ORIGINAL ARTICLE

Effectiveness of the International Consensus Group criteria for manual peripheral smear review

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ABSTRACT

Context: The International Consensus Group for Hematology Review (ICGHR) are essentially review criteria designed to reduce the number of manual smear reviews following analysis in automated hematology analyzers (AHAs). Although AHAs are an indispensable part of the present-day clinical laboratory, manual smear reviews still play an integral role in identifying morphological abnormalities and to confirm the results of the analyzers. **Aims:** The aim of this study is to evaluate the efficacy of the ICGHR criteria and our laboratory criteria using the Sysmex XN-1000 for manual peripheral smear review (MSR). **Study Design:** A prospective cross-sectional comparative study between the two sets of criteria for MSR was performed. **Material and Methods:** A total of 860 whole blood samples sent over a period of 19 months for complete blood count testing to our laboratory were collected using systematic random sampling. Truth tables were prepared for each set of criteria. Tests of proportion were used to compare performance specifications between both sets of criteria. **Results:** Using ICGHR criteria, sensitivity was 81.58%, specificity was 84.61%, 83.38% positive predictive value, and 82.92% negative predictive value. The microscopic smear review rate was 47.56% and efficiency was 83.14%. Using our laboratory criteria, sensitivity was 98.80%, specificity was 41.40%, positive predictive value of 61.46%, and negative predictive value of 97.34%. The microscopic smear review rate was 78.14% and efficiency 69.30%. **Conclusions:** There was a significant reduction in the microscopic smear review rates using the ICGHR criteria compared to our laboratory criteria. The ICGHR criteria can thus be adapted to daily laboratory practice provided they are first optimized and locally validated before use.

KEY WORDS: Automated hematology analyzers, International Consensus Group for Hematology Review criteria (ICGHR), manual peripheral smear review

INTRODUCTION

Automated hematology analyzers (AHA) have reduced the number of manual hematology procedures and increased the speed of reporting without sacrificing the quality of results. In the era of sophisticated AHAs, it is, therefore, unnecessary to perform manual peripheral smear review (MSR) for each and every hematology sample.[1]

AHAs are superior to manual methods for the count of white blood cells (WBCs), red blood cells (RBCs), and platelets and for differential counting of mature WBC. Despite great precision, high accuracy and expandability of AHAs, MSR still plays an important role in identifying morphological abnormalities, immature cells, and certain sample characteristics such as platelet clumps. MSRs are also used to confirm the results produced by the analyzer.[1-4]

To reduce the rate of MSR, the International Society for Laboratory Hematology (ISLH) through the International Consensus Group for Hematology Review (ICGHR) published a set of rules for peripheral smear review following analysis of samples on AHAs.[1] These rules are essentially review criteria for automated blood count analysis and have since been considered an international standard for MSR. The ICGHR has also put forth procedures to follow when complete blood count (CBC) results do not meet the criteria, which specifically include preparation of a peripheral blood smear followed by MSR. These rules take into account gender and age of the patients, whether the sample is sent for the first time or a subsequent sample has been sent to monitor the CBCs and whether there has been a significant difference between the results.[2,4] Application of these criteria

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will, in turn, reduce the laboratory cost and turnaround time thus improving productivity.[5]

The aim of this study was to evaluate the effectiveness of the ICGHR criteria alongside our laboratory criteria for MSR to determine optimal review criteria for our laboratory to enhance productivity and cost-effectiveness.

SUBJECTS AND METHODS

A prospective cross-sectional comparative study was performed on whole blood samples sent for CBC testing to the central laboratory in our hospital. The study included a total of 860 blood samples collected from both inpatients and outpatients from all the departments in the hospital during 19 months. The study has been approved by the institutional ethical committee.

Under aseptic precautions, 2 ml of venous blood was collected from antecubital vein into K3 EDTA (tripotassium salt of ethylenediaminetetraacetic acid) vacutainers and mixed well by gentle inversion. Using systematic random sampling, first ten samples were collected from the daily workload and analyzed within 1 h of collection. Analysis of all blood samples was performed using the 6-part differential automated hematology analyzer, Sysmex XN-1000. Procedures for quality control and quality assurance were followed during the entire period of this study.

Thin blood smears were prepared for all the samples in the study and were stained with Leishman stain. MSR along with a 100-cell manual differential count was performed to identify morphological abnormalities, immature cells and to confirm results produced by the analyzer. Each sample was reviewed according to adapted ICGHR criteria and our laboratory criteria. A rule in the criteria would be triggered when the result was beyond the specified range and/or a specified flag appeared.

