

Digital Hematocrite Test, a New Breakthrough in the Medical Equipment for Non Invasive Hematocrite Level Measurement in Dengue Patients

Prihartini Widiyanti^{1,3*}, Nasronudin^{2,3}

1. Biomedical Engineering Program, Faculty of Science and Technology, Universitas Airlangga.
2. Faculty of Medicine, Universitas Airlangga.
3. Institute of Tropical Disease, Universitas Airlangga.

Abstract

In Early 2004 Dengue Haemorrhagic Fever become an epidemic with big number of cases. Dengue Haemorrhagic Fever (DHF) is a disease caused by dengue virus that is transmitted through the mosquito bite of *Aedes aegypti*. It is quite difficult to determine the diagnosis due to the similarity of symptoms with another disease and the status of asymptomatic of the disease. People often came to hospital in the late condition and it increase the mortality of Dengue because the lack of monitoring 2 main indicators of dengue which are thrombocyte level and haematocrite level. In dengue, it needed to check the level of trombocyte and haematocrite oftenly. It is not suitable for elderly man that have collapse vessels and kids that have needle syndrome.

The purpose of this research is designing medical equipment to detect level of hematocrit non invasively. Measurable magnitude by the instrumentation is non-absorb intensity electromagnetic waves emitted by transmitter captured by receiver. The signal then converted to electrical signal, which is the levels of hematocrite.

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Introduction

Dengue fever (DF)/dengue haemorrhagic fever (DHF) is a growing public health problem in the subtropics.¹ In South-East Asia, with a total population of 1.5 billion, approximately 1.3 billion people live at risk of acquiring DF or DHF. Currently, DHF is the leading cause of hospital admissions and death among children in this region.²

The incidence of dengue has grown dramatically around the world in recent decades. The actual numbers of dengue cases are underreported and many cases are misclassified. Another study, of the prevalence of dengue, estimates that 3.9 billion people, in 128 countries, are at risk of infection with dengue viruses. The first time dengue fever in Indonesia was discovered in 1968, in Surabaya it happened in

1972. Since then, the disease spread across the area, until 1980 to every province in Indonesia. There were, for the first time show an increase of the number of cases in the area of or infected by or in a sporadic extraordinary occurrence always happening every year.³

Some of people especially kids and senescence have problem with blood taking procedure of hematocrit. Kids usually have needle syndrome which lead to uncooperative behaviour. Senescence have the collapse vessel which could not good for the repetitive blood taking procedure for hematocrit level determination.^{4,5}

Based on it above, digital hematocrit test (DHT) is needed to presenting detection methods levels a hematocrit fast, economical and non-invasive. Magnitude measured by instrumentation system is non-absorb intensity of electromagnetic waves emitted by transmitter captured by receiver as the result the remaining non-absorb waves of 560 nm. Signal captured by receiver then converted into electrical signal. The electrical signal of receiver is showed levels of hemoglobin in the veins. Levels of hemoglobin then converted to hematocrit level. Through the technology of this hematocrit level as an indicator

*Corresponding author:

Prihartini Widiyanti
Institute of Tropical Disease Universitas Airlangga, Surabaya, Indonesia.
Biomedical Engineering Program, Faculty of Science and Technology, Universitas Airlangga, Surabaya, Indonesia
E-mail: pwidiyanti@fst.unair.ac.id

plasma leakage could be monitor as often as possible continuously to prevent Dengue Shock Syndrome.⁶

Materials and methods

Spectrophotometri UV, Transmission Electron Microscope, Multimeter Hybrid, PC Computer, SPO₂ sensor, Male – Female Cable, GPS Sensor, Arduino, dan LCD Graphic.

The research was conducted in Institute of Tropical Disease and Airlangga University Hospital. 20 subjects divided into two group with the balance number of members. Subject is DBD patients based on WHO criteria 1997 in <15 years, and conducted hematocrit examination. Clinical criteria are sudden high fever, bleeding (including weir test positive, petechiae, epistaxis, and hematemesis), hepatomegali, shock with quick and weak pulse; with pulse pressure < 20 mmhg, or hypotension with agitation and cold acral. Laboratorial criteria including thrombocytopenia ($\leq 100.000 / \mu\text{L}$), hemoconcentration (hematocrit level $\geq 20\%$ than normal).

First two clinical symptoms and 2 laboratorial symptoms is enough to determine dengue diagnosis. The protocol has been approved by the Ethical commission in Research and Community Services Institute in Universitas Airlangga. The protocol are including several steps as follows : subjects who have receive explanation will be ask to fulfilled Informed Consent form, subject has been choosed randomly and chosen subject will be measure the hematocrite level by conventional method and also measure by Digital Hematocrite test equipment. Data then will be analyze by statistic.

