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STEM CELL THERAPY: BIOMEDICAL SCIENCE INNOVATIONS

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Abstract

Stem cell therapy, which is also known as regenerative medicine, is one of the new biomedical science innovations. It involves using stem cells and derived products in medical treatments. This revolutionary innovation has become necessary, considering the increasing numbers of incurable diseases that ravage the world today. Stem cells are cells from which all other cells with specialized functions are generated. Normally, stem cells divide to form more cells known as daughter cells. These daughter cells either become new stem cells (self-renewal) or become specialized cells (differentiation) with a more specific function, such as blood cells, brain cells, heart muscle cells or bone cells. The knowledge of stem cell enables biomedical researchers and physicians to have a better understanding of cellular and molecular mechanisms of human diseases, to generate healthy cells to replace diseased cells (regenerative medicine), and to test new drugs for safe and effective medical treatments.

Keywords: *Stem cell therapy, stem cells, biomedical research, innovation, regenerative medicine.*

INTRODUCTION

Stem cell therapy may offer the potential to treat diseases, including the incurable ones. It promotes the repair of diseased, dysfunctional or injured tissue using stem cells. Stem cells are special human cells that are able to develop into many different cell types. They have the potential to repair, restore, replace, and regenerate cells—they serve as a repair system for the body—and thus, could possibly be used to treat many medical conditions and diseases.

There are two main types of stem cells: embryonic stem cells and adult stem cells. Stem cells differ from other cells in the body in different ways—they can divide and renew themselves, they cannot do specific functions in the body because they are unspecialized, and they have the ability to become specialized cells. Examples of the stem cells in the body include muscle cells, blood cells, and brain cells. There are two major types of stem cells, which are embryonic stem cells and adult stem cells, though there are other types. Embryonic stem cells come from embryos that are three to five days old. They are pluripotent stem cells; thus, they can divide into more stem cells or can even become any type of cell in the body. However, adult stem cells are found in most adult tissues, such as bone marrow or fat. They have a more limited potential to divide into various cells of the body like embryonic stem cells.

Considering the fact that human embryonic stem cells are extracted from human embryos, there has been controversy about embryonic stem cell research. Thus, according to Mayo Clinic (2019), National Institutes of Health created guidelines for human stem cell research in 2009, which stated that embryonic stem cells from embryos created by in vitro fertilization could be used only when the embryo was no longer needed.

REVIEW OF LITERATURE

One of the main problems facing mankind today is the outbreaks of diseases. Ever since late 20th century, disease outbreaks have been on the increase. According to NIAID Research (2012), numerous infectious and non-infectious diseases have been diagnosed since last century. What could be the cause of this increasing rate of disease upsurges? Despite other causes, human activities, especially our unhealthy eating habits and lifestyles, have contributed immensely to the rapid proliferation of diseases that ravage human race today. It is unfortunate that some of these diseases still remain incurable. However, in attempts to discover cures for the diseases, biomedical research has made different discoveries—of which, stem cell therapy was one of them.

Stem cell therapy is the use of stem cells to treat or prevent a disease (Mahla, 2016). It basically involves injecting or infusing healthy stem cells into the body of a patient to replace damaged or diseased stem cells. This therapy becomes necessary if a patient's bone marrow stops working or if it does not produce enough healthy stem cells. The stem cell research can make use of different types of stem cells. Stem cells are non-specialized cells that can produce other types of specific cells, such as blood cells, tissue cells, muscle cells, or brain cells. They are undifferentiated cells that have the ability to renew themselves and differentiate into specialized cells. Found in all parts of the body, stem cells are more potent in fetus than in an adult body.

There are two main types of stem cells in human: embryonic stem cells (derived from the inner cell mass of blastocysts) and adult stem cells (found in different body tissues). However, they can be classified into five broad categories, depending on their ability to differentiate, which includes totipotent stem cells, pluripotent stem cells, multipotent stem cells, oligopotent stem cells and unipotent stem cells. The totipotent stem cells are found only in early embryos. The pluripotent stem cells exist in the undifferentiated inner cell mass of the blastocyst and can form any of the over 200 different cell types in the body. The multipotent stem cells are derived from fetal tissue, cord blood, and adult stem cells. The oligopotent stem cells can differentiate into only a few cell types like lymphoid stem cells, while the unipotent stem cells can produce only one cell type—their own, such as muscle stem cells.

The history of stem cell therapy actually started in mid 1800s, with stem cell research that led to the discovery that some cells could generate other cells, though it was in early 1900s that the first real stem cells were discovered to generate blood cells. According to Becker (1963), research into stem cells grew out of the findings by Ernest A. McCulloch and James E. Till at the University of Toronto in the 1960s. At first, bone marrow was administered by mouth to patients with anemia and leukemia. Even though such therapy failed, further laboratory experiments proved that mice with defective marrow could be restored to health with infusions into the blood stream of marrow taken from other mice. This convinced the medical researchers that it was possible to transplant bone marrow from one person to another. It was not until a French medical researcher made a critical discovery about the human immune system that bone marrow transplants in humans became notably successful. This discovery granted physicians reasonable knowledge of human histocompatibility antigens, which made bone marrow transplants between identical twins possible as early as in 1950s. However, the first successful stem cell therapy between two siblings who were not identical twins was performed in 1968

using bone marrow transplant. Another laudable achievement was made in stem cell research in 1973 when a team of medical experts successfully performed bone marrow transplant between two unrelated persons.

