The accuracy of noninvasive total hemoglobin measurement in critically ill patients

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Background and Goal of Study

In critically ill patients, monitoring total hemoglobin concentrations (tHb) is essential. The Pronto Pulse CO-Oximeter (Masimo Corporation, Irvine, CA) monitors tHb noninvasively (SpHb). Although good correlations between the SpHb and invasively measured tHb are reported in healthy patients, the relationship between the two indices in critically ill patients is not well investigated.

The aim of this study was to evaluate the accuracy of SpHb measurements in critically ill patients.

Pronto®
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Materials and Methods

We enrolled patients admitted to the ICU of Fukushima Medical University Hospital, from August 2016 to February 2017. The study was approved by the ethical committee at Fukushima Medical University, and all patients or their family provided written informed consent.

Blood was collected during routine blood examinations and analyzed using a cellular analysis system (UniCel DxH 800; Beckman Coulter, Brea, CA). Within 30 minutes of the invasive blood sampling, SpHb values were recorded for a comparative study.

The data were analyzed using Spearman rank-order correlation and Bland-Altman analysis. A p value of ≤ 0.05 was considered significant.

Results and Discussion

Of 120 measurements from 34 patients, 88 measurements were successfully obtained. Table 1 shows the characteristics of enrolled patients.

Figure 1 shows the correlation between tHb and SpHb. The R value was 0.68 (P<0.001).

To assess the agreement between SpHb to tHb, Bland-Altman plot was applied(figure 2). The bias was 1.43 g/dL (95% confidence interval, 1.17–1.68 g/dL), and 95% limits of agreement (LOA) was -1.39–4.24 g/dL.

In our study, the accuracy of SpHb measurement was acceptable and the LOA was almost comparable to that of other recent studies[1] (-2.90–3.26 g/dL). Several studies have demonstrated that the accuracy of SpHb measurements is significantly reduced in the presence of vasoconstriction, which is observed in critically ill patients. This probably explains the relatively wide LOA observed in the present study.

Nevertheless, SpHb levels could not be measured in 20% (22) of the cases. Phillips et al.[2] have reported that hypoxia and hypothermia were predictors of failure of the device. Patients in the ICU tend to experience such conditions; therefore, we should be careful with clinical decisions based on this technology.

Conclusion

The accuracy of SpHb measurement was acceptable, but clinicians should carefully consider the wide LOA and the probability of capturing failure in critically ill patients before making clinical decisions based on this measurement.

Table 1. Characteristics of Enrolled Patients

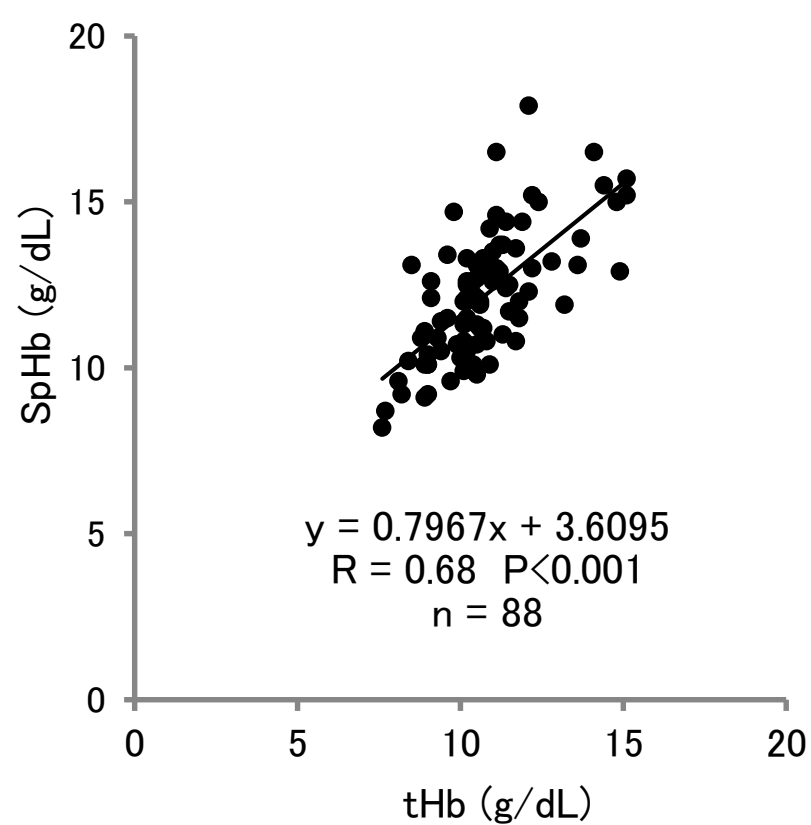| Variable	Mean ± SD [range]
Age (years)	67.2 ± 10.1 [42 – 85]
Male gender (%)	44.1
Weight (kg)	54.3 ± 14.4 [35 – 96]
Height (cm)	156.2 ± 11.3 [132 – 176.6]
BMI (kg/m^2)	22.1 ± 4.5 [14.4 – 35.7]
Reason for ICU admission	**n (%)**
Cardiovascular surgery	21 (61.8)
Major open surgery	6 (17.6)
Pneumonectomy	2 (5.9)
Pneumonia	2 (5.9)
Others	3 (8.8)

