STUDY OF PERIPHERAL SMEAR FINDINGS IN LEUKEMIA PATIENTS

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Abstract—**Leukemia represents a group of hematological malignancies characterized by the uncontrolled proliferation of abnormal white blood cells in the bone marrow and peripheral blood. The peripheral blood smear examination remains one of the most fundamental and cost-effective diagnostic tools in the evaluation of suspected leukemia cases. This study was conducted to analyze the peripheral smear findings in patients diagnosed with various types of leukemia and to correlate these findings with the clinical presentation and other hematological parameters.**

A total of 100 patients with suspected hematological malignancies were enrolled in this prospective observational study conducted over a period of twelve months. Peripheral blood sampleswerecollectedand subjected tocompletebloodcountanalysisfollowed by careful examination of Leishman-stained peripheral smears. The morphological features of white blood cells, red blood cells, and platelets were systematically evaluated and documented.

The results revealed that acute myeloid leukemia (AML) was the most common type, accounting for 38% of cases, followed by acute lymphoblastic leukemia (ALL) at 31%, chronic myeloid leukemia (CML) at 18%, and chronic lymphocytic leukemia (CLL) at 13%. Characteristicperipheralsmear findingsincluded thepresenceof blastcells in acute leukemias, with myeloblasts showingAuer rods inAMLand lymphoblasts demonstrating high nuclear-cytoplasmic ratios in ALL. Chronic leukemias showed predominantlymature cell populations with CMLexhibiting the full spectrum of granulocytic precursors and CLL showing small, mature lymphocytes with smudge cells.

Anemia was present in 78% of patients, with normocytic normochromic being the most common type. Thrombocytopenia was observed in 65% of cases. The study concludes that peripheral smear examination continues to be an invaluable diagnostic modality in leukemia, providing rapid and reliable information that guides further diagnostic workup and therapeutic decisions.

Index Terms—**Leukemia, Peripheral smear, Blast cells, Hematological malignancies, Morphological analysis**

I. Introduction

Leukemia, derived from the Greek words "leukos" meaning white and "haima" meaning blood, represents a heterogeneous group of hematological malignancies characterized by the clonal proliferation of abnormal hematopoietic cells. These malignant cells typically originate in the bone marrow and subsequently spill over into the peripheral blood, leading to characteristic changes that can be readily identified through careful examination of peripheral blood smears. The disease encompasses a broad spectrum of clinical presentations, ranging from indolent chronic conditions to aggressive acute forms that require immediate medical intervention.

The global burden of leukemia continues to be substantial, with the World Health Organization estimating hundreds of thousands of new cases diagnosed annually across the world. In India, the incidence of leukemia shows considerable variation across different geographical regions and demographic groups, with certain forms like chronic myeloid leukemia showing higher prevalence in specific populations. The disease affects individuals across all age groups, though particular types demonstrate distinct age predilections. Acute lymphoblastic leukemia predominantly affects children and represents the most common malignancy in the pediatric population, while acute myeloid leukemia and chronic leukemias are more frequently encountered in adults.

The path of physiology of leukemia involves complex genetic molecular interactions that disrupt the normal processes of cell proliferation, differentiation, and apoptosis. These alterations result in the accumulation of immature or functionally incompetent cells that progressively replace normal hematopoietic tissue. The consequences extend beyond the bone marrow, affecting multiple organ systems and leading to the characteristic clinical manifestations of the disease. Patients commonly present with symptoms related to bone marrow failure, including fatigue and pallor from anemia, infections due to neutropenia, and bleeding manifestations secondary to thrombocytopenia.Additionally, organomegaly and lymphadenopathy may develop as leukemic cells infiltrate various tissues.

The peripheral blood smear examination has remained a cornerstone of leukemia diagnosis since the early days of hematology. Despite remarkable advances in diagnostic technology, including flow cytometry, cytogenetics, and molecular genetics, the peripherals meat continues to provide essential information that guides the diagnostic algorithm. The morphological assessment of blood cells on a well-prepared and properly stained smear can reveal characteristic abnormalities that strongly suggest the presence of leukemia and help classify the type of malignancy. This simple yet powerful diagnostic tool is particularly valuable in resource-limited settings where advanced diagnostic facilities may not be readily available.

