Usefulness of Pulse Oximeter That Can Measure SpO₂ to One Digit After Decimal Point

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ABSTRACT
Pulse oximeters are used to noninvasively measure oxygen saturation in arterial blood (SaO₂). Although arterial oxygen saturation measured by pulse oximeter (SpO₂) is usually indicated in 1% increments, the value of SaO₂ from arterial blood gas analysis is not an integer. We have developed a new pulse oximeter that can measure SpO₂ to one digit after the decimal point. The values of SpO₂ from the newly developed pulse oximeter are highly correlated with the values of SaO₂ from arterial blood gas analysis (SpO₂ = 0.899 × SaO₂ + 9.944, r = 0.887, P < 0.0001). This device may help improve the evaluation of pathological conditions in patients.

Key words blood gas analysis; hypoxia; oxygen saturation; pulse oximeter; respiratory failure

Oxygen saturation in arterial blood (SaO₂) is used to monitor the clinical condition of patients with chronic respiratory failure and hypoxemia during anesthesia.1, 2 Arterial oxygen saturation measured by pulse oximeter (SpO₂) is based on the principle that oxyhemoglobin and deoxyhemoglobin differentially absorb red and near-infrared light, respectively.1, 2 The pulse oximeter can noninvasively assess SaO₂. The value of SpO₂ is usually an integer ranging between 0% and 100%. However, the value of SaO₂ from arterial blood gas analysis is not an integer. We have developed a new pulse oximeter that can measure SpO₂ to one digit after decimal point. In this study, we evaluated the new pulse oximeter by comparing it with conventional pulse oximeters.

SUBJECTS AND METHODS
We investigated 21 patients (8 with interstitial pneumonia, 4 with chronic obstructive pulmonary disease, 2 with restrictive lung disease, 2 with lung cancer, 1 with vasculitis, 1 with hypersensitive pneumonia, 1 with prostate cancer, 1 with pulmonary, and 1 with unidentified fever). Overall, 25 samples of blood gases from the radial artery were analyzed (ABL800 FLEX, Radiometer Medical Aps, Bronshoj, Denmark). The values of SaO₂ were determined based on the results of arterial blood gas analysis, and the values of SpO₂ were simultaneously measured using finger probe with three pulse oximeters: the newly developed pulse oximeter, Nellcore pulse oximeter (Medtronic, Minneapolis, MN), and SmartPulse pulse oximeter (Beijing Choice Electronic Technology, Beijing, China). Three pulse oximeters were randomly attached with the 2nd, 3rd and 4th fingers of the right hand, respectively. The values of SpO₂ were calculated with moving average of 16 beats. Nellcore is a more expensive pulse oximeter than SmartPulse. The protocol was approved by the local ethics committee of Tottori University (#2034), and written informed consent was obtained from each patient.

Statistical analyses
The values of SaO₂ and SpO₂ are presented as means ± SD. Correlation between the values of SaO₂ and SpO₂ was calculated using a simple linear regression and Pearson’s coefficient. The agreement between the values of SpO₂ and SaO₂ for each pulse oximeter was examined by Bland-Altman analysis.3 The mean difference between the SpO₂ and SaO₂ values is the bias. The 95% limits of agreement between the two methods are defined as mean ± 1.96 SD (GraphPad Prism 6, GraphPad Software, La Jolla, CA). Differences were considered to be statistically significant at P < 0.05.

RESULTS
There were significant correlations between SaO₂ and SpO₂. The values of SpO₂ from the newly developed pulse oximeter that can measure SpO₂ to one digit after decimal point highly correlated with the values of SaO₂ from arterial blood gas analysis, and linear regression was close to the identity line (SpO₂ = 0.899 × SaO₂ + 9.944, r = 0.887, P < 0.0001). The Bland-Altman plot indicates that there was a trend for SpO₂ to slightly over-
estimate SaO2 (Fig. 1). This trend was higher with the SmartPulse pulse oximeter.

**DISCUSSION**

The pulse oximeter is used in clinical medicine to continuously monitor SaO2. The mechanism of pulse oximetry is based on the principle that oxyhemoglobin and deoxyhemoglobin differentially absorb red (660 nm) and near-infrared (940 nm) light. Oxyhemoglobin absorbs greater amounts of near-infrared light and lower amounts of red light than does deoxyhemoglobin, and the values of absorbance of the two transmitted lights are measured by a pair of small light-emitting diodes in the finger probe. The relative amounts of red and near-infrared light absorbed are used to calculate SpO2.1, 2 The values of SaO2 from arterial blood are usually indicated in one digit after decimal point. Although the conventional pulse oximeter usually indicates SpO2 in 1% increments, we have developed a pulse oximeter that can measure SpO2 to one digit after decimal point by shortening the sampling time of measurement, thereby improving the accuracy.

We evaluated this device and two conventional pulse oximeters by Bland–Altman analysis and examined the correlation between SpO2 and SaO2. As this device indicated a good correlation between the SpO2 and SaO2 of arterial blood, the clinical physician will be able to improve the evaluation of the pathological condition of patients. The present study is associated with several limitations, with its relatively small sample size, and there were only a few cases with oxygen saturation below 90%. Further study will be needed to clarify the usefulness of this new pulse oximeter.

The authors declare no conflict of interest.

**REFERENCES**

