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Case Report

False pulse oximetry readings due to interference of nail polish affecting critical blood transfusion decisions during thyroidectomy

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Abstract: The following case is an account of interference of clear nail polish with pulse oximetry readings almost affecting critical surgical decisions previously not described in literature. A 19 years old female patient was diagnosed with papillary thyroid carcinoma and scheduled for total thyroidectomy and left cervical lymph node dissection surgery under general anesthesia. During the surgery, the patient lost 400 mL of blood and a critical blood transfusion decision was needed to be made. Based on the pulse oximetry readings, the patient SpHb was ranged between 7.1-7.3 g/dL. However, using invasive conventional blood testing methods the patient SpHb was ranged between 9.5-9.8 g/dL. Upon careful investigation, we noticed our patient had clear ultra-reflective nail polish on. We suspect that this was the reason and it is interfering with the pulse oximetry readings. Based on this discovery, a decision was made to not transfuse blood for the patient. The rest of the surgery was unproblematic and 20 minutes after surgery our patient woke up with no other problems. The above case should act as an important warning for future surgical staff and especially surgical preparation team. Clear nail polish is similar to having no nail polish except the ultra-reflective surface; therefore it is easily missed during surgical preparations. We suggest that all nails should be cleaned prior to surgery despite the presence of nail polish and we feel all surgical staffs should be warned on the possible danger of using pulse oximetry readings on a patient with clear nail polish.

Keywords: Patient care, oncology, anesthesiology, nail polish, pulse oximetry

Introduction

The term oximeter was first coined by British researcher and Nobel laureate Dr. Robert A. Millikan when he invented the first lightweight aviation ear oxygen meter back in the 1940s [1-4]. Over the past 75 years, pulse oximetry has become standard practice in clinic and during anesthesia in the operating room [5-7]. It provides non-invasive, immediate and continuous monitoring of arterial oxygen saturation and total hemoglobin readings [8, 9].

The heavy reliant of pulse oximetry by doctors and nurse makes this technology an inseparable part of clinical practice and surgery. However, according to the American Association for Respiratory Care's Clinical Practice Guidelines, several factors can affect the accuracy of pulse oximetry [8]. These factors can be generally divided in two categories, physiological and external. Physiological factors may include: dyshemoglobinopathies such as ethemoglobinemia and carboxyhemoglobinemia; [10-12] shivering, [13] poor tissue perfusion, [14] oxygen saturation values below 70%, [15] skin pigmentation, [16, 17] low perfusion pressure, [18] venous pulsations, [18] extreme anemia [19]. External factors include improper training of doctors and nurses. In one report 87% of nurses claimed that pulse oximetry was regularly used, but only 37% thought they had adequate training and knowledge of pulse oximetry [9]. In addition, external factors may include interference from certain lighting systems such as surgical lamps, fluorescent lighting and fibroscopic instruments; [20, 21] movement of the sensor; [18] sensor not compatible with the equipment and lack of calibration and nail polish [22-24].

Figure 1. A. Ring finger of our patient with ultra-reflective clear nail polish. B. Ring finger without any nail polish.

The effect of using nail polish on pulse oximetry readings is contradictory. Some studies did not observe any effect of nail polish on pulse oximetry readings while others reported significant reductions [22, 25-27]. It has been previously reported that blue, green and black nail polish interferes with pulse oximetry readings [22, 28]. These findings correlated best with nail polish colors that had the greatest difference in light absorbance between 660 nm and 940 nm [29].

To our knowledge little is known about the effect of clear nail polish on pulse oximetry readings. Clear nail polish provides a shiny, reflective nail surface where it is easy to miss during surgical preparation procedures (**Figure 1A**, **1B**). Here we present a case where clear nail polish significantly skewed the pulse oximetry readings nearly affecting the anesthesiologist's critical decision on blood transfusion during total thyroidectomy.

Case report

We had a 19 years old female patient admitted for unknown mass in the neck region. She is 162 cm and 48 kg. Physical examination showed she had a class II thyroid carcinoma, 2.0*2.0 cm nodule with unclear divisions, on the left lobe. The diagnosis upon arrival was papillary thyroid carcinoma. She had a history of hyperthyroidism and takes Methimazole and Propranolol regularly. Upon testing, her TSH, T3 and T4 levels were all normal. She had no history of cardiovascular diseases. She was scheduled for total thyroidectomy and left cervical lymph node dissection surgery under general anesthesia. Her blood type is Rh (-), before the surgery her HGB level was 12.5 g/dL (**Table 1**). Her vitals were normal upon entering the surgery room: BP 109/78 mmHg, HR 92 bpm, 98% SpO_2 saturation. She underwent general anesthesia with 4 mg Imidazole, 25 μg Sufentanyl, 70 mg Propofol and 50 mg Rocuronium. She was intubated normally and end-tidal CO_2 was maintained between 30-35 mmHg.

During the total thyroidectomy, due to the large size of the thyroid and the unclear boarders, there was more blood loss than originally expected. After 2 hours and 30 minutes, the thyroid was successfully dissected but the patient has lost around 400 mL of blood. She

Table 1. Blood work of our patient before and during the surgery

Blood Work	Before Surgery	During Surgery
WBC (10^9/L)	5.14	6.31
GR (%)	52.3	58.4
LYMPH (%)	37.8	33.7
MONO (%)	7.7	6.3
RBC (10^{12}/L)	4.25	3.56
HCT (%)	38	29
PLT (10^9/L)	207	188
CRP (mg/L)	3.36	4.13
HGB (g/dL)	12.5	9.8

Note: The HGB levels during the surgery is significantly different from the pulse oximetry readings.

was transfused with 1800 mL of Lactated Ringer's solution. At this point her vitals were: BP 101/70 mmHg, HR 88 bpm and 100% SpO_2 saturation. To get a quick hemoglobin level, pulse oximetry was used (MasimoSET). The pulse oximetry was connected to her ring finger as recommended by the manufacturer. Upon testing, her SpHb was 7.2 g/dL. The SpHb ranged from 7.1-7.3 g/dL after 5 minutes of continuous testing.

