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ORIGINAL RESEARCH

Effect of road traffic accident contaminants on pulse oximetry among normoxaemic volunteers

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Abstract

Objectives

Pulse oximetry is a simple and reliable non-invasive method used widely in emergency care. Signal strength is usually easy to interpret in most monitors and is used as a simple validation tool for the reliability of the readings. However it is known from the literature that in certain circumstances the oxygen saturation readings could be false in spite of a deceptively normal signal. The aim of this study was to compare the pulse oximetry readings on fingers contaminated with natural contaminants which might appear in a road traffic accident (RTA) scenario.

Methods

50 healthy volunteers were included. Beside the control fingers, the others were contaminated by (1) dried blood (B), (2) soil (S), (3) oil grease (O) and (4) green extract from natural leaves (G).

Results

The average control reading was 99.1% (SD 1.11). The average readings on the contaminated fingers were as follows: B: 98.6% (SD 1.27); S: 98.7% (SD 1.17); O: 98.5% (SD 1.09); G: 98.7% (SD 1.06). There was a statistically different decrease in the readings between the B and O groups compared to control.

Conclusion

Pulse oximetry could give unreliable readings despite a normal signal when a patient's fingers are contaminated - especially with dried blood or black oil grease which are both common in road traffic accidents. Cleaning the fingers before pulse oximetry therefore should be considered.

Keywords: *accident; hypoxia; non-invasive monitoring; pulse oximetry*

Introduction

Pulse oximetry is one of the most clinically relevant non-invasive monitoring techniques of vital signs and is widely used in both hospital and prehospital emergency environments. The strength of the signal is usually visible on most monitors and is used as a simple validation tool for the reliability of the reading. However this relatively simple technique also has a

number of limitations.¹ A reasonably good peripheral circulation is needed to provide reliable readings transcutaneously on the fingers, and motion artefacts can interfere with readings, especially during transport.² Since the method is based on spectrophotometric absorption, it seems logical that anything between the source of light and the sensor, which absorbs or reflects light, can modify readings. In some cases the signal is visibly poor, which can usually be seen and adjusted to avoid misinterpretation of the readings. However, in certain circumstances the signal might be normal but the readings false.

A few papers in the literature have already investigated the effect of different nail polishes on the accuracy of transcutaneous pulse oximetry.^{3,4,5} However, sometimes not only nail polish is present on the nail plates when one would like to take accurate pulse oximetry. For example, a number of other contaminations can be found on nail plates which originate from the environment at the time of the accident. The aim of our study was to investigate the effect of those different contaminations of the nail plate on the accuracy of transcutaneous pulse oximetry. The contaminants we used were those commonly found in the RTA environment: i.e. grease of engine oil, soil, dried blood from the victim and chlorophyll rich fluid from the green leaves and grass.

Methods

After obtaining approval from the Human Research Ethics Committee of the Trust, we recruited 50 healthy volunteers to participate in the study. The index finger was used to record the normal arterial oxygen saturation (SpO₂) using a transcutaneous transducer of the AGILENT V24CT modular critical care monitor system. This was used as the control. The SpO₂ on all fingers were then measured and only subjects with the same readings in all fingers were included (50 of 50). The index finger of the opposite hand was smeared by a drop of the same volunteer's blood and allowed to dry. The other fingers were coated with soil, green leaves extract and vehicle grease and oil. We used visual reference in order to obtain the same amount of contamination for all volunteers. The SpO₂ readings were then taken, ensuring that the sensor was adequately cleaned and dried before each reading. The measurement for each finger was continued until a stable signal and reading was obtained and the value recorded in the 30th second. The results are shown as means and standard deviations (SD) and were compared to the control. Data was analysed using a single tailed, paired T-test and significance level considered at p<0.05. All the recordings were made using the same pulse oximeter while the volunteers breathed normally from room air.

Results

All volunteers had the same baseline readings on all fingers. The average age was 37 (SD 12), male: female ratio (34:16). Out of the 50 subjects 12 were smokers but there was no difference in baseline readings of the smokers and non-smokers.

The average control was 99.1% (SD 1.114) with no statistically significant difference between genders or smokers and non-smokers. On the fingers contaminated with dried blood, the average reading of SpO₂ was 98.6% (SD 1.27; p<0.05). In case of contamination with soil the average SpO₂ was 98.7% (SD 1.17; p=0.082). When the fingers were contaminated by the green extract of the natural leaves the average SpO₂ reading was 98.7% (SD 1.06; p=0.072). The average SpO₂ was measured on fingers contaminated by the grease of the engine oil was 98.5 % (SD 1.09; p=0.05) as shown in Figure 1.

