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Pulse Oximetry for Pregnant Ladies

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Abstract: ***Pulse Oximeters are low cost non-Invasive medical sensors used to continuously measure the Oxygen saturation (SPO2) of hemoglobin in blood. It displays the percentage of blood that is loaded with oxygen. Pregnant women are recommended to have this medical device at home. As soon as women get pregnant, children get all the necessary vitamins from blood, which can contribute to the decrease of the level of hemoglobin, which can cause severe complications. Women are recommended to take vitamins and eat a lot of fruit and products that contribute to the increase of the level of hemoglobin. Good nutrition and regular determination of finger pulse is the guarantee of improved health conditions of a pregnant woman and future children.***

Keywords: Pulse oximetry (SpO2), Pulse rate, PPG

1. Introduction

Pregnancy is the most exciting and rewarding experiences for any woman in their entire life. The thought that one is carrying the life of another person in their body is very significant and can be a bit overwhelming at times. During pregnancy it is important to monitor the health of the mother, because generally the child will share the health of the mother and as a result it is important that pregnant individual is operating at normal levels of health. The most important significant indicators of health is the pulse rate and the oxygen levels in the body and it is agreed by the Physicians. The heart rate is essential because it serves the function of distributing oxygen rich blood throughout the body. This oxygen rich blood is what sustains the cells and thus allows the body to function properly, and oxygen in it is the most basic element for life and without it no person can survive. Physicians recommend for pregnant women to utilize a pulse oximeter to accurately measure these vitals. Pregnant women have been using pulse oximeter technology more and more throughout the decade. Many have realized that their health is extremely important to the health of their own babies. Pulse oximetry (SpO2) value less than or equal to 93% confers particular risk, and the symptom complex of chest pain and/or Shortness of breath adds strength to the association and may be a valuable early warning of pulmonary edema in women [1]. SpO2 can also be used to screen newborn infants for congenital heart defects and for other hypoxemic conditions such as acute respiratory infection, chronic obstructive pulmonary disease, and shock due to acute blood loss [2]. Oximetry is the measurement of transmitted light through a translucent measuring site to determine a patient's oxygen status noninvasively. Oximetry measurement is traced in 1930's when German investigators used spectrophotometers (instruments that measure different wavelengths and intensities of light) to research light transmission through human skin. In 1934, one investigator reported measuring oxygen saturation in blood flowing through closed vessels in animals.In 1939, German researchers reported use of an "ear oxygen meter" that used red and infrared light to compensate for changes in tissue thickness, blood content, light intensities and other variables. Between 1940 and 1942, a British researcher, Millikan, used two wavelengths of light to produce a practical, lightweight aviation ear oxygen meter for which he coined the word "oximeter". He noted that light transmitted through a red filter was oxygen-saturation-sensitive and light passing through a green filter was independent of oxygen saturation. It was later determined that oxygen insensitive-signals were not due to the green light filter but instead to infrared light.In the late 1970's, the Biox Corporation in Colorado made significant advances in pulse oximetry, 2-wavelength measurements. They first introduced the use of Light Emitting Diodes (LED's) for the red and infrared light sources. They marketed their device directly to respiratory therapists and anesthesiologists who could see the benefit of continuous, real time, noninvasive oxygen saturation readings. Ohmeda Corporation purchased Biox, and in the 1980's, along with Nellcor (started by an anesthesiologist, Bill New), and Nova Metrix, continued to make significant advances in size reduction, cost, and development of multiple site probes.In 1990's, 'new generation' pulse oximeters have been introduced that have elevated the accuracy of pulse oximeter readings significantly.

2. Literature Review

The healthcare has enter in a new stage of the digital age. Traditionally care where taken by nurses and phone-based tele health applications, each with its ownproblems. But today technological advances lead the healthcare industry in different direction. During the last few years there has been a significant increase in the number of various pulse oximeterson the market ranging from simple pulse monitors to portable wireless digital pulse oximeters. The wireless measurement of oxygen saturation is mostly carried out with finger or ear lobe sensors. Aoyagi T et al., (1974) invented the fundamental pulse oximetry concepts by describing the use of the arterial pulse for oximetry.

