International Journal of Trend in Research and Development, Volume 5(2), ISSN: 2394-9333
www.ijtrd.com

A Review Paper on Non-Invasive Methods for Determination of Anemia

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Abstract- Anemia is a major health concern in developing countries. Hemoglobin level assessment can be a reliable source of estimation of anemia. There are several invasive and non-invasive techniques available for determination of hemoglobin level. In this paper we are mainly focusing on invasive techniques based on image, diffuse reflectance spectroscopy, Optoacoustic Method and Photo-plethysmography. From this study we found that image based techniques hold better scope in determination of hemoglobin concentration and to improve the success rate of existing methods work must be done on ambient lighting condition.

Keywords- hemoglobin, anemia, conjunctiva, non-invasive, diffuse reflectance spectroscopy

I. INTRODUCTION

Anemia is a condition in which the red blood cell count or hemoglobin is less than normal. For men, anemia is typically defined as hemoglobin level less than 13.5 gram/100 ml and in women hemoglobin less than 12.0 gram/100 ml. Hemoglobin concentration is commonly used to assess the severity of anemia. The health consequences of anemia can include poor pregnancy outcome, impaired physical and cognitive development, increased risk of morbidity in children and reduced work productivity in adults. According to the World Health Organization (WHO), anemia is a major health concern that affects more than 60% of the population in developing countries [1]. According to new Global Nutrition Report 2017, 51% of Indian womens whoes age between 15 to 49 are anaemic. There are several methods are available to detect hemoglobin concentration.

II. METHODOLOGY

A. Invassive

The measurement of hemoglobin has traditionally done by services provided by clinical laboratory. Direct cyanmethemo globin method has been the gold standard for hemoglobin estimation and it is cheap but time consuming method [2]. To discuss this more is beyond the scope of this paper and hence we are concentrating on second method of measurement called noninvasive measurement technique.

B. Non-invassive

Non invenssive measurment in now being very popular nowdays. Tit is basedn on four basic technique Image based technique, diffuese reflectant spetroscopy, optoacoustic technique, Photoplethysmo-graphy. Each of one is discussed in detail below.

a. Image Based Techniues

In this digital photographs of palpebral conjuctva can be used to determine hemoglobin value. Suner et. al. proposed a non-invasive method to determine hemoglobin. Here they select the area of interest from captured image and then separated into red, green and blue channels. They design formula utilizing the pixel values from the conjunctiva and standard constant values were determined by an iterative process to optimize the predicted hemoglobin by comparing the results to known hemoglobin values and repeating the calculation after varying the constants. To standardized the separated images they uses 18% photographic standard gray image card. The utility of this algorithm was not tested under differing light conditions and in patients with hypoxia or hyperbilirubinemia [3].

Where as Collings et. al. correlates hemoglobin concentration with conjunctival erythema index (EI) calculated from digital photographs taken in ambient lighting conditions to detect anemia in non-invasive way. To standardized the capture image of conjunctiva, each image is split into 8-bit red, green and blue channels and brightness is adjust by using mean brightness of color calibration card's white square. To calculate EI they used red and green channels only. The EI was determined using the equation

$$EI = \log(Sred) - \log(Sgreen)$$

where S is the brightness of the conjunctiva in the relevant color channel. There are some limitations in this study, although the method of image standardization used reduced the effect of ambient lighting on EI, it did not eliminate it, various lighting conditions, lighting variability have weakened the observed association between EI and hemoglobin [4].

Chen et. al. proposes two algorithms for anemia diagnosis. The first algorithm consist of two-stage classifier, in first stage they uses a thresholding decision technique based on a feature called high hue rate (HHR) and in second stage they derive pixel value in the middle (PVM) (extracted from the RGB color space), followed by the use of a minimum distance classifier based on Mahalanobis distance. Second algorithm works on 18 features extracted from palpebral conjunctiva image. To improve the performance of algorithm more sample data should collected from patients to determine better parameters of the proposed approach, such as the threshold related to HHR. This algorithm cannot handle the anemia case involving excessive anger or high blood pressure because the color distribution of palpebral conjunctiva in this case is very similar to that of a non-anemia case [1].

