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, Michał Widuch, Szymon Mizera, Szymon Sychta, Łukasz J. Krzych

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 (SpO₂) values in healthy female volunteers.

MATERIAL AND METHODS: 169 females with nail polish applied to nails had their SpO₂ measured with a pulse oximeter. After five minutes of rest, SpO₂ 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 enamelled (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 SpO₂ readings. The differences in the measurements were 1%.

CONCLUSIONS: Classic nail polish, hybrid polish, and the colours beige, red and violet may affect SpO₂ readings but this effect is low and of no clinical significance.

KEY WORDS
saturatoin, polish nails, puls oximetry

Received: 25.02.2022 Revised: 03.04.2022 Accepted: 13.04.2022 Published online: 25.08.2022

Address for correspondence: Tomasz Cyganek, Studentko 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

This is an open access article made available under the terms of the Creative Commons Attribution-ShareAlike 4.0 International (CC BY-SA 4.0) license, which defines the rules for its use. It is allowed to copy, alter, distribute and present the work for any purpose, even commercially, provided that appropriate credit is given to the author and that the user indicates whether the publication has been modified, and when processing or creating based on the work, you must share your work under the same license as the original. The full terms of this license are available at https://creativecommons.org/licenses/by-sa/4.0/legalcode.

Publisher: Medical University of Silesia, Katowice, Poland
INTRODUCTION

Pulse oximetry is a popular non-invasive technique that measures the percentage of hemoglobin oxygen saturation in capillaries [1]. Saturation (SpO\textsubscript{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 (deoxygenymoglobin), 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\textsubscript{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\textsubscript{2} result. In the emergency setting, this issue becomes of significant importance.

Previous studies regarding the influence of nail polish on SpO\textsubscript{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\textsubscript{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\textsuperscript{®} 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\textsubscript{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 SpO₂ 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 SpO₂ from enameled and hybrid nails was statistically significantly lower than median value from the earlobes (Table I) and SpO₂ 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 earlobe, taking into account type of nail polish

| 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 (96–100)       | 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 earlobe, taking into account the color of nail polish

| 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 (99–99)        | 99 (99–99)     | 0 [0–0]                | 0.97    |
| Gold                 | 6                            | 97.5 (96–98)      | 97.5 (97–99)   | 0 [1–(1–1)]            | 0.81    |

## DISCUSSION

In this short study we confirmed that nail polish may affect SpO₂ 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 SpO₂ 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 SpO₂ 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 SpO₂ 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 SpO2 readings. Secondly, an earlobe oximetry probe was used to assess the reference SpO2 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 SpO2 readings but this effect is low and of no clinical significance.

