

Consumer Reports on Health

June 2005

Stem-Cell Therapy: Promise and Reality

The potential of stem cells to treat devastating diseases has been hailed as one of the greatest medical breakthroughs of all time. But the rapidly unfolding ability of scientists to manipulate those undifferentiated cells into any type of specialized cell, including the pulsing cells of the heart, the insulin-producing cells of the pancreas, and the nerve cells in the spinal cord and brain, has also aroused controversy.

While President Bush has said there's great promise in this research, in August 2001 he announced that federal funding for embryonic stem-cell research would be limited. He cited "profound ethical questions" as the reason for restricting government-funded studies to some 60 embryonic stem-cell lines that were in use when the executive order was signed. Research on adult and animal stem cells was not limited.

The combination of high hopes and contention has left many people confused about where those potential treatments stand today, seven years after human embryonic stem cells were isolated and grown in the laboratory. This report separates the hype from the hope and reports on the current state of stem-cell treatments for a wide variety of chronic diseases and disabilities.

BASIS OF THE THERAPY

All of the 200 specialized cell types in the human body derive from the undifferentiated cells that begin to divide when an egg is fertilized by a sperm. If the ability of those early dividing cells to change into any type of cell could be harnessed, the theory goes, it might someday be possible to replace diseased or defective cells that cause degenerative diseases and disabilities. One day, researchers may even be able to use stem cells to grow entire hearts, livers, or kidneys.

Stem cells are found in embryos and in the umbilical-cord blood of newborns. They have also been identified in adults. Adult stem cells have been found in blood, bone marrow, brain, liver, skeletal muscle, skin, and even fat cells. Unlike embryonic stem cells, the ability of adult stem cells to morph into specialized cells and grow appears to be limited.

SOURCES OF CELLS USED IN RESEARCH

Federally funded embryonic stem-cell research uses stem-cell lines derived before Aug. 9, 2001, from fertilized eggs donated by infertile couples who underwent in-vitro fertilization procedures. Some people object to such research on fertilized eggs because extracting the stem cells destroys the potential for life.

When the fertilized eggs are smaller than a grain of sand, stem cells lining the inner surface of a hollow ball of cells called a blastocyst are taken out. Some researchers customize unfertilized eggs by removing their genetic material and replacing it with DNA from the stem-cell recipient. This experimental technique creates an embryonic stem-cell line that is almost genetically identical to the DNA donor, reducing the chance that stem cells transplanted back into the donor would trigger an immune response and cause rejection of the transplanted stem cells.

TREATMENTS AVAILABLE TODAY

Blood-forming stem cells found in adult bone marrow and the circulatory system develop into the red blood cells that carry oxygen, white blood cells that fight infection, and platelets that help the blood to clot. They are commonly collected from a matched donor and given to cancer patients to replace the bone-marrow cells destroyed by chemotherapy or radiation.

Some 45,000 to 50,000 bone-marrow transplants are performed worldwide each year for patients with life-threatening diseases who urgently needed stem cells to regenerate their bone marrow.

About 4.5 million Americans have registered as volunteer bone-marrow donors. In addition, doctors have begun to collect cancer patients' own stem cells, returning them as autologous transplants after treatments have ended and the drugs have washed out of patients' systems. When patients get back their own stem cells, there is no chance of immune mismatch or potentially fatal graft-vs.-host disease. An additional problem is that not all patients who need transplants can find suitably matched donors, and not all diseases can be treated with adult stem cells.

Stem-cell treatment is also being used for blood disorders, including aplastic anemia, sickle-cell anemia, and amyloidosis, a rare disease that can damage major organ systems. Some insurance companies will pay for all or part of stem-cell transplants. The federal government announced in March that Medicare is considering covering stem-cell transplants for amyloidosis.

Private and public banks are now available for freezing and storing blood left over in the umbilical cord after a child is born. This blood is rich in the stem cells used in the treatment of certain cancers and blood disorders. Private banking of the cord blood for personal use is considered an option for families with a child who has a disease that could someday require a stem-cell transplant. Public cord-blood banks accept donations of umbilical cord blood and make them available to patients who need a transplant, if a close match can be found.

