How Useful Are CBC and Reticulocyte Reports to Clinicians?

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Abstract
We surveyed 1,353 attending and 689 house staff physicians of the University Hospitals of Cleveland to ascertain the parameters of the CBC, leukocyte differential, and reticulocyte reports perceived as useful in clinical practice. The response rate was 33% for attending and 22% for house staff physicians. Only 4 of 11 parameters routinely reported in the CBC battery were selected as frequently or always useful by more than 90% of physicians: hemoglobin, hematocrit, platelet count, and WBC count. Among primary care physicians, the mean cell volume also attained this level of usefulness for the evaluation of anemia. There were no differences between academic physicians and community physicians in the use of RBC indices; however, physicians who had been in practice for fewer than 10 years indicated higher use of the red cell distribution width than physicians practicing for more than 10 years. Most physicians prefer differentials reported as percentages rather than absolute counts. Among physicians who monitor reticulocyte counts, the immature reticulocyte fraction is not widely used. Our results indicate that many physicians do not use much of the data provided in routine CBC/differential and reticulocyte reports. Some modifications of report formats may facilitate physician perception of hematology laboratory results.

The CBC count, leukocyte differential count, and reticulocyte count are time-honored hematology laboratory tests with demonstrated clinical usefulness. Originally performed by manual methods, these tests are gradually being supplanted by automated technology. Concurrent with these changes in methods, laboratory computerization has emerged and dramatically changed the way in which laboratory results are reported and transmitted to clinicians. As a consequence of these dynamic changes in laboratory hematology, CBC, differential, and reticulocyte count reports have tended to become longer and more complicated. Factors that may contribute to the report complexity are the following: (1) long-standing traditions in laboratory hematology, (2) the routine inclusion of more hematologic parameters and indices that are produced by automated hematology analyzers, and (3) the belief that more is better. As a result, many physicians might be receiving more data than they want or find useful for the management of their patients. Although speculative, it is conceivable that excess data that are not useful to clinicians might actually impede their perception and comprehension of essential data and contribute to errors in medical judgment.

The purpose of this study was to ascertain which components of the CBC, differential, and reticulocyte count reports issued by the Core Laboratory of the University Hospitals of Cleveland (UHC), Cleveland, OH, are perceived as useful in clinical practice. Understanding the clinical usefulness of laboratory data might suggest changes in laboratory report design and lead to more effective communication of laboratory information to clinicians.
Materials and Methods

The components of the UHC CBC/differential reports are listed in Table I. Reticulocyte count reports include the reticulocyte percentage; reticulocyte absolute count; the low, medium, and high fluorescence fractions; and the immature reticulocyte fraction (IRF), which is the sum of the medium and high fractions. We designed a survey that asked physicians to rate the usefulness of each component of the CBC/differential and reticulocyte count reports for patients with anemia or quantitative abnormalities of platelets or WBCs. We used a 5-point Likert scale, ranging from “never useful” to “always useful” as the response categories. Physicians also were asked to select their preferences for differential and reticulocyte reports, indicate the way in which they most frequently retrieved laboratory results, and provide their opinion about the amount of data contained in the CBC/differential count reports (“too little, too much, or just right”). Physician variables included medical specialty, years in practice, and primary practice affiliation. The survey, designed in Microsoft Word (Microsoft, Redmond, WA), was a multicolored, 1-page, 2-sided form with check boxes for each of the response categories. Surveys were mailed to the entire attending physician staff of UHC with a cover letter that explained the purpose of the survey and was signed by the Director of the Hematology Laboratory (L.M.S.) and the vice-president of the Quality Center. A stamped, addressed return envelope was included with each survey. House staff surveys were distributed through the interdepartmental mail system with the same cover letter and return envelopes.

The study population consisted of the 1,353 attending physician staff and 689 house staff physicians of the UHC. Attending physicians included full-time faculty of the Case Western Reserve University School of Medicine, Cleveland, OH, and community-based physicians in private practice. The survey results were analyzed in Microsoft Excel (Microsoft). Frequency distributions were done, and the chi-square test was used to determine whether there were statistically significant differences in response patterns between groups.