Samples showing sampling errors such as inappropriate blood to anticoagulant proportion, tiny clots or inadequate blood sample were excluded from the study. Samples from the pediatric population were also excluded as the ICGHR criteria in the study were taken with respect to adults.

With respect to the ICGHR review criteria, certain adaptations were made as per the study done by Comar *et al.*[2] [Table 1], henceforth referred to as the ICGHR criteria. These main adaptations were made with regard to delta check rules and rules for reticulocytes owing to the limitations in the instrument used in this study and record systems during the study period. The AHA's results were also reviewed according to our laboratory criteria which have been adapted from the normal reference ranges specified in Dacie[6] and Wintrobe.[7] Criteria for positive smear followed in this study are shown in Table 2.

A sample was classified as true positive (TP) if it was positive for the screening criteria with positive findings on the peripheral smear, false positive (FP) if it was positive for screening criteria with no abnormal findings on the peripheral smear, false negative (FN) if it was negative for screening criteria but with abnormal findings on the peripheral smear and true negative (TN) if it was negative for both screening criteria and MSR.

Tabulation of data was done using Microsoft Excel software. TP, TN, FP and FN rates, efficiency, sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and microscopic smear review rates (MRRs) for both the ICGHR criteria and the laboratory criteria were calculated and truth tables were prepared accordingly. The various parameters calculated were sensitivity (%) = (TP/[TP + FN]) × 100,

Table 1: Adapted International Consensus Group for Hematology Review criteria and our laboratory criteria for automated complete blood counts - Screening Criteria

Parameter	*Adapted ICGHR criteria*	*Laboratory criteria*
RBC parameters		
HB	<7 or >18.5 g/dL	<11 or >17 g/dL
MCV	<75 or >105 fL	<80 or >100 fL
MCHC	<30 or >36.5 g/dL	<31.5 or >35.5 g/dL
RDW-CV	>22%	>14%
nRBC	Any value	Any value
WBC parameters		
TLC	<4 or >30 × 10^3/µL	<4 or >11 × 10^3/µL
ANC	<1 or >20 × 10^3/µL	<2 or >7 × 10^3/µL
AL	>5 × 10^3/µL	<1 or >3 × 10^3/µL
AM	>1.5 × 10^3/µL	>1 × 10^3/µL
AE	>2 × 10^3/µL	>0.50 × 10^3/µL
AB	>0.5 × 10^3/µL	>0.1 × 10^3/µL
Platelet parameters		
Platelet count	<100 or >1000 × 10^3/µL	<150 or >400 × 10^3/µL
MPV	<5 or >12.5 fL	<7.4 or >11.4 fL
Suspect flags		
WBC suspect flags: IG, left shift, atypical lymphocyte, abnormal lympho/blast and nRBC	Flag	Flag
RBC suspect flags: dimorphic population, fragments?, turbidity /HB interference?, HB defect?	Flag	Flag
Platelet Suspect flags: Platelet clumps, platelet flags (except platelet clumps)	Flag	Flag
(*)	This symbol beside the counts on the AHA read out indicates that automated counts are not reliable	
(-)	This symbol beside the counts on the AHA read out indicates that automated counts are not available for the sample in question	

RBC: Red blood cells; HB: Hemoglobin; MCV: Mean corpuscular volume; MCHC: Mean corpuscular hemoglobin concentration; RDW-CV: Red cell distribution width-coefficient of variation; WBC: White blood cells; ANC: Absolute neutrophil count, nRBC: Nucleated RBC; TLC: Total Leukocyte Count; AL: Absolute lymphocyte count; AM: Absolute monocyte count; AE: Absolute eosinophil count; AB: Absolute basophil count; MPV: Mean platelet volume; ICGHR: International Consensus Group for Hematology Review; IG: Immature granulocyte; AHA: Automated Hematology Analyzer

