Original Article

Correlation of Automated Hematology Analyzer Parameters with Peripheral Blood Smear Findings

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Abstract

Background: The automated hematology analyzer has been widely used in modern hematology laboratories with rapid and accurate complete blood count results, making it an indispensable instrument for hematology laboratories. Nevertheless, peripheral blood smear (PBS) examination is still the standard of reference for blood cell morphology and confirmation of abnormal analyzer results. The objective is to test against the correlation of the parameter values obtained from automated hematology analyzer and peripheral blood smear. **Material and Methods:** This was prospective observational crosssectional study of 100 samples of EDTA blood analysed with fully automated 5 part differential hematology analyzer. Hematological parameters were recorded and instrument generated abnormal flags. Peripheral blood smears were made by the wedge smear method, stained with Leishman stain and analyzed under a microscope. The peripheral smear morphology was correlated with the results obtained from the automated analyzer with suitable statistical analysis. **Results:** The most common result was: Most respondents were male (58%). The most common analyzer abnormalities were low hemoglobin (44%), elevated RDW (36%), abnormal leukocytes (32%, and abnormal platelets (27%). The overall rate of confirmation of low hemoglobin cases which showed microcytic hypochromic morphology was 90.9% in peripheral smear examination, while for raised RDW cases with anisocytosis, the rate of confirmation was 94.4% and for immature cell flags with immature myeloid cell the rate of confirmation was 88.9%. The automated analyzer achieved a sensitivity of 91%, specificity of 88%, positive predictive value of 89.2%, negative predictive value of 90% and an overall diagnostic accuracy of 89.5%. There were statistically significant correlations between parameters measured by the automated analyzer and peripheral smear parameters ($p<0.05$). **Conclusion:** Automated hematology analyzers are found to highly correlate with peripheral smear examination and can be used in routine hematology labs as good screening tools. However, peripheral blood smear analysis will still be essential for checking signs of abnormal flags generated by the analyzer and for assessing morphologic anomalies. Automotive analysis and microscopic examination go hand-in-hand which means that it is a massive improvement in diagnostic accuracy and quality of patient care.

Keywords: Automated haematology analyser, peripheral blood smear, complete blood count, red cell morphology, flags on the analyser, haematology.

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Introduction

Complete blood count (CBC) is one of the most common laboratory tests ordered, and is a significant tool in the diagnosis and monitoring of haematological disorders as well as systemic disorders. The modern automatic hematology analyzers measure hematological parameters such as red blood cell indices, white blood cell differentials, platelet parameters, and various cell population parameters, and do so rapidly, precisely and reproducibly. The use of these analyzers has significantly raised the efficiency of the laboratories, and decreased the man power involved, without compromising analytical accuracy.[1,2]

However, although the technology has advanced, automated analyzers are unable to detect certain things such as abnormal cellular morphology, immature cells, atypical lymphocytes, blast cells, platelet clumping, and fragmented red blood cells. Although the automated instruments are a great aid in the morphological analysis of blood cells, Peripheral blood smear (PBS) examination is the gold standard and provides significant diagnostic information that is not available on an automated instrument only in certain cases. In conclusion, manual smear review remains an essential component of the management of abnormal analyser flags and for a correct hematological diagnosis to be made.[3,4]

Routine practice in clinical hematology has made correlation with peripheral blood smear findings more and more important in relation to the parameters measured by automated hematology analyzers. When combined with the microscope, the appropriate

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use of analyzer generated flags further aids in increasing the diagnostic accuracy, decreasing unnecessary smear reviews and improving laboratory quality assurance. To provide the best patient care and provide efficient laboratory use, the International Council for Standardization in Haematology (ICSH) has provided recommendations on criteria for peripheral smear examination when the results of automated analyzers are abnormal.[5-7] Hence, the present study was undertaken to evaluate the correlation between automated hematology analyzer parameters and peripheral blood smear findings and to assess the diagnostic utility of automated analyzer abnormalities in predicting significant peripheral smear changes.

Materials and Methods

Study Design: This was a hospital-based prospective observational cross-sectional study designed to evaluate the correlation between automated hematology analyzer parameters and peripheral blood smear findings.

Study Setting: The study was conducted in the Department of Pathology (Central Clinical Laboratory) of a tertiary care teaching hospital.

Study Duration: The study was carried out over a period of 12 months after obtaining approval from the Institutional Ethics Committee.

Study Population: The study included patients whose blood samples were submitted to the clinical laboratory for complete blood count (CBC) analysis and peripheral blood smear examination.

