Santos Maciel, Tavany Elisa; Comar, Samuel Ricardo; Perlingeiro Beltrame, Miriam
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Avaliação do desempenho analítico do analisador hematológico Sysmex® XE-2100D

Tavany Elisa Santos Maciel[1]; Samuel Ricardo Comar[2]; Miriam Perlingeiro Beltrame[3]

ABSTRACT

Introduction: The Sysmex® XE-2100D is a multiparameter hematology analyzer designed for hematology testing in samples with ethylenediamine tetraacetic acid (EDTA). **Objectives:** Considering the importance of this hematology analyzer for clinical and laboratory practice, the objective of this study was to evaluate its analytical performance, comparing the obtained results with quality specifications described in literature. **Material and method:** In the evaluation of analytical performance, according to recommendations of the document H26-A2 of the Clinical and Laboratory Standards Institute (CLSI), intra-run imprecision, inter-run imprecision, linearity, carryover, autosampler evaluation, clinical sensitivity of the atypical lymphocytes flag ($n = 400$ samples) were included, as well as the comparison between automated and manual leukocyte differential count ($n = 400$ samples), based on an adaptation of the document H20-A2 of CLSI. **Results:** Repeatability, reproducibility, linearity and carryover were satisfactory according to the manufacturer's specifications. The clinical sensitivity of the atypical lymphocytes flag showed efficiency, sensitivity and specificity of 92.5%, 65.2% and 94.1% respectively. The correlation coefficients between the automated and manual differential counts of neutrophils, lymphocytes, monocytes, eosinophils and basophils were 0.991, 0.99, 0.872, 0.974 and 0.557, respectively. **Conclusions:** The results were in accordance with quality specifications described in literature, indicating reliability in Sysmex® XE-2100D. This fact ensures certainty to both laboratory professionals and medical staff. We conclude that the Sysmex® XE-2100D showed excellent analytical performance, and is useful to provide reliable hematology data.

Key words: automation; hematology analyzer; Sysmex® XE-2100d; analytical performance; quality control.

INTRODUCTION

One of the most important discoveries in the development of hematology analyzers was the formulation of the principle of electrical impedance, patented by the American engineer Wallace Henry Coulter on October 20, 1953. Originally created to count the number of particles in dairies, the impedance method was soon adapted to count blood cells, especially due to the increased demand for blood tests. That made it possible to reduce time of cell counting from 30 minutes to 15 seconds when compared to manual microscopic methods, and to reduce counting errors by a factor of 10. In 1963, seven years after the Coulter Counter model A (Coulter Electronics, Hialeah, Florida), the first hematology analyzer, became commercially available, a small factory in the Japanese town of Kobe, initially called TOA Medical Electronics and since 1998 renamed Sysmex Corporation, developed and launched

a new hematology analyzer, called Microcell Counter, model CC-1001. In order to avoid the use of the impedance principle, patented by Coulter, Sysmex then developed the capacitance method, that would be replaced by impedance as soon as Coulter's patent expired in 1976[10, 12, 23, 28].

More than 40 years went by since hematology parameters began being measured by automated methods. During those years analyzers continually evolved due to companies' efforts and abilities to meet the market needs, and to scientific processes related to the peripheral technologies necessary to make such development possible. Sysmex XE-2100D is a fully automated hematology analyzer that determines eight validated parameters for the red blood cells, 13 for the white blood cells and two for platelets that may also be used for body fluid cell counts. It is classified as a high-volume hematology analyzer, designed for hospitals with intense work routines and for reference laboratories that perform thousands of tests per day. It has a nominal capacity of approximately 150 tests per hour, besides being able to warn users as to the presence of qualitative and quantitative abnormalities in blood cell populations. It uses fluorescence flow cytometry with light scattering as a principle for differential and total leukocyte count. For erythrocyte and platelet count, it uses the principle of impedance with hydrodynamic focusing, and for hemoglobin measurement, a method with sodium lauryl sulfate [6, 16, 19].

The analytical performance of hematology analyzers is traditionally assessed by tests for precision, accuracy, linearity, carryover, comparability, reproducibility and clinical sensitivity of analyzer-generated flags. When one interprets the results from patients' samples, it is important to understand the possible occurrence of random errors or analytical imprecision of the results, irrespective of the likely influence of analytical variability and patients' health condition on results. Performance evaluation of the automated hematology analyzers must be carried out in all laboratories, mainly in those with a large number of samples with very high or very low cell counts and that serve populations with potential to present relevant blood alterations [5, 7, 8, 15, 26].