These researchers studied the effects of fetal hemoglobin (HbF) on pulse oximeter measurements on 22 infants with HbF range of 0% - 100%. They found no significant influence on SpO2 for any level of HbF present for the Nellcor N-200 in the SpO2 range of 78% - 98% [3].These researchers studied the effects of sensor malpositioning on pulse oximeters from different manufacturers, used on hypoxemic subjects. Early studies had shown that improperly positioned sensors could read erroneously low on normoxemic subjects. 12 healthy volunteers were

studied. Each had a radical artery cannula inserted and 5 of the 8 sensors applied were malpositioned. The subjects breathed a mixture of N2 and O2 sufficient to vary SaO2 slowly from 100% to 70%. Five stable levels of SaO2 were measured for each subject. The researchers found that the pulse oximeters varied greatly with their behavior depending on both the SaO2 and the manufacturer. One oximeter underestimated saturation at all SaO2 levels, while three others underestimated at high SaO2 and overestimated at low SaO2. The researchers recommended that sensor position be checked frequently and that inaccessible sensor locations be avoided whenever possible [4].The authors studied the accuracy of a new motion resistant pulse oximeter (Masimo SET) and a conventional pulse oximeter (Nellcor N-200) during non-motion in sick newborns. Sixty-eight (68) samples of arterial blood were analyzed (CO-Oximetry) from 18 sick newborns. They found a bias of 0.9% and precision of 2.4% for the Masimo; and a bias of 1.0 and precision of 5.1 for the N-200. The Nellcor N-200 findings included a spurious point of 63% (97% SaO2 and 99% SPO2 Masimo) where the Nellcor pulse rate matched the ECG. In addition, three N-200 zero outs (due to poor perfusion) were excluded from the calculations. They conclude that Masimo SET accurately reflects the SaO2 in sick infants [5].The authors conducted a prospective study of pulse oximetry (Ohmeda 3740) on 200 patients during rotary-wing aircraft transport. Thirty-four patients (17%) were found to have significant hemoglobin desaturation to less than 90%. These desaturations often were noted prior to alterations in vital signs or clinical appearance. In 32 of the 34 hypoxemic patients, therapeutic interventions corrected the low SpO2. They conclude that pulse oximetry is a practical and valuable adjunct for monitoring critically ill patients transported by rotary-wing aircraft [6].

There are many researchers since 1974 till now toachieve high efficiency and reliability and reducing cost inpulse oximetry field.

Digital technology has produced new medical devices such as networked glucose readers, digital thermometers, and stethoscopes, as well as innovative applications such as motion sensors and video-conferencing tools. A pulse oximeter is one of them; it is intended for the non-invasive measurement of arterial blood oxygen saturation and pulse rate [7].The wireless measurement of oxygen saturation is mostly carried out with finger or ear lobe sensors. Aoyagi T et al., (1974) invented the fundamental pulse oximetry concepts by describing the use of the arterial pulse for oximetry [8].Webster JG in 2008 have been try to design pulse oximetry which measures the presence of a third substance, carboxyhaemoglobin (HbCO), by unfiltered LEDs at 660 nm, 810 nm, and 940 nm. and defines the three absorption equations at three separate wavelengths for non-focused LED sources. The result of this design was some erroneous data due to high levels of sulfhemoglobin and met hemoglobin and which giving wrong result [9]. In 2009 when we had the first wireless pulse oximetry. Furthermore, (José M. Castillo et.al) propose prototype to convert a conventional pulse oximeter into a wireless device. And they used zigbee protocol where the data is sent through the wireless network to a central server the system generates alarms to the medical staff when vital signals are critical. And the result of this proposal was accurate and reliable [10].Collin schreiner et al. (2010) presents a prototype novel chest based pulse oximetry system and reports on test results from comparative trials with a commercially available finger based pulse oximetry system.

