Red cell distribution curves are an integral part of RBC automated hematology analysis and are available on virtually all automated hematology analyzers. Normal RBC curves have a tight distribution around a mean MCV of about 89fL. Routine measurements of the variation around this mean can be generated and these are known as the Red Cell Distribution Width (RDW) parameters. Many Beckman Coulter instruments have provided the RDW (also known as the RDW-CV for years). An additional parameter, the RDW-SD, is introduced on the COULTER® LH 780.

Essentially RDW (RDW-CV) is meant to represent an indication of the amount of variation (anisocytosis) in cell size present in a patient sample. Beckman Coulter, with the aid of Dr. JD Bessman, pioneered much of the early work on usefulness of the RDW and classification of red cell disorders.

Red Cell Distribution Width (RDW) - The RDW is the most commonly reported index of the variation or degree of anisocytosis in cell volume within the red cell population. It is a parameter provided by both impedance and flow cytometric analyzers and is directly calculated from the RBC histogram. Mathematically, it is the coefficient of variation, i.e. RDW (CV)% = 1SD/MCV x 100%

RDW = (One Standard deviation of red cell volume ÷ mean cell volume) x 100 and is reported as a %.

The RDW may also be known as the RDW-CV on other instruments.

The normal value for RDW (CV) is 11% - 14.5%. The RDW (CV%) Reference (normal) range recorded in the COULTER® LH 750 on-line help is 12.09 to 15.19% and represents 131 male/females. The selection of donors was consistent with guidelines stated in CSLI, C28.A.
The RDW-SD is measured by calculating the width in fl at the 20% height level on the RBC curve.

The normal value for RDW-SD is reported in some studies to be 39-47 fl in adults (Walters JL et al.), however, information on normal values in children is not available.

$\text{RDW-SD}$

![Diagram of RDW-SD](image)

$f \text{ Scaling (Red histogram channel resolution)} = 1.3125 \text{ fl/channel}$

Figure 1. Calculation of RDW SD

The normal value for RDW-SD is reported in some studies to be 39-47 fl in adults (Walters JL et al.), however, information on normal values in children is not available.

![Diagram of RDW-CV](image)

$\text{RDW-CV} = 15D \times 100 \text{ MCV}$

Figure 2. Calculation of RDW (RDW – CV)
Notes on RDW SD and CV

- The calculation is performed for each red cell histogram
- Voting is performed on the three values
- After voting, the results are averaged
- Flagging for RDW SD will be the same as current LH 750 RDW

The flags are:

- No Flag
- RDW-25 flagged
- Algorithm RDW
  R flag due to secondary population exceeding threshold

RDW SD is a parameter which has been cleared for *in vitro* diagnostic use.
Comparison of the results to the predicate method was excellent.
Classification of Disorders using RDW (CV) and MCV

In the early 1980s Dr. J. David Bessman compiled a classification table of possible disorders based on MCV and RDW values (see Table 1 below).

Although not diagnostic nor an exhaustive list, it is a useful initial guide for further investigations. Although there have been no third party published grids on RDW-SD versus MCV, it is likely that the grid would be similar to RDW vs. MCV as shown in Table 1.

Other Classifications of RBC Disorders using RDW Associated Parameters

Over the years, a number of discriminant functions based on the use of the RDW and other RBC parameters have been proposed. A recent review by Demir A, et al., showed that none of the discriminators has 100% sensitivity and specificity for discrimination between Thal Minor and Iron Deficiency in particular (See abstract in Appendix A). As implicated by this abstract, any discriminators utilizing the RDW and RDW-SD for diagnosis of disease should be used with caution and are useful only as a guide, i.e., not diagnostic. This includes the England, Mentzer indexes.

A report by Bartels et. al., showed that by utilizing a complicated formula involving RDW-SD, RBC count, Retic count and Zinc protoporphyrin levels, 90% of subjects with Iron Deficiency and Heterozygote Thalassemia can be accurately classified. Again this algorithm was shown to be unsatisfactory for diagnostic purposes but should be used as a guide only.

Another study by Lin, et al., found that a low RDW SD might have value in differentiating between iron deficiency anemia and thalassemia trait patients.

Table 1. Classification based on RDW (CV) and MCV (Bessman JD et al.)

<table>
<thead>
<tr>
<th>Low MCV RDW Normal</th>
<th>Low MCV RDW High</th>
<th>Normal MCV RDW Normal</th>
<th>Normal MCV RDW High</th>
<th>High MCV RDW Normal</th>
<th>High MCV RDW High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thalassemia Minor</td>
<td>Iron Deficiency</td>
<td>Normal Regeneration</td>
<td>Refractory Anemia</td>
<td>S12, Folate Deficiency</td>
<td></td>
</tr>
<tr>
<td>Anemia Chronic Disease</td>
<td>Hbs/Thal HgbH</td>
<td>Renal Chemotherapy</td>
<td>Early Iron Def.</td>
<td>Preleukemia</td>
<td>AIHA</td>
</tr>
<tr>
<td>Normal Children (1-6 yrs)</td>
<td>Fragment Anemias (MAH)</td>
<td>Aplasia</td>
<td>Heterozygote Hemoglobinopathy (AS, AC)</td>
<td>Sideroblastic</td>
<td>Liver Disease</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Acute Blood Loss</td>
<td>Hemolysis - G6PD</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Classification based on RDW (CV) and MCV (Bessman JD et al.)
Grading of Anisocytosis

Another proposed use of RDW SD is similar to RDW – grading of anisocytosis, but without the impact of MCV on the calculation.

Figure 4. At an MCV of 65 fL, the RDW-SD is increased at 52 fL. The RDW-CV is markedly elevated at 21.2%. Note moderate degree of anisocytosis

Figure 5. At an MCV of 90 fL, the RDW-SD is 52 fL and the RDW (CV) is 15.3% indicating a moderate degree of anisocytosis
Figure 6. The MCV is 115 fL with an RDW-SD of 52 fL indicating presence of anisocytosis. The RDW (CV) is 12%. The smear is typical of a megaloblastic anemia.

- Because the RDW-SD is a direct measure across the RBC histogram, it is “theoretically” a better and more accurate measure of RBC anisocytosis across the entire spectrum of MCV values.
- The RDW (CV) shows better correlation according to published reports as an indicator of anisocytosis if the MCV is in the normal range when anisocytosis may be difficult to detect.
References


Appendix A


Background: Iron deficiency anemia (IDA) and thalassemia trait (TT) are the most common forms of microcytic anemia. Some discrimination indices calculated from red blood cell indices are defined and used for rapid discrimination between TT and IDA. However, there has been no study carried out in which the validity of all of the defined indices are compared in the same patient groups. Youden’s index is the most reliable method by which to measure the validity of a particular technique, because it takes into account both sensitivity and specificity. METHODS: We calculated eight discrimination indices (Mentzer Index, England and Fraser Index, Srivastava Index, Green and King Index, Shine and Lai Index, red blood cell (RBC) count, red blood cell distribution width and red blood cell blood distribution width index (RDWI)) in 26 patients with IDA and in 37 patients with beta TT (betaTT). We determined the number of correctly identified patients by using each discrimination index. We also calculated sensitivity, specificity, positive and negative predictive value and Youden’s index of each discrimination index. RESULTS: None of the discrimination indices showed a sensitivity and specificity of 100%. Youden’s indices of RBC count and RDWI were the highest with the value of 82 and 80%, respectively Ninety percent and 92% of the patients were correctly identified with RBC and RDWI, respectively. CONCLUSIONS: Red blood cell count and RDWI are the most reliable discrimination indices in differentiation between betaTT and IDA.