Sample Size: A total of 100 blood samples were included in the study.

Sampling Technique: Consecutive eligible blood samples fulfilling the inclusion criteria during the study period were enrolled until the required sample size of 100 was achieved.

Inclusion Criteria

- Patients of all age groups and both sexes undergoing complete blood count analysis.
- EDTA-anticoagulated venous blood samples with adequate volume.
- Samples for which both automated hematology analyzer results and peripheral blood smear examination were available.

Exclusion Criteria

- Hemolyzed or clotted blood samples.
- Inadequately labeled or insufficient blood specimens.
- Repeated samples from the same patient during the study period.
- Poor-quality peripheral blood smears unsuitable for evaluation.

Data Collection: Approximately 2 mL of venous blood was collected in EDTA vacutainer tubes under aseptic precautions. Complete blood count was performed using a fully automated 5-part differential hematology analyzer according to the manufacturer's recommendations and standard laboratory operating procedures.

The following parameters were recorded:

- Hemoglobin (Hb)
- Total leukocyte count (TLC)
- Red blood cell (RBC) count
- Hematocrit (HCT)
- Mean corpuscular volume (MCV)
- Mean corpuscular hemoglobin (MCH)
- Mean corpuscular hemoglobin concentration (MCHC)
- Red cell distribution width (RDW)
- Platelet count
- Mean platelet volume (MPV)
- Differential leukocyte count
- Instrument-generated abnormal flags

Peripheral blood smears were prepared immediately from each sample using the wedge smear technique and stained with Leishman stain. Smears were independently examined under light microscopy by experienced pathologists. Morphological assessment included evaluation of:

- Red blood cell morphology
- White blood cell morphology
- Platelet morphology
- Presence of immature cells, blast cells, atypical lymphocytes, nucleated RBCs, platelet clumps, schistocytes, and hemoparasites where applicable.

Study Variables: The automated hematology analyzer findings were correlated with peripheral blood smear findings to determine the concordance between instrument-generated abnormalities and microscopic morphology.

Outcome Measures

- Correlation between automated hematology analyzer parameters and peripheral blood smear findings.
- Frequency of abnormal analyzer flags confirmed on peripheral blood smear.
- Diagnostic utility of automated analyzer parameters in predicting significant hematological abnormalities.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using SPSS version 25.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were expressed as frequencies and percentages. Pearson's or Spearman's correlation coefficient was used to determine the correlation between automated analyzer parameters and peripheral blood smear findings. The Chi-square test or Fisher's exact test was applied for categorical variables. A p-value <0.05 was considered statistically significant.

Results

A total of 100 peripheral blood samples were analyzed using an automated hematology analyzer and subsequently correlated with peripheral blood smear (PBS) findings. The results are presented below.

Table 1: Demographic Distribution of Study Participants (n = 100)

Variable	Frequency (n)	Percentage (%)
Age Group (years)		
<20	14	14.0
20–40	38	38.0

41–60	30	30.0
>60	18	18.0
Gender		
Male	58	58.0
Female	42	42.0

The majority of study participants belonged to the 20–40 years age group (38%), followed by 41–60 years (30%). Males constituted 58% of the study population, resulting in a male-to-female ratio of approximately 1.4:1.

Table 2: Distribution of Abnormal Automated Hematology Analyzer Parameters (n = 100)

Automated Parameter	Abnormal Cases (n)	Percentage (%)
Low Hemoglobin	44	44.0
Abnormal Total Leukocyte Count	32	32.0
Abnormal Platelet Count	27	27.0
Raised RDW	36	36.0
Low MCV	28	28.0
High MCV	10	10.0
Analyzer Flag for Immature Cells	18	18.0
Analyzer Flag for Blast Cells	7	7.0
Platelet Clump Flag	11	11.0

Low hemoglobin (44%) was the most frequent abnormal parameter detected by the automated hematology analyzer, followed by raised RDW (36%) and abnormal total leukocyte count (32%). Instrument-generated flags for immature cells and blast cells were observed in 18% and 7% of samples, respectively.

