CENTRAL ASIAN JOURNAL OF MEDICAL AND NATURAL SCIENCES
https://cajmns.casjournal.org/index.php/CAJMNS
Volume: 07 Issue: 04 | July 2026 ISSN: 2660-4159

Article

Clinico-Hematological Signature of Acute Leukemia: A Case-Control and Subtype-Based Analysis of Blood Cell Parameters

Zainab K. Lafta*[1], Alaa Shakir Alnahi[2], Mazin S. Salman[3]

1. *College of health and medical technologies - Southern technical University*
2. *College of health and medical technologies - Southern technical University*
3. *Basrah medical technichal institute - Southern technical University*

Corresponding Author: zainabkhudair19998@gmail.com

Citation: B. Kh. Matkarimov &Kh. T. Musahaykhov Current Issues of Surgical Ethics and Deontology. Central Asian Journal of Medical and Natural Science 2026, 76-85.

Received: 10th Feb 2026
Revised: 21th Mar 2026
Accepted: 08th Apr 2026
Published: 16h July 2026

Abstract: ***Background****: Acute leukemia is an aggressive hematological malignancy characterized by clonal expansion of immature hematopoietic precursors with suppression of normal marrow activity. Primary lab parameters paradoxically, despite the need for next-generation sequencing (NGS) and advanced histopathologic classification to choose treatment options in leukaemia patients, blood count parameters still provide an essential first window into burden of disease, risk of marrow failure and clinical risk groups. The study aimed to investigate the hematological parameters of acute leukemia patients vs healthy controls and find out if blood cell parameters differ according to sex, age group or Leukemia sub type.*

Methods*: A total of 88 samples were used in a case-control study, consisting of 48 acute leukemia cases and 40 healthy controls (CD). Patients were those with acute lymphoblastic leukemia and acute myeloid leukemia. Blood samples prior to chemotherapy Blood was analyzed for complete blood count and differential leukocyte counts using the ADVIA 2120i Hematology System. The parameters studied were WBC, RBC, platelet count, Hb, HCT MCV and MCHC.*

Results*: patients and controls were matched for age, sex distribution. The median values of WBC, RBC, platelet count, Hb, HCT, MCV, MCH and MCHC were significantly lower in patients than controls (P<0.05) but the percentage of neutrophils and eosinophil was much higher while percentages of lymphocytes were much higher compared with controls. The difference was not significant for monocytes and basophils. Results of sex comparison, significant only for MCHC. An analysis stratified by diagnosis showed that WBC and platelet counts were substantially greater in AML than ALL (all p<0.001). When analysed according to age, Hb lower in older patients was the only significant difference.*

Conclusions*: Acute leukemia most often produced a recognizable hematologic picture characterized primarily by anemia, thrombocytopenia, reduced neutrophils and disorganized distribution of leukocyte output. The majority of blood parameters were not significantly affected by sex or age indicating that the abnormal hematological change is mainly determined by leukemic marrow disruption.*

Keywords: *acute leukemia; complete blood count; hematological markers; AML; ALL; anemia; thrombocytopenia;* ***leukopenia***

1. INTRODUCTION

Acute leukemia represents a biologically heterogeneous group of malignant disorders arising from immature hematopoietic precursors. The disease is broadly classified into acute myeloid leukemia (AML) and acute lymphoblastic leukemia (ALL), depending on the lineage of the malignant clone. Modern classification relies on

integrated interpretation of morphology, immunophenotyping, cytogenetics, and molecular genetics rather than morphology alone [1][2][3]. Risk assignment has also moved toward genomic and response-adapted frameworks, particularly in AML and adult ALL, where cytogenetic and molecular findings shape prognosis and treatment selection [4][5]. Nevertheless, the complete blood count remains the earliest and most accessible laboratory investigation that raises suspicion of acute leukemia and reflects the degree of marrow failure.

