J Bras Pneumol. 2021;47(1):e20200251
https://dx.doi.org/10.36416/1806-3756/e20200251

Agreement among four portable wireless pulse oximeters and in-office evaluation of peripheral oxygen saturation

Saulo Maia d'Avila Melo[1,2], Marília Ferraz de Oliveira Macedo[3], Juliana Silva Santana Pereira[2]

TO THE EDITOR:

Early diagnosis is essential in the medical practice. Measured via pulse oximetry, SpO_2 is currently considered as the "fifth vital sign" because it shows not only the values of respiratory function but also the presence, amplitude, and frequency of the pulse.[1,2]

During the coronavirus pandemic, the measurement of SpO_2 with portable wireless pulse oximeters has garnered considerable attention as an important vital sign in the early detection of hypoxemia, thereby facilitating the clinical decision-making process.[3,4]

The use of portable pulse oximetry is well-established in the hospital environment. The use of portable wireless pulse oximeters in office visits is growing rapidly, and some patients present oxygen desaturation even when they feel relatively well.[1,2,5,6] Many models of portable wireless pulse oximeters, from different manufacturers and at various prices, are sold in Brazil.

Questions have arisen regarding the use of SpO_2 measurement in outpatient settings: What is the minimum time required to obtain a proper SpO_2 reading?; How long before the SpO_2 stabilizes?; and Is there agreement among the readings of the various oximeters used in Brazil? The objective answers to these questions have not been clearly established. Therefore, the objective of the present study was to evaluate the minimum time necessary for the appropriate measurement of SpO_2, to determine the time necessary for the SpO_2 reading to stabilize, and to evaluate the agreement among the results of four different portable wireless pulse oximeters used in Brazil.

This was a cross-sectional study, performed in a physician office and approved by the research ethics committee of the institution (CAAE No. 52677816.3.0000.5371). All the participants signed a free and informed consent form and there were no conflicts of interest.

The sample size required in order to identify good agreement (above 0.81) among the four oximeters and to measure SpO_2 was estimated with an error below 0.20, a level of significance of 5%, a confidence interval amplitude of 0.1, and the addition of 10% to compensate for losses and refusals.[7,8] Thus, we found that a minimum sample of 45 patients would be required in order to evaluate the agreement among the oximeters.

We evaluated a convenience sample comprising all volunteers ≥ 18 years of age. Patients with hypotension, hypothermia, digital clubbing, Raynaud's phenomenon, significant anemia, or fever were excluded, as were those with fake or painted nails, those in whom there were hand movement artifacts, and those who had any cognitive deficit that would prevent them from filling out the questionnaire (in the absence of information provided by family members).

The SpO_2 data were collected after the volunteers had rested for at least 5 min, during which time they were comfortably seated in a chair, with one hand resting on a table. The four portable wireless pulse oximeters used were as follows: GO_2 Achieve (Nonin Medical, Inc., Plymouth, MN, USA); ChoiceMMed (ChoiceMMed America Corp., Bristol, PA, USA); Rossmax SB100 (Rossmax, Taipei, Taiwan); and Finger Type & Oximeter (Beijing Choice Electronic Technology Co., Beijing, China). The oximeters were placed simultaneously and distributed randomly on the fingertips of the same hand. The SpO_2 was measured at three different time points (30 s, 60 s, and 120 s), determined with a stopwatch and verified photographically.

To evaluate the agreement among the oximeters, we chose the highest SpO_2 reading obtained from each device at each of the three time points and calculated the intraclass correlation coefficients (ICCs).[7,8] The results were interpreted using the criteria established by Landis and Koch,[9] in which the ICC is categorized as excellent if > 0.91, good if 0.71-0.90, moderate if 0.51-0.70, fair if 0.31-0.50, and poor if < 0.31. The level of statistical significance was set at $p \leq 0.05$. The data collected were processed with the IBM SPSS Statistics software package, version 22.0 (IBM Corporation, Armonk, NY, USA).

We evaluated 133 patients, of whom 60 (45.1%) were male and 73 (54.9%) were female. The mean age in the sample as a whole was 55.34 ± 18.90 years (95% CI: 52.09-58.88; range, 18-95 years).

The SpO_2 measurements did not differ significantly among the time points evaluated (30 s, 60 s, and 120 s), for any one device or among the four oximeters evaluated, and the SpO_2 remained stable for 120 s (Table 1). For each oximeter, the highest reading was found at the 120-s time point, and that value was used to evaluate the agreement among the devices.[9] The agreement among the four oximeters was considered excellent (ICC = 0.902; 95% CI: 0.857-0.933).

Previous studies have not clearly defined the ideal time to begin reading a portable wireless pulse oximeter or the window of time necessary for the oximeter reading to stabilize.[5,6,10] To our knowledge, there have been

1. Departamento de Medicina, Universidade Tiradentes, Aracaju (SE) Brasil.
2. Residência em Clínica Médica, Hospital de Urgência de Sergipe, Aracaju (SE) Brasil.
3. Residência em Pneumologia, Universidade Federal de Sergipe, Aracaju (SE) Brasil.

