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Evaluation of Hematological Parameters as Predictors of Disease Severity in Patients with Hematological Cancers: A Cross-Sectional Study from a Private Hospital in Baghdad City

Mustafa A.K ALTaie

Department of Biology, College of sciences, University of Baghdad, Baghdad, Iraq
Email: mustafa.altaie@sc.uobaghdad.edu.iq
ORCID: 0009-0001-6782-9652

ABSTRACT:

Background: Hematological malignancies, i.e., leukemias, lymphomas, and multiple myeloma, are known to cause significant abnormalities in the numbers of blood cells found in peripheral blood. Several parameters derived from complete blood counts (CBCs) have been proposed as inexpensive, readily available biomarkers of prognostic significance and disease severity, including the neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), and mean platelet volume (MPV).

Objective: To investigate whether or not there is a relationship between baseline hematological indices (i.e.,hemoglobin, total white blood cell count, absolute neutrophil count, absolute lymphocyte count, platelet count, NLR, PLR, MPV) and the clinical severity of hematological malignancies in patients who had been recently diagnosed with a hematologic malignancy and were attending a private hospital in Baghdad.

Methods: This was a descriptive cross-sectional study that included 110 patients newly diagnosed with hematological malignancies (i.e., acute leukemia, chronic leukemia, non-Hodgkin lymphoma, Hodgkin lymphoma, and multiple myeloma) who were evaluated by ahematologist/oncologist at a private hospital between March 2024 and February 2025. Each patient's disease severity was classified as mild/moderate or severe according to the clinical and laboratory staging criteria established for their specific hematological malignancy. Each patient provided a venous blood sample, which was prepared and analyzed with an automated hematologyanalyzer. Statistical comparison of hematological indices between disease severity groups was conducted using either the independent-samples t-test or the Mann-Whitney U test. Receiver operating characteristic (ROC) analysis was used to assess the strength of the relationship between patients' hematological indices and disease severity.

Results: Of the 110 patients, 46 (41.8 percent) had severe disease. The severity groups differed significantly with respect to hematological parameters, with patients with a severe disease exhibiting significantly lower hemoglobin (8.6 ± 1.9 g/dL vs. 11.2 ± 2.1 g/dL, $p < 0.001$), lower lymphocyte counts, and significantly higher NLR (6.8 ± 3.4 vs. 3.1 ± 1.6, $p < 0.001$) and PLR (215 ± 88 vs. 142 ± 61, $p < 0.001$) compared to patients with a mild or moderate disease. Patients with a severe disease exhibited significantly lower platelet counts (98 ± 62 × 10^9/L vs. 186 ± 84 × 10^9/L, $p < 0.001$). The NLR had the highest area under the ROC curve (0.81) for identifying patients with severe disease compared with those with mild or moderate disease. The second best predictor was hemoglobin (0.78), followed by PLR (0.74).

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Conclusion: Simple, inexpensive hematological parameters, especially NLR, hemoglobin, and PLR, show a significant correlation with the severity of hematological malignancies and may serve as adjunctive tools for risk-stratifying patients in resource-constrained clinical settings, such as a private hospital in Baghdad.

INTRODUCTION

Hematologic cancers are a diverse group of malignant diseases originating from the tissues of the lymphatic system, blood, or bone marrow, includingleukemia, lymphoma, and multiple myeloma [1]. These cancers account for approximately 6-8% of all newly diagnosed cancers globally, and they contribute greatly to the overall morbidity and mortality associated with cancer, particularly in low- and middle-income countries where access to advanced diagnostic tests and risk stratification may be limited [2,3]. In Iraq, hematological malignancies comprise a considerable amount of registered cancer cases, especially acute leukemia and non-Hodgkin lymphoma, and there have been several local studies that have noted an upward trend in incidence over the last two decades, which may be due to various environmental factors, infectious agents, or improved diagnostic capabilities [4,5].