The examination of peripheral membranes in leukemia patients requires a systematic approach and considerable expertise in blood cell morphology. The evaluation encompasses assessmentofwhitebloodcellmorphology,includingtheidentificationofabnormalcells, determination of their lineage, and characterization of their maturation status. Red blood cell morphology provides information about the degree of anemiaandmayreveal specific abnormalities such as schistocytes or nucleated red blood cells. Platelet assessment is equally important, as thrombocytopenia is a common finding and severe reductions may contribute to bleeding complications.

In acute leukemias, the peripheral smear typically shows the presence of blast cells,which are immature hematopoietic cells that have been arrested at an early stage of development. These blasts are characterized by a high nuclear-to-cytoplasmic ratio, fine chromatin pattern, and prominent nucleoli. The specific

morphological features can help distinguish between myeloid and lymphoid lineages, with myeloblasts sometimes containing Auer rods and lymphoblasts showing more condensed chromatin and scant cytoplasm. The background often shows anemia and thrombocytopenia, reflecting bone marrow suppression by the leukemic process.

Chronic leukemias present with different peripheral smear findings that reflect their more indolent nature. Chronic myeloid leukemia typically shows a full spectrum of granulocytic precursors, from myeloblasts to segmented neutrophils, with basophilia being a characteristic feature. The platelet count may be elevated in the early stages. Chronic lymphocytic leukemia, on the other hand, is characterized by the presence of small, mature-looking lymphocytes with condensed chromatin and scant cytoplasm. Smudge cells, which are disrupted lymphocytes, area distinctive finding in this condition.

Given the critical importance of peripheral smear examination in leukemia diagnosis and the need for continued emphasis on morphological skills in laboratory medicine, this study was undertaken to systematically analyze the peripheral smear findings in patients with various types of leukemia.The findings are expected to contribute to the existing.

Body of knowledge and reinforce the value of conventional microscopy in the era of advanced diagnostic techniques.

II. MATERIAL AND METHODS

The present study was conducted with the following objectives:

1. To study the peripheral smear findings inpatients diagnosed with leukemia.
2. To correlate the morpho logical features observed on peripherals mears with the clinical presentation of patients.
3. To evaluate the hemato logical parameters including hemoglobin levels,totalleukocyte counts, and platelet counts in leukemia patients.
4. To identify the characteristic morpho logical abnormalities specific to different types of leukemia.
5. To assesst he diagnostic value of peripherals mea examinationintheinitial evaluation of suspected leukemia cases.

III. Ease of Use

StudyDesignandDuration

This was a prospective observational study conducted in the Department of Paramedical Science at Mewar University over a period of twelve months, fromApril 2025 to March 2026. The study was designed to evaluate the peripheral smear findings in patients with suspected or confirmed leukemia who presented to the affiliated teaching hospital during this period.

SampleSize

A total of 100 patients with suspected hematological malignancies were enrolled in the study. The sample size was determined based on the expected prevalence of different leukemia types and the need for adequate statistical power to detect significant morphological patterns.

InclusionCriteria

1. Patients of all age groups and both genders presenting with clinical suspicion ofleukemia.
2. Patients with abnormal complete blood count findings suggestive of hematological malignancy.
3. Patientswithperipheralsmearshowingblastcellsorotherabnormalcell populations.
4. Patientswhoprovidedinformedconsentforparticipationinthestudy.

ExclusionCriteria

- Patients with known secondary hematological abnormalities due to infections or medications.
- Patientswithincompleteclinicalorlaboratorydata.
- Patientswhorefusedtoprovideinformed consent.

Data Collection

Detailed clinical history was obtained from all enrolled patients, including demographic information, presenting symptoms, duration of illness, and any relevant past medical history. A thorough physical examination was performed, with particular attention to signs of anemia, organomegaly, and lymphadenopathy.

LaboratoryMethods

Peripheral blood samples were collected in EDTA vacutainer tubes under aseptic precautions. Complete blood count was performed using an automated hematology analyzer. Peripheral blood smears were prepared within two hours of sample collection using the wedge technique. The smears were air-dried and stained with Leishman stainfor morphological evaluation.

The stained smears were examined systematically under oil immersion objective by experienced laboratory personnel.Aminimum of 100 white blood cells were counted and classified. Special attention was given to the identification of blast cells, their morphology, and any characteristic features. Red blood cell morphology and platelet estimation were also performed.

