An Integrative Review of Leukemia in Relation to Ayurvedic Fundamentals and Experimental Evidence

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ABSTRACT

Neoplasms are defined as abnormal masses of tissue resulting from uncontrolled, autonomous, and excessive cellular proliferation. Leukemia, a malignant hematological neoplasm, is characterized by clonal expansion of immature myeloid or lymphoid blast cells, leading to abnormal elevation of circulating white blood cells and progressive bone marrow failure. Despite significant advances in diagnosis and therapy, leukemia continues to pose a major global health burden. Worldwide cases have increased substantially over recent decades, reflecting improved survival rates, population growth, and aging, alongside a growing demand for supportive and holistic care approaches.

Classical Ayurvedic texts do not describe leukemia as a distinct disease entity; however, its pathophysiology can be interpreted through Ayurvedic fundamentals such as Rakta Dushti, Dhatu Dushti, Arbuda, and derangement of Agni and Srotas. While Raktaja Arbuda is often considered the nearest conceptual correlate, leukemia differs in its diffuse, systemic, and non-localized nature. Ayurveda emphasizes understanding disease at the level of causative factors (Nidana), tissue involvement, and imbalance of Doshas, offering a framework for integrative interpretation rather than direct nosological equivalence.

Several classical Ayurvedic formulations and medicinal plants—such as Guduchi (Tinospora cordifolia), Haridra (Curcuma longa), Triphala, Kanchanara Guggulu, Punarnava, and Shigru—have demonstrated immunomodulatory, antioxidant, anti-inflammatory, and detoxifying properties in experimental and preliminary clinical studies. These interventions may support host immunity, mitigate chemotherapy- and radiotherapy-induced adverse effects, and improve overall quality of life.

This integrative review explores leukemia through Ayurvedic conceptual frameworks alongside experimental evidence, highlighting the potential role of Ayurveda as an adjunct in comprehensive leukemia care. The study underscores the need for systematic experimental and clinical research to validate Ayurvedic interventions and facilitate their evidence-based integration into modern oncology.

Keywords: Arbuda, Ayurveda, Holistic Approach, Leukemia, Post-chemotherapy, Radiotherapy, Rakta Dushti

1. Introduction

Leukemia is a heterogeneous group of hematological malignancies characterized by uncontrolled proliferation of abnormal hematopoietic cells in the bone marrow, peripheral blood, and lymphoid tissues. Conventionally, leukemias are classified into; Myeloid and Lymphoid on the basis of cell types predominantly involved, and on the basis of natural history of the disease, leukemia can be classified into Acute and Chronic[1]. According to recent estimates, leukemia remains a major contributor to the global cancer burden. In 2021, there were about 461,423 new cases of leukemia worldwide, and deaths numbered approximately around 300,000-311,000 in 2022[2] for all haematologic malignancies, with leukemia accounting for a large share of incidence and mortality for blood cancers. Among the subtypes, acute myeloid leukemia (AML) remains the most common in adults globally[3]. In India, the burden of blood cancers (leukemia + lymphomas) has also been increasing. The GLOBOCAN 2022 estimates report approximately 120,000 new cases of blood cancer in India per year, with about 70,000 deaths in 2022[4]. Leukemia is the most common blood cancer in India, with about 49,883 new leukemia cases annually. For children (0-14 years) in India, leukemia remains the leading childhood cancer, representing over 40% of new childhood cancer cases[5]. This data indicates that while global leukemia incidence rates are stabilizing, the absolute number of cases and deaths continues to rise, especially in developing countries like India, where leukemia is the most common blood cancer and the leading childhood cancer. This highlights the urgent need for early diagnosis, better access to treatment, and strengthened cancer care systems. The conventional healthcare system needs to work alongside holistic sciences because modern cancer treatments — such as chemotherapy, radiotherapy, and surgery — often leave patients with reduced immunity and lowered strength to fight the disease. There is also a risk of cancer returning, sometimes in a more aggressive form. Ayurveda plays a crucial role here by focusing on strengthening the patient's immunity and overall vitality. Through personalized diet, herbal medicines, lifestyle guidance, and rejuvenative therapies, Ayurveda supports the body's natural ability to heal, reduces treatment-related side effects, and improves mental resilience. When combined, modern medicine and Ayurveda can offer a more complete approach to cancer care, addressing both the disease and the patient's overall well-being.

In *Ayurveda*, leukemia can be conceptualized as a manifestation of *Rakta Dhatu* vitiation accompanied by *Dosha* imbalance, reflecting both systemic and hematopoietic dysfunction. *Rakta Dhatu*, responsible for oxygen transport, nourishment of tissues, and overall vitality, is central to maintaining homeostasis. Vitiation of this dhatu leads to impaired hematopoiesis, abnormal proliferation of blood cells, and disruption of immune competence, paralleling the pathophysiological changes observed in modern leukemia.

Aim

To explore and interpret leukemia from an Ayurvedic perspective by correlating classical concepts of *Doṣha, Dhātu, Agni, Ojas,* and *Srotas* with contemporary clinical and experimental evidence.

Objectives

1. To conceptualize leukemia in terms of *Rakta Dhātu Duṣhṭi* and *Tridoṣha* involvement as described in classical Ayurvedic literature.
2. To examine the relevance of Ayurvedic diagnostic frameworks, including *Trividha Parīkṣā* and *Daśavidha Parīkṣā*, in the assessment and understanding of hematological disorders.
3. To establish a scientific correlation between fundamental Ayurvedic principles and modern concepts of leukemia pathophysiology.
4. To highlight the scope and potential role of Ayurveda as a supportive and integrative approach in the prevention, management, and post-treatment care of leukemia.