Hematological malignancies are heterogeneous diseases that can present with very different clinical courses, ranging from indolent diseases that can be managed with close observation to aggressive diseases that require intensive therapy due to the need for immediate intervention [6]. Therefore, hematological malignancies must be evaluated accurately and early to guide treatment options, predict therapeutic response, anticipate complications such as tumor lysis syndrome or febrile neutropenia, and counsel patients and their families regarding prognosis [7]. Historically, the severity of disease (prognosis) in hematological malignancies has typically been assessed by clinical staging, cytogenetic and/or molecular markers, bone marrow morphology, and imaging studies [8].The cost, complexity, and demands of using specialized laboratories, and the lack of accessibility in many health care settings (especially in private hospitals in developing countries, where such advanced testing is limited), have resulted in many prognostic tools being inaccessible to practitioners in these areas. [9].

CBCs are an inexpensive, rapid, and widely available test performed in nearly all laboratories worldwide to assess disease extent in patients with hematological malignancies. CBCs can be performed as routine tests for new patients at nearly every clinic or outpatient facility that serves patients with suspected hematologic malignancies. [10]. In addition to providing diagnostic data, CBCs provide considerable quantitative information on the extent of marrow invasion by malignant cells, the balance between normal and malignant hematopoiesis in the patient, and the inflammatory and immune response (or lack thereof) to their malignancy.

Anemia is a prominent finding in individuals with extensive bone marrow involvement by malignant cells and is associated with later-stage disease or poor prognosis across many hematological malignancies, including multiple myeloma, chronic lymphocytic leukemia, and acute leukemia [12,13]. The presence of thrombocytopenia at diagnosis suggests both failings in hematopoietic function of the bone marrow and consumption of platelets due to disease processes in the patient; both of these present at the time of diagnosis reflect a higher tumor burden in the patient and significantly reduced survival among patients when evaluating large cohorts of patients with hematological malignancies. [14,15].

In recent years, derived indices that combine the output from various blood cell lineages (particularly neutrophils and lymphocytes) have been investigated, and potential associations have been defined (particularly NLR and PLR) [16]. These derived indices purportedly represent the balance between the systemic inflammatory response to malignant processes (as evidenced by elevations in neutrophil and/or platelet production) and the anti-tumor immune response (as evidenced by decreased lymphocyte counts) in an individual with malignant disease [17].Templeton and colleagues conducted a groundbreaking meta-analysis that found a direct association between an elevated neutrophil-to-lymphocyte ratio (NLR) and poorer overall survival among patients with a range of solid tumors. As seen in the review by Templeton et al., subsequent studies have confirmed this association among people with hematological malignancies [18]. People with diffuse large B-cell lymphoma had an increased NLR at diagnosis. They were more likely to be diagnosed at a higher Ann Arbor stage, as they had higher International Prognostic Index scores, and had a poorer overall and progression-free survival compared to those with a normal NLR. Similarly, NLRs and PLRs have been correlated with the International Staging System stage and the presence of high-risk cytogenetic abnormalities in multiple myeloma [19].

An additional hematological variable, MPV, has also been studied as a biomarker in hematological malignancies. MPV is a routinely generated parameter from automated hematologyanalyzers and indicates megakaryocyte function and platelet turnover [20-23]. Disrupted megakaryocyte function or platelet turnover can result from bone marrow infiltration by leukemic blasts or lymphoma cells. Several studies have documented significantly lower MPV values in patients with acute leukemia than in healthy controls, and this trend has held for patients with higher percentages of leukemic/blast cells and greater bone marrow infiltration at diagnosis [24-26]. By contrast, abnormalities in MPV and platelet size distribution have been associated with thrombotic risk and disease stage among people with chronic myeloproliferative neoplasms [27].Although many studies worldwide show that CBC-derived parameters are useful for prognostic purposes in patients with blood cancer, very few studies from Iraq — specifically from private hospitals in Baghdad — have been published [28,29]. Private hospitals in Baghdad are an important source of healthcare for patients with hematological malignancies, as they often provide initial workup and referrals to public oncology centers for chemotherapy [30]. If it is determined that simple, locally available CBC parameters can reliably assess disease severity in this patient population, there could be significant benefits for clinicians in resource-limited settings. By better triaging patients in resource-limited clinics, clinicians will be able to more easily identify patients requiring urgent referrals to a public oncology center or supportive care (e.g., transfusion) and provide a preliminary prognosis until definitive evaluations can occur [31,32].

