diagnosis, intraoperative hypoxemia has a number of causes which must be rapidly sorted out. On the other hand, the diagnosis of an accidental extubation would seem to us to be easier to make by such measures as lack of breath sounds, feel of the breathing bag, ventilator alarms, noise of escaping gas, etc. We agree that the *treatment* of accidental extubation may be more difficult. The bottom line is that any technique must be used with proper medical judgment. A tall person in whom surgery is being performed where access to the head is limited should have the endotracheal tube taped so that the tip is more than 23 cm from the teeth. The technique for securing the tube in patients who are either taller or shorter than average is referenced in the article.

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Carboxyhemoglobin and Pulse Oximetry

To the Editor:—I read with interest the Laboratory Report by Barker and Tremper[1] which showed that the pulse oximeter saturation reading (SpO_2) overestimates oxyhemoglobin (O_2Hb) in the presence of carboxyhemoglobin (COHb). In their introduction, it is stated that the Instrumentation Laboratories IL-282 Co-oximeter "measures the light absorbance of blood samples at six or more discrete wavelengths." This is incorrect. In this particular instrument, absorbance is measured at each of *four* wavelengths to compute the four measured hemoglobin (Hb) species in the sample (Operator's Manual, IL-282 CO-Oximeter, Instrumentation Laboratory, Lexington, MA, 1978). The IL-282 measures only O_2Hb, COHb, reduced Hb (RHb), and methemoglobin. The total hemoglobin value (THb) is the sum of the four concentrations.

In their discussion, the authors state that "it is interesting that the SpO_2 values in figures 2 and 3 (plots of SpO_2 and O_2Hb *versus* COHb at $FIO_2 = 1.0$ and $FIO_2 = 0.2$, respectively) approximate the sums of the O_2Hb and COHb values," as measured by the IL-282. I would suggest that this approximation might be predictable based upon the principles of operation of the pulse oximeter and the spectrophotometric characteristics of the hemoglobins involved. The pulse oximeter continuously compares the pulse-added light absorbance signals at 660 nm with those at 940 nm, and, from the ratio, estimates SpO_2 using an algorithm.[2] Because the millimolar extinction coefficient (light absorbance) of RHb (0.8) is much greater than that of O_2Hb (0.08) at 660 nm, whereas the coefficients are less dissimilar at 940 nm (RHb 0.2; O_2Hb 0.3),[3] the ratio of pulse-added absorbances at 660/940 is more directly related to desaturation, *i.e.*, RHb/THb. Oximeter saturation readings (SpO_2) would, therefore, normally be based on the assumption that what is not RHb, is O_2Hb. In this study, what was not RHb was O_2Hb plus COHb. At 660 nm, COHb has an extinction coefficient of 0.07 and is, therefore, almost indistinguishable from O_2HB at this wavelength.[3] Because COHb does not affect the light absorbance due to RHb at 660 nm, the "desaturation ratio" (RHb/THb) would essentially be read correctly. The error in the SpO_2 estimation of O_2Hb in the presence of COHb therefore arises when it is generated, in effect, as $[1 - (RHb/THb)] \times 100\%$.

The algorithm used in the pulse oximeter is such that when the ratios of the pulse-added absorbances (660/940 nm) are 3.4, 1.0, and 0.43, the SpO_2 readings are 0, 85, and 100%, respectively; thus, the higher the ratio, the lower the SpO_2 reading.* At 940 nm, COHb has an extinction coefficient of zero, *i.e.*, it does not absorb light at this wavelength. Increasing amounts of COHb therefore tend to decrease the denominator (total absorbance at 940 nm), increase the ratio, and cause the SpO_2 to show a slight decreasing trend, as was observed (figs. 2, 3) in this study.[1]

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* How Does A Pulse Oximeter Work? Informational publication, Ohmeda, Boulder, CO.