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Comparison of Pulse Oximeter with Arterial Blood Gas Analysis in Determination of Spo2 in Covid 19 at a Tertiary Care Centre in Central India.

[1]Priya Pratapan (Nair), [2]Ranjit Ambad, [3]Ujwalla Gawande, [4]Dattu Hawale, [5]Ujwalla Gawande

[1]Assistant Professor, Department of Obstetrics and Gynaecology, Datta Meghe Medical College and Shalinitai Meghe Hospital and Research Centre, Wanadongri, Hingna – 441110.
[2]Associate Professor and Registrar, Department of Biochemistry, Datta Meghe Medical College and Shalinitai Meghe Hospital and Research Centre, Wanadongri, Hingna – 441110.
[3]Associate Professor Dept. of Information Technology, Yeshwantrao Chavan College of Engineering, Nagpur, 441110.
[4]Tutor, Dept. of Biochemistry Jawaharlal Nehru Medical College, Datta Meghe Institute of Medical Sciences, Sawangi (Meghe), Wardha
[5]Associate Professor Dept. of Information Technology, Yeshwantrao Chavan College of Engineering, Nagpur, 441110.

Abstract

BACKGROUND: Covid 19 or SARS-COV-2 has created havoc in recent years and has put the world into a standstill with a high mortality and morbidity putting a pressure on the infrastructure of health system and making it difficult to manage all patients in hospital. As the search for triage system to judge the patients who would require home isolation and self-monitoring and the patients who will require in hospital management is still going on, some minor instruments and apparatus can be of great help in self-monitoring by patients and early detection of hypoxia or deterioration of condition can prompt then to contact health professional at an early stage. One such minor pocket apparatus is pulse oximeter. But, its effectiveness of determining the oxygen saturation can be misleading in some critical patients and they may require invasive procedure like arterial blood gas estimation for triaging patients of critical care. The present study compares the efficacy of pulse oximeter versus arterial blood gas analysis in measuring the accuracy of oxygen carrying capacity in critical covid 19 cases on oxygen therapy by different means.

METHODOLOGY: Patients with COVID-19 who required oxygen to maintain saturation and the intubated patients on mechanical ventilation were admitted to the COVID ICU set-up of Datta Meghe Medical College and Shalinitai Meghe Hospital and Research Centre, Wanadongri, Hingna were analysed and documentation of their vitals were done. The study was a prospective cross-sectional hospital-based study from July 2020 till Dec 2020. Total 50 patients who fulfilled the criteria were recruited for the study group. The degree of discordance between value of PaO2 with the saturation shown by pulse oximeter was recorded.

RESULT: Out of total 50 patients in study, 15 patients (30%) had a SpO2 of >90% with a measured PaO2of <60 mmHg which was discordant according to the standard curve.

CONCLUSION: The discordance of oxygen measurements between arterial blood gas analysis and peripheral pulse oximeter reading is an important factor in determining the evaluation and management of the acute hypoxemic respiratory failure in patients who required mechanical ventilatory support as seen in patients with COVID-19.

KEY WORDS: Covid 19, SARS-COV-2, Covid ICU, Pulse oximeter, Arterial blood gas analysis.

INTRODUCTION:

Pulse oximeter is a small, handy, pocket device which is simple and non-invasive method for examination of oxygen saturation (SpO2) in different parts of the body. [1] Pulse oximeters are one of the most commonly used tools in critical care medicine especially important in ICU set up. SpO2 probe measures blood oxygen when placed onto a fingertip, or other peripheries like earlobe or foot tip and can be used to indicate whether a patient needs urgent medical care. Health providers use them when they take vital signs and when they evaluate patients for treatment. Ever since the COVID 19 pandemic started, doctors have encouraged patients with Covid to use them at home. During the coronavirus outbreaks, the inexpensive devices have also become a widely sold item online, used by consumers to monitor their own oxygen levels at home when doctors have told them they're not sick enough to be hospitalized. Pulse oximeters work by shining two wavelengths of light, a red light and an infrared light, that pass through the skin of a finger. The device detects the colour of blood, which differs depending on the amount of oxygen. Oxygenated blood is bright cherry red, and deoxygenated blood has a more purplish hue. Depending on the hue, different amounts of light from the device are absorbed, and the oximeter analyses the proportions of the absorption and calculates the amount of oxygen. Use of pulse oximetry helps in early determination of weaning a person out of ventilatory support and extubation of intubated person and it also reduces the frequency of doing arterial blood gas analysis (ABG) for determination of various blood gas values especially in estimation of oxygen saturation in peripheral arteries. [2,3] Pulse oximeter has advantages of being convenient to use, non invasive and accurate to certain extent in determination of oxygen saturation with advantage of being used for continuous monitoring. [3,4,5] The device detects the amount of both oxyhaemoglobin as well as deoxygenated haemoglobin in the arterial blood and shows it together as Oxyhemoglobin saturation (SpO2) [6] which amounts to an indirect estimation of the arterial oxygen saturation (SaO2). [7] The normal oxygen saturation in a healthy individual is around 97% to 99%. [8]

If the SaO2 level which is obtained by blood gas analysis from an artery mostly preferred is radial artery is 70% to 100%, the amount of SpO2 measured from pulse oximetry kept at the peripheral level has high accuracy and is only 2% different from the SaO2 that is saturation obtained from arterial blood sample. [5] even though pulse oximeter can to a certain extent predict proper analysis, in more critically ill patients like those who are in ICU with hypoxaemia or who requires artificial support for maintaining oxygen saturation of body, the amount of error is reported as 7.2%. [9] Various factors can be responsible for the dependency of accuracy of the device which includes the physiological, environmental, technological and human errors. [1,3,7,10,11,12]

Forehead and finger probes which are common places of measuring peripheral oxygen saturation have higher reliability of detection in normal patient condition. However, these methods are not commonly effective in critically ill patients in intensive care unit who have changes in vital signs because they have certain limitations like oedema at the attached sites as compared to normal people with lesser comorbidities. [13,14]

Considering the current scenario of COVID 19 pandemic situation where it is taking a toll of human lives with limited availability of hospital set up for managing all patients of COVID, the triage of patients who present with symptoms of the pandemic is necessary to differentiate between patients requiring hospitalised treatment as those patients who require just home based isolation and care. [15] In such situations, pulse oximeter comes into play in diagnosing patients who comes with hypoxaemia and dyspnoea. Some patients even present to us with severe hypoxemia in the absence of dyspnoea, it is

a problem which is unofficially referred to as “silent hypoxemia” which poses a big challenge to the medical fraternity as thy won’t show any signs of hypoxia. To decrease the risk of complications in such patients, one proposed solution is the self-monitoring of oxygen saturation by the patients diagnosed with COVID- 19 with pulse oximetry at home and present for care when they show evidence of hypoxemia. While the ease of use and low cost of pulse oximetry makes this an attractive option for identifying problems at an early stage, the accuracy of it and precision to detect hypoxemia as compared to arterial blood gas analysis remains underrated.

The current study was undertaken to judge and compare the accuracy of pulse oximeter as compared to arterial blood gas analysis for detection of hypoxaemia as to detect the extent of reliability to be given to this non-invasive apparatus in a pandemic situation for triage of patient for better management of cases.

METHOD:

Patients with COVID-19 who required oxygen to maintain saturation and the intubated patients on mechanical ventilation were admitted to the COVID ICU set-up of Datta Meghe Medical College and Shalinitai Meghe Hospital and Research Centre, Wanadongri, Hingna were analysed and documentation of their vitals were done. The study was a prospective cross-sectional hospital-based study from July 2020 till Dec 2020. Total 50 patients were recruited for the study.