The use of locally derived reference data is especially important because the parameters measured in the CBC can be affected by factors such as genetics, nutrition, the presence of infections such as malaria and tuberculosis, and the prevalence of hemoglobinopathies – all of which can differ between populations [33,34]. Studies conducted in neighboring Middle Eastern countries have found that patients with leukemia and lymphoma, compared with those in Western countries, have slightly different baseline CBC parameters, including hemoglobin level, White Blood Cell Differential (WBC) Count, and platelet indices. This indicates that each country should establish its own reference ranges for each CBC parameter [35,36].

Several Iraqi studies have examined the effects of various hematological parameters on certain malignancies (e.g., the relationship between anemia and disease stage in patients with chronic lymphocytic leukemia, or between leukocyte counts and risk group stratification in patients with acute lymphoblastic leukemia) [37,38]. To our knowledge, however, there have been no studies conducted in a private hospital setting in Baghdad that have examined a larger number of routine and derived hematological parameters (including NLR, PLR, and MPV) regarding their relationship with a standardized definition of disease severity across several categories of hematological malignancies [39,40].

The purpose of this study is to examine the relationship between baseline hematological parameters (hemoglobin concentration, total (or absolute) white blood cell count, absolute/valid neutrophil count, absolute/valid lymphocyte count, platelet count, NLR, PLR, and MPV) and clinical disease severity in newly diagnosed hematological malignancies from patients presenting to a private hospital in Baghdad. Additionally, we will evaluate which of these parameters best discriminates between patients with severe disease, to support the use of these CBC-derived parameters as practical, readily obtainable methods for identifying patients at higher risk of serious illness at the time of diagnosis in similar clinical settings.

METHODOLOGY

The research was designed as an observational lens through which patients at a private hospital in Baghdad who presented for evaluation due to concern for having a hematologic malignancy would be descriptively analyzed using both laboratory results and health care provider recommendations for the treatment of hematologic malignancies. The principal participant in the project was a patient with malignant hematologic disease. Eligible participants were screened for participation over a 12-month period, from March, 24, 2024, to February 26, 2025. In this hospital, the participants were supported by diagnostically comprehensive services, including: complete blood count analyses via automated methods; peripheral film reading via automated and manual methods; bone marrow aspiration and biopsy; flow cytometry immunophenotyping via referral laboratories; and minimal imaging resources. The medical records of these participants are used in the study to create a clinical history of each participant's hematologic process, treatment recommendations, and outcomes after treatment.

Initially, 130 patients with clinical suspicion of hematologic malignancies were considered eligible for the study (which was cohort-based); however, 20 patients (15%) were subsequently excluded from the final sample based on the criteria above, yielding a final sample size of 110 patients. Sample size calculations were determined by using one-sample proportion calculation (p-hat) to estimate proportionate prevalence of patients with severe disease represented to the study site over the twelve month study period based on previous studies suggesting prevalence of 40%, 95% confidence level of one estimated will be +/-9%

on a variable base, and the +/- result was increased to 110 patients for confounding invalidity due to variable patient demographic displacement. Consequently, the variable demographic displacement could have mediated the fact that these would have been normal variables (based solely on normal demographics) for the study sample of 110. Remember that for this study, patients who completed evaluations as part of their MDC between May 15 and Oct 31 of each year were used (i.e., only building attractions during this period) to validate that any patient who sought out the physician for similar reasons was considered as a potential/incapable candidate for this study.To be included in this trial, patients had to be male or female, have a diagnosis of the following acute or chronic leukemias: acute myeloid leukemia (AML); acute lymphoblastic leukemia (ALL); chronic myeloid leukemia (CML); chronic lymphocytic leukaemia (CLL); either hodgkin's lymphoma or non-hodgkin's lymphoma; multiple myeloma, confirmed with peripheral blood and bone marrow testing, based on histology/ pathology; and immunophenotyping when available. To qualify for the trial, patients must not have received chemotherapy, corticosteroids, or blood products via transfusion before the baseline complete blood count (CBC) to reduce confounding of hematological measures by prior treatments.

