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significant role in the accurate measurement of venous and arterial oxygen saturation

Salah Taha Mohammed

IBN Khaldun University College, Baghdad.
Email: Salah.taha@ik.edu.iq

Abstract:

Specific wavelengths play a significant role in the accurate measurement of venous and arterial oxygen saturation. Furthermore, the distance from the radiation source influences physical calculations based on radiation laws concerning absorption, transmission, and scattering. By virtue of its comprehensive approach, this study contributes a valuable addition to existing research in the field.

Pulse oximetry—a method for measuring oxygen saturation and pulse rate—has been in use for a relatively short period. This study focuses on the scientific aspects regarding the fundamental principles of radiation physics and electromagnetic radiation, specifically within the wavelength ranges corresponding to dominant visible colors. It highlights the importance of optimizing the methods used to identify and diagnose measurement errors.

Keywords: Physical Principles, Application. venous ,arterial ,oxygen saturation, Deoxygenated hemoglobin.

Introduction:

The pulse oximeter (the clip placed on the finger) does not use the Doppler effect for measurement. Instead, it relies on spectral absorption and pulse oximetry [1]. Hemoglobin (the protein that carries oxygen in the blood) changes color and physical properties depending on the amount of oxygen it is bound to. Colors and Light:Oxygenated hemoglobin absorbs infrared light more. Deoxygenated hemoglobin absorbs red light more.

Does the Doppler effect affect oxygen measurement?

No, they are two different techniques. Conventional pulse oximeters rely on light, while Doppler oximeters use sound waves to measure blood flow.

However, stable blood flow (which can be assessed with Doppler) is crucial for accurate oxygen readings, as cold extremities reduce blood flow and can interfere with the device's performance.

As a standard monitoring indicator during anesthesia, pulse oximetry is not a new technology. Since its introduction in the 1980s, pulse oximeters have incorporated more advanced technologies due to technological advancements, but these have primarily focused on improving the accuracy of blood oxygen readings. In 2015, researchers published an interesting study demonstrating the effect of each finger on blood oxygen saturation measurements.

All volunteers in this study were healthy individuals, with the exception of certain conditions such as pregnancy and low blood pressure. During the monitoring period, everyone used the same monitor and the same measurement mode, and the measurements were taken at the same location. Blood oxygen saturation measurements were taken on all ten fingers. Oxygen saturation was highest on the middle finger of the right hand in 370 results from 37 volunteers, while two left-handed volunteers had higher levels on their middle finger than on their left. In a survey of medical staff, approximately 80 percent would clip the blood oxygen sensor onto their index finger. This is because the index finger is supplied by the deep palmar arch, which belongs to the artery, while the middle finger is supplied by the ulnar artery. The study also showed that each finger has a different perfusion index, with the middle finger exhibiting the highest perfusion index regardless of whether it was normal or deficient. Due to the limited number of volunteers, no statistically significant differences in blood oxygen saturation between the fingers were measured[2].

The researchers say that studying differences in blood oxygen saturation between the fingers may not be clinically important, but in the context of low perfusion, it is meaningful. If you are right-handed, the middle finger of your right hand undoubtedly has the highest blood oxygen saturation. Therefore, the researchers say they believe that the middle finger of the dominant hand may provide the most accurate measurement of blood oxygen saturation[3].

The next time you go to the hospital to have your blood oxygen saturation measured, if you think the result isn't very accurate, you can try measuring it

again with your dominant middle finger to see if your blood oxygen saturation is normal.

How it works:

1. The device emits red light and infrared radiation from one side of the finger.

2. The radiation passes through the tissues and blood to the other side.

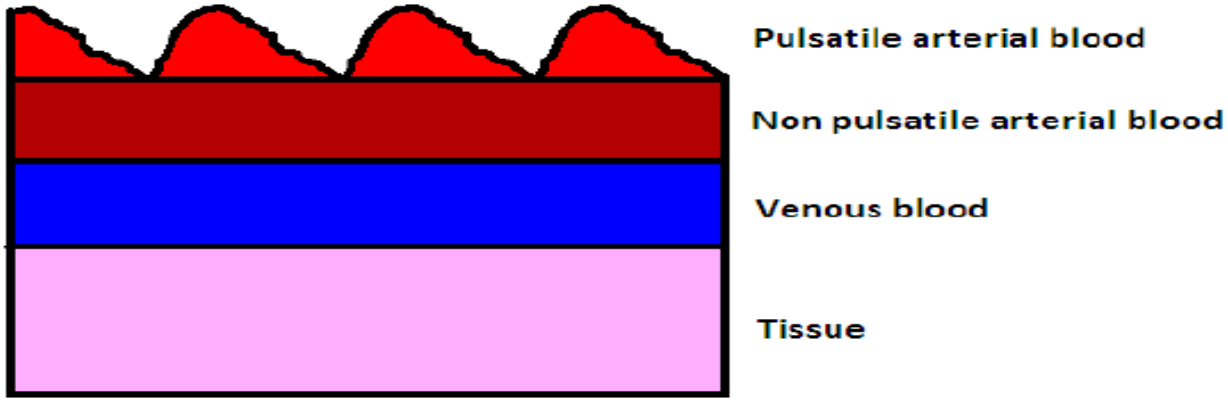
3. The device measures the amount of light absorbed.

4. The device separates arterial blood (pulsating with each heartbeat) from steady venous blood to accurately calculate the ratio and display it on the screen. [1, 2]

Theory:

Checking oxygen levels in the fingers (pulse oximetry) relies on sending light photons through the finger. The device measures the amount of light absorbed and determines the difference in absorption of hemoglobin (the blood protein that carries oxygen) between two states: oxygenated and deoxygenated, to accurately calculate the percentage. National Institute of Standards and Technology (NIST) (.gov) +3 The Physical and Practical Basis of the Process: Types of Light: The device sends two types of light photons through the finger: red light and infrared light. ar.contecmedsystems.com Iowa Head and Neck Protocols: Beer-Lambert's Law (Beer-LambertLayu): This is a physical law that relates the amount of light absorbed to the concentration of the absorbing substance. The law states that the concentration of oxygenated hemoglobin is proportional to the amount of light absorbed at a specific wavelength. The basic equation is: I = I0e−μCl, where: Icap II: received light intensity; I0cap I sub μI0: initial light intensity; μmuμ: light absorption coefficient; Ccap Cl: hemoglobin concentration; lll: distance traveled by the light through the finger. · Pulse Blood Isolation: To separate arterial (pulsating) blood from venous (steady) blood, the device uses a technique called photoplethysmography. The device senses the change in blood volume with each heartbeat and measures the amount of light absorbed at the peak of

the pulse, allowing for accurate calculation of oxygen saturation. PubMed Central (PMC) (.gov) +3 To learn more about the technique and details of pulse oximetry, you can read the Wikipedia article on pulse oximetry.



Light absorption diagram

The pulse oximeter analyzes the light absorption of two wavelengths from the pulsatile-added volume of oxygenated arterial

blood (AC/DC) and calculates the absorption ratio using the following equation 1.

$$\frac{(AC_{660})/(DC_{660})}{(AC_{940})/(DC_{940})}$$

ratio by using equation. SpO_2 following is the value of RX100.

Equation 2:

$$R = \frac{\log_{10}(I_{ac})\lambda 1}{\log_{10}(I_{ac})\lambda 2}$$

SpO2 is taken out from a table stored on the memory calculated with empirical formulas. A ratio of 1 represents a SpO_2 of 85%, a ratio of 0.4 represents SpO2 of 100 %, and a ratio of 3.4 represents SpO2 of 0 %. For more reliability, the table must be based on experimental measurements of healthy patients[4].

Another way for calculating SpO2 is taking the AC component of only the signal and determinat

I_{ac} = Light intensity at 1 (660 nm) or 2 (940 nm), where only the AC level is present.

A typical pulse oximetry signal is represented in Figure_. The signal represents the pulsatile arterial blood absorption. The beats per minute can be calculated using this signal.

What is spectroscopy? It is a branch of science concerned with studying and measuring the spectra produced by the interaction of matter with electromagnetic radiation or its emission[5].

Principle: The principles of spectroscopy vary depending on the type of spectroscopy.

