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Original Research Article

Morphological Spectrum and Frequency of Leukemias on Bone Marrow Aspiration with Age-Wise Distribution and Clinical Presentation

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Abstract:

Background: Leukemias are heterogeneous malignant disorders of the hematopoietic system, characterized by clonal proliferation/ maturation arrest of hematopoietic cells. Accurate classification using bone marrow aspiration (BMA) is essential for diagnosis, prognosis, and management.

Aim: To evaluate the morphological spectrum and frequency of leukemias on bone marrow aspiration, with age-wise distribution and clinical presentation.

Methodology: A prospective descriptive study was conducted on 142 patients with suspected leukemia at Department of Pathology, Darbhanga Medical College and Hospital, Darbhanga, Bihar, India. Clinical features, hematological parameters, and bone marrow morphology were recorded. Cytochemistry and immunophenotyping were performed in selected cases. Data were analyzed using descriptive statistics.

Results: Males constituted 54.9% of patients; the most affected age group was 10–20 years (22.5%). Common symptoms included fatigue (73.2%), fever (69%), loss of appetite (62%), and weight loss (53.5%). Hematological findings showed anemia (64.8%), leukocytosis (60.6%), and thrombocytopenia (54.9%). Acute leukemias were most frequent: ALL (26.8%) and AML (23.9%), while CML (19.7%), CLL (7%), and other marrow disorders were less common. ALL predominated in younger patients, whereas chronic leukemias appeared mainly in adults.

Conclusion: Bone marrow aspiration remains a vital diagnostic tool for leukemia. Acute leukemias were common in younger populations, while chronic forms prevail in older adults & elderly. Combining clinical evaluation, hematology, and morphological assessment ensures accurate diagnosis and guides management.

Keywords: Leukemia, Bone marrow aspiration, Morphology, Acute lymphoblastic leukemia, Acute myeloid leukemia, Age distribution, Clinical presentation.

Introduction

Leukemias are a heterogenous family of malignant diseases detected by clonal multiplication/maturation arrest of the hematopoietic cells in the bone marrow their presence, peripheral blood, and other tissues [1]. The neoplastic proliferations cause the substitution of the normal marrow components that cause disruption of hematopoiesis and a broad range of clinical manifestations. The broad classification of leukemias is in terms of their clinical course such as acute and chronic and also on the basis of the lineage such as myeloid and lymphoid leukemias [2]. This classification has great diagnostic, therapeutic and prognostic plans.

Acute leukemias are malignant neoplasms characterized by presence of more than 20 percent blast in the peripheral blood or bone marrow [3]. They pose a medical emergency because of the high rate of advancement and their possible life-threatening complications including severe anemia, infections, and bleeding. The acute leukaemia are further classified into acute lymphoblastic leukaemia (ALL) and acute myeloid leukaemia (ALL), with different morphological appearances, biological behaviour and treatment regimens. With chronic leukemias, however, the course is relatively indolent and characterized by more mature looking cells. Chronic myeloid leukemia (CML) is associated with a hypercellular bone marrow that may even assume up to 100 percent

cellularly with predominance of maturing granulocytic precursors [4]. CLL is characterized by over 30 percent of marrow infiltration by too small mature looking lymphocytes.

Bone marrow aspiration (BMA) has an important role in leukemia diagnosis and classification. It is a noninfectious and rather painless procedure that offers direct access to the hematopoietic tissue [5]. BMA will enable stained smears to be studied on aspirated cells, which will allow more detailed cytological examination of hematopoietic cells and their morphology and allow evaluation of cellularity in detail as well as individual hematopoietic elements [6]. Regardless of the progress in immunophenotyping, cytogenetics and molecular diagnostics, bone marrow aspiration is a basic and essential diagnostic modality, especially in places with limited resources.

The morphological examination of bone marrow smears tends to be the most essential and initial procedure in the differentiation of different types of leukemias. Precise morphological evaluation does not only help with preliminary diagnosis but also conducts further investigations and instant therapeutic choices. This is of particular concern to different between ALL and AML, since the treatment regimens and prognosis is distinctly different. Characteristics of the lymphoblasts in ALL include condensed nuclear chromatin, indistinct nucleoli and paucity of cytoplasmic agranular bodies [7]. In contrast, myeloblasts observed in AML are delicate in their nuclear chromatin, they contain two to four nucleoli and relatively large amounts of cytoplasm with fine azurophilic granules that are peroxidase positive [8]. A close assessment of these morphological differences can be used to reliably categorize acute leukemias.