Considering that the complete blood count is one of the most frequently ordered exams in medical appointments and a fundamental exam to detect any pathology that is reflected in the blood stream, the validation of results from a hematology analyzer becomes an item of special importance, especially for reflecting the quality of laboratory work and directly influencing patients clinical conduct. Aimed at increasing quality of the complete blood count results provided by laboratories, is it necessary to assess the analytical performance of hematology analyzers, so as to ensure that the obtained results are the most reliable possible.

The objective of this study was to evaluate the analytical performance of hematology analyzer Sysmex® XE-2100D, given its relevance in laboratory and clinical practices. It is important to highlight that this study, besides being a basis upon which other hematology laboratories understand the usefulness of validating a hematology analyzer, will provide data for the validation of hematology analyzers in laboratory routines.

MATERIALS AND METHODS

Study site, samples and patients

This study was conducted in the Hematology sector of Laboratório Municipal de Análises Clínicas Dr. Gerson Bruschini Ribeiro, in the town of Araucária, Paraná. All used samples came from residue material of the laboratory routine, randomly selected and belonging to patients whose complete blood count was ordered. Samples were collected in tubes containing ethylenediamine tetraacetic acid dipotassium salt (EDTAK$_2$) as anticoagulant. All samples were analyzed at the hematology equipment Sysmex® XE-2100D within three hours after collection.

Linearity

This test allowed establishing the linear correlation between theoretical values and those observed in practice by means of the analysis of several dilutions of a certain sample. Linearity for leukocytes and platelets was assessed by the conduction of seven dilutions: 1\2; 1\4; 1\8; 1\16; 1\32; 1\64; 1\128 of two samples selected from laboratory routine. One sample obtained the leukocyte values of $> 65 \times 10^3$/µl, and another sample obtained the platelet value of $> 730 \times 10^3$/µl. Dilutions were performed with the equipment solvent (Cellpack, Sysmex). Prior to dilution analysis, Sysmex® XE-2100D was washed with 5% sodium hypochlorite and distilled water. Dilutions were homogenized and inverted 20 times; afterwards, they were analyzed in duplicate. The linear equation and the correlation coefficient between theoretical and practical values were calculated for leukocytes and platelets[29].

Carryover

It indicates, in percentage, how much a sample with high results may falsely raise results of a cytopenic sample subsequently analyzed. This evaluation was performed in triplicate of a sample with high concentration of the analyte in question (H1, H2 e H3), with a subsequent analysis in triplicate of a sample with low concentration of the same analyte. The percentage of carryover

for each parameter was calculated with the following formula: carryover (%) = |L1 - L3|/(H3-L3) × 100[3]. Where L1 and L3 were the results of the first and third measurement of samples with low concentration, and H3 was the third measurement of the sample with high concentration. For leukocytes, the low and the high sample contained values of $0.34 \times 10^3/\mu l$ and $100 \times 10^3/\mu l$, respectively. For erythrocytes, $1.5 \times 10^6/\mu l$ and $6 \times 10^6/\mu l$, respectively. For hemoglobin, 4 g/dl and 18g/dl, respectively. For globular volume, 14% and 55%, respectively; for platelets, $20 \times 10^3/\mu l$ and $1,020 \times 10^3/\mu l$ respectively.

Autosampler evaluation

A rack with 10 random samples was analyzed, previously homogenized during five minutes. Next, samples were allowed to stand in vertical position during four hours. Afterwards, they were analyzed directly and with no prior homogenization. Sample homogenization was done exclusively by the autosampler, which does it by inverting tubes 10 times. Erythrocyte, leukocyte and platelet counts were compared. The maximum allowed variations between these both procedures were: erythrocytes (± 1.5%), leukocytes (± 3%), and platelets (± 5%)[21, 27].

Intra-run imprecision or repeatability

The objective of this test was to determine the analyzer capacity to reproduce the results for a certain parameter in a given sample. Analyses were carried out in normal conditions, by the same operator, in the same period of the day and with the same reagent lots. In order to adequate samples to the analytical ranges to be assessed, their dilutions were performed. A sample with normal values, one with increased leukocyte values ($> 50 \times 10^3/\mu l$) and a sample with increased platelet values ($> 1,000 \times 10^3/\mu l$) were used. The prepared samples were analyzed 10 consecutive times in the closed mode of Sysmex® XE-2100D. The mean, the standard deviation (SD) and the coefficient of variation (CV) were calculated for each parameter. It is worth highlighting that before samples were analyzed, the analyzer was washed with 5% sodium hypochlorite and distilled water. Prior to the analysis, samples were homogenized and inverted 20 times.