REFERENCES

1. Fousaz S, Priftis K.N., Anthracopoulos M.B. Pulse oximetry in pediatric practice. Pediatrics 2011; 128(4): 740–752. doi: 10.1542/peds.2011-0271.
2. Chan E.D., Chan M.M., Chan M.M. Pulse oximetry: Understanding its basic principles facilitates appreciation of its limitations. Respir. Med. 2013; 107(6): 789–799. doi: 10.1016/j.resmed.2013.02.004.
3. Sünçü Çöçek H., Gümus S., Deniz Ö., Yildiz S., Açıkel C.H., Çakir E. et al. Effect of nail polish and henna on oxygen saturation determined by pulse oximetry in healthy young adult females. Emerg. Med. J. 2011; 28(9): 783–785. doi: 10.1136/empl.2010.096073.
4. Callahan J.M. Pulse oximetry in emergency medicine. Emerg. Med. Clin. North Am. 2008; 26(4): 869–879. doi: 10.1016/j.emecl.2008.08.006.
5. Eisenkraft J.B. Pulse oximeter desaturation due to methemoglobinemia. Anesthesiology 1988; 68(2): 279–282. doi: 10.1016/0003-289X(87)91800-8.
6. Barker S.J., Tremper K.K. The effect of carbon monoxide inhalation on pulse oximetry and transcutaneous Po2. Anesthesiology 1987; 66(5): 677–679. doi: 10.1097/00000542-198705000-00014.
7. New W. Pulse oximeter versus measurement of transcutaneous oxygen. J. Clin. Monit. 1985; 1(2): 126–129. doi: 10.1007/BF02822200.
8. Hanowell L., Eishek J.H., Downs D. Ambient light affects pulse oximeters. Anesthesiology 1987; 67(5): 864–865. doi: 10.1097/00000542-198711000-00057.
9. Schnapp L.M., Cohen N.H. Pulse oximetry: uses and abuses. Chest 1990; 98(5): 1244–1250. doi: 10.1378/chest.98.5.1244.
10. Coté J.C., Goldstein E.A., Fuchsum W.H., Hoaglin D.C. The effect of nail polish on pulse oximetry. Anesth. Analg. 1988; 66(7): 683–686.
11. Rubin A.S. Nail polish color can affect pulse oximeter saturation. Anesthesiology 1988; 68(5): 825. doi: 10.1097/00000542-198805000-00049.
12. Yamamoto L.G., Yamamoto J.A., Yamamoto J.B., Yamamoto B.E., Yamamoto P.P. Nail polish does not significantly affect pulse oximetry measurements in mildly hypoxic subjects. Respir. Care 2008; 53(11): 1470–1474.
13. Hinkelnbein J., Koehler H., Genzweker H.V., Fiedler F. Artificial acrylic fingernail may alter pulse oximetry measurement. Resuscitation 2007; 74(1): 75–82. doi: 10.1016/j.resuscitation.2006.11.018.
14. Yek J.J., Abdulliah H.R., Goh J.P.S., Chan Y.W. The effects of gel-based manicure on pulse oximetry. Singapore Med. J. 2019; 60(8): 432–435. doi: 10.11622/smj.2019031.
15. Katari B.K., Lampkins R. Nail polish does not affect pulse oximeter saturation. Anesth. Analg. 1986; 65(7): 824. doi: 1213/00000539-198607000-00029.
16. Brand T.M., Brand M.E., Jay G.D. Enamel nail polish does not interfere with pulse oximetry among normoxic volunteers. J. Clin. Monit. Comput. 2002; 17(2): 93–96. doi: 10.1023/A:1016385225656.
17. Dicci S., Pereira E.M., Im S.Y., Shida L.Y., de Cásia Bettencourt A.R. Evaluation of pulse oximetry measurements in healthy subjects with nail polish. Acta Paul. Enferm. 2011; 24(6): 784–788. doi: 10.1590/S0103-21002011000600009.
18. Chan M.M., Chan M.M., Chan E.D. What is the effect of fingernail polish on pulse oximetry? Chest 2003; 123(6): 2163–2164. doi: 10.1378/chest.123.6.2163.
19. Rodden A.M., Spicer L., Diaz V.A., Steyer T.E. Does fingernail polish affect pulse oximeter readings? Intensive Care Nurs. 2007; 23(1): 51–55. doi: 10.1016/j.iccn.2006.08.006.
20. Hinkelnbein J., Genzweker H.V., Sogl R., Fiedler F. Effect of nail polish on oxygen saturation determined by pulse oximetry in critically ill patients. Resuscitation 2007; 72(1): 82–91. doi: 10.1016/j.resuscitation.2006.08.024.
21. Severinghaus J.W., Naifeh K.H., Koh S.O. Errors in 14 pulse oximeters during profound hypoxia. J. Clin. Monit. 1989; 5(2): 72–81, doi: 10.1007/BF01617877.

22. Severinghaus J.W., Spellman M.J. Jr. Pulse oximeter failure thresholds in hypotension and vasoconstriction. Anesthesiology 1990; 73(3): 532–537, doi: 10.1097/00000542-199009000-00025.

23. Jay G.D., Hughes L., Renzi F.P. Pulse oximetry is accurate in acute anemia from hemorrhage. Ann. Emerg. Med. 1994; 24(1): 32–35, doi: 10.1016/s0196-0644(94)70158-x.

24. Miyake M.H., Diccini S., de Cásia Bettencourt A.R. Interference of nail polish colors and time on pulse oximetry in healthy volunteers. J. Pneumol. 2003; 29(6): 386–390, doi: 10.1590/S0102-35622003000600011.