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Determination of Oxygen Tension in Peripheral Neuropathy and Diabetes using Nirs Method

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Abstract*: According to WHO, India had 69.2 million people living with diabetes in 2015 and is expected to rise by more than a 5th from 406 million in 2018 to 511 million in 2030. Diabetes currently affects over 425 million people worldwide. Chronic Blood sugar and diabetes may cause severe nerve damage known as Peripheral neuropathy. Approximately 15% of patients with diabetes are affected with diabetes. Various studies have indicated that peripheral vascular disease is related to tissue hypoxia and clinical device monitors uses pulse oximetry principle to measure changes of light absorption in oxygenated and deoxygenated blood. In this project we intend to develop a portable device to assess oxygen tension near foot ulcerate area using NIRS (Near infrared spectroscopy) method in diabetic subjects. The results can be visualized in the LCD and Visual display. The main purpose of oxygen tension estimation is to have a better understanding in wound healing potential, assessment of success in revascularization, and predictability of amputation level and the study the need of hyperbaric oxygen in therapy.

***Keywords* : Oxygen, tension, Peripheral Neuropathy, NIRS, Foot Ulcer, Hypoxia**

I. INTRODUCTION

Oxygen is basis for human survival. Level of oxygen for a particular organ is important as it determines the proper functioning of the body parts (organs). The inspired partial pressure of oxygen will reduce from 160 mmHg to 100 mmHg When water vapour and carbon dioxide are added when the as air moves into the alveoli. Values lower than 60 mm Hg usually indicates the need for supplemental oxygen. If there is a poor oxygen supply in the small blood vessels it leads to peripheral neuropathy and foot ulcerate, where the nerves get damaged. Diabetic foot is a complex of acute and persistent symptoms occurring in patients suffering from long-lasting not compensated diabetes mellitus, related to damages in foot vascular and nervous system, as well as a tendency to delayed wound healing, infection or gangrene of the foot. The main risk factors that cause diabetic foot ulcer are diabetic neuropathy. Peripheral Neuropathy is nerve damage caused by chronically high blood sugar and diabetes. It leads to numbness, loss of sensation, and sometimes pain in the feet, legs, or hands. Blood oxygen saturation assessments are routinely performed for both screening and monitoring of patients with cardiac and pulmonary diseases, for trauma patients, in surgery and more. Common diseases and conditions like chronic obstructive pulmonary disease (COPD), asthma and migraine are also associated with a disruption in the supply of oxygen to tissues in the body and can benefit from oxygen saturation monitoring. The hypoxia is the condition where the body doesn't have enough oxygen. This may cause major problems to lungs and brain. The hypoxemia (low oxygen in blood) can cause hypoxia (low oxygen in the tissue) when the blood doesn't carry enough oxygen. Near Infrared Spectroscopy (NIRS) is a non-invasive, Optical technique applying the principle of light transmission and absorption to investigate dynamic changes in tissue oxygenation [3]. The NIR wavelength is 700nm-950nm. In NIRS reflectance mode is used to estimate the value. In NIRS light is used to calculate the concentration of Oxygenated Haemoglobin ([HbO2]) and Deoxygenated Haemoglobin ([HHb]) in deep tissues. Light attenuation is correlated to [HbO2] and [HHb] by the Modified Beer-Lambert Law [1].

$$A\lambda=\ln (I0/I)=\alpha\lambda.[c].d.DPF+G. \quad (1)$$

Where A is the light attenuation (in optical densities) at a specific light wavelength λ, I and IO are respectively the transmitted light intensities during and at the beginning of the measurement, αλ is the attenuation coefficient of a substance at λ, [c] is the concentration of the substance (i.e,[HHb] and [HbO2]), d is the distance between light source and detector, DPF is the Differential Path length Factor and G is the parameter of scattering [1]. Oxygenated haemoglobin and deoxygenated haemoglobin both absorb light differently in NIR region. At 780nm, deoxygenated blood has a superior absorption, whereas at 830nm, oxygenated blood has a higher absorption. NIRS light interaction with tissue is based on absorption, scattering and reflection. Thus the oxygen tension is measured using NIRS method. The main purpose of oxygen tension estimation is to have a better understanding in wound healing potential, assessment of success in revascularization, and predictability of amputation level and the study the need of hyperbaric oxygen in therapy. Partial pressure of oxygen (O2 tension) amount of O2 dissolved in the blood.

