SPO_2 Vital Sign: Definition, Ranges, and Measurements

Eng. Ibrahim M. ALhyari, Eng. Mahdi A. Alabadi, Eng. Ghassan J. Hijazin, Eng. Fadi T. Alasasfeh

Royal Medical Services- Institute of Biomedical Technology

DOI: 10.29322/IJSRP.8.7.2018.p7945
http://dx.doi.org/10.29322/IJSRP.8.7.2018.p7945

Abstract- Saturation of Oxygen in the Blood (SPO2) is one of the most important vital signs. Moreover, determining its value is considered an imperative task for healthy and sick people.

Motivation: in this paper, worthy information about the SPO2 vital sign is presented as well as the associated medical issues and the various ways to measure the SPO2 were discussed.

Method: referring to some significant different resources, precise definitions of this vital sign and some medical details were provided.

Conclusion: every single person should be interested in knowing little essential information of the SPO2 vital sign. This information might save lives.

Index Terms- SPO2. Body Oxygenation, Normal Ranges, and Pulse Oximeter

I. Introduction

SPO2 stands for peripheral capillary oxygen saturation, a measurement of the oxygen in the blood. This measure is presented as a percentage of 100 since it is the division of oxygenated hemoglobin by the total amount of hemoglobin in the blood [1]. If the SPO2 measurement was 97%, then this means that each red blood cell is made up of 97% oxygenated hemoglobin and 3% of non-oxygenated hemoglobin. The blood flows in the body contains many proteins, one of the most important proteins is the hemoglobin which its primary duty is carrying the oxygen in the blood, and this is the reason behind the red color of the blood[2][3][4]. Each molecule of hemoglobin can bind to four molecules of oxygen. Considering the weight of the hemoglobin, each one gram of hemoglobin can bind to 1.39 ml of oxygen. Figure (1) below illustrates how oxygen bound to hemoglobin and how it dissolved in the blood.

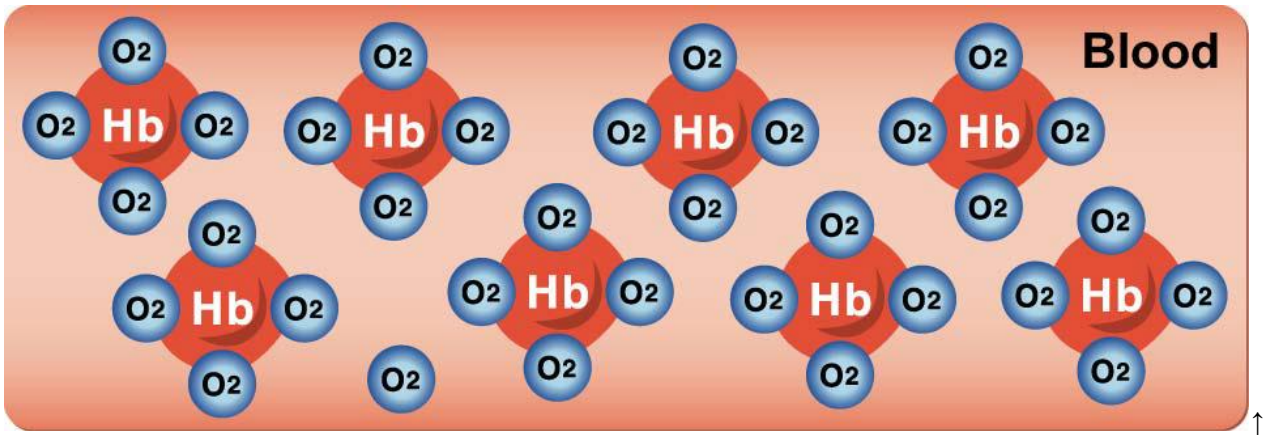

Figure (1): Dissolved Oxygen vs. Oxygen Bound to Hemoglobin

Figure (2) below shows the oxygenated blood which is in red, and that flows in the arteries as well as the non-oxygenated blood which is in blue color and that flows through the veins.

