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Effect of Blood Cancer in Human

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Abstract: *Hematological cancer, commonly referred to as blood cancer, is a form of cancer that originates in the organs responsible for blood production, such as the bone marrow or lymphatic system. It disrupts the production or function of blood cells and can occur when cancer impacts the bone marrow, a spongy tissue inside the bones, or the small lymph nodes that help fight infections (lymph nodes). Doctors use different ways to fight it. Older methods include chemotherapy, which uses strong medicines to kill cancer cells, and radiation therapy, which uses powerful beams to target specific areas. Another method is stem cell transplantation, where unhealthy blood-making cells are replaced with healthy ones, which can sometimes cure the cancer. More recently, new treatments have been developed. Immunotherapies help your own body's defense system (immune system) fight cancer. The treatment that's best for someone depends on the exact type of blood cancer they have, how advanced it is, and their overall health. Scientists are constantly working to improve these treatments and find new ones that work better and have fewer side effects for people with blood cancer. This review discusses the mechanism, application and benefits of therapies for blood cancer treatment.*

Key Word: *Chemotherapy, Radiation therapy, Stem cell transplantation, Immunotherapy.*

I.INTRODUCTION

Cancer remains one of the top causes of mortality globally (1). Tumors that originate in the blood, bone marrow, or components of the lymphatic system, such as lymph and lymphoid tissues, are classified as hematopoietic and lymphoid tissue neoplasms (2, 3). These tissues are connected through the circulatory and immune systems, so a disease in one often affects the others. This makes conditions like aplasia, myeloproliferative, and lymphoproliferation (leading to leukemias, myelomas, and lymphomas) closely linked. One of the frequent underlying causes involves chromosomal translocations, which play a significant role in both the diagnostic process and treatment planning. Blood cancers are typically treated by hematology or oncology specialists, and while these fields may be combined in some places, they are separate in others (4). Non-cancerous blood disorders are also managed by hematologists. Blood cancers can originate from myeloid or lymphoid cells. Myeloid progenitor cells give rise to red blood cells, platelets, and various types of white blood cells, including neutrophils, eosinophils, basophils, and monocytes. In contrast, lymphoid progenitor cells develop into B lymphocytes, T lymphocytes, and natural killer (NK) cells .Diseases such as lymphomas, lymphocytic leukemias, and myelomas fall under the lymphoid category, whereas conditions like myelogenous leukemia are classified as myeloid. Some of these disorders are highly aggressive and are collectively referred to as hematological malignancies or blood cancer, also known as liquid tumors (5) the current approaches for treating blood cancer often include the use of chemotherapy, radiation, immune-based therapies, and stem cell transplants. (6).Although various chemotherapeutic drugs are accessible for the treatment of blood cancers, there is no conclusive cure available in clinical practice, as these cancers tend to progress over time and may result in bone metastasis (7).