There was no statistically significant difference between either the control group and the soil contaminated group, or the control and the green contaminated groups. There was a weak but statistically significant difference between the control group and the blood contaminated group ($p=0.034$) and between the control group and the engine oil grease contaminated group ($p=0.008$).

Discussion

Pulse oximetry is a differential measurement based on the spectrophotometric absorption method using the Beer–Lambert Law for optical absorption. Two wavelengths of light, one in the red (660 nm) and the other in the infra red (920nm) spectrum are directed across the vascular bed of (usually) a finger and measured by a photodetector sensitive to these wavelengths. The ratio of the absorption between these two spectrums is correlated to the relative concentration of oxygenated and deoxygenated haemoglobin molecules. The arterial component of the signal is separated from the venous, bone and tissue component by analysing the pulsatile component only, hence the name “pulse oximetry”. The resulting measurement is adjusted according to a calibration curve embedded in the instrument to yield an arterial oxygen saturation measurement.¹

However, pulse oximetry readings may not be accurate in various situations, as readings can still be false in visibly normal signals. As acute oxygen therapy is now recommended *to be titrated* to a specific target saturation, a false pulse oximetry might cause inadequate treatment, jeopardizing for example, patients with chronic obstructive lung disease.⁶ Presently available pulse oximetric readings overestimate arterial oxygenation in patients with severe CO poisoning.⁷ When methaemoglobin concentrations increase above 35%, the pulse oximetry reading is virtually independent of MetHb concentrations and reaches a plateau of 84 – 86% saturation.⁸ Mechanical motion did affect oximetric function, particularly when the sensors were connected during motion, which requires signal acquisition during motion.² Pulse oximetry readings are not significantly affected by light sources commonly used in

clinical settings and ambient light in clinical setting has no clinically importance on pulse oximetry readings.⁹

There have been a few studies regarding the effect of nail polish on pulse oximetry. Red nail polish interferes with pulse oximetry and therefore it should be routinely removed prior to monitoring.³ In another study it was shown that there is a small decrease in SpO₂ (by approximately 2%) in fingernails painted with either brown or black nail polish when measured with the probe in top to bottom position. However placing the probe in a side-to-side position precluded any minor effects.⁴ However these results were not replicated in a laboratory setting using spectrophotometry and healthy volunteers.⁵

There has not been any data regarding the effect of potential road traffic accident contaminants on pulse oximetry. The present study was intended to find the effect of four potential contaminants, dried blood, soil, vehicle oil and green leaves on SpO₂ levels carried out on healthy normoxaemic volunteers.

Our results suggest that contamination of fingers with dried blood or oil grease might reduce the reliability of transcutaneous pulse oximetry in spite of a deceptively normal signal strength. These results can be most probably explained by the colour – as in the light absorbing characteristics of these contaminants which is similar to what has been already published regarding the effects of red and black/brown nail polish.^{3,4} The differences in the readings were never greater than 1% (suggesting more of a statistical than clinical significance) it might be different in cases when oxygen saturation is lower. The clinical significance of a false reading could be more obvious when the patient suffers from chronic obstructive lung disease and the acute oxygen treatment is guided by the actual SpO₂. This might lead to unnecessary oxygen administration which is now considered potentially harmful according to the recent guideline for emergency oxygen use issued by the British Thoracic Society.⁶ However, to prove the clinical significance of our finding in this patient group, would require a much larger scale clinical trial. Interestingly the other natural contaminants – green from leaves and soil also caused a slight reduction in the values measured but these were not statistically significant. The findings on the effect of the green coloured contamination are also confirmed by earlier studies with green nail polish.³ The limited effect of soil contamination however might be explained by the fact that it failed to create a uniform layer on the nail and light might have come through the uncovered areas.

Limitations

The study was carried out on healthy normoxaemic volunteers. We think that these results would most likely be the same in hypoxic patients or in cases of major trauma. However a much larger scale clinical study would be needed to prove this.

Summary

Our results suggest that in spite of a seemingly normal signal strength, pulse oximetry readings can be false and unreliable in the case of specific contaminants on the finger. In prehospital practice, visibility is sometimes suboptimal and dried contamination on the fingers could easily be overlooked. Therefore it seems advisable to firstly clean the nails of those patients with dried blood or oil grease contaminations on their fingers before obtaining pulse oximetry - even when the readings on the monitor look normal.

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Conflict of Interest

None

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