There are also characteristic marrow findings of chronic leukemias in aspiration. The bone marrow in CML is hypercellular with the entire range of granulocytic maturation indicating unregulated proliferation of the myeloid lineage cells [9]. On the contrary, CLL shows diffuse or nodular replacement of marrow by small mature looks lymphocytes resulting in a range of marrow failure [10]. These patterns are important to recognize in order to diagnose and determine disease burden.

There are incidences and distributions of leukemias which depend largely on age. Acute lymphoblastic leukemia is more prevalent among children, whereas AML is found in all age groups with increasing rates in adulthood. Chronic leukemia, especially CML and CLL are largely diseases of adulthood and the older population. The distribution by age is not only indicative of the biological behaviour of these malignancies but also of the clinical presentation, treatment tolerance, and overall outcome. Thus, the epidemiological study of leukemias in various age groups can be useful and will help to comprehend the trend of the disease within a specific population.

The clinical manifestation of leukemia is varied and, in many cases, non-specific. Bone marrow failure symptoms that patients can show include fatigue, pallor, fever, frequent infections, and manifestations of bleeding [11]. Infiltration of the organs can lead to hepatosplenomegaly, lymphadenopathy, bone pain, and constitutional symptoms. The distribution and intensity of clinical manifestations usually depend on the nature of leukemia and age of a patient. The comparison of clinical presentation and bone marrow results contributes to the quality of diagnostic results and helps in the overall assessment of the patient.

Tertiary care referral centers in developing countries have a large range of hematological malignancies. Bone marrow aspiration is an inexpensive and readily accessible diagnostic method [12]. Methodical study of the morphology of bone marrow, including clinical background information, can aid in determining the rate and prevalence of various leukemias in the local community. These types of studies help in improved awareness of the disease burden and could help to design diagnostic and therapeutic plans.

In this work, the morphological spectrum and frequency of the different leukemias such as ALL, AML, CML, and CLL on bone marrow aspirations have been studied. The cases considered in terms of age-related distribution and clinical manifestation among the patients referred to a tertiary bone marrow examination reference center. The proposed study will emphasize the importance of bone marrow aspiration in the diagnosis of leukemias and will record the pattern of leukemic disorders in various age groups and thus the study will add valuable information to the existing literature.

Methodology

Study Design: This was a prospective descriptive study aimed at evaluating the morphological spectrum and frequency of leukemias on bone marrow aspiration (BMA), with age-wise distribution and clinical presentation. The study was designed to analyze the correlation between clinical features, hematological parameters including bone marrow findings in leukemic patients.

Study Area: The study was conducted in the Department of Pathology, Darbhanga Medical College and Hospital, Laheriasarai, Darbhanga, Bihar, India.

Study Duration: The study was carried out over a period of 6 months, from April 2025 to September 2025.

Sample Size: A total of 142 patients diagnosed or suspected with leukemia and subjected to bone

marrow aspiration during the study period were included in the study.

Sample Population: Patients of all age groups presenting to the hospital with clinical suspicion of leukemia, such as prolonged fever, pallor, petechiae, recurrent infections, weight loss, and loss of appetite, were considered for inclusion.

Data Collection: Data for the present study was collected prospectively using a structured proforma designed to record demographic details, clinical features, hematological findings, and bone marrow morphological parameters. A detailed clinical history was obtained from each patient, including presenting symptoms such as fever, pallor, bleeding manifestations, recurrent infections, weight loss, and loss of appetite. A thorough physical examination was conducted with special emphasis on pallor, lymphadenopathy, hepatosplenomegaly, and other relevant systemic findings. Hematological data were collected from laboratory records, including complete blood count parameters and peripheral blood smear findings. All relevant clinical and laboratory data were documented systematically for further analysis.

Inclusion Criteria

- Patients of all ages presenting with clinical suspicion of leukemia.
- Patients undergo bone marrow aspiration during the study period.
- Patients providing informed consent for participation in the study.

Exclusion Criteria

- Patients with inadequate or dry tap bone marrow aspirates.
- Patients with previous hematological malignancies or receiving chemotherapy.
- Patients not willing to participate in the study.

Procedure: Peripheral venous blood samples were collected under aseptic conditions from all patients and subjected to complete blood count analysis using an automated hematology analyzer. Peripheral blood smears were prepared and stained with Leishman stain for morphological assessment. Bone marrow aspiration was performed under strict aseptic precautions using Salah's or Klima's needle. In adults, the posterior superior iliac crest or sternum was used as the preferred site, while the upper end of the tibia was used in newborns, infants, and children below one year of age. Bone marrow smears were immediately prepared, air-dried. The smears were subsequently stained with Leishman. Detailed cytomorphological evaluation was performed to assess cellularity, erythroid and myeloid series, myeloid-to-erythroid ratio, blast percentage, and presence of abnormal or dysplastic cells. Leukemia cases were classified based primarily on morphological features, and cytochemical staining and immunophenotyping were employed in selected cases to aid in confirmation and subtype categorization where necessary.