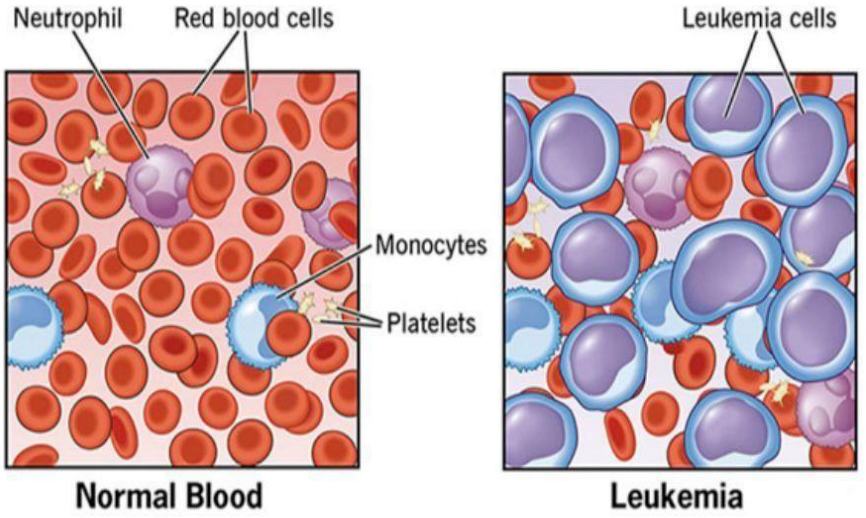
II.BLOOD CANCER

Blood cancer affects how blood cells develop and function, often starting in the bone marrow where these cells are made. Instead of developing normally, stem cells turn into abnormal cells that grow uncontrollably and prevent the blood from fighting infections or stopping bleeding. The exact cause is unknown, but factors like older age, family history, and a weakened immune system—especially after infections—may increase the risk(8).Common symptoms of blood cancer include fatigue, frequent infections, unexplained weight loss, fever, night sweats, bone pain, easy bruising or bleeding, swollen organs or glands, abdominal discomfort, nausea, and increased urination. Blood cancer is generally classified into three major types that written below:

1. Leukemia: this type of cancer originates in the bone marrow and also interferes with the body's ability to produce healthy blood cells.

2. Lymphoma: this type of cancer affects the lymphocytes, which are essential white blood cells and are involved in immune response.

3. Myeloma: the cancer called myeloma generally develops in plasma cells, a specific kind of white blood cell that helps to produce antibodies.



Leukemia: Leukemia begins when mutations in cell DNA cause the body to produce immature white blood cells that are unable to perform their normal roles. These white blood cells are important for fighting infections, but when they grow abnormally, they take over the bone marrow and stop it from working properly, causing the disease to spread (9)

Types of Leukemia and Their Causes:

1. Acute Lymphocytic Leukemia (ALL): It targets lymphocytes, a kind of white blood cell, causing them to stay undeveloped and interfere with how the bone marrow functions. The exact cause isn't clear, but things like exposure to chemicals (like benzene), radiation, chemotherapy, and problems with chromosomes can increase the risk of getting ALL..

2. Acute Myelogenous Leukemia (AML): it starts in the bone marrow, where immature cells that would normally become white blood cells grow uncontrollably. It's often caused by exposure to harmful chemicals, radiation, blood disorders, or a weak immune system. It is one of the most frequently diagnosed types and tends to progress at a fast rate.

3. Chronic Lymphocytic Leukemia (CLL): CLL is a slow-growing disease that affects lymphocytes, leading to swollen lymph nodes and spleen. The cause isn't known and it's not linked to radiation. However, people who were exposed to Agent Orange during the Vietnam War have a higher risk of getting CLL. Over time, it can make the bone marrow stop working.

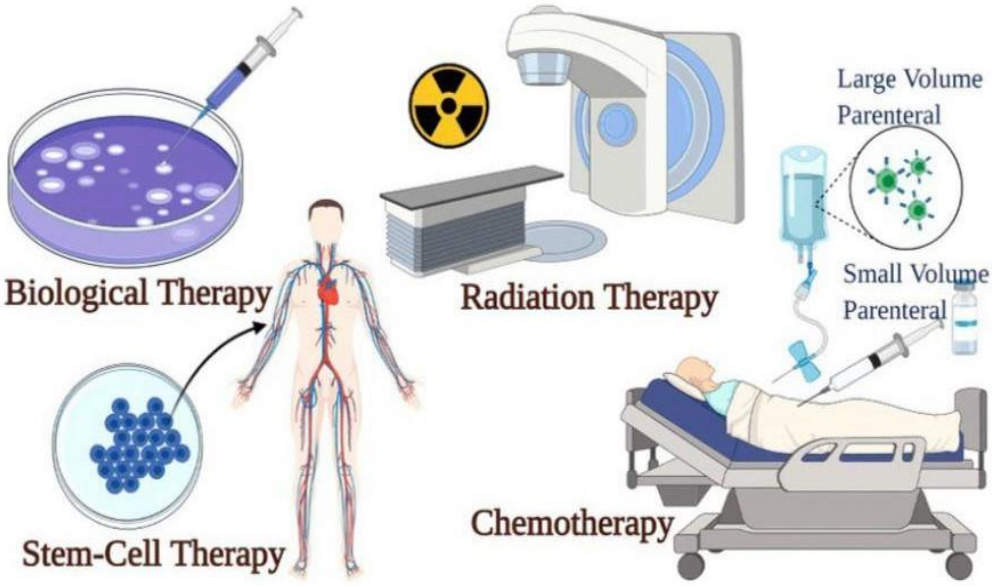
4. Chronic Myelogenous Leukemia (CML): CML grows slowly from abnormal white blood cells and interferes with bone marrow function. The main cause of CML is an abnormal chromosome called the Philadelphia chromosome. Being exposed to radiation may also increase the chances of developing the disease.