At this time, a critical decision needs to be made on whether or not to give the patient blood transfusion. In consideration of the patient's age, a history of hyperthyroidism and hemoglobin level, the general surgeon suggested blood transfusion. But she has a relatively rare Rh (-) blood type, and extra blood was not prepared before the surgery, therefore blood transfusion would be difficult. At the same time, an important question rose in our hearts. The patient's hemoglobin level was 12.5 g/dL before the surgery; during the surgery, the patient lost about 400 mL of blood. This does not equal to 7.2 g/dL, a reading gave by the pulse oximetry. With this question in mind, her blood was drawn and a blood sample was analyzed. Her results showed that her blood hemoglobin level was 9.8 g/dL (**Table 1**).

With this result in mind, we double checked the connection of the pulse oximetry, everything was connected correctly. Her finger blood perfusion index was around PI 6.0, warm with a finger thickness of 11.59 mm and a nail thickness of 0.45 mm. Upon careful inspection, the patient had clear nail polish on her finger nails and this was missed for preparation before the surgery.

With these findings in mind, blood transfusion was not necessary. Instead, 500 ml of blood volume expander was given to the patient. The patient then continued with the left cervical lymph node dissection with no additional problems. When the operation was completed, her blood was analyzed again and results showed that her hemoglobin level was 9.2 g/dL while pulse oximetry still showed a reading between 6.8-7.1 g/dL. In conclusion, the patient lost 500 mL of blood, given 2500 mL of Lactated Ringer's solution and blood volume expander, no blood transfusions. Twenty minutes after the surgery, the patient woke up, intubation tube was removed and she returned to her room for further monitoring. Her vital signs at the end of surgery were: BP 115/80 mmHg, HR 95 bpm and 98% SpO_2 saturation.

Discussions

The above case should act as an important warning for future surgical staff and especially surgical preparation team. Clear nail polish is similar to having no nail polish except the ultra-reflective surface; therefore it is easily missed during surgical preparations (**Figure 1A**, **1B**). Although there are some studies on the effect of nail polish on pulse oximetry, but to our knowledge, this is the first case report to show that indeed nail polish could interfere with pulse oximetry and affect critical surgical decisions [27-29]. In addition, the majority of clinical cases looked at the effect of colored nail polish on the effect of pulse oximetry, ie. blue, red, brown and black, but little is known on the ultra-reflective clear nail polish [28, 29].

The invention of pulse oximetry greatly benefited the non-invasive, immediate and continuous monitoring of arterial oxygen saturation and total hemoglobin readings. In most cases, if used correctly, pulse oximetry can provide an accurate and reliable reading of arterial oxygen saturation and total hemoglobin levels. However, pulse oximetry is in no way perfect. Numerous studies showed both physiological and external factors will affect pulse oximetry readings [10-24]. Our case provided an unique example of clear nail polish affecting pulse oximetry readings and in turn almost affected critical surgical decisions.

Majority of clinical cases looking at the interference of nail polish on pulse oximetry readings looked at hue or dark colors [25, 27-29]. Colors such as black, blue, red and brown. Our unique case brought a previously under-looked clear nail polish into questions. Clear nail polish is similar to colored nail polish with one exception of the ultra-reflective nail surface (**Figure 1A**, **1B**). The clear nail surface can be easily missed during surgical preparations, which is then quite dangerous if used with pulse oximetry results to make surgical decisions. Our cased demonstrated a 19 years old female who was diagnosed with papillary thyroid carcinoma. She was scheduled for total thyroidectomy and left cervical lymph node dissection surgery under general anesthesia. During the surgery, due to the unnoticed clear nail polish and its interference with pulse oximetry readings, a wrong surgical decision was almost made which could cause potential unwanted complications to our patient.

Although it is possible that the interference we saw in the pulse oximetry readings could be caused by something other than clear nail polish. We have tried our best to eliminate and look for other possible interferences that could result in the decreased pulse oximetry reading saw in our case. First, the standard lighting used in our surgical room is the same with every surgery and we have not seen this interference in any other surgeries. Next, our patient has no known interference factors noted above and the pulse oximetry was used by a highly trained anesthesiologist which had a thorough understanding of the pulse oximetry system. Finally, this machine was used on a surgical staff during the surgery to make sure that the interference we saw was not a result of faulty system. After eliminated these possible factors, we were confident that the interference we saw with the pulse oximetry readings was due to the clear nail polish on the patient's finger.

We hope this case can prevent similar oversight from happening again. We suggest that all nails should be cleaned prior to surgery despite the presence of nail polish. We feel all surgical staffs should be warned on the possible danger of using pulse oximetry readings on a patient with clear nail polish. Our case can also open doors for future investigation on the interference effect of clear nail polish with pulse oximetry readings. Finally, we hope this case can bring to light the possible dangers of nail polish on pulse oximetry readings to the manufacturers and idealistically improvements can be made to eliminate this bias in their equipment.

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Disclosure of conflict of interest

None.

Authors' contribution

SZ: conceived and designed the study, read and analyzed the documents, collected data. YM: read and analyzed the documents, collected data. YT: critically revised the manuscript and gave valuable advice to the study. LZ: critically revised the manuscript and gave valuable advice to the study. YL: conceived and designed the study,read and analyzed the documents, drafted and revised the manuscript and given final approval of the version to be published. All authors take responsibility for the content of the paper.

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