Results

A total of 447 attending physicians responded to the survey, representing an overall response rate of 33%. Of the respondents, 50% identified themselves as full-time academic faculty and 34% as members of university-affiliated private practice groups; 16% did not identify their practice affiliation. The departments of pediatrics and internal medicine accounted for 67% of the respondents (37% and 30%, respectively), with the departments of family medicine, obstetrics and gynecology, and surgery contributing another 23% of total respondents. For house staff physicians, the overall response rate was 22%, with similar representation by departments.

The reported usefulness of CBC parameters for attending physicians is shown in Table II. Only 4 of the 11 parameters in the CBC battery were selected as frequently or always useful by more than 90% of physicians: hemoglobin, for each of the response categories.
hematocrit, platelet count, and WBC count. Among primary care physicians, the mean cell volume (MCV) also attained this level of usefulness in the evaluation of anemia. Overall, pediatrics gave higher ratings to more components of the CBC battery than did other practitioners. There were no apparent differences between full-time academic faculty and community practitioners in their ratings of erythrocyte and reticulocyte parameters. The responses for house staff physicians were similar to those of attending physicians (data not shown), with one difference: 44% of attending physicians rated the red cell distribution width (RDW) as very useful, in comparison with 60% of house staff physicians ($P < .01$).

Among attending and house staff physicians in nonsurgical specialties, the comments about erythrocyte morphologic features were consistently rated as more useful than the RBC, mean cell hemoglobin (MCH), mean cell hemoglobin concentration (MCHC), and RDW parameters.

The usefulness ratings for the differential expressed as percentages or absolute counts and physician preferences for differential reports are shown in Figure 1. It is clear that both attending and house staff physicians find percentage differentials more useful than absolute differentials. About one half of all physicians stated that they would like the report to include both the percentages and the absolute counts. However, a substantial proportion (41%) would prefer to eliminate the absolute differential in favor of reporting only the percentage differential. There was no identifiable group of physicians who preferred absolute differentials to percentage differentials.

Physician preferences for the reporting of reticulocyte results are shown in Figure 2. The majority of attending and house staff physicians who monitor the reticulocyte count prefer only the reticulocyte percentage and absolute number. A subset analysis by specialty indicated that 8 (40%) of 20 pediatric hematologist-oncologists and hematologist-oncologists who treat adults and 2 (33%) of 6 nephrologists would like to have the IRF included in the report. The IRF usefulness rating was highest among house staff physicians (44%).

At UHC, the laboratory information system (LIS) is interfaced with the hospital information system and a patient care information system, all of which are accessible to clinicians for retrieval of laboratory results. Chart copies are printed at the inpatient nursing stations and charted daily. Hard copies are mailed or delivered directly to physician offices. The survey asked physicians to indicate the way in which they most frequently retrieve CBC results. Of the house staff physicians, 90% reported that they most frequently retrieve results from the main hospital information system or the patient care information system. In contrast, 62% of attending physicians used hard copies most often, while only 38% regularly accessed 1 of the 3 available computer systems for laboratory data. Use of the LIS by both attending and house staff physicians as the primary source of laboratory results was negligible.

### Discussion

Physicians are notoriously difficult to survey. The response rates of 33% for attending physicians and 22% for house staff physicians, while low, are encouraging, and suggest that mailed surveys may be a feasible approach for exploring physician preferences and laboratory utilization patterns. This survey succeeded in identifying several patterns of CBC, differential, and reticulocyte count use that might influence the design of computerized laboratory reports. The inclusion of academic and community-based physicians in the study contributes to the generalizability of the results.

### RBC Indices

Across all physician specialties, the self-reported use of RBC, MCV, MCH, MCHC, and RDW data indicated that MCV is regarded as the single most useful erythrocyte index in the evaluation of anemia. There was little variation among physicians in their relatively low use of RBC, MCH, and MCHC data. In laboratory practice, MCH and MCHC values have found their greatest usefulness in longitudinal quality control and seem to contribute little to the clinical evaluation of anemia.¹

The RDW, which is the coefficient of variation of the MCV, represents the degree of size variation (anisocytosis) in the erythrocyte population.² The usefulness of the RDW showed the greatest variation among attending physicians: 70% of pediatricians reported that they find this index frequently or always useful in the differential diagnosis of anemia, in comparison with 44% of internists and 18% of surgeons. The differences in RDW ratings between specialties may be due to different practice patterns and patient populations. At UHC, pediatricians frequently are engaged in the evaluation of microcytic anemia in an ethnically

