Accuracy in Noninvasive and Continuous Hemoglobin Monitoring Trends during Liver Transplantation.
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Introduction
Liver transplant patients routinely require blood transfusions during the operative procedure due to the vascular nature of the surgery. The possible adverse events to blood transfusion are well known as well as the additional cost of the process and maintaining an adequate supply of blood. Blood transfusions increase morbidity, mortality, and cost of treatment.[1,2,3,4], , placing additional emphasis on blood management for the anesthesiologist.

Noninvasive and continuous hemoglobin monitoring with Pulse CO-Oximetry (SpHb) has the potential to provide the clinician with real time hemoglobin trend information which may facilitate blood management by reducing delays in initiating necessary transfusions and preventing over-transfusions. We sought to evaluate the trend accuracy of SpHb monitoring in a case series of high blood loss, liver transplant surgery patients.

Methods
Following IRB approval a convenience sample of patients scheduled for liver transplantation were enrolled in the study. During surgery, patients received standard ASA monitoring and anesthesia care at the discretion of the attending physician. Additionally, a spectrophotometric sensor was placed on the patients ring or middle finger of the non-dominant hand. It is a wrap-around sensor that adheres to the finger and provides hemoglobin measurement for continuous and noninvasive monitoring. . The noninvasive monitoring platform enables the assessment of multiple blood constituents and physiologic parameters that previously required invasive or complicated procedures. The sensor was connected to a Pulse CO-Oximeter and the Pulse CO-Oximeter was connected to a laptop with data logger software for the continuous recording of SpHb values and notation of blood draws. When a blood sample was needed for standard care, the SpHb value was recorded at the exact time of the blood draw. Blood samples were analyzed by the central lab with a automated hematology analyzer. Bias, precision (1 standard deviation of the bias) and limits of agreement of SpHb to Hb were calculated. Trend accuracy was assessed by regression analysis of the paired sequential changes in SpHb and Hb. Changes of SpHb and Hb over time were plotted.

Results
Thirty SpHb and Hb data pairs were collected from 7 patients. Bias±precision and limits of agreement were 0.6±1.1 g/dL and -1.6 to 2.7 g/dL, indicating acceptable agreement with the reference device. Regression analysis of trend is shown in Figure 1. Coefficient of determination was 0.85 indicating excellent trending of SpHb. Two example case plots showing both large excursions in hemoglobin values and relatively stable hemoglobin values over time during liver transplantation surgery are shown in Figure 2.

Conclusion
Hemoglobin concentration is frequently used to determine if patients require a RBC transfusion during surgery. But, hemoglobin changes may be rapid and difficult to assess in a timely manner with intermittent blood analysis. SpHb monitoring with spectrophotometric sensor provides continuous, real-time data on changes in hemoglobin during dynamic conditions such as high blood loss liver transplantation and therefore may be useful in guiding blood management

A convenience sample of patients scheduled for liver transplantation were enrolled in a study to determine the accuracy of noninvasive, continuous hemoglobin monitoring compared to standard central lab automated hematology analyzer. Could real-time data on changes in hemoglobin during dynamic conditions such as high blood loss liver transplantation be useful in guiding blood management?

Figure 2. SpHb over time in 2 patients during liver transplantation.