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ORIGINAL ARTICLE

DERIVATION OF BLOOD HEMOGLOBIN CONCENTRATION FROM HEMATOCRIT: A SIMPLE METHOD FOR RURAL AREAS

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Abstract

Background-**Hematocrit and red blood cell count can be easily measured with an acceptable accuracy in most rural health care centers.**

Methods-**A linear regression analysis was performed on the hemoglobin (dependent variable) and hematocrit (independent variable) levels of 22 patients with isolated iron-deficiency anemia, 26 known cases of isolated β-thalassemia trait, and 25 normal individuals.**

Results-**It was found that the mean corpuscular hemoglobin concentration (MCHC) has an almost constant value of 33 g/dL in the three conditions studied. The relative error was below 3% in determining the Hb concentration from hematocrit among normal people and patients with either iron deficiency or minor β-thalassemia.**

Conclusion-**Using this finding, we tried to explain how to derive other important hematological indices, i.e. blood hemoglobin level, mean corpuscular volume, and mean corpuscular hemoglobin from hematocrit and red blood cell count, with an acceptable accuracy in the situations studied. This could be considered as a useful method to determine blood hemoglobin concentration in rural health care centers without recouse to Coulter analyzers.**

Keywords • Hemoglobin • hematocrit • mean corpuscular volume • mean corpuscular hemoglobin • mean corpuscular hemoglobin concentration

Introduction

It is well known that blood hemoglobin (Hb) concentration and hematocrit (Hct) vary in proportion to one another in several clinical situations.[1] As a consequence, the question arises as to whether routine measurement of both Hb concentration and Hct is necessary.

Iron-deficiency anemia and β-thalassemia trait are the most common clinical conditions associated with microcytic hypochromic anemia.[2] Since the measurement of Hct is very simple, the current study was conducted to determine whether blood Hb level can be derived from Hct in those with iron-deficiency anemia, in β-thalassemia minor patients, and in normal individuals.

Materials and Methods

The study group included 22 patients with isolated iron-deficiency anemia and 26 known cases of isolated β-thalassemia minor. Peripheral blood samples taken from the patients were collected in ethylene diamine tetra-acetic acid (EDTA) tubes and analyzed by a Coulter analyzer (Model T890, USA). Samples from 25 more individuals were also included in this study. They were apparently healthy people who attended our center for a routine checkup and had a normal complete blood count.

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Data analyses were performed by the SPSS® for Windows™, version 6.0. A linear regression through the origin (the no-intercept model) was performed on each set of data, with Hb as the dependent and Hct as the independent variable.

Results

The measured parameters for the three study groups are shown in Table 1. Regression lines are shown in Figure 1.

From the results obtained (Table 1), it is obvious that the slope of the regression line has a merely small variation of <3% from 33 g/dL in different conditions. This implies that assuming a slope of 33 g/dL in normal people, and in those with either iron-deficiency anemia or β-thalassemia trait (the two most common causes of microcytic hypochromic anemia), the Hb concentration can be derived from Hct with a relative error of <3%. This level of accuracy is well accepted in clinical situations and at the bedside. Therefore, measurements of both Hb and Hct for the conditions studied, are not necessary and increase the workload.

Discussion

During the past decades, we have witnessed many advances in medical technology and laboratory equipment. Introduction of automated cell counting and flowcytometry has revolutionized the field of hematology. Due to the shortage of financial and technical supports, however, several rural health care centers, especially those in the developing countries, cannot enjoy the valuable information provided by such sophisticated machines. The physicians practicing in these centers have to diagnose disease conditions and manage their patients albeit with the very limited laboratory methods available there.