Today, stem cell research has dramatically advanced with numerous research studies published regularly in scientific journals. The therapy employs stem cells from different sources in the body, ranging from embryonic stem cells, umbilical cord stem cells, amniotic stem cells, and adult stem cells. The ability of biomedical scientists to isolate and culture embryonic stem cells and create stem cells from a non-pluripotent cell like adult somatic cells to give rise to induced pluripotent stem cells (iPS) had taken stem cell research to a more sophisticated level. It should be recalled that the first embryonic stem cell lines were developed when James Thompson of University of Wisconsin-Madison isolated cells from the inner cell mass of early embryos and John Gearhart of John Hopkins University derived germ cells from cells in fetal gonadal tissue (primordial germ cells) in 1998.

Stem cell therapy—also referred to as stem cell transplant, blood transplant, or bone marrow transplant—was discovered as a safer alternative to chemotherapy or radiation therapy. During chemotherapy, most growing cells are killed by the cytotoxic agents. This is because these cytotoxic agents cannot differentiate between the hematopoietic stem cells and neoplastic cells (leukemia) in the bone marrow. It is as a result of this danger associated with chemotherapy that biomedical researchers, after many years of research, discovered a safer therapy—stem cell therapy—to replace chemotherapy. Unlike in chemotherapy, stem cell transplant reintroduces healthy stem cells to replace the cells lost in a patient's body, and these transplanted cells also generate an immune response to kill the cancer cells. Therefore, this procedure is often used in place of chemotherapy to treat blood infections like leukemia, lymphoma, multiple myeloma or sickle cell anemia. It helps the body to produce enough healthy white blood cells, red blood cells or platelets.

Study shows that adult stem cells have the potential to produce many other cell types and tissues like liver cells, and so, are more frequently used in medical therapies. This is why bone marrow transplant is the most widely used form of stem cell therapy, with more than 30,000 transplants to date for the treatment of immunodeficiency and leukemia. Stem cell transplant assumes different names, depending on the source of stem cells used: it is known as Autologous Stem Cell Transplant, when one's own cells are used; Allogeneic Stem Cell Transplant, when another individual's (a donor) cells are used; and Syngeneic Stem Cell Transplant, when an identical twin's cells are used. Of all the stem cell types, autologous stem cell transplant has been proven to be the safest.

Inasmuch as stem cell therapy has really advanced over the years, and has been used to treat many disease conditions, such as heart disease, leukemia, etc, more is still needed to be done in stem cell research to harness the full potentials of stem cells. To this end, research projects are still underway to develop more sources for stem cell, and the following diseases are being investigated for treatment: physical trauma, diabetes, Parkinson's disease, osteoarthritis, stroke and traumatic brain injury repair, heart infarction, baldness, rheumatoid arthritis, wound healing, anti-cancer, spinal cord injury repair, HIV/AIDS, Alzheimer's disease, birth defects, spinal cord injuries, learning defects, Crohn's disease, genetic diseases, replace missing teeth,

neurodegenerative diseases, and other conditions. However, the use of human embryonic stem cells and the creation of stem cells from adult somatic cells in stem cell therapy have generated controversy. The stem cell controversy concerns only with the stem cell research that involves the creation, usage, and destruction of human embryos. The method employed to derive new embryonic stem cell lines involves taking tissue from an aborted embryo to get proper material to study. This is normally done just after few days of conception or between the 5th and 9th week of conception. This is because not all stem cell research involves the creation, usage and destruction of human embryos. Stem cell research like adult stem cells, amniotic stem cells, and induced pluripotent stem cells involve no creation, usage and destruction of human embryos. Opposition to the use of human embryonic stem cells in research is often based on religious, moral, or philosophical objections (Mlsna, 2010). The critics of the therapy believe that the practice of stem cell research makes mockery of God, and argue that in the far future that such knowledge can lead to clone of humans. Nevertheless, stem cell research has been accepted and practiced worldwide. According to Dr. Arvin Fanndo, the Cordlife Philippine Medical Director, the strides made in stem cell therapy have made this manner of treating diseases more widely accepted by people.

Having seen all the extraordinary benefits which stem cell therapy holds for the treatment of human diseases, the question now is: are all these stem cell treatments totally safe? Despite the religious and ethical concerns about stem cell therapy, study has shown that there are still some shortcomings associated with the therapy. Stem cell treatments are not very commonly done, because they are expensive. In using stem cell transplants to generate an immune response that kills off the cancer cells, a disease condition called Graft-vs-host disease (GvHD), often arises as a side effect, although another stem cell therapy—Prochymal (a stem cell drug therapy made by Osiris Therapeutics)—has been approved in Canada since 2012 to control the condition. Moreover, there is likelihood that the following will occur during stem cell transplant: inappropriate stem cell migration, tumor formation, immune rejection of transplanted stem cells, hemorrhage during neurosurgery and postoperative infection (Dudek, 2004).

CONCLUSION

Despite the associated controversy, stem cell research has been used globally to treat many diseases, thereby alleviating the sufferings of the people. Indeed, stem cell therapy has potentially proven to be an answer to numerous diseases ravaging mankind today.

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