The public-health relevance of acute leukemia is supported by global cancer statistics and subtype-specific burden analyses. GLOBOCAN-based estimates show that leukemia remains an important contributor to cancer incidence and mortality worldwide, with variation by geography, sex, age, and subtype [6][7][8]. Recent burden analyses also indicate that AML and ALL follow different epidemiological patterns: AML is more common in older adults, whereas ALL has a major pediatric and adolescent component [9][10]. These epidemiological differences justify studying CBC patterns across diagnosis and age categories.

The clinical picture of acute leukemia is largely explained by replacement of normal bone marrow elements by leukemic blasts. This process reduces effective erythropoiesis, megakaryopoiesis, and granulopoiesis, resulting in anemia, thrombocytopenia, neutropenia, or variable total leukocyte counts. Patients may present with fatigue, pallor, fever, infection, bleeding tendency, bruising, or bone pain. Although these features are nonspecific, their association with abnormal blood cell parameters often leads to further diagnostic evaluation through peripheral smear review, bone marrow aspiration, flow cytometry, cytogenetic analysis, and molecular testing [11][12][13][14].

AML and ALL differ in their age distribution, biology, clinical course, and treatment approach. AML is more frequent in adults and older individuals, whereas ALL is more common in children, although both diseases can occur at any age [15][16][17]. These differences may influence peripheral blood findings, but hematological profiles often overlap because both diseases disrupt normal marrow production. For this reason, CBC parameters cannot replace definitive diagnostic methods, but they remain clinically valuable for initial assessment, risk recognition, and monitoring.

Previous studies have shown that anemia and thrombocytopenia are common findings at diagnosis in acute leukemia. Jaime-Pérez et al. [18] reported that CBC abnormalities in childhood ALL were highly heterogeneous but frequently included anemia and thrombocytopenia. Shuchismita et al. [19] also described anemia, leukocyte abnormalities, and platelet reduction as major laboratory findings among acute leukemia cases. Broader clinical reviews of AML and ALL have similarly emphasized that peripheral blood abnormalities are important at presentation but vary by age, subtype, genetic background, and degree of marrow replacement [20][21][22]. However, the direction and severity of WBC changes may vary considerably, as acute leukemia may present with leukocytosis, normal leukocyte count, or leukopenia depending on blast release, marrow suppression, and disease subtype.

In this context, the current study was designed to evaluate the hematological signature of acute leukemia in a local patient cohort. The study compared CBC and differential leukocyte parameters between patients and healthy controls and explored whether these markers varied according to sex, AML/ALL diagnosis, and age category.

2. MATERIALS AND METHODS

Study design and participants

This case-control study included 88 participants divided into two groups: 48 newly diagnosed patients with acute leukemia and 40 apparently healthy controls. Patients were recruited from Al-Sayyab Teaching Hospital and Basra Children Specialty Hospital during the period from September 26, 2025, to April 25, 2026. The patient group included 28 AML cases and 20 ALL cases according to the final statistical results. The age of patients ranged from childhood to older adulthood, allowing evaluation across different age categories.

The control group included healthy individuals without clinical or laboratory evidence of diseases that could affect the measured hematological parameters. Controls

were selected to be comparable with the patient group in age and sex distribution.

Inclusion and exclusion criteria

Patients were included if they had a confirmed diagnosis of acute leukemia based on clinical evaluation, complete blood count, bone marrow examination, and immunophenotyping by flow cytometry. This diagnostic approach is consistent with contemporary recommendations that acute leukemia classification should combine clinical, morphologic, immunophenotypic, cytogenetic, and molecular information when available [23][24][25][26]. Blood samples were collected before the initiation of chemotherapy to avoid treatment-related changes in blood parameters.

Patients with chronic leukemia, secondary hematological disorders, severe hepatic dysfunction, renal failure, major cardiovascular disease, or previous chemotherapy were excluded. Control subjects with chronic disease, recent infection, regular medication use, or antioxidant supplementation were also excluded.