Table 2: Criteria for a positive smear based on cell morphology and cell type

Parameter	*Cell morphology on peripheral smear*
Based on morphology	
RBC morphology	Anisocytosis ≥2+, Hypochromia ≥2+, Macrocytes ≥2+, Microcytes ≥2+, Elliptocytes ≥3+, Stomatocytes ≥3+, Codocytes ≥2+, Dacrocytes ≥2+, Schistocytes ≥1+, Acanthocytes ≥2+, Dreopanocytes present, Spherocytes ≥1+, Howell-Jolly present, Cabot ring present, Basophilic stippling ≥1+, Rouleaux present, Polychromatophilia ≥2+, RBC agglutination present, HB C crystal present, Hematozoa present
WBC morphology	Döhle bodies ≥1+, Toxic granulations ≥1+, Cytoplasmic Vacuoles ≥1+, Hypersegmented neutrophils, Hyposegmented neutrophils ≥2+, Neutrophil hypo/degranulation present, Auer rod present, Pseudo-pelger-huet present, dysplastic cells present
Platelet morphology	Giant platelets ≥1+, degranulated platelets present, gray platelets present, platelet aggregates present
Based on counts of abnormal cell types	
Blasts	≥1
Metamyelocytes	≥2
Myelocytes /promyelocytes	≥1
Band forms	≥8
Atypical lymphocytes	≥5
Prolymphocytes	≥1
nRBCs	≥1/100 leukocytes
Plasma cells	≥1

RBC: Red blood cells; WBC: White blood cells; nRBC: Nucleated RBC

specificity (%) = (TN/[TN + FP]) × 100, positive predictive value (%) = (TP/[TP + FP]) × 100, negative predictive value (%) = (TN/[TN + FN]) × 100, efficiency (%) = ([TP + TN]/[TP + FP + FN + TN]) × 100 and microscopic review rate (%) = ([TP + FP]/[TP + FP + FN + TN]) × 100. Further statistical analysis was performed using tests of proportion to compare the different performance specifications between both sets of criteria. A value of $P < 0.05$ was considered statistically significant.

RESULTS

Of the total of 860 samples analyzed in this study, 409 samples (47.56%) were positive and 451 samples (52.44%) were negative for the ICGHR review criteria. Out of the total number of samples positive for the review criteria, 341 samples out of 409 (83.37%) had positive smear findings and 68 samples (16.63%) were negative for smear findings. Among the samples that did not trigger any review criteria (451 samples), 374 (82.92%) were truly negative on peripheral smear examination, but 77 out of 451 (17.07%) had positive smear findings. An MRR of 47.56% was observed using the ICGHR review criteria.

Using our laboratory review criteria, 672 out of 860 were positive (78.14%) and 188 were negative (21.86%). Of all the positive samples, 413 samples (61.46%) showed positive smear findings, and 259 samples out of 672 (38.54%) were negative for smear findings. Five samples (2.66%) out of the 188 samples negative for the laboratory review criteria showed positive smear findings, i.e., morphological abnormalities and 183 samples (97.34%) were negative for both our laboratory's review criteria and positive smear criteria. A higher MRR of 78.14% was observed with the use of the laboratory criteria.

The samples that required review were further analyzed according to the criteria triggered, i.e., the total number of triggers for each parameter was analyzed regardless of the other parameters triggered in that sample, to analyze the most common reasons for MSR.

There were a total of 1323 and 3232 positive occurrences using the ICGHR and our laboratory criteria, respectively. The proportions of the commonly triggered criteria with respect to the total number of positive occurrences were then calculated accordingly. With the ICGHR criteria, the suspect flags (522 samples; 39.46%) were most commonly triggered followed by RBC (456 samples; 34.46%), platelet (211 samples; 15.97%), and WBC parameters (134 samples; 10.11%). With our laboratory criteria, the RBC parameters (1245 samples; 38.52%) were the most common causes for positive samples followed by WBC parameters (1073 samples; 33.20%), suspect flags (522 samples; 16.15%) and platelet parameters (392 samples; 12.13%).

The three most common flags triggered contributing to MSR were immature granulocytes (IG) suspect flag (151 samples; 11.41%) followed by mean corpuscular volume <75 fL (117 samples; 8.84%) and platelet flags excluding platelet clumps (117 samples; 8.84%) using the ICGHR criteria and red cell distribution width - coefficient of variation >14% (412 samples; 12.75%), absolute neutrophil count (ANC) >7 × 10^3/μL (315 samples; 9.75%) and hemoglobin <11 g/dL (275 samples; 8.51%) using our laboratory criteria.

The three most common triggers for MSR among the RBC parameters, WBC parameters, platelet parameters and suspect flags are shown in Tables 3. The suspect flags for both the ICGHR and our laboratory criteria were the same but as the total number of positive occurrences in either criteria were different, the proportion of each of the suspect flags responsible for triggering MSR in either criteria were varied.