Table 3: Correlation Between Automated Hematology Analyzer Findings and Peripheral Blood Smear Findings (n = 100)

Automated Analyzer Finding	Corresponding Peripheral Smear Finding	Confirmed on PBS n (%)	p-value
Low Hemoglobin	Microcytic/Hypochromic RBCs	40 (90.9)	<0.001
Raised RDW	Anisocytosis	34 (94.4)	<0.001
Low MCV	Microcytosis	25 (89.3)	<0.001
High MCV	Macrocytosis	8 (80.0)	0.002
Immature Cell Flag	Left Shift/Immature Myeloid Cells	16 (88.9)	<0.001
Blast Cell Flag	Blast Cells Present	6 (85.7)	<0.001
Platelet Clump Flag	Platelet Clumps	10 (90.9)	<0.001

A strong correlation was observed between abnormal automated analyzer parameters and peripheral blood smear findings. Raised RDW showed excellent agreement with anisocytosis (94.4%), while low hemoglobin strongly correlated with microcytic hypochromic morphology (90.9%). All major correlations were statistically significant.

Table 4: Diagnostic Performance of Automated Hematology Analyzer Compared with Peripheral Blood Smear

Parameter	Value (%)
Sensitivity	91.0
Specificity	88.0
Positive Predictive Value	89.2
Negative Predictive Value	90.0
Overall Diagnostic Accuracy	89.5

The automated hematology analyzer demonstrated high diagnostic performance, with an overall accuracy of 89.5%. The sensitivity (91%) and specificity (88%) indicate that automated analyzer parameters reliably predict peripheral blood smear abnormalities, although microscopic examination remains essential for confirmation of abnormal cell morphology and pathological findings.

Discussion

The advent of automated hematology analyzer has completely transformed the laboratory analysis of routine haematology and enabled it to deliver fast, accurate, and reproducible complete blood count (CBC). Nevertheless, though there have been some technological progress, the careful analysis of the peripheral blood smear (PBS) is still essential for assessing the morphology of blood cells and/or for A total of 100 samples of peripheral blood were used in the present study to evaluate the correlation between parameters of automated hematology analyzer and peripheral blood smear.

In the current study, the most frequent abnormalities are found by the automated hematology analyzer are low hemoglobin, high red cell distribution width (RDW), abnormal leukocytes and thrombocytopenia. Most of these abnormalities were confirmed by peripheral blood smear examination and fair agreement was seen in the parameters of anisocytosis, microcytosis, platelet clumps, and immature leukocyte flags. The findings are in line with the International Council for Standardization in Haematology (ICSH) recommendations that abnormal analyzer parameters should send for microscopic examination to improve diagnostic accuracy and patient safety.[8]

Demonstrating high sensitivity (91%) and high specificity (88%)

at predicting peripheral smear abnormalities, modern automated hematology analyzers can be used to serve as reliable screening devices. In addition, Barnes et al. also stated that new review criteria from the analyzer will assist in reducing unnecessary smears for review, while maintaining the reliability of the diagnosis, and Briggs has added that new analyzer parameters will provide a wealth of information related to red cell morphology, leukocyte abnormalities and platelet disorders, while enhancing laboratory efficiency without sacrificing the need for microscopic examination at the bench.

Buoro et al. reported that contemporary hematology analyzers demonstrated very good discriminatory capability between the different cell types, and in abnormal cases – in particular – the morphology of the blood smear remains essential for the hematological diagnosis.[11] Lee et al. stressed the need for the standardized morphological examination for proper hematological diagnosis in cases of abnormal peripheral blood parameters, especially in patients with suspected hematological malignancies and dysplastic disorders.[12]

Additionally, ICSH use of standardized nomenclature and peripheral blood cell morphology grading further emphasize the complementary use of automated analyzers and peripheral blood smear exam. The analyzer technology has improved significantly, but, despite these advances, microscopic examination still is the gold standard for the detection of abnormal cell morphology, atypical cells, blast cells, schistocytes, and platelet aggregates.[13]

In conclusion, the present study results suggest a good agreement between automated haematology analysers and peripheral blood smear results during routine haematology practice. However, peripheral smear examination is still very useful for confirming abnormal flags on the analyzers and for detailed morphology examination.

Conclusion

Automated hematology analyzers offer fast, high sensitivity, high specificity, accurate and reliable hematological parameters for abnormal blood finding. There exists a fairly significant correlation between the abnormalities found in the automated analyzers and the peripheral blood smear which is especially notable in the case of anemia, anisocytosis, abnormalities of leukocytes, and disorders of platelets. Peripheral blood smear examination is the "gold standard" in terms of morphological evaluation and confirmation of abnormal flags that are generated by the analyzer. Automated hematology analysis and peripheral smear examination in combination improve the diagnostic values, quality assurance in the laboratory and clinical decision making.

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Conflicts of interest

There are no conflicts of interest.

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