Discrepancy in finger pulse oximetry reading related to positioning: a case report

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Abstract

Pulse oximetry is one of the five cardinal vital signs used to monitor patients in the clinical setting, and has contributed significantly to patient safety. Unfortunately, extremes in patient positioning may lead to changes in peripheral perfusion pressures resulting in erroneous pulse oximetry readings. We present a case of a relatively well patient coming for robot-assisted laparoscopic radical prostatectomy who became hypoxic in the Trendelenburg position that spontaneously resolved upon transitioning to supine. The reliability of the traditional method of assessing the pulse oximeter value via the plethysmograph is questioned and we discuss other modalities to assist in interpretation of the suspicious pulse oximetry reading.

Keywords

Trendelenburg position, pulse oximetry, anaesthesia

Background

The development of pulse oximeters in medicine has greatly influenced medicine and has led to a significant improvement in patient care and safety. Since its invention, pulse oximetry use is associated with a 19-fold increase in detection of hypoxemia episodes.1 Despite its relevance in today’s practice in providing continuous oxygen saturation monitoring, it is not without its flaws. We present an interesting case of a large discrepancy in the finger pulse oxygen saturation reading in the Trendelenburg position to the actual arterial oxygen saturation and discuss the possible reasons for this. We also explore the use of ancillary tools to assist in determining the validity of the pulse oxygen saturation reading.

Written consent was taken from patient for publication.

Case

A 67-year-old gentleman (60.8 kg, 1.57 m, body mass index 24.7 kg/m2), non-smoker, with good effort tolerance, was admitted electively for a robot-assisted laparoscopic radical prostatectomy for prostate cancer. He had a history of quiescent gastric reflux disease, dyslipidaemia and impaired fasting glucose. One month prior, he underwent an uneventful prostate biopsy under general anaesthesia. An hour into surgery, after placement of the robotic arms and positioning into a steep Trendelenburg incline, patient’s finger oxygen saturation (Phillips FAST SpO2 reusable rigid finger probe, standard adult size) started to fall from 100% to 60% on FiO2 0.5 despite a good waveform, BP 110–120/70–80 mmHg, HR 70–80 bpm (see Figure 1). There was no change in ventilator setting: volume controlled ventilation, tidal volume 450 ml and a respiratory rate of 12, and airway pressures remained stable at 15 cmH2O. Procedure was halted, and he was placed on 100% O2. The endotracheal tube was pulled out by 2 cm to 20 cm at the lips in view of suspected endobronchial intubation, chest was clear with bilateral equal air entry and the table was levelled, with resolution of the desaturation episode. However, was conducted using propofol, atracurium and fentanyl, and he was intubated with a size 8 endotracheal tube and thereafter maintained on an oxygen/air/desflurane mixture. Both arms were kept tucked in and he was shifted into lithotomy. An hour into surgery, after placement of the robotic arms and positioning into a steep Trendelenburg incline, patient’s finger oxygen saturation (Phillips FAST SpO2 reusable rigid finger probe, standard adult size) started to fall from 100% to 60% on FiO2 0.5 despite a good waveform, BP 110–120/70–80 mmHg, HR 70–80 bpm (see Figure 1). There was no change in ventilator setting: volume controlled ventilation, tidal volume 450 ml and a respiratory rate of 12, and airway pressures remained stable at 15 cmH2O. Procedure was halted, and he was placed on 100% O2. The endotracheal tube was pulled out by 2 cm to 20 cm at the lips in view of suspected endobronchial intubation, chest was clear with bilateral equal air entry and the table was levelled, with resolution of the desaturation episode. However,
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upon transitioning to the Trendelenburg position, patient started to desaturate again. No difference was noticed when a nasal saturation probe was used (Phillips FAST SpO2 reusable nasal probe). This time, direct bronchoscopy was performed confirming adequate endotracheal tube positioning. We suspected then that the SpO2 readings were inaccurate as the patient looked pink, and the haemodynamics remained within normal limits despite a suspected severe hypoxia. This was confirmed with an arterial blood gas (PaO2 of 220 mmHg).

By this time, a low perfusion probe (Philips Masimo module, reusable rigid finger probe, standard adult size) was available and when applied onto the same finger showed a significant discrepancy in readings (100% vs 59%). The procedure thereafter proceeded uneventfully. Much later in the case, the perfusion index (PI) function was activated on the Philips monitor (Philips, IntelliVue MP70 Anaesthesia, SW revision J) which demonstrated a difference in both the Masimo and FAST modules and their corresponding values when applied on different fingers on the same hand (see Figure 2). He was discharged home well on postoperative day 3.