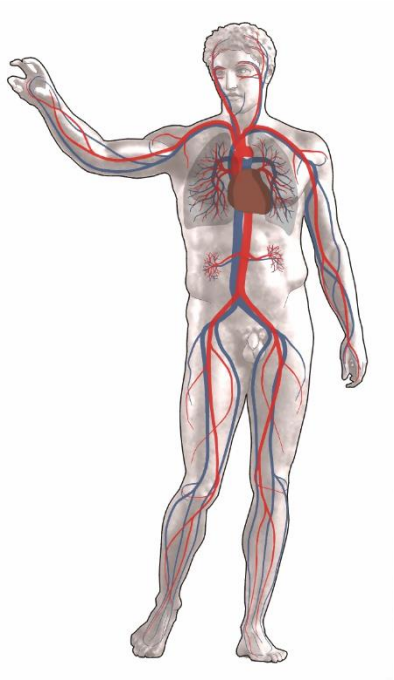

Figure (2): Blood Circulation

Indeed, the respiratory system is the one responsible for supplying the body with oxygen. The oxygen is gathered in the lungs and distributed to the rest of the body via the circulation of the blood.In general, the importance of oxygenated blood is to supply body muscles with energy, so that the person can perform the works and duties smoothly and correctly. So, during exercises, the person needs more oxygen and try hard to breath faster.

The saturated blood cell is defined as the cell that carries a reasonable amount of oxygen [5]. Both too high and too low levels can have counteractive effects on the body.

II. Ranges and Associated Diseases

Typical ranges of the SPO2 vital sign vary between 96% and 100%.However, when patients have some medical troubles such as cardiovascular, chronic diseases and pneumonia, the level of SPO2 may drop rapidly. Ranges between 95% and 90% are considered to be low but with no evidence of impairment.Moreover, when the level of SPO2 gets lower than 90%, then this causes acute respiratory failure. In fact, some people have normal levels of SPO2 that are lower than 90% such as those who live in high altitudes. In addition, levels of SPO2 drop considerably in some cases such as sleep and physical exercises. Indeed, when the value of oxygen that is saturated in the artery which is abbreviated as SaO2 is below 90%, this cause a problem called hypoxemia. Hypoxemia is a crucial problem and may result in different symptoms, such as shortness of breath.There are some factors needed to continuously supply the different cells, tissues, and organs in the body with oxygen such as:

1. Enough amount of oxygen in the surrounding environment.
2. Lungs efficiency to inhale the oxygen-containing air and to exhale the carbon dioxide.
3. The efficiency of blood arteries and veins to circulate the blood to the lungs.

Any problem with any factor of the above factors such as high altitude, diseases like asthma and heart diseases might cause this significant problem hypoxemia.

Furthermore, when the range of SaO2 is between 65% and 55%, then this will cause an impaired mental function on average. Besides, when the percentage in SaO2 reading is started from 55% and less, then this will cause a loss of consciousness on average[6][7].

Consequently, there are some situations; the person is advised to visit the doctor for obtaining consultancy. The situations might be:

1. Shortness of breath after small exertion or when the person is at rest.
2. Shortness of breath that becomes worse when doing exercise.
3. Sudden awakening with shortness of breath and this is indeed might be symptoms of sleep apnea[8][9].

It is very imperative to mention that there is some advice to avoid falling under chronic shortness of breath, such as:

1. Quit smoking: smoking affects lungs and may cause many severe heart diseases.
2. Avoid passive smoking: passive smoking is as dangerous as direct smoking.
3. Doing regular exercises: regular exercise can progress the aggregate strength and endurance[10].

III. Measurements

The most common method to measure the SPO2 vital sign is by using the pulse oximeter. The pulse oximeter is indeed a

non-invasive technique. It depends mainly on the absorption property of both oxy and deoxyhemoglobin. However, the pulse oximeter provides two wavelengths, which are the 940 nm and the 600 nm from two different light sources. In addition to the two light sources, there is also a light detector to provide the photoplethysmographic (PPG) signal to detect both the oxy and deoxyhemoglobin. The parameters of the two PPG signals are used to evaluate the SPO2 [11][12][13][14].