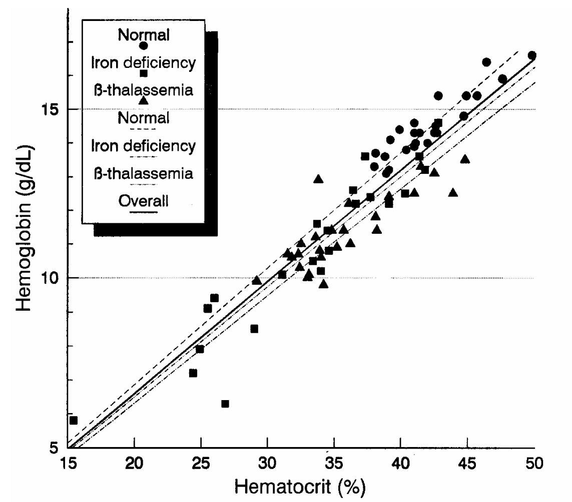

Figure 1. The regression lines (the no intercept model).

The red blood cell (RBC) indices were first introduced by Wintrobe in 1929.[3] These indices include the mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC). MCHC is defined as the hemoglobin concentration in the average RBC, and therefore, is calculated as follows:[4]

$$MCHC = \frac{\mathrm{MCH}}{\mathrm{MCV}} \quad (1)$$

But

$$MCH = \frac{\mathrm{Hb}}{\mathrm{RBC\ Count}}, \quad (2)$$

and

$$MCV = \frac{\mathrm{Hct}}{\mathrm{RBC\ Count}}. \quad (3)$$

Combining the equations 1, 2, and 3, then:

Table 1. The evaluated parameters in the study groups.

Parameter	Normal	Iron deficiency	Beta-thalassemia	Overall
N	25	22	26	73
Blood hemoglobin concentration (mean±SD) (g/dL)	14.56±1.04	10.71±2.46	11.38±1.10	12.27±2.32
Hematocrit (mean±SD)	0.424±0.035	0.330±0.070	0.359±0.041	0.373±0.063
Correlation coefficient*	1.000	0.997	0.998	0.998
Slope of the regression line †* (g/dL) ($CI_{95\%}$)	34.31 (33.91-34.71)	32.46 (31.35-33.58)	31.63 (30.82-32.43)	32.99 (32.50-33.49)

† The no intercept model, * significantly (p<0.0001) different from zero.

$$MCHC = \frac{\text{Hb}}{\text{Hct}}$$

hence

$$Hb = \text{MCHC} \cdot \text{Hct} \qquad (4)$$

Comparing the equation 4 with the no-intercept linear model used in our regression analysis, it became clear that the slopes of the regression lines (Table 1), are in fact, the MCHC values for different clinical situations studied.

While the MCV is a remarkably useful value in classification of anemia, the MCH and MCHC generally do not add any important clinical information. The MCH and MCHC, however, play a significant role in laboratory quality control since these values remain stable for a given sample.[4]

Accepting an almost constant MCHC (slope of the regression line) has several consequences; measurement of Hct and RBC count is easy and can be performed in most rural health care centers. The Hb level, as pointed out, can be derived with an acceptable accuracy. MCV, by definition, is Hct divided by RBC count (equation 3). Assuming a constant MCHC of 33 g/dL, then MCH can be derived from MCV (equation 1). The relative error in calculation of these parameters (not mentioning the errors occurring in measurements of Hct and RBC count) is <3%. These values are the most important hematological parameters a Coulter counter can provide.

References

1 Daae LN. Routine determination of both hemoglobin and hematocrit is not necessary. *Tidsskr Nor Laegeforen*. 1998; **118:** 414-5.

2 Eldibany MM, Totonchi KF, Joseph NJ, Rhone D. Usefulness of certain red blood cell indices in diagnosing and differentiating thalassemia trait from iron-deficiency anemia. *Am J Clin Pathol*. 1999; **111:** 676-82.

3 Wintrobe MM. A simple and accurate hematocrit. *J Lab Clin Med.* 1929; **15:** 287.

4 Perkins SL. Examination of the blood and bone marrow. In: Lee GR, Foerster J, Lukens J, Paraskevas F, Greer JP, Rodgers GM, eds. *Wintrobe's Clinical Hematology*. 10th ed. Baltimore: Lippincott, Williams and Wilkins; 1999: 9-35.