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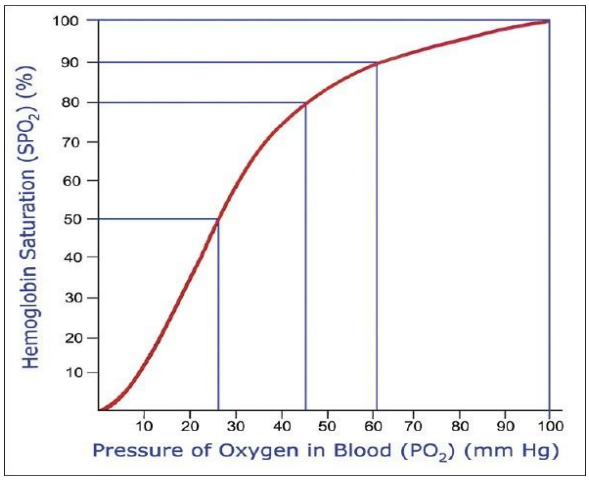
The saturation of Oxygen is the level of arterial haemoglobin oxygenated blood, which is the ratio of oxygenated haemoglobin concentration [HbO2] to total haemoglobin concentration in the blood ([HbO2] + [Hb]).

SpO2 is haemoglobin saturation where PO2 is plasma saturation. SpO2 can be measured using red and infrared light based on the absorption spectra of different wavelength. In Near infrared region oxygenated haemoglobin absorbs 830nm whereas deoxygenated haemoglobin absorbs 780nm. NIRS wavelength is 700- 950nm. PO2 cannot be calculated using NIRS method, but there is a correlation between the SpO2 and PO2.

So the Spo2 is calculated using NIR method then the value is equalised to PO2 value using some correlation. The sigmoid shape of the oxy– haemoglobin (Hb) dissociation curve reflects the mutual interaction between Hb and oxygen (O2) molecules.



Correlation between SpO2 and PO2

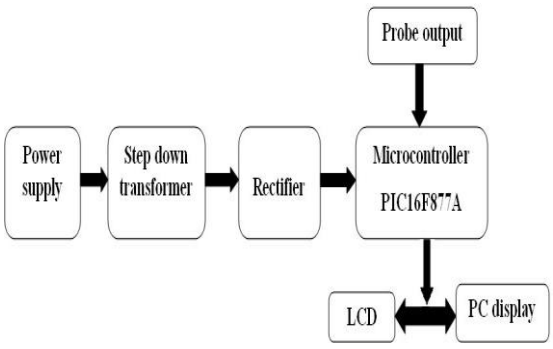
SpO2(%)	PO2(mmHg)
100%-90%	100-60 mmHg
90%-80%	60-45mmHg
<80%	40mmHg

II. MATERIALS AND METHODOLOGY

A. Submission of the paper

B. *Quality Check*

The simple block diagram shows the entire working of the prototype. The output of the probe is fed into the optical sensing unit. The incoming signal is processed and the output is fetched from the output unit.

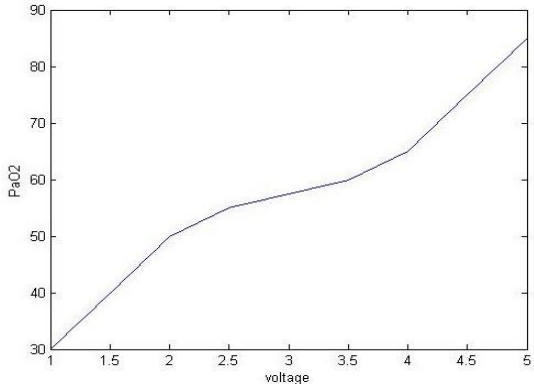


The IR sensor collects the reflected coefficient and transfers it to the optical sensing unit. The optical sensing unit consists of power supply, transformer, rectifier and microcontroller. The 230V power supply is given to the circuit and it is step downed to 12V by using the step down transformer. The ac voltage from transformer is converted to pulsating dc voltage by full wave rectifier. After the rectification the voltage is given to the microcontroller for working. The microcontroller gets the input value from the probe output. The microcontroller is programmed as such it displays the incoming input in the value as output in the LCD. The displayed output is send to the PC by the RS232 cable. Through this serial communication setup the value is displayed in the PC by using visual basic.

