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The effect of nail polish on pulse oximetry measurements – a pilot study in female volunteers

Wpływ lakierów do paznokci na wyniki saturacji – badanie pilotażowe z udziałem kobiet

Tomasz Cyganek[1], Michał Widuch[1], Szymon Mizera[1], Szymon Sychta[1], Łukasz J. Krzych[2]

[1]Students' Scientific Society, Department of Anaesthesiology and Intensive Care, Faculty of Medical Sciences in Katowice, Medical University of Silesia, Katowice, Poland
[2]Department of Anaesthesiology and Intensive Care, Faculty of Medical Sciences in Katowice, Medical University of Silesia, Katowice, Poland

ABSTRACT

INTRODUCTION: It is recommended to remove all nail polish before hospital admission to prevent erroneous oximeter readings. Although studies on the effect of color and type of nail polish on pulse oximetry are scarce, some differences were observed depending on the color of nail varnish. In this study we sought to evaluate the impact of the type and color of nail polish on saturation (SpO_2) values in healthy female volunteers.
MATERIAL AND METHODS: 169 females with nail polish applied to nails had their SpO_2 measured with a pulse oximeter. After five minutes of rest, SpO_2 was assessed from a finger and, as control, from an earlobe. The differences were subjected to statistical analysis.
RESULTS: 169 paired measurements were obtained. Statistically significant differences were observed for enameled ($p < 0.01$) and hybrid ($p < 0.01$), but not for gel ($p = 0.25$) nails. As far as the colors are concerned, beige ($p < 0.01$), red ($p < 0.01$) and violet ($p = 0.047$) cover had a significant impact on the SpO_2 readings. The differences in the measurements were 1%.
CONCLUSIONS: Classic nail polish, hybrid polish, and the colours beige, red and violet may affect SpO_2 readings but this effect is low and of no clinical significance.

KEY WORDS

saturation, polish nails, puls oximetry

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Address for correspondence: Tomasz Cyganek, Studenckie Koło Naukowe przy Klinice Anestezjologii i Intensywnej Terapii, Wydział Nauk Medycznych w Katowicach, Śląski Uniwersytet Medyczny w Katowicach, ul. Medyków 14, 40-752 Katowice, tel. +48 533 637 312, e-mail: d201093@365.sum.edu.pl

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STRESZCZENIE

WSTĘP: Przed przyjęciem do szpitala zaleca się usunięcie lakieru z płytki paznokciowej, aby zapobiec nieprawidłowym wynikom saturacji. Mimo iż badania dotyczące wpływu koloru i rodzaju lakieru na pulsoksymetrię są nieliczne, zaobserwowano w nich pewne różnice uzależnione od koloru lakieru do paznokci. W niniejszym badaniu podjęto próbę oceny wpływu rodzaju i koloru lakieru do paznokci na wyniki saturacji (SpO_2) u zdrowych ochotniczek.
MATERIAŁ I METODY: U 169 ochotniczek z nałożonym na paznokcie lakierem dokonano pomiaru SpO_2 za pomocą pulsoksymetru. Pomiaru dokonano po 5-minutowym odpoczynku, na palcu oraz na płatku ucha. Wyniki poddano analizie statystycznej.
WYNIKI: Uzyskano 169 sparowanych wyników. Statystycznie istotne różnice zaobserwowano w przypadku lakierów klasycznych ($p < 0,01$) oraz hybrydowych ($p < 0,01$), nie wykazano ich natomiast w przypadku lakierów żelowych ($p = 0,25$). Istotny statystycznie wpływ na pomiar SpO_2 miał kolor beżowy ($p < 0,01$), czerwony ($p < 0,01$) i fioletowy ($p = 0,047$). Różnice wynosiły 1%.
WNIOSKI: Klasyczny lakier do paznokci, lakier hybrydowy oraz kolory beżowy, czerwony i fioletowy mogą wpływać na wyniki SpO_2. Jednak efekt ten jest niewielki i nieistotny klinicznie.