The "Truth Table" comparing the ICGHR and our laboratory criteria is shown in Table 4. All the parameters obtained from our laboratory criteria were significantly different from the ICGHR criteria with a value of $P < 0.001$.

DISCUSSION

AHAs have undergone impressive development over the past 3 decades. Changes in software along with the introduction of new principles in cell analysis have been foremost in this regard.

Table 3: Three most common parameters triggering MSR by the adapted ICGHR criteria and our laboratory criteria

Adapted ICGHR criteria (total number of positive occurrences=1323)			*Laboratory criteria(total number of positive occurrences=3232)*		
Parameter	*Rule triggered*	***n* (%)**	*Parameter*	*Rule triggered*	***n* (%)**
RBC parameters					
MCV	<75 fL	117 (8.84)	RDW-CV	>14%	412 (12.75)
nRBC	Any value	98 (7.41)	HB	<11 g/dL	275 (8.51)
RDW-CV	>22%	72 (5.44)	MCV	<80 fL	218 (6.75)
WBC and platelet parameters					
MPV	>12.5 fL	114 (8.63)	ANC	>7×10³/µL	315 (9.75)
Platelet count	<100 × 10³/µL	96 (7.26)	TC	>11 × 10³/µL	268 (8.29)
TC	<4 × 10³/µL	49 (3.70)	MPV	>11.4 fL	179 (5.54)

Suspect flags			
Parameter	***n***	*Percentage (ICGHR)*	*Percentage (laboratory)*
IG	151	11.41	4.67
Platelet flags (except platelet clumps)	117	8.85	3.63
Abnormal lympho/blast?	96	7.26	2.97

IG: Immature granulocyte; ICGHR: International Consensus Group for Hematology Review; RBC: Red blood cells; WBC: White blood cells; nRBC: Nucleated RBC; MCV: Mean corpuscular volume; RDW-CV: Red cell distribution width-coefficient of variation; HB: Hemoglobin; MPV: Mean platelet volume; TC: Total WBC count; ANC: Absolute Neutrophil Count

Table 4: The "Truth Table" comparing of performance of the adapted ICGHR criteria with our laboratory criteria

Parameters	*Laboratory criteria*	*Adapted ICGHR criteria*	***P***
TP (%)	48.02	39.65	<0.001*
TN (%)	21.28	43.49	<0.001*
FP (%)	30.12	7.91	<0.001*
FN (%)	0.58	8.95	<0.001*
Sensitivity (%)	98.80	81.58	<0.001*
Specificity (%)	41.40	84.61	<0.001*
PPV (%)	61.46	83.37	<0.001*
NPV (%)	97.34	82.92	<0.001*
MRR (%)	78.14	47.56	<0.001*
Efficiency (%)	69.30	83.14	0.0203*

ICGHR: International Consensus Group for Hematology Review; TP; True positive; TN; True negative; FP: False positive; FN: False negative; PPV Positive predictive value; NPV: Negative predictive value; MRR: Microscopic review rate; *value of $P<0.05$ considered statistically significant.

AHAs provide rapid analysis of the blood samples, they are more precise for cell counts, efficient, reliable, and cost-effective and preferred for counting WBCs, RBCs, and platelets with differential counts of mature forms. For the above reasons, AHAs are now the preferred method for CBC and WBC differentials thereby sidestepping MSR without sacrificing the quality of results.[1] The results produced by the AHAs, however, require validation while analyzing cells with morphological abnormalities as the results are not confirmatory.[4,5,8]

The MSR is an essential diagnostic tool, a gold standard to confirm the morphological assessment of abnormal cells, especially IG, blasts, atypical lymphocytes or cell count (granulocytes and platelets) when the AHAs detect abnormalities, thereby providing a definitive diagnosis. It can also detect or identify cells that the AHA may not be able to classify. On the other hand, examination of the manual smear is tedious, imprecise and time-consuming, labor-intensive and has higher overall laboratory costs when compared to the AHAs, thereby increasing turnaround time.[5,8,9]

The commission on laboratory accreditation of the College of American Pathologists (CAP) recommends that each laboratory should establish certain criteria to determine when to perform MSR following automated blood count analysis.[10] In 2002, Dr. Berend Houwen invited 20 experts to generate internationally acceptable guidelines ("rules") as there were no uniform criteria applied to AHAs for MSR. Dr. Houwen founded the ICGHR and published a set of 41 rules as review criteria for peripheral blood smear review.[1] They also recommended validation of these rules first, before implementing them for use on patient samples.[1,3]

