Ilkogretim Online - Elementary Education Online, 2021; Vol 20 (Issue 1): pp.7573-7577
http://ilkogretim-online.org
doi: 10.17051/ilkonline.2021.01.782

Stem Cells: A Novel Tool In Regenerative Medicine

Dr. S.Indumathi Assistant Professor, Department of Biochemistry, New Prince Shri Bhavani Arts & science College, Chennai, Tamil Nadu, India.

ABSTRACT:

Stem cells are a group of undifferentiated cells with an ability to self- renew and differentiate into any cell type. Based on potential stem cells can be classified as pluripotent stem cells, multipotent stem cells, Oligo potent stem cells and induced pluripotent stem cells. Pluripotent stem cells can differentiate into either the ectoderm, mesoderm and endoderm. Multipotent stem cells can differentiate into bone, cartilage, nerve or adipose tissue. Oligo potent stem cells can form terminally differentiated cells of a particular tissue. Stem cell therapy opens promising areas to replace damaged cells and regenerate organs. Similarly stem cells have been utilized to study developmental biology, disease pathogenesis and drug discovery. This review is focused to discuss the origin, classification of stem cells and their application in regenerative medicine and ethical issues regarding stem cells.

Key words: Stem cells, Pluripotent stem cells, Stem cell therapy, regenerative medicine

INTRODUCTION:

Stem cells are undifferentiated cells present in human body. They are found in the embryo, fetus and adult humans. Stem cells arise from a single cell, proliferative extensively and can differentiate into any cell type (totipotency) [1]. During fertilization the sperm fuses with the egg which results in the formation of blastocyst. The blastocyst has two types of cells namely the inner cell mass and the trophectoderm. The trophectoderm develops into extra embryonic structure (placenta) which support the growth of the embryo. The inner cell mass contains cells which are undifferentiated, pluripotent and proliferative. These cells are the embryonic stem cells and they develop into the germ layers namely ectoderm, mesoderm and endoderm of the fetus and adult. These germ layers give rise to specific organs and tissues. Some progenitor cells that develop into organs do not differentiate but remain as tissue stem cells. These include the cells of gut, bone marrow, blood, brain, skin, liver and muscles [2]. These stem cells remain dormant in the particular tissue and proliferate when needed (during cell damage/ injury or cell growth).

CLASSIFICATION OF STEMCELLS BASED ON POTENCY:

Based on their potential to differentiate stem cells can be classified into many types. They can be totipotent, pluripotent, multipotent, oligopotent and unipotent. This ability of differentiation depends on the origin of stem cells.

TOTIPOTENT STEMCELLS:

These are undifferentiated stem cells found in early stages of embryo formation. These include the cells formed by the first two divisions of fertilization.[3]

PLURIPOTENT STEMCELLS:

These cells can differentiate into the 3 germ layers from which all the tissues and organs develop. Pluripotent stem cells are embryonic stem cells derived from the inner cell mass of blastocyst.[4]

MULTIPOTENT STEMCELLS:

These include the mesenchymal stem cells. They are found in tissues and organs. They develop from a single germ layer. They can differentiate into a variety of organs like the adipose tissue, bone marrow, blood, bone, kidney etc. They possess specific cell surface markers.[5]

OLIGOPOTENT STEMCELLS:

These cells are able to self- renew and differentiate into 2 or more lineage within a particular tissue. Oligo potent stem cells of lungs develop into bronchiolar and alveolar epithelium.[6]

UNIPOTENT STEMCELLS:

These cells can self- renew and differentiate into a single lineage. Muscle cells can differentiate into mature muscle cells and hence are unipotent. [7]

INDUCED PLURIPOTENT STEMCELLS:

These are generated by reprogramming somatic cells. They share similar properties of Embryonic stem cells. Induced pluripotent stem cells were generated by reprogramming mouse fibroblast cells by Takahashi and Yamanaka in 2006. [4] Similarly in 2007, Yamanaka generated human pluripotent stem cells by reprogramming adult human dermal fibroblast. [8] Induced pluripotent stem cells have emerged as novel tool in drug development, developing disease model and in regenerative medicine. Induced pluripotent stem cells serve as identical match to cell donor and prevent issues of rejection. [9]

APPLICATIONS OF STEMCELLS:

Stem cells are widely used in basic research and drug development. Their specific nature has enabled their utilization in both biological and medical fields. Stem cells are used to study developmental biology and organogenesis. Similarly induced pluripotent stem cells are used

in drug research, to develop human models for understanding disease pathogenesis and improve cell therapy for degenerative disorder including diabetes mellitus,[10] cirrhosis,[11] cardiac failure, [12] myeloid leukaemia, [13] chronic disease, inflammation and nervous system disorders.[14]

After childbirth, cord blood stem cells are collected from the umbilical cord and frozen in cell banks for the use in future. These frozen cord blood cells are useful in treatment of leukemia and genetic diseases of children. [15]

Similarly stem cells from amniotic fluid are also isolated and used in the prenatal diagnosis of genetic disease.

Stem cells are currently used in regenerative medicine. [16] Recently keratinocytes from epidermal cells were used to induce skin recovery in epidermolysis bullosa. Similarly, Induced pluripotent stem cells were transplanted to patients suffering from macular degeneration. These induced pluripotent stem cells were induced to differentiate into pigment epithelial cells of retina. [17] These cell- based therapies serve as a promising field in the treatment of degenerative disease.

Stem cells are used in toxicity analysis of drugs, to study side effects of drug molecules and to identify lead molecules in drug discovery.

