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Single Cell Biology

Perspective

Highly Efficient Insulin Dependent Treatment of Hematopoietic Stem Cells

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DESCRIPTION

Hematopoietic Stem Cells (HSCs) are stem cells that give rise to other blood cells. This process is called hematopoiesis. An immature cell can develop into any type of blood cell, including white blood cells, red blood cells, and platelets. Hematopoietic stem cells are found in peripheral blood and bone marrow and are also called blood stem cells. HSCs are responsible for generating mature blood cells in the bone marrow. Peripheral pancytopenia is a common clinical manifestation resulting from a variety of conditions, including hematologic or extra-hematologic disorders (mainly cancer) that impair bone marrow function. Hematopoietic stem cells are found in adult bone marrow, especially in the pelvis, femur, and sternum. They are also found in cord blood and small numbers in peripheral blood. Just before birth, HSCs migrate to the bone marrow and reside in a specialized niche throughout adult mammalian life. Hematopoietic stem cells are generated from a subset of embryonic endothelial cells with hematopoietic potential. The two key properties of hematopoietic stem cells are their ability to differentiate into all blood cell types and their ability to self-renew. Adult bone marrow contains far more hematopoietic stem cells than previously thought, with between 50,000 and 200,000 stem cells.

Blood cells from HSC are divided into two lineages, Lymphoid cells, and Myeloid cells. Both myeloid and lymphatic systems are involved in the formation of dendritic cells. Myeloid cells include monocytes, macrophages, neutrophils, basophils, eosinophils, erythrocytes, and megakaryocytes to platelets. Lymphoid cells include T cells, B cells, natural killer cells, and innate lymphoid cells. The definition of hematopoietic stem cells has evolved since HSCs were first discovered in 1961. Cells of the hematopoietic lineage of the bone marrow do this after receiving a signal from a hormone called erythropoietin. This hormone is produced primarily in the kidneys and increases the Epo levels up to 1000-fold in response to the desaturation of blood oxygen.

Hematopoiesis is the production of blood cells. The human body is constantly making new blood cells to replace old ones. Hematopoiesis supplies oxygen to tissues (red blood cells), fights infections (white blood cells) and keeps blood clotting when injured. HSCs ensure a healthy supply of blood cells (platelets) that help identify and function major hematopoietic and lymphoid tissues like bone marrow, spleen, thymus, and lymph nodes. HSCs and primitive hematopoietic cells that are characterized by the absence of lineage-specific markers and the presence of certain other cell surface antigens such as CD133 (for human cells), c-kit, and Sca-1 (for mouse cells), can be distinguished from mature blood cells. Hematopoietic stem cells are involved in the daily production of all blood and immune cells in the body and are commonly transplanted to treat patients with leukemia, lymphoma, some solid tumors, and autoimmune diseases.

In the developing human embryo and fetus, hematopoiesis has three developmental waves and is conceptually divided into three anatomical stages, mesoblastic, hepatic, and myeloid. Hematopoietic stem cells are rare cells with pluripotent and self-renewing properties that can generate an entire hematopoietic lineage. Through the identification of specific niches within the bone marrow, including the endosteum and endothelium, tight interactions between HSCs and regulatory components of the bone marrow microenvironment determine HSC proliferative state, pool size, differentiation, and recruitment is now recognized. The discovery and characterization of hematopoietic stem cells required decades of research. The identification of adult bone marrow as a source of hematopoietic cells that can protect organisms from lethal radiation has prompted an intense investigation into their identity and properties. Functional assays can be used together with evolving techniques for isolating hematopoietic cells to enrich hematopoietic stem cell populations and analyze their properties. Definitive hematopoiesis in the embryo begins with the appearance of the first identifiable HSCs in the aorta-gonad-mesonephros region.

HSCs are used in the treatment of many malignant diseases (leukemia, lymphoma, etc.) and non-malignant diseases (sickle cell anemia, etc.) to replace or remodel the patient's hematopoietic system. This type of treatment is called a bone marrow or stem cell transplant. HSC is also being used in US FDA-regulated clinical trials to treat autoimmune diseases, genetic disorders, and other indications.

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