Vitoantonio et. al. design a wearable device to capture the image of palpebral conjunctiva and they identified "distinctly red" region from image and by using support vector machine results are calculated, to improve the performance of the device there must be a method which automatic disqualification of images which are not suitable for analysis [5]. Anggraeni et. al. design a non-invasive anemia detection method based on the palpebral color observation using a smartphone camera. Here author measured the color intensity (Red, Green, and Blue) using a Colorgrab software (Loomatix) and compared to the known hemoglobin concentration of the samples [6]. McMurdy et al. used diffuse reflectance spectroscopy on the palpebral conjunctiva and found that it improves the diagnosis over observational studies. This leads

to an improvement in the methods of non-invasive hemoglobin detection [7].

b. Diffuse reflectance spectroscopy

Diffuse reflectance spectroscopy is a non invasive technique that measures the characteristic reflectance spectrum produced when the light is passed through the medium. The basic mechanisms involved this technique are absorption and scattering of light, which always vary with the wavelength to produce the reflectance spectrum which is recorded and has the information about the optical properties and also structure of the medium being measured [8].

Bender et al. described a system using diffuse reflectance spectroscopy (DRS) to monitor hemoglobin concentration changes due to surgical blood loss. They used fiber-probe-based spectra to calculate the diffusion and absorption of light in tissues [8] and Sakudo et al. presents a non-invasive method for the prediction of hematocrit levels. It was developed on the basis of a chemometric analysis of visible and near-infrared (Vis–NIR) spectra of the thumbs using portable spectrophotometer [9].

c. Optoacoustic Method

Opto acoustic imaging is a biomedical imaging modality based on the photo acoustic effect. In photo acoustic imaging, non-ionizing laser pulses are delivered into biological tissues. Some of the delivered energy will be absorbed and converted into heat, leading to transient thermo elastic expansion and thus wideband ultrasonic emission. The generated ultrasonic waves are detected by ultrasonic transducers and then analyzed to produce images. It is known that optical absorption is closely associated with physiological properties, such as hemoglobin concentration and oxygen saturation. [10]

Esenaliev et al. showed that optoacoustic methods have the potential for non-invasive and real-time measurement of hemoglobin by optoacoustic signals induced by short optical pulses in blood circulating in arteries or veins. They found a very good result for in vitro experiments but results from in vivo experiments were not available [11-12].

d. Photoplethysmography

A photoplethysmogram (PPG) is an optically obtained plethysmogram, a volumetric measurement of an organ. A PPG is often obtained by using a pulse oximeter which illuminates the skin and measures changes in light absorption [15].

Golam et al. present a smartphone-based non-invasive hemoglobin detection method. Here author correlate the images collected from the fingertip of a person with hemoglobin concentration [13]. Ulrich Timm et al. developed a non-invasive, real-time, hemoglobin monitor system based on the photo-plethysmography (PPG) method and he uses LEDs as the source of frequency. He clipped Hb sensor on a fingertip and light is transmitted through fingertip [14].

III. DISCUSSION

Assessment of hemoglobin concentration is the first step towards detection of anemia. There are several invasive as well as non-invasive methods available to check hemoglobin concentration. Most of the non-invasive method uses the digital photograph of palpebral conjunctiva. Before extracting data from image we have to standardize the image, for that Collings uses white card at the time of photography, and depending on the brightness of white card they adjust brightness of red, green and blue channel where as Suner uses 18% photographic standard gray image card. Then red, green and blue channels are generated from digital photographs and pixel values calculated from these channels are correlate with the known hemoglobin values. Although the method of image standardization used reduced the effect of ambient lighting, but it did not eliminate it, various lighting conditions, lighting variability have weakened the results. Diffuse reflectance spectroscopy on the palpebral conjunctiva is one of mostly used method and found that it improves the diagnosis over observational studies. Photoplethysmography measures the changes in light absorption.

CONCLUSION

Several non-invasive methods are available for diagnosis of anemia by determining hemoglobin concentration. This paper has reviewed the methods used to determine hemoglobin count such as image based techniques, Diffuse reflectance spectroscopy, Opto acoustic Methods and Photo plethysmography. Imaging based techniques have shown lot of advantages over the optical methods. There is scope to improve the performance of the existing methods by eliminating ambient lighting.

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