Blood collection and hematological analysis

Six milliliters of venous blood were collected from each participant. Two milliliters were placed in EDTA tubes for hematological analysis. Complete blood count and automated differential leukocyte counts were performed using the ADVIA 2120i Hematology System (Siemens Healthcare Diagnostics, Germany). Samples were processed within two hours of collection to preserve cellular stability.

The analyzed hematological variables included total WBC count, RBC count, hemoglobin concentration, hematocrit, MCV, MCH, MCHC, platelet count, neutrophil percentage, lymphocyte percentage, monocyte percentage, eosinophil percentage, and basophil percentage.

Statistical analysis

Continuous variables were expressed as mean ± standard deviation and median with interquartile range according to distribution. Categorical variables were expressed as frequencies and percentages. Comparisons between two groups were performed using appropriate parametric or non-parametric tests according to data distribution, while categorical variables were analyzed using Fisher's exact test or chi-square test when suitable. Comparisons among more than two age categories were performed using appropriate multi-group testing. A P-value below 0.05 was considered statistically significant.

3. RESULTS

Baseline characteristics of the studied groups

The study included 48 acute leukemia patients and 40 healthy controls. The mean age of patients was 31.29 ± 18.95 years, while the mean age of controls was 38.33 ± 18.13 years. There was no statistically significant difference in overall age between patients and controls. Age-category distribution also showed no significant difference between groups. Males represented 75.0% of both patients and controls, and females represented 25.0% of both groups, with no significant sex difference. Regarding diagnosis, AML represented 58.3% of the patient group, while ALL represented 41.7%.

Table 1. Socio-demographic characteristics among the study groups

Characteristic	Patients group (n=48)	Control group (n=40)	P-value
Age (year), overall mean ± SD	31.29 ± 18.95	38.33 ± 18.13	0.08 NS*
<18 years	12 (25.0%)	8 (20.0%)	0.36 NS**
18-39 years	18 (37.5%)	11 (27.5%)	
>=40 years	18 (37.5%)	21 (52.5%)	
Sex: Male	36 (75.0%)	30 (75.0%)	1.0 NS**
Sex: Female	12 (25.0%)	10 (25.0%)	
Diagnosis: ALL	20 (41.7%)	0 (0.0%)	<0.001**
Diagnosis: AML	28 (58.3%)	0 (0.0%)	

NS: non-significant; *t-test; **Fisher exact test.

Hematological profile of patients compared with controls

Acute leukemia patients showed marked alterations in hematological parameters compared with healthy controls. WBC count was significantly lower in patients than controls. RBC count, hemoglobin, and hematocrit were also significantly reduced, indicating a clear anemic profile among patients. Platelet count was markedly lower in the patient group, reflecting severe impairment of megakaryocytic activity. Red-cell indices, including MCV, MCH, and MCHC, were significantly lower in patients compared with controls. Neutrophil percentage and eosinophil percentage were significantly reduced, while lymphocyte percentage was significantly increased in patients. Monocyte and basophil percentages did not show significant differences between the two groups.