To be excluded from the trial: if patients had previously been diagnosed with a solid malignancy; had an active, uncontrolled infection requiring intensive care at the time of diagnosis; had chronic kidney disease (stage IV or V); had liver disease that hadn't compensated; if pregnant; or had a family history of hematologic disorders like thalassemia major or hereditary spherocytosis would also be excluded because these diagnosis independently modify CBC parameters. From the final analysis, patients with incomplete clinical documentation (e.g., missing baseline CBC data) were excluded.

Using a structured data collection format, demographic data for all eligible patients (e.g., age, sex), the exact type of hematological malignancy they have, as well as selected clinical characteristics of patients, such as presenting signs/symptoms (B symptoms = fever, night sweats, and/or weight loss), organomegaly, and lymphadenopathy, were documented. Stages of disease-related systems were retrieved from medical records (e.g., Revised International Staging System for multiple myeloma; Ann Arbor Staging with B-symptom status for Hodgkin and Non-Hodgkin lymphoma, Rai or Binet Staging for chronic lymphocytic leukemia; standard risk stratification for acute... Continue reading the full story.

Definition of disease severity: For this study, hospitalized patients were divided into two disease-severity groups: mild-to-moderateand severe. To classify patient disease severity, composite definitions of disease staging criteria and objective clinical measures of acute decompensation were used. Patients with severe disease at presentation met one of the following definitions (for presentations): R-ISS stage III; Ann Arbor stage III or IV with B Symptom status; Rai stage III or IV or Binet stage C; high risk cytogenetic or leukocyte based risk with lots of Leila; lot of Leila with either extramedullary disease present at diagnosis; Hmgb<8 g/dL at diagnosis with Tx; Plt<30 x 10^9/L and... Continue reading full story) and... all others were admitted to ICU or HDU within 48 hours of diagnosis.All patients in the study were classified as having mild-to-moderate disease severity. The verification of each patient's level-of-severity diagnosis was completed independently by two consultant hematologists, and any discrepancies were resolved by consensus.

Laboratory Testing: Venous blood samples were collected from all patients at the time of their initial diagnostic evaluation, before any chemotherapy, corticosteroids, or blood products were administered. Each patient had a 3 mL venous sample collected in a vacuum tube containing dipotassium ethylenediamine tetraacetic acid (K2-EDTA) as the anticoagulant. All blood samples were analyzed within two hours of collection using a five-part differential automated hematologyanalyzer (Sysmex XN-1000, Sysmex Corporation, Kobe, Japan), which underwent daily internal quality control using commercial control materials as per the manufacturer's recommendations. Each patient's blood sample was analyzed to obtain the following parameters: hemoglobin concentration (g/dL), total leukocyte count ($\times 10^9$/L), absolute neutrophil count ($\times 10^9$/L), absolute lymphocyte count ($\times 10^9$/L), platelet count ($\times 10^9$/L), and mean platelet volume (fL). All blood samples underwent manual peripheral blood film analysis by an experienced hematopathologist to confirm the differential count and exclude technical artifacts, especially in patients with very high leukocyte counts and significant numbers of circulating blasts, in which the manual differential count was used instead of the automated count when discrepancies were noted.Deriving values of certain factors: To compute the neutrophil-to-lymphocyte ratio (NLR), these two groups (neutrophils & lymphocytes) were divided into their respective categories based on the same patient's absolute count. The same methodology would apply to deriving the platelet-to-lymphocyte ratio (PLR) by dividing platelets by the patient's absolute lymphocyte count.

Statistical processing & analysis of results: Data was entered into an Excel spreadsheet and analyzed with the Statistical Package for the Social Sciences (SPSS) version 26.0 (IBM Corp). Normality of continuous variables was initially assessed with the Shapiro-Wilk test. Typically distributed continuous variable results were expressed & compared between severe and

mild/moderate groups via an independent-samples t-test, and non-normally distributed results were expressed as median and interquartile range, with comparisons made using a Mann-Whitney U test. Discrete categorical variables were expressed via frequencies and percentages, with comparisons made using either chi-square or Fisher's Exact Statistical tests as appropriate. Selected numerical and categorical variables were submitted for receiver operating characteristic (ROC) curve analysis to determine predictive ability for severe disease, with corresponding area under the curve (AUC) calculations & optimal cut-off values, sensitivity & specificity calculations, and the Youden index. For all analyses, statistically significant results were defined as $p < 0.05$.

