Reduction in Red Blood Cell Transfusions during Neurosurgery with Noninvasive and Continuous Hemoglobin Monitoring

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Introduction

While blood loss during surgery is a known risk factor, red blood cell (RBC) overuse increases patient risk and cost of care. Hemoglobin concentration (Hb) is used as a primary indicator for RBC transfusion, but laboratory measurements are only available intermittently and results can be delayed in the period between blood draw and laboratory analysis. Noninvasive and continuous Hb (SpHb) monitoring provides real-time trends in the direction of Hb, such as indicating stable Hb when it may be perceived to be dropping and rising Hb when it may be perceived to not be rising fast enough. SpHb monitoring has been shown to reduce RBC transfusion frequency and average units transfused per patient in a randomized controlled trial in moderate to low blood loss orthopedic surgery.[1] The objective of this study was to evaluate SpHb monitoring impact on RBC transfusions in high blood loss surgery.

Methods

Following ethics committee approval, we conducted a prospective cohort study in patients scheduled for neurosurgery at an academic, tertiary hospital. During the study period, one patient scheduled for neurosurgery the next day was randomly selected using the sealed envelope method to be screened for SpHb Group inclusion. Following enrollment into the SpHb Group, the other patients also scheduled for surgery on the same day were screened for inclusion into the Standard Care Group. The Standard Care Group received typical anesthesia care including estimated blood loss (EBL) assessment and intraoperative Hb measurements from the central laboratory (GEN-S hematology analyzer, Beckman-Coulter Inc., Brea CA.) Blood samples were taken when EBL was ≥15% of total blood volume. RBC transfusion was initiated if Hb was ≤10 g/dL and continued until the EBL was replaced and Hb >10g/dL was confirmed. The SpHb Group was monitored with a Pulse CO-Oximeter and multi-wavelength sensor (Radical-7 monitor version 7748, R2-25 adult ReSposable sensor revision "E", Masimo, Irvine, CA) (Figure 1). The SpHb Group followed the same transfusion practice as the Standard Care Group except the anesthesiologist was guided by the addition of SpHb, with blood samples still taken pre- and post-transfusion. Differences in variables were assessed with the Student t-test method. Potential cost savings from RBC transfusion reduction were estimated using an activity-based RBC cost range ($522 to $1,1832).[2] To assess agreement between SpHb and laboratory hemoglobin measurements, pre- and post-transfusion bias and standard deviation were calculated and a Bland and Altman plot was constructed. Accuracy of trending was assessed by regression analysis of sequential changes in SpHb compared to sequential changes in Hb.

Table 1. Patient Characteristics

	Standard Care Group (n=61)	SpHb Group (n=45)	p-value
Gender, % male	49%	44%	NS
Age, mean±SD	38.2±13.4	36.9±15.1	NS

Figure 1. Radical-7 Pulse CO-Oximeter and rainbow ReSposable sensor

Results

A total of 106 patients were enrolled with an average age of 39.8+14.9 years. Patient characteristics are shown in Table 1. As shown in Table 2, there were no differences in baseline Hb, patients transfused (%), or pre-transfusion Hb. In the SpHb Group, there were a lower number of RBC units transfused over all subjects, lower number of RBC units transfused in subjects receiving transfusions, lower % of transfused patients receiving >3 RBC units, lower Hb increase after RBC transfusion was initiated, and shorter time to transfusion after transfusion need was established. The bias and standard deviation of SpHb compared to laboratory hemoglobin at baseline, pre-transfusion, and post-transfusion was 0.1±0.9 g/dL, -0.1±0.8 g/dL, and -0.1±0.5 g/dL, respectively. The composite bias and standard deviation for comparisons (n=83) was 0.03±0.8 g/dL (Figure 2). Regression analysis of changes in SpHb to changes in Hb demonstrated excellent trending (R^2 = 0.96) Based on the average 0.9 RBC unit reduction per patient in the SpHb Group, SpHb monitoring could save $470 to $1,065 per patient monitored and $469,800 to $1,064,700 per 1,000 surgeries performed.

