APPLICATION OF PULSE OXYMETER IN MEDICAL SCIENCE

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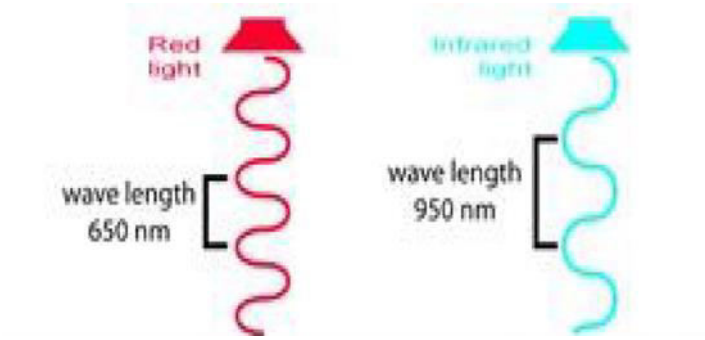
Abstract:
"Pulse oxymeter" A medical device is quiet popular and used widely throughout during the COVID19 pandemic.Almost every household has one pulse Oxymeter and ubiquotiosly used nowadays to monitor the body oxygen saturation on room air. Portable pulse oximetry can be used by patients of any age.The present paper throws light on the working Principle of Pulse oxymeter and its applications in medical and other than hospital settings which is an application of physics(photo plethysmography).

Keyword: Pulse oximeter, pulse oxygen saturation (SpO_2), Photoplethysmography.

Introduction:
"Pulse oxymeter" A medical device was quiet popular and used widely throughout during the COVID19 pandemic.Almost every household has one pulse Oxymeter and ubiquotiosly used nowadays to monitor the body oxygen saturation on room air.It is a non-invasive method of determining blood oxygen saturation, whereas arterial blood gas is an invasive method of investigation in which arterial blood is drawn from deep seated arteries, which is a difficult, doctor-dependent, and painful process with the possibility of getting venous blood drawn; therefore, pulse oxymeter, a physics application, has proven to be revolutionary in modern medical practise.This device is useful in monitoring critically ill patients(The patients in the Intensive care unit),patients in the Emergency,woman undergoing labour,patients with pneumonia and other respiratory diseases etc.
The birth of pulse oxymeter by science and technology is a revolution in modern medicine with its capability to monitor oxygenation in an accurate and continuous way The Pulse oxymeter was first available in 1983 in market Pulse oxymetry ,an instrument easily available, simple to use, non-invasive used to measure pulse oxygen saturation (SpO_2). The instrument is used by placing the small probe of pulse oxymeter on the ear lobe, toe, and finger of a patient. Portable pulse oximetry can be used by patients of any age (from premature babies to the eldest adult), any size, any place (offices setting, rock climbing from virtual setting to hospital setting). The "fifth" vital sign is now considered as SpO_2 measurements, as it very easily computed. [(1)]

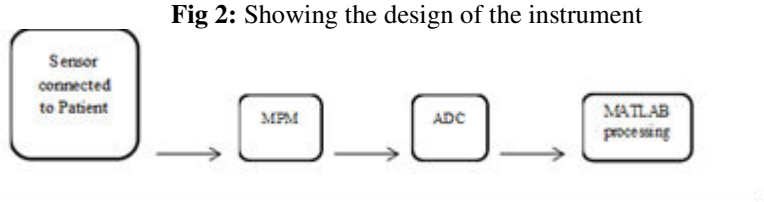
Principle of Pulse oxymeter:
The principle of Photo-plethysmography is used in pulse oximetry (PPG). It is a noninvasive method for determining the proportional amount of blood change in biological tissues by observing light absorption events in biological tissues. When red and infrared light are shone on a fingertip, the photodetector detects either red or infrared light, depending on the amount of oxygenated blood present..The basis of working of pulse oxymeter is the Beer lamberts law of physics stating "for a given material sample path length and concentration of the sample are directly proportional to the absorbance of the light". Pulse oxymeter the oxygenated haemoglobin (O_2Hb) and deoxygenated haemoglobin (HHb) have contrasting ability to absorb red light and near infrared light. Because O2Hb has a greater propensity to absorb IR light than red light, whereas HHb (deoxygenated haemoglobin) absorbs more red light, purely oxygenated blood appears brilliant red to the naked eye because red light scatters more. Pulse oximeters are equipped with a pair of tiny light-emitting diodes located in one arm of the finger probe that eject red and near-IR light of different wavelengths, 660nm and 940nm, respectively, to take advantage of this phenomenal property of oxygenated and deoxygenated blood light absorption and their difference.Another photodiode on the opposite arm of the finger probe recognizes the transmitted light through the tissues of finger containing blood. This eventually concludes the proportion of Hb bound to oxygen in blood.
Fig1.shows absorption spectra of red and infrared at different wavelegths. Wavelengths of two lights red light and infrared light are 650nm and 950nm respectively

Fig:1- showing the red light and infra -red light with wavelength



Design: Pulse oxymeter system consists of a SpO2 sensor, MPM (Multi Parameter Monitoring) module, ADC (Analog to Digital Converter) and MATLAB[5]

Fig 2: Showing the design of the instrument



Pulse Oxymeter Sensor: This sensor uses red and infrared LEDs as well as a photo detector to detect light absorption. Two lights shone through the fingertip, and the signals were sent through the skin and perceived back using a photo detector.