The patients were included in the study according to the following criterias:

1. Any patient of any age who was suspected or diagnosed as case of coronavirus disease after RTPCR report with risk of hypoxia.
2. Patients presenting with fever with hypoxaemia, pneumonia, dyspnoea, tachypnoea of any age group with or without coronavirus disease were initially considered to have SARS- COV- 2 and were included in study.

The patients who were either on low or high flow oxygen or who required intubation with mechanical ventilation were monitored using the pulse oximeter, non-invasive method and simultaneously the arterial blood was collected for gas analysis from right radial artery to measure various gas parameters to measure the severity of hypoxaemia.

The degree of discordance between value of PaO2 with the saturation shown by pulse oximeter was recorded in a chart as shown below:

RESULT:

TABLE 1. Arterial blood gas pH and PaO2 (mm Hg) values when compared to pulse oximetry values in patients diagnosed with COVID-19 who were intubated and mechanically ventilated.

Patient	pH	PaO2 (mm Hg)	Spo2 (%)
1	**7.43**	**66**	**91**
2	**7.37**	**72**	**93**
3	**7.32**	**45**	**90**
4	**7.21**	**57**	**93**
5	**7.45**	**79**	**95**
6	**7.39**	**54**	**95**

7	**7.35**	**58**	**95**
8	**7.39**	**58**	**95**
9	**7.37**	**70**	**95**
10	**7.41**	**61**	**94**
11	**7.43**	**88**	**96**
12	**7.26**	**85**	**96**
13	**7.39**	**74**	**96**
14	**7.37**	**56**	**96**
15	**7.36**	**67**	**96**
16	**7.32**	**60**	**96**
17	**7.44**	**106**	**95**
18	**7.2**	**88**	**95**
19	**7.43**	**54**	**95**
20	**7.39**	**57**	**94**
21	**7.47**	**96**	**96**
22	**7.43**	**55**	**97**
23	**7.47**	**52**	**97**
24	**7.27**	**62**	**97**
25	**7.37**	**70**	**97**
26	**7.44**	**108**	**97**
27	**7.35**	**167**	**100**
28	**7.37**	**197**	**100**
29	**7.46**	**172**	**100**
30	**7.469**	**102**	**100**
31	**7.41**	**55**	**100**
32	**7.45**	**79**	**100**
33	**7.45**	**54**	**100**
34	**7.36**	**134**	**97**
35	**7.34**	**92**	**99**
36	**7.36**	**88**	**99**
37	**7.449**	**68**	**98**
38	**7.453**	**54**	**100**
39	**7.44**	**108**	**97**
40	**7.38**	**131**	**97**
41	**7.45**	**59**	**100**
42	**7.502**	**91**	**100**
43	**7.469**	**102**	**100**
44	**7.27**	**62**	**97**
45	**7.43**	**88**	**96**
46	**7.47**	**52**	**97**
47	**7.36**	**99**	**96**
48	**7.37**	**79**	**97**
49	**7.45**	**82**	**97**

50	**7.36**	**88**	**99**

Of the 50 patients included in the study, (Table1), 15 patients (30%) had a SpO2of >90% with PaO2 of <60 mmHg. According to the oxyhaemoglobin dissociation curve, patients with SpO2 of at least 90% are predicted to have a PaO2 of at least 60 mmHg. [16]

DISCUSSION:

To assess and judge the need of initiation or titration of the oxygen therapy is important and critical in patient management and is largely dependent on the evaluation of patient's oxygen saturation status. Normally, 2% of the total oxygen carried by blood obtained from lungs is dissolved in the plasma. [17] This oxygen dissolved in plasma is available readily for tissue use which we measure it as partial pressure of oxygen in arterial blood (PaO2), which has a normal range of 80–100 mmHg. The remaining 98% of oxygen is bounded to the haemoglobin molecules of the red blood cells. [17] The measurement of arterial blood gas analysis possesses various factors like palpation of artery, painful procedure with repeated punctures, chances of infection and not a continuous monitoring process whereas, pulse oximeter is patient friendly, non invasive, painless and can be used for continuous monitoring of patient's saturation level and prompt attempt can be made to correct the hypoxaemia. The two assumptions of the pulse oximeter technology is: first: Haemoglobin exists in two forms, either as haemoglobin or oxyhaemoglobin; and second: The only pulsations of the body tissue on which a pulse oximeter is placed are due to arterial blood flow. [17,18,19] A pulse oximeter works on the principle that it analyses the pulsatile and the non-pulsatile signal components of two wavelengths of light that is (red(660 nm) and infrared (940 nm)) which are continuously emitted from a pair of LEDs, after which they travel through the fingertip, earlobe or forehead wherever the probe is placed to reach a photodetector. [17,18] The photodetector then generates a photo plethysmographic waveform as its output. The electrical circuits separates the non-pulsatile and pulsatile components of the waveforms for each of the two wavelengths. [17,18] The non-pulsatile components are from the non vascular tissue, capillary blood, venous blood or the arterial blood during diastole. [17, 18] and the pulsatile components are the absorption of the light by all four of the above-mentioned places along with the extra volume of arterial blood during systole. [17,18] The non-pulsatile component normalises the pulsatile component of each of the two wavelengths, an algorithm is then used to create a ratio of the normalized red light. As the haemoglobin absorbs more red light than the infrared light, and oxyhaemoglobin absorbs more infrared light than red light, this ratio is converted into SpO2 using the Beer–Lambert Law. A normal pulse oximetry saturation is considered to be >95%, although it is adjusted according to patient's comorbidities. For example, in the case of patients with COVID-19, oxygen therapy is often titrated to maintain an SpO2 of at least >88%. In normal circumstances, PaO2 can be predicted from the SpO2 using a standard oxyhaemoglobin dissociation curve. [8,20] but in certain circumstances, like carbon monoxide poisoning, methaemoglobin the pulse oximeter reading will not reflect actual oxygen carrying capacity, in such situations, arterial blood gas analysis is more accurate. In some covid patients it has been observed that the false assurance of spo2 100% but the PaO2 being less than 50 mm Hg can be seen and it can be alarming. So, one need to weight the importance of when to rely on saturation probe and which patients will require the arterial blood analysis so as to avoid unnecessary mishaps.

Nessler et al. (2012) in their study showed that amongst the patients with vasopressors, the forehead pulse oximeter sensor had higher accuracy in detection of SpO2 compared to pulse oximeter of fingers. [21] Wilson et al. (2010), in a retrospective cohort study, reported the difference of 2.7%

between SpO2 and SaO2 in the emergency patients presenting with severe sepsis and septic shock and suggested the use of ABG as compared to spo2.
The analysis, of 10,789 paired test results from 1,333 white patients and 276 Black patients hospitalized at the University of Michigan earlier this year, found that pulse oximetry overestimated oxygen levels 3.6 percent of the time in white patients, but got it wrong nearly 12 percent of the time, or more than three times more often, in Black patients.

In these patients, the pulse oximeter measures erroneously indicated the oxygen saturation level was between 92 and 96 percent, when it was actually as low as 88 percent (the results were adjusted for age, sex and cardiovascular disease).

Oxygen levels below 95 percent are considered abnormal, so the range of 92 to 96 percent could make difference in deciding whether the patient is really sick or not as does he/ she actually requires treatment for hypoxaemia.

CONCLUSION:

We concluded with the fact that patients of critical care who require ventilation and mechanical support should not be left for monitoring alone on the basis of pulse oximeter as it can produce erroneous results. These patients should be evaluated additionally with blood gas analysis to determine the need of further support or the weaning of support. The discordance of oxygen measurements with peripheral non-invasive method and invasive arterial method is an issue of critical concern for the evaluation and management of the acute hypoxemic respiratory failure seen in patients with COVID-19.

CONFLICT OF INTEREST: No conflicts of interest.

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