3. Principles of Pulse Oximetry

Pulse oximeters measure how much hemoglobin in blood is carrying oxygen (oxygen saturation) the main way oxygen is carried in our blood is by means of hemoglobin. The hemoglobin without oxygen is called as de oxygenated hemoglobin (deoxy Hb). The hemoglobin with oxygen is called as oxygenated hemoglobin (oxy Hb). Pulse oximetry uses light to work out oxygen saturation. Light is emitted from light sources which goes across the pulse oximeter probe and reaches the light detector. If a finger is placed in between the light source and the light detector, the light will now have to pass through the finger to reach the detector. Part of the light will be absorbed by the finger and the part not absorbed reaches the light detector.The principle of pulse oximetry is based on the red and infrared light absorption characteristics of oxygenated and deoxygenated hemoglobin. Oxygenated hemoglobin absorbs more infrared light and allows more red light to pass through. Deoxygenated (or reduced) hemoglobin absorbs more red light and allows more infrared light to pass through. Red light is in the 600-750 nm wavelength light band. Infrared light is in the 850-1000 nm wavelength light band.Pulse oximetry uses a light emitter with red and infrared LEDs that shines through a translucent site with good blood flow. Typical the sites are the finger, toe, pinna (top) or lobe of the ear. Infant sites are the foot or palm of the hand and the big toe or thumb. Opposite the emitter is a photodetector that receives the light that passes through the measuring site.There are two methods of sending light through the measuring site: transmission and reflectance. In the transmission method the emitter and photodetector are opposite of each other with the measuring site in-between. The light can then pass through the site. In the reflectance method, the emitter and photodetector are next to each other on top the measuring site. The light bounces from the emitter to the detector across the site. The transmission method is the most common type used and for this discussion the transmission method will be implied.After the transmitted red (R) and infrared (IR) signals pass through the measuring site and are received at the photodetector, the R/IR ratio is calculated. The R/IR is compared to a "look-up" table (made up of empirical formulas) that convert the ratio to a SpO_2 value. Typically an R/IR ratio of 0.5 equates to approximately 100% SpO_2, a ratio of 1.0 to approximately 82% SpO_2, while a ratio of 2.0 equates to 0% SpO_2 [11]. At the measuring site there are constant light absorbers are present. They are skin, tissue, venous blood, and the arterial blood. With each heart beat the heart contracts and there is a surge of arterial blood, which momentarily increases arterial blood volume across the measuring site. This results in more light absorption during the surge[12]. If light signals received at the photodetector are looked at 'as a waveform', there should be peaks with each heartbeat and troughs between heartbeats. If the light absorption at the trough is subtracted from the light absorption at the peak thenthe resultants are the absorption characteristics due to added

volume of blood only; which is arterial. Since peaks occur with each heartbeat or pulse, the term "pulse oximetry" was coined.

Uses of pulse Oximetry

Pulse oximetry can replace blood gas analysis in many clinical situations. It is cheaper, easier to perform, less painful and can be more accurate. Pulse oximetry allows accurate use of O2 and avoids wastage. For example, in patients with respiratory failure, rather than limit the use of O2 to maintain hypoxic ventilator drive, it can be adjusted to a saturation of ~90% which is clinically acceptable.

Neonatal care - the safety limits for oxygen saturations are higher and narrower (95-97%) compared to those for adults [13]. Pulse oximetry is not yet a standard of care in the screening of neonates for asymptomatic congenital heart disease but may become so [14]. It appears to be significantly more reliable than clinical methods alone, as shown by recent studies [15].Fetal monitoring has been some interest in the use of fetal pulse oximetry in combination with routine cardiotocography (CTG) monitoring, although its use does not reduce the operative delivery rate [16].

Factors affect Pulse Oximeter Reading

Several factors can interfere with the correct function of a pulse oximeter including:

- **Light** – bright light (such as the operating theatre light or sunlight) directly on the probe may affect the reading. Shield the probe from direct light.
- **Shivering** – movement may make it difficult for the probe to pick up a signal.
- **Pulse volume** – the oximeter only detects pulsatile flow. When the blood pressure is low due to Hypovolemic shock or the cardiac output is low or the patient has an arrhythmia, the pulse maybe very weak and the oximeter may not be able to detect a signal
- **Vasoconstriction** reduces blood flow to the peripheries. The oximeter may fail to detect a signal if the patient is very cold and peripherally vasoconstrictor.
- **Carbon monoxide poisoning** may give a falsely high saturation reading. Carbon monoxide Binds very well to hemoglobin and displaces oxygen to form a bright red compound calledCarboxyhaemoglobin. This is only an issue in patients following smoke inhalation from a fire.

Source of error

- **Environmental interference**: vibration at 0.5-3.5 Hz, excessive movement and perhaps high level of ambient light, including infrared heat lamps. [17]
- **Cold hands** - warm extremity if local poor perfusion.
- **Nail polish** should be removed, as it may cause false readings. [18]
- **Intravascular dyes**, such as methylthioninium chloride, may also temporarily falsely reduce saturation readings.

4. Conclusion

In this paper we address the current status of information technology solution based on pulse-oximeter for a better monitoring of pregnant women. It is a medical device that monitors the level of oxygen in a patient's blood. We review some applications of pulse-oximeter in health systems.

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