SCIENTIFIC BARRIERS TO STEM-CELL THERAPIES

Many scientific hurdles to stem-cell transplants remain. To use adult stem cells more widely, researchers need to find ways to identify them in the body and grow them in

sufficient numbers. For both embryonic and adult stem-cell lines, methods need to be found to enable the cells to differentiate into the desired cell types. Then techniques are needed to transplant the stem cells so that they integrate and survive in the surrounding tissue and function as desired.

Investigators would need to somehow modify these cells and the recipient's immune system to help prevent rejection of the stem cells as foreign material. Another concern is the possible risk that transplanted stem cells could turn cancerous if cell division went out of control. However, encouraging results are beginning to be reported in human clinical studies involving patients with congestive heart failure, and from lab and animal research into other major diseases and disorders.

STATE INITIATIVES

Last fiscal year, the National Institutes of Health awarded \$24 million for embryonic stem-cell research. That's not enough to advance research, say some experts. They worry that this may lead to a brain drain as scientists leave for labs outside the U.S., where there are fewer restrictions and more money for research. California and New Jersey are currently the only states that expressly permit embryonic-stem-cell research, according to the National Conference on State Legislatures. Ten other states are considering such legislation. Last year California voters approved a statewide referendum that earmarks \$3 billion in state funding over the next 10 years for studies on embryonic stem cells and, secondarily, umbilical-cord blood and adult stem cells. In New Jersey, a state-funded stem-cell research center will be constructed at Rutgers University. In Massachusetts, seven teaching hospitals have collaborated to form the Harvard Stem Cell Institute to develop therapies from embryonic and adult stem cells.

PROGRESS IN FINDING TREATMENTS FOR CHRONIC DISEASES

* For many major diseases, stem-cell research is still largely in the early phases of laboratory and animal studies, and it is unlikely that specific treatments will be available for many years. However, for certain cancers and for heart failure, results from human studies are emerging.

Alzheimer's disease. Animal studies suggest that transplanting stem cells into the brain may not be enough. So researchers are trying to find the molecular signals that may activate adult stem cells already in the brain and to integrate them within the affected brain regions.

Cancer. Doctors already routinely use stem cells from bone-marrow transplants to help replenish depleted blood cells in patients after radiation or chemotherapy. In animal experiments, stem cells are being used as "smart bombs" to target cancer cells and deliver treatments that will destroy or modify them.

Cystic fibrosis. In lab experiments, stem cells are being studied in combination with gene therapy to combat this fatal lung disorder. The latest research shows that adult stem cells

can be transformed into cells that line the lungs' airways. Scientists are encoding these cells with normal copies of the gene that is defective in cystic fibrosis to try to keep the airways clear of the thick bronchial-plugging mucus.

Diabetes. Embryonic stem cells injected into mice have formed pancreatic islet cells that produce the insulin needed by patients with type 1 diabetes, an autoimmune disorder that destroys those (islet) cells. Efforts to do so using adult stem cells have so far failed. Scientists are also trying to chemically coax embryonic stem cells in the lab to create islet cells suitable for transplantation. Experts say stem-cell technology may also help type 2 diabetes, the most common form of the disease.

Heart disease. In early clinical trials, researchers have successfully used minimally invasive surgery to transplant adult stem cells from bone marrow directly into the heart muscle of 15 patients with severe congestive heart failure, University of Pittsburgh scientists reported in January at the annual meeting of the Society for Thoracic Surgery in Tampa. Heart functions improved in all 15 patients who received stem cells; 15 other patients randomized to receive their own blood serum as a control remained unchanged. The researchers speculate that the stem cells may have become integrated into the heart muscle or perhaps changed to cells that promote blood-vessel growth.

Multiple sclerosis. Injections of embryonic stem cells into mice have helped create myelin, the nerve-insulating tissue that the immune system attacks in multiple sclerosis. The investigators from the University of California, Irvine, plan studies to measure improvements in sensory and motor function following stem-cell treatments.

Parkinson's disease. In lab studies, embryonic and adult stem cells have been transformed into cells that produce dopamine, a nerve chemical that eases muscle movements, which patients with Parkinson's disease lack. Researchers also report that transplanted stem cells helped restore dopamine production in experiments in primates.

Spinal-cord injury. Animal studies have shown that stem-cell transplants help rats with spinal-cord injuries recover some function. Now experiments in injured primates have found that stem-cell transplants became nerve cells, and test animals showed improved function compared with control animals given sham treatments.