How it works: Here's how a spectrometer works. A lamp provides the light source. The light beam strikes a diffraction grating that acts like a prism, separating the light into its constituent wavelengths. The grating is rotated so that only a specific wavelength of light reaches the exit. The light then interacts with the sample. From this point, the detector measures the sample's transmittance and absorption. Transmittance indicates the amount of light that passes through the entire sample and reaches the detector. Absorption measures the amount of light absorbed by the sample. The detector senses the light passing through the sample and converts this information into a digital display.

The physical basis for measuring blood oxygen saturation using light photons (in a pulse oximeter) relies on two main phenomena: light absorption and heart rate.The device uses a sensor that attaches to the finger and works according to the following steps:

Medical

• Hemoglobin nature: Hemoglobin (the oxygen-carrying protein in blood) changes color depending on the amount of oxygen it carries.

OpenOximetry

• Different wavelengths: The device sends two types of light photons through the finger:

1. Red light (wavelength 660 nm).

2. Infrared light (wavelength 940 nm).

Absorption law: Oxygen absorbed in the blood (oxyhemoglobin) absorbs infrared light more readily. Deoxyhemoglobin (blood devoid of oxygen) absorbs red light more readily. OpenOximetry

Arterial Isolation: The device uses heartbeats to separate arterial blood from the rest of the finger tissue. Arterial blood flows with each heartbeat, changing the amount of light reaching the photoreceptor.

Result: The microprocessor calculates the percentage of light absorbed by the arteries, and based on this equation, it accurately calculates the oxygen saturation and displays it on the screen.A fingertip pulse oximeter uses light to measure your blood oxygen. Its electrical circuit contains three main parts: light transmitters, a light detector, and a computer chip. [1, 2, 3, 4, 5]

1. The Light Transmitters

The Parts: One Red LED (660 nm) and one Infrared (IR) LED (940 nm). [1, 2]
How It Works: A timing circuit switches these two LEDs on and off very fast. For example, the Red LED flashes, then the Infrared LED flashes. This happens hundreds of times per second. [1, 2]

2. Filters and Processing

The Parts: Filters and a Microcontroller Unit (MCU). [1]
(Note: AC represents the pulsing arterial blood signal, and DC represents the steady absorption of tissue and bone). [1, 2, 3]

3. Display

The Output: The MCU sends the final calculation to a screen (like an LCD or OLED) to show your blood oxygen percentage and heart rate