Ethical approval: The study protocol received scientific ethics approval from the ethics committees of both hospitals before data collection. Before initiating data acquisition, participants signed written informed consent forms, which included a thorough explanation of the study objectives and methods to their guardians (if <18 years). An individual subject's confidentiality has been maintained through anonymization using numerical codes assigned to each participant and by storing all project-related data on a password-protected computer accessible only to the research study team. The study was conducted in accordance with the ethical principles defined in the Declaration of Helsinki.

RESULTS

In total, 110 patients diagnosed with hematological malignancies were enrolled in this final analysis. The study sample had an average (mean) age of 44.6 ± 16.2 years, with 63 (57.3%) male and 47 (42.7%) female patients. Of these 110 patients, 46 (41.8%) were classified as having severe disease using the established composite criteria developed before the analysis. The remaining 64 patients (58.2%) were classified as having mild-to-moderate disease. The demographic characteristics of the study population, stratified by disease severity and by each patient's diagnoses, are presented in Table 1.

Table 1. Demographic and diagnostic characteristics of the study population according to disease severity.

Variable	Mild-to-moderate (n=64)	Severe (n=46)	p-value
Age, years (mean ± SD)	42.1 ± 15.3	48.0 ± 16.8	0.058
Male sex, n (%)	34 (53.1)	29 (63.0)	0.292
Acute myeloid leukemia, n (%)	9 (14.1)	14 (30.4)	0.034
Acute lymphoblastic leukemia, n (%)	7 (10.9)	8 (17.4)	0.337
Chronic myeloid leukemia, n (%)	12 (18.8)	6 (13.0)	0.430
Chronic lymphocytic leukemia, n (%)	13 (20.3)	6 (13.0)	0.328
Non-Hodgkin lymphoma, n (%)	15 (23.4)	9 (19.6)	0.617
Hodgkin lymphoma, n (%)	5 (7.8)	1 (2.2)	0.262
Multiple myeloma, n (%)	3 (4.7)	2 (4.3)	1.000

Baseline hematological parameters for the two severity groups were compared in Table 2. Patients with a severe form of illness had significantly lower hemoglobin and platelet counts, and significantly lower absolute lymphocyte counts than patients with mild to moderate forms of illness. Conversely, patients in the severe illness category had significantly higher absolute neutrophil counts, neutrophil-to-lymphocyte ratios (NLRs), and platelet-to-lymphocyte ratios (PLRs) than those in the mild and moderate categories. There were more total leukocytes in patients classified as having severe disease, but this difference was not statistically significant. However, the sample mean platelet volume (MPV) was significantly lower than that of patients with mild to moderate disease.

Table 2. Comparison of baseline hematological parameters between mild-to-moderate and severe disease groups (mean ± standard deviation).

Parameter	Mild-to-moderate (n=64)	Severe (n=46)	p-value
Hemoglobin, g/dL	11.2 ± 2.1	8.6 ± 1.9	<0.001
Total leukocyte count, $\times 10^9$/L	18.4 ± 22.6	26.7 ± 31.4	0.112
Absolute neutrophil count, $\times 10^9$/L	6.1 ± 4.2	9.8 ± 6.7	0.001
Absolute lymphocyte count, $\times 10^9$/L	2.4 ± 1.3	1.6 ± 1.0	0.001
Platelet count, $\times 10^9$/L	186 ± 84	98 ± 62	<0.001
Mean platelet volume, fL	10.4 ± 1.2	9.3 ± 1.4	<0.001
Neutrophil-to-lymphocyte ratio	3.1 ± 1.6	6.8 ± 3.4	<0.001
Platelet-to-lymphocyte ratio	142 ± 61	215 ± 88	<0.001

To determine whether hemoglobin, NLR, PLR, platelet count, and/or MPV could distinguish mild/moderate disease from severe disease using ROC analysis, the area under the ROC curve (AUC), optimal cut-off, sensitivity, and specificity are provided in Table 3. NLR had the best discrimination (AUC=0.81), with hemoglobinsecond-best (AUC=0.78), platelet count third (AUC=0.76), PLR fourth (AUC=0.74), and MPV fifth (AUC=0.69). The NLR cut-off of >4.5 had a sensitivity of 76.1% and specificity of 73.4% for detecting severe disease.

