Factors contributing to the accuracy of initial screening values measured by noninvasive spectrophotometric hemoglobin monitoring in an Emergency Department

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Abstract

***Objective*: Spectrophotometric hemoglobin (SpHb) monitoring is a new noninvasive technology for measuring hemoglobin (Hb). However, few studies have assessed the usefulness of the initial screening SpHb values, especially when measured in an Emergency Department. In this study, we examined the correlation between the initial screening SpHb values and laboratory-measured hemoglobin (Hb) concentrations.**

***Design*: This was a retrospective, single center study.**

***Setting*: Emergency Department in a University hospital.**

***Patients*: 105 cases between February and July 2016.**

***Interventions*: The correlation between SpHb and Hb was determined in univariate analysis. Multiple regression analysis was then performed with ΔHb (defined as the absolute difference between SpHb and Hb [|SpHb-Hb|]) as the dependent variable to identify factors associated with reduced accuracy of SpHb.**

***Results*: The initial screening SpHb value was only moderately correlated with Hb in univariate analysis ($r=0.736$, $p<0.001$). In multiple regression analysis, male sex and diastolic blood pressure were significantly associated with ΔHb ($p=0.003$ and $p=0.022$, respectively).**

***Conclusions*: The initial screening SpHb value was only moderately correlated with Hb. SpHb might affected by patient factors, including male sex and diastolic blood pressure.**

Key words: Pulse wave, male, diastolic blood pressure.

Background

Noninvasive spectrophotometric hemoglobin (SpHb) is a new technology for noninvasive monitoring of hemoglobin. This real-time monitoring technology could be used to help the physicians decide whether or not to perform blood transfusion in emergency settings. However, recent studies did not consistently show advantages of real-time SpHb monitoring. (1,2) The present study had two objectives. First, we assessed the accuracy of the initial screening SpHb value. Second, we investigated which factors might reduce the accuracy of the SpHb value.

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Methods

Study design

Between February and July 2016, we used an SpHb monitor (Masimo Radical-7TM, Masimo, Irvine, CA, USA) as the initial screening monitor in our Emergency Department. The data were retrospectively collected from medical records and were analyzed.

Patients

The patients' characteristics are shown in **Table 1**. Patients were transferred by public ambulances to our department, and the SpHb monitor was used for initial screening. There were no interventions and patients also underwent complete blood cell count tests as part of their routine initial screening. The laboratory tests also included measurement of the actual Hb concentration.

Statistical analysis

First, the correlation between SpHb and Hb was determined to assess the accuracy of the SpHb value. Second, multivariable analysis was performed to determine which patient factors were associated with ΔHb (absolute difference between SpHb and Hb [|SpHb-Hb|]). The correlation analysis was performed using Spearman's rank correlation coefficient. Multiple regression analysis was performed to identify which factors were significantly associated with the dependent variable, ΔHb. The independent variables included in the analysis were age, male sex (vs female), heart rate, systolic blood pressure, diastolic blood pressure, spectrophotometric oxygen saturation, and body temperature. All statistical analyses were considered significant at $p<0.05$. All statistical analyses were performed using SPSS software version 23.0 (IBM, Armonk, NY, USA).

Results

The patients' characteristics are shown in **Table 1**. The study comprised 105 patients, of which 21 were admitted with stroke, 16 with gastrointestinal diseases, 13 with trauma, 10 with heart diseases, 8 with disturbed consciousness, and 37 had other reasons for admission. The median SpHb and Hb were 11.3 g/dl and 12.7 g/dl, respectively, and the median ΔHb was 1.4 g/dl. **Figure 1** shows a scatterplot of SpHb vs Hb. The correlation was moderate with a correlation coefficient of 0.736 ($p<0.001$). **Table 2** shows the results of the multiple regression analysis with ΔHb as the dependent variable. Male sex ($p=0.003$) and diastolic blood pressure (DBP) ($p=0.022$) were significantly associated with ΔHb.

Discussion

The correlation analysis revealed that SpHb and Hb were only moderately correlated with each other ($R=0.736$) in this clinical setting. This result suggested that the initial screening SpHb value did not show sufficient accuracy. However, the SpHb monitor had an in vivo adjustment system. Adjustment improved the accuracy of the SpHb monitor in surgical patients. (3,4) In an emergency department, the initial value is an important factor in deciding the patient's treatment strategy. Therefore, the SpHb monitor could be considered for screening purposes, and its use in the clinic is an emerging research topic.

The results of the multiple regression analysis suggested that male sex and high DBP were significantly associated with increased ΔHb. It was possible that ΔHb was affected by the spectrophotometric quality of the detected pulse, which might be influenced by patient factors. In particular, males have thicker skin than females and high DBP might decrease the pulse waves.

Overall, the results of this retrospective study suggested that the SpHb technology is not yet mature. Nevertheless, the results have revealed the importance of improving the technology and to evaluate noninvasive monitoring techniques.

Conclusions

The initial screening SpHb value was only moderately correlated with the laboratory measured Hb concentration. Male sex and DBP, which might reflect the quality of pulse waves, might reduce the accuracy of SpHb measurements.

Acknowledgment

The authors had no conflicts of interest to declare.

This clinical study involved human participants. The present study was retrospective and data were collected from clinical record, therefore there was no intervention. Informed consent form was noticed in our University Hospital. In case of patients' disagree, we eliminated the data. This study was approved by the Institutional Review Board of our University Hospital.