Table 1. Measurement of SpO_2 at three different time points with four different pulse oximeters.[a]

Oximeter	Time point			p*
	30 s	60 s	120 s	
ChoiceMMed	96.38 ± 1.84 (96.06-96.69)	96.38 ± 1.79 (96.07-96.68)	96.39 ± 1.88 (96.07-96.71)	0.988
GO_2 Achieve	95.75 ± 2.46 (95.33-96.17)	95.78 ± 2.11 (95.42-96.14)	95.89 ± 2.22 (95.50-96.27)	0.455
Rossmax SB100	96.06 ± 2.20 (95.68-96.44)	96.07 ± 2.32 (95.67-96.46)	96.29 ± 2.22 (95.91-96.67)	0.063
Finger Type & Oximeter	94.97 ± 2.62 (94.52-95.42)	95.14 ± 2.65 (94.69-95.60)	95.22 ± 2.47 (94.79-95.64)	0.122

[a]Values expressed as mean ± SD (95% CI). *ANOVA and Bonferroni test.

no studies evaluating the agreement among wireless oximeters in physician offices.

In the present study, we have demonstrated that, in hemodynamically stable patients, the SpO_2 can be read at 30 s and remains stable up to 120 s, with no significant differences in readings among the three time points evaluated (Table 1). With the current technical qualification of the new portable pulse oximeters, future studies will be able to evaluate SpO_2 levels with confidence in less than 30 s.

In the absence of previous studies on the objectives under discussion, our results can help health professionals (physicians, nurses, and physiotherapists) evaluate the SpO_2 objectively and safely in as little as 30 s, optimizing their outpatient consultation time and allowing a flexible choice in the acquisition of these different devices to be used in the daily practice, with a good cost-benefit ratio.

Our study has some limitations. Because of the cross-sectional study design, the durability of the wireless pulse oximetry devices was not evaluated. To evaluate the accuracy of the oximeters used, it would be necessary to compare them with the gold-standard system (arterial blood gas analysis with the determination of the SaO_2).

We concluded that, in a physician office, SpO_2 can be measured properly in as little as 30 s with any of the oximeters evaluated here. We also found that the reading remains stable for 120 s and that the agreement among the four oximeters was excellent.

AUTHOR CONTRIBUTIONS

SMDM: idealization, conception, and planning of the study; interpretation of the data; drafting and revision of the manuscript; and approval of the final version. MFOM: conception and planning of the study; interpretation of the data; and drafting and revision of the manuscript. JSSP: interpretation of the data; and revision of the manuscript.

REFERENCES

1. Pretto JJ, Roebuck T, Beckert L, Hamilton G. Clinical use of pulse oximetry: official guidelines from the Thoracic Society of Australia and New Zealand. Respirology. 2014;19(1):38-46. https://doi.org/10.1111/resp.12204
2. O'Driscoll BR, Howard LS, Earis J, Mak V; British Thoracic Society Emergency Oxygen Guideline Group; BTS Emergency Oxygen Guideline Development Group. BTS guideline for oxygen use in adults in healthcare and emergency settings. Thorax. 2017;72(Suppl 1):ii1-ii90. https://doi.org/10.1136/thoraxjnl-2016-209729
3. Brasil. Ministério da Saúde. Protocolo de Manejo Clínico para o Novo Coronavírus (2019-nCoV) [monograph on the Internet]. Brasília: Ministério da Saúde; 2020 cited 2020 Apr 5]. Available from: https://portalarquivos2.saude.gov.br/images/pdf/2020/fevereiro/11/protocolo-manejo-coronavirus.pdf
4. World Health Organization. Institutional Repository for Information Sharing [homepage on the Internet]. Geneva. World Health Organization; c2020 [updated 2020 Mar 13; cited 2020 Apr 12]. Clinical management of severe acute respiratory infection (SARI) when COVID-19 disease is suspected: interim guidance. Available from: https://apps.who.int/iris/handle/10665/331446
5. Mechem CC. Pulse oximetry. Parsons PE, Finlay G, editors. UpToDate. Waltham, MA: UpToDate Inc. [cited 2018 Nov 10]. Available from: https://www.uptodate.com/contents/pulse-oximetry
6. American Thoracic Society [homepage on the Internet]. New York: American Thoracic Society [cited 2020 Feb 17]. Pulse Oximetry. [Adobe Acrobat document, 2p.]. Available from: https://www.thoracic.org/patients/patient-resources/resources/pulse-oximetry.pdf
7. Zou GY. Sample size formulas for estimating intraclass correlation coefficients with precision and assurance. Stat Med. 2012;31(29):3972-3981. https://doi.org/10.1002/sim.5466
8. Miot HA. Agreement analysis in clinical and experimental trials. J Vasc Bras. 2016; 15(2):89-92. https://doi.org/10.1590/1677-5449.004216
9. Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics. 1977;33(1):159-174. https://doi.org/10.2307/2529310
10. Sociedade Brasileira de Pneumologia e Tisiologia. Diretrizes para Testes de Função Pulmonar. J Pneumol. 2002;28(Suppl 3):S1-S238.