5. Hairy Cell Leukemia (HCL): HCL is a rare type of leukemia that affects white blood cells that look "hairy" under a microscope. The cause of HCL is still unknown (10, 11).

Lymphoma: Lymphoma is a type of cancer that affects the blood by attacking lymphocytes, a special type of white blood cell. These cells are essential for defending the body against infections and are located in lymphatic tissues like the lymph nodes, spleen, and bone marrow... When lymphoma develops, these lymphocytes multiply without control, leading to the formation of solid tumors in the affected regions. Lymphocytes are mostly of two types — B cells, which make antibodies, and T cells, which help fight infections in other ways... In lymphoma, these cells begin to behave abnormally, dividing rapidly and forming masses in lymph nodes and other lymphatic tissues. Since lymphatic tissue is spread throughout the body, and lymphoma can develop in almost any area. There are two main types of lymphoma: Hodgkin's lymphoma and non-Hodgkin's lymphoma.. Non-Hodgkin's lymphoma, which includes around 30 subtypes, has become more common over recent decades. It is more frequent in males and is seen more often in white individuals compared to other racial groups. One factor that may contribute to the increase in non-Hodgkin's lymphoma is the rise in people with weakened immune systems, such as those with HIV or individuals who have had organ transplants and take immunosuppressive medications' cells are often the cells involved in lymphoma because abnormalities in their development or signaling pathways can cause them to grow uncontrollably. These changes can lead to tumors forming in lymphatic tissues, making lymphoma a serious health concern (12, 13).

Myeloma: Myeloma is a cancer that starts when plasma cells in the bone marrow grow in an unusual way. These cells normally produce antibodies and help the immune system fight infections.In myeloma, abnormal plasma cells multiply too much, forming lumps that weaken the bones. As a result, the bone marrow can't make normal blood cells properly. The exact reason why myeloma develops is still not fully known. However, exposure to harmful substances or radiation may increase the risk of developing this diseases (14)

Treatment of blood cancer and what are their mechanism we follow and response after the treatment of cancer in human body:



(2) Chemotherapy: In the early 1900s, German chemist Paul Ehrlich introduced chemical treatments for infections and later found they could also target cancer. His work laid the groundwork for modern chemotherapy used against various cancers (15). Chemotherapy involves the use of chemical substances to block the growth of cancerous cells or to combat harmful microorganisms responsible for a disease (16).Chemotherapy medications may be administered orally through an injection into the muscle or by intravenous administration to enter the bloodstream. Unfortunately, these drugs do not specifically target only cancer cells. These medications can also harm normal cells that divide rapidly, including those in the hair follicles, digestive lining, and bone marrow, potentially causing serious side effects and damage.to normal body tissues. Because of this, chemotherapy should not be used too often, and it's important to carefully consider the benefits and risks. The right dosage of chemotherapy is usually based on factors like the number of cancer cells, how resistant the cancer is to the drug, and the potential side effects. The effectiveness of chemotherapy is usually measured by how many cancer cells remain and how severe the side effects are. (17-20). Most monoclonal antibodies do not harm all cells but instead work by focusing on specific proteins that are found in large amounts on cancer cells and are important for their growth (21).Nowadays, chemotherapy can be delivered through various methods, with the aim either to fully eliminate the disease or to extend the patient's lifespan.