Inter-run imprecision or reproducibility

It was aimed at determining the capacity of the analyzer to reproduce results of hematological parameters, when samples were analyzed several times during the same day or in the course of several days. Reproducibility was carried out by analyzing sample results of internal quality control through three concentrations

levels (low, normal and high). Such samples were analyzed during 57 consecutive days, before the beginning of the routine. At the lot expiration date, data were sent to Sysmex external proficiency testing, called Insight Program. For each hematologic parameter, the mean, SD and CV were calculated.

Comparison between the manual and automated differential count of leukocytes

During a period of five consecutive days, 400 samples were collected from routine with their printed results of Sysmex XE-2100D, along with blood smears, so as to allow comparison between the manual and automated differential count of leukocytes. Blood smears were manually created and stained by May-Grünwald and Giemsa method. Manual differential count was performed in 400 cells per slide at an optical microscope. This count was based on an adaptation of the document CLSI H20-A2[7]. According to this document, comparisons between manual and automated differential leukocyte counts must be performed by counting two blood smears of each sample, in which 200 cells are counted in each slide by two different observers. In case an accentuated difference is observed, a third slide must be created and analyzed by a third observer. Just then average percentages are calculated for each cell type. In this work 400 cells per slide were counted, in a total of 400 blood smears, by a single observer only. In an attempt to minimize errors inherent in the technique, 400 cells per slide were counted, as it was not possible to create more than one blood smear per sample. For each slide read, the percentage of neutrophils, lymphocytes, monocytes, eosinophils and basophils was calculated. The obtained results were compared with other studies and with the manufacturer's specifications.

Clinical sensitivity for atypical lymphocytes flag

Morphologic flag refers to a warning the analyzer emits indicating that the sample in analysis may have a relevant morphologic abnormality, such as the presence of immature cells, which are not normally quantifiable by current hematology analyzers. The morphologic flag plays an important role to warn about the need to undertake a blood smear review[1]. Clinical sensitivity for atypical lymphocytes flag was verified in the 400 samples used for assessment of correlation between the manual and automated differential count of leukocytes. The atypical lymphocytes flag was chosen for evaluation because of its incidence in the analyzed samples. In order to assess performance of this parameter, efficacy, sensitivity, specificity, positive predictive value and negative predictive value were determined. If a sample was positive for the atypical lymphocytes flag and in the microscopic evaluation had ≥

2% of atypical lymphocytes, the sample was classified as true positive (TP). If a sample was positive for the atypical lymphocytes flag and no atypical lymphocytes ≥ 2% were found at microscopy, the sample was classified as false positive(FP). If a sample was negative for the atypical lymphocytes flag and had ≥ 2% of atypical lymphocytes in the microscopic analysis, the sample was classified as false negative (FN). Finally, if a sample was negative for the atypical lymphocytes flag and did not present any relevant finding on the slide, the sample was classified as true negative (TN)[1, 9, 24].

Statistical analysis

The obtained results were statistically analyzed by using the program Excel (Microsoft Corporation, USA). The correlation between the manual and automated differential count of leukocytes was made by regression analysis, determining the correlation coefficient (r) and comparing it with current specifications in literature. Sensitivity, specificity, positive predictive value, negative predictive value and efficiency related to the clinical sensitivity for atypical lymphocytes flag were calculated as follows: sensitivity (%) = (VP/VP + FN) × 100; specificity (%) = (VN/VN + FP) × 100; negative predictive value (%) = (VN/VN + FN) × 100; positive predictive value (%) = (VP/VP + FP) × 100; and efficiency (%) = (VP + VN/VP + FP + FN + VN) × 100[14].

RESULTS

Linearity

Linearity was verified for leukocytes and platelets, and for both it presented an excellent correlation coefficient (0.999) between theoretical and observed values (**Figure 1**).
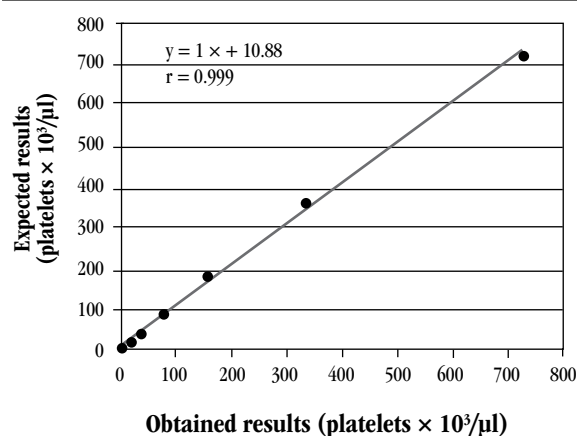
Carryover

For all the assessed parameters the carryover was ≤ 1%, according to the manufacturer's specifications[27]. Results are shown in **Table 1**.

