
# Methods of Measuring Blood Haematocrit Levels

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ABSTRACT

The article considers the methods of blood haematocrit level measurement, their advantages and disadvantages are given. The prospects of development of conductometric methods of haematocrit measurement and implementation of these methods are described.

Haematocrit is the ratio of the total volume of blood form elements to the total volume of blood. Changes in the level of blood haematocrit may indicate the presence of such pathological conditions as erythrocytosis, leukaemia, dehydration (increase in haematocrit), anaemia, hyperhydration (decrease in haematocrit). Especially important is the need to control the haematocrit level during haemodialysis procedures

**Keywords:** Haematocrit, form elements, anaemia, haemodialysis

**Introduction.** Haematocrit is the ratio of the total volume of blood formations to the total blood volume. Changes in blood haematocrit level may indicate the presence of such pathological conditions as erythrocytosis, leukaemia, dehydration (increase in haematocrit), anaemia, hyperhydration (decrease in haematocrit). Especially important is the need to monitor haematocrit levels during haemodialysis procedures.

Let us consider in more detail the methods of measuring the level of blood haematocrit.

1. Centrifugation method (foreign name - Microhematocrit). This method is based on the separation of the plasma and formate elements by centrifugation. Determination is made in haematocrit capillaries, which is a glass tube divided by a scale into 100 equal parts. The centrifugation process takes a long time (10-30 minutes). The haematocrit is determined by the number of divisions in the tube occupied by the formational elements. Despite the prolonged impact of centrifugal force on the blood, part of the plasma remains in the thickness of the precipitated mass of erythrocytes, which leads to errors in the measurement of haematocrit. Nevertheless, this method is the most common due to the relatively low cost of the measurement procedure.

**Materials and methods**: Let's consider in more detail the methods of blood haematocrit level measurement.

1. Centrifugation method. This method is based on the separation of the plasma and formate elements by centrifugation. Determination is made in haematocrit capillaries, which is a glass tube divided by a scale into 100 equal parts. The centrifugation process takes a long time (10-30 minutes). The haematocrit is determined by the number of divisions in the tube occupied by the formational elements. Despite the prolonged impact of centrifugal force on the blood, part of the plasma remains in the thickness of the precipitated mass of erythrocytes, which leads to errors in the measurement of haematocrit. Nevertheless, this method is the most common

due to the relatively low cost of the measurement procedure [1].

2. Calculated method of haematocrit determination. Haematocrit level (HCT) can be calculated from data such as total haemoglobin concentration (ctHB), red blood cell count (RBC), mean erythrocyte volume (MCV), mean haemoglobin concentration in erythrocyte (MCHC). This method is described by formulas (1-3). The method of calculating haematocrit number is described in more detail in [2].

HCT(%)=(0.485·ctHB(ммоль\л+0.0083)·100 %. (1)

HCT(%)=0.1·MCV·RBC. (2)

NCT(%)=ctHB÷MSNS·100. (3)

3- Direct blood cell count method (Complete blood count). The method can be implemented either manually [3] or using haematology analysers. In turn, haematological analysers use the so-called multivariate analysis, when the blood sample is examined in several ways (conductometric, photometric, chemical). This method has high accuracy, the measurement process takes little time (1-5 minutes), but the equipment that implements this method has a high cost.

4. Conductometric method of haematocrit measurement. The method is based on the measurement of the total complex resistance of blood. When haematocrit level decreases, there is a decrease in the active component of blood impedance and a shift of the maximum of the capacitive component of impedance to the low frequency region [4]. The advantages and disadvantages of the above methods are summarised in Table 1.

Results: Advantages and disadvantages of different methods of measuring blood haematocrit level.

Centrifugation method small volume of blood sample; - no dilution required; - simple implementation; - low cost of equipment and consumables long measurement process (10-30 minutes); - error due to the presence of plasma in the thickness of red blood cells after centrifugation (2-4%) [5]; - error due to manual calculation of haematocrit (human factor); - error due to haemolysis of red blood cells [6].

Calculation method small volume of blood sample; - possibility to determine haematocrit along with other parameters; - low cost of equipment and consumables. errors caused by deviation of haemoglobin level from the standard value in different age groups [7]; - errors caused by changes in haemoglobin level in different pathologies; - errors of calculation algorithm.

Method of direct blood cell counting high accuracy; - short measurement time (1-5 minutes); - small blood sample volume; - possibility of a large number of haematological parameters; - automatic sample dilution high cost of equipment; - need for qualified specialists; - high cost of consumables.

Conductometric method small blood sample volume; - short measurement time; - possibility of online measurements - low cost of equipment - need to treat blood sample with heparin; - error caused by the presence of proteins in plasma; - need for thermostatisation.

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*Method Advantages Disadvantages*

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Conductometric methods can be divided into invasive and non-invasive. Invasive methods are defined as techniques for determining haematocrit in a selected blood sample (in vitro). The development of non-invasive techniques for determining the level of blood haematocrit is currently an urgent task during haemodialysis procedures and surgical operations.

Among modern developments in the field of noninvasive determination of blood haematocrit level we can single out the technique of continuous impedance spectroscopy of blood in haemodialysis machines proposed by German scientists D. Trebbels, R. Zengerle [8]. The idea of this technique is to assess the electrical impedance of blood flow during the haemodialysis procedure. In this case, the electrodes are placed directly on the supply silicone tube of the haemodialysis machine. The key indicator in this case is the capacitive component of electrical impedance, the dependence of the value of which on the level of haematocrit is almost linear at frequencies of about 400 kHz.

As the disadvantages of this methodology can be highlighted high requirements to the accuracy of the measuring system, because the order of the measured value of the capacitive component of electrical impedance is units of picofarads. It should also be noted the high temperature drift of electrical impedance parameters, so there is a need to develop methods to compensate the temperature drift and thermostatisation of the measuring system.

The technique of noninvasive estimation of blood haematocrit level proposed by Spanish scientists P. Riu, O. Surkhy, P. Bogonez [9] deserves attention. According to this technique, the estimation of haematocrit level is performed by continuous recording of blood pressure and electrical impedance changes. The measuring system contains a blood pressure measurement unit and an electrical impedance measurement unit. The electrodes are placed directly on the forearm of the subject. The haematocrit level is estimated based on the ratio of blood pressure change and blood conductivity (4).

$\Delta Y \div \Delta P = C \div L_2\ \sigma p(1\text{-}NST)2 \div 3$

ΔY - change of blood conductivity due to compression;

ΔP - change of arterial pressure [mm Hg];

C - arterial compliance [μl/mm Hg];

L - distance between electrodes [m];

σp - blood plasma conductivity [Cm];

HCT - haematocrit.

The advantages of this technique are its non-invasiveness, short time of haematocrit determination, as well as the possibility to control the parameters of the vascular channel state. As disadvantages of this method should be highlighted the errors associated with the location of electrodes, their area, individual features of the skin of patients.

**Conclusions:** The conducted analysis reflects the promising use of conductometric techniques for non-invasive assessment of blood haematocrit level. Thus, the development of devices implementing these techniques will significantly improve the efficiency of procedures in which continuous monitoring of haematocrit level is a key requirement.

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