



## Reasons to love and hate Dr. Beer

Razones para querer y odiar al Dr. Beer

Razões para amar e odiar a Dr. Beer

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Many of us as medical students learn physiology in the notorious and famous medical book written by connoted physiologist Arthur C. Guyton (1919-2003), «Textbook of Medical Physiology», an indispensable work in any library, with 60 years of existence and whose 14<sup>th</sup> edition is actually in preparation. As a fellow I attended a Friday 7:00 am Anesthesiology Conference, not for the coffee and donuts offered to all attendees, but to meet Professor Guyton who was visiting the Clinic for a while. That one hour physiological lecture full blackboard was my first approach to non-invasive monitoring in the form of pulse oximetry and capnography between others. Later on I found he was doing tests with prototypes in the OR and was astonished with the advancement of science and technology, although these initial devices would seem to us today crude and of gigantic dimensions.

That day I heard for the first time about exciting Beer concepts as Dr. Guyton developed his lecture in a totally crowded classroom, stunned by both the depth of his physiological knowledge and the way in which he illuminated that room despite the physical disability that polio left him many years ago, being his presence and personality, stage representation and lecture a source of inspiration for many.

Some years later I published a review paper on the new non-invasive respiratory monitoring options (Rev Iberolat C Int 1993; 2(5): 216-235) that picks up much of the message from that morning, and that in part inspires this editorial, because the pulse oximetry, «the fifth vital sign» and the most significant technological advance of all times in the area of monitoring has become one of the forms of respiratory monitoring most widely used in medicine, both in intensive care, such as anesthesiology and pulmonary medicine, operating and recovery rooms, endoscopic suites, physiology laboratories, sports and sleep medicine among others, has caught the attention of today's society that lives the terror of the COVID-19 pandemic and uses it in an unlimited and often irrational way, being widely available in commerce, cheap and risk-free, allowing uninterrupted use for long periods

and in a wide variety of clinical settings, although paradoxically many times in pandemic years without a health professional who correctly interprets the data, further favoring the fear and anxiety on the part of the misinformed society.

The spectrophotometric method used by the pulse oximeter is rather complex and is based on the Beer-Lambert Law which establishes that the intensity of incoming light in a medium is related to the outgoing intensity after absorption is established in said medium.

This is expressed mathematically by the formula:  $Ltr = Lin e^{-DCa}$ , where «Ltr» is the intensity of the transmitted light, «Lin» is the intensity of the incident light, «e» is the base of the natural algorithm, «D» is the distance that the light passes through, «C» is the concentration of a substance, in this case hemoglobin and «a» represents the extinction or absorption coefficient of the solute.

The system consists of two light-emitting diodes or LEDs that operate in the range of the 660 and 940 microns in the red and infrared bands respectively and whose light has to pass through the thickness of the respective tissue, independently evaluating the pulsatile arterial flow (component of alternate current or AC) from the capillary and venous (direct current component or DC).

Using a photodetector system the signal is received from the opposite side of the selected anatomical site, which can be any finger or toe (and not necessarily the ring finger of the left hand «the hearts finger» as some illuminated ones proclaim), with a response time of 50 seconds, or better the earlobe as we do regularly in bronchoscopy, with a delay of only 10 seconds. The reason why it is required that the light emission be exactly in the range of 660 and 940 microns, is because at this wavelength it is precisely at which the light absorption spectrum for oxyhemoglobin and reduced hemoglobin is different and pulse oximetry what actually does is compare both absorption spectra with a known extinction coefficient and thus determines the concentration of a single substance ( $O_2$ ). In the red region, oxyhemoglobin absorbs more light than reduced hemoglobin, with the opposite occurring in the infrared region.

The equipment measures the AC component of light absorption at each wavelength and divides it by the corresponding component of the DC component, applying a mathematical model that calculates  $O_2$  pulse saturation ( $SpO_2$ ) with a delay of approximately

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10 seconds, using the formula:  $R = \frac{\text{pulsatile absorption (red)}}{\text{basal absorption (red)}} \div \frac{\text{pulsatile absorption (infrared)}}{\text{basal absorption (infrared)}}$ , the result of which is empirically calibrated against direct measurements of  $\text{SaO}_2$  from healthy volunteers, obtained by means of co-oximetry.

The resulting calibration curve is stored in the equipment by means of microprocessors and is subsequently used to estimate  $\text{SpO}_2$  in real time, which correlates well with the arterial  $\text{O}_2$  saturation measured in a conventional way, with an  $r = 0.88$ , although like all vital signs recorded in real time, it normally moves within a small range both in health and in illness, and it is modified with maneuvers of total lung capacity.

In the saturation range between 70 and 100%, the method is quite accurate, but not below this level, with a possibility of error of less than 4%, which is reduced by half when considering exclusively clinically important saturations, those greater than 90%, given that taking into account the dynamic characteristics of the slope of the oxyhemoglobin dissociation curve, it is precisely below 92% that we find the critical level of hypoxemia, a  $\text{PaO}_2$  less than 60 mmHg, in such a way that in these circumstances arterial blood gases should ideally be performed to determine the magnitude of hypoxemia.

Pulse oximetry is not the same as arterial blood gas analysis, in addition to the known limitations of the former: dyshemoglobinemia, hypoperfusion, fever, motion artifacts, increased venous pulsations (right ventricular failure, tricuspid regurgitation, tourniquets, etc.) and deviation of the oxyhemoglobin dissociation curve, there are factors such as pigments and dyes, nail varnishes, anemia, potent external light sources, cardiac arrhythmias and electrical interference among others, or simply the use of poor quality uncalibrated equipment used at the least representative moment of the actual condition of the patient.

It should be remembered that  $\text{SpO}_2$  constitutes only one piece of information in the global understanding of tissue oxygenation, the delivery of  $\text{O}_2$  is also determined by the level of hemoglobin, cardiac output and the affinity of hemoglobin for  $\text{O}_2$ .

It is always important to define in the clinic what needs to be known and what is being measured, as well as the technological characteristics and limitations of the monitoring equipment, something that patients or their relatives certainly cannot carry out. We will probably continue to receive photographs on our cell phones of the hand of a SARS-CoV-2 pneumonia patient with a different cheap pulse oximeter on each finger, all with different and false readings.

An obligatory question is whether medical equipment should be sold to whoever requests it and can pay for it, how far should this situation go? Many years of study, exams and licenses are necessary to operate different medical equipment and devices. The apparent simplicity of a miniaturized but complex monitor can be misleading if you don't know what an  $\text{SpO}_2$  estimate means, and it certainly does not constitute per se an absolute indication for hospitalization and even less for mechanical ventilator support.

So the next time a patient wakes you up at 3:00 am because his  $\text{SpO}_2$  dropped to 89%, don't hate Beer and focus on educating your patients and colleagues in the best possible way, and reinforce the idea that medical information requires the correct analysis by a physician. Medicine is not as simple as a percentage and needs to be re-signified and respected.

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