Table 3. Receiver operating characteristic curve analysis of hematological parameters for prediction of severe disease.

Parameter	AUC (95% CI)	Cut-off	Sensitivity (%)	Specificity (%)
Neutrophil-to-lymphocyte ratio	0.81 (0.72-0.89)	>4.5	76.1	73.4
Hemoglobin, g/dL	0.78 (0.69-0.87)	≤9.5	73.9	70.3
Platelet count, $\times 10^9$/L	0.76 (0.66-0.85)	≤120	71.7	68.8
Platelet-to-lymphocyte ratio	0.74 (0.64-0.84)	>170	69.6	65.6
Mean platelet volume, fL	0.69 (0.58-0.79)	≤9.8	65.2	62.5

DISCUSSION

This research examined how specific types of blood tests can help determine how bad cancer is for 110 patients with blood cancers who went to a private hospital in Baghdad. This study found that patients with the most severe forms of the cancer had much lower levels of certain important blood cells than those with less severe forms. The lowest levels of red blood cells (hemoglobin), platelets, and a certain type of white blood cell (absolute lymphocyte count), the lower number of the largest white blood cells (mean platelet volume), and higher counts of specific types of white blood cells (absolute neutrophil), and higher ratios of neutrophils to lymphocytes (neutrophil-lymphocyte ratio), and platelets to lymphocytes (platelet-lymphocyte ratio) than patients with less serious forms of the disease. Of these blood tests, the neutrophil-lymphocyte ratio was the best indicator of disease severity, followed closely by hemoglobin.

The finding that low hemoglobin concentrations are associated with more severe disease has been reported in many other studies. A variety of things causes Aneia in blood cancers, including when cancerous cells take up space in the bone marrow, the production of red blood cells doesn't happen normally because of the effects of certain inflammatory substances made by the body when there is cancer, autoimmune destruction of red blood cells, and subdivision of the spleen (also known as hypersplenism) can all cause a person with blood cancer to have low hemoglobin levels [12]. In people with chronic lymphocytic leukemia, the presence of low hemoglobin levels is part of the criteria that define advanced stages of disease (Rai and Binet) and consistently determines how long a patient can live after being diagnosed with the disease [13]. Similarly, in patients with multiple myeloma, hemoglobin is included as a marker in several different prognostic scores since it reflects both the amount of normal red blood cells in the bone marrow and the effect of the inflammatory substances produced as a result of the disease on producing red blood cells in the bone marrow [12].Our discovery that individuals in our sample with a mean hemoglobin level of approximately 2.6 g/dL differ between severity classifications, along with the AUC score of 0.78 for the diagnosis of severe disease by use of hemoglobin as a biomarker, supports the use of this inexpensive, universally available parameter as the first indicator of disease burden among the members of this population.

The results support the use of thrombocytopenia as a strong predictor of severe disease in this population, with mean platelet levels in the severe disease group approximately half those in the non-severe disease group. This finding is consistent with previous studies demonstrating that thrombocytopenia at diagnosis is predictive of increased tumor burden, extensive bone marrow infiltration, and higher risk of bleeding in a variety of hematologic malignancies [14,15]. In acute leukemias, one large review has shown a direct relationship between severe thrombocytopenia present on the day of diagnosis and incidence of early hemorrhagic complications, and several risk models for predicting early mortality have included severe thrombocytopenia at diagnosis [14]. The large number of patients with acute myeloid leukemia who comprise a disproportionate percentage of the severe disease group likely contributed to these findings, as it is common for patients with acute myeloid leukemia to have markedly low platelet counts at diagnosis due to marrow replacement by leukemic blasts.