a. Combined Chemotherapy: means using more than one type of treatment at the same time, like chemotherapy along with radiation, surgery, or heat therapy (hyperthermia). Induction chemotherapy refers to the initial use of anti-cancer medications aimed at reducing the size of the tumor (22).
b. Consolidation Chemotherapy: it is given after the cancer goes into remission (meaning it gets better or disappears) to help keep it from coming back (23).
c. Intensification Chemotherapy: it is similar to consolidation therapy, but it uses a different drug than the one used in the first (induction) treatment.
d. In combination chemotherapy: multiple drugs that act through different mechanisms are used at the same time.. This approach helps lower the chances of cancer cells becoming resistant to any one drug. It also allows doctors to give smaller doses of each drug, which helps reduce side effects and toxicity.
e. Neoadjuvant Chemotherapy: is given before treatments like surgery. Its main purpose is to shrink the main tumor (24) It's also used when there is a high risk of cancer spreading to other parts of the body, even if it's not yet visible. This type of therapy can be helpful when there are only small signs of cancer or when there is a risk that the cancer might return. It also helps destroy cancer cells that may have already spread to other areas (25)
f. Maintenance Chemotherapy: uses repeated, low doses of drugs to help keep the cancer from coming back and to maintain remission.
g. Salvage chemotherapy: is given as a last option when previous treatments have failed to control the disease. It aims to reduce the size of the tumor and help the patient live longer (26).
h. Dose-Dense Chemotherapy: This approach involves administering chemotherapy sessions more frequently than the standard schedule. While traditional chemotherapy might occur every three weeks, dose-dense regimens shorten the gap to about two weeks. This technique is primarily employed for cancers that are more advanced and beginning to spread (27).
i. Combined Modality Chemotherapy: Combined modality therapy refers to the use of multiple treatment types in coordination

to fight cancer. For instance, in stage 3 or aggressive cancers, the treatment plan may consist of surgery followed by chemotherapy, radiation, and extended use of targeted therapies like Herceptin over a year (28).

j. Palliative Chemotherapy: Palliative chemotherapy focuses on enhancing the patient's comfort and overall well-being, rather than attempting to cure the cancer. It helps relieve pain, shrink tumors, and improve organ performance. While it is often associated with end-of-life care, palliative treatments can also be introduced at any stage of the cancer journey to address quality-of-life concerns (29).

k. Photodynamic Therapy (PDT): Photodynamic therapy is a three-part cancer treatment that uses a light-sensitive drug, oxygen in the tissues, and a specific light source—often lasers—to target cancer cells. It is commonly used for treating basal cell carcinoma and lung cancer, and it can also help eliminate remaining malignant cells after the surgical removal of a tumor (30).

All the chemotherapy treatments mentioned earlier are given only to patients who are healthy enough to go through them. To check if a patient can continue with the treatment or if the dose needs to be reduced, doctors use a tool called performance status, which helps assess the patient's overall health. Since each session of chemotherapy becomes slightly less effective at killing cancer cells, several rounds are needed to keep reducing the size of the tumor. Chemotherapy is typically administered in repeated rounds, following a set schedule over specific time intervals. The number of cycles and their timing depend on how well the patient is coping with the treatment's side effects (31).

(3) Radiation Therapy: Another approach to treating blood cancer is through the use of radiation therapy. It works by using high-energy rays to destroy cancer cells. This treatment can be used by itself or along with other methods like chemotherapy or stem cell transplants. A specialized device focuses radiation on the cancer, breaking the DNA inside the cells so they can no longer grow or reproduce. If the cancer has spread throughout the body, radiation can be given to the whole body. If it's only in one area, the radiation is focused on that specific spot (32).radiation therapy used, as well as the amount and time of treatment, may vary based on the type and stage of the cancer as well as the patient's overall condition. Among other things, exhaustion, skin irritability, nausea, and diarrhea are possible side effects of radiation therapy. The amount and duration of radiation therapy, as well as the area of the body being treated, can all affect how severe the side effects are. To control their symptoms and side effects as well as to track their response to treatment, patients undergoing radiation therapy should communicate often with their doctors. While radiation therapy has the potential to be a successful treatment for blood cancer, there are also potential downsides, such as a higher chance of later-life cancer development. Before beginning radiation therapy, patients should speak with their doctor about the possible risks and benefits (33).While radiation affects both healthy and cancerous cells, the main goal is to target cancer cells more heavily while protecting nearby normal tissues. Healthy cells are usually better at healing and can return to normal function faster than cancer cells. In contrast, cancer cells are less effective at repairing radiation damage, which helps make the treatment more focused and effective in killing them (34). Radiation therapy is used in the treatment of about one out of every two people diagnosed with cancer.(35,,36). It's estimated that radiation therapy plays a role in curing around 40% of cancer cases (37).