Table 2. Hematological markers between acute leukemia patients and controls

Variable	Patients Mean ± SD	Control Mean ± SD	Patients Median (IQR)	Control Median (IQR)	P-value
WBC	3.02 ± 8.03	6.82 ± 1.40	1.81 (0.49 - 2.46)	6.80 (5.83-8.22)	<0.01
RBC	2.98 ± 0.68	5.00 ± 0.44	2.80 (2.44 - 3.49)	4.97 (4.72-5.30)	<0.01
Platelets	50.31 ± 32.67	278.75 ± 73.71	41.50 (25.00-65.50)	293.50 (216.25-315.25)	<0.01
Hb (g/dL)	8.18 ± 1.68	12.84 ± 1.42	7.85 (6.88 - 9.12)	12.75 (11.78 - 13.62)	<0.01
HCT (%)	25.13 ± 4.81	43.30 ± 3.35	24.80 (20.45-27.94)	43.65 (40.55 - 46.62)	<0.01
MCV (fL)	78.19 ± 1.79	87.09 ± 4.01	78.40 (76.88-79.10)	86.75 (83.67 - 90.35)	<0.01
MCH (pg)	28.18 ± 1.74	30.11 ± 1.75	27.90 (27.20-29.30)	30.20 (28.77 - 31.35)	<0.01
MCHC (g/dL)	32.88 ± 1.54	34.31 ± 1.00	32.60 (32.08-34.17)	34.35 (33.72 - 35.20)	<0.01
Neutrophils %	21.63 ± 6.20	56.35 ± 5.08	21.60 (16.40-26.42)	56.20 (53.65 - 59.75)	<0.01
Lymphocytes %	69.20 ± 11.08	33.10 ± 4.85	71.15 (66.12-75.78)	34.70 (30.25 - 35.97)	<0.01
Eosinophils %	1.62 ± 0.93	3.78 ± 1.80	1.70 (0.97 - 2.20)	3.40 (2.00-5.28)	<0.01
Monocytes %	4.86 ± 1.53	5.60 ± 2.41	4.85 (3.58 - 6.15)	5.65 (3.80-7.10)	0.194
Basophils %	1.22 ± 0.66	1.17 ± 0.72	1.30 (0.67 - 1.52)	1.10 (0.90-1.80)	0.737

Hematological markers according to sex among patients

Comparison of hematological markers according to sex showed that most variables did not differ significantly between male and female patients. WBC, RBC, Hb, HCT, MCV, MCH, platelet count, neutrophils, lymphocytes, monocytes, eosinophils, and basophils were comparable between both sexes. The only significant difference was observed in MCHC, which was higher in males than females.

Table 3. Hematological markers in acute leukemia patients according to sex

Hematological marker	Male Median (IQR)	Female Median (IQR)	P-value
WBC (10^9/L)	1.65 (0.55-2.37)	2.37 (0.49-2.63)	0.475
RBC (10^12/L)	2.75 (2.44-3.44)	3.16 (2.51-3.65)	0.668
Hb (g/dL)	7.85 (6.97-9.12)	8.05 (6.45-9.15)	0.677
HCT (%)	24.15 (20.18-28.12)	26.35 (23.12-27.60)	0.721
MCV (fL)	78.40 (76.88-79.53)	78.45 (76.97-78.90)	0.512
MCH (pg)	27.90 (27.27-29.35)	28.40 (27.18-29.00)	0.971
MCHC (g/dL)	32.85 (32.25-34.52)	31.40 (30.53-32.23)	0.002
PLT (10^9/L)	38.50 (23.75-60.25)	65.00 (32.25-83.50)	0.143
Neutrophils %	21.10 (16.40-26.42)	22.40 (16.85-26.42)	0.868
Lymphocytes %	71.55 (66.58-74.65)	68.80 (65.28-77.02)	0.634
Monocytes %	4.55 (3.45-6.15)	5.35 (4.07-6.17)	0.365
Eosinophils %	1.55 (0.78-2.20)	1.75 (1.35-2.35)	0.262
Basophils %	1.30 (0.90-1.62)	1.15 (0.45-1.32)	0.107

Hematological markers according to leukemia subtype

When patients were compared according to diagnosis, AML cases showed significantly higher WBC count than ALL cases. Platelet count was also significantly higher in AML compared with ALL. No significant differences were observed between AML and ALL in RBC count, Hb, HCT, MCV, MCH, MCHC, neutrophils, lymphocytes, monocytes, eosinophils, or basophils.

