CORRESPONDENCE

Outsmarting a pulse oximeter: teaching spectrophotometry with a Foley catheter

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To the Editor,

Pulse oximetry has become an essential monitor in the modern practice of anesthesiology. Since the first commercial pulse oximeter was patented in 1974, it has become a ubiquitous fixture in a variety of clinical environments.¹ Nevertheless, an understanding of its use is paramount to recognizing its limitations and accurately interpreting its findings.

Spectrophotometry, the precursor to pulse oximetry, makes use of the Beer-Lambert law. Stated simply, the Beer-Lambert law describes the relationship between the concentration of a light-absorbing substance in solution and the amount of light transmitted through that solution. The more concentrated the substance is, or the greater distance the light travels through that substance (sample length), the more it will absorb light and the less light will be transmitted through that sample. To use blood as an example, oxyhemoglobin absorbs red light poorly compared with deoxyhemoglobin, which is why oxygenated blood appears a brighter red colour as more red light is reflected back to the observer's eye. In the infrared range, the situation is reversed as oxyhemoglobin absorbs infrared light much better than deoxyhemoglobin. Numerous technical issues with the simple application of the Beer-Lambert law in early devices led to the development of pulse oximetry.

To create a value for peripheral arterial oxygen saturation (SpO_2), the pulse oximeter compares the absorption of two different wavelengths of light (red light at 660 nm and infrared light at 940 nm) taking advantage of

the different absorption patterns of oxyhemoglobin and deoxyhemoglobin at these points in the spectrum. To determine the saturation of only the pulsatile component of blood in a patient's finger, it has to subtract the non-pulsatile venous and capillary components. To do this, it analyzes the overall change in absorption of light over time and generates pulsatile (alternating current) and non-pulsatile (direct current) absorption readings, ultimately determining the final value of SpO_2 using a ratio of these terms at both 660 nm and 940 nm and comparing this "ratio of ratios" to volunteer-derived data sets.²

As an interesting demonstration of its function for the purposes of education, one can generate a convincing pulse wave contour and value for SpO_2 simply by utilizing a Foley catheter and a syringe filled with either saline or sterile water. Water absorbs visible light poorly and therefore appears transparent. It does, however, absorb small amounts of infrared light and can thus act as a blood surrogate in our "Foley finger". One only needs to manually apply intermittent pressure on the syringe to generate a trace similar to that presented in the Figure. The pulsatile signal seen is likely a product of the expanding and contracting balloon during intermittent manual syringe "pulsations" that transiently increases the lightwave pathlength resulting in more significant overall light absorption and therefore a significant pulsatile signal. The high value of SpO_2 obtained could be a result of the fact that water, like oxyhemoglobin, absorbs red light poorly relative to infrared light.

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FIGURE The pulse oximeter reading and waveform created by manually applying an intermittent pressure on a saline-filled syringe into the balloon port of a Foley catheter. The high value of peripheral arterial saturation (SpO_2) could be because water, like oxyhemoglobin, absorbs red light poorly relative to infrared light.

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