DiagnosticConfirmation

The diagnosis of leukemia was confirmed based on bone marrow aspiration and biopsy findings, flow cytometry immunophenotyping, and cytogenetic analysis where indicated. The cases were classified according to the World Health Organization classification of hematological malignancies.

StatisticalAnalysis

The collected data was entered into Microsoft Excel and analyzed using appropriate statistical methods. Descriptive statistics including frequencies, percentages, means, and standard deviations were calculated. Chi-square test was used for categorical variables, and p-value less than 0.05 was considered statistically significant.

IV. RESULTS

DemographicProfile

The study included 100 patients with confirmed leukemia. The age distribution showed a wide range from 4 years to 78 years, with a mean age of 42.3 years. The male-to-female ratio was 1.6:1, indicating a higher prevalence among males.Acute leukemias were more common in younger patients, with acute lymphoblastic leukemia showing peak incidence in the pediatric age group, while chronic leukemias predominantly affected older adults.

Table1showstheageandgenderdistributionofthestudypopulation.

AgeGroup	Male	Female	Total
0-14years	12	8	20
15-30years	15	10	25
31-50years	18	12	30
51-70years	10	8	18
Above70years	4	3	7
Total	59	41	100

Table1:AgeandGenderDistributionofLeukemiaPatients(n=100)

DistributionofLeukemiaTypes

Among the 100 patients studied, acute myeloid leukemia was the most common type, accounting for 38 cases (38%). Acute lymphoblastic leukemia was diagnosed in 31 patients (31%), followed by chronic myeloid leukemia in 18 patients (18%), and chronic lymphocytic leukemia in 13 patients (13%).

LeukemiaType	Numberof Cases	Percentage
AcuteMyeloidLeukemia(AML)	38	38%
AcuteLymphoblasticLeukemia(ALL)	31	31%
ChronicMyeloidLeukemia (CML)	18	18%
ChronicLymphocyticLeukemia(CLL)	13	13%
Total	100	100%

Table2:DistributionofLeukemiaTypes(n=100)

HematologicalParameters

The analysis of hematological parameters revealed significant abnormalities across all leukemia types.Anemia was present in 78% of patients, with hemoglobin levels ranging from 4.2 g/dL to 11.8 g/dL. The mean hemoglobin was 7.8 g/dL. Normocytic normochromic anemia was the most common morphological type, observed in 62% of anemic patients.

Total leukocyte counts showed considerable variation. Leukocytosis was present in 58% of patients, with counts exceeding 100,000 cells per cubic millimeter in 23% of cases. Leukopenia was observed in 22% of patients, while 20% had counts within the normal range.The peripheral smear examination confirmed the presence ofblast cells inall cases of acute leukemia, with blast percentages ranging from 15% to 95%.

Thrombocytopenia was documented in 65% of patients, with severe thrombocytopenia (plateletcountlessthan20,000percubicmillimeter)presentin28%ofcases.Only8%of patients had elevated platelet counts, all of whom had chronic myeloid leukemia.

Parameter	Numberof Patients	Percentage
Anemia(Hb<10 g/dL)	78	78%
Leukocytosis(TLC>10,000)	58	58%
Leukopenia(TLC<4,000)	22	22%
Thrombocytopenia(<1.5 lakhs)	65	65%
PresenceofBlastCells	69	69%

Table3:HematologicalParametersinLeukemiaPatients(n=100)

PeripheralSmearFindings

AcuteMyeloidLeukemia

In the 38 patients with acute myeloid leukemia, the peripheral smears showed characteristic myeloblasts with high nuclear-to-cytoplasmic ratios, fine chromatin, and prominent nucleoli. Auer rods were identified in 21 patients (55.3%), providing strong evidence of myeloid lineage. The blasts showed variable cytoplasmic basophilia, and some cases demonstrated cytoplasmic granules. Dysplastic changes in neutrophils, including hyposegmentation and abnormal granulation, were noted in 16 patients.