Results

Research subjects have divided into 2 groupd which are normal subjects (11 male and 19 female) and DBD patients (6 male and 9 female). They will be examined the SpO₂, Hb and HCT parameters using 2 type of methods. First method is by using pulse oxymetry for SpO₂, Haemometer for Hb, macrohematocrit method for HCT (conventional method invasive method by blood taking procedure). Second method is by using Digital Haemotocrit Test (non – invasive method). 11 normal male adult subjects (19-41 years old) who were examined by the Digital Hematocrit Test have the mean value SpO₂

levels, Hb and HCT 3 times : 97,30 %; 13,33 g/dl, 40,31% subsequently. 19 normal female adult subjects (18-25 years old) who were examined by the Digital Hematocrit Test have the mean value SpO₂ levels, Hb and HCT 3 times : 97,36 %; 13,33 g/dl, 40,20% subsequently. The results of oxygen saturation in normal male adult from this DHT instrument is 97,3 % and in accordance with normal range of SpO₂ level. Hb level 13,33 g / dl from DHT instrument approaching normal range of Hb level. The HCT level adult male 40,31 % in accordance with normal range of HCT level. While the result of oxygen saturation in normal female adult from this DHT instrument is 97,36 % and in accordance with normal range of SpO₂ level. Hb level 13,33 g / dl from DHT instrument approaching normal range of Hb level. The HCT level adult male 40,20 % in accordance with normal range of HCT level. All result of SpO₂, Hb and HCT level in male and female normal adult subjects were in accordance with the normal range of SpO₂, Hb and HCT level. The normal range of SpO₂ level is b 95-100%. The normal range of Hb for female is 12.1–15.3 g/dl and for male is 13.8–17.5 g/dl. The normal range of HCT level for female is 36-46% and for male is 40-50%.^{7,8,9}

6 DBD male adult subjects (19-41 years old) who were examined by the Digital Hematocrit Test have the mean value SpO₂ levels, Hb and HCT 3 times : 94,06 %; 17,98 g/dl, 54, 67 % subsequently. 9 DBD female adult subjects (18-25 years old) who were examined by the Digital Hematocrit Test have the mean value SpO₂ levels, Hb and HCT 3 times : 94,15 %; 15 g/dl, 45 % subsequently. We only check the hematocrit level by conventional method using macrohematocrit for confirmation method and testing the proximity of non invasive method and invasive method to measure HCT level.

The results of hematocrit level in DBD male adult subjects from this DHT instrument is 54,67 % is close with the hematocrit level obtain from blood taking procedure macrohematocrit method which is 54,83. The results of hematocrit level in DBD female adult subjects from this DHT instrument is 45 % is close with the hematocrit level obtain from blood taking procedure macrohematocrit method which is 45,11.

The referral value of hematocrit could be seen in Table 1.^{7,8,9}

Age	Hematocrit (%)
Neonatus	44-65
Toddler (1-3 years old)	29-40
Child (4-10 years old)	31-43
Adult Male	40-50
Adult Female	36-46

Table 1. The referral value of hematocrit.^{7,8,9}

Discussion

Hematocrit (HcT) is the volume of red blood cells compared to the total blood volume (red blood cells and plasma).¹⁰ Hematocrit is one of indicator of Dengue Hemorrhagic Fever.¹¹ Early hematocrit level related with clinical degree of dengue fever according to WHO criteria. Not only to assess the factual condition of patients, but also to estimate risk of patient (predictor factor), so that it could be taken steps immediately and also done early prevention steps. As previously mentioned, outflowing plasma is the cause of hipovolemia which could trigger shock in the case of dengue fever. It has been proven that outflowing plasma has already happened since early fever before shock happened.^{12,13,14}

Digital Hematocrit Test (DHT) utilizing red value at a wavelength of 540–900 nm and Infra Red (IR). HbO₂ and Hb values are the result of constituent values of saturation (SaO₂). To find the value of the voltage absorption wavelength generated by HbO₂ and Hb should be based on the amount of voltage that is absorbed in the SpO₂. The division of red voltage value with IR voltage value generating absorption voltage values (R) which were used to search Hb value patient. Saturation value minus the result of filtering constant. Hemoglobin (Hb) is obtained by multiplying the value of the saturation (SaO₂) to hemoglobin absorption constant value. Percentage of HcT values obtained from 1/3 hemoglobin value.¹⁵

From Smirnov Kolmogorof test, both age group, SpO₂, Hb, HcT invasive and non invasive have normal distribution (p>0.05). The t independent test is used to compare the HcT value from invasive method (blood taking procedure) and non invasive method (DHT instrument). As a result there is no difference between the two groups treatment (p = 0.952). It

means the value of HcT from the non invasive method using DHT instrument is similar with the value of HcT from invasive method (blood taking procedure). It means the method to measure the hematocrit using Digital Hematocrit Test could be considered as the candidate detector of hematocrit level because it has proximity with the established method which are macrohematocrit and microhematocrit.

Conclusions

Digital Hematocrit Test has potency to be detector of hematocrite level candidate non invasively due to the proximity of value comparing the invasive method using blood taking procedure. This system still need further study to develop.

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Declaration of Interest

The authors report no conflict of interest.

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