Table 4. Hematological markers in acute leukemia patients according to diagnosis

Marker	AML Median (IQR)	ALL Median (IQR)	P-value
WBC (10^9/L)	2.30 (1.33-2.65)	0.90 (0.19-1.86)	0.010
RBC (10^12/L)	2.81 (2.48-3.55)	2.80 (2.42-3.45)	0.908
Hb (g/dL)	7.85 (7.07-9.03)	7.75 (6.47-9.83)	0.660
HCT (%)	26.20 (23.25-28.17)	22.25 (19.77-27.38)	0.100
MCV (fL)	78.40 (76.90-78.93)	78.65 (76.72-79.70)	0.572
MCH (pg)	28.35 (27.27-29.32)	27.55 (26.98-28.43)	0.194
MCHC (g/dL)	32.65 (32.10-34.17)	32.50 (31.45-34.12)	0.346
PLT (10^9/L)	57.50 (36.50-74.75)	25.50 (19.75-39.75)	0.003
Neutrophils %	21.60 (17.23-27.25)	20.85 (16.40-25.97)	0.699
Lymphocytes %	71.30 (66.12-76.15)	70.45 (66.68-73.30)	0.843
Monocytes %	4.40 (3.30-5.88)	5.55 (4.13-6.30)	0.067
Eosinophils %	1.65 (1.08-2.25)	1.45 (0.50-2.20)	0.917
Basophils %	1.30 (0.78-1.60)	1.15 (0.88-1.48)	0.248

Hematological markers according to age category

Age-based comparison showed a significant difference only in hemoglobin concentration. The highest median Hb level was observed in patients younger than 18 years, while lower values were observed in adult and older age groups. Other hematological parameters, including WBC, RBC, HCT, MCV, MCH, MCHC, platelet count, and differential leukocyte percentages, did not differ significantly across age categories.

Table 5. Hematological markers in acute leukemia patients according to age category

Marker	<18 Median (IQR)	18-39 Median (IQR)	>=40 Median (IQR)	P-value
WBC	1.48 (1.01-2.08)	1.60 (0.51-2.45)	2.30 (0.41-2.56)	0.866
RBC	2.75 (2.25-3.36)	2.75 (2.52-3.62)	2.92 (2.48-3.40)	0.793
Hb	9.20 (8.32-10.25)	7.80 (7.03-9.07)	7.00 (6.65-8.50)	0.025
HCT	27.25 (23.68-29.07)	23.90 (20.77-28.05)	23.45 (19.80-27.50)	0.255
MCV	79.20 (77.72-80.03)	78.50 (77.00-79.07)	78.30 (76.43-78.70)	0.295
MCH	28.20 (27.27-29.50)	28.35 (27.23-29.23)	27.50 (27.15-28.53)	0.596
MCHC	32.70 (31.88-34.12)	32.80 (32.15-34.55)	32.30 (32.02-32.85)	0.528
PLT	37.00 (25.75-65.75)	44.00 (25.50-65.00)	37.50 (23.75-65.50)	0.851
Neutrophils %	22.05 (14.75-27.75)	20.00 (14.75-26.12)	22.00 (20.55-25.02)	0.539
Lymphocytes %	71.40 (66.60-77.08)	71.95 (65.42-76.75)	70.90 (66.33-71.88)	0.680
Monocytes %	4.45 (3.35-6.15)	5.20 (4.58-6.07)	4.30 (3.35-6.20)	0.371
Eosinophils %	1.75 (0.97-2.45)	1.45 (0.72-2.12)	1.75 (1.25-2.18)	0.656
Basophils %	1.15 (0.40-1.82)	1.30 (0.75-1.50)	1.30 (1.02-1.40)	0.921

4. DISCUSSION

The present study demonstrated a clear hematological disturbance among patients with acute leukemia compared with healthy controls. The most prominent findings were reduced RBC count, hemoglobin, hematocrit, platelet count, WBC count, neutrophil percentage, and eosinophil percentage, together with increased lymphocyte percentage. This pattern reflects the central biological process of acute leukemia: expansion of

malignant blasts within the bone marrow and suppression of normal hematopoiesis. As normal erythroid, myeloid, and megakaryocytic lineages are displaced, patients commonly develop anemia, thrombocytopenia, and variable leukocyte abnormalities. This interpretation agrees with the established marrow-failure phenotype described in AML and ALL clinical reviews and diagnostic recommendations [27][28][29].

