



Role of Stem Cells in Health Science and Medicine

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Abstract

Stem cells have a great potential to divide and present in all multicellular organism throughout their life. It holds a wide range of applications in novel therapies for the cure of many diseases and injuries by using early embryonic cells as well as adult stem cells. In research, they provide the whole knowledge of how humans develop from a cell. Understanding the phenomena of stem cells we can use these cells for the specific purpose in treating diseases such as modeling disease, cell-based therapies or drug screening. Adult as well as embryonic stem cells collectively used to treat such problems for the benefits of society. The power of plasticity in adult stem cells has yet determined. Use of stem cells can carry various ethical impacts along with several applications.

Keywords: Stem cell, Gene therapy, Health science, Clinical trials

Abbreviations: NSCs- Neural Stem Cells, DMT- Disease Modifying Treatment, HSCT-Hemopoietic Stem Cell Transplantation, COPD- Chronic Obstructive Pulmonary Disease, BM-MNC- Bone-Marrow Mononuclear Cells, MSC- Mesenchymal Stem Cells

Introduction

Stem cells are defined as the cells have the ability to divide into multiple cell lineages. They are the versatile type of cells that can renew themselves and give rise to the specialized type of cells. Stem cells are uncommitted until they receive signal and develop into the specialized cell while other cells of the body like heart and skin are used to transfer its function. Stem cells are present in our body from the early stages to the end of life. Present in all multicellular organism having the totipotency to divide. Although the early embryonic stem cells demonstrate totipotency while the adult stem cells possess multipotent.

From years researches are finding the way to use stem cells to replace cells and tissues that cause disease or damage. In the last century, Pluripotent cells were first isolated from a human embryo and grown in culture media [1]. Stem cell holds a wide range of applications in novel therapies for the cure of many diseases and injuries by making use of early embryonic cells as well as adult stem cells. In Russia, one of the scientists proposed the term “stem cells” for the very first time of scientific use. Stem cells have the ability to differentiate into another form of body cells. A different disease can be cured by using novel technologies of stem cells now a day [2].

Stem cell

A stem cell is an unspecialized cell that can make identical copies of it and have the ability to differentiate into various type cells and tissue in body. Stem cells are classified on two types as

Basis of potency

- Totipotent
- Pluripotent
- Multipotent
- Oligopotent
- Unipotent

Basis of their source

- Embryonic stem cell
- Adult stem cell
- Pluripotent stem cells

Totipotent cells have the ability to divide in all possible types of cells. Also the Pluripotent cells can differentiate in all possible form of cells. Some cells can divide in closely related family of cells as multipotent. Oligopotent cells can divide only in little type of cells. While, Unipotent cells can produce only their relevant type of cells. Some cells are derived from embryo as embryonic stem cells also. In short the goal of stem cell is the repairing in body cells and tissues that are damaged [3].

Gene Therapy by stem cells

Stem cells are present in the embryo and early stages of the fetus, amniotic fluid, the placenta, and umbilical cord. Stem cells have a great capability to increase the rate of health. In research, they provide the whole knowledge to search how to develop human from a cell. Understanding the phenomena of stem cells we can use these cells for a specific purpose in treating diseases such as modeling disease, cell-based therapies or drug screening. Stem cells are also used for transplant. Now the scientist has the knowledge that stem cells are also present in brain and heart. Stem cells are used to replace the cellular damaged cells by healthy cells or regenerate the organ. The innovative treatments of stem cells transplant was done at Apollo hospital Ahmedabad and demonstrate steady growth. No surgery involved in the transplantation of stem cells in patients and donor. This can be done by blood transfusion. The stem cells delivered in the patients and regenerate or replace the damage inpatient. These cells can be taken by the own body of patients which are healthy cells or by the other person known as the donor. The International Society for Stem Cell Research has developed some guidelines that help us in regarding stem cells treatment. Most of the clinical trials are generally concerned with the



monogenic disordered. There are many diseases which can be cured by using stem cells given below:

Parkinson

Parkinson is a disease of the nervous system in which the successive injury to neurons of midbrain occurs. In which the motor sign becomes rigid and tremor due to the successive injury in neurons in basal ganglia also occur in the caudate nucleus and putamen which results in nervous disordered. An amino acid named as Levodopa works by being converted to dopamine in the brain can improve the symptoms. This amino acid is one of the drugs used to handle the symptoms of this disease at all stages [4].

The main symptoms are as:

- Unconscious twinkling and temblor
- Decelerate movements
- Balance issues and standing problems
- Contraction and tighten of limbs

Causes: However, the main causes of this disease remain unclear yet. About 15 percent of these patients have a family history. These families can be caused by a mutation in genes or by the alteration of genes that have not been identified [3]. Today stem cells gene therapy is supposed as a novel treatment and different disease can be cured by using stem cells. For this purpose, several forms of cells are studied such as;

Embryonic stem cells: The most common example of the embryonic stem cells found within an early-stage embryo. Then, the damaged cells are replaced in disease or wound, mainly used to treat the neuron damaged cell; replace neurons damaged by the spinal cord injury, Parkinson disease or other neurological diseases.