Stem cells of blood are transplanted in the treatment of blood and immune system disorders and in the treatment of cancer.

Stem cells from skin are used for skin graft in patients with skin burns. Mesenchymal stem cells are grafted into bone cells to heal fracture.

CONCLUSION

Stem cells serve as prominent tools for studying organ development and totipotency of the body. They help in studying the pathology of disease and to develop disease models. Although research on stem cells are encouraging in their use for tissue regeneration, genetic stability of stem cells is still questioned. The genetic instable nature of stem cells may cause carcinogenesis, teratomas or tumor development. [18] Also the destruction of embryos to obtain embryonic stem cells has created ethical concern among the scientific community. Despite all these the upcoming research and development offer new horizons of hope for the successful utilization of stem cells in regenerative medicine.

References

1. Ilic D, Ogilvie C. Concise review: human embryonic stem cells-what have we done? What are we doing? Where are we going? Stem Cells. 2017;35:17–25.
2. Lane S, Rippon HJ, Bishop AE: Stem cells in lung repair and regeneration. Regen Med 2007;2:407–415

3. Smith A: A glossary for stem-cell biology. Nature 2006;441:1060.
4. Takahashi K, Yamanaka S: Induction of pluripotent stem cells from mouse embryonic and adult fibroblast cultures by defined factors. Cell 2006;126:663–676.
5. Ratajczak MZ, Zuba-Surma E, Kucia M, Poniewierska A, Suszynska M, Ratajczak J: Pluripotent and multipotent stem cells in adult tissues. Adv Med Sci 2012;57:1–17.
6. Kim CF, Jackson EL, Woolfenden AE, Lawrence S, Babar I, Vogel S, Crowley D, Bronson RT, Jacks T: Identification of bronchioalveolar stem cells in normal lung and lung cancer. Cell 2005;121:823–835.
7. Bentzinger CF, Wang YX, von MJ, Rudnicki MA: The emerging biology of muscle stem cells: implications for cell-based therapies. Bioessays 2012, DOI: 10.1002/bies. 201200063.
8. Takahashi K, Tanabe K, Ohnuki M, Narita M, Ichisaka T, Tomoda K, Yamanaka S: Induction of pluripotent stem cells from adult human fibroblasts by defined factors. Cell 2007;131:861–872
9. Pietronave S, Prat M: Advances and applications of induced pluripotent stem cells. Can J Physiol Pharmacol 2012;90:317–325.
10. Kroon E, Martinson LA, Kadoya K, Bang AG, Kelly OG, Eliazer S, Young H, Richardson M, Smart NG, Cunningham J, Agulnick AD, D'Amour KA, Carpenter MK, Baetge EE: Pancreatic endoderm derived from human embryonic stem cells generates glucose-responsive insulin-secreting cells in vivo. Nat Biotechnol 2008;26:443–452.
11. Pai M, Zacharoulis D, Milicevic MN, Helmy S, Jiao LR, Levicar N, Tait P, Scott M, Marley SB, Jestice K, Glibetic M, Bansi D, Khan SA, Kyriakou D, Rountas C, Thillainayagam A, Nicholls JP, Jensen S, Apperley JF, Gordon MY, Habib NA: Autologous infusion of expanded mobilized adult bone marrow-derived CD34+ cells into patients with alcoholic liver cirrhosis. Am J Gastroenterol 2008;103:1952–1958.
12. W, Reichenspurner H, Trinquart L, Vilquin JT, Marolleau JP, Seymour B, Larghero J, Lake S, Chatellier G, Solomon S, Desnos M, Hagege AA: The Myoblast Autologous Grafting in Ischemic Cardiomyopathy (MAGIC) trial: first randomized placebocontrolled study of myoblast transplantation. Circulation 2008;117:1189–1200.
13. Hackanson B, Waller CF: Long-term follow-up of patients with chronic myeloid leukemia having received autologous stem cell transplantation. Ann Hematol 2011;90: 395–399.
14. Burt RK, Loh Y, Cohen B, Stefoski D, Balabanov R, Katsamakis G, Oyama Y, Russell EJ, Stern J, Muraro P, Rose J, Testori A, Bucha J, Jovanovic B, Milanetti F, Storek J, Voltarelli JC, Burns WH: Autologous nonmyeloablative haemopoietic stem cell transplantation in relapsing-remitting multiple sclerosis: a phase I/II study. Lancet Neurol 2009;8:244–253.
15. Rocha V, et al. Clinical use of umbilical cord blood hematopoietic stem cells. Biol Blood Marrow Transplant. 2006;12(1):34–4.

16. Gerontology, Rejuvenation by cell reprogramming: a new horizon in. Rodolfo G. Goya, Marianne Lehmann, Priscila Chiavellini, Martina Canatelli-Mallat, Claudia B. Hereñú and Oscar A. Brown. Stem Cell Res Therapy. 2018, 9:349. https://doi.org/10.1186/s13287-018-1075-y
17. Osakada F, Jin ZB, Hirami Y, Ikeda H, Danjyo T, Watanabe K, Sasai Y, Takahashi M. In vitro differentiation of retinal cells from human pluripotent stem cells by small-molecule induction. J Cell Sci. 2009;122:3169–79.
18. Christodoulou I, Goulielmaki M, Devetzi M, Panagiotidis M, Koliakos G, Zoumpourlis V. Mesenchymal stem cells in preclinical cancer cytotherapy: a systematic review. Stem Cell Res Ther. 2018;9(1;336). https://doi.org/10.1186/s13287-018-1078-8.