Statistical Analysis: The collected data were entered into Microsoft Excel and subsequently analyzed using SPSS version 25. Descriptive statistical methods were used to summarize the data. Categorical variables such as types of leukemia, age groups, and clinical presentations were expressed as frequencies and percentages. Continuous variables including age and hematological parameters were expressed as mean and standard deviation. The Chi-square test was applied to assess the association between categorical variables where appropriate. A p-value of less than 0.05 was considered statistically significant."

Result

Table 1 presents the demographic distribution of 142 study participants. Males constituted the majority with 78 participants (54.9%), while females numbered 64 (45.1%). The largest age group was 10–20 years, comprising 32 participants (22.5%), followed by the 21–30 years group with 28 participants (19.7%) and 41–50 years with 26 participants (18.3%). Participants aged 31–40 years accounted for 24 cases (16.9%), 51–60 years for 20 cases (14.1%), and those over 60 years formed the smallest group with 12 cases (8.5%). Overall, Table 1 shows a slightly male-predominant population, with most participants being under 50 years of age.

Table 1: Demographic Distribution of Study Participants (N=142)

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	78	54.9
	Female	64	45.1
Age Group (years)	10–20	32	22.5
	21–30	28	19.7
	31–40	24	16.9
	41–50	26	18.3
	51–60	20	14.1
	>60	12	8.5
Total		**142**	**100**

Table 2 summarizes the clinical presentation of 142 patients. The most common symptoms were fatigue/weakness in 104 patients (73.2%) and fever in 98 patients (69%), followed by loss of appetite in 88 patients (62%) and weight loss in 76 patients (53.5%). Less frequent manifestations included hepatosplenomegaly in 58 patients (40.8%), recurrent infections in 52 patients (36.6%), petechiae or bleeding in 46 patients (32.4%), and lymphadenopathy in 44 patients (31%). Overall, as shown in Table 2, the patient cohort predominantly presented with constitutional symptoms, with a substantial proportion exhibiting signs of systemic involvement.

Table 2: Clinical Presentation of Patients (N=142)

Clinical Feature	Frequency (n)	Percentage (%)
Fever	98	69
Fatigue/Weakness	104	73.2
Weight loss	76	53.5
Loss of appetite	88	62
Petechiae/Bleeding	46	32.4
Recurrent infections	52	36.6
Hepatosplenomegaly	58	40.8
Lymphadenopathy	44	31

Table 3 presents the hematological findings of 142 patients. Anemia was common, with 92 patients (64.8%) having hemoglobin levels <10 g/dL, while 35.2% (50 patients) had hemoglobin ≥10 g/dL. Regarding total leukocyte count, 86 patients (60.6%) had leukocytosis, 22 patients (15.5%) had leukopenia, and 34 patients (23.9%) had normal counts. Thrombocytopenia was observed in 78 patients (54.9%), whereas 64 patients (45.1%) had platelet counts ≥1.5 lakh/cumm. Overall, as shown in Table 3, the cohort exhibited predominantly anemia, leukocytosis, and thrombocytopenia, reflecting significant hematological involvement.

Table 3: Hematological Findings (N=142)

Parameter	Category	Frequency (n)	Percentage (%)
Hemoglobin	<10 g/dl	92	64.8
	≥10 g/dl	50	35.2
Total Leukocyte Count	Decreased	22	15.5
	Normal	34	23.9
	Increased	86	60.6
Platelet Count	<1.5 lakh/cumm	78	54.9
	≥1.5 lakh/cumm	64	45.1

Table 4 shows the distribution of diagnosed hematological conditions among 142 patients. Acute leukemias were the most common, with Acute Lymphoblastic Leukemia (ALL) in 38 patients (26.8%) and Acute Myeloid Leukemia (AML) in 34 patients (23.9%). Chronic Myeloid Leukemia (CML) was diagnosed in 28 patients (19.7%), Chronic Lymphocytic Leukemia (CLL) in 10 patients (7%), and Chronic Eosinophilic Leukemia (CEL) in 4 patients (2.8%). Multiple Myeloma accounted for 12 patients (8.5%), while other marrow disorders were seen in 16 patients (11.3%). Overall, as depicted in Table 4, acute leukemias constituted the majority of diagnoses in this study population.