SŁOWA KLUCZOWE

saturacja, polakierowane paznokcie, pulsoksymetria

INTRODUCTION

Pulse oximetry is a popular non-invasive technique that measures the percentage of hemoglobin oxygen saturation in capillaries [1]. Saturation (SpO_2) is defined as the ratio of oxygenated hemoglobin (oxyhemoglobin – HbO) to the sum of oxygenated and deoxygenated hemoglobin. There are two light emitting diodes and a photo detector in a pulse oximeter sensor. The first diode emits red light with a wavelength of 660 nm, which is selectively absorbed by deoxygenated hemoglobin (deoxyhemoglobin), while the second, infrared light with a wavelength of 940 nm, is selectively absorbed by HbO [2]. The light emitted by both diodes is absorbed by the blood, and its intensity is measured by a photo detector.
Saturation measurements are advised when the patient is at risk of hypoxemia, including the period of anesthesia, procedural sedation and monitored anesthetic supervision [3]. Pulse oximetry is a quick, easily accessible, inexpensive, non-invasive method and has an acceptable diagnostic accuracy [4]. Unfortunately, there are several clinical and environmental situations in which pulse oximetry results cannot reflect the true SpO_2, including not only but also shock, hypotension, anemia, methemoglobinemia, carboxyhemoglobinemia, excessive ambient light and incorrect positioning of the pulse oximeter sensor [5,6,7,8,9].
Over the years, nail painting has gained popularity among women. Due to the fact that the saturation measurement is routinely performed by placing the pulse oximeter clip on the nail plate, it is important to assess whether nail polish, including its type and color, is an affecting factor of the SpO_2 result. In the emergency setting, this issue becomes of significant importance.
Previous studies regarding the influence of nail polish on SpO_2 readings gave inconsistent results [3,10,11,12,13,14,15,16] and included no more than 80 participants [17]. Most of them were carried out on nails covered with classic enamel [10,11,12] or acrylic polish [13], and there was only one study investigating the impact of gel nail polish [14].
In this study we sought to evaluate the impact of the type and color of nail polish on SpO_2 values in healthy female volunteers.

MATERIAL AND METHODS

This cross-sectional study was performed from 01.03.2020 till 11.03.2020 and included 169 healthy female students of medical professions. The study was approved by the ethical committee of the Medical University of Silesia (nr PCN/0022/KB1/7/20) and written consent was obtained from all the participants. Each participant rested for 5 minutes before the measurements were collected. Oxygen saturation was measured with an ACCURO® pulse oximeter on the index right finger and on the right earlobe, using proper finger and earlobe sensors. The sensor probe was placed directly on the center of the polished nail and earlobe. In case of having any jewelry in the earlobe, the participants were asked to remove it before taking the measurements. The colors were classified using the participants' declaration. Saturation was recorded after observing an effective signal for at least of 5 seconds. 169 paired measurements were recorded.
Statistical analysis was performed using licensed MedCalc v.18 software (MedCalc Software, Ostend, Belgium). The qualitative data were expressed as an absolute numbers. The quantitative variables were presented as medians and interquartile ranges (IQR; non-normal distribution of data). The distribution of the quantitative variables was verified by means of the Shapiro-Wilk test. The Wilcoxon signed-rank test was used to compare the SpO_2 measured from the nail and

the earlobe. Two-sided tests were applied. $P < 0.05$ was considered statistically significant.

RESULTS

All of the participants were female with age mean value 21.5 ± 1. The SpO_2 from the polished nails (regardless its type and color) and earlobes were 98 (IQR 97–99) and 99 (IQR 98–100), respectively ($p < 0.001$). The median SpO_2 from enameled and hybrid nails was statistically significantly lower than median value from the earlobes (Table I) and SpO_2 measured on beige, red and violet nails was lower than the value from the earlobes (Table II). These differences were on average 1%.

Table I. Differences in oxygen saturation measured from the varnished nails and the earlobe, taking into account type of nail polish
Tabela I. Różnice w saturacji mierzonej na polakierowanych paznokciach oraz na płatku ucha z uwzględnieniem rodzaju lakieru do paznokci

Type of nail polish	Number of paired measurements	Value from earlobe	Value from nail	Measurement difference	P
Enamel	86	99 (98–99)	98 (97–100)	1 [1–(-1)]	0.008
Hybrid	75	99 (98–100)	98 (97–99)	1 [1–1]	0.005
Gel	6	100 (99–100)	98 (96–100)	2 [3–0]	0.25

Table II. Differences in oxygen saturation measured from the varnished nails and the earlobe, taking into account the color of nail polish
Tabela II. Różnice w saturacji mierzonej na polakierowanych paznokciach oraz na płatku ucha z uwzględnieniem koloru lakieru do paznokci

