

Anesthesiology
68:301, 1988

In Reply:—Dr. Eisenkraft is correct regarding the IL-282: it measures light absorbance at four wavelengths. Other oximeters have been built using up to eight wavelengths of light. The important point is that the oximeter must use at least as many wavelengths as the number of hemoglobin species present to be able to calculate the concentration of each species.

Dr. Eisenkraft also correctly points out that the pulse oximeter estimates SpO₂ using an empirical algorithm. However, he then states that the ratio of pulse-added absorbances is related to the desaturation ratio, RHb/THb, implying that the pulse oximeter measures RHb and THb, and then calculates SpO₂ using the formula given in the last sentence. This is not correct. The pulse oximeter does not calculate either RHb or THb, and it is not a "desaturation meter." The algorithm used to generate SpO₂ values is purely empirical. It is based upon a "look-up table," in which each value of the ratio of absorbances R is related to a specific value of SpO₂. This table represents the results of experimental data obtained in awake human volunteers. The dyshemoglobins present in these volunteers were less than 2% of the total hemoglobin. Nellcor actually states in their literature* that their pulse oximeter measures "functional saturation" because these small dyshemoglobin levels in the volunteer data were subtracted from the total hemoglobin before saturation was calculated. This is misleading. The pulse oximeter measures neither functional nor fractional saturation in the presence of significant levels of dyshemoglobins. It can only refer to its built-in table, which uses data obtained from volunteers with very low levels of dyshemoglobins. The results of the look-up table will obviously be in error for high dyshemoglobin levels.

If the pulse oximeter were measuring desaturation ratio as Dr. Eisenkraft implies, then the SpO₂ values at

FI_{O2} = 1.0 should remain near 100% for all values of COHb. This is clearly not the case, as our data show in figure 2. In a recently completed study of methemoglobinemia,¹ we show that, in the presence of MetHb, the pulse oximeter also overestimates SaO₂. However, in this case, the SpO₂ values decrease to approximately 85% when MetHb reaches levels of 60%. Once again, in the presence of high MetHb levels, the pulse oximeter measures neither fractional saturation, functional saturation, nor desaturation ratio. These facts are not surprising if we bear in mind the fact that the pulse oximeter measures absorbance at only two wavelengths, and thus cannot possibly account for more than two hemoglobin species.

It has also been argued that MetHb and COHb are ignored by the pulse oximeter because their arteriovenous differences are zero. This implies that the pulse oximeter measures arteriovenous differences in hemoglobin species, which is absolute nonsense. By measuring the pulse-added absorbance signal, the pulse oximeter becomes sensitive to the light absorbance of arterial blood. However, it does not determine arteriovenous differences in hemoglobin species.

To conclude, I feel that much of the discussion of functional saturation and desaturation ratio serves to increase the confusion over how the pulse oximeter works, which is really fairly simple.

STEVEN J. BARKER, PH.D., M.D.
Associate Professor and Vice Chairman
Department of Anesthesiology
University of California, Irvine
Medical Center
Orange, California 92668

REFERENCE

1. Barker SJ, Tremper KK, Hyatt J, Zaccari BS: Effects of methemoglobinemia on pulse oximetry and mixed venous oximetry. *ANESTHESIOLOGY* 67:A171, 1987

(Accepted for publication October 6, 1987.)

* Nellcor Pulse Oximetry Note #2: "Measurement of Functional and Fractional Oxygen Saturation," Nellcor, Inc., 1987.