Ain Shams University
Faculty of Medicine
General Surgery Department

Application Of Stem Cell In Surgery

Essay
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By
Mohamed Mahmoud Gabr Mohamed
(M.B.B.Ch.)

Supervisors
Prof. Dr.
Ahmed Mohamed Lotfy
Professor of General Surgery
Faculty of Medicine
Ain Shams University

Dr.
Mohamed Ibrahim Hassan
Lecturer of General surgery
Faculty of Medicine
Ain Shams University

Faculty of Medicine
Ain Shams University

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Mohamed Mahmoud Gabr

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Abbreviations

ABIs	Ankle brachial indices
ANT	Altered nuclear transfer
ASCs	Adult stem cells
BMSCs	Bone marrow stem cells
CD	Crohn's disease
CNS	Central nervous system
EB	Embryonic body
EC	Embryonic carcinoma
EG	Embryonic germ cells
EHBA	Extra hepatic biliary atresia
ES	Embyonic stem cell
GFP	Green fluorescent protine
HDC	High dose chemotherapy
hESC	Human embryonic stem cell
HSCs	Hematopiotic stem cells
HSCT	Hematopiotic stem cell transplantation
IBD	Inflamatory bowel disease
ICM	Inner cell mass
IPSCs	Induced pluripotent stem cells
IVF	In vitro fertilization
LIF	Leukemic inhibitory factor
MEF	Mouse embryonic fibroblast
MSCs	Mesenchymal stem cells
NSCs	Neural stem cells
OCT-4	Octamer binding gene
OS	Over all survival
PAD	Peripheral arterial disease
PBSCs	Peripheral blood stem cells
PGCs	Primordial germ cells
PSC	Pluripotent stem cell
RFS	Relapse -free survival
rhG-CSF	Recombinant granulocytes colony stimulating factor

SCI	Spinal cord injury
SCNT	Somatic cell nuclear transfer
SSEA-3	Stage specific embryonic antigen-3
SSEA-4	Stage specific embryonic antigen -4
STAT3	Signal transducer and activators of transcription

Introduction

In the last several decades, investments in basic research have yielded extensive knowledge about the many and complex processes involved in the development of an organism, including the control of cellular development. But many questions remain, one of them is how does a single cell (the fertilized egg) give rise to a complex, multi-cellular organism ***(Davila et al., 2004).***

Stem cell is a special kind of cell that has a unique capacity to renew itself and to give rise to different specialized cell types. **Stem cell Plasticity** is the ability of stem cells from one adult tissue to generate the differentiated types of another tissue ***(Weissmasi, 2000).***

The practical definition of a stem cell is functional definition which is the ability to regenerate tissues over a life time. Stem cells have two main characters which specify them from any other cell in the body. The first one is self-renewal which is the ability to go through numerous cycles of cell division while maintaining the undifferentiated state. The second one is potency which is the capacity to differentiate into several specialized cell types ***(Tuch, 2006).***

Stem cells are categorized by their Potency into ***(Schöler, 2007):***

- Totipotent - the ability to differentiate into all possible cell types. Examples are the zygote formed at egg fertilization and the first few cells that result from the division of the zygote ***(Mitalipov and Wolf, 2009).***
- Pluripotent - the ability to differentiate into almost all cell types. Examples include embryonic stem cells and cells that are derived from the mesoderm, endoderm, and ectoderm germ layers that are formed in the

beginning stages of embryonic stem cell differentiation ***(Ulloa-Montoya et al., 2005).***

- Multipotent - the ability to differentiate into a closely related family of cells. Examples include hematopoietic (adult) stem cells that can become red and white blood cells or platelets ***(Schöler, 2007).***
- Oligopotent - the ability to differentiate into a few cells. Examples include (adult) lymphoid or myeloid stem cells ***(Schöler, 2007).***
- Unipotent - the ability to only produce cells of their own type, but have the property of self-renewal required to be labeled a stem cell. Examples include (adult) muscle stem cells ***(Schöler, 2007).***

In **1981**, researchers reported methods for growing mouse embryonic stem cells in the laboratory, and it took nearly 20 years before similar achievements could be made with human embryonic stem cells. In **1998**, **James Thomson** and his college at the University of Wisconsin-Madison, isolated cells from the inner cell mass of the early embryo, called the blastocyst, and developed the first human embryonic stem cell lines ***(Thomson et al., 1998) .***

Studying stem cells will help to understand how they transform into many different specialized cells. Some of the most serious medical conditions, such as birth defects, are due to problems that occur somewhere in this process. A better understanding of normal cell development will allow us to understand and perhaps correct the errors that cause these medical disorders ***(Tuch, 2006).***

Most diseases facing physicians are degenerative in origin so, there is often no definitive treatment to such diseases. Current stem-cell research has the potential to lead to new methods for the treatment of cardiovascular, neurodegenerative, and musculoskeletal diseases, as well as diabetes and cancer ***(Shahverdian, 2008).***

Cell therapy can be defined as a group of new techniques that rely on replacing diseased or dysfunctional cells with healthy, functioning ones. These new techniques are being applied to a wide range of human diseases, including many types of cancer, Parkinson's disease, diabetes and myocardial diseases ***(Tuch, 2006)***.