TABLE 1 – Carryover (%), Sysmex® XE-2100D

Parameters	%
Leukocytes	0.08
Erythrocytes	0.36
Hemoglobin	0.46
Globular volume	0.4
Platelets	0.04

Autosampler evaluation

The average variation between the analyzed samples with or without previous homogenization for erythrocytes, leukocytes and platelets was 0.51%, 1.34% and 5.38%, respectively. Erythrocytes and leukocytes were below the allowed limits of 1.5% and 3%, respectively. The variation for platelets was above the allowed limit of 5%.

Intra-run imprecision or repeatability

Results are presented in **Table 2**. The CV for repeatability of the leukocyte count of 4-10 × 10³/µl was 2%, and for the platelets 10-20 × 10³/µl it was 6.5%. Globular volume also presented satisfactory results, with CV between 0.34% and 0.36%. Intra-run imprecision for all levels was acceptable; however, samples with low levels demonstrated high CV.
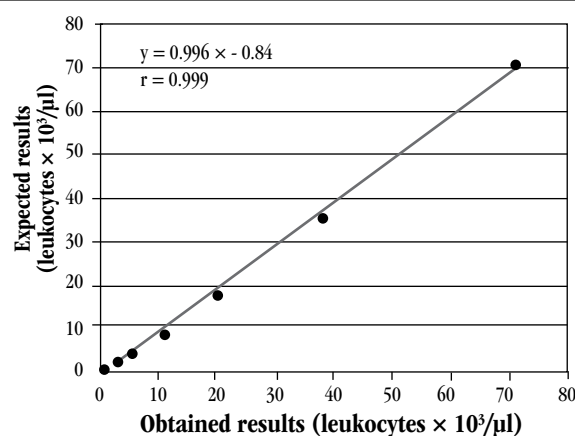

FIGURE 1 – *Linearity for platelets and leukocytes (Sysmex® XE-2100D)*

Leukocytes (× 10³/µl)	CV (%)	Platelets (× 10³/µl)	CV (%)	Globular volume (%)	CV (%)
< 1	8.6	10-20	6,5		
1-4	3	20-50	5	< 20	0.3
4-10	2	150-400	1	38-45	0.4
10-20	2.4	400-1,000	2	> 50	0.92
> 50	1	> 1,000	1		

CV: coefficient of variation.

Inter-run imprecision or reproducibility

Results are shown in **Table 3**. There are quality specifications that suggest that the maximum intra-analyzer imprecision for hematological parameters must be lower than half of the intra-individual biological variability ($CV_{(analytical)}$ or imprecision $< 0.5 \times CV_{(intra)}$). All the CVs observed in this trial, except relative and absolute monocyte count in the three used levels were lower than the cited specification[4]. Erythrocytes, hemoglobin, globular volume and the corpuscular constants showed exceptional precision, with CV $< 1.5\%$ for the three levels. Neutrophil and lymphocyte differential counts were also excellent, with CVs $< 5\%$.

