Evaluation of Noninvasive Hemoglobin Monitoring in Surgical Critical Care Patients

Introduction
The Rad-87 Rainbow(R) SET pulse co-oximeter (Masimo Corporation) allows continuous, noninvasive monitoring of hemoglobin concentrations (SpHb). The clinical accuracy of SpHb requires further validation in the surgical ICU setting.

Methods
547 patients from two adult surgical ICUs were enrolled in the study. Patients had the SpHb pulse co-oximeter placed on arrival to the ICU; Core and Stat lab Hb measurements were taken at the discretion of the clinicians, who were blinded to SpHb values. We compared all SpHb and lab values point to point and at thresholds commonly used to trigger transfusion.

Results
383 patients had at least one time-paired SpHb and lab for a total of 2474 time points. There was a poor linear regression correlation between SpHb and labs [$R2 = 0.29$]. Concordance rates between SpHb and labs within 0.5 g/dL, 1.0 g/dL, and 2.0 g/dL were 20.2%, 40.1%, and 70.0%, respectively. Bland-Altman analysis showed a bias of 1.0 g/dL and limits of agreement of 4.6 g/dL and -2.5 g/dL. Accuracy was best at lab values of 10.5-14.5 g/dL (bias = -0.8-0.9 g/dL) and least at lab values of 6.5-8 g/dL (bias = 1.8-3.3 g/dL). The bias was not caused by SpHb being consistently lower in some patients and higher in others. When sequential lab values declined below 8 g/dL, the sensitivity and specificity of SpHb were 16% and 95% (N=103); at 7 g/dL, they were 7% and 99% (N=13). At a threshold of 8 g/dL, continuous SpHb values predicted the need for transfusion before the labs in 44 of 103 instances (43%); at 7 g/dL, it did so in 4 of 13 instances (31%). The predictive utility of SpHb was consistent within individual patients but not across patients (P=0.002) and was not influenced by age, sex, ethnicity, or BMI.

Conclusions
SpHb shows a greater bias in ICU patients than has previously been reported, especially at lower Hb ranges. There appears to be no consistent or predictable bias across different patient groups. Based on these results noninvasive Hb monitoring has poor sensitivity at critical Hb thresholds and is unable to identify the need for transfusion before labs in most patients. The accuracy of SpHb needs to be improved to support clinical decision-making in surgical critical care patients.