One of the most significant findings in this study was the very high correlation between elevated NLR values and severe disease, with the NLR demonstrating the highest AUC among all variables examined. This finding is consistent with the growing body of literature demonstrating an association between systemic inflammation, as assessed by relative neutrophilia and lymphopenia, and poor outcomes in patients with malignancies. Templeton and others undertook a comprehensive meta-analysis of studies involving over 40000 people with various forms of solid tumors. They found a clear correlation between an elevated NLR and poor overall survival. In addition to their investigation into solid tumors, they also provided a strong basis for investigating the NLR as an indicator of long-term prognosis for people suffering from hematological malignancies (19).

In diffuse large B-cell lymphoma, studies demonstrate that patients with an elevated baseline NLR are more likely to have advanced Ann Arbor stage, have higher International Prognostic Index scores, report B symptoms, and have bulky disease. That elevated NLR serves as an independent prognostic indicator for progression-free and overall survival (20,21).

The association between neutrophilia and tumor aggressiveness likely reflects neutrophils' ability to release substances such as pro-angiogenic factors, matrix metalloproteinases, and reactive oxygen species, which collectively enhance tumor angiogenesis and overall tumorgrowth. At the same time, the lymphopenic aspect of elevated NLR is associated with impaired anti-tumor immunity, in part due to low numbers of cytotoxic T cells and natural killer cells (17). Because NLR has an acceptable cut-off value of > 4.5 for identification of patients with severe disease, our results are comparable to other similar studies investigating the prognostic significance of NLR as an independent predictor of severe disease in both lymphoma and leukemia populations, in which cut-offs have been reported between 2.5 and 6.0 depending on the type of malignancy and outcome being studied (20,22).

Similar to the NLR, the PLR demonstrated a statistically significant correlation with severe disease in our patient population, with patients with severe disease having a higher PLR than those with non-severe disease (AUC 0.74). Furthermore, elevated PLR has been associated with advanced International Staging System stage and inferior survival in multiple myeloma, as well as with more advanced Clinical Staging System stages and poorer outcomes across various lymphoma subtypes (21,22).The association of relative thrombocytosis as a paraneoplastic inflammatory response caused by interleukin-6-inducedmegakaryopoiesis, along with lymphopenia that is a consequence of reduced immune surveillance, likely explains the prognostic value of PLR,like NLR [16,17]. Our cohort showed paradoxically that the severe disease members had lower absolute platelet counts compared to the mild cases, while they still had higher PLRs; the explanation for this apparent contradiction is

due to the much lower lymphocyte counts in the severe members compared to the lymphocyte counts in mild members (in the denominator of the ratio), even though the platelet counts are lower in the numerator.

The patients in our study with severe disease also had lower MPVs than those with mild disease; the group 1 patients had an average MPV approximately 1.1 fL lower than that of the group 2 patients. This is consistent with other studies showing that patients with acute leukemias have lower MPVs, particularly those with higher blast percentages and greater marrow infiltration, reflecting a lack of megakaryocyte maturation and an inability to produce a normal platelet count [25,26]. However, the ability of MPVs to discriminate between severe and mild disease was lower than the ability of the other variables evaluated in this study (AUC = 0.69); therefore, the use of MPV for the purpose of determining the overall severity of different hematologic malignancies (i.e., heterogeneous differences in diseases as determined by the marrow function) is probably not very helpful when evaluating patients from our study.In our investigation, the total leukocyte count was higher in the severe disease group than in the non-severe disease group. Still, the difference in the counts between these groups was not statistically significant because of the wide differences in leukocyte counts for patients with differing diagnoses (i.e., patients diagnosed with chronic myeloid leukaemia may have high leukocyte counts at all phases of the disease, and patients diagnosed with Aplastic-phase acute leukaemia may have low leukocyte counts; many patients diagnosed with lymphomas that have marrow infiltration may have low leukocyte counts as well). This variability in leukocyte counts likely diluted any relationship between the total leukocyte count and our composite measure of severity. It is consistent with other recent studies showing that total leukocyte counts are less reliable as markers of severity than leukocyte differential counts or ratios derived from them, when used in heterogeneous populations of patients with hematological malignancies [11].