Another method is used to measure the SPO2 reading, which is the conventional pulse oximetry (CPO). In this technique, the arterial blood is assumed to be the only light-absorbing pulsatile component in the path of light. Indeed, the SPO2 is calculated by dividing the value of the Pulsatile Transmitted Red (PTR) to the Infrared (IR) Light by using the following formula[15]

$$Optical\ Density\ Ratio = \frac{Pulsatile\ Transmitted\ Red}{Infrared\ Light} \quad (1)$$

Recently, another recent technique is used to measure the SPO2 vital sign. In fact, the smartphone's camera is used to evaluate the SPO2. In this method, the effects of the environmental light sources are compensated. In fact, this method depends mainly on evaluating the quality of the PPG signals, and this is done by analyzing the intensity of the light in both red and green light channels of the video scopes of the patient fingertip. Here, a suitable digital way initiates the scale factor of the PPG to gather the effects of external light for increasing the estimation of the SPO2 reading [16].

IV. Conclusions

Studies are underway to re-evaluate SPO2 as a crucial, vital sign in improving patient medical health and reducing the bills referring to medical issues and diseases. In conclusion, anyone must take care of the vital sign SPO2, keep the readings of this vital sign within the normal ranges by using the different ways to measure this percentage provided in this paper and take the advice presented in this paper into consideration to keep the health as possible.

References

[1] Oei, J.L., et al., Clinicians in 25 countries prefer to use lower levels of oxygen to resuscitate preterm infants at birth. Acta Paediatrica, 2016. 105(9): p. 1061-1066.

[2] Shin, T.G., et al., Comprehensive interpretation of central venous oxygen saturation and blood lactate levels during resuscitation of patients with severe sepsis and septic shock in the emergency department. Shock, 2016. 45(1): p. 4-9.

[3] Swan, M., Emerging patient-driven health care models: an examination of health social networks, consumer personalized medicine and quantified self-tracking. International journal of environmental research and public health, 2009. 6(2): p. 492-525.

[4] Yang, R., et al. When fitness trackers don't'fit': end-user difficulties in the assessment of personal tracking device accuracy. in Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing. 2015. ACM.

[5] Klein, H.G. and D.J. Anstee, Mollison's blood transfusion in clinical medicine. 2014: John Wiley & Sons.

[6] Ahmed, F., et al., Australian adults: findings of a population based study in Queensland, Australia. Asia Pacific Journal of Clinical Nutrition.; 17 (1): 40-7. Ait-Yahia D, Madani S, Prost E, Prost J, Bouchenak M, Belleville J.,(2003). Tissue Antoxidant Status Differs in Spontaneously Hypertensive Rats. Sciences. 133: p. 479-82.

[7] Schutz, S.L., Oxygen saturation monitoring by pulse oximetry. AACN procedure manual for critical care, 2005: p. 101-107.

[8] Cook, D.A., et al., Getting maintenance of certification to work: a grounded theory study of physicians' perceptions. JAMA internal medicine, 2015. 175(1): p. 35-42.

[9] Broaddus, V.C., et al., Murray & Nadel's Textbook of Respiratory Medicine E-Book. 2015: Elsevier Health Sciences.

[10] Wilkins, M.R., et al., Pathophysiology and treatment of high-altitude pulmonary vascular disease. Circulation, 2015. 131(6): p. 582-590.

[11] Wieben, O., Light absorbance in pulse oximetry, in Design of pulse oximeters. 1997, CRC Press. p. 53-68.

[12] Webster, J.G., Design of pulse oximeters. 1997: CRC Press.

[13] Nitzan, M. and H. Taitelbaum, The measurement of oxygen saturation in arterial and venous blood. IEEE Instrumentation & Measurement Magazine, 2008. 11(3).

[14] Nitzan, M., et al., Measurement of oxygen saturation in venous blood by dynamic near IR spectroscopy. Journal of Biomedical Optics, 2000. 5(2): p. 155-163.

[15] Goldman, J.M., et al., Masimo signal extraction pulse oximetry. Journal of clinical monitoring and computing, 2000. 16(7): p. 475-483.

[16] Carni, D.L., et al. Setting-up of PPG scaling factors for SPO2 % evaluation by smartphone. in Medical Measurements and Applications (MeMeA), 2016 IEEE International Symposium on. 2016. IEEE.

Authors

First Author – Eng. Ibrahim M. ALhyari, Royal Medical Services- Institute of Biomedical Technology
Second Author – Eng. Mahdi A. Alabadi, Royal Medical Services- Institute of Biomedical Technology
Third Author – Eng. Fadi T. Alasasfeh, Royal Medical Services- Institute of Biomedical Technology
Fourth Author – Eng. Ghassan J. Hijazin, Royal Medical Services- Institute of Biomedical Technology