Reduction in Red Blood Cell Transfusions during Neurosurgery with Noninvasive and Continuous Hemoglobin Monitoring
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Background: 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. A total of 106 patients were enrolled with an average age of 39.8±14.9 years. The Standard Care Group (n =61) received typical anesthesia care including estimated blood loss (EBL) assessment and intraoperative Hb measurements from the central laboratory. 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 (n = 45) 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). 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 $1,183[2]).

Results
As shown in Table 1, 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. 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.

	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
Hb increase 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 after need established (min)	50.2±7.8	9.2±0.7	**<0.001**

Conclusions
SpHb monitoring reduced intra-operative RBC transfusions during high blood loss surgery. Based on the RBC reduction shown with SpHb monitoring, hospitals could significantly reduce costs with this approach.

1 Ehrenfeld JM et al. ASA. 2010. LB05 (abstract).

2 Shander et al. *Transfusion*. 2009;50:753-65.