About 41.8% of the participants in our research were considered to be experiencing severe disease, a percentage that falls within the range of other research conducted in this area, which ranges between 30-50%, based on the mix of cancers that are included and the criteria that are used to assess the severity of disease [28,29]. The proportion of participants who had an Acute Myeloid Leukaemia diagnosis and were experiencing severe disease (30.4%) was significantly higher than those diagnosed and experiencing mild-moderate disease (14.1%, p=0.034), which is consistent with the aggressive nature of this form of cancer; as Acute Myeloid Leukaemia will often cause high levels of cytopenia in patients, and those patients are at high risk for developing complications (e.g., tumour lysis syndrome or infections) in the early phases of this leukaemia [6,7].The relevance of our findings for clinical use in private hospitals in Baghdad and comparable resource-limited areas is highly significant. Our findings show that the CBC, as well as the derived NLR and PLR, can be collected in a short time and at minimal cost using standard equipment found in most private hospitals. This contrasts with other types of studies, such as cytogenetic, molecular, and immunophenotyping studies, which may require referral to a centralized laboratory and take days or weeks to return results [30][34]. CBC parameters collected at the time or before an initial visit could identify patients at a higher risk of developing a severe case of disease, which would allow for more timely referrals for specialized care, the early implementation of supportive measures like transfusions or prophylaxis for infection, and more informed counseling of patients and their families while waiting for the definitive staging [31][32].

Although the study's cross-sectional design has some limitations, we should recognize them. We cannot assess the relationship between baseline hematologic parameters and subsequent outcomes over time, such as treatment response, relapse, or survival, given the cross-sectional study design. We will need to conduct a longitudinal cohort study to clarify how broadly applicable these baseline parameters are to future outcomes. Secondly, the composite definition of disease severity we developed for this study has not been externally validated. Thus, it will be impossible to compare our composite definition of severity with other definitions used to measure disease severity in other studies. Furthermore, the mixed population of patients, comprised of patients diagnosed with multiple different hematologic malignancies that have various underlying characteristics, may have created inconsistencies between patients and the malignancy-specific associations that can be established; any subgroup analyses in this cohort with respect to distinct types of malignancies were limited by the number of samples available. Moreover, because this study was conducted at a single private hospital, the findings may be less generalizable to patients in public hospital settings, as they tend to differ in socioeconomic status, disease stage at first visit, and access to healthcare [33][34]. Lastly, while the automated hematology analyzer we used in this study has been adequately validated, a very high white blood cell count and the presence of several circulating blasts could cause an abnormal automated differential count. We attempted to reduce the risk of error with a visual review of the peripheral blood smear; therefore, while it is conceivable that this measurement error may remain, we are not able to fully rule it out [35].

Future studies should be prospective and multi-center studies with larger sample sizes, malignancy-specific subgroup analysis and longitudinal data that follow therapy outcome and survival of patients so that the prognostic value of these laboratory parameters, specifically NLR, PLR, hemoglobin and other hematologic parameters identified in this study, can be confirmed and refined to develop risk stratification algorithms that can help facilitate early clinical decision making among patients with hematological malignancies in private hospitals in Baghdad and throughout Iraq [36][37][38][39][40].

CONCLUSION

According to research performed on patients with blood cancer who were being treated in a private hospital in Baghdad (cross-sectional study), some hematological parameters, particularly neutrophil-to-lymphocyte ratio, hemoglobin level, platelet number, platelet-to-lymphocyte ratio, and mean platelet volume, were significantly correlated with the clinical severity of the disease. The neutrophil-to-lymphocyte ratio had the best overall ability to differentiate between patients with severe disease and those without. These parameters can serve as practical, inexpensive supplemental tools for identifying patients with blood cancers who are at risk of developing severe disease in private hospitals and other resource-poor settings due to their availability, cost, and quick turnaround, but this needs to be confirmed in studies with a larger number of patients conducted over longer periods of time.

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