2. Materials & Methods

This study was conducted as a conceptual analysis of classical Ayurvedic texts and contemporary scientific literature related to leukemia. Classical references were collected from authoritative Ayurvedic texts including *Charaka Samhita*, *Sushruta Samhita*, and *Ashtanga Hridaya*, focusing on descriptions of *Rakta Dhatu*, *Raktapitta*, *Pandu*, *Ojas*, and *Tridosha* imbalance. Contemporary literature

was reviewed from indexed journals and electronic databases such as PubMed, Google Scholar, and Scopus. Relevant in vitro, in vivo, and review articles were screened to identify studies evaluating the antileukemic effects of Ayurvedic herbs, herbomineral preparations, and isolated phytoconstituents. Data were systematically analyzed to correlate Ayurvedic concepts with modern hematological findings, experimental outcomes, and proposed mechanisms of action. Emphasis was placed on studies demonstrating antiproliferative, proapoptotic, immunomodulatory, and antioxidant activities relevant to leukemia.

Leukemia- Blood is defined as the red coloured fluid that circulates through vascular system in humans and other vertebrates, carrying nutrients and oxygen to and waste products including carbon dioxide from all parts of the body. It is also known as fluid of connective tissue, fluid of life, fluid of growth and fluid of health[6]. Blood contains the blood cells which are called formed elements and the fluid matrix called the Plasma[7]. Three types of Blood cells are present in the blood; Red Blood Cells or Erythrocytes, White blood Cells or Leukocytes and Platelets or Thrombocytes. These cells are made from the stem cells (Stem cells differentiates into specialized cells and are capable of reforming themselves by mitotic division[8] as the body needs them. When cells grow old or get damaged, they die, and new cells take their place. First a stem cells matures into either a myeloid stem cell or a lymphoid stem cell:

- A myeloid stem cell matures into a myeloblast. The blast can form a red blood cell, platelets, or one of several types of white blood cells.
- A lymphoid stem cell matures into a lymphoblast. The blast can form one of several types of white blood cells, such as B cells or T cells.

In a person with leukemia, the bone marrow makes abnormal white blood cells. The abnormal cells are leukemic cells. Unlike normal blood cells, leukemia cells don't die when they should. They may crowd out normal white blood cells, red blood cells, and platelets. This makes it hard for normal blood cells to do their work.

Types of Leukemia-

The types of leukemia can be grouped based on how quickly the disease develops and gets worse. Leukemia is either chronic (which usually gets worse slowly) or acute (which usually gets worse quickly):

- Chronic leukemia: In the early stages of chronic leukemia, abnormal cells can still work like normal white blood cells, so there may be no symptoms. It's often found during a routine checkup. Over time, as these cells increase, symptoms like swollen lymph nodes or more frequent infections may appear. These usually start mild and get worse gradually.
- •Acute leukemia- The abnormal cells cannot perform the work of normal white blood cells. These leukemia cells multiply rapidly, and the disease usually progresses quickly.

The types of leukemia can also be grouped based on the type of white blood cell that is affected. Leukemia can start in lymphoid cells or myeloid cells. Leukemia that affects lymphoid cells is called lymphoid, lymphocytic, or lymphoblastic leukemia. Leukemia that affects myeloid cells is called myeloid, myelogenous, or myeloblastic leukemia.

There are four common types of leukemia:

- Chronic lymphocytic leukemia (CLL): CLL affects lymphoid cells and usually grows slowly. Each year, over 15,000 new cases are diagnosed, mostly in people over age 55. It rarely occurs in children.
- Chronic myeloid leukemia (CML): CML affects myeloid cells and usually grows slowly at first. Around 5,000 new cases are diagnosed each year, mainly in adults.
- Acute lymphocytic (lymphoblastic) leukemia (ALL): ALL affects lymphoid cells and grows quickly. It accounts for over 5,000 new cases annually. ALL is the most common type of leukemia in young children but also occurs in adults.
- Acute myeloid leukemia (AML): AML affects myeloid cells and grows rapidly. Each year, there are more than 13,000 new cases. AML occurs in both adults and children.

- Hairy cell leukemia: This is a rare form of chronic leukemia. It is not covered in this booklet. Together, all rare leukemias account for fewer than 6,000 new cases each year[9].
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Table 1- Classification of Leukemia based on disease progression-

Acute	Chronic
Rapid increase in the number of blast cells.	Excessive and slow buildup of relatively mature, but still abnormal cells.
Takes weeks or months to express.	Takes months or years to progress.
Fulminant presentation of all cardinal symptoms.	Vague symptoms will be present.
Immediate treatment is required.	Sometimes monitored for a while, to treat them effectively.
Can be fatal within weeks to six months if left untreated.	Median survival is one to two years if left untreated.

Based on the nature of cells involved leukemia can be classified into Lymphoblastic or lymphocytic Leukemia and Myeloblastic or Myelogenous leukemia.

Table 2- Classification of leukemia based on types of cells affected[10]

Lymphoblastic	Myeloblastic
Involvement of bone marrow cells which normally goes onto form Lymphocytes.	Involvement of bone marrow cells which normally goes onto form Red blood cells, some type of WBCs and platelets.
More common in children and adolescents.	Common in adults
Often involves a prolonged maintenance phase after initial treatment	Typically includes induction and consolidation therapy without a maintenance phase
Generally has a higher 5-year survival rate than acute myeloid leukemia	Has a lower 5-year survival rate than lymphoblastic leukemia, though treatment has improved significantly

Combining both these classification, leukemia can be differentiated further into,

1. Acute Lymphoblastic/Lymphocytic Leukemia,
2. Acute Myeloblastic/Myelogenous Leukemia,
3. Chronic Lymphoblastic/Lymphocytic Leukemia,
4. Chronic Myeloblastic/Myelogenous Leukemia[11]