Table 1. Patient characteristics

Variable	Value
N	105
Age (years)	61 (40-79)
Male (%)	45 (43%)
Heart rate (beats/min)	83 (75-100)
SBP (mmHg)	131 (113-154)
DBP (mmHg)	80 (72-92)
SpO2 (%)	98 (96-99)
Body temperature (°C)	36.6 (36.3-37.2)
SpHb (g/dl)	11.3 (10.4-12.1)
Hb (g/dl)	12.7 (11.1-14.1)
ΔHb (g/dl)	1.4 (0.6-2.5)
ΔHb/Hb (%)	12 (6-19)

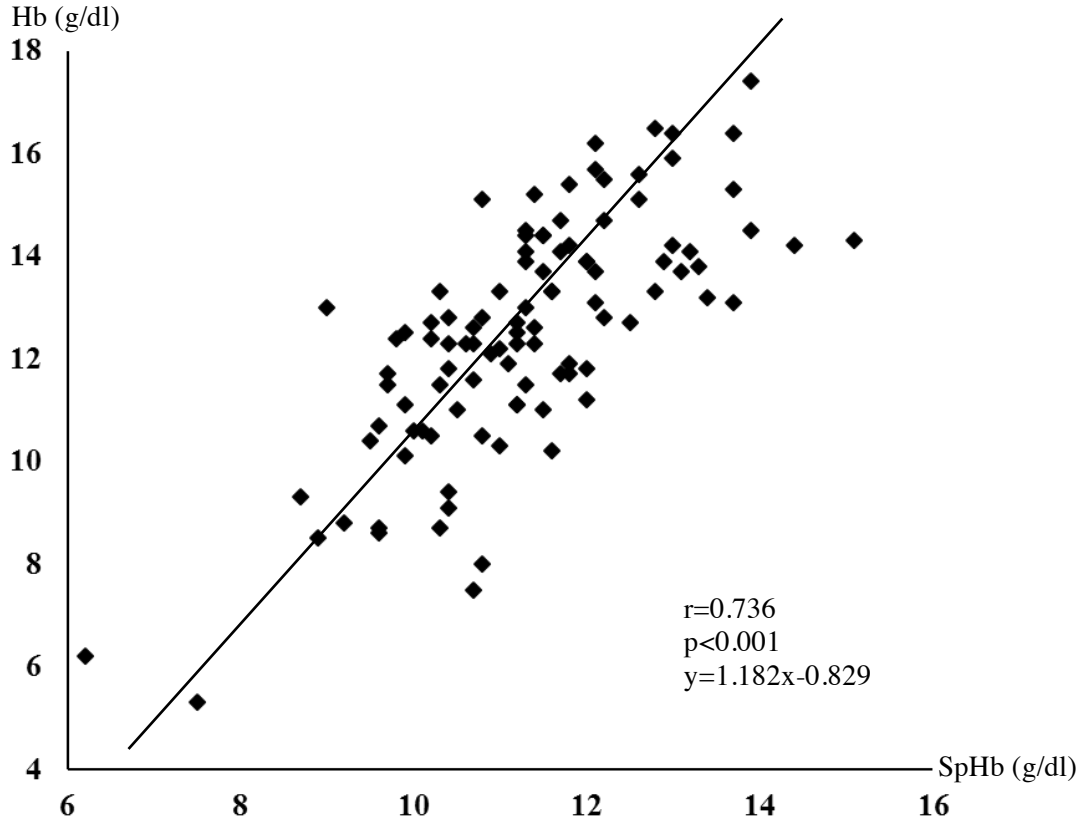
Legend: Values are presented as the median (interquartile range) or n (%). SBP=systolic blood pressure; DBP=diastolic blood pressure; SpO2=spectrophotometric oxygen saturation; SpHb=spectrophotometric hemoglobin; Hb=hemoglobin; ΔHb=absolute difference between SpHb and Hb (|SpHb-Hb|).

Table 2. Results of multiple regression analysis with ΔHb as the dependent variable

Variable	p value	Regression coefficient (95% CI)	Standard regression coefficient
Age (years)	0.399	-0.004 (-0.014 to 0.006)	-0.089
Male (%)	0.003	0.678 (0.240 to 1.116)	0.308
Heart rate (beats/min)	0.441	0.005 (-0.008 to 0.018)	0.083
SBP (mmHg)	0.646	0.000 (-0.002 to 0.001)	-0.047
DBP (mmHg)	0.022	0.016 (0.002 to 0.030)	0.239
SpO2 (%)	0.819	0.011 (-0.086 to 0.109)	0.025
Body temperature (°C)	0.173	-0.174 (-0.427 to 0.078)	-0.149
R2=0.116	0.013		

Legend: ΔHb=absolute difference between SpHb and Hb (|SpHb−Hb|); CI=confidence interval; SBP=systolic blood pressure; DBP=diastolic blood pressure; SpO2=spectrophotometric oxygen saturation; SpHb=spectrophotometric hemoglobin; Hb=hemoglobin.

Figure 1. Correlation between spectrophotometric hemoglobin (SpHb) and hemoglobin (Hb)



Legend: The Spearman's correlation coefficient was 0.736 ($p<0.001$).

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