Comparison between the manual and automated differential count of leukocytes

Results were excellent, as can be seen in **Figure 2**. All correlation coefficients were above the limits specified by the manufacturer[27].
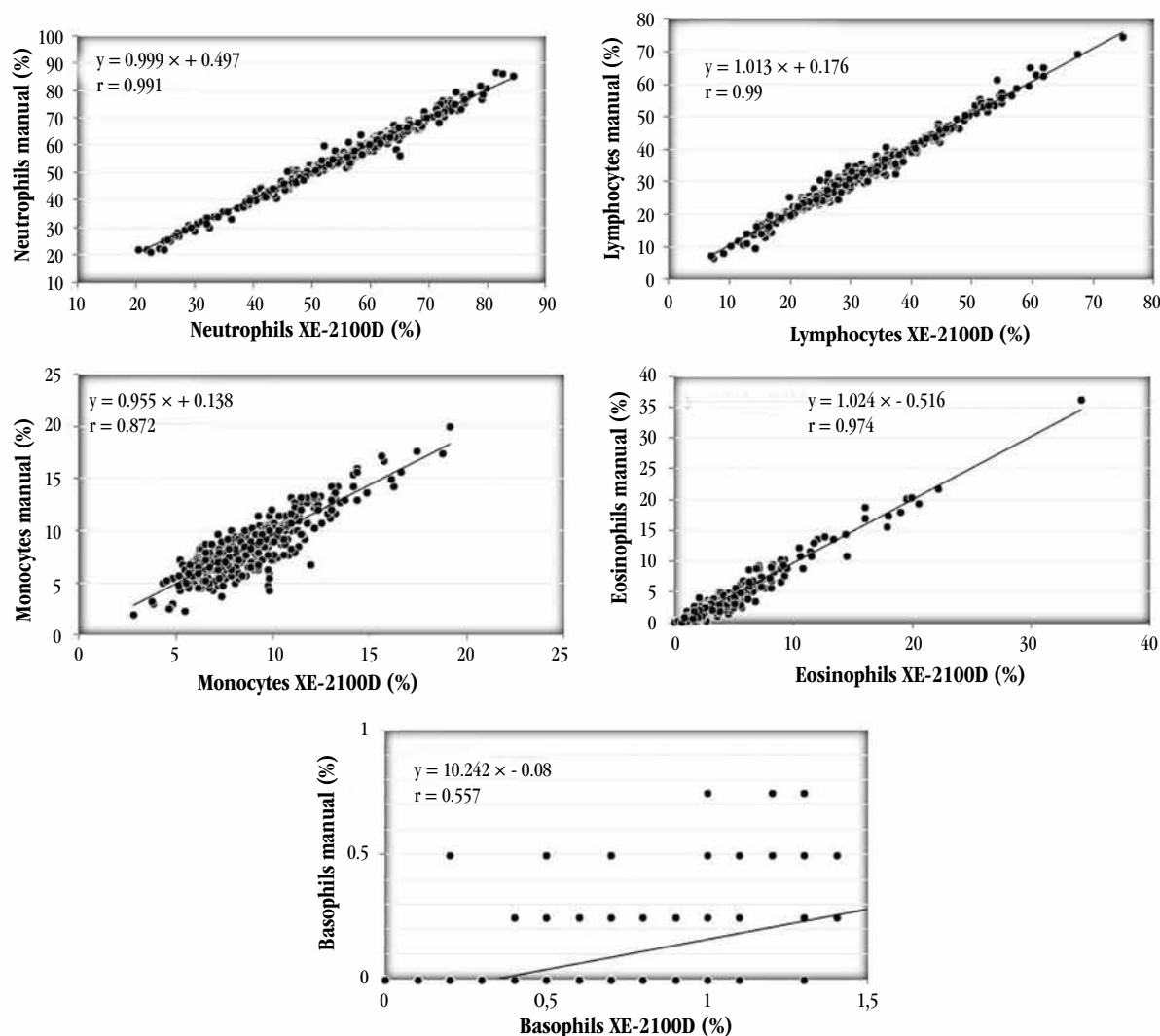

FIGURE 2 – *Comparison between the automated (XE-2100D) and the manual (CLSI H20-A2) differential count of leukocytes (*n = 400)*

TABLE 3 – Reproducibility results, Sysmex® XE-2100D

Parameters	Low control			Normal control			High control		
	SD	Mean	CV	SD	Mean	CV	SD	Mean	CV
Erythrocytes	0.021	2.31	0.9	0.030	4.36	0.7	0.036	5.27	0.7
Hemoglobin	0.07	5.7	1.2	0.09	11.9	0.8	0.11	15.7	0.7
Globular volume	0.17	17.2	1.0	0.34	35.1	1	0.38	45.3	0.8
MCV	0.52	74.4	0.7	0.45	80.5	0.6	0.42	86	0.5
MCH	0.25	24.5	1.0	0.2	27.4	0.7	0.19	29.8	0.6
MCHC	0.42	32.9	1.3	0.36	34	1.1	0.27	34.7	0.8
RDW	0.13	16.1	0.8	0.08	14.6	0.5	0.07	14.6	0.5
Leukocytes	0.086	2.95	2.9	0.101	6.7	1.5	0.257	16.69	1.5
Neutrophils%	1.25	46.5	2.7	1.04	50.2	2.1	1.08	54.2	2
Lymphocytes%	1.27	34.3	3.7	1.05	29.9	3.5	0.96	26.4	3.6
Monocytes%	0.89	9.8	9.1	1.07	9.4	11.4	1.11	8.1	13.7
Eosinophils%	0.77	9.4	8.2	0.63	10.5	6	0.87	11.3	7.7
Basophils%	1.31	65.6	2.0	1.02	69.9	1.5	0.49	75.8	0.6
Neutrophils#	0.056	1.37	4.1	0.078	3.37	2.3	0.231	9.05	2.6
Lymphocytes#	0.051	1.01	5.0	0.071	2	3.5	0.182	4.41	4.1
Monocytes#	0.028	0.29	9.7	0.075	0.63	11.9	0.182	1.35	13.5
Eosinophils#	0.022	0.28	7.9	0.044	0.7	6.3	0.148	1.88	7.9
Basophils#	0.072	1.94	3.7	0.089	4.68	1.9	0.206	12.65	1.6
Platelets	2.6	55	4.7	4.6	205	2.2	8.5	469	1.8
MPV	0.29	9.1	3.2	0.11	9.3	1.2	0.09	9.4	1