(i)Acute Lymphoblastic/Lymphocytic Leukemia[12]- Acute lymphoblastic leukemia (ALL) happens when young lymphoid cells in the bone marrow start multiplying too fast and do not mature properly. This overcrowds the bone marrow and reduces normal blood cells. A few genetic conditions like Down syndrome, Fanconi anemia or ataxia telangiectasia can increase the risk, and some environmental factors such as radiation, pesticides or infections like EBV or HIV may also contribute, but most cases appear in healthy people without any known cause. ALL is strongly linked with chromosome changes such as t(12;21), t(1;19), t(9;22) and MLL rearrangements. A high-risk group called Ph-like ALL looks similar to Philadelphia-positive leukemia and often has deletions in important B-cell genes (IKZF1, E2A, EBF1, PAX5) and mutations in growth-signaling pathways, which may respond to targeted drugs like dasatinib, ruxolitinib or crizotinib. Another aggressive type, hypodiploid ALL, shows very low chromosome numbers and often has mutations in p53, Ras pathway genes or RB1. Symptoms mainly occur because the bone marrow fails to produce normal cells, leading to tiredness, infections, bleeding, fever, weight loss and swollen lymph nodes or organs. Some patients also have brain or spinal involvement or a chest mass in T-cell ALL. Diagnosis is confirmed when 20% or more cells in the bone marrow or blood are lymphoblasts, and tests like flow cytometry, cytogenetics, lumbar puncture, blood counts and biochemical tests help in classification and management.

FAB classification of acute lymphoblastic leukemia[13]

- ALL-L1: Small cells with homogeneous nuclear chromatin, a regular nuclear shape, small or no nucleoli, scanty cytoplasm, and mild to moderate basophilia
- ALL-L2: Large, heterogeneous cells with variable nuclear chromatin, an irregular nuclear shape, 1 or more nucleoli, a variable amount of cytoplasm, and variable basophilia
- ALL-L3: Large, homogeneous cells with fine, stippled chromatin; regular nuclei; prominent nucleoli; and abundant, deeply basophilic cytoplasm. The most distinguishing feature is prominent cytoplasmic vacuolation

(ii) **Acute Myeloblastic/Myelogenous Leukemia**- Acute myeloid leukemia (AML) occurs when immature myeloid cells, called blasts, multiply uncontrollably in the bone marrow and fail to develop into normal blood cells. This happens because of multiple genetic and chromosomal abnormalities that disrupt normal cell growth, leading to failure of red cell, platelet and normal marrow production. AML is a very mixed and variable disease, so each patient needs detailed cytogenetic and molecular testing. Based on the ELN 2022 guidelines, AML is grouped into favorable, intermediate or high-risk categories. Favorable-risk AML usually involves translocations like t(8;21) (a chromosome swap between chromosome 8 and 21 that causes abnormal cell behaviour) or inv(16) meaning a piece of chromosome breaks flips upside down and reattaches, or the presence of NPM1 (a gene that helps keep the nucleus functioning properly) or CEBPA (bZIP), a gene that helps blood cells mature, mutations without FLT3-ITD, When FLT3 is mutated, the cell receives a constant "grow" signal and becomes cancerous. NPM1 mutations are quite common and may occur in about one-third of patients. Intermediate-risk AML includes cases with FLT3-ITD or t(9;11) (KMT2A) rearrangements. High-risk AML involves abnormalities such as monosomy 5 or 7, deletions of 5q or 7q, complex karyotype, or mutations in genes like TP53, ASXL1, EZH2 or SRSF2. One of the well-known mutations, RUNX1 translocation with RUNX1T1 causing t(8;21), appears in around 12% of AML cases and is often linked with trisomies 13 or 21 and resistance to standard chemotherapy. Other important mutations include IDH1 or IDH2, found in 15–20% of all AML patients and more common in older adults, and TP53 mutations, which are strongly associated with poor outcomes and treatment resistance.

FAB classification of acute Myelooblastic leukemia[14] –

M0: Minimally differentiated
M1: Myeloblastic leukemia without maturation
M2: Myeloblastic leukemia with maturation
M3: Hypergranular promyelocytic leukemia
M4: Myelomonocytic leukemia
M4Eo: Variant, increase in marrow eosinophils
M5: Monocytic leukemia
M6: Erythroleukemia
M7: Megakaryoblastic leukemia

(iii)Chronic Lymphoblastic/Lymphocytic Leukemia[15]- CLL/SLL develops in two stages. First, some B-cells (a type of white blood cell) become abnormal due to long-term stimulation, genetic changes, or chromosome abnormalities. These early abnormal cells are called MBL (Monoclonal B-cell Lymphocytosis).

Second, these MBL cells receive more genetic damage or changes in the bone marrow environment, and then they slowly turn into CLL/SLL, which is cancer.

In CLL, these B cells have CD5 on their surface, and they become overactive because they keep sending signals to grow even without any infection or antigen. Because of continuous activation, these abnormal B cells start dividing in the lymph nodes, creating a large clone (a group of identical cancer cells). This causes lymph nodes to become enlarged, especially in the neck, above the collarbone, and armpits.

As these cancerous B cells increase in the lymph nodes, they begin to spill into the bloodstream, which is why lymphocytosis (high lymphocyte count) is found on CBC.

These cancer cells do not die normally (they escape apoptosis), so they keep accumulating. They enter the spleen and bone marrow, causing splenomegaly and overcrowded bone marrow. Because the spleen traps more red blood cells and platelets, patients may develop anemia (low RBCs) and thrombocytopenia (low platelets). Patients can also develop autoimmune hemolytic anemia or autoimmune thrombocytopenia, because the immune system mistakenly destroys its own RBCs or platelets.

As the disease spreads throughout the body, patients may experience fever, night sweats, weight loss, fatigue, and early satiety (feeling full quickly).

