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An Overview of Stem Cell Therapy and Its Application to Cancer Treatment

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Abstract

Cancer is still a leading cause of death around the world. Despite significant progress in understanding the molecular basis of cancer, as well as advances in cancer detection and treatment, cancer mortality remains high, and despite significant advances in medicines, there is no cure. Regenerative medicines based on stem cells have sparked hopes for new therapeutic techniques. Stem cells are cells that have the ability to self-renew and differentiate into adult cells of a particular tissue. A critical comparison of the characteristics of numerous types of stem cells is presented, with a focus on qualities that are crucial for the therapeutic use of these cells.

It is emphasized the relevance of an autologous source of pluripotent stem cells. Cancer Stem Cells (CSCs), like normal tissue stem cells, can self-renew through symmetric or asymmetric cell division and are the only cells capable of reproducing malignant tumors indefinitely. Understanding the physiology and metabolism of CSCs could be critical in the development of new, effective treatments. Because they target all rapidly dividing cells, current chemotherapies have severe adverse effects. Due to the similarities between CSCs and regular tissue stem cells, medications that target exclusively CSCs have less negative effects for patients. The lack of sufficient specificity is thought to be the main impediment to the development of effective cancer therapies. Since the discovery of Mesenchymal Stem Cells (MSCs) tumor-oriented homing capabilities, the use of particular anticancer gene-engineered MSCs has held considerable promise for cancer therapy.

Keywords: Stem Cell; Cancer; Embryonic Stem Cells

Introduction

Cancer is one of the most common causes of death and illness all over the world. Many diseases that cause death have fallen considerably during the last 50 years, but cancer fatalities have not. The genetic and pharmacological pathways that generate drug resistance have received a lot of attention in the past. Cancer, on the other hand, is widely recognized as a heterogeneous illness, and there is growing recognition that intra tumoral heterogeneity contributes to therapy failure and disease progression [1].

Stem cell therapy has the potential to treat degenerative diseases, cancer, and tissue repair in patients who now have no or few treatment options. The first type of stem cells employed in clinical regenerative medicine was MSCs, or mesenchymal stem cells. Symptomatic and passive cancer treatments such as surgery, chemotherapy, and radiotherapy are currently accessible. Traditional cancer therapy's efficacy is severely limited due to a lack of tumor selectivity. Aside from anti-cancer medications' therapeutic specificity, tumor cell drug resistance is another factor that contributes to inefficient cancer treatment. SCs are unique in that they can differentiate into one or more specialized cell types [2]. Stem cell-based regenerative medicines have raised hopes for new cancer treatments.

Stem cells used in regenerative medicine include Embryonic Stem Cells (ESC), Induced Pluripotent Stem Cells (iPSC), and Adult Stem Cells (adult SCs). Almost every successful stem-cell therapy today relies on adult stem cells. In a living organism, adult stem cells' principal functions are to maintain and repair the tissue in which they are present. Current thinking believes that these cells' regenerative properties are related to trophic paracrine actions rather than real regeneration, and that they are more essential as immune modulators. Stem cells have three characteristics: Self-renewal, the potential to grow into several lineages, and the ability to multiply broadly [3]. Stem cells are distinguished by the combination of these three traits. Self-renewal is notable since its interruption has been related to oncogenesis and cancer. Stem cells have the ability to regenerate all of an animal's tissues. As a result, stem cells hold a lot of promise for future tissue regeneration and repair medicinal applications. General methods for identifying and isolating CSCs in malignancies include xenotransplantation assays, which are the gold standard for identifying CSCs; sorting based on cell surface markers; efflux of Hoechst 33342 or Rhodamine dyes; the enzymatic activity of Aldehyde Dehydrogenase (ALDH); and colony and sphere forming assays, which require specific culture conditions [4].

Cancer stem cells exist in niches, which are microenvironments that are important for stem cell survival. The niche is made up of fibroblasts, endothelial cells, perivascular cells, tissue macrophages, extracellular matrix, and soluble chemicals expelled from cells or released from the stroma [5].

Some stromal cells in the niche may produce chemicals that influence CSC self-renewal characteristics. Cancer stem cells prefer a hypoxic microenvironment to preserve homeostasis over normal stem cells, which prefer a glycolytic microenvironment. In terms of proliferating, differentiating, invading, and metastasizing, CSCs and niches communicate in such a way that CSCs instruct the niche and are directed by the niche. Cancer Stem Cells (CSCs), also known as Tumor Initiating Stem-Like Cells (TICs), are a form of cancer cell that may self-renew and is resistant to chemotherapeutic drugs. This sub-population behaves like stem cells because it divides symmetrically or asymmetrically and keeps its population within the tumor [6]. CSCs and normal tissue stem cells both have the ability to self-renew; however, because CSCs appear to be selectively endowed with the ability to self-renew and are important for long-term tumor growth and progression maintenance, self-renewal in CSCs is generally unregulated. CSCs may potentially be involved in tumor metastasis.