MCV: mean corpuscular volume; MCH: mean corpuscular hemoglobin; MCHC: mean corpuscular hemoglobin concentration; RDW: red cell distribution width; %: relative value; #: absolute value; MPV: mean platelet value; SD: standard deviation; CV: coefficient of variation.

Clinical sensitivity for atypical lymphocytes flag

The values found for efficacy, sensitivity, specificity, positive predicted value and negative predictive value are shown in **Table 4**. Efficiency in the classification of samples with or without atypical lymphocytes ≥ 2% was 92.5%, that is, of the 400 analyzed samples, 370 were correctly classified. Specificity of 94.1% indicated that 355 samples in 377 that did not present atypical lymphocytes ≥ 2% at microscopy (TN + FP) were correctly classified. The negative predictive value observed indicated that in 97.7% of the times that the analyzer did not generate the atypical lymphocytes flag, the microscopic counterpart was not observed either (atypical lymphocytes ≥ 2%).

TABLE 4 – Clinical sensitivity for the atypical lymphocytes flag of the hematology analyzer Sysmex XE®-2100D

Parameters (%)	Total ($n = 400$)
True positive	3.75
False positive	5.5
True negative	88.75
False negative	2
Specificity	94.1
Sensitivity	65.2
Positive predictive value	40.5
Negative predictive value	97.7
Efficiency	92.5

DISCUSSION

The linearity study was satisfactory in comparison with other studies. Regression lines went through the origin and the *r* values were close to 1, evidencing linearity at very low and very high concentrations. Nakul-Aquaronne *et al*.[22] obtained an *r* value of 0.99 for platelets and 1 for leukocytes in the linearity study at

top-of-the-line Sysmex XE-2100. In this study, for the XE-2100D, the *r* found was 0.999 for both parameters (Figure 1). In the assessment by Walters and Garrity[29], Sysmex® XE-2100 showed results similar to these in our study (*r* of 0.997 for leukocytes and 0.998 for platelets). The obtained results in this assay have great importance to demonstrate there was a linear relationship for leukocytes and platelets in several dilutions during the analytical range of Sysmex® XE-2100D.

The carryover values in this study (Table 2) were satisfactory when compared with those recommended by the equipment manufacturer[27]: the carryover for leukocytes, erythrocytes, hemoglobin, globular volume and platelets must be ≤ 1%. Nakul-Aquaronne et al.[22] observed a carryover of 0.05% for leukocytes and 0.04% for platelets at XE-2100. Another study with XE-2100 found values for leukocytes of 0.04%, erythrocytes of 0.14% and platelets of 0.04%, while for globular volume and hemoglobin there was no carryover[14]. It is worth highlighting that before the analysis, washes with hypochlorite and water were made at Sysmex XE-2100D so as to avoid a background count. The results of this assessment confirmed the efficiency of the wash made between a sample analysis and another.

There is a time interval between collection and the conduction of the exam, when the tube stands still and erythrocyte sedimentation occurs. In order to adequately count the sample, it must be homogenized before the exam, in hematologic homogenizers for five minutes, especially if the hematologic analyzer does not have a sample loader system in racks. In case it does, an evaluation of the counter sampler must be done to verify the possibility of forgoing previous homogenization, what helps decrease sample processing time. The results obtained in this study demonstrate that Sysmex XE-2100D sampler was able to adequately homogenize samples for erythrocyte and leukocyte count. For platelets, the 5.38% result was above the recommended limit of 5%. Therefore, a previous sample homogenization is recommended before they are analyzed at Sysmex XE-2100D. A suggestion to decrease variation would be homogenizing samples in the rack, manually, for 10 times, before placing it in the hematologic analyzer autosampler.