y = 0.7967x + 3.6095
R = 0.68 P<0.001
n = 88

Figure 1. The Relationship Between THb and SpHb

Observed noninvasive and continuous hemoglobin monitoring (SpHb) measurements plotted against laboratory CO–Oximeter Hb (tHb) values.
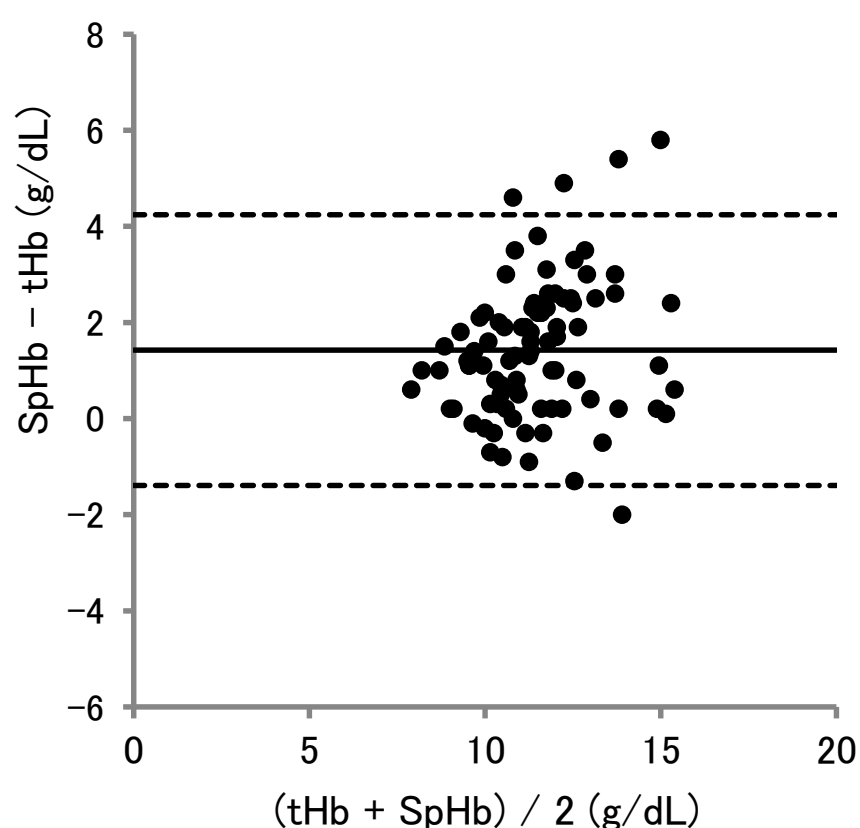

Figure 2. Bland–Altman Plot for Overall Data

Relationship between the observed differences of hemoglobin measured by laboratory CO–Oximeter (tHb) and noninvasive and continuous hemoglobin monitoring (SpHb) and the mean of the 2 measurements.

References

1. Anaesth Intensive Care. 2015; 341–350
2. J Surg Res. 2015; 257–62