Mesenchymal cells: Mesenchymal stem cells are of various forms of cells, including cartilage, muscles cells and adipocytes (fat cells which give rise to marrow adipose tissue). Some scientist injected mesenchymal cells in some patients and noticed important improvements and with no side effects.

Fetal neural stem cells: Neural Stem Cells (NSCs) are multipotent cells that can give rise to various cell types in the Central System (CNS), including neurons, astrocytes, and oligodendrocytes. These stem cells improve the conditions of patients and no tumors found. Up till now, there is no stem cells therapy or transplant therapy for Parkinson's disease. But we are making huge trials in this regard.

Alzheimer: Alzheimer is the commonest cause of premature senility. It is a chronic neurodegenerative disease. It usually starts slowly but worse over time. So, at an old age when a person has some other age-related disease such as heart disease or kidney failure, it becomes difficult to manage once someone develops this disease [5].

Complications of the decline in the brain function are what lead to death. A number of stem cells are being used in the treatment of this disease, discuss below:

Neural stem cells: Neural stem cells can be developing into a number of body cells such as neurons, astrocytes, and oligodendrocytes. Some scientist injected neural cells and some glial cells in two groups of mouse and observed the improvements. No improvement was noticed in these two groups, the cognitive ability is the same but there is a significant difference in that mouse which does not receive any kind of injection of cells.

Mesenchymal stem cells: Lee at al. performed an experiment on Alzheimer mice by injecting mesenchymal stem cells derived from the human umbilical cord and observed the significant changes in oxidative stress, learning, and memory in mice were returned [6].

Recently, a number of clinical trials have been done that are based on amyloid cascade hypothesis but it gives disappointed results. The failure of this therapy gives us the idea of disease model and necessities of cell therapy.

Multiple sclerosis: A severe form of disease-causing damage to the brain and spinal cord progressively to sheaths of newer cells. It causes muscle metabolism and insight vision with severe fatigue.

Commonly early signs of multiple sclerosis (MS) include:

- Sight problems
- Pain
- Weakness or fatty cells
- Anxiety
- Digestive issues
- Sexual disability
- Arteries problems

The early signs or symptoms of multiple sclerosis normally begin at teenage to 40 years of life. Only about 2% to 5% of all people diagnosed with MS have symptoms before 18 [7]. Recent clinical trials shows that patients treated with nonmyeloablative Hemapoeitic Stem Cell Transplantation (HSCT) performed better than those patients that are treated with Disease Modifying Treatment (DMT). Research shows that significant number of people that are treated with (HSCT) progressive better condition and are able to slow disease when compare with (DMT) treated patients [1].

Liver disease: Cirrhosis causes liver injury and it does not perform its function in a proper way. The main causes are alcohol consumption, HBV, HCV, and non-alcoholic fatty liver diseases. This damage is treated by the replacement of healthy liver cell tissue by the damaged cells. Stem cells transplantation is now the best treatment for cirrhosis disease. A number of stem cells are capable for the diagnoses of cirrhosis such as embryonic stem cells, annex stem cells etc. different types of treatment have been done in this respect. In 2006, an experiment was performed in which CD₃₄ cells were injected in at least five patients and results found that balance in bilirubin and albumin level, improvement in patients with no side effect.

Later in 2006, the patient was injected with bone marrow mononuclear stem cells and it improves the patient's albumin level. Further study shows that the same types of stem cells were injected in 10 male patients, decrease their bilirubin level and increase the albumin level [8]. The stem cells transplantation and therapy have done many improvements in cirrhosis disease. Some patients may die in this treatment of some radiotherapy and neurological problems. Mohammad Nejad et.al has shown injection of autologous mesenchyma cells in phase trials. In another group of same study, three out of four patients, significantly improve their liver function while one of the patients died due to nephropathy that caused hepatorenal syndrome type 1 [9].

Asthma: Another health care contributes to the major portion of asthma. About 10 percent of patients are suffering from severe asthma having inhaling problem with the inefficiency of lungs. Stem cells are now used to cure asthma by performing different trials. In 2010, mesenchymal cells were injected into the mouse as the asthma model. This is one of the major contributions towards asthma patients for their cure. Mesenchymal cells show effective results. In result of all these studies, the immunomodulatory capacities of stem cell can be effective in immune based diseases. In near future stem cells differentiation can form a promising therapy in organ and tissue defect.

Diabetes

Extensiveness of diabetes is increasing all over the world rapidly. The increase in hunger and more intakes of fluids are the major symptoms of diabetes. Insulin is produced in the liver cells and secreted in the



pancreas, it breakdown the glucose in the blood. The abnormal working of insulin is the main cause of diabetes. Recently, the insulin has been generated by the stem cells of a mouse but these cells have short cell life. It was published in 2000.