Table 2. Transfusion variables

|	Standard Care Group (n=61)	SpHb Group (n=45)	p-value
Baseline Hb (g/dL)	11.8±1.6	11.6±0.8	NS
Patients transfused, %	49	44	NS
Pre-transfusion Hb (g/dL)	8.3±1.2	8.6±1.2	NS
Avg Hb change after transfusion (g/dL)	2.6±1.2	1.8±0.9	<0.05
RBC transfusions per subject (units)	1.9±2.3	1.0±1.5	<0.001
RBC transfusions per subject receiving a transfusion (units)	3.9±1.7	2.3±1.5	<0.01
Transfused patients receiving ≥3 RBC units (%)	73	32	<0.01
Time to transfusion start after need established (min)	50.2±7.8	9.2±0.7	<0.001

Figure 2. Bland Altman plot of SpHb and laboratory Hb
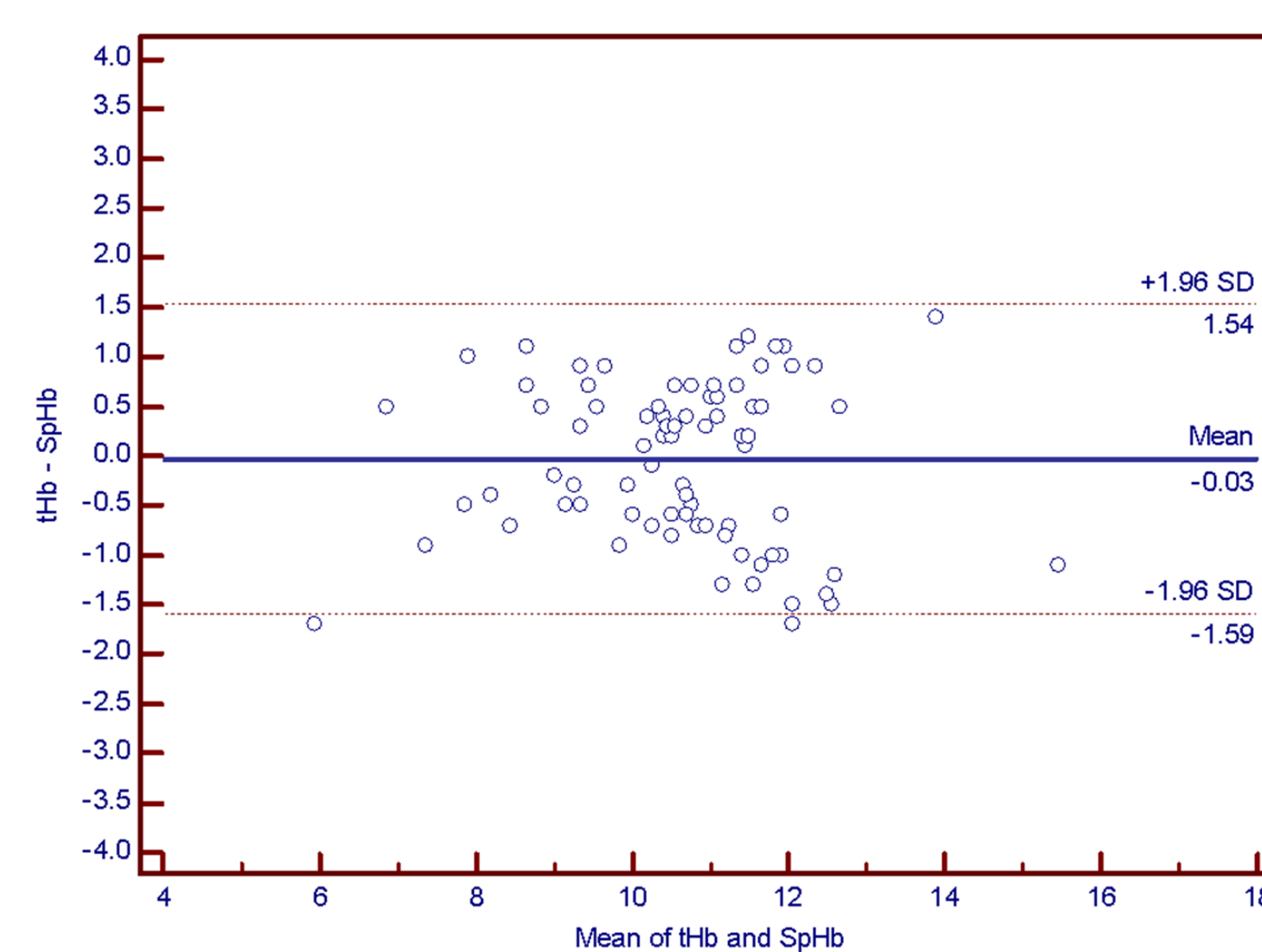
Figure 3. Regression plot of changes in SpHb to change in Hb.

