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Original Research Article

Alerts in displays of pulse oxymeter observed during first wave of COVID 19 pandemic in India

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ABSTRACT

Use of instrument Pulse Oxymeter (PO), domesticated since COVID-19 outbreaks, have been sending ripples in individual users, communities, and social media(SM). The application, modus operandi, optical issues, technicality of the instrument and operation were raising eyebrows amongst the professionals, clinicians, and non-technical users. SM was awestruck when a picture displaying four different SpO₂ readings on four PO simultaneously attached to four digits of a hand, were shared. The authors decided to take up the study instantly. Since it was the 'no contact', social distancing, no medicine and vaccine for COVID-19 phase, the entire research was carried out using telemedicine and personal communications with total reliance on the data provided by self motivated persons who are being referred to as 'volunteers', 'patients', 'people', 'person' with same perception. Attempt has been made in this original research article to provide with basic technical idea and alerts for sensitization / comprehensible use of PO at least for domestic monitoring of patient's care.

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1. Introduction

Impact of social media (sm or SM) is undisputedly very high amongst the community at large and to some extent amongst medical professionals. In the era of super specialization it cannot be expected that the level of comprehension about the basic and essential instruments used for anesthesia in operation theatres, in clinical biochemistry and intensive care units would be acceptably of same standard among practitioners of all clinical systems and physicists. Pulse Oxymeter (pulse oxymeter, PO) which was hitherto essential equipment restricted to the anesthetists', is now a house hold thing, courtesy the COVID-19 pandemic. As such it becomes obligatory to inculcate the basic concept about the display of reading on this now common house hold instrument. For the reason, in the article attempt has been made to use non-technical jargon, as far as possible, for easy comprehensibility of non-professional commoners also. Lack of regulations in social media makes basic technical information easily accessible, which often is incomplete, inadequate, incomprehensible to some, and incorrect. But social media serves the information which is usually more acceptable by not only the common people but at times by professionals. Information in social media may drive people to shun or rush for a product or brand in the market. It becomes a competitive tool for building up marketing strategy. No scientific reference was needed for panic buying of N95 masks, pulse oxymeter, sanitizers,

* Corresponding author. E-mail address: sharma_anup@yahoo.com (A. Sharma). alcohol, antiseptics, antibiotics, anti-malarial, anti viral, without understanding the valid use of the products. Hugely publicized supposedly good immune boosters, antibiotics, herbals, dilution medicines, etc were purchased off the counter without a single scientifically proven / validated data. Government of India's Medical bulletins for disease control successfully curbed the malpractice and quackery regarding treatment of Covid and allied accessories to some extent. Volumes of information and data got generated and even the judiciary had to intervene, the reference need not be cited here for the obvious reasons.

Pulse oxymetry has been considered by anesthetists' and cardiologists as the '5th' vital sign. A pulse oxymeter provides valuable data regarding the percentage of hemoglobin molecules loaded with oxygen in arterial blood in patients with normal oxygen-dissociation curves which is reflected clinically as the peripheral oxygen saturation.¹ Awareness of the working principle, nuances, and shortcomings of pulse oxymetry will allow a clinician to make better judgment of the true tissue oxygenation status of a patient and be better prepared for making treatment decisions.

The pulse oxymeter works on the principal that O_2Hb and Hb have different absorption spectra in 660nm and 940nm. In the red region O_2Hb absorbs less light compared to Hb, and the vice versa happens in infra red region. Light emitting diodes are used to emit light of 660 nm and 940 nm wavelength.²

Clinically alertness is essential as 100% saturation on the oxymeter does not guarantee that tissues are sufficiently oxygenated. Normally Hemoglobin can bind approximately 1.34 mL of O₂/g Hb and a normal Hb concentration of 15g/dL makes the O₂ binding capacity approximately 20 mL O2/dL blood in 100% saturation. When the concentration of Hb is decreased, there is a decrease in total O2 content of the blood, but there might not be any change in the O₂ saturation, hence oxymetry is not an effective tool here. In an anaemic patient with normally functioning hemoglobin but with concentration of 8g/dL the O₂ binding capacity is approximately 10.7 mL O₂/dL.³ Essentially half of the amount of oxygen is being delivered, but the oxymeter reading may still read 100%. These are some common physiological issues which need careful assessment in patient care. And these biochemical concepts make the pulse oxymeter a half- learned tool in the hands of a common man.⁴

We were intrigued by a photograph of four pulse oxymeters attached in four different fingers of the same hand and all four displaying different SpO_2 . The picture was being widely circulated in the social media and its authenticity or source is not known to the authors. However, this gave us the impetus to take up the study of pulse oxymeter readings on four digits of the same hand among readily willing volunteers who contributed their finding of

their own, of varied age group, and were not suffering from any respiratory or cardiac illnesses. The objective of the study was to try to find out if the same type of variable readings as was shown in the social media picture could be possible naturally among the volunteers, or is reproducible, and to assess what could be the reasons for such variable recordings. Related one picture of the same is shown in Figure 1. Readings as seen is given hereunder in Table 1.

In view of the prolonged pandemic episodes of COVID-19, where treatment protocols, drug regimes and clinical findings were changing frequently with the disease pattern, the pitfalls of SpO_2 measurement in pulse oxymeter deserves attention and awareness.

In this article the words patients and persons have been used interchangeably with the same meaning.



