surgery, but significantly different than at least two other published studies in surgery evaluating SpHb revision E technology.[10] Berkow *et al.* also evaluated revision E SpHb sensors in complex spine surgery and reported a 1.0 g/dl SD and clinically acceptable trend accuracy.[8] Lamhaut *et al.* evaluated revision E in major urologic surgery and showed a similar 1.1 g/dl SD, whereas a point of care device showed a 0.7 g/dl SD.[11]

We are confident that SpHb will reduce inappropriate blood transfusions during periods of visible blood loss but with stable hemoglobin status, and will enable earlier detection of occult bleeding. We believe these evaluations have greater clinical relevance than point-to-point accuracy comparisons. A randomized controlled trial has already been presented in abstract form that showed decrease in blood transfusion frequency (from 4.5 to 0.6%) in orthopedic surgery patients monitored with SpHb compared with a group managed by standard care, with no negative impact on patient safety.[12] We expect this to be the first of many studies showing SpHb's impact on patient care.

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In Reply:

We thank Dr. O'Reilly for his interest in our study and we appreciate the opportunity to respond. We would like to address several points that he raised related to our methods. We compared hemoglobin reported by the Radical-7® Pulse Co-Oximeter (SpHb®; Masimo Corporation, Irvine, CA) to hemoglobin determined by cooximetry from an arterial blood gas analyzer.[1] Although mentioned as a limitation, this use reflects the care of many patients undergoing surgery during which blood loss is likely in surgery suites that have arterial blood gas analysis immediately available. Although comparison to the hemiglobincyanide method would be the best standard, as Dr. O'Reilly points out this is not practical in the clinical setting. Data collection and specimen handling were the responsibility of a research team member who had no other clinical responsibility. This controlled errors in specimen handling and data entry. The blood sample handling methods used during a previous volunteer study[2] were also used for this study, and the arterial hemoglobin measurements were all performed on one device. Further, the research staff had been involved in the previous volunteer study and received training from Masimo for that study. The research staff received device-specific clinical training along with retraining from Masimo in correct methods of sensor application and shielding for this study. We believe this attention to training eliminated errors related to sensor placement.

Dr. O'Reilly also raises questions regarding interpretation of our data. It is clear that hemoglobin changes rapidly during rapid bleeding, and that use of the 3-min averaging time could lead to differences between hemoglobin measures. In 192 of 269 paired sequential hemoglobin measurements we found the value changed in the same direction, which may support the concept that 3-min averaging still allows detection of a trend in hemoglobin concentration. However, in 42 sequential measurement pairs the direction of change was not the same, including some in which the amount of difference was large. The suggestion that we not compare hemoglobin changes within 2.0 g/dl to pulse cooximetry hemoglobin changes deserves comment. At measured hemoglobin of 7, this range would imply that SpHb between 5 and 9 should be accepted as equivalent. We

suspect many clinicians would be uncomfortable with use of SpHb readings in this manner. Our finding of larger bias and wider limits of agreement at lower hemoglobin values suggests an area for further algorithm or device refinement. Perhaps a user-selectable "low hemoglobin range" setting could be developed to provide tighter limits of agreement in this lower range.

Comparison of our results to others is important. We found larger bias and wider limits of agreement in patients with larger blood loss or lower hemoglobin. As pointed out, the limits of agreement we found (−2.3 to + 3.3 g/dl) are similar to those reported by Miller *et al.*[3] (−3.2 to + 3.7 g/dl) and Lamhaut *et al.*[4] (−2.7 to + 2.75 g/dl); slightly larger than that reported by Berkow *et al.*[5] (−2.0 to + 1.8 g/dl); but larger than that reported by Frasca *et al.*[6] (−1 to + 1 g/dl). Of note in the study by Frasca *et al.*, sample pairs from patients who were treated with norepinephrine infusion more than 0.2 mcg/kg/min or obtained when the perfusion index was less than 0.5 had greater bias and wider limits of agreement (−1.4 to + 1.4 g/dl). Miller *et al.*[7] reported that digital nerve block performed on the finger to which the sensor was applied improved accuracy of pulse hemoglobin compared with standard laboratory cooximetry. This finding suggests that differences between intensive care and intraoperative blood loss could induce changes in peripheral circulation that affect the accuracy of pulse cooximetry. We believe this is an important area of future research.

We are impressed by the innovations Masimo has brought to patient care. The company has demonstrated sincere commitment to improving their devices. We are convinced that pulse cooximetry could be used to inform clinical transfusion decisions. We also believe that differences in clinical situations in which blood loss occurs may have important effects on peripheral circulation, and thus potentially influence the accuracy of pulse cooximetry. Dr. O'Reilly noted that Ehrenfeld *et al.*[8] reported less transfused blood was given to patients monitored with pulse cooximetry in comparison with standard care. However, transfusion was expected in only 4.5% of patients they studied, whereas 55% of our patients received ≥1 unit of transfused erythrocytes during surgery. We do not have access to all information about patients in the abstract from Ehrenfeld *et al.*, but the average blood loss they reported was nearly 600 ml less than in our study. The larger amounts of blood loss and transfusion in our patients could be associated with changes in peripheral circulation affecting pulse cooximetry accuracy and thus would seem to make patients similar to those we studied more appropriate for determining the effect of pulse cooximetry on transfusion decisions.

Further research is warranted to delineate which patient or intraoperative factors contribute to larger differences between pulse cooximetry and invasive hemoglobin measurements. We believe this will lead to studies that verify a positive effect of SpHb® on patient care and perioperative outcome.

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Perioperative Ischemic Optic Neuropathy and Spine Surgery: Are We Asking the Right Questions?

To the Editor:

The recent article and editorial regarding intraoperative vision loss in the prone position continue to promote real advances in understanding and reducing the occurrence of this devastating complication.[1,2] The importance of prone positioning, obesity, gender, and use of the Wilson frame clearly invite the conclusion of perioptic venous back pressure and edema formation as causative mechanisms. However, the commonality for all four factors is perhaps, at least partially, one of simple geometry. The gender factor may not

These letters were sent to the author of the mentioned Editorial View, who felt that a reply was not necessary.—James C. Eisenach, M.D., Editor-in-Chief.