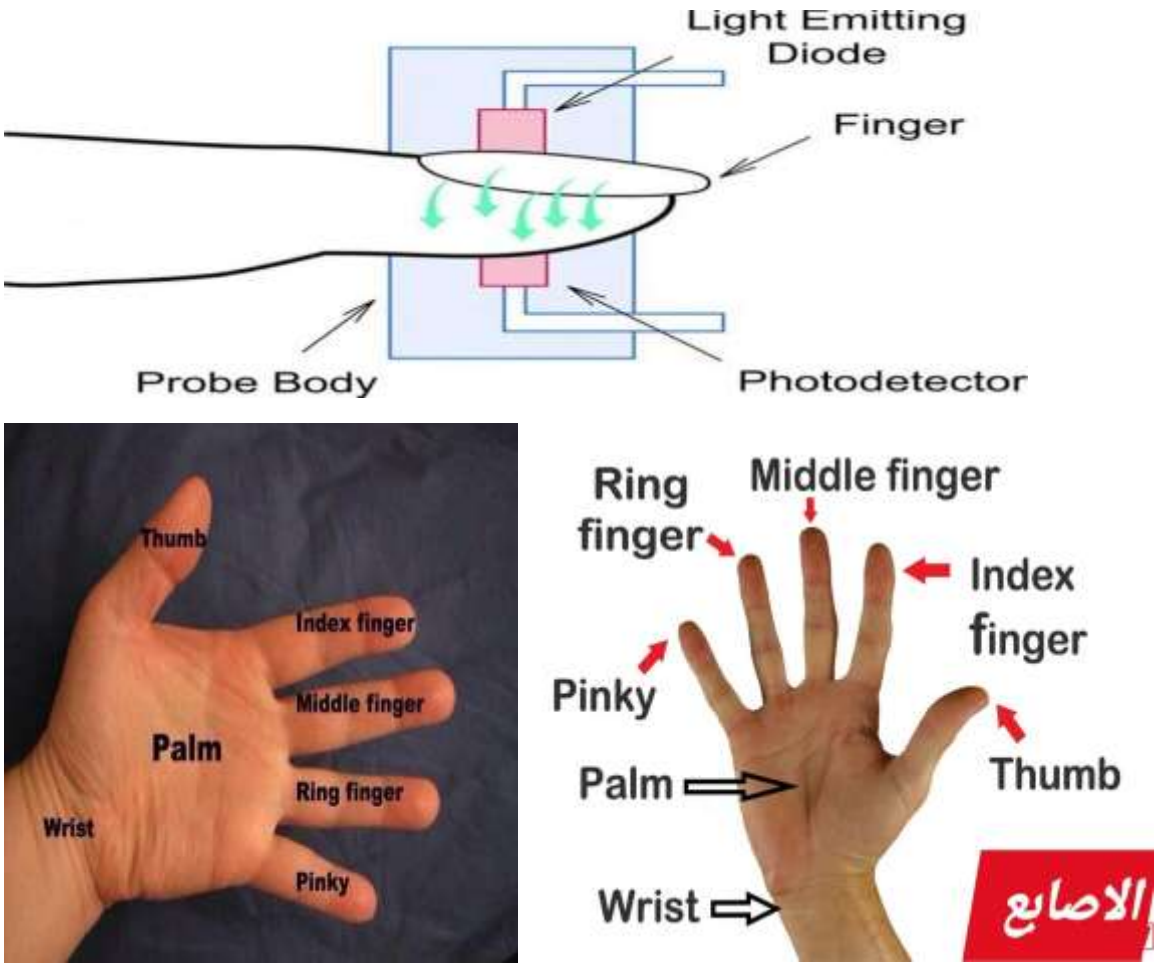


Figure 1: Fingers of hand.

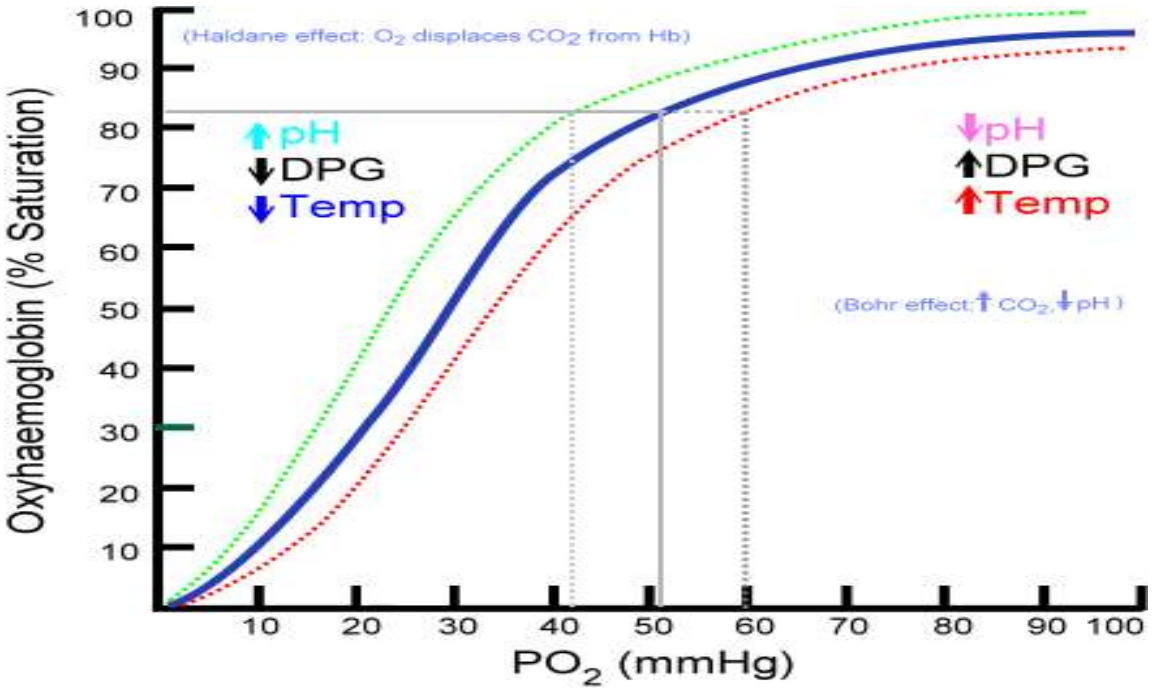


Figure 2:Representaion of saturation and PO_2 as a function of Ph,DPG and Temp[6].

