Trending, Accuracy and Precision of Noninvasive Hemoglobin Monitoring During Hemodilution

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Introduction

Blood hemoglobin (tHb) is a fundamental laboratory value used to assess oxygen carrying capacity and need for transfusion. It is an indirect indicator of blood loss during hemorrhage and plasma volume in the absence of bleeding. Laboratory measurement of tHb is an effective tool for perioperative management of blood loss and fluid replacement. However, this approach is invasive, time consuming and requires further removal of red blood cells. Noninvasive pulse CO-oximetry is an attractive alternative offering the hemoglobin value (SpHb) non-invasively, immediately, continuously and avoiding delays in decision making. Many studies, in different clinical settings, have compared SpHb versus tHb using linear regression and Bland-Altman plots (1, 2, 3, 4). Few have assessed the effectiveness of continuous data and their trending (4, 5, 6, 7, 8). The present study evaluates trending, accuracy and precision of SpHb during dynamic hemodilution.

Methods

IRB approved, written informed consent was obtained from 12 healthy volunteers aged 21 to 35 years. Under general anesthesia, hemorrhage (10 ml/kg) was performed concurrently with Lactated Ringer`s infusion (30 ml/kg over 20 minutes) delivered by pump. SpHb was measured continuously (Masimo Radical-7®), while tHb was measured by arterial blood sampling (Sysmex XE2100/XT1800).

Results

A total of 105 data pairs were collected over 120 minutes, starting at the onset of hemodilution. The correlation coefficient between the two methods was 0.81, Fig1. The bias and SD were -1.1 ± 0.8 g/dl (limits of agreement: -2.7, 0.5), Fig2. Concordance was assessed using the four-quadrant plot technique. Outside of the central exclusion zone (0.5 g/dl), 95.3% of the data pairs lie within the zones corresponding to correct direction of change, Fig3. However, most impressive were the continuous data plots showing consistent, uninterrupted trend of decreasing SpHb during hemodilution, Fig 4.

Discussion

Data suggest SpHb lends itself to effective trend analysis and accurate assessment of changes in tHb during periods of significant hemodilution. Trending was highly reliable in terms of concordance and trending ability, while spot measurements can be considered to have only moderate accuracy. Trend graphs may be a better decision support tool to predict need for transfusion.

Fig1: Scatter plot of 105 paired measures of SpHb and tHb collected from 12 volunteers subjected to hemodilution ($r2=0.81$, $p<0.000$).

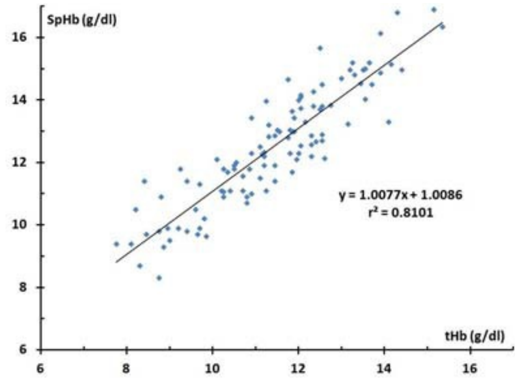


Fig2: Bland-Altman plot with bias (straight line) and limits of agreement (dotted lines) of 105 paired measures of SpHb and tHb collected from 12 volunteers subjected to hemodilution. Bias=-1.1 ± 0.8 (SD) g/dl.

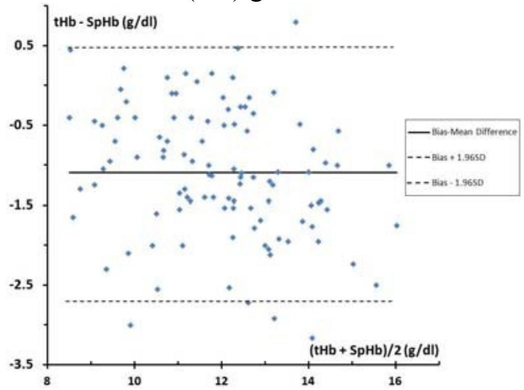


Fig3: Four-quadrant trend plot of 93 paired changes in sequential measurements from SpHb and tHb. The 4-quadrant plot shows direction of the trend with a central exclusion zone of 0.5 g/dl hemoglobin. The concordance rate (a measure of the number of data points that fall into 1 of the 2 quadrants of agreement) was 95.3%.

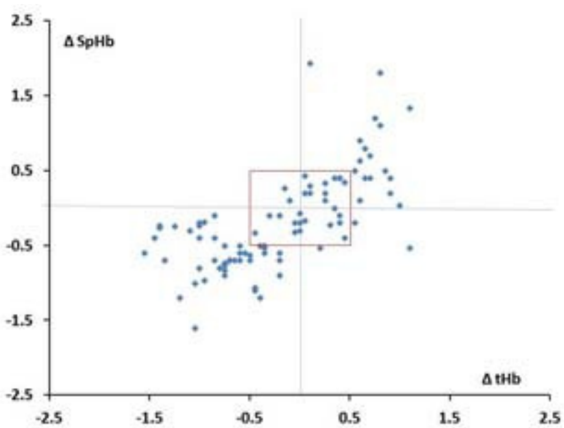
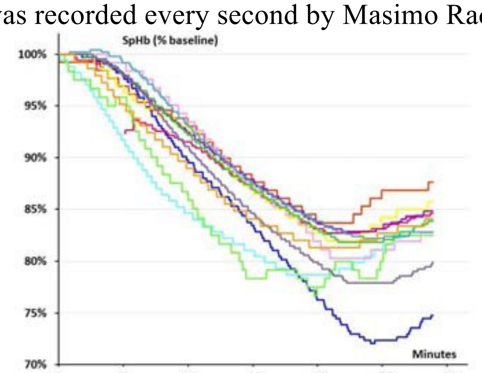


Fig4: Trend plot of SpHb (as percentage of baseline) in 12 volunteers during hemodilution. Data was recorded every second by Masimo Radical-7®.



References: 1-Anesth Analg 2011;113:1052-7, 2-Crit Care Med 2012;40:2576-82, 3-Anesthesiology 2012;116:65-72, 4-Am J Surg 2011;201:592-8, 5-Br J Anaesth 2012;109:522-8, 6-Anesth Analg 2012;115:1302-7, 7-Crit Care Med 2011;39:2277-82, 8-J Clin Monit Comput 2012;26:69-73.