It has however been found that many laboratories have adopted the ICGHR criteria without validation and optimization despite the fact that they are not standardized for use. In order to maximize efficiency, the review criteria should first be validated before use, taking into consideration the following points: The type of facility, laboratory budget, laboratory requirements, instrument model and characteristics, workload and sample volume, number of staff members capable of operating the AHA and carrying out the MSR, rate of review of MSRs, turnaround time and type of patient population in that area.[2,4] Failure to consider the above points before validation and implementation of these criteria may, in fact, lead to an increase in false results or an unnecessary MSR thus leading to an increase in the workload and turnaround time.[4]

The use of the ICGHR criteria in the present study generated an MRR of 47.56%. This is comparable to the MRR of 46.06% as reported by Comar *et al.*,[2] and 54.25% in the study done by Eldanasoury *et al.*,[8] using the ICGHR criteria.

A MRR of 30% has been recommended by the CAP.[10] The MRR using our laboratory criteria was higher (78.14%) than the ICGHR criteria (47.56%) due to a greater number of positive samples (672 samples) out of which 413 samples (61.46%) were TP and 259 (38.54%) were FP.

The type of hospital along with the population attending for healthcare services varies from place to place, and this can lead to differing results with the ICGHR's smear review criteria if they have been introduced without validation.[4] Comar *et al.*[2]

stated that local peculiarities should be taken into account during the analysis of samples with positive smear findings so as not to overlook them. A majority of our patients are from the rural population and although our hospital provides a variety of clinical and laboratory services, most patients tend to present clinically in the late stage possibly due to low socioeconomic status. We have hence found a higher percentage of positive samples which in turn has led to high MRR.

The MRR also depends on the patient composition, i.e., inpatients versus outpatients. This study was conducted on samples from both inpatients and outpatients. Application of delta check rules is another criterion that can lower the MRR.[2,8] Due to limitations in the hospital's instrument and record systems, rules for delta check could not be applied in this study and all the patient's samples were considered first-time samples.

To obtain a comprehensive and effective evaluation of the review criteria, the FN rate is of paramount importance which reveals the effectiveness with which the review criteria can screen samples with positive smear findings, i.e., samples with morphological abnormalities. Barnes *et al.*[1] recommended a maximum acceptable FN rate of 5% to ensure patient safety. FN rate of 0.58% and 8.95% was obtained using our laboratory and the ICGHR criteria, respectively. The threshold cutoffs for our laboratory criteria were more sensitive than the ICGHR criteria which would probably explain the low false negativity of our laboratory criteria [Table 5].

Sireci *et al.*[11] optimized thresholds for WBC flags based on the ICGHR criteria. These optimized criteria, however, missed cases with abnormalities, which would have been flagged by factory default settings. These included myeloid precursors including band count as was the case with the present study. Considering the debatable clinical utility of the band count and limited reproducibility of the atypical lymphocyte count, Sireci *et al.* felt that underreporting of band forms or some cases with increased numbers of atypical lymphocytes was acceptable.

Analysis of FNs also includes looking into whether any hematologic malignancies have been missed. In the study done by Cui *et al.*,[4] two cases of acute leukemia on chemotherapy were missed. Comar *et al.*[2] revealed that one FN sample contained blasts in a case of acute leukemia in their study. Both authors stated that it was unacceptable to miss a case of serious hematologic disease, whether on treatment or undiagnosed. They recommended that each institution evaluate the need to perform MSR in all patients in the hematology unit even at the expense of an increased MRR. There were 5 cases of hematologic malignancy in the present study, and none were missed by either the ICGHR or our laboratory criteria.[2,4]

FP samples are responsible for increasing the MRRs and decreasing the specificity. The FP rate of 30.12% and 7.91% was obtained using our laboratory and the ICGHR criteria, respectively. The difference in the parameters causing false positivity for the ICGHR and our laboratory criteria can be explained by the fact that the threshold cutoffs for all the parameters were not the same for both sets of criteria [Table 5]. The cutoffs for our laboratory criteria were more sensitive than the ICGHR criteria.