Intra-run imprecision results were excellent when compared with the specifications of the equipment manual[27], which indicates that the CV for leukocytes ≥ 4 × 10³/µl must be ≤ 3%. In this study the found value was 2% (Table 2), what confirms that Sysmex XE-2100D has operated beyond the specifications defined by the manufacturer. For platelets with counts ≥ 100 × 10³/µl the precision limit must be ≤ 4% and in this study it was ≤ 4% (Table 2).The globular volume also presented satisfactory results, since the CV must be ≤ 1.5% and the values found in this study ranged from 0.34% to 0.36% (Table 2). As expected, for low platelet and leukocyte values, CV was higher. Similar results were found in the study conducted by Nakul-Aquaronne et al.[22], in which precision for low platelet and leukocyte values resulted in high CV in analyzers Abbott Cell-Dyn 4000, Sysmex SE-9500 and XE-2100. A bigger variation in low counts may happen because the low leukocyte and platelet concentrations are on the extreme of linearity in this hematologic analyzer, which may be not able to perform counts with high precision due to the lower number of counted cells, taking into account that the dilution performed by the analyzer is always in the same proportion for any sample.

There are quality specifications that recommend intra-analyzer imprecision may range from 25% to 50% in relation to biological variation for a certain parameter; however, when one intends to compare results between two different analyzers, the acceptable limit of variation must be higher, principally because they are independent analytical systems and there is the need to consider the existence of small differences in the target values of commercial controls for each equipment, when they come from different manufacturers or belong to different models, what implies small differences in accuracy[9]. The determination of intra-run imprecision was important to show the analyzer quality in test conduction and to confirm the fact that when the sample is analyzed more than once, differences will be minimum.

Imprecision, as well as the other tests of analytical performance, must be obtained in the environment where the hematologic analyzer will work and by the technical staff that will operate it. The scope of the evaluations depends, above all, on the hematological parameter ranges reported by the laboratory. Hospital laboratories must evaluate imprecision in the lower extremes of hematological parameters. Platelet count of 10-20 × 10³/µl showed intra-run imprecision of 6.48%, which was better than the previously documented imprecision for the platelet count by impedance at Sysmex XE-2100, which was 13.6% in counts within these ranges[11]. Nowadays there are analyzers, like the recently launched modular system Sysmex XN, with imprecision of just 4% in the platelet count by optical fluorescence method in these same intervals[2].

Reproducibility was assessed to document calibration stability over time for all the parameters reported in the complete blood count. Reproducibility must always be verified in samples with several levels of concentration, so as to comprise the analytical intervals that occur in the laboratory. As expected, at low levels CVs were higher for erythrocytes, leukocytes and platelets due to their low concentrations in the blood. The differential count of monocytes presented high CVs in the three assessed levels (Table 3). Goosens et al.[13] documented the precision problem of monocyte count in hematology analyzers, as well as this study; however the clinical significance of this imprecision is low.

With the CV values obtained from the internal control and with the bias values obtained from the proficiency trial, the total allowed error was calculated, as well as the sigma index for all parameters. Total error was below that specified in literature for all parameters, and the sigma was higher than 3 for all parameters (data not presented).

The comparative study between the XE-2100D manual and automated differential count of leukocytes showed excellent comparability, even in leukopenic samples. The five-part differential count of the XE-2100D is precise, accurate and reliable. The correlation coefficient of basophils was 0.557, probably because there is a low basophil count in normal people's blood, what increases imprecision in the differential count of this specific parameter. In spite of this, the correlation of basophil count was acceptable, for the manufacturer recommends the correlation coefficient to be ≥ 0.5. Studies of leukocyte differential count with XE-2100D were not found in literature, but studies performed with XE-2100, which uses similar detection principles, showed identical results to those of this study[29]. The coefficients found in this study for neutrophils, lymphocytes, monocytes and eosinophils were 0.991, 0.99, 0.872 and 0.974, respectively (Figure 2). The manufacturer recommends they are higher than 0.9, 0.9, 0.75 and 0.8, respectively. Therefore, the performance of Sysmex XE-2100D as regards comparability far outweighs the specifications recommended by the manufacturer. Just in few cases with low absolute and relative counts imprecision increased. Herklotz and Huber[17] made a comparison between the manual and automated differential count of XE-2100D by the analysis of 500 cells in normal and pathological samples, and the correlation was also high for neutrophils and lymphocytes ($r >$ 0.98) and eosinophils ($r = 0.95$).

Assessing the efficiency of morphologic flags is of utmost importance for laboratories, because it helps professionals that analyze blood smears microscopically. Sensitivity for a flag refers to the capacity to detect truly positive samples, specificity is the capacity to detect truly negative samples, positive predictive value is the probability that a positive result is truly positive, and negative predictive value is the probability that a negative result is truly negative. In order to be useful, a morphologic flag must present low rate of false positives and false negatives, so as to result in high efficiency to identify samples showing relevant morphological abnormalities. However, it is known that there are situations when the occurrence of false positive and false negative rates is unavoidable. One must maximize efforts to keep false negative rates within safe and acceptable limits.