Since these B cells are abnormal, they do not produce proper antibodies, which leads to low immunoglobulin levels (hypogammaglobinemia) and increases the risk of infections.

The skin is the most common non-lymphoid organ affected. CLL can cause leukemia cutis, which appears as bumps, patches, ulcers, blisters, or nodules on the skin, especially on the face. Other skin problems may occur from infections, bleeding, inflammation (vasculitis), or exaggerated reactions to insect bites.

Histopathology of CLL[15]- In CLL, the earliest and most important lab finding is a high number of lymphocytes in the blood and bone marrow. On a peripheral blood smear, these cancerous lymphocytes look small and mature, with a dark, round nucleus, tightly clumped chromatin, no visible nucleoli, and only a thin rim of blue cytoplasm. A very typical feature seen on the smear is the presence of "smudge cells" or "basket cells," which appear because the abnormal CLL lymphocytes are very fragile and break apart when the slide is prepared. To confirm the diagnosis, flow cytometry is done on the blood to check for surface markers. Most CLL cells show a combination of CD5, CD19, CD20, and CD23, along with only one type of immunoglobulin light chain—this proves that all the cells are from the same clone. These cells also show low levels of surface immunoglobulins, usually IgM, and sometimes IgD as well. Although rare, some cases may show biclonal patterns. FISH testing is used to detect common chromosomal problems such as deletion 17p, deletion 11q, deletion 13q, and trisomy 12, which help assess prognosis before treatment. Deletion of 17p affects the TP53 gene, a key tumor-suppressor that normally helps damaged cells undergo apoptosis; losing TP53 allows mutated cells to survive. Deletion of 11q removes the ATM gene, which is needed to activate TP53 when DNA damage occurs. Without ATM, TP53 cannot function properly, so damaged cells continue to divide instead of being stopped or destroyed, leading to more aggressive disease.

(iv) Chronic Myelogenous Leukemia[16]- Chronic myelogenous leukemia (CML), which is BCR-ABL1–positive, is a type of myeloproliferative cancer where granulocytes (a type of white blood cell) grow abnormally and in excess. It is defined by the presence of the Philadelphia chromosome, caused by a translocation between chromosomes 9 and 22, written as t(9;22)(q34;q11.2). CML involves both the bone marrow and the peripheral blood, where these abnormal cells are found in large numbers.

The abnormal protein BCR-ABL1 is what defines CML. In about 90–95% of patients, this protein is created because of a swap of genetic material between chromosome 9 and chromosome 22, called t(9;22). This forms the Philadelphia chromosome, which is a shortened version of chromosome 22.

The ABL1 gene (from chromosome 9) normally makes a tyrosine kinase enzyme, and BCR (from chromosome 22) is the region where the break happens. When they fuse, they create the BCR-ABL1 oncoprotein—usually the p210 type. Sometimes other versions (p190 or p230) appear because of different splicing, and these may cause slightly different disease patterns.

This fusion protein acts like a tyrosine kinase that is always switched ON, causing uncontrolled cell growth. It activates pathways like JAK/STAT, PI3K/AKT, and RAS/MEK, which promote cell survival and stop normal cell death.

The small percentage of patients who do not have the classic Philadelphia chromosome may have complex or hidden (cryptic) translocations, which can be detected by tests like FISH or PCR.

Viewpoint of Ayurveda on Neoplastic Disorders- In Ayurveda, neoplasms are understood through the classical concepts of *Arbuda, Granthi, Vidradhi, and Dushta Vrana*, which represent abnormal, uncontrolled tissue growth resulting from vitiation of *Tridosha*, especially *Kapha*, the dosha responsible for excessive tissue proliferation. *Kapha* contributes to the heaviness and solid nature of tumors, *Pitta* adds inflammation and ulceration, and Vata leads to irregularity and rapid spread, mirroring features of malignancy. *Arbuda* corresponds to large, deep-seated, non-suppurative tumors, while Granthi denotes smaller nodular swellings; *Dushta Arbuda* aligns closely with malignant neoplasms due to its rapid growth, invasion, ulceration, recurrence, and tissue destruction. The etiological factors include long-standing *Agnimandya*, incompatible foods, excessive intake of heavy and oily items, chronic inflammation, suppression of natural urges, and mental stress leading to impaired immunity. Both *Caraka Samhita*[17] (c. 1000 BC) and *Susruta Samhita*[18] (c. 800 BC), the foundational treatises of *Ayurveda*, mention two categories of abnormal growths: *Granthi*[19], referring to smaller, localized swellings, and *Arbuda*[20], denoting larger and more serious tumors. These descriptions can be contextually aligned with the contemporary understanding of cancer. As described by *Acharya Sushruta*, when the vitiated doshas accumulate in a specific region of the body, they disturb *Mamsa* and other *dhatus*, resulting in the formation of a firm, rounded, deeply rooted, slowly expanding mass that is non-inflammatory in nature and may present with mild pain.

Perspective On Leukemia through Ayurveda-

From an *Ayurvedic* perspective, blood disorders are primarily conceptualized as *Rakta Dhatu* vitiation, often accompanied by *Dosha* imbalance. *Ayurveda* recognizes the central role of *Rakta* in maintaining vitality, immunity, and systemic equilibrium. The three *doshas—Vata*, *Pitta*, and *Kapha*—govern physiological processes, and their simultaneous or sequential imbalance can lead to hematological dysfunction. For instance, vitiation of *Pitta* may manifest as inflammatory changes and abnormal cell proliferation, *Kapha* imbalance may contribute to stagnation and accumulation of defective cells, and *Vata* disturbance can lead to irregular hematopoiesis and systemic instability. Understanding *leukemia* through this lens provides a conceptual framework that correlates classical *Ayurvedic* pathology with modern hematological manifestations, offering potential avenues for preventive, supportive, and integrative therapeutic strategies.

