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Accuracy of non-invasive hemoglobin level measurement in the emergency department

Approximately 32.9% of the global population has anemia, sometimes associated with nonspecific complaints, making its diagnosis difficult [1]. According to data from the Centers for Disease Control and Prevention, Number of visits to emergency departments (ED) with anemia as the primary diagnosis is 890,000 [2].

Rapid and continuous assessment of total hemoglobin is extremely important to assess blood loss, the need for transfusion, and detect hidden bleeding [3,4]. Conventional methods to confirm hypovolemia, such as hemoglobin and hematocrit measurements, are not always available at point-of-care, and hemodynamic monitoring may not detect relevant blood loss. If treatment is delayed because of delayed laboratory results or diagnostic studies, patient outcomes may be negatively impacted [5-7].

The accurate measurement of blood hemoglobin is an important step in the management of both chronic and acute blood loss; however, invasive methods have potential drawbacks such as consumption of valuable time, phlebotomy-induced anemia, pain, infection, and more involvement of human resources and equipment. [8,9]

Restrictive over liberal thresholds of hemoglobin levels are recommended to reduce reduce the risk of adverse events of blood transfusion [10]. The practice of liberal packed red blood cell (PRBC) transfusion in EDs is an everyday concern as it is associated with medical and surgical situations and severity [11]. The early assessment of the hemoglobin level and its threshold have been used during PRBC transfusion in most guidelines, and the early identification of hemoglobin levels plays a major role in this regard [12].

There are few studies done to test accuracy of SpHb compared to Lab Hb in the ED. [13-17] We studied that on bigger sample size of patients.

In this study, we aimed to compare between non-invasive hemoglobin measurement (SpHb) with laboratory hemoglobin measurement (Lab Hb) to evaluate the accuracy of non-invasive hemoglobin measurement in the ED.

After institutional ethical committee approval, a prospective observational study was conducted at King Khaled (KKUH) and King Abdul Aziz (KAUH) university hospitals, which belong to King Saud University Medical City (Riyadh, KSA). Both are urban academic institution with high volume and high acuity. The study was conducted on all patients who visited the EDs of the two hospitals and required complete blood count measurements from March 2022 to May 2022.

Patients aged >14 years who required blood testing were enrolled. Written informed consent was obtained from all the participants or their first-degree relatives for those not able to provide consent before enrollment.

Data on complaints and full medical histories were obtained from the patients. After vital signs measurement and thorough clinical examination, they were categorized by the triage team using the CTAS.

Hemoglobin concentrations were measured using the SpHb measurement device Rad-67® (Fig. 1) (DCI®-mini sensor; Masimo Corporation, Irvine, CA, USA) [18]. Simultaneously, blood samples were collected from the participants' veins in the same room. All complete blood counts were measured at the same time of collection using the same automated analyzer (UniCel DxH 800 Coulter Cellular Analysis System; Beckman Coulter, CA, USA).

Pulse CO-Oximetry (Rad-67®, Masimo Corporation, Irvine, CA, USA) is a multi-wavelength spectrophotometric technique that enables continuous non-invasive monitoring of total Hb (SpHb). The method has received clearance from the Food and Drug Administration 510(k) and Saudi Food and Drug Administration SFDA. It has the unique ability to measure dyshemoglobins such as carboxyhemoglobin and methemoglobin, and total hemoglobin concentration [18]. Given the life-threatening dangers of methemoglobin and carboxyhemoglobin toxicity, a pulse oximeter capable of measuring these dyshemoglobins would be an important addition to monitoring armamentarium [19].

In total, 711 patients were eligible for this study. Of these, 61 patients were excluded because of the unavailability of complete blood count results; therefore, 650 patients were available for the final analysis. Demographic and clinical data are shown in Table 1. The SpHb, lab measurements and bias are shown in Table 2.

A highly significant correlation was observed between SpHb and LabHb (Pearson correlation coefficient = 0.812, $p < 0.01$) (Fig. 2). The Bland–Altman analysis showed a low bias, with moderate limits of agreement between SpHb and Lab Hb. The mean bias was 0.146 g/dL, with limits of agreement as −2.58 and 2.87 g/dL. The margin of error (95% confidence interval) was 2.7 g/dL (Fig. 3)

In the present study, we found a low level of bias between SpHb and Lab Hb (0.146 ± 1.39 g/dL) levels, with moderate limits of agreement (−2.58 and 2.87 g/dL). However, a higher level of bias was found in a study conducted on patients in the intensive care unit [20].

