



Evaluation of pulse oximetry measurements in healthy subjects with nail polish*

Avaliação das medidas de oximetria de pulso em indivíduos sadios com esmalte de unha

Evaluación de las medidas de oximetría de pulso en individuos sanos con esmalte de uña

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ABSTRACT

Objective: To evaluate the changes in measurements of pulse oximetry in healthy individuals with nail polish. **Methods:** Cross sectional study with 80 healthy volunteers. The colors of enamel used to assess oxygen saturation (SpO₂) were: coffee with milk, coffee, chocolate, red and plum. These colors were distributed among the finger nails of his left hand. The fingers of the right hand were the controls. **Results:** The colors red (p = 0.047) and coffee (p = 0.024) showed lower values in SpO₂ in comparison to the control. The other colors did not change the measurement of SpO₂. **Conclusion:** The colors red and coffee caused reduction in the measurement of SpO₂, but the clinical relevance of this finding is questionable, because the values were within the normal range.

Keywords: Cosmetics/adverse effects; Nails; Oximetry; Monitoring; Nursing

RESUMO

Objetivo: Avaliar as alterações nas medidas da oximetria de pulso em indivíduos sadios com esmaltes de unha. **Métodos:** Estudo transversal com 80 voluntárias sadias. As cores de esmalte utilizadas para avaliar a saturação periférica de oxigênio (SpO₂) foram: café com leite, café, chocolate, vermelho e ameixa. Estas cores foram distribuídas entre as unhas dos dedos da mão esquerda. Os dedos da mão direita foram os controles. **Resultados:** As cores vermelha (p=0,047) e café (p=0,024) mostraram valores menores na SpO₂ quando comparados ao controle. As outras cores não alteraram a medida da SpO₂. **Conclusão:** As cores vermelha e café causaram redução na medida da SpO₂, porém a relevância clínica deste achado é questionável, pois os valores estavam dentro do intervalo de normalidade.

Descritores: Cosméticos/efeitos adversos; Unhas; Oximetria; Monitoramento; Enfermagem

RESUMEN

Objetivo: Evaluar las alteraciones en las medidas de la oximetría de pulso en individuos sanos con esmalte de uña. **Métodos:** Estudio transversal realizado con 80 voluntarias sanas. Los colores de esmalte utilizados para evaluar la saturación periférica de oxígeno (SpO₂) fueron: café con leche, café, chocolate, rojo y ciruela. Estos colores fueron distribuidos entre las uñas de los dedos de la mano izquierda. Los dedos de la mano derecha fueron los controles. **Resultados:** Los colores rojo (p=0,047) y café (p=0,024) mostraron valores menores en la SpO₂ cuando fueron comparados al control. Los otros colores no alteraron la medida del SpO₂. **Conclusión:** Los colores rojo y café causaron reducción en la medida del SpO₂, sin embargo la relevancia clínica de este hallazgo es cuestionable, pues los valores estaban dentro del intervalo de normalidad.

Descriptores: Cosméticos/efectos adversos; Oximetría; Monitoreo; Enfermería

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INTRODUCTION

Pulse oximetry is widely used for patients who require continuous monitoring of oxygen saturation in various locations such as: inpatient units, outpatient pulmonary function testing, emergency care, intensive care, home care and surgical centers. Its main purpose is the early detection of hypoxemia in diverse situations and the monitoring of perfusion and circulation⁽¹⁻⁶⁾.

It also represents a significant advance in noninvasive monitoring, it has the advantage of being safe and inexpensive, requiring no specialized staff, providing a response in a short period of time, allowing reliable measurements of oxygen saturation, and of avoiding the discomfort and risk caused by arterial punctures for arterial blood gas studies^(1,3,7).

Despite the lack of definitive evidence, the use of pulse oximetry has, probably, reduced the morbidity and mortality of patients. This monitoring system offers an assessment of the level of oxygenation from moment to moment in real time, reflecting the efficacy of interventions as well as the progression of the illness⁽⁸⁾.