Ayurvedic texts do not directly describe Leukemia or its specific types. However, *Acharya Sushruta's* explanation of *Raktaja Arbuda*[21] shows some similarity to certain features of both lymphocytic and myeloid leukemias—such as enlarged lymph nodes, reduced platelet count, and related symptoms. To be precise, *Acharya Sushruta* states that when the *doshas* become severely aggravated, they cause abnormal compression and disturbance within the blood and blood vessels. This leads to the formation of *Raktaja Arbuda* – a type of growth or swelling that arises mainly from vitiated blood. Classical features of *Raktaja Arbuda* include: Suppuration – formation of pus within the growth, A solid muscle-like mass resembling a round lump, Continuous discharge of vitiated or impure blood. According to Ayurveda, *Raktaja Arbuda* is considered incurable. Individuals suffering from this condition may experience significant complications, especially excessive blood loss, which gradually weakens the body. Over time, this can lead to *Pandu Roga* (anemia) due to depletion and vitiation of blood.

Still, the exact cause and development of Leukemia something even modern science hasn't fully understood, cannot be completely matched with the *samprapti* of *Raktaja Arbuda* described by *Sushruta*. To make a meaningful comparison, we can only try to propose a probable Ayurvedic correlation by looking at dosha imbalance, affected *dhatus*, *samprapti*, and involved *strotas*. For this, it becomes essential to understand how blood formation (hematopoiesis) can be interpreted in *Ayurvedic* terms.

When properly consumed food undergoes complete digestion, the essence portion that is formed from it is called *Rasa*. *Rasa* normally remains in its natural state for five days and nights and one-and-a-half daṇḍa. During this period, the *Rasagata Agni* gradually processes and transforms the *Rasa*.

When the final stage of this process arrives, the *Ranjaka Pitta*, through its own *Agni*, imparts red colour to the fully processed *Rasa*, converting it into *Rakta*.

Rakta is considered *Aagneya* and *Ushna* in nature. This heat arises from two factors:

1. The cooking action of *Rasagata Agni*, and
2. The support of *Ranjaka Pitta*, which itself is of the nature of Agni.

Pitta is inherently regarded as *Agni-svaroopa*, and because *Ranjaka Pitta* produces *Rakta* through its *Agni*-like function, *Rakta* is called *Aagneyam*. Acharya Sushruta also states that Here, the phrase "Pittauṣmaṇaḥ" refers to the Agni-like nature of Rañjaka Pitta[22].

As Acharya Sushruta further explains:
Rasa Dhatu, which is *Apya* in nature (predominantly constituted by the water element and exhibiting water-like properties), undergoes a crucial transformation upon reaching the Yakrit (liver) and Plīhā (spleen). Within these organs, the Tejas component—specifically manifested as Rañjaka Pitta, the fire-like catalytic agency—acts on the otherwise colourless and clear Rasa. Through the metabolic influence of this Rañjaka Pitta, the *āpya Rasa* is imparted with a red hue, thereby undergoing qualitative transformation into Rakta Dhatu (blood). When this process occurs without any vitiation, the resultant Rakta is considered pure, stable, and functionally competent.

Thus, in Ayurvedic terms, the formation of blood represents the successful interaction of the water-dominant Rasa with the Agni-dominant Rañjaka Pitta, highlighting the coordinated interplay of *Āp* and *Tejas* Mahābhūtas in dhatu nirmāṇa. Acharya Sushruta explains that the Pitta located in the Yakrit and Pleeha is known as Ranjaka Agni, and it is described as the one responsible for imparting colour to the Rasa[24].

Hence, we may infer that a condition comparable to leukemia could arise due to disturbances in any of the following: (i) impaired formation of Rasa, (ii) defective production or functioning of Ranjaka Pitta, (iii) structural or functional abnormalities of the Yakrit (liver) or Plīhā (spleen).

Ayurvedic Pathophysiology

In Ayurveda, leukemia can be conceptualized as a manifestation of *Rakta Dhatu* vitiation accompanied by *Dosha* imbalance, reflecting both systemic and hematopoietic dysfunction. *Rakta Dhatu*, responsible for oxygen transport, nourishment of tissues, and overall vitality, is central to maintaining homeostasis. Vitiation of this *dhatu* leads to impaired hematopoiesis, abnormal proliferation of blood cells, and disruption of immune competence, paralleling the pathophysiological changes observed in modern leukemia.

The three doshas *Vata, Pitta, and Kapha* play distinct yet interrelated roles in this process. *Vata dosha*, governing movement and cellular transport, when aggravated, can disrupt the orderly formation and circulation of blood cells, resulting in irregular hematopoiesis and systemic instability. Pitta dosha, associated with metabolic processes and transformation, when imbalanced, may contribute to excessive cellular proliferation and inflammatory changes, reflecting features such as rapid blast cell accumulation seen in acute leukemias. Kapha dosha, which maintains structural integrity and stability, when vitiated, can lead to stagnation of cellular elements, impaired differentiation, and accumulation of defective blood cells.

Further, *Agni* (digestive and metabolic fire) plays a pivotal role in the transformation of nutrients into *dhatus*, including *Rakta*. Impaired *Agni*, whether at the *Jatharagni*[25] (digestive), *Dhatvagni* (tissue), or *Bhutagni* (elemental) levels, can compromise the quality and quantity of *Rakta Dhatu*, predisposing to hematological dyscrasias. Additionally, *Ojas* depletion, representing the subtle essence of dhatus and vital immunity, may exacerbate systemic vulnerability, manifesting as recurrent infections, anemia, and fatigue.