A retrospective review of his anaesthetic one month later did not reveal any episodes of desaturation for a procedure which was performed in the lithotomy position.

Discussion

Oxygen saturation monitors have revolutionized medicine particularly in areas of neonatology, anaesthesia and intensive care. Pulse oximetry provides us with a non-invasive, continuous means to monitor oxygen saturations. It is reliable and accurate with a fast response time, and also has good correlation between directly measured arterial oxygen saturation ($r = 0.95$) and measured arterial partial pressure of oxygen ($r = 0.95$). However, it is not without its limitations.

In patients with poor perfusion pressures, it is difficult for the traditional pulse oximeter to eliminate venous pulsations thereby resulting in inaccurate SpO2 readings. The improved technology in low perfusion monitors is able to identify these aberrant venous signals and extract the arterial signal from them. Low perfusion pulse oximeters have since been developed, e.g. by Masimo and Nellcor, to counteract the limitations of the traditional pulse oximeter. The algorithms used are specifically targeted to reduce motion artefacts and to improve the integrity of the SpO2 reading.

In particular, the Masimo pulse oximeter (Masimo Corporation, Mission Viejo, California, USA) analyses SpO2 through the signal extraction technology (SET). SET calculates the patient’s arterial oxygen saturation by the use of five different but parallel algorithms. This enhanced technology removes movement artefacts and noise to produce a clearer arterial signal.

In contrast, the FAST technology by Philips works by applying the fast Fourier transformation to break down the red and infrared signals into individual frequencies, and uses this to distinguish artefacts from actual signals. Simulated conditions of decreased peripheral perfusion and increased motion in healthy individuals have been found to lead to a higher number of erroneous SpO2 readings, and where the SpO2 deviation was within ±3% less than 62% of the time.

In a comparison of finger, nasal, ear and forehead probes in poorly perfused cardiac surgery patients, it was found that nasal and forehead probes performed the most poorly, and finger probes were the best when globally assessed using five criteria (accuracy, precision, number and percentage of readings within 3% of standard and expected over-read limit in 95% of cases).

True desaturation can occur in a patient undergoing a laparoscopic procedure in a steep Trendelenburg position. The reasons can be divided into anaesthetic-, surgical- or equipment-related. For anaesthesia factors, the endotracheal tube may migrate and become endobronchial with a resultant one lung ventilation or bronchospasm due to irritation of the carina. During positioning, there may be inadequate tidal volumes generated, particularly if patients were placed on pressure controlled ventilation as the abdominal contents splints the diaphragm and causes an elevated airway pressure. There may also be inadvertent surgical port insertion to the subcutaneous tissues leading to subcutaneous emphysema which may track up to the thorax region or lead to pneumothorax. In addition, spuriously low SpO2 readings may occur due to the inability of the pulse oximeter to read from poorly

Figure 1. Discrepancy between Phillips FAST module finger probe monitor and Philips Masimo module.

Figure 2. Perfusion numeric activated on the Philips monitor (Philips, IntelliVue MP70 Anaesthesia, SW revision J). The orange circles are reflective of the Phillips FAST SpO2 reusable rigid finger probe while the green circles represent data from the Philips Masimo module, reusable rigid finger probe.
perfusion pressures as the cause of hypoxia should be a diagnosis of exclusion and all the above tests one and problems excluded before it is suspected. A value of $<1$ will suggest an inaccurate $\text{SpO}_2$ reading and should be confirmed with an arterial blood gas specimen and/or a low perfusion pulse oximeter.

To our knowledge, no studies have been done on the perfusion pressures of the fingers in different positions. We feel that this case report can lead to further studies to confirm our findings and to find out how this influences the pulse oximetry readings.

**Conclusion**

In conclusion, we present an unusual case of ‘hypoxia’ measured by traditional pulse oximetry that was caused by poor peripheral perfusion, which can be mitigated by the application of a low perfusion probe. We suggest that in addition to configuring the pulse oximeter to show the waveform, it should display the signal quality indicator and the perfusion numeric/index as a default. More studies are required to determine if there is any association between perfusion pressures in various positions and their effects on pulse oximetry.

**Authors’ contributions**

YLL analysed, interpreted and wrote the manuscript. MHG and YYO were involved in the review and final approval of the manuscript.

**Availability of data and material**

Not applicable.

**Ethical approval**

SingHealth IRB does not require ethical approval for reporting individual cases or case series.

**Informed consent**

Written informed consent was obtained from the patient for their anonymized information to be published in this article.

**Declaration of conflicting interests**

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

**Funding**

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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