Table 4: Distribution of Diagnosed Conditions (N=142)

Diagnosis	Frequency (n)	Percentage (%)
Acute Lymphoblastic Leukemia (ALL)	38	26.8
Acute Myeloid Leukemia (AML)	34	23.9
Chronic Myeloid Leukemia (CML)	28	19.7
Chronic Lymphocytic Leukemia (CLL)	10	7
Chronic Eosinophilic Leukemia (CEL)	4	2.8
Multiple Myeloma	12	8.5
Other marrow disorders	16	11.3
Total	**142**	**100**

Table 5 illustrates the age-wise distribution of major leukemia types among 142 patients. Acute Lymphoblastic Leukemia (ALL) predominated in the younger age groups, especially 10–20 years (18 patients) and 21–30 years (10 patients). Acute Myeloid Leukemia (AML) was more evenly distributed

across ages, with notable cases in 21–30 years (8 patients), 31–40 years (6 patients), and 41–50 years (6 patients). Chronic Myeloid Leukemia (CML) was predominantly seen in adults aged 31–50 years (6 patients in each 31–40 and 41–50 groups). Chronic Lymphocytic Leukemia (CLL) occurred mainly in middle-aged groups, with cases in 31–60 years, while other marrow disorders were distributed across all age groups, peaking in 31–50 years. Overall, as shown in Table 5, ALL is more common in younger patients, whereas chronic leukemias and other marrow disorders are seen in older age groups.

Table 5: Age-wise Distribution of Major Leukemia Types (N=142)

Age Group (years)	ALL	AML	CML	CLL	Others	Total
10–20	18	6	4	0	0	28
21–30	10	8	6	0	4	28
31–40	4	6	6	2	6	24
41–50	4	6	6	4	6	26
51–60	2	6	4	4	4	20
>60	0	2	2	0	2	6
Total	**38**	**34**	**28**	**10**	**16**	**142**

Table 6 summarizes the diagnostic modalities employed for 142 patients. Complete blood count (CBC), peripheral blood smear, and bone marrow aspiration were performed in all patients (100%), ensuring baseline hematological assessment. Cytochemistry was utilized in 96 patients (67.6%), while immunophenotyping was performed in 88 patients (62%) to further classify leukemia subtypes. Overall, as shown in Table 6, a combination of morphological, cytochemical, and immunological techniques was employed, with CBC, peripheral smear, and bone marrow aspiration universally applied.

Table 6: Diagnostic Modalities Used (N=142)

Diagnostic Tool	Frequency (n)	Percentage (%)
CBC	142	100
Peripheral Blood Smear	142	100
Bone Marrow Aspiration	142	100
Cytochemistry	96	67.6
Immunophenotyping	88	62

Discussion

The leukemias distribution in the current study was slightly male predominant (54.9%), which is in accordance with the other previous studies that have shown that leukemia has a high incidence in males when compared to women, but the difference is usually mild (Singh, 2017) [13]. In terms of age, most of the patients were of 10-20 years age group (22.5%), then were those of 21-30 years age group (19.7%). It is in line with the established pattern of acute lymphoblastic leukemia (ALL) often occurring in younger people, especially children and adolescents with the highest rates observed among 15-5 years of age (Singh, 2017) [13]. This pattern is supported by our data because ALL was the most prevalent in the 1020 years bracket and accounted for 26.8 percent of the cases. In its turn, acute myeloid leukemia (AML) constituted 23.9% of cases and had a comparatively wider age distribution, as reports in the literature indicate that about 60% of AML cases fall into the 40-70 age range, and 40% of them fall in the 1030 age range (Singh, 2017). Chronic myeloid leukemia (CML) had an incidence of 19.7% of the participants and was mostly observed in adults aged 21 50 years as it is related to the adult predilection and the fact that CML normally presents itself in the third to fifth decades (Kantarjain & Cortes, 2013) [14] . The prevalence of chronic lymphocytic leukemia (CLL) and chronic eosinophilic leukemia (CEL) was relatively low in our cohort (7 and 2.8 percent, respectively), as well as in established epidemiological trends (Singh, 2017) [13].”

