The Potential of Cardiomyocytes from Stem Cells

By Jamie Overton

What if we could repair a heart after a heart attack, prevent heart failure, or help a baby born with a congenital heart defect? Stem cells have that potential and might give us that opportunity.

Stem cells offer a wide range of possibilities for studying and treating diseases, injury, and even cancer. Among the many areas that stem cells can save and extend lives is in patients with heart disease or cardiovascular disease (CVD). CVD is the number one killer in the United States and the world. Almost 900,000 people die of heart related diseases in the U.S. every year at a cost of over $300 billion. How can stem cells help? Stem cells can be turned into heart cells to treat and study CVD.

Most cells in our body are what they are, they can't become another cell type. For example, a skin cell can't turn into a heart cell. Alternatively, most stem cells are not restricted to a single cell type, and can develop into to multiple cell types. Pluripotent stem cells are a type of stem cell that can give rise to ANY cell type in the body.

In the past, pluripotent stem cells were harvested from 7 to 10 day embryos (usually donated from IVF clinics). This led to ethical questions about the use of stem cells. However, now it is possible to take cells from an individual, like skin cells, and reprogram them back into stem cells called human induced pluripotent stem cells (hiPSCs). hiPSCs have the potential to be directed into any kind of cell in the body, including heart cells. Researches are working to perfect directing hiPSCs into heart muscle cells, otherwise known as cardiomyocytes (CMs).

CMs have a lot of potential for research and regenerative medicine. Currently, CMs can be used to test drugs for safety, study disease, and learn more about congenital heart defects and genetic disorders. Researchers are working to repair tissue damaged by heart attacks and replace electronic pacemakers using CMs.

CVD deprives the heart of oxygen which can lead to heart attack and the death of heart muscle cells. The damaged area scars and is no longer functional. This causes other parts of the heart to work harder and eventually can lead to heart failure or even death. Researchers are developing techniques to transplant CMs into the heart to replace damaged heart tissue. Multiple studies have had success remuscularizing damaged hearts in primates. Eventually, CMs could be used to repair the damage from a heart attack in human patients.

Testing drugs for safety with regards to the heart is difficult. It is dangerous to test drugs on people and there is a limited supply of heart cells for testing. Twenty-eight percent of drugs withdrawn from use in the U.S. are due to unexpected side effects on the heart. CMs can be used to test drugs and make sure they are not toxic to the heart. This testing could prevent drugs that are unsafe for the heart from ever reaching the public. HiPSCs give us the opportunity to create an unlimited supply of CMs to test the safety and effectiveness of drugs.

Disease modeling and individualized treatments are other benefits CMs from hiPSCs. Patient derived stem cells have the same DNA and surface proteins as the person they originate from, so these cells can be transplanted back into the patient with less worry of immune rejection. It also means that we can use the patient's own cells to recreate or model a genetic disease the patient might have and find patient-specific treatments.

Stem cell research continues to move forward at blazing speeds. For heart disease the potential treatments could improve and save millions of lives. From infants to the elderly, and everyone in between, all of us may benefit from current and future stem cell research.