The significant decrease in RBC count, Hb, and HCT agrees with previous studies showing anemia as one of the most frequent findings at diagnosis in acute leukemia. Jaime-Pérez et al. reported that anemia was common among children with newly diagnosed ALL, while Shuchismita et al. described anemia as a major hematological abnormality across acute leukemia cases. Similar patterns are biologically plausible because both myeloid and lymphoid leukemic blasts interfere with erythroid maturation, and genomic studies show that the underlying disease biology is highly heterogeneous even when the final peripheral-blood phenotype appears similar. In the current cohort, the median Hb level was markedly reduced compared with controls, supporting the view that ineffective erythropoiesis is a major feature of acute leukemia.

Thrombocytopenia was another dominant finding in the current study. Platelet count was substantially lower in patients than controls, indicating severe disruption of megakaryocyte production. This agrees with Jaime-Pérez et al., who reported frequent thrombocytopenia in childhood ALL, and with Khalid et al., who observed reduced platelet count in children with B-cell ALL. Platelet reduction is also clinically important because hemorrhagic complications remain a serious early risk in acute leukemia, especially in highly aggressive or coagulopathic presentations.

The significant reduction in WBC count in the patient group deserves careful interpretation. Many acute leukemia cases present with leukocytosis, particularly when blasts are released into the peripheral blood. However, leukopenic or low-WBC presentations are also well recognized. Jaime-Pérez et al. emphasized the heterogeneity of WBC findings in ALL, where patients may present with low, normal, or high leukocyte counts. Reports comparing AML and ALL also show that myelosuppression patterns and leukocyte counts are variable rather than uniform across acute leukemia subtypes. Therefore, the reduced WBC count in the present study may reflect severe marrow suppression, low peripheral blast spillover, early sampling before leukocytosis develops, or differences in the distribution of leukemia subtypes.

The marked reduction in neutrophil percentage among patients is clinically meaningful because neutrophil depletion and dysfunction increase susceptibility to bacterial and fungal infections. In acute leukemia, infection risk is not determined only by total WBC count, since circulating leukemic cells do not provide effective immune protection. The relative increase in lymphocyte percentage may partly reflect lymphoblast predominance in ALL cases or a relative change caused by the marked decrease in neutrophils. In this setting, automated differential results should be interpreted with peripheral smear and bone marrow morphology because blast cells may influence leukocyte classification.

The reductions in MCV, MCH, and MCHC suggest that red-cell indices were also affected. Although leukemia-related anemia is often normocytic, lower indices may occur due to iron-restricted erythropoiesis, inflammation, nutritional deficiency, chronic bleeding, or mixed anemia. This finding may be particularly relevant in populations where iron deficiency or nutritional anemia is common. However, red-cell indices in acute leukemia should not be interpreted in isolation, because marrow infiltration and systemic inflammation can modify erythrocyte production and hemoglobinization.

Sex-based analysis showed that most hematological markers were not significantly different between male and female patients. Only MCHC was significantly higher in males. In healthy populations, sex-related variation in RBC parameters, Hb, HCT, and red-cell indices is expected because of hormonal effects, body composition, and menstrual blood loss in females. In the present study, however, these ordinary sex differences were largely masked, likely because leukemic marrow failure had a stronger effect than biological sex. This does not exclude sex-related biological differences in leukemia outcomes, but it suggests that CBC abnormalities at presentation may be dominated by marrow infiltration in small mixed cohorts.