MPM Board: A physician can monitor heart rate, SpO2 rate, respiration rate, perspiration rate, body temperature, and blood pressure with an economical and efficient MPM Board. The SpO2 signals are acquired by MPM, which filters and amplifies weak signals before passing them to an Analog to Digital Converter to transform them to digital values.

Microcontroller C8051F380: The MPM Board's amplified and filtered signals are supplied to the microcontroller, which is programmed to convert analogue to digital data. Data can be exchanged between a PC and serial devices using the Universal Asynchronous Receiver Transmitter [5].

MATLAB: Matrix Laboratory is a numerical computing environment that supports multiple paradigms. The microcontroller stores and transmits the data collected from the ADC unit via UART serial communication. The collected signal was then analysed in MATLAB to determine the SpO2 value. AC peak to peak voltage is monitored for both red and infrared signals to calculate oxygen saturation by calculating the difference between maximum and minimum peaks on the waveform.The calculation in the process is done by the following formula [6]

SpO2 = (10.0002*R3)-(52.887*R2)+(26.871*R)+98.283

R is calculated using the formula

$$R = \frac{(Vmax(Red) - Vmin(Red)) * Vmin(Infrared)}{(Vmax(Infrared) - Vmin(Infrared)) * Vmin(Red)}$$

Application of pulse oxymeter :

1)Monitoring of rhythm, pulse rate and oxygenation suitable for use in hospitals and all other non-hospital settings.

2)Monitoring the cardiorespiratory status of patients with comorbidity,before any major or minor surgery during general and regional anaesthesia,in the emergency ward,intensive care unit and pre and post operatively.The continuous monitoring of the vitals like pulse rate of the patient and oxygen saturation during an ongoing surgery where patient is on anesthesia is the important factor in any surgical intervention.

3)Pulseoxymeters identifies the presence of cyanosis more better than an experienced doctor.

4)The calibration of the pulse oxymeter is a reliable indictatoravoid oxygen toxicity, damage to the lungs and retinas in premature neonates.

5)Detection of oxgen saturation in many conditions like allergic reactions,obstructive sleep Apnea,heartfailure,drowing, poisoning,choking ,suffocation, cancer, pneumonia.

6) It can detect whether a limb is getting a blood supply or assess the viability of limbs after orthopaedic and plastic surgery.

7)Tracking changes in peripheral perfusion index.

8)A guide for fluid management in body as patients with dehydration present with tachycardia as feature which can be easily detectable by the use of pulse oxymeter.

9) Indicating lethal side effects in people taking cannabies, heroin,cocaine,nicotine that affects breathing or oxygen saturation.

10)It gives a peaceful mind to people with impaired cardiac and respiratory function as they can check their oxygen saturation in one touch.Also during the pandemic of COVID19,where many people suffered the “Happy hypoxia” phenomenon of the SARS-COV-2 infection,COVID19 induced viral atypical Pneumonia,pulseoxymeter proved to be useful to monitor oxygen saturation levels of the patients even in the isolations.

11)Cost effectiveness-The use of pulse oxymeter has reduced the cost of arterial blood gas sampling,also the ease of this device has helped the healthcare workers to monitor various critically ill patients at a time

Limitations of pulse oximetry[7]

Shape of oxygen dissociation curve

Dyshemoglobins

- Carboxyhemoglobin

- Methemoglobin

Dyes

Low perfusion state

Skin pigmentation

Anemia

Nail polish

Motion artifact

Limited knowledge of the technique

Conclusion:

Pulse oximeters are a non-invasive device that monitors the oxygen saturation of arterial haemoglobin. Removes the need for self-monitoring of oxygen saturation. It is a useful tool for clinical evaluation of a patient, but it is not a reliable indicator of a patient's breathing. Pulse oximetry has been identified as one of the most significant tools for respiratory monitoring. Over the last 20 years, technical factors have been investigated, and the degree of accuracy, combined with the ease of operation of most equipment, has led to pulse oximetry being employed for patient monitoring in hospitals.

The accuracy of commercially available oximeters varies depending on the algorithm used to create them. Most conventional oximeters employ two leds to assess oxygen saturation based on oxyhemoglobinanddeoxyhemoglobinabsorbtioncoeffients. With new scientific breakthroughs, Pulse oximetry may be used to quantify respiratory efforts and detect changes in blood pressure in the future. The oximeter has a variety of flaws that can provide incorrect readings. The many elements that affect the reading in oximetry include carboxyhemoglobin, methemoglobin, anaemia, dyes, nail polish, ambient light, false alarms, motion artefact, skin pigmentation, and poor perfusion condition.

Acknowledgement:

We are Thankful to the Principal of our Institute Dr.KalhapureG.B,for his motivation and support which empowers us to contribute to the scientific community on innovative topics.

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