III. RESULTS AND DISCUSSION

The blood consists of two different types of haemoglobin oxygenated haemoglobin and deoxygenated haemoglobin. Both absorb light in different wavelength. Spectrophotometry is a method to measure a chemical substance that absorbs light by measuring the intensity of light as a beam of light passes through sample solution. The basic principle is that each compound absorbs or transmits light over a certain range of wavelength. Human tissue is relatively transparent to light in the NIR region of the spectrum. The NIR range is between 700nm-1000nm. The blood absorption property is evaluated by using the spectrophotometer. At the wavelength of 780nm the absorbance coefficient is 1.409 and at the wavelength of 830nm the absorbance coefficient is 1.290. This shows the absorbance property of blood at different wavelength.

The IR sensor transmits the wavelength of light at one end and it receives it at other end. The output from the sensor is the electrical quantity. This electrical value is equalized to the PaO2 value in the mmHg. The electrical output range varies from 1V to 5V. The PaO2 value ranges from 25-100 mmHg. There should be minimum 01 to 02 week time window for it.



Relationship between sensor output voltage and partial pressure.

Pulse oximetry is a non-invasive method for monitoring oxygen saturation. It uses an electronic processor and a pair of small light emitting diodes (LED) facing a photodiode. A sensor is placed in a fingertip to measure oxygen saturation.

The amount of oxygen

dissolved in the blood is proportional to the partial pressure of oxygen in solution in the plasma and is measured with a blood gas machine with a silver anode/platinum cathode system in an electrolyte solution (polarography) separated from the unknown solution (the blood) by a semi permeable (to oxygen) membrane. The arterial PO2 is a measure of the ability of the lungs to efficiently move oxygen from the atmosphere to the lungs. The above tabulated result shows the mean and standard deviation. The estimation is made between different age groups. The group of 4 or 5 members chooses between different age groups.

The SpO2 is compared with PaO2 value. This is used as a validation in this project.

From the result, 75-100mmHg is the normal PO2 value. The partial pressure can calculate from the saturated pressure. This is an innovative solution which shows the spo2 is equal to the po2 at some instance. This can help in assessing the diabetic wound healing by measuring the po2 value non-invasively. Common diseases and conditions like chronic obstructive pulmonary disease (COPD), asthma and migraine are also associated with a disruption in the supply of oxygen to tissues in the body and can benefit from oxygen saturation monitoring. The hypoxia is the condition where the body doesn't have enough oxygen. This may cause major problems to lungs and brain. These can also assess using this device.

IV. CONCLUSION AND FUTURE WORK

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A. Abbreviations and Acronyms

Recently large people are affected by diabetes which cause foot ulcer and peripheral neuropathy because of poor oxygen supply to the blood vessels. Assessment of oxygen tension using near infrared (NIR) light is a simple noninvasive diagnostic test. The portable device measures the oxygen tension in the body which supports in predicting the amputation in the diabetes due to less oxygen supply. Decreased oxygen level assessment is also used to identify pulmonary disease, heart failure due to poor oxygen delivery, peripheral vascular disease, Edema and inflammation. Assessment of oxygen tension in skin can be visualized in the LCD and Visual display for efficient monitoring. The power supply can be replaced by the battery and the telemetry technique can also incorporate into this module. This portable device can made as compact by using micro technology. The module can made as wearable to measure oxygen content which used to identify the peripheral vascular, edema, hypoxia and inflammation.Do not use abbreviations in the title or heads unless they are unavoidable.

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