y = 0.9372x - 0.0063
R^2 = 0.9588
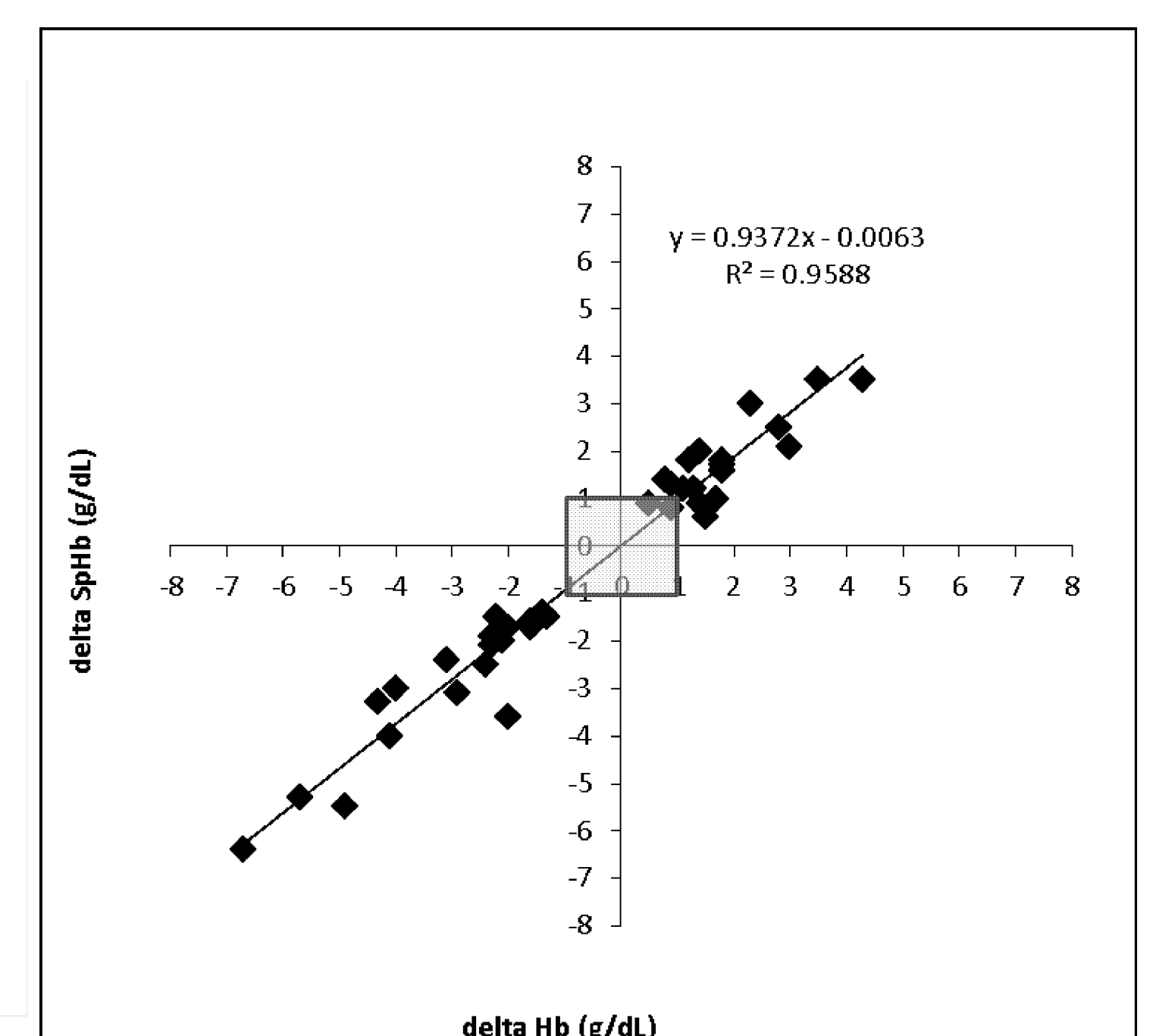
Conclusions

SpHb monitoring reduced intra-operative RBC transfusions during high blood loss surgery. SpHb monitoring also significantly reduced the time to initiate transfusions when they were clinically indicated, which may provide additional clinical benefits. Based on the RBC reduction shown with SpHb monitoring, hospitals could significantly reduce costs with this approach. The accuracy of SpHb compared to laboratory Hb was clinically acceptable given the known variation in laboratory Hb values.

References

1 Ehrenfeld JM et al. ASA. 2010. LB05 (abstract).
2 Shander et al. Transfusion. 2009;50:753-65.