Obtaining embryonic stem cells require the destruction of human embryos and/or the creation of human embryos (**therapeutic cloning**) for the sole purpose of providing stem cells ***(Panno, 2005).***

In the field of Surgery, stem cells could be used for treatment of liver diseases ***(Ehnert el al., 2011)***, short bowel syndrome ***(Day, 2008)***, severe Crohn's disease ***(Cassinotti el al., 2010)***, gastrointestinal motility disorders ***(Burns et al., 2006)***, esophageal disorders that need esophageal replacement ***(Saxena et al., 2011)*** Also stem cells have the potential for prevention of amputation of limbs in diabetes and critical limb ischemia by stimulation of angiogenesis ***(Pearce et al., 2010)***. Another application is to use stem cells for soft tissue replacement ***(Stosich and Mao, 2009)***, and treatment of burns and skin ulcers ***(Upjohn el al., 2008)***. Stem cells also could be used for repair of spinal cord injuries ***(Nandoe Tewarie et al., 2008)***, repair of diseased myocardium and diseased heart valves ***(Mo et al., 2009).***

Aim of the work

The main of this essay is to discuss what are stem cells? The properties characterizing stem cells and to stress upon potential uses of stem cells in surgery.

Stem Cell Basics

Stem cells have recently generated a great public and professional interest more than any other topic in biology. The understanding of the unique properties of stem cells will provide deep insights into the biology of cells. The ability of these cells to replace diseased or damaged cells provides cures for number of diseases were considered incurable by normal therapies ***(Melton and Cowen, 2006).***

Definitions of stem cells:

Stem cells are defined functionally as cells that have the capacity to self renew as well as the ability to generate differentiated cells ***(Weissman et al., 2001).*** Stem cells are unspecialized undifferentiated cells in the human body that are capable of differentiation into specialized cells, each with new specialized function. These undifferentiated stem cells can be pluripotent which means the ability to give rise to cells from all three germ layers; the ectoderm, mesoderm and endoderm or multipotent which means the ability to give rise to a limited number of other specialized cell types ***(Kiessling and Anderson, 2003).***

Basically, a stem cell remains uncommitted until it receives a signal to develop into a specialized cell. Stem cells have remarkable properties of developing into a variety of cell types in the human body. They serve as a repair system by being able to divide without limit to replenish other cells. When a stem cell divides, each new cell has the potential to either remain as a stem cell or become another cell type with new special functions, such as blood cells, brain cells, etc. ***(Bongso and Lee, 2005)***.

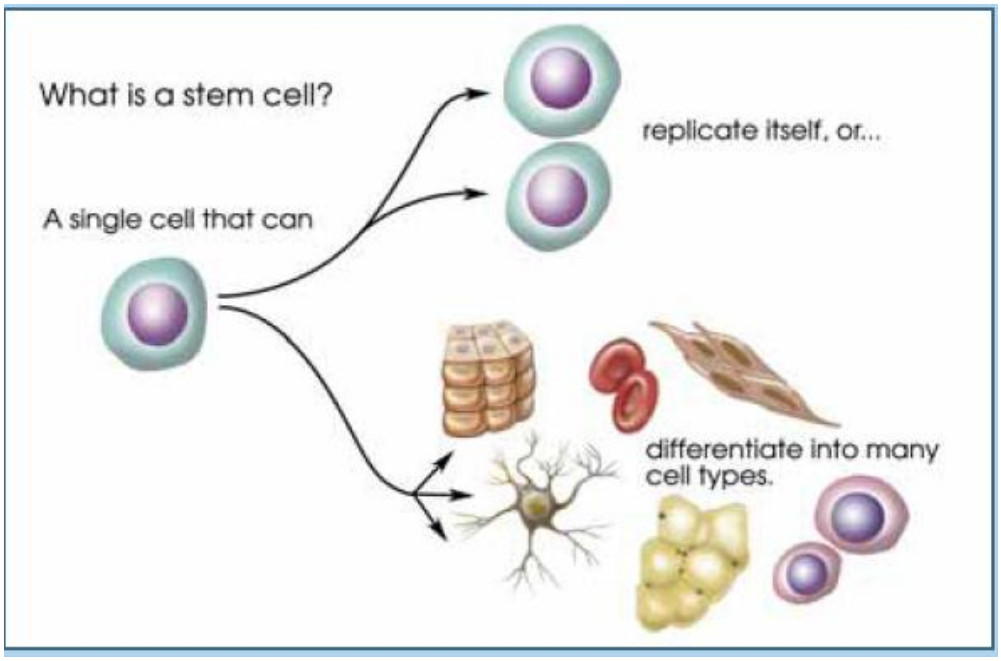

Figure (1): What is a stem cell ? ***(National academies,2010)***

Classification and Sources of Stem Cells:

Stem cells can be classified into four broad types, based on their origin; stem cells from embryos, stem cells from the fetus, stem cells from the umbilical cord and stem cells from the adult. Each of these can be grouped into subtypes ***(Bongso and Lee, 2005).***

I. Embryonic cells:

The embryonic stem cell (ES) is defined by its origin. They are derived from the inner cell mass of the blastocyst at a stage 5-6 day old before it would implant in the uterine wall. The embryonic stem cell can self-replicate and is pluripoten —it can give rise to cells derived from all three germ layers ***(Yu and Thomson, 2006).***

Defining properties of an human embryonic stem cell:

- Derived from the inner cell mass/epiblast of the blastocyst.
- Capable of undergoing an unlimited number of symmetrical divisions without differentiating.
- Exhibit and maintain a stable, full (diploid), normal complement of chromosomes.
- Pluripotent ES cells can give rise to differentiated cell types that are derived from all three primary germ layers of the embryo (endoderm, mesoderm, and ectoderm).

- Capable of integrating into all fetal tissues during development.
- Capable of colonizing the germ line and giving rise to egg or sperm cells.
- Expresses the transcription factor Oct-4, which then activates or inhibits a host of target genes and maintains ES cells in a proliferative, non- differentiating state.
- Can be induced to continue proliferating or to differentiate.
- Do not show X inactivation. In every somatic cell of a female mammal, one of the two X chromosomes becomes permanently inactivated. X inactivation does not occur in undifferentiated ES cells.

(Marshak et al., 2001)