Fig. 1: Pulse oxymeters readings displayed in four fingers, as was seen in social media

 Table 1: Readings on four digits after placement of four pulse oxymeters

	Index finger	Middle finger	Ring finger	Little finger
SpO ₂	83	98	77	91
Pulse	66	62	66	75

2. Materials and Methods

This is a community based, cross-sectional observational study. Hundred volunteers randomly chosen were of age 18 to 72 yrs. Most of the volunteers were urban dwellers from various parts of India. All of them are educated persons who voluntarily shared data and gave informed consent. There were 45 males and 55 female volunteers who were not suffering from any respiratory tract or cardiac illness during the study.⁵

Pulse oxymeters of various brands available in open market was used for the study.

Before placing the oxymeter on the fingers, the following points were noted:

1. The hands were checked for any anatomical anomalies

- 2. Skin of the fingers, surface of the skin, injury or any other dermatological conditions were checked.
- 3. The volunteers were asked to wash their hands meticulously to wash off grease, sweat or any other surface active agents. Hands were allowed to dry before application of the PO.
- 4. Volunteers with nail polish were excluded from the study.

The brand of PO is not disclosed in this article to avoid any controversy. Subscribers were asked to repeat their observations by following the protocols given here. Pulse oxymeter was placed in all four fingers simultaneously excepting the thumb. The display was allowed to settle down till it showed results without flickering. First four fingers of right hand and then fingers of left hand were taken for observation. In every individual finger multiple readings were taken and the mean was used in data generation. In case the flicker took longer time than usual to settle, new sets of high performance alkaline battery were replaced in the pulse oxymeter. Main focus was made on display of SpO₂ level, since pulse rate variability was persistent. Cases displaying SpO₂ level between 94 and 100% were only included in the study. Cases displaying SpO₂ level below 94% were asked to take deep breath for a while upto 5 to 10 times. Patients who reported drop of oxygen level below 92% were advised to get themselves evaluated in the nearest Covid hospitals duly approved by the government. This helped in early detection and early intervention of cases with undiagnosed respiratory tract illness.

3. Observations, Clinical Significance, and Results

 SpO_2 level as observed in patients is given in Figure 2 of the graph. The display as given in Figure 1 however could not be reproduced in any of the case, in any of our multiple set ups. It was further observed that even in cases of hypertension, diabetes mellitus, and in persons above 65yrs of age SpO_2 level could easily improve with deep inspiration.

Cases displaying SpO_2 level below 95% were asked to take deep breath for a while for about 10 times or till the improvement continues. It was found that such patients reached a 98 to 99 % saturation level with this breathing exercise.

These clinical findings pave the path for prospective studies.

Pondering over the social medial picture, in four POs attached to four fingers of right hand (thumb excluded), possible reasons for unacceptably wide variations in display may be attributed mainly to factors based on the measurement principle of PO. Initially in the PO at the manufacturer's end the ratio of absorbencies at the two wavelengths 660nm and 940nm is calibrated empirically against direct measurements of arterial blood oxygen saturation (S_aO_2) in volunteers. The resulting calibration



Fig. 2: % of SpO₂ as displayed in RH = right hand, LH = left hand, IF = index finger, MF = middle finger, LF= little finger

algorithm is stored in a digital microprocessor within the pulse oxymeter. During subsequent use the calibration curve is used to generate the pulse oxymeter's estimate of arterial saturation, SpO_2 .^{6,7} So wide variations of reading could be a result of technical anomaly in any of these logistics or pathophysiological conditions in the person whose SpO_2 is being measured. To mention a few, they can be:

Path length of light, interference between device probe and skin,^{8,9} surface contact issue, stabilization of the display on device, sensor related issues, internal instrumental errors / variations (10% variation is not uncommon), summation / addition of pulse waves, unwanted, undesirable, unintended wave filter setting, artifacts etc.

Variations in anatomical structure and / or associated pathology cannot be ruled out. Variations in pulse wave due to narrowed artery, integrity of the artery etc. are the prime factors which may give rise to variable SpO₂ reading in PO.

Operational protocols like device calibration, ¹⁰ ignoring the check list that was mentioned in the methodology described above, could be possible reasons for the erroneous variable readings in the four PO attached to four fingers.

4. Conclusion

Although Pulse Oxymeter has been an important monitoring device for anesthetists and clinicians in intensive care units, it cannot be given in the hands of layman. As the operational protocols, and the technical issues which arise out of pathophysiological conditions are beyond the comprehension of the general population. Observations made by untrained person should be interpreted and analysed only by medical personnel.

5. Limitations of Study

Since different company manufactured pulse Oxymeters with varying price range have been used so quality or standards check could neither be assessed nor claimed. Since it was the 'no contact', social distancing, no medicine and vaccine for COVID-19 phase, the entire research was carried out using teleconferencing and personal communications with total reliance on the data provided by self motivated persons.¹¹ Most of the data acquisition was

not supervised by medical personnel, although exhaustive checklist was given to all volunteers. This study was an attempt to create awareness for commonly used medical devices in domestic care unsupervised by any medical personnel. This was to drive home the fact that although these devices are made broadly available in the society at large, as doctors we should exercise utmost caution before we take any clinical decision based on these readings reported by the patients.

6. Future Scope

Similar study should be undertaken in large scale using different groups, material, and product and brand range to avoid any negative impact for erroneous results.

7. Source of Funding

None.

8. Conflict of Interest

None exists.

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