Table (1): Measurements of Right hand Male- SpO2-PRbpm and Lift hand Male-SpO2 – PRbpm

	Thump	Index finger	Middle finger	Ring finger	Pinky
Right hand Male- SpO_2-PR_{bpm}	82 70	95 80	98 80	91 78	93 82
Lift hand Male-SpO_2 - PR_{bpm}	80 77	87 76	90 76	94 76	94 78
Perfusion Index					

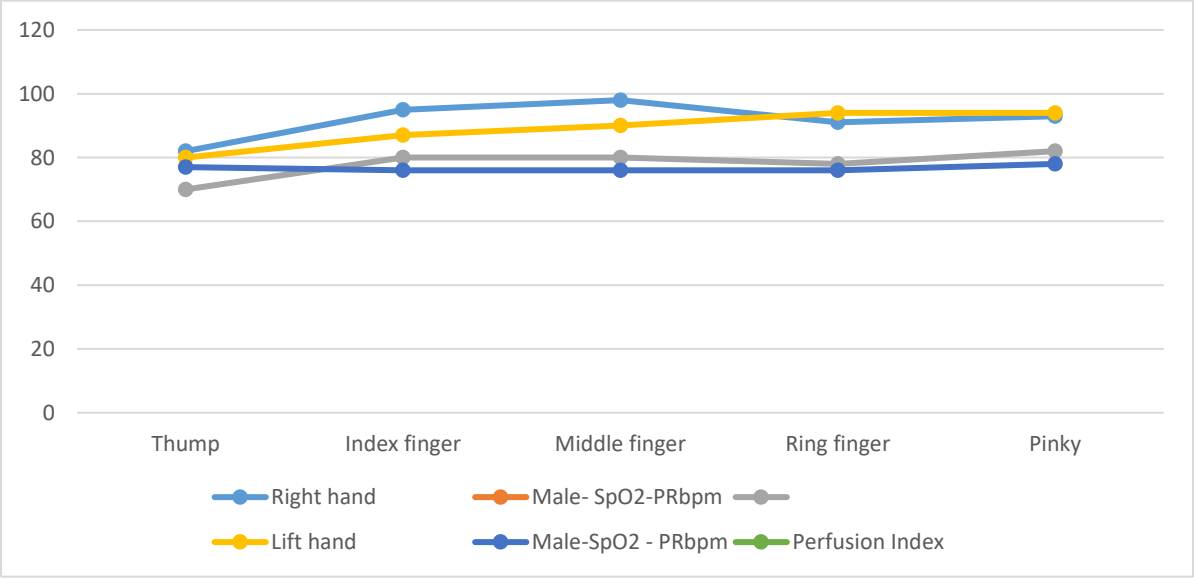


Figure 3:The relation of SpO_2 and PRb for right and lift hand of male.

Table (2): Measurements of Right hand Female- SpO2-PRbpm and Lift hand Female-SpO2 - PRbpm

	Thump	Index finger	Middle finger	Ring finger	Pinky
Right hand Female- SpO_2- PR_{bpm}	98 85	94 82	96 80	97 78	97 81
Lift hand Female- SpO_2 - PR_{bpm}	94 81	98 86	98 80	99 80	98 80
Perfusion Index					