The principle of pulse oximetry is based on spectrophotometry, defined as detection and quantification of the unique characteristics of light absorption of the components of a solution. It is based on the Beer-Lambert law where the concentration of a solute can be determined by the intensity of light transmitted through a solution⁽⁸⁻¹¹⁾.

This technique evaluates the behavior of oxyhemoglobin and deoxyhemoglobin that absorb and transmit light differently as it hits them. The sensor contains two light-emitting diodes (LEDs) that alternatively emit red (660nm) and infrared light (940nm). Opposite to the diodes, there is a photoreceptor, with the tissue to be examined being placed between the photoreceptor and the LEDs^(1, 11-13).

The transmission of light through tissue is constant, and with arterial pulsation the oxygenated blood enters the tissue, changing the characteristics of reflection and absorption of light. The oxygen-saturated hemoglobin absorbs more infrared light while the desaturated hemoglobin absorbs more red light. A microprocessor calculates the hemoglobin saturation of arterial blood, continuously analyzing the difference between the two components of pulsatile (arterial) and nonpulsatile (venous) light absorption^(3,11-13).

But factors exist that lead to inaccuracy of pulse oximetry, among these are: the situation in which the oxygen saturation is below 70%; skin pigmentation; nail polish; light in the environment, such as surgical lamps; fluorescent and fiberoptic instruments; movement of the sensor; sensor is not compatible with the device; shock state in which there is poor tissue perfusion, carboxyhemoglobin (COHb) - hemoglobin that has a higher affinity to carbon monoxide, reducing the bond to oxygen, methemoglobin (MetHb) -

oxidation of ferrous ion to ferric form which impedes the hemoglobin from binding to oxygen; errors in readings due to increases in serum lipid and bilirubin levels artificially altering the levels of COHb and MetHb; lack of calibration of the device; intravascular dyes such as blue methylene, indocyanine green and indigo red and onychomycosis^(7,14-19).

Different brands and colors of nail polish can change the oxygen saturation reading. The interference in the pulse oximetry depends on the absorption of red and infrared light, resulting in a decrease of 3% to 5% in the peripheral oxygen saturation (SpO₂) results^(1,15-16,20-24).

However, contradictory results have been reported, since some studies did not observe alterations in SpO₂ measurements with the use of enamel, while others observe a decrease in SpO₂. Thus, it appears that the changes are linked to some specific colors^(14-16,20-24).

Due to the limited availability of evidence-based scientific papers related to the interference of enamel on pulse oximeter readings, we were motivated to conduct this study in order to evaluate changes in the pulse oximeter readings in healthy individuals with polished nails.

METHODS

This was a cross-sectional study conducted with student volunteers from the undergraduate nursing course at the Paulista School of Nursing, Federal University of São Paulo (UNIFESP). The sample included volunteers over 18 years of age. Exclusion criteria were: difference in measured values of SpO₂ greater than $\pm 2\%$ between the fingers⁽³⁾, previous use of nail polish, history of pulmonary disease, hematologic and metabolic disorders with lipids and bilirubin⁽⁸⁾. This study was approved by the Ethics Committee of UNIFESP, under number 1.733/08 and students who were included were oriented about the objective and signed an informed consent form.

Data collection was completed in the nursing laboratory, during the period of July to September 2009. We used a data collection instrument, on which was included: the number and initials of each volunteer, age in years, and SpO₂ measurements for each finger of the right hand (without enamel) and left (with enamel).

Each volunteer was placed in a chair for 10 minutes, maintaining the limb at rest and exposed to ambient light. After this time period, we performed a measurement of SpO₂ to verify if a difference existed in SpO₂ between the fingers of his left hand and right hand, without enamel, ensuring uniformity of measurements.

The left hand was selected as the hand to receive the nail polish colors (experimental). The fingers of the right hand were used as controls, because they had no enamel.

