Accuracy of Carboxyhemoglobin Detection by Pulse CO-Oximetry during Hypoxemia

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Background

Carbon monoxide poisoning is a significant problem in most countries, and a reliable method of quick diagnosis would greatly improve patient care. Until the recent introduction of a multiwavelength "pulse CO-oximeter" (Masimo Rainbow SET® Radical-7), obtaining carboxyhemoglobin (COHb) levels in blood required blood sampling and laboratory analysis. In this study, we sought to determine whether hypoxemia, which can accompany carbon monoxide poisoning, interferes with the accurate detection of COHb.

Methods

Twelve healthy, nonsmoking, adult volunteers were fitted with 2 standard pulse-oximeter finger probes and 2 Rainbow probes for COHb detection. A radial arterial catheter was placed for blood sampling during 3 interventions: (1) increasing hypoxemia in incremental steps with arterial oxygen saturations (Sao2) of 100% to 80%; (2) normoxia with incremental increases in %COHb to 12%; and (3) elevated COHb combined with hypoxemia with SaO2 of 100% to 80%. Pulse-oximeter (SpCO) readings were compared with simultaneous arterial blood values at the various increments of hypoxemia and carboxyhemoglobinemia (≈25 samples per subject). Pulse CO-oximeter performance was analyzed by calculating the mean bias (SpCO- %COHb), standard deviation of the bias (precision), and the root-mean-square error (Arms).

Results

The Radical-7 accurately detected hypoxemia with both normal and elevated levels of COHb (bias mean ± SD: 0.44% ± 1.69% at %COHb <4%, and -0.29% ± 1.64% at %COHb ≥4%, $P < 0.0001$, and A_{RMS} 1.74% vs 1.67%). COHb was accurately detected during normoxia and moderate hypoxia (bias mean ± SD: -0.98 ± 2.6 at SaO2 ≥95%, and -0.7 ± 4.0 at Sao2 <95%, $P = 0.60$, and A_{RMS} 2.8% vs 4.0%), but when SaO2 decreased below approximately 85%, the pulse CO-oximeter always gave low signal quality errors and did not report SpCO values.

Conclusions

In healthy volunteers, the Radical-7 pulse CO-oximeter accurately detects hypoxemia with both low and elevated COHb levels, and accurately detects COHb, but only reads SpCO when SaO2 is more than approximately 85%.