In addition, our results showed better SpHb accuracy than that of Osborn et al. (2019), who compared SpHb with Hemocue 201 Lab Hb measurements in 201 patients in the ED and found that the bias between SpHb and Lab Hb was −0.52 ± 1.41 g/dL [14].

Fig. 1. Masimo Rad-67 device and Mini DCI sensor.

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Table 1
Demographic and clinical data.

Characteristics	
Age	(14–106) 43.89 ± 19.55
Sex (male/female)	274 (42.2%)/376 (57.8%)
CTAS	
CTAS 1	8 (1.2%)
CTAS 2	223 (37.5%)
CTAS 3	347 (53.4%)
CTAS 4	51 (7.8%)
CTAS 5	8 (1.2%)
DM	129 (19.8%)
HTN	128 (19.7%)
Cardiac patients	51 (7.8%)
Other medical conditions	279 (42.9%)
Blood pressure	
Systolic blood pressure	(74–260) 124.96 ± 21.22
Diastolic blood pressure	(26–150) 74.79 ± 13.45
Pulse	
Rate	(11–170) 87.13 ± 17.56
Patients on vasopressors	17 (2.6%)
Patients with nail polish or Henna	39 (6%)

Data are presented as the range and mean ± SD for numerical variables and frequency (percentage) for non-numerical values. CTAS, Canadian Triage and Acuity Scale; DM, diabetes mellitus; HTN, hypertension.

Table 2
SpHb and Lab Hb data.

Measurements	
SpHb	(5.4–17) 12.15 ± 1.9 g/dL
Lab Hb	(4.3–17.6) 12.29 ± 2.39 g/dL
Bias	(−4.4–4.9) 0.146 ± 1.39 g/dL

SpHb, non-invasive hemoglobin; Lab Hb, laboratory hemoglobin.

We found a highly significant correlation between SpHb and Lab Hb levels ($r = 0.812$), corroborating the results of Adel et al. (2018), who found an excellent correlation between SpHb and Lab Hb (0.938) levels. [21]

In conclusion, non-invasive hemoglobin (SpHb) measurement showed acceptable accuracy and excellent correlation with Lab Hb and provided an easy, quick, feasible, cheap, and accurate solution for Hb measurement in the ED. Further research is required to study its effects on patient outcomes and blood transfusion and time and cost effectiveness.

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The principal author received conference fees as a speaker from Masimo Corporation, and company provided their machines for the study free of cost.

Author contributions

ZA contributed to design, idea, analysis, manuscript writing, and supervision of the study. BA wrote the manuscript, formulated the study methodology, supervised data collection and results, and reviewed the manuscript. AA prepared the proposal and contributed to discussion, writing, and reviewing. HM collected the clinical data collection and undertook documentation. AQ, HA, MA, TA, FA, and LA contributed to proposal preparation and data validation.

CRediT authorship contribution statement

Zohair Ahmed Ali Al Aseri: Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Methodology, Formal analysis, Data curation, Conceptualization.