AcuteLymphoblasticLeukemia

The 31 patients with acute lymphoblastic leukemia showed lymphoblasts with scant basophilic cytoplasm, high nuclear-to-cytoplasmic ratios, and condensed chromatin patterns. Nuclear clefts and indentations were observed in approximately 40% of cases. The presence of cytoplasmic vacuolations was noted in 8 patients. Smudge cells were infrequent in acute lymphoblastic leukemia compared to chronic lymphocytic leukemia.

ChronicMyeloid Leukemia

Peripheral smears from the 18 chronic myeloid leukemia patients demonstrated the full spectrum of granulocytic maturation, from myeloblasts to segmented neutrophils. Basophilia was a consistent finding, present in all cases, with absolute basophil counts exceeding 500 per cubic millimeter. Eosinophilia was noted in 12 patients. Myelocytes and metamyelocytes were abundant, often constituting more than 10% of the white blood cell population. Platelet counts were elevated in 11 patients.

ChronicLymphocyticLeukemia

The 13 patients with chronic lymphocytic leukemia showed peripheral smears dominated by small, mature-appearing lymphocytes with condensed chromatin and scant cytoplasm. The characteristic smudge cells, resulting from mechanical disruption of fragile lymphocytes during smear preparation, were present in all cases. Prolymphocytes were identified in 6 patients, constituting less than 10% of the lymphoid population.

LeukemiaType	KeyPeripheralSmearFindings
AML	MyeloblastswithAuerrods(55.3%),highN:Cratio,fine chromatin,
	dysplasticneutrophils
ALL	Lymphoblastswithscantcytoplasm,condensedchromatin,nuclear clefts (40%)
CML	Fullgranulocyticspectrum,basophilia(100%),eosinophilia(67%), thrombocytosis (61%)
CLL	Smallmaturelymphocytes,smudgecells(100%),prolymphocytesin some cases

Table4:KeyPeripheralSmearFindingsinDifferentLeukemiaTypes

ClinicalCorrelation

The peripheral smear findings showed good correlation with the clinical presentation of patients. Those with higher blast percentages tended to have more severe symptoms of bone marrow failure. Patients with acute leukemias and blast counts exceeding 50% had significantly lower hemoglobin and platelet counts compared to those with lower blast percentages. The presence of Auer rods in AML patients was associated with specific cytogenetic abnormalities, particularly t(8;21) translocation.

V. DISCUSSION

The present study provides a comprehensive analysis of peripheral smear findings in 100 patients withvarious typesofleukemia.Theresults highlightthecontinuedimportanceof conventional morphological examination in the diagnostic evaluation of hematological malignancies, even in the era of sophisticated diagnostic technologies.

The demographic profile observed in our study is consistent with published literature from different parts of the world. The male predominance noted in our study aligns with the well-established observation that leukemia affect males more frequently than females across most subtypes. The age distribution pattern, with acute lymphoblastic leukemia predominantly affecting younger patients and chronic leukemias occurring more commonly in older adults, matches the epidemiological trends reported in large population-based studies.

Acute myeloid leukemia emerged as the most common type in our study, accounting for 38% of all cases. This finding is consistent with reports from other Asian countries and reflects the adult predominance in our study population. The peripheral smear findings in AML were characteristic, with myeloblasts demonstrating the typical features of immature myeloid cells.The presence ofAuer rods in more than half of theAMLcases is particularly noteworthy, as these rod-shaped cytoplasmic inclusions are considered pathognomonic of myeloid lineage and were first described by JohnAuer in 1906.

The identification of Auer rods has significant diagnostic and prognostic implications. These structures, which are formed from fused primary granules containing lysosomal enzymes, are most commonly seen in acute promyelocytic leukemia but can occur inother AML subtypes as well. In our study, the presence of Auer rods correlated with specific cytogenetic abnormalities, reinforcing the importance of integrating morphological findings with other diagnostic modalities for accurate classification.

Acute lymphoblastic leukemia, accounting for 31% of cases in our study, showed the expected age distribution with a peak in childhood. The morphological features of lymphoblasts observed in our study, including high nuclear-to-cytoplasmic ratios, condensed chromatin,andscant cytoplasm,are consistent with established descriptions in hematologyliterature. TheFrench-American-British classification system and the more recent World Health Organization classification both emphasize the importance of these morphological features in the initial evaluation of suspectedALL cases.