Ayurvedic texts also emphasize the concept of *Srotodushti*[26] (channel obstruction), where the microcirculatory pathways of the Rakta Dhatu are impaired, potentially correlating with bone marrow

microenvironment dysfunction, impaired cell trafficking, and the clinical manifestations of leukemia. Collectively, this framework integrates dosha dysregulation, dhatu impairment, Agni dysfunction, and Ojas depletion, providing a holistic understanding of leukemogenesis from an Ayurvedic perspective. By mapping these classical concepts onto modern hematological phenomena, practitioners can explore dosha-targeted adjunctive interventions, preventive strategies, and supportive care, thereby bridging traditional wisdom with contemporary clinical practice.

Clinical Correlation

The clinical presentation of leukemia, when viewed through an Ayurvedic lens, can be interpreted as a result of Rakta Dhatu vitiation in association with Tridosha imbalance. Classical Ayurvedic symptoms of vitiated *Rakta*[27] such as *Pandu* (pallor), *Daurbalya* (weakness), *Shrama* (fatigue), *Hriddrava* (palpitations), and *Pindikodweshtana* (cramps in calf muscles), closely parallel the modern haematological features of anemia, generalized weakness, and reduced oxygen-carrying capacity.

Bleeding manifestations, which are commonly observed in leukemia due to thrombocytopenia, correspond to Ayurvedic descriptions of *Raktapitta*[28] (hemorrhagic disorders) and *Asrigdara*[29] (excessive bleeding conditions). Epistaxis, gum bleeding, and petechiae can thus be interpreted as outcomes of aggravated Pitta dosha in *Rakta Dhatu*.

Recurrent infections and immunosuppression in leukemia may be correlated with *Ojas kshaya*[30] (depletion of vital immunity), a state where the body loses its inherent resistance, making it vulnerable to frequent illnesses. This also aligns with the *Ayurvedic* principle that *Rakta Dhatu* and *Ojas* are intimately connected, and impairment in one directly influences the other.

Further, organomegaly such as hepatosplenomegaly, often seen in leukemia, can be related to *Yakrit-Pliha Vriddhi* (enlargement of liver and spleen) mentioned in Ayurvedic texts, caused by accumulated and vitiated Rakta along with Kapha stagnation.

Systemic features like fever, night sweats, and bone pain, characteristic of hematological malignancies, may be linked to *Ama* accumulation (toxic metabolic by-products), *Srotorodha* (obstruction of microchannels), and *Vata-Pitta* aggravation, which together lead to deranged tissue metabolism and inflammatory responses.

Thus, a symptom-to-symptom mapping shows significant overlap between the *Ayurvedic* conceptual framework of *Dosha-Dhatu-Srotas* dysfunction and the modern clinical profile of leukemia. This integrative understanding not only validates the classical descriptions but also provides a foundation for developing dosha-specific diagnostic and therapeutic strategies in hematological disorders.

Identification of Vitiated (*Vikrita*) Blood in Ayurveda

Ayurveda describes distinctive methods for assessing the purity and vitiation of blood (*Rakta*). One such traditional approach involves mixing the patient's blood with food and offering it to animals or birds such as dogs or crows. If the mixture is rejected, it is considered indicative of *Pitta Dushta Rakta*, suggesting impurity of blood associated with bile vitiation. Another method, described by *Acharya Charaka*, involves soaking a white cloth in the blood sample and allowing it to dry. When the cloth is later washed with warm water, persistence of discoloration indicates *Pittaja Rakta Dushti*, whereas restoration of whiteness suggests relatively pure or healthy blood[31].

Diagnostic Perspectives-

1.Trividha Pariksha in the Assessment of Leukemia

Ayurveda emphasizes *Trividha Pariksha*, namely *Darshana*, *Sparshana*, and *Prashna*, as a fundamental clinical approach for disease evaluation, which can be meaningfully applied in the assessment of leukemia[32].

***Darshana* (Inspection)** involves observation using the physician's visual faculty (*Darshanendriya*). In leukemia, visible features such as pallor (*Pandu*) and bleeding manifestations (*Rakta Srava*) can be identified through careful inspection.

***Sparshana* (Palpation)** plays a crucial role in physical examination. Findings such as splenic enlargement (*Pliha Vriddhi*), hepatomegaly, fever, and sternal tenderness can be assessed through palpation, aiding in clinical correlation with leukemic pathology.
***Prashna* (Interrogation)** includes systematic questioning of the patient regarding subjective symptoms. Complaints such as fatigue, unintended weight loss, bone pain, and night sweats are elicited through this method and provide valuable insights into disease progression.

Together, *Trividha Pariksha* offers a holistic diagnostic framework that complements modern clinical assessment, enabling early recognition and comprehensive understanding of leukemia from an Ayurvedic perspective. To further refine the understanding of *Dosha* involvement, *Dhatu* status, and systemic imbalance, classical texts advocate additional supportive examinations. Among these, *Nadi Pariksha*, *Mutra Pariksha*, and *Jihva Pariksha* serve as valuable tools for assessing internal pathological changes, particularly in disorders involving *Rakta Dhatu*

2. Potential Correlations with Modern Investigations
To bridge traditional and modern perspectives, *Ayurvedic* diagnostic signs can be correlated with standard hematological investigations:

- CBC (Complete Blood Count): Confirms anemia, leukocytosis, or thrombocytopenia. It parallels Ayurvedic observations of *Panduta*[33] (pallor), *Daurbalya* (weakness), or *Shotha* (edema).
- Peripheral Smear: Offers morphological details of blood cells, such as blasts in *leukemia* or microcytosis in *anemia*. This can be linked to the qualitative assessment of *Rakta Dhatu* integrity in Ayurveda.
- Bone Marrow Biopsy: Provides definitive evaluation of hematopoietic activity, correlating with Ayurvedic understanding of *Dhatu utpatti* (formation of tissues). Bone marrow dysfunction can be viewed as impaired *Dhatu agni*[34] leading to defective *Rakta Dhatu* production.
- Biochemical Markers: LDH, uric acid, and other metabolic indicators reflect disease burden and cellular turnover. *Ayurveda* interprets such systemic imbalances as Ama (toxic byproducts of incomplete metabolism) or *Doshic* aggravation at the *Dhatu* level.