### Table

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<th>Comments on Morphologic Features</th>
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<th>WBC Count</th>
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diverse patient population with a high prevalence of iron deficiency, thalassemia, and hemoglobinopathies. The RDW has demonstrated usefulness in the differential diagnosis of microcytic anemia in this context. Internists are less frequently involved in the differential diagnosis of congenital anemias. Surgeons are the least likely to be engaged in the differential diagnosis of anemia, since generally their main interest in the CBC is to determine the hematologic stability of their patients. More house staff and attending physicians who had been in practice for fewer than 10 years rated the RDW as sometimes, frequently, or always useful, in comparison with attending physicians in practice for longer than 10 years (78% vs 55%; \( P < .001 \)). Recently trained physicians may have a better understanding of the usefulness of this index than many physicians who have been in practice for some time, some of whom received their training before the RDW was routinely available.

An unexpected finding was the relatively high usefulness rating that both internists and pediatricians gave to the comments about RBC morphologic features. These comments are notoriously difficult to standardize, yet it seems that many clinicians rely more on a subjective description of RBCs than on objectively measured RBC indices. This response pattern suggests that many physicians prefer an interpretive comment, such as “hypochromic microcytic anemia,” to a list of numeric indices. Current laboratory practice standards require that a review of erythrocyte morphologic features be performed whenever a peripheral blood smear is reviewed for a WBC differential count. However, the goal of hematology automation is to minimize the performance of microscopic peripheral smear reviews, which also will reduce the frequency of comments about RBC morphologic features in CBC reports.

**Reticulocyte Counts**

The IRF represents the proportion of young reticulocytes with the highest RNA content. The IRF can be derived from automated reticulocyte counts that are based on flow cytometric determination of erythrocyte RNA content. An elevated proportion of immature reticulocytes is an early indicator of increased erythropoietic response in the bone marrow and may precede a measurable increase in the absolute reticulocyte count. Our survey results indicate that 77% of attending physicians who order reticulocyte counts use only the reticulocyte absolute number and percentage. Academic and nonacademic physicians did not differ in their use of the IRF. Nephrologists and hematologist-oncologists might be expected to find the IRF useful, because their patients are the most likely to be recovering from bone marrow suppression or receiving erythropoietin, clinical circumstances in which the IRF has predictive value for hematologic recovery. Yet, among internal medicine and

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**Figure 1** Frequency distributions for physician usefulness ratings for WBC differential counts in percentages (A) and absolute counts (B) and physician preferences for reporting of WBC differential counts (C). White bars, house staff; black bars, attending physicians.
pediatric physicians, only 40% of hematologist-oncologists (8/20) and 33% of nephrologists (2/6) indicated that they would like the reticulocyte reports to include the IRF.

There are several possible reasons that the IRF has not been embraced widely by clinicians. First, the IRF is available only in laboratories that have automated reticulocyte analyzers, and not all laboratories that use automated analyzers report the IRF.11 Second, the reference ranges are not standardized across different analyzers, which makes it difficult for clinicians to become “fluent” in interpreting IRF results.12-14 Another possible explanation relates to the time-limited contribution of this reticulocyte index. The reticulocyte count and IRF are both useful predictors of hematologic recovery in a subset of patients for a brief window of time, after which changes in the hemoglobin or hematocrit levels can be monitored and are easily interpreted.

WBC Differential Counts

Historically, the WBC differential count was based on a 100-cell microscopic count and reported in percentages. Correct interpretation of the differential count requires calculation of absolute counts by multiplying the percentage of each cell type counted by the total WBC count. In contrast, automated hematology analyzers enumerate thousands of WBCs and calculate percentages from the absolute numbers. Failure to convert WBC percentages into the absolute cell counts can result in misinterpretation of abnormalities in the relative cell proportions. For example, a reversal of the neutrophil/lymphocyte ratio can be misinterpreted as lymphocytosis, when in fact the patient is neutropenic. To facilitate the correct interpretation of the differential count, many laboratories, including our own, began reporting both percentages and absolute cell counts, adding length and complexity to the report. Some laboratories report only the absolute WBC counts.15 The physicians who responded to our survey expressed a strong preference to continue the reporting of differentials in percentages. One possible explanation for this preference is that it is easier to conceptualize relative proportions of cells than absolute cell counts per unit volume. Most physicians have reviewed blood smears and have performed a microscopic 100-cell differential count at some point during their training and may be able to translate the visual perception of leukocytes dispersed on a slide into proportions. It is more difficult to remember reference ranges for absolute cell counts and then mentally perform the reverse operation of converting these values into proportions.