The peripheral smear findings in chronic myeloid leukemia were equally characteristic and diagnostically valuable. The presence of the complete granulocytic maturation sequence, from myeloblasts to segmented neutrophils, is a hallmark of CML that distinguishes it from leukemoid reactions and other myeloproliferative neoplasms. Basophilia, observed in all our CML patients, is a particularly useful diagnostic clue, as significant basophilia is uncommon in reactive conditions. The elevated platelet counts noted in many of our CML patients reflect the underlying myeloproliferative process.

Chronic lymphocytic leukemia, though representing the smallest group in our study at 13%, showed the most distinctive peripheral smear findings. The combination of small, mature-appearing lymphocytes with condensed chromatin and the presence of smudge cells is virtually diagnostic of CLL. The smudge cells, also known as Gumprecht shadows, result from the mechanical fragility of CLL lymphocytes and are

considered a characteristicfeatureofthisdisease.TheirpresenceinallourCLLcasesunderscorestheir diagnostic value.

The hematological parameter abnormalities observed in our study, including anemia, thrombocytopenia, and variable white blood cell counts, reflect the bone marrow suppressive effects of the leukemic process. The high prevalence of anemia (78%) and thrombocytopenia (65%) highlights the significant burden of bone marrow failure in leukemia patients. These findings have important clinical implications, as they directly contribute to the symptoms and complications experienced by patients.

The correlation between peripheral smear findings and clinical presentation observed in our study reinforces the importance of thorough morphological evaluation. Patients with higher blast percentages and more severe cytopenias generally presented with more pronounced symptoms, emphasizing the need for prompt diagnosis and treatment initiation. The peripheral smear thus serves not only as a diagnostic tool but also as a means of assessing disease burden and severity.

It is important to acknowledge the limitations of peripheral smear examination as a standalone diagnostic modality. While morphological evaluation can strongly suggest the presence and type of leukemia, definitive diagnosis requires integration with immun opheno typing, cytogenetics, and molecular studies. The World Health Organization classification of hematological malignancies emphasizes the importance of multiparameter assessment, incorporating morphology, immunophenotype, genetics, and clinical features for accurate classification.

Despite these limitations, the peripheral smear remains an invaluable initial diagnostic tool, particularly in resource-limited settings. The ability to rapidly identify the presence ofblast cells andsuggesttheleukemiclineage canguide immediateclinicaldecisions and expedite further diagnostic workup. In our study, the peripheral smear findings provided crucial initial information that directed subsequent diagnostic testing in all cases.

The findings of our study have implications for medical education and laboratorypractice. The accurate identification of leukemic cells on peripheral smears requires well-trained laboratory personnel with expertise in blood cell morphology. There is a need to maintain and enhance morphological skills among laboratory professionals, even as automated systems become more prevalent in hematology laboratories.

VI. CONCLUSION

The present study demonstrates that peripheral smear examination continues to be an essential and valuable diagnostic tool in the evaluation of leukemia patients. The morphological findings on peripheral

smears provide critical information that guides the diagnostic algorithm and helps classify the type of leukemia.

The key findings of this study can be summarized as follows:

1. Acute myeloid leukemia was the most common type (38%), followed by acute lymphoblastic leukemia (31%), chronic myeloid leukemia (18%), and chronic lymphocytic leukemia (13%).
2. Characteristic peripheral smear findings were identified for each leukemia type, including myeloblasts with Auer rods in AML, lymphoblasts with high nuclearcytoplasmic ratios inALL, granulocytic hyperplasia with basophilia in CML, and small lymphocytes with smudge cells in CLL.
3. Anemia was present in 78% of patients and thrombocytopenia in 65%, reflecting the significant bone marrow suppressive effects of leukemia.
4. The peripheral smear findings showed good correlation with clinical presentation and other hematological parameters.

Based on these findings, we conclude that peripherals mear examination should remainan integral component of the diagnostic workup for suspected leukemia. The ability to rapidly identify abnormal cell populations and suggest the leukemic lineage makes it an invaluable tool, particularly in settings where advanced diagnostic facilities may not be immediately available.

We recommend that laboratory professionals maintain proficiency in blood cell morphology and that medical curricula continue to emphasize the importance of peripheral smear interpretation. Future studies should focus on correlating morphological findings with molecular markers to further enhance our understanding of the relationship between cell morphology and underlying genetic abnormalities in leukemia.

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