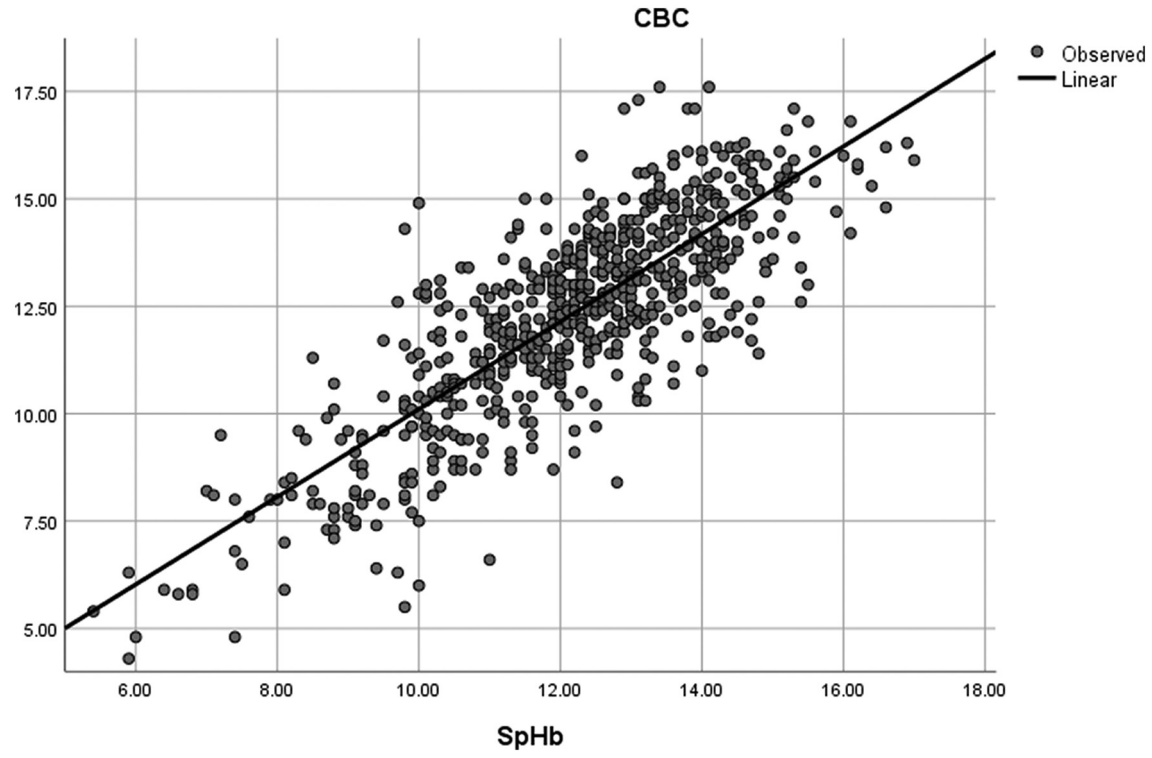

Fig. 2. Linear regression.

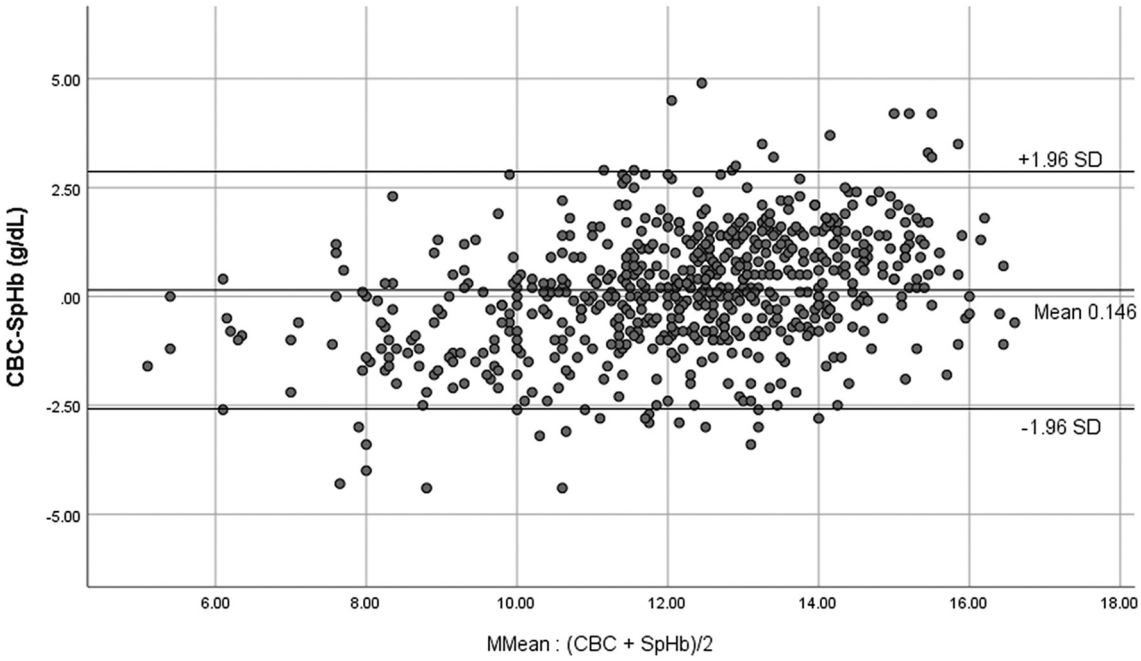

Fig. 3. Bland Altman Plot.

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Declaration of Competing Interest

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