Usefulness of Pulse Oximeter That Can Measure SpO_2 to One Digit After Decimal Point

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ABSTRACT

Pulse oximeters are used to noninvasively measure oxygen saturation in arterial blood (SaO_2). Although arterial oxygen saturation measured by pulse oximeter (SpO_2) is usually indicated in 1% increments, the value of SaO_2 from arterial blood gas analysis is not an integer. We have developed a new pulse oximeter that can measure SpO_2 to one digit after the decimal point. The values of SpO_2 from the newly developed pulse oximeter are highly correlated with the values of SaO_2 from arterial blood gas analysis ($SpO_2 = 0.899 \times SaO_2 + 9.944$, $r = 0.887$, $P < 0.0001$). 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 (SaO_2) 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 (SpO_2) 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 SaO_2. The value of SpO_2 is usually an integer ranging between 0% and 100%. However, the value of SaO_2 from arterial blood gas analysis is not an integer. We have developed a new pulse oximeter that can measure SpO_2 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 pnlmonary, 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 SaO_2 were determined based on the results of arterial blood gas analysis, and the values of SpO_2 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 SpO_2 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 SaO_2 and SpO_2 are presented as means ± SD. Correlation between the values of SaO_2 and SpO_2 was calculated using a simple linear regression and Pearson's coefficient. The agreement between the values of SpO_2 and SaO_2 for each pulse oximeter was examined by Bland-Altman analysis.[3] The mean difference between the SpO_2 and SaO_2 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 SaO_2 and SpO_2. The values of SpO_2 from the newly developed pulse oximeter that can measure SpO_2 to one digit after decimal point highly correlated with the values of SaO_2 from arterial blood gas analysis, and linear regression was close to the identity line ($SpO_2 = 0.899 \times SaO_2 + 9.944$, $r = 0.887$, $P < 0.0001$). The Bland-Altman plot indicates that there was a trend for SpO_2 to slightly over-

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Abbreviations: SaO_2, oxygen saturation in arterial blood; SpO_2, arterial blood oxygen saturation measured by pulse oximetry

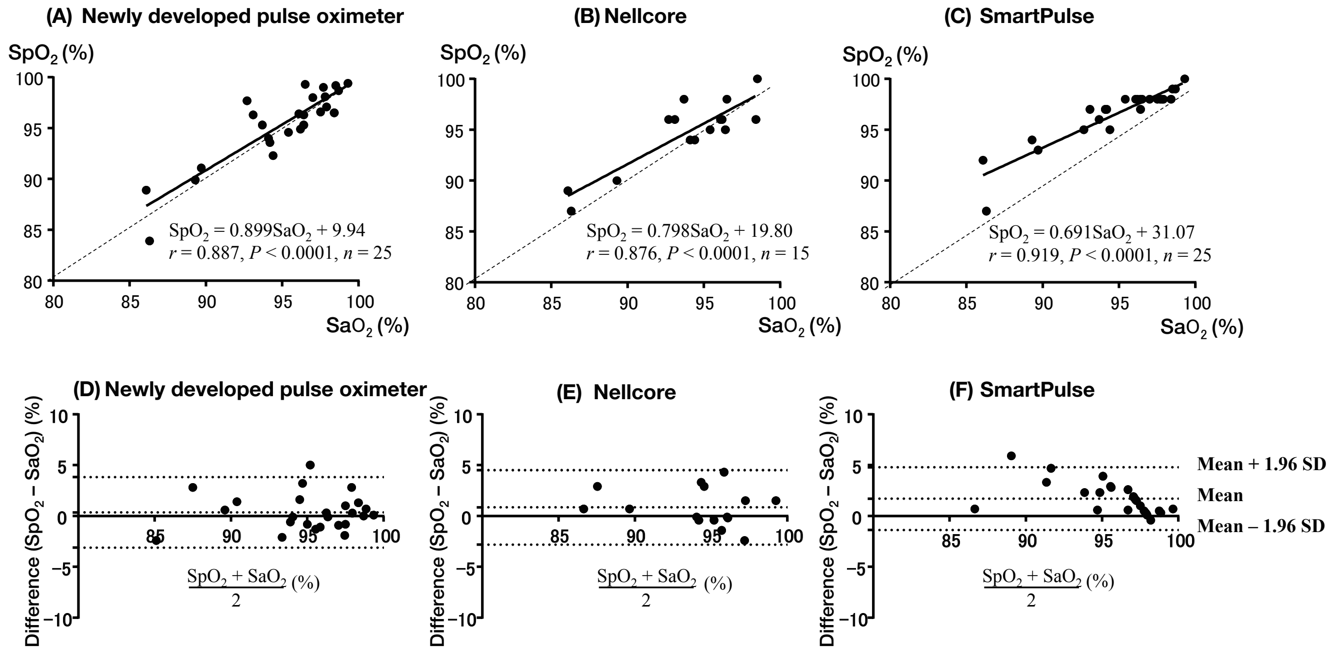

Fig. 1. Correlation and Bland–Altman plot between SaO_2 from arterial blood gas analysis and SpO_2.
Correlation between SaO_2 from arterial blood gas analysis and SpO_2 from the newly developed pulse oximeter (**A**), the Nellcore pulse oximeter (**B**), and the SmartPulse pulse oximeter (**C**), respectively. Dashed line indicates $SaO_2 = SpO_2$ in a simple linear regression analysis. Bland–Altman plot between SaO_2 from arterial blood gas analysis and SpO_2 from the newly developed pulse oximeter (**D**), the Nellcore pulse oximeter (**E**), and the SmartPulse pulse oximeter (**F**), respectively. Vertical axis indicates the difference (i.e., $SpO_2 - SaO_2$), and horizontal axis indicates the mean [i.e., $(SpO_2 + SaO_2)/2$] in Bland–Altman plot analysis. Horizontal dashed lines indicate the mean difference between the SpO_2 and SaO_2 values and ± 1.96 SD.
SaO_2, oxygen saturation in arterial blood; SpO_2, arterial blood oxygen saturation measured by pulse oximetry.

estimate SaO_2 (Fig. 1). This trend was higher with the SmartPulse pulse oximeter.

DISCUSSION

The pulse oximeter is used in clinical medicine to continuously monitor SaO_2. 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 SpO_2.[1, 2] The values of SaO_2 from arterial blood are usually indicated in one digit after decimal point. Although the conventional pulse oximeter usually indicates SpO_2 in 1% increments, we have developed a pulse oximeter that can measure SpO_2 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 SpO_2 and SaO_2. As this device indicated a good correlation between the SpO_2 and SaO_2 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.

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