Diagnosis-based comparison showed that AML patients had significantly higher WBC and platelet counts than ALL patients. This finding suggests that the ALL subgroup in the current cohort had more pronounced leukopenia and thrombocytopenia. Previous studies have shown that CBC patterns differ between acute leukemia subtypes, but these differences are not consistent enough to establish diagnosis without marrow and immunophenotypic confirmation. Chen et al. reported differences in myelosuppression patterns between AML and ALL, while Jaime-Pérez et al. and Khalid et al. demonstrated that ALL commonly presents with thrombocytopenia and anemia. Therefore, the lower platelet count observed in ALL patients in the current study may reflect greater suppression of megakaryopoiesis by lymphoblast infiltration or differences in disease stage at presentation.

The absence of significant AML/ALL differences in Hb, RBC, HCT, red-cell indices, and most differential leukocyte percentages suggests that both subtypes shared a common marrow-failure phenotype. This is expected because AML and ALL, despite different cell lineage origins, both impair normal hematopoietic activity through blast expansion. Therefore, peripheral blood markers may support clinical suspicion and risk assessment, but they cannot reliably replace flow cytometry, cytogenetic testing, or molecular classification, which remain central to current AML and ALL diagnostic frameworks.

Age-based comparison revealed a significant difference only in hemoglobin level. Patients aged younger than 18 years had higher Hb values than adult and older patients. This may indicate more severe anemia among older patients, possibly due to reduced marrow reserve, higher frequency of AML, chronic inflammation, nutritional deficiency, renal impairment, or delayed diagnosis. Global and regional burden studies show that AML incidence rises with age, while ALL is proportionally more common in children and adolescents. Older AML patients also show more complex clinical risk profiles, and baseline anemia can contribute to worse tolerance of therapy. The lack of significant differences in WBC, platelets, and differential leukocyte percentages across age categories suggests that leukemic marrow involvement can produce comparable cytopenic patterns regardless of age, while anemia severity may be more sensitive to age-related physiological and clinical factors.

The current study has several strengths. Blood samples were collected from newly diagnosed patients before chemotherapy, reducing the influence of treatment-induced cytopenias. The inclusion of both AML and ALL cases allowed subtype-based comparison. The use of an automated hematology analyzer improved analytical consistency. However, some limitations should be acknowledged. The sample size was relatively small, especially after stratification by sex, age, and diagnosis. The study included both pediatric and adult patients, which increases biological heterogeneity. The absence of blast percentage, cytogenetic risk, molecular subtype, transfusion history, and nutritional markers limits deeper interpretation of hematological variation. Future studies should include larger cohorts, peripheral smear blast quantification, bone marrow blast percentage, molecular classification, and diagnostic performance analyses such as ROC curves and multivariable models.

5. CONCLUSION

Acute leukemia Patients in comparison to respective healthy controls showed statistically significant marked hematological derangements (p0.05), when compared to the respective controls e.g. WBC, RBC, platelet count, Hb, HCT, MCV,MCH,MCHC,neutrophils and eosinophils in acute leucemia discharged patients and control but significant rise percentage of lymphocyte compared with controls which was also found statistically highly significant $p<0.001$. MCHC was different according to sex ($p = 0.03$), WBC and platelet count were different according to AML/ALL diagnosis alone (p Conclusion: Hematology parameters vary from healthy values based on cancer type, age, and sex. Conclusions: The results support the potential utility of CBC as a quick, inexpensive and clinically-relevant tool for an initial assessment in cases of acute leukemia. Nevertheless, CBC findings must be regarded as suggestive but not replacing studies that address bone marrow examination or flow cytometry and molecular classification.

Recommendations

Future work should assess the diagnostic performance of hematological markers using ROC curve analysis and multivariable logistic regression. Stratification by bone marrow blast percentage, immunophenotype, cytogenetic risk, and molecular subtype would strengthen the clinical interpretation of CBC patterns in acute leukemia. Larger multicenter studies are also recommended to determine whether WBC and platelet count can contribute meaningfully to early AML/ALL differentiation in local clinical settings.

Ethical Considerations

Ethical approval details and institutional review board number should be inserted before journal submission. Informed consent should also be clearly documented according to the requirements of the target journal.

Funding

This study did not receive external financial support.

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