Table 5: Causes for FP and FN occurrences with the adapted ICGHR criteria and our laboratory criteria

FN		
Smear findings	*ICGHR criteria*	*Laboratory criteria*
	***n* (%)**	***n* (%)**
Total number of RBC abnormalities	46 (35.38)	0
Anisocytosis	11 (8.46)	0
Hypochromia	20 (15.38)	0
Macrocytosis	8 (6.15)	0
WBC abnormalities	70 (53.85)	1 (20)
Toxic changes (toxic granules, toxic vacuolations, Döhle bodies)	50 (38.46)	0
Hypersegmented neutrophils	5 (3.85)	0
Myelocytes, metamyelocytes, band forms	14 (10.77)	0
Platelet abnormalities - platelet clumps	14 (10.77)	4 (80)
Total number of FN samples	77 (8.95)	5 (0.58)
FP		
Criteria	***n* (%)**	
ICGHR criteria (total number of FP occurrences=88)		
Abnormal lymphocyte/blast flag	23 (26.14)	
IG suspect flag	15 (17.05)	
MPV <5.0 fL or >12.5 fL	7 (7.95)	
Laboratory criteria (total number of FP occurrences=742)		
ANC<2 or >7 × 10^3/μL	125 (16.85)	
TC<4 or >11 × 10^3/μL	100 (13.48)	
RDW-CV >14%	96 (12.94)	

FP: False positive; FN: False negative; IG: Immature granulocyte; ICGHR: International Consensus Group for Hematology Review; RBC: Red blood cells; WBC: White blood cells; MPV: Mean platelet volume; TC: Total count; ANC: Absolute Neutrophil Count; RDW-CV: Red cell distribution width-coefficient of variation

Hematology analyzers use suspect flags to notify the user that the automated differential WBC count may not be correct and requires review. Eldanasoury *et al.*[8] showed that suspect flags were responsible for 60.2% of their FP results using the ICGHR criteria. This indicated that the hematology analyzers used were guilty of over flagging, i.e. they gave more warnings than necessary thus responsible for an increase in unnecessary MSR. The same was the case with the present study where the suspect flags alone were responsible for 59.09% of FP results with the ICGHR criteria. Our laboratory criteria, however, showed that 7.01% of the FP results were due to suspect flags indicating that triggers from the other parameters were responsible for the majority of the FP samples. This point again emphasizes the downside of having strict threshold cutoffs, as with our laboratory criteria, which of course have greater sensitivity but at the cost of a higher MRR.

As the sensitivity of the suspect flags is adjusted by technicians of the hematology analyzer's manufacturer, Comar *et al.*[2] suggested that each laboratory should first evaluate the efficiency of each suspect flag from the analyzers and then make proper adjustments

to the sensitivity of the hematology analyzer or define whether a suspect flag is actually useful as a screening criterion.

In the same line of thought, Kim *et al.*[5] stated that the rates of slide review have distinct characteristics among the studied analyzers and that individual laboratories should consider selecting the most appropriate analyzer in accordance with clinical characteristics including clinic size and patient population. In the present study, however, as only one analyzer was used, the above aspect could not be reviewed.

The sensitivity using our laboratory criteria (98.80%) was much higher than the specificity (41.40%). This may be in view of the high MRR (78.13%) using our laboratory criteria. The sensitivity using the ICGHR criteria in their study was, however, lower than the specificity and accordingly, the MRR was lower (47.56%).

The greatest modification made to the ICGHR criteria in the present study was regarding the delta check rules. These rules are important for the efficiency and reliability of the CBC results directly released without an MSR. Due to high software development costs, many clinical laboratories cannot implement the delta check rules in their electronic records or interfacing systems.

CONCLUSIONS

In the present day and scene where the sophistication of the AHAs is only improving with the launch of every new analyzer, it is essential for clinical laboratories to consider methods for reducing the number of MSRs to improve their productivity and efficiency.

The ICGHR criteria are ideal to decrease the number of MSRs in the clinical laboratory. Although our laboratory criteria performed better with regard to sensitivity and negative predictive value, it came at the expense of a very high MRR which in turn may lead to decrease in laboratory productivity and increase in the turnaround time. Therefore, development of optimized criteria based on the ICGHR criteria followed by their validation will improve turnaround time and efficiency in our laboratory.

It is therefore advisable for all laboratories to develop their own criteria for smear review. These laboratory criteria can be based on the criteria established by ICGHR but should be verified before adoption or optimized to be suitable for different requirements. Manual microscopic examination of a stained blood film complementing automated analysis can help to validate these established criteria and thus improve the accuracy.

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Conflicts of interest

There are no conflicts of interest.

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