Because of their inability to effectively target CSC populations, current systemic cancer therapies frequently fail to destroy advanced tumors. The physiology and metabolism of CSCs could be crucial in

the creation of novel, effective therapeutics. Tumors are complicated biological entities whose growth and progression are strongly reliant on reciprocal interactions between genetically altered (neoplastic) cells and their non-neoplastic environment, regardless of their origin [7].

All cancer therapies, including surgery, hormone therapy, anti-angiogenesis therapy, and immunotherapy, are poor in terms of long-term outcomes due to their failure to target cancer stem cells and toxicity due to non-specific effects on normal cells. The use of anticancer gene-engineered MSCs has held tremendous promise for cancer therapy since the discovery of Mesenchymal Stem Cells (MSCs) tumor-oriented homing capabilities. With the discovery of specific anticancer genes and the revelation of MSCs' tumor-directed migratory and integration capacities, a new research field devoted to producing effective cancer therapy using modified MSCs has emerged.

Stem Cells

Stem cells are self-renewing congenic cells that can develop into a variety of lineages. One of the most difficult problems in stem cell biology is figuring out how to govern self-renewal. Because many types of stem cells require self-renewal to live for the rest of an animal's life, it is critical for stem cell function. Furthermore, whereas stem cells from different organs have varying developmental potential, all stem cells are self-renewing and regulate the relative balance between self-renewal and differentiation. Because cancer is a disease of uncontrolled self-renewal, understanding how normal stem cells self-renew is regulated is just as important as understanding how cancer cells proliferate [8].

Self-renewal is the basic biological method of cell division; a stem cell produces one (asymmetric division) or two (symmetric division) self-renewing daughters. The stem cell population is maintained or increased for long-term clonal expansion. Stem cells have the potential to self-renew and differentiate into a variety of lineages over a long period of time (proliferation) (asymmetric replication). These characteristics are more prominent in younger sources. Because of asymmetric replication, one cell retains its self-renewing capacity after each cell division, while the other Transit-Amplifying (TA) cell enters a differentiation pathway and joins a mature non-dividing population [9]. When an unspecialized stem cell transforms into a specific tissue, it acquires the characteristics of that tissue. Stem cells come in three varieties pluripotent, multi-potent, and unipotent. The totipotent zygote is the only mammalian cell capable of producing all of an organism's cells and tissues.

Pluripotent cells can produce cells and tissues from all three germ layers, including the ectoderm, mesoderm, and endoderm. Multi-potent cells can generate many cell lineages within a closely related family of cells. Stem cells are undifferentiated cells that are maintained dormant or slowly cycling until they are required for the organism's normal functioning.

Stem Cell Sources and Classification

There are two types of stem cell harvesting: Allogeneic and autologous. Autologous stem cells are taken from the host in whom they will be employed, whereas allogeneic stem cells are obtained from an unrelated donor prior to transplantation. The use of allogeneic stem cells may predispose a patient to a variety of immunologic disorders as a result of treatment; however this technique of treatment results in a significant reduction in graft rejection. Autologous therapies' capacity to grow and generate cells could be a drawback. When assessing the therapeutic benefits and limitations of stem cell transplantation, immunological obstacles such as graft versus host disease and the necessity for host immunosuppression are constantly taken into account [10].

Embryonic Stem Cells (ESC) are stem cells derived from pre-implantation embryos (morulae or the inner cell mass of the early blastocyst) that, when cultured under the appropriate conditions, can be encouraged to develop into cells of all three germ layers (ectoderm, mesoderm and endoderm). ESC can be easily produced as undifferentiated cells under particular conditions, resulting in an unlimited supply of pluripotent stem cells. Adult stem cells are Induced Pluripotent Stem Cells (iPSC) that are formed from somatic cells and a variety of primary cell types, including Endothelial Progenitor Cells (EPC), Mesenchymal Stem Cells (MCS), Cardiac Derived Progenitor Cells (CDP), and cardiac stem cells (CSC) (adult SCs).

Stem cells are divided into three categories: Embryonic Stem Cells (ESC), adult stem cells, and induced stem cells. When it comes to bioprocess development, each type of stem cell has its own set of benefits, downsides, and challenges. They all have the ability to reproduce indefinitely (infinite self-renewal), although their differentiation potential varies. Many laboratories to clinic translational concerns, such as cell source, extraction, immunogenicity, proliferative capability, and cell yield, must be evaluated first with the rising spectrum of stem cell sources available for donor cells in transplantation therapy.

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