In the present study sensitivity was not very high (65.2%), but specificity was very good (94.1%). Ruzicka et al.[24] found sensitivity of 36% for atypical lymphocytes flag and suggested that the broad morphologic definition of atypical lymphocytes may have been responsible for the low sensitivity. Nakul-Aquaronne et al.[22] found sensitivity and specificity > 90% and a negative predictive value of 98% for atypical lymphocytes flag in the XE-2100. The value of false negatives for atypical lymphocytes in this study was 2%, what demonstrates high quality equipment screening. False positive rates were 5.5%, indicating that 22 slides in 400 were unnecessarily read.

The type of sample selected for such analysis is an important source of variation because they influence the sensitivity and specificity of the analyzer being evaluated. The use of outpatients' samples, as in this study, normally has fewer false positive and false negative results than that of inpatients' samples. Laboratory staff is recommended to be well-acquainted with the strong and weak points of their specific hematology analyzer[18].

In hematology analyzers, the cutoff values to determine sensitivity and specificity of flags are adjusted to offer more false positive results, because the consequences of errors due to excessive analysis of blood smears are less dramatic than omissions of information relevant to patients' diagnosis and follow-up[1]. Thus, some works proposed a way to maximize flags efficiency, through the development of a probability rate that helps in the definition of cutoff values set in analyzers, which would minimize the occurrence of false negative and false positive values[20, 25].

CONCLUSION

The equipment Sysmex XE-2100D proved to be a hematology analyzer of high analytical performance, being suitable for medium and large laboratories. The results obtained in this study indicate the reliability of parameters offered by this analyzer, besides certainty in the analysis of blood smears.

RESUMO

Introdução: O Sysmex® XE-2100D é um analisador hematológico multiparamétrico destinado à realização de testes hematológicos em sangue anticoagulado com ácido etilenodiamino tetra-acético (EDTA). Objetivos: Considerando a sua importância na prática clínica e laboratorial, o objetivo deste estudo foi avaliar seu desempenho analítico, comparando os resultados obtidos com especificações de qualidade descritas na literatura. Material e método: Na avaliação de desempenho analítico, conforme recomendações do documento H26-A2 do Clinical and Laboratory Standards Institute (CLSI), foram

incluídos ensaios de verificação da imprecisão intraensaio ou repetitividade, imprecisão entre ensaios ou reprodutibilidade, linearidade, carryover *(arraste), avaliação do mecanismo homogeneizador de amostras, sensibilidade clínica do alerta morfológico (*flag*) de linfócitos atípicos (*n = 400 amostras*) e a comparação entre a contagem diferencial de leucócitos automatizada e a manual (*n = 400 amostras*), baseada em uma adaptação do documento H20-A2 do CLSI.* **Resultados:** *Os ensaios de verificação da repetitividade, reprodutibilidade, linearidade,* carryover *(arraste) foram satisfatórios conforme especificações do fabricante. O ensaio de sensibilidade clínica do alerta morfológico (*flag*) de linfócitos atípicos mostrou eficiência, sensibilidade e especificidade de 92,5%; 65,2% e 94,1% respectivamente. Os coeficientes de correlação entre as contagens diferenciais automatizadas e manuais de neutrófilos, linfócitos, monócitos, eosinófilos e basófilos foram de 0,991; 0,99; 0,872; 0,974 e 0,557 respectivamente.* **Conclusões:** *Os resultados obtidos mostraram-se de acordo com as especificações da qualidade analítica descritas na literatura, indicando confiabilidade no Sysmex® XE-2100D. Esse fato confere segurança tanto aos profissionais do laboratório quanto à equipe médica. Conclui-se que o Sysmex® XE-2100D apresentou excelente desempenho analítico, sendo de grande utilidade para fornecer resultados hematológicos confiáveis.*

Unitermos: *automação; analisador hematológico; Sysmex® XE-2100D; desempenho analítico; controle de qualidade.*

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MAILING ADDRESS

Samuel Ricardo Comar
Laboratório Municipal de Análises Clínicas Dr. Gerson Bruschini Ribeiro; Rua Guilherme da Mota, 55 – Centro; CEP: 83702-210, Araucária- PR, Brazil; Tel.: +55(41) 3614-1623; e-mail: srcomar@ufpr.br.