

Variability in estimating shunt from single pulse oximetry measurements.

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Virtual shunt describes the overall loss of O₂ content between the alveolar gas and arterial blood. Clinicians indirectly estimate the magnitude of the virtual shunt by monitoring peripheral blood oxygen saturation (SpO₂) using non-invasive pulse oximetry. An inherent limitation of this method is the variable precision of pulse oximeters and the non-linear relationship between virtual shunt and SpO₂ which is rarely depicted. We propose a model using a combination of basic physiological equations to analyze the estimation of virtual shunt from inspired oxygen (FiO₂) and SpO₂. The model emphasizes the effect of the non-linearity of the Hb-O₂ dissociation curve. Furthermore, it accounts for the variability in SpO₂ measurements due to the precision of pulse oximeters. The model was validated with experiments conducted on healthy subjects in a normobaric hypoxia chamber comparing the simultaneous readings from two different commercial pulse oximeters at FiO₂ = 21% and 17%. SpO₂ probability distributions calculated from the model were estimated. Although a variable bias (1.2-2.1%) in SpO₂ between the pulse oximeter brands was observed, the tested pulse oximeters were both within tolerance specified by the manufacturers and matched the probability distributions from the model. The theoretical and experimental findings show that the estimation of virtual shunt is challenging with a single SpO₂ measurement using pulse oximeters with tolerances of 2%. Clinical decisions must be based on an appreciation of these limitations.