Each fingernail of his left hand received the colored nail polish, in the following sequence: the little finger received the "coffee with milk" color; the ring finger,

coffee color; the middle finger, chocolate color; the index finger, red; and thumb, plum color. After the nail polish was applied to each nail, the entire process began again with the little finger, adding a second layer of the colored enamel. To dry the enamel, a professional hair dryer was used, with high power using cold air for 7 minutes. The distance between the hair dryer and hand was 10 cm.

For measurement of SpO₂, a portable pulse oximeter was used, specifically the brand of *Dixtal DX-2405* (Dixtal Biomedical Ind. Com., São Paulo) with a finger sensor that included an alligator clip. The equipment calibration was performed before testing⁽³⁾. The time of pulse oximetry measurement was 30 seconds for each finger, and this time started from the moment the reading was stabilized with the device.

Data were analyzed with SPSS (Statistical Package for the Social Sciences) - IBM ® for Windows, version 12.0. The SpO₂ measurements were summarized using the mean, standard deviation, median, minimum and maximum, for the fingers of the right and left hands. SpO₂ measurements were subjected to an analysis of variance (ANOVA) to evaluate the effect of finger, the hand involved, and the interaction between the finger and the hand involved (left or right). In cases in which there were significant effects, we continued the analysis based on the construction of contrasts allowing comparison. Throughout the analysis, we adopted a significance level of 5%, i.e., results were considered significant with p value of less than 5% (p <0.05).

RESULTS

In total, our sample included 80 volunteers with a mean age of 22 years (standard deviation of ± 2 years), ranging from 17 to 30 years.

The data in Table 1 present the descriptive measurements of oxygen saturation (%), by finger, the color of the enamel and the right hand (without enamel) and the left hand (with enamel).

Table 1 shows that regardless of finger, right hand measurements taken in without color (control) showed an average slightly higher than those taken in the left-hand

with color (experimental). This behavior was observed in all colors evaluated. We also found that the average SpO₂ of the thumb was lower than that observed for the other fingers in both hands, with and without enamel.

The analysis of variance (ANOVA) verified that there was no statistically significant effect of interaction between the finger and the side of the hand (p = 0.910). There was a statistically significant effect of finger (p <0.001) and side (p <0.001). For the construction of contrasts, it was observed that the left hand, with colored nail polish, showed on average a lower value of 0.16% ± 0.04% SpO₂ than the right hand without nail polish (p <0.001). There was no statistically significant difference between SpO₂ measurements performed on the right and left thumbs (color plum, p = 0.353), the middle finger (color chocolate, p = 0.112) and little finger (coffee with milk, p = 0.085). The index finger of left hand (red color) showed, on average, a value that was lower by 0.19% ± 0.09% as compared to the right finger (SpO₂ p = 0.047). There was also a statistically significant difference between the measurement of SpO₂ between the left ring finger (coffee color) and the right (p = 0.024), in other words, the finger with the coffee polish showed a lower value of 0.22% ± 0.09% SpO₂, as compared to the ring finger without nail polish.

The thumb presented an average value of SpO₂ lower than the values presented by the other fingers on either hand: without enamel (p <0.001) and with enamel (p <0.001). The estimated mean difference for the comparison between the thumb (plum color) and the other fingers was 0.50% ± 0.07% and 0.41% ± 0.07% of the right and left hands, respectively.

Despite these observed differences, it must be noted that in none of the fingers on the right or left hand, were measurements of SpO₂ outside the reference values stipulated as normal.

DISCUSSION

Pulse oximetry is a noninvasive method of measuring oxygen saturation of arterial hemoglobin (SpO₂) and heart rate, which are essential for patient monitoring. It

Table 1 - Descriptive measurements of oxygen saturation (%) by finger, nail polish color, and the right hand (without enamel) and the left hand (with enamel).