(4) Stem Cell Transplantation: Stem cell transplantation is a process where damaged or diseased bone marrow is replaced with healthy stem cells. In autologous transplants, the patient's own stem cells are used, while allogeneic transplants involve stem cells from a donor (38,39). Stem cell transplants are often given to patients with advanced or aggressive blood cancers who haven't responded to previous treatments or who have relapsed. The objective is to replace the patient's damaged bone marrow with healthy stem cells, which helps generate new, healthy blood cells. The procedure involves collecting stem cells from the patient or a donor, preparing the patient's body to accept the new cells, and then injecting them into the patient's bloodstream. After the transplant, patients are carefully monitored for any complications (40). After a stem cell transplant, patients may need to take medication and get regular care to stop the body from rejecting the new stem cells. This treatment can help cure blood cancer or keep it from coming back for a long time, while also improving the patient's overall well-being. However, there are serious risks, such as infections, graft-versus-host disease (GVHD), and other problems that can occur after the transplant (41, 42). Stem cell (SC) therapies became a major focus of research after the first successful bone marrow transplant(43)

(5) Immunotherapy: The immunotherapy is also known as biological therapy. Immunotherapy is a cancer treatment that enhances the body's immune system, helping it better identify and destroy cancer cells.(44,45). These therapies enhance the immune system's ability to recognize and destroy cancerous cells. (46-51). Immunotherapies, such as checkpoint inhibitors, monoclonal antibodies, and CAR-T cell therapy, are treatments used for blood cancers. These treatments can be used alone or together with other options like chemotherapy or targeted therapies. The advantages of immunotherapy include better chances of responding to the treatment, longer periods of remission, and in some cases, the possibility of a cure (52). Immunotherapy can also cause side effects, and these may differ based on the type of treatment being used (53). It's important to note that not all patients with blood cancer may be eligible for targeted therapy or immunotherapy, and the effectiveness of these treatments can differ depending on the patient's specific condition and overall health. Those considering these treatment options should consult closely with their doctors to fully understand the possible risks and benefits and to decide if these therapies are suitable for their individual needs (52). Blood cancer is a challenging and complicated disease that can affect individuals of any age or socioeconomic status. Although the precise causes of blood cancer remain unclear, ongoing research has led to the development of new treatments, which are helping to improve patient outcomes. It is vital to continue supporting research and the creation of new therapies to enhance the quality of life for those impacted by this illness (54).

III.CONCLUSION

Blood cancer encompasses a diverse group of malignancies originating in the blood, bone marrow, or lymphatic system. Advancements in medical research have led to improved diagnostic methods, enabling earlier detection and more personalized treatment approaches. Therapeutic options such as chemotherapy, radiation therapy, stem cell transplantation, and immunotherapy—including CAR-T cell therapy—have significantly enhanced patient outcomes, offering hope for remission and, in some cases, potential cures. However, challenges remain, including the risk of relapse, treatment-related side effects, and the need for individualized care plans. Ongoing research is crucial to develop more effective and less toxic therapies, as well as to better understand the genetic and molecular underpinnings of these cancers. Collaboration among researchers, healthcare professionals, and patients is essential to continue making strides in the fight against blood cancer. For those affected, seeking support from healthcare providers and connecting with support groups can provide valuable resources and emotional assistance. With continued dedication to research and patient care, the outlook for individuals diagnosed with blood cancer continues to improve.

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