Evaluation of Non-Invasive Measurement of Haemoglobin using PPG in Clinically Ill Pediatric Patients

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Abstract*: Non-invasive haemoglobin (SpHb) estimation using Photoplethysmograph signal has gained enormous attention among researches in order to provide an earlydiagnosis to polycythemia, anaemia, various cardiovascular diseases, etc. The primary objective of this work is to evaluate the performance efficiency of SpHb monitoring using PPG in clinically ill pediatric population. PPG signal was obtained from the pediatric patients, and SpHb was calculated from the characteristic features of PPG. Haemoglobin value obtained through venous blood sample was compared with SpHb. Theabsolute mean difference between the SpHb and Hb_{ref} was 0.78g/dL (SD 0.99; 0.1 to 4.1).For a statistical analysis of the correlation between SpHb and Hb_{lab}, IBM SPSS statistics software was used. Bland-Altman analysis, T-test and Linear regression analysis were further used for finding the agreeability limits. Overestimation of SpHb value was observed for lower Hb_{lab} values, and SpHb failed to detect anaemic subjects.

Keywords: Haemoglobin, Neural Networks, Non-invasive, PPG, Regression

I. INTRODUCTION

Haemoglobin (Hb) is a complex protein molecule in red blood cells. Its main responsibility is to transport oxygen to the body's tissues. Hbmeasurement is a part of routine blood test and is one of the most widely/commonly performed laboratory tests. A routine blood test is generally advised during a general health assessment or when an individual shows indications and signs of anaemia (a very low Hb level) or polycythemia (condition with elevated Hb level) [1-3]. Haemoglobin test is one of the mandatory steps to make decisions during blood transfusions. Haemoglobin measurement is generally performed by the traditional "fingerstick method" i.e., by invasively drawing blood from the body. Although the conventional laboratory measurement is accurate, it has its own limitations such as time delay, inconvenience of the patient, exposure to biohazards and lack of real-time monitoring in critical situations. The above said limitations can be overcome by Non-invasive haemoglobin (SpHb) monitoring. SpHb monitoring has gained enormous attention as a point of care testing that facilitates to monitor haemoglobin concentration in a continuous, accurate, and non-invasive fashion. Various technologies and methods are employed by researches all over the globe to develop a system/device for SpHb monitoring [5-13]. Among the various methods, research on SpHb monitoring using Photoplethysmograph (PPG) is huge [14-18]. PPG signal is generally used for measuring oxygen saturation, to monitor the depth of anesthesia, heart rate, respiration monitoring and blood pressure [19-23]. Currently, SpHb, using the characteristic features of PPG signal, has shown an excellent correlation with the Haemoglobin (Hb) measured using an invasive method [4]. However, the procedure was conducted over a sample of 33 subjects and it did not include any pediatric subjects. So, the study was conducted to evaluate the performance efficiency of calculating SpHb among clinically ill pediatric population using the characteristic features of PPG and machine learning, and the results are discussed in the following sections.

II. MATERIALS AND METHODS

A. PPG Signal Acquisition

The subject database acquisition was done in Sri Ramakrishna Hospitals, Coimbatore after obtaining permission for collecting the PPG signals of pediatric patients. A formal consent was obtained from the parents or the representative of the pediatric patients before enrolment. Subjects aged between 3 and 13 years were enrolled. The subjects' data were stored in a spreadsheet of Microsoft Excel. The IR Plethysmograph transducer and Labchart software (version 7) of ADInstruments was used for signal acquisition. The sensor was placed in the forefinger of the left arm of the subjects. While the venous blood sample was collected by the trained professionals for calculating Hb_{lab}, corresponding PPG signal was acquired for a 15-period sample. The study flow of the work is presented in Fig 1. In total 132 pediatric subjects were approached, out of whom 83, aged between 3 and 13 were enrolled for the study after receiving consent. Subjects with a mean age of 8 were chosen for the study with a standard deviation (SD) of 3.3.

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