Finger Color Hand	Thumb Plum		Índex Red		Middle Chocolate		Ring Coffee		Little Coffee with Milk	
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
Mean	96.99	96.90	97.39	97.20	97.46	97.31	97.63	97.41	97.46	97.30
SD(+)	0.72	0.84	0.67	0.70	0.71	0.79	0.62	0.76	0.75	0.77
Median	97	97	97	97	98	97	98	97	97	97
Minimum	96	96	96	96	96	96	96	96	96	96
Maximum	98	100	99	99	99	99	99	99	99	99

SD - standard deviation

represents a significant advance because it allows for reliable measurements of oxygen saturation, avoiding the discomfort and the risk caused by arterial punctures, as well as quickly identifying situations of hypoxia, facilitating clinical decisions^(7-8,14,17,21-28).

The influence of nail polish color on pulse oximetry is a concern that has been discussed for over two decades⁽²⁹⁾. The results of the literature is conflicting, as some studies have concluded that the colored nail polish decreases the SpO₂ values in clinically significant percentages, while others found no difference^(14, 20-22, 30).

The first study described in the literature that compared the interference of nail polish on pulse oximetry examined 15 healthy volunteers and found no difference in SpO₂ in the presence of nail polish, however, it did not specify the colors of enamel used⁽²⁹⁾.

Another study involving 14 volunteers showed that the nail polish colors black, dark brown, blue and green produced a significant drop in the SpO₂ reading, ranging from 1.7% to 5.9% when compared to no use of nail polish (control). Colors such as red and wine showed no change in the reading of SpO₂⁽²⁰⁾. These results are similar to those found in the study by Chan⁽²³⁾, where black and brown polishes showed a decrease of $\geq 2\%$ and ten other colors showed a smaller decline compared to the control. Other research has confirmed that blue enamel showed a decrease of up to 10% in SpO₂. However, 28 other colors of nail polish tested, which included colors described in previous work⁽²³⁾, showed no influence in altering the oximetry values⁽²⁴⁾.

A study in which ten different colors were analyzed in 12 non-smoking volunteers, concluded that the colors blue, green and lime green, caused no statistically significant difference in pulse oximetry⁽²²⁾, contradicting the results of previous studies.

In this study, we observed that the nails colored plum, chocolate and coffee with milk, showed no significant differences in SpO₂ ($p = 0.353$, 0.112 and 0.085 , respectively), while the colors red ($p = 0.047$) and coffee (0.024) showed statistically significant differences in SpO₂, but without clinical importance. These results are

similar to those seen in other studies^(14,21).

The literature also assessed changes in measurement of SpO₂ in hypoxic patients. A study using nine different colors of nail polish in 50 patients receiving mechanical ventilation showed a small decrease in SpO₂, less than 2%, in black, purple and dark blue nail polish, but without clinical relevance⁽¹⁾.

Important limitations were found in studies that analyzed the interference of nail polish on SpO₂, and it was difficult to make comparisons between them. These limitations lie in the lack of data on the volunteers, small sample sizes studied, and the use of the limited number and type of different colors, as well as the different pulse oximetry devices used.

The divergent results of previous studies may also be explained by differences in light absorption through the thickness of the enamel layer on the nail, causing the oximeter to detect a greater or lesser proportion of deoxy-hemoglobin. Some studies did not describe the circumstances in which the volunteers were recruited, nor the time for stabilization of the values for the measurement of pulse oximetry.

Our study was conducted in healthy volunteers, but studies conducted with patients in situations of hypoxia also did not show clinically significant differences⁽¹⁾.

Although pulse oximetry is widely used in clinical practice, recognized as one of the biggest advances in monitoring the condition of oxygenation of patients, and provides non-invasive SpO₂ readings, enabling rapid identification of potential problems, more studies should be performed to identify the impact of nail polish on the SpO₂ reading of pulse oximetry in patients with cardiovascular, hematological and lung disorders, among others.

CONCLUSION

The red and coffee colors showed statistically significant differences in the reading of SpO₂, but the changes were without clinical relevance, because all measurements obtained were within the normal range.

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