3. Concept of *Prakriti* and Susceptibility
Ayurveda emphasizes the role of *Prakriti* in disease predisposition:

- *Vata Prakriti*: Individuals may show heightened vulnerability to marrow depletion, dry pallor, and neurological complications in blood disorders.
- *Pitta Prakriti*: Greater susceptibility to rapid disease progression, feverish states, inflammatory markers, and hemorrhagic tendencies due to *Rakta-Pitta* association.
- *Kapha Prakriti*: Predisposition to sluggish disease course, edema, lymphoproliferative disorders, and immune suppression.

Management-
1. Classical *Ayurvedic* Management
Ayurveda emphasizes restoring *doshic* balance, purifying *Rakta Dhatu*, and strengthening the body's innate defense mechanisms. In the context of hematological dyscrasias such as leukemia, the following therapeutic modalities are particularly relevant:

***Rasayana* Therapy**: Rasayanas are rejuvenative agents aimed at promoting tissue integrity, immunity (Ojas), and hematopoietic support. Key formulations include:

- *Ashwagandha (Withania somnifera)*[35]*:* Acts as a *balya* (strength-promoting) and *ojovardhaka* (immunity enhancer). Its adaptogenic properties may counteract fatigue and immunosuppression associated with hematological malignancies.

- *Guduchi* (Tinospora cordifolia)[36]: Recognized for its immunomodulatory and detoxifying actions. In *Rakta* disorders, it helps pacify Pitta dosha and enhances resistance to recurrent infections.
- *Amalaki* (Emblica officinalis)[37]: A rich source of vitamin C and described as a potent *Rasayana* in *Ayurveda*. It supports *rakta poshana* (nourishment of blood) and offers antioxidant protection against cellular damage.

***Panchakarma* Procedures**: *Panchakarma* serves to eliminate aggravated doshas and purify body channels. In blood disorders, selected procedures may include:

- *Virechana* (therapeutic purgation): Effective in expelling excess *Pitta* and toxins (*Ama*) that accumulate in Rakta Dhatu.
- *Raktamokshana* (bloodletting): Although traditionally employed in localized blood vitiation, its principle of eliminating vitiated *Rakta* can be conceptually related to modern detoxification and cytoreductive strategies.
- *Basti* (medicated enema): Particularly beneficial in controlling *Vata dosha*, which often dominates in degenerative stages of marrow failure.

Together, these therapies aim to restore *Doshic* equilibrium, improve haematopoiesis, and strengthen the systemic defense mechanisms.

2. Modern Integrative Approach

Given the aggressive nature of hematological malignancies such as leukemia, Ayurveda is best utilized as an adjunct to conventional therapies rather than as a replacement. Integrative care seeks to reduce treatment toxicity, improve quality of life, and enhance therapeutic outcomes.

Adjunct Use with Chemotherapy and Targeted Therapies: *Rasayana* herbs such as *Ashwagandha* and *Guduchi* have shown potential in mitigating chemotherapy-induced fatigue, immunosuppression, and oxidative stress[38-39]. Integrating these with modern regimens may provide synergistic support in reducing side effects while not interfering with cytotoxic efficacy.

Dosha-Based Dietary Modifications: *Ayurveda* places strong emphasis on *ahara* (diet) as a therapeutic measure.

- For *Pitta*-aggravated *Rakta* disorders, cooling and *Pitta-shamana* foods such as ghee, pomegranate, and bitter vegetables are encouraged.
- For *Kapha*-dominant presentations, light, easily digestible foods with spices like ginger and black pepper help counter sluggish metabolism.
- For *Vata* involvement, nourishing and unctuous foods such as sesame oil, milk substitutes, and warm preparations maintain tissue stability. Such tailored dietary regimens not only help in balancing doshas but also provide nutritional reinforcement in haematological recovery.

Experimental Evidence Supporting Ayurvedic Drugs in Leukemia

Apart from classical descriptions and individual clinical experiences, several experimental studies have explored the effects of *Ayurvedic* herbs and herbomineral formulations on leukemia. Research conducted through in vitro cell line studies, in vivo animal models, and selected clinical observations has shown that many traditionally used drugs possess antileukemic potential. These drugs have been found to act by inducing programmed cell death, regulating abnormal cell proliferation, reducing inflammation, and supporting immune function. Classical *Ayurvedic* pharmaceutical processes such as *Bhasmikarana* appear to enhance the bioavailability and cellular action of certain herbomineral preparations, providing a scientific explanation for their therapeutic effects. Rather than acting on a single target, these interventions influence multiple biological pathways, which is particularly relevant in a complex disease like leukemia. The following table presents a concise overview of experimental studies highlighting the antileukemic activity of selected Ayurvedic drugs and their proposed mechanisms.

