Noninvasive Hemoglobin Assessment

Case Study

Justin presents for a radical retropubic prostatectomy. He receives chronic steroid therapy for rheumatoid arthritis. Additionally, he has a history of hypertension and suffered a myocardial infarction 6 months ago. You plan to tailor Justin’s fluid management according to your hospital’s ERAS protocol. His starting hemoglobin is 10 g/dL, and you’re concerned that you’re going to cause hemodilution as you optimize his fluid status.

Given the risks of blood transfusion, you’d rather not transfuse unnecessarily. What monitors are available that will provide real-time assessment of Justin’s hemoglobin concentration? How can you use this data to inform clinical decision making? In this objective, we’re going to discuss noninvasive, continuous hemoglobin assessment in the operating room.

Overview

Traditional methods of assessing a patient’s hemoglobin concentration involve an invasive blood draw, sending the specimen to the lab for analysis, and waiting for the results. Point of care devices speed up this process by eliminating the need for the lab, however the results may not always correlate with lab-derived data (particularly in critically ill patients) (1,2). Finally, each blood draw carries the risk of exposure to blood-born pathogens.

Whether a sample is sent to the lab or tested at the bedside, a significant drawback of both methods is that they only provide single data points over time, so it’s up to the provider to determine if and when hemoglobin should be assessed. Continuous hemoglobin assessment solves these problems by allowing noninvasive measurement of the hemoglobin concentration in real-time.

How It Works

Similar to the pulse oximeter, noninvasive hemoglobin monitors use spectrophotometric techniques to provide a continuous assessment of total hemoglobin (SpHb). Recall that the pulse oximeter transmits two wavelengths of light (660 and 940 nm) through a tissue bed. Throughout the pulse cycle, varying amounts of light are absorbed by hemoglobin, plasma, muscle, skin, and bone, while a spectrophotometric sensor measures the remainder of light that passes through the tissue bed. An algorithm then compares how the 660 nm and 940 nm wavelengths are absorbed by deoxyhemoglobin and oxyhemoglobin, respectively, which permits calculation of the $\text{SpO}_2$ value.

Let’s shift our attention as we consider two ways in which we can use spectrophotometric techniques to noninvasively monitor hemoglobin. The first method utilizes pulse co-oximetry technology developed by Masimo. This device emits 7 or more wavelengths of light through a tissue bed, which can be used to calculate a variety of clinical data including hemoglobin, methemoglobin, and carboxyhemoglobin concentrations as well as oxygen saturation, pulse rate, pleth variability index, and perfusion index (1). Because the Masimo devices are more widely available, we’re going to focus our discussion on this technology.
How Does SpHb Guide Clinical Decision Making?

In its current form, SpHb monitoring is not intended to replace laboratory hemoglobin assessment. Instead, the appeal of this technology stems from the value-added benefits of having continuous, real-time trend data that supplements periodic laboratory assessment. This is useful in the following circumstances:

- The provider thinks that the hemoglobin is decreasing, but the SpHb trend shows that hemoglobin is stable. Observing the trend saved the patient an unnecessary transfusion.
- The provider thinks the hemoglobin is not increasing appropriately following transfusion, but the SpHb trend shows that hemoglobin is, in fact, increasing. Observing the trend saved the patient an unnecessary transfusion.
- The provider thinks that the hemoglobin is stable, but the SpHb trend shows that hemoglobin is falling. Observing the trend prompted further clinical investigation leading to the decision to transfuse.

In addition to the economics of blood storage, blood transfusion conveys significant risks to the patient including transfusion-related acute lung injury (TRALI), transfusion associated circulatory overload, (TACO), transfusion-related immunomodulation (TRIM), hemolytic reactions, and anaphylaxis. If monitoring SpHb gave you data to help you decide not to transfuse (when you otherwise would have transfused), then this technology helped save money while improving patient care by avoiding an unnecessary transfusion. Conversely, if it compelled you to seek further clinical data that ultimately led to transfusion when the patient needed it, then using the trend data from the SpHb monitor also helped improve clinical decision making (1,2,3).

Clinical Considerations

How accurate is lab-derived hemoglobin? Inaccurate data that contributes to poor decision making is always a concern with any monitoring device. Although laboratory analysis is the gold standard, we must recognize that there’s usually variability between different devices in the same lab (this holds true even if both devices are identical). Some evidence suggests that the variability can be as high as 0.5 – 1.2 g/dL. This is something to keep in mind when you compare a lab-derived value to a firm transfusion trigger. You should also consider lab variability when you calibrate lab-derived data to the SpHb. Indeed, the difference between the lab-derived hemoglobin and the SpHb may change over time as a function of this variability.

How accurate is SpHb? Although the literature is somewhat mixed (and likely affected by study design and populations studied), deviations of +/-1 g/dL (sometimes more) were not uncommonly reported. The general consensus is that SpHb is accurate enough to provide clinically useful trend data, but the decision to transfuse should also include lab-derived assessment of hemoglobin concentration.

How does tissue perfusion affect SpHb? When using the Masimo SpHb, there’s data that states that the quality of the signal can be affected by degree of perfusion at the monitoring site. The monitor quantifies a perfusion index, which examines the relationship between pulsatile blood and non-pulsatile blood at the monitoring site (1). The perfusion index can be impacted by changes in sympathetic nervous system tone, and some data suggest that vasodilation produced by a digital nerve block can be used to improve tissue perfusion and thus accuracy (2). Since the accuracy of the monitor relies on tissue perfusion, there are concerns that a very poor perfusion index may reduce accuracy. There is emerging data that SpHb shows a strong correlation with lab-derived hemoglobin values in high PI and low PI states as well as in fluid responders and non-responders. Accuracy of the OrSense technology seems to be not impacted by low perfusion states (3).
Does the FiO₂ affect SpHb? Researchers prospectively evaluated the relationship between FiO₂ and the determination of hemoglobin with the use of two different noninvasive monitors (the Pronto 7 from Masimo and the NBM 200MP from OrSense). The authors discovered that breathing supplemental oxygen affected the SpHb value with the OrSense device but not the Masimo device (4). Given the study’s limitations, further investigation is warranted to arrive at a definitive practice recommendation.

Can SpHb be used in children? Masimo makes several probe sizes, so this monitor can be used in neonates and children. As of this writing, the OrSense technology can’t be used in pediatrics.

**Key Points**

SpHb is not intended to replaced laboratory assessment of hemoglobin concentration.

Continuous hemoglobin assessment provides the value-added benefits of having continuous, real-time data that can be used to supplement intermittent laboratory assessment.

There is always variability between lab-derived data and SpHb, so this must be factored into clinical decision making. Having said this, the variability is usually small enough where the data obtained is clinically useful.

SpHb monitoring may help reduce the incidence of unnecessary transfusion as well as prompt earlier transfusion in cases where it’s needed.

Post-operative hemoglobin trending can be used to identify continued bleeding that is not otherwise apparent.

**References**

**Textbooks:** These books are included on the CPC Exam Bibliography published by the NBCRNA


**Articles:**


Hiscock R et al. Systemic review and meta-analysis of method comparison studies of Masimo pulse co-oximeters (Radical-7 or Pronto-7) and HemoCue absorption spectrometers (B-Hemoglobin or 201+) with laboratory haemoglobin estimation. Anaesth Intensive Care. 2015;43:341-350.