The most frequent presenting symptom clinically was fatigue or weakness (73.2%), then fever (69), then loss of appetite (62), and weight loss (53.5). Bleeding manifestations were also seen in 32.4 percent of patients, recurrent infections and hepatosplenomegaly were seen in 36.6 and 40.8 percent of patients respectively. The least common was lymphadenopathy, that was observed in 31 percent of the participants. These results are mostly comparable to those reported in the literature, whereby both ALL and AML are commonly characterized by nonspecific symptoms as depicted by fatigue, fever, pallor and bleeding disposition, hepatosplenomegaly and lymphadenopathy (Kumar et al., 2004) [15]. On the same note, the patients of CML are often characterized by weakness, weight loss, and big splenomegaly as were evident in our research (Kumar et al., 2004) [15]. In CLL, hepatosplenomegaly and lymphadenopathy are less uniform and have a rate of occurrence around 50-60 per cent, which is also reflected by a smaller rate in our own cohort (Kumar et al., 2004) [15].

Even Hematological parameters reflected patterns in accordance with known values. Here, 64.8% of patients were found to have hemoglobin below 10 g/dl, which implies that anemia was prevalent in 64.8 percent, whereas in 60.6 percent of cases, leukocytosis was present, whereas in 15.5 percent of cases, leukopenia was observed, and in 23.9 percent of cases, it was normal. Thrombocytopenia, a platelet counts of less than 1.5 lakh/cumm, was in 54.9% of the subjects. The trends are in line with the predicted laboratory characteristics of acute leukemias, which are normally characterized by anemia, fluctuating leukocyte counts, and thrombocytopenia, with the peripheral blood smears showing over 40 per cent blasts (Singh, 2017; Chakraborty, 2010) [13,16]. Absolute lymphocytosis above 10 10 9/L is characteristic of CLL, and in classic cases, more than 90 per cent of the peripheral blood cells are mature lymphocytes (Singh, 2017) [13]. Our study results revealed that CML patients experienced significant leukocytosis, an event characterized by the total leukocyte of 30500 × 10 9/l, which is consistent with literature descriptions, and CEL cases exhibited eosinophilia of more than 1.5 x 10 9/L (Kantarjain and Cortes, 2013) [14].

A morphological difference between AML and CML was that AML showed a clonal proliferation of myeloid precursors with decreased differentiation, whereas CML showed uncontrolled proliferation of mature granulocytes and their precursors. These leukemias were differentiated with the help of cytochemical and immunophenotypic analyses. Myeloperoxidase, Sudan black, and NSE of blasts in AML were positive but PAS and acid phosphatase of ALL blasts were positive, and classical cytochemical patterns were supported (Singh, 2017) [13]. The diagnosis was based on bone marrow aspiration (BMA), which enabled cytological examination and differentials counts in detail with the help of cytochemistry in 67.6% of samples and immunophenotyping in 62, which was an expression of integration of conventional and cutting-edge diagnostic approaches in line with current practice (Singh, 2017; Chakraborty, 2010) [13,16].

In general, the research presents similarities and differences with current literature. The prevalence rates, clinical presentation, and laboratory results are mostly in line with previous reports; however, minor variations in the relative prevalence rates of the different leukemia subtypes (i.e., the increased prevalence rate of ALL over AML) may indicate differences in the epidemiology of the disease depending on regions, genetics, and environment. The results support the significance of overall hematologic testing, which involves BMA, cytochemistry, immunophenotyping, in the proper diagnosis, prognostication, and treatment of leukemias in different age groups.

Conclusion

A morphology spectrum and frequency of leukemia through the study of bone marrow aspiration showed important information regarding the demographic patterns, clinical presentation, as well as hematology of people who are affected. The patients were both male and female with a large age range, which also indicates that leukemias may affect any age, yet some of them were more common among particular age groups. Most patients presented with non-specific but widespread symptoms which include fatigue, fever, and loss of appetite as well as signs such as hepatosplenomegaly, bleeding manifest, and frequent infections, indicating the systemic effect of such hematological malignancies. Hematological examination revealed that most patients were anaemic, abnormal leukocyte counts and thrombocytopenia, which is an indication of marrow suppression and abnormal hematopoiesis in leukemia. Some of the cases diagnosed included acute leukemias and acute lymphoblastic leukemia and acute myeloid leukemia were a significant percentage with chronic leukemias and other marrow disorders being less common. The age-wise distribution showed that acute leukemias were more prevalent in the younger age groups, whereas in older age groups; the chronic forms were more prevalent. This paper also highlighted the need to use several diagnostic modalities that include complete blood counts, peripheral smears, bone marrow aspiration, cytochemistry and immunophenotyping in order to definitively classify and diagnose the specific types of leukemia. In general, the presented results point to the manifold clinical and hematological phenotypes of leukemia and the importance of sophisticated diagnostic assessment in the selection of effective treatment options.

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