Table 3: Experimental Evidence of Herbal and Herbomineral Drugs in Leukemia

Drug / Herb (Ayurvedic Name)	Study Model	Key Antileukemic Mechanism / Outcome
Arsenic compounds (ATO, *Manahshila*, *Kajjali*, *Abhraka Bhasma*)[40]	In vitro, in vivo, clinical reports	Induction of apoptosis, nanoparticle enhanced bioavailability, effective in APL, CML and AML
Withania somnifera (*Ashwagandha*)[41]	In vitro (THP-1)	Antioxidant, anti-inflammatory, cytokine modulation, apoptosis induction
Curcuma longa (*Haridra*, curcumin)[42]	In vitro, animal, human studies	Cell cycle arrest, NF-κB inhibition, proapoptotic protein upregulation, safe at high doses
Andrographis paniculata (*Bhunimba*)[43]	In vitro	G0/G1 cell cycle arrest, CDK inhibition, cytotoxic to leukemia and APL cells
Zingiber officinale (*Ardraka*, *Shunthi*)[44]	In vitro (K562)	Mitochondrial apoptosis, caspase-3 activation, antioxidant effect
Berberis (*Daruharidra*, berberine)[45]	In vitro (HL-60, WEHI-3)	Topoisomerase II inhibition, caspase activation, p53-independent apoptosis
Semecarpus anacardium[46]	In vivo (leukemic mice)	Clearance of leukemic cells, metabolic enzyme modulation
Tinospora cordifolia (*Guduchi*)[47]	In vivo (mice)	Myeloid differentiation, macrophage recruitment, immunomodulation
Moringa oleifera (*Shigru*)[48]	In vitro (AML)	Antiproliferative and cytotoxic effects
Punica granatum (Pomegranate)[49]	In vitro	Apoptosis induction across lymphoid and myeloid leukemia cell lines
Azadirachta indica (*Nimba*)[50]	In vitro	NF-κB pathway modulation, G1 arrest, antiproliferative activity

3. Discussion

Leukemia, although defined in contemporary medicine as a malignancy of the hematopoietic system, can be comprehensively interpreted through the Ayurvedic understanding of systemic imbalance. Ayurveda does not view disease as an isolated cellular abnormality but as a progressive disruption involving *Dosha*, *Dhatu*, *Agni*, and *Ojas*. From this perspective, leukemia reflects a deep-seated pathology primarily affecting *Rakta Dhatu*, accompanied by impaired digestion, altered metabolism, and gradual depletion of vitality. Clinical manifestations such as pallor, fatigue, fever, bleeding tendencies, organ enlargement, recurrent infections, and weight loss show striking resemblance to classical descriptions of *Pandu*, *Raktapitta*, *Jvara*, *Pleehodara*, and *Ojakshaya*, indicating a strong conceptual overlap between ancient observations and modern clinical presentations.

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Rather than prescribing disease-specific regimens, Ayurveda derives treatment principles based on symptom patterns and underlying *Dosha–Dhatu* involvement. Persistent fever, loss of appetite, and fatigue are interpreted as *Jvara* associated with *Ama*, guiding the use of *Ama Pachana* and *Jvaraghna Chikitsa*. Pallor and generalized weakness resembling anemia are understood as *Pandu* arising from *Rakta Dhatu Dushti*, emphasizing *Rakta Prasadana* and *Rasayana Chikitsa*. Bleeding manifestations such as epistaxis and gum bleeding indicate *Raktapitta* due to *Pitta Vriddhi*, where *Pitta Shamana* and *Rakta Stambhana* measures become essential. Enlargement of the spleen and liver corresponds to *Pleehodara* and *Yakrit Vriddhi*, suggesting the application of *Kapha Shamana* and *Lekhana* therapies. Lymph node enlargement and abnormal tissue proliferation are interpreted as *Granthi* or *Arbuda*, guiding treatment toward *Shothahara* and *Granthi Prashamana*. Excessive cellular proliferation along with tissue depletion reflects *Vata* aggravation with *Dhatu Kshaya*, necessitating *Vata Shamana* and *Dhatu Poshana*. Recurrent infections and immune suppression signify *Ojas Kshaya*, where *Ojasvardhaka* and *Rasayana* therapies play a crucial role. General debility and reduced tolerance to disease are indicative of *Agni Mandya*, highlighting the importance of *Deepana* and *Pachana* interventions. Through this structured and individualized interpretation, Ayurveda provides a rational framework for supportive care in leukemia.

Experimental studies support the relevance of Ayurvedic principles in leukemia, with several in vitro and in vivo reports demonstrating antiproliferative, proapoptotic, antioxidant, and immunomodulatory effects of herbs and herbomineral formulations. Traditional pharmaceutical processes such as *Bhasmikarana* have gained attention for enhancing bioavailability and cellular uptake, supporting the classical emphasis on proper processing and individualized therapy.

Ayurveda functions as a complementary approach rather than an alternative to modern oncology, focusing on restoration of *Agni*, regulation of *Ahara*, preservation of *Ojas*, and maintenance of systemic balance. This holistic perspective aligns with integrative medicine and highlights Ayurveda's role in supportive care and quality-of-life improvement in leukemia.

4. Conclusion

Public awareness about health is very important, because lack of knowledge often causes neglect, while too much worry comes from not knowing what really matters. Cancer exemplifies this paradox, where fear being the main factor and ignorance the secondary one, contribute more to delayed diagnosis and mortality than the disease itself. Fear prevents timely consultation, even among educated individuals, leading to advanced-stage detection and poor outcomes. Statistically, cancer incidence is lower than commonly perceived, with many cases being curable if diagnosed early. This is exactly what *Chakrapanidutta,* a *Charak-Samhita* commentator says that effective treatment depends on the right information of *Hetu* and the disease process.

Leukemia, when viewed through the lens of Ayurveda, reveals itself not merely as a disorder of blood but as a reflection of deeper systemic imbalance involving *Rakta*, *Agni*, and *Ojas*. By understanding disease through harmony rather than isolation, Ayurveda offers a perspective that values balance, individuality, and long-term resilience. The convergence of classical wisdom with emerging scientific evidence suggests that mindful nourishment, restoration of digestive strength, and preservation of vitality hold enduring relevance even in complex diseases. Thus, Ayurveda stands not in opposition to modern medicine, but beside it, quietly reminding us that healing begins with balance and is sustained through conscious care.

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