The White Blood Cell (WBC) count is a very important hematological parameter produced on a hematocrit analyzer. On Beckman Coulter’s UniCell DxH 800 Analyzer, the WBC count is computed in a double aperture, measurement channel in which the volume of WBC is proportional to the change of impedance measurement due to displacement of electrolyte in the electrical zone of an orifice tube.

On the UniCell DxH 800 Analyzer, the traditional method for WBC counting can be augmented with data from the two VCS modules: NRBC and Differential. These modules are designed to utilize multiple optical signals as well as DC and RF impedance signals to distinguish and count dispersed and non-dispersed white blood cells.

The NRBC and Differential modules are optimized to separate interference from the white blood cells with the power of multi-dimensional pattern recognition technology (MDPRRT). Using the data from each module and the Coulter WBC count, the optical WBC counts can be used to improve instances when the impedance-based WBC encounters severe interference.

A statistical study shows that the coefficient of correlation between the impedance-based WBC count and new optical WBC counts are as high as 0.98. Furthermore, a variety of case studies demonstrate the benefits of the new optical WBC counts in various situations.

The UniCell DxH 800 Analyzer manufactured by Beckman Coulter is a quantitative, automated hematocrit analyzer for in vitro diagnostic. The UniCell DxH 800 Analyzer provides [1]

- Complete Blood Count (CBC)
- Hemoglobin (Hb, Hematocrit, MCH, MCHC, MCV, RDW, Hct, MCHC, MCV, RDW)
- Leukocyte (5 Part Differential (Diff))
- Reticulocyte (Retic)

Among the above clinical parameters, the WBC count is a key parameter that measures the number of white blood cells, a.k.a. leukocytes, per unit volume. The white blood cells are named after the buffy coat after centrifugation of a blood sample. They are usually categorized into different types depending on the presence of granules and internal structure. The most common types of white blood cells are Neutrophils (The band forms B cells and T cells), Monocytes, Eosinophils, and Basophils.

The white blood cells are key players of human body’s defense system to defend the body against both foreign organisms and infectious disease. Therefore, the number of the white blood cells in blood circulation is an important indicator of human body’s health. The normal range of the WBC count for healthy adults is between 4,000 to 10,000 cells / mm³. If the white blood cell count is above the normal range, it may indicate infection, acute inflammation, uric, leukemia, pregnancy, and so on. If the white blood cell count is below the normal range, it may imply viral infection, some drug use, chemotherapy, lupus, cirrhosis of liver, and so on.

The UniCell DxH 800 Analyzer provides an improved method for red blood cell count in the CBC module using the Coulter Principle, which was described by W.H. Coulter in [2]. As illustrated in Figure 1, each blood cell, which is considered as an insulator to direct current (DC), passes through a small structure submerged in a liquid, producing a corresponding DC signal. The surface of blood cell behaves as conductors to high-frequency current so that the conductivity signal is able to penetrate the cell surface and probe internal structure of the blood cell.

Optical WBC Counts from Beckman Coulter’s UniCell® DxH™ 800 Coulter® Cellular Analysis System

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Abstract

The White Blood Cell (WBC) count is a very important hematological parameter produced on a hematocrit analyzer. On Beckman Coulter’s UniCell DxH 800 Analyzer, the WBC count is computed in a double aperture, measurement channel in which the volume of WBC is proportional to the change of impedance measurement due to displacement of electrolyte in the electrical zone of an orifice tube.

On the UniCell DxH 800 Analyzer, the traditional method for WBC counting can be augmented with data from the two VCS modules: NRBC and Differential. These modules are designed to utilize multiple optical signals as well as DC and RF impedance signals to distinguish and count dispersed and non-dispersed white blood cells.

The NRBC and Differential modules are optimized to separate interference from the white blood cells with the power of multi-dimensional pattern recognition technology (MDPRRT). Using the data from each module and the Coulter WBC count, the optical WBC counts can be used to improve instances when the impedance-based WBC encounters severe interference.

A statistical study shows that the coefficient of correlation between the impedance-based WBC count and new optical WBC counts are as high as 0.98. Furthermore, a variety of case studies demonstrate the benefits of the new optical WBC counts in various situations.

Methods

The COULTER VCS technology, as shown in Figure 3, is applied on the UniCel DxH 800 Analyzer in three VCS modules, NRBC, Diff, and Ratio. Three types of signals are measured by the VCS technology in each module:

- DC signal. This signal measures DC resistance of the blood cell, which correlates with the volume of the blood cells.
- Conductivity signal. The surface of blood cell behaves as conductors to high-frequency current so that the conductivity signal is able to penetrate the cell surface and probe internal structure of the blood cell.
- Optical signals. Laser and optical sensors are configured to measure the light scatterers in several angles and the light loss due to scotopia and absorption. These signals reflect the size of the blood cells as well as the reflectivity of the blood cells.

Seven parameters are collected in each VCS module. They are DC, RF (conductivity), Axial Light Loss (ALL), Low Angle Light Scatter (LALS), Lower Median Angle Light Scatter (LMALS), Upper Median Angle Light Scatter (UMALS), and Median Angle Light Scatter (MALMS), as shown in Figure 3. Then multi-dimensional pattern recognition technology (MDPRRT) is applied in each VCS module to remove unwanted interference and gate desired blood populations. For example, three key parameters in the Diff modules, DC, OP (normalization factor), and MALMS, determine the primary space to perform intelligent gating. The gated populations are displayed in different colors in two major two-dimensional histograms, as shown in Figure 4 for the Diff module. Similarly, a sophisticated analysis is performed to select high-dimensional space in the NRBC module as well and gated populations are displayed in different colors in two major NRBC histograms, as shown in Figure 5.

In both NRBC and Diff modules, the white blood cells are gated from interference, including unlysed red blood cells, debris, and cellular clumps and so on. Thus it is possible to calculate WBC counts from both NRBC and Diff modules. The WBC count is defined as the number of white blood cells per unit volume as described in Eq. (1).

\[
\text{WBC Count} = \frac{N \cdot \text{Volume}}{\text{Acquisition Time}} \quad \text{(1)}
\]

where \( N \) is the number of white blood cells acquired for the given sample. Eq. (1) can be rearranged as Eq. (2) for implementation.

\[
\text{WBC Count} = \frac{N}{\text{Acquisition Time}} \cdot \text{Flow Rate} \quad \text{(2)}
\]

Figure 1. Coulter Principle – impedance WBC count [1]