves built using stem cells from their umbilical cord blood, according to research presented at the American Heart Association's Scientific Sessions 2008.

When infants are born with malfunctioning heart valves that can't be surgically repaired, they rely on replacements from animal tissue, compatible human organ donations or artificial materials. These replacements are lifesaving, but don't grow and change shape as a child develops; so two or more surgeries may be needed to replace outgrown valves. The animal tissue may also stiffen over time as well and be less durable than a normal human valve. With artificial valves, children also must be treated with blood thinners.

"In our concept, if prenatal testing shows a heart defect, you could collect blood from the umbilical cord at birth, harvest the stem cells, and fabricate a heart valve that is ready when the baby needs it," said Ralf Sodian, M.D., lead author of the study and a cardiac surgeon at the University Hospital of Munich.

The tissue engineering of heart valves is still in its infancy, with various researchers investigating the possibility of using cells from blood, bone marrow or amniotic fluid.

In the study, the research team used stem cells (CD133+ cells) derived from umbilical cord blood. The cord blood was frozen to preserve it. After 12 weeks, the cells were seeded onto eight heart valve scaffolds constructed of a biodegradable material and then grown in a laboratory.

Afterwards, examination using electron microscopes revealed that the cells had grown into pores of the scaffolding and formed a tissue layer. Biochemical examination indicated that the cells had not only survived and grown, but had produced important elements of the "extracellular matrix," the portion of body tissue that functions outside of cells and is essential to tissue function and structure. Compared with human tissue from pulmonary heart valves, the tissue-engineered valves formed:

-- 77.9 percent as much collagen (the main protein in connective tissue);
-- 85 percent as much glycosaminoglycan, a carbohydrate important in connective tissue); and
-- 67 percent as much elastin (a protein in connective tissue)

Furthermore, using antibodies to detect various proteins, the researchers found the valves contained desmin (a protein in muscle cells), laminin (a protein in all internal organs), alpha-actin (a protein that helps muscle cells contract) and CD31, VWF and VE-cadherin (components of blood vessel linings).

"These markers all indicate that human cardiovascular tissue was grown in the lab," Sodian said.

Several important questions remain to be solved regarding tissue-engineered functional heart valves, including identifying the optimal scaffold material and learning how to condition the valves in the laboratory so they work properly after being implanted, Sodian said.

"Tissue engineering provides the prospect of an ideal heart valve substitute that lasts throughout the patient's lifetime and has the potential to grow with the recipient and to change shape as needed," he said.

Source: American Heart Association