Platelet Indices

Platelet indices generated by automated hematology analyzers include the mean platelet volume (MPV) and the platelet dispersion width (PDW), which is analogous to the RDW for erythrocytes.16 The UHC Core Laboratory reports the MPV but not the PDW. Our survey indicates that the MPV is the least useful index reported in our CBC. The MPV is an indicator of the size distribution of platelets (analogous to the MCV), and was introduced into laboratory and clinical hematology as a potentially useful index in the differential diagnosis of thrombocytopenia. The MPV is directly correlated with the rate of platelet production and, on this basis, was proposed as a discriminator of consumptive vs hypoproliferative thrombocytopenias.16 However, the contribution of the MPV to clinical practice has been disappointing, as confirmed by our survey. Overall, 14% of attending physicians and 33% of house staff physicians reported that they find the MPV frequently or always useful in evaluating quantitative abnormalities of platelet counts. Only 20% of hematologist-oncologists (4/20) rated this index as frequently or always useful in the evaluation of quantitative abnormalities of platelets, while 60% (12/20) rated it as rarely or never useful. A flow cytometric method for measuring reticulated platelets, analogous to reticulocytes, has been developed and shows promise as a more specific indicator of platelet regeneration.17-20 The measurement of this platelet index has not been standardized or integrated into automated hematology analyzers, and so it is too early to know whether it will become widely available and embraced in clinical practice.

Implications for Clinical Laboratory Practice

Clinical laboratories should produce results and laboratory reports that are useful to clinicians. The results of this study suggest that much of the data that are typically reported in a routine CBC/differential count report are not...
used by a substantial proportion of physicians. This conclusion raises questions about the overall usefulness of hematology laboratory reports as they are currently constructed. Should these reports continue to include all of the traditional parameters, some of which have limited usefulness to a minority of physicians? Approximately one third of UHC physicians believe that the CBC reports contain too much information, while two thirds believe that the reports contain just the right amount of information. These survey results would not seem to justify deleting any of the data currently reported in our CBC/differential count reports. On the other hand, modifying the format in which the data are provided might help some clinicians find the information that they are looking for more efficiently.

Laboratory report design often is determined more for ease of data entry than for data retrieval. Investigators in the field of medical informatics have observed that physicians tend to skim reports while continuously making assessments of data relevance. Others have shown that information density has a consistent effect on the accuracy of laboratory data retrieval from computer screens. As information density increases, search time lengths and accuracy decreases. On the other hand, decision making is faster and less error-prone if all the data needed to support a decision can be viewed on a single page. Changing the reporting order of the CBC components, so that the parameters that all physicians find useful are given at the beginning of the report, might facilitate perception of essential CBC data by eliminating the need to scroll through the entire report to find essential data. Alternatively, a hierarchical report could be designed in which the essential CBC/differential data are displayed on the initial screen, and a toggle key could “bridge” to a second screen that displays the supplemental data. Ideally, LIS software could be designed to support customized CBC/differential reports for different physician user groups, based on their needs and preferences.

The study also has implications for the selection and implementation of new laboratory hematology instrumentation. In recent years, technologic advances in automated hematology technology have led to the development of more hematologic parameters that are generated by analyzers but are not yet routinely reported. Many laboratory professionals believe that physician education about the usefulness of these new parameters is the key to their acceptance into clinical practice. However, the results of this survey clearly demonstrate that several CBC parameters that have been around for a long time are rarely used by many clinicians, despite extensive medical education and abundant literature about their usefulness. Laboratory data must be interpreted in the context of a patient to be clinically useful. The fact that a parameter or index is available does not necessarily mean that it should be reported routinely, particularly if clinicians are not sufficiently prepared or motivated to interpret the results for individual patients. On the other hand, a parameter that is occasionally useful to a minority of clinicians, but has demonstrated clinical validity in a subset of patients, should be available to clinicians and included in the patient’s record. The design of effective laboratory reports should include consideration of clinician preferences, patient population, and the capabilities of the laboratory and hospital information systems.

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References