Several forms of stem cells are used in the therapy of diabetes such as embryonic stem cells, mesenchymal stem cells, skin fibroblast cells and many other types of cells. It is one of major disease prevailed vastly that it is supposed in the year 2030, there are about 366 million people suffered from this. The only treatment of diabetes is transplantation of pancreatic islet cell but it is limited to organ presence as a donor [10].

Stem cells are placed to cure diabetes now a day. Different types of stem cells being used and worked wonderfully as;

Embryonic stem cells: In 2002, first-time insulin-producing cells were made from mouse embryonic cells to cure the diabetic patient. Different other experiments were performed over and over to get a more precise form to produce insulin.

Mesenchymal cells: Mesenchymal cells show immunomodulation in laboratory and clinical studies through myocard. But limited performance it was unable for the cell metabolism of a patient to treat diabetes. Mesenchymal Stem Cells (MSC) is one of the best method to treat both type1 and type2 diabetes mellitus. MSC are responsible for reducing the blood glucose level by different mechanisms.

Most clinical trials in 2017, an experiment is done, in this some people are treated with bone-marrow BM-MSC and compare with people treated with Bone-Marrow Mononuclear Cells (BM-MNC). Ten people received BM-MSC under control condition for 12 months and ten received BM-MNC served same procedure. BM-MSC group shows only a significant reduction in daily requirements of insulin on the other hand the group treated with BM-MNC shows significant reduction in daily insulin requirements and also increased production of C-peptides in 12 months.

Sepsis

Stem cells can modulate their inflammatory response to infection and show unclear pathophysiology. Stem cells can also be used for the treatment of sepsis due to inflammatory and reduction way of action [11].

Human Embryonic Stem Cell: It was reported that human embryonic cells significantly worked to decrease inflammation and produce interferon and Tumor Necrosis Factor (TNF) cells. In mice, ACE+cells have the ability to decrease the risk of sepsis [12].

Mesenchymal Stem Cells: Firstly scientist injects E.coli endotoxin in the lungs of mice than after 4 hours; they directly inject mesenchymal cells into the lungs of mice. However, mice show less effect and more survival [13].

In 2007 at Emory University a mice divided into 4 groups received Escherchia-coli endotoxin in peritoneum. The first group injected with BMDMSC, second group with endotoxin and BMDMSC, third with endotoxin and mouse lung fibroblasts and one of the last with only endotoxin. It was concluded that BMDMSC effects due to chemo attractants in lung of mice stem cells.

Respiratory diseases

Chronic Obstructive Pulmonary Disease (COPD): It is the airway obstruction disease having the symptoms of a cough and sputum. 210 people suffered from COPD in the report of the World Health Organization (WHO). In 2030, maybe it will be the third major disease to cause death in patients [14]. Emphysema model of rats scientists in China 2008, injected mesenchymal cells from male rats to female rats. It was concluded that some rats to produce improved results. Y

chromosome was detected present in the recipient lungs containing mesenchymal cells [15]. A trial has been performed in patients of adult human mesenchyma cells having acute myocardial infection. The patients who received MSC injection show different responses as forced expiratory volume in 1 second and improved forced vital capacity.

Future aspects

Stem cells can work wonder in the treatment of several diseases as a miracle. They are performing a huge range of experiments to perform their research for the cure of such diseases. It forms revolutionary changes in medicine, degenerative diseases, and cancer. New discoveries are forming day by day. Adult as well as embryonic stem cells collectively used to treat such problems for the benefits of society. The potential plasticity of adult stem cells has yet determined. Use of stem cells can carry various ethical impacts along with several applications. However, stem cells are not treated as the first discovery of human to treat while it has to be considered [16].

However the Human Stem Cells (HSC) can raises several ethical issues regarding its treatment and political controversies over its use. There are ethical problems to produce Pluripotent induced stem cells from the reprogramming of somatic cells regarding its research in embryonic stem cells. Clinical trials, downstream research and consent to donate material therapies on HSC are a major ethical concern. Scientific challenges are used to ensure the ethical and policy issue on the research and treatment of these stem cells in appropriate manner.

Risks and benefits in stem cells clinical trials

Formation of tumor, uneven behavior of cells, immunological reactions and long-term unknown health side effects are the major risks of stem cells therapy. Thus appropriate preclinical trials should be established on animal's model as well as in human study of similar cell based interventions also. If Pluripotent derived stem cells are manipulated in vitro there should be higher proof of principle and safety requirements in its treatment. In all clinical research, these trials should follow ethical principles that balance its risks and benefits.

Conclusion

Stem cells are used in different fields for the treatment of diseases. They have great potential to divide and regenerate. Several forms of these cells can be used to treat various diseases. These cells can also play its role in medicine and treatment of diseases as cancer also with the degenerative properties. It also possesses a wide range of potential plasticity. Cells based therapies and drug screening can also be done by the use of these stem cells. In research, they also provide a whole knowledge of how humans develop from a cell.

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