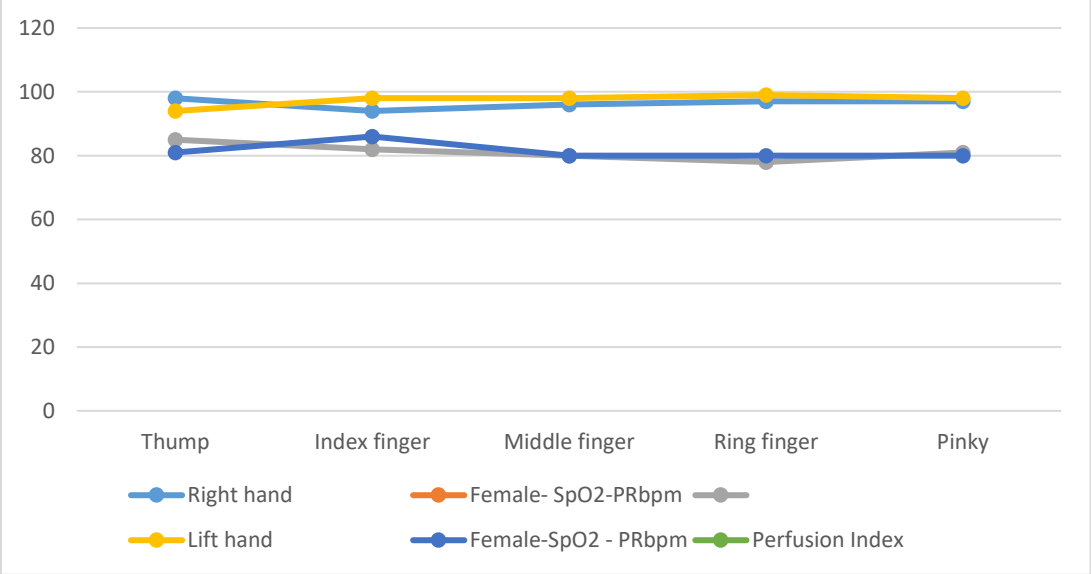


Figure 4:The relation of SpO_2 and PRb for right and lift hand of Female.

<u>Follow these basic steps for O_2 meter tips to achieve maximum reading accuracy:</u>

Preparation:

Remove nail polish, artificial nails, or jewelry from your chosen finger. Make sure your hands are warm by rubbing them together or washing them with warm water if they feel cold. Cold fingers significantly reduce blood flow and affect the accuracy of the measurement. Sit comfortably and remain still for two to three minutes before taking the measurement to allow your blood circulation to stabilize.

Proper Positioning:

Insert your middle finger into the pulse oximeter with your fingernail facing upward. Position the sensor so that it rests comfortably on your fingertip without being too tight or too loose. The sensor should feel secure in place, but not uncomfortable or restricting blood flow[7].

Environmental and Personal Factors Affecting Accuracy

Similarly, excessively loose sensor can lead to disconnections and inconsistent readings.

Another common mistake is taking a single reading and assuming it's accurate. For more reliable results, it's advisable to take two or three consecutive readings and look for consistent values rather than relying on a single measurement.

Conclution:

Blood oxygen saturation (SpO_2) measurement effected by factors affecting .

One such symptom is cyanosis, a bluish discoloration of the skin. In some cases, hypoxia can progress to hypoxemia, a decrease in the oxygen level in the body's tissues.There are several ways to measure blood oxygen saturation (SpO_2). The most common method is using oximeter..

The blood oxygen saturation (SpO_2) and blood pressure to appear on the screen.

The blood oxygen saturation (SpO_2) within a margin of error of ±2%. An ideal range is between 96% and 99%, indicating sufficient oxygen-carrying hemoglobin in the blood. If the reading is below 90%, consult your doctor.

Pulse oximeters may sometimes give falsely low readings if a person has poor circulation in their extremities, such as hands were very cold at the time of reading.

Many COVID-19 patients experience low oxygen levels, even when they feel well. While low oxygen levels may indicate the need for medical attention, pulse oximetry should not be relied upon as a definitive diagnostic test for COVID-19. Mastering Normal Pulse Oximeter Readings. Normal pulse oximeter readings—SpO_2 (95–100%), pulse rate (60–100 bpm.

Understanding which finger is best for measuring blood oxygen saturation is crucial for reliable home health management.Most Accurate Finger is the middle finger .

Doctors and medical device manufacturers consistently recommend the middle finger as the best choice for measuring blood oxygen saturation in adults. The middle finger provides optimal blood flow and ideal sensor contact area, resulting in readings that are 1–3% more accurate than other fingers. The index finger is another excellent option, offering similar reliability when the middle finger is unavailable or uncomfortable to use.

Your middle and index fingers have several physiological advantages: they maintain consistent blood flow, have sufficient tissue thickness for light penetration, and provide a stable position within the sensor clip. These factors combine to provide the clearest signal for accurate O_2 saturation readings.

Choosing the wrong finger can result in weak signals, causing error messages or unreliable readings that may mislead your health monitoring efforts.

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