Color of nail polish	Number of paired measurements	Value from earlobe	Value from nail	Measurement difference	P
Colorless	21	99 (99–99)	99 (98–100)	0 [1–(-1)]	0.16
Pink (dark, medium)	28	99 (98–100)	99 (98–100)	0 [0–0]	0.42
Beige	27	99 (98–100)	98 (97–98)	1 [1–2]	0.0007
Red	20	99 (99–100)	98 (97–99)	1 [2–1]	0.0001
Pink (light)	12	99 (99–99)	99 (98–100)	0 [1–(-1)]	0.94
Black	11	99 (98–100)	99 (98–99)	0 [0–1]	0.94
Burgundy (reddish-purple)	10	99 (98–100)	98 (97–99)	1 [1–1]	0.31
Violet (purple)	8	100 (99–100)	98 (98–99)	2 [1–1]	0.047
White	6	98.5 (98–99)	99 (97–100)	0.5 [1–(-1)]	1.0
Blue	6	99 (98–99)	99 (99–99)	0 [(-1)–0]	0.97
Gold	6	97.5 (96–98)	97.5 (97–99)	0 [(-1)–(-1)]	0.81

DISCUSSION

In this short study we confirmed that nail polish may affect SpO_2 readings but this effect is low and rather of no clinical significance.

Pulse oximetry uses the pulsatile light-absorption of hemoglobin to determine oxygen saturation. In theory, static objects such as nail polishes and hybrid nails should not influence the measurement. The exact mechanism of interference of various nail covers is not yet understood. A possible explanation for the slight decrease in oxygen saturation readings with nail polish could be a reduction in the pulse wave signal quality due to an increased absorption of light [10].

Our findings are comparable with previous studies. Many investigators found no impact of nail enamel on pulse oximetry readings or this effect was rather clinically insignificant, i.e. lower than 2% [3,17,18,19]. In contrast, a few studies with a similar design confirmed a considerable interference of nail polish on SpO_2 results, regarding rather dark (i.e. red, blue, purple, green, brown and black) or beige enamel [3,10,11,18,20].

All the above-mentioned studies were performed in healthy volunteers. We found only one paper which described how nail polish interfered with SpO_2 readings in the real clinical setting [20]. Unfortunately, due to the specific impact of critical illness in that project, the differences between SpO_2 assessed by pulse oximetry and arterial blood gas analysis might arise not only from nail polish but also the underlying condition and applied treatment. Therefore, they should be interpreted with caution. Nail polish may affect SpO_2 readings in patients with hypoxia, shock, hypoperfusion, treatment with catecholamines, hemodilution or anemia [21,22,23]. In emergency situations, rotation of the sensor probe of 90° may help

to reduce the bias arising from nail polish [19,24]. In regular cases, it is recommended to remove all nail polish before hospital admission to prevent erroneous oximeter readings.

Interestingly, only one study verified the differences arising from different devices; in that case Rapido Portable, Petas KMA 275 and 515 Novametrix [3]. The readings obtained with the Petas KMA 275 pulse oximeter were significantly higher than those obtained with the Rapido Portable and 515 Novametrix devices. No previous papers verified the influence of hybrid nail polish on oximetry. Despite its different chemical composition, the mechanism in which hybrid nail cover influences pulse oximetry is probably similar to other nail covers that are better documented, i.e. enameled, acrylic and gel-based polish [13,14].

Our study has several limitations. Firstly, this is a pilot study only. Nevertheless, we are planning to extend the recruitment to include more than 1000 participants to verify our preliminary results. It will also enable us to create research groups with a given type of nail plate coating and to verify whether the time from applying for example, hybrid, gel, acrylic, may affect the results. We planned to include about 1000 participants but the study was prematurely terminated due to the SARS-CoV-2 pandemic. Therefore, the results in subgroups of particular colors and types of nail polishes may be underestimated: the samples were too small to determine whether green, brown and yellow polishes might impact SpO_2 readings. Secondly, an earlobe oximetry probe was used to assess the reference SpO_2 value. This value may be biased due to environmental conditions. The measurement of functional oxygen saturation in the arterial blood by the means of a hemoximeter is considered a gold standard. Thirdly, one ought to remember that different brands of nail polish of the same color have a different INCI composition, and therefore their effect on oximetry readings might be different. Unfortunately, we had no influence of the polish nail used by women and the varnishes of different producers were tested, which may bias the observations.

CONCLUSIONS

Enamel and hybrid polish, but not gel, and beige, red and violet colors may influence SpO_2 readings but this effect is low and of no clinical significance.

Author's contribution

Study design – Ł.J. Krzych
Data collection – T. Cyganek, M. Widuch, S. Mizera, S. Sychta
Data interpretation – Ł.J. Krzych, T. Cyganek
Statistical analysis – T. Cyganek
Manuscript preparation – Ł.J. Krzych
Literature research – T. Cyganek, M. Widuch, S. Mizera, S. Sychta

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