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Challenging Perioperative Monitoring: A Case Report of False Pulse Oximetry Readings in a Neonate with Severe Aortic Hypoplasia and Diaphragmatic Hernia

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Abstract

Anesthetic monitoring is critical for patient safety, providing real-time data to guide clinical decisions. However, the accuracy of monitoring devices, such as pulse oximeters, can be compromised under certain conditions, potentially leading to misinterpretation and adverse outcomes. We report the case of a 5-day-old neonate with a severe diaphragmatic hernia and significant aortic arch hypoplasia who underwent surgical correction. During the perioperative period, pulse oximetry readings in the right upper limb (RUL) indicated unexpectedly low oxygen saturation compared to the left lower limb (LLL). This discrepancy was inconsistent with the patient's underlying congenital heart condition. Arterial blood gas analysis revealed higher oxygen saturation and partial pressure of oxygen (PaO2) in the RUL compared to the LLL, confirming the inaccuracy of the pulse oximeter readings. This case emphasizes the importance of understanding the principles, limitations, and potential biases of monitoring devices to prevent misinterpretation. Anesthetic management requires critical evaluation of data, particularly in complex cases, to ensure optimal patient outcomes.

Keywords: anesthesia; monitoring; pulse oximetry; aortic hypoplasia; transcranial doppler ultrasound

Introduction

Monitoring during anesthesia is an essential procedure that ensures the patient's safety and comfort, helping to prevent complications and promoting a smooth recovery [1]. Thirty years ago, patient monitoring was performed solely through the observation of visual signs (pupil movement, skin coloration, coloration of mucous membranes, and the surgical field), tactile signs (pulse, ventilatory sounds, and temperature), and auscultatory signs (cardiac, ventilatory, and peristaltic sounds) [1]. The instruments available included the stethoscope, the manual pneumatic device for measuring blood pressure, the thermometer for measuring temperature, and, in more advanced situations, the measurement of central venous pressure (using a liquid column) and arterial pressure measurement using a mercury column [2]. Fortunately, technology has evolved over the years, providing us with real-time information on blood pressure, heart rate and rhythm, oxygen saturation of hemoglobin, body temperature, the intensity of neuromuscular blockade, and the depth of anesthesia. However, this is of no use if the anesthesiologist does not know how to recognize situations where the information provided by the monitors may be inaccurate and our analysis is subject to biases [1]. The following is a case description of a 5-day-old patient with a severe diaphragmatic hernia and severe hypoplasia of the aortic arch, who underwent surgical correction of the aforementioned hernia, with a focus on the challenging monitoring and its changes during the perioperative period.

Case Report

This is a case of a late preterm newborn (35 weeks of gestation), appropriate for gestational age (AGA), and low birth weight, with a prenatal diagnosis via fetal ultrasound (USG) of a left diaphragmatic hernia and hypoplasia of the aortic arch. The patient was born via cesarean delivery and required resuscitation with positive pressure ventilation (PPV) and orotracheal intubation (OTI) in the delivery room before being transferred to the neonatal intensive care unit (NICU). In the following days, during the NICU stay, a transthoracic echocardiogram (TTE) revealed significant hypoplasia of the aortic arch (The transverse aortic diameter measured 2.9 mm (Z-score:

-5.6)), a large patent ductus arteriosus (PDA) with a diameter of 4.5 mm and bidirectional shunting was observed, coarctation of the aorta just after the PDA insertion (The aortic isthmus measured 1.8 mm (Z-score: -6.0)), a patent foramen ovale (PFO), and pulmonary hypertension with an estimated systolic pulmonary artery pressure (sPAP) of 57 mmHg. After 5 days, the patient was admitted to the surgical suite for the surgical correction of the diaphragmatic hernia, with a 3.0 orotracheal tube (OTT) without a cuff, a pulse oximeter on the right upper limb (RUL), and a peripheral venous access (PVA) in the RUL. Mechanical ventilation (MV) was connected to nitric oxide (NO) at 20 ppm. As soon as the patient was transferred to the surgical table, monitoring was initiated with cardioscopy, a second pulse oximeter on the left lower limb (to monitor pre- and post-ductal oxygen saturation [SpO2]), a new 24G PVA, and invasive blood pressure (IBP), both in the left upper limb (LUL). The right radial artery was not punctured due to technical difficulties. Upon completion of monitoring, an SpO2 discrepancy was observed: RUL saturation was <4% compared to LLL. This could not be explained by the underlying cardiopathy, as illustrated below:

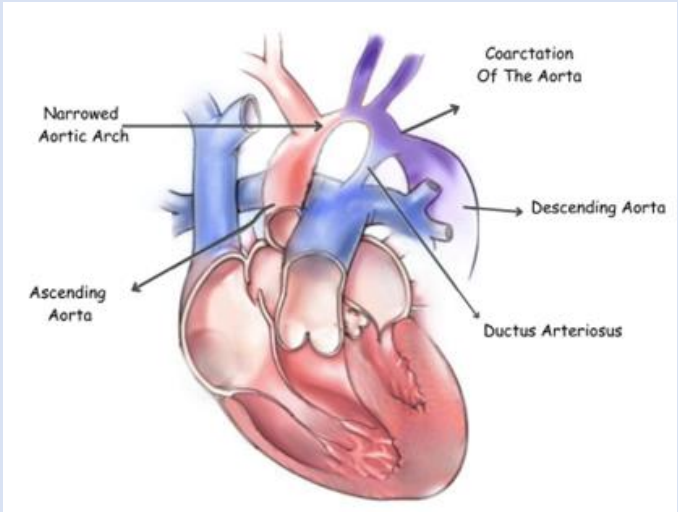

Figure 1: Illustration of the patient's congenital heart defect.

Note the hypoplasia in this patient is located after the insertion of the brachiocephalic trunk. Thus, the right subclavian artery supplies the right upper limb (RUL) with oxygen-rich blood, whereas the left subclavian artery and the descending aorta, which supply the left upper limb (LUL) and lower limbs (LL), respectively, carry mixed blood.

Analyzing the image, the blood supplying the right upper limb (preductal) through the right subclavian artery is composed of oxygen-rich blood, while the rest of the body is supplied with mixed blood. Therefore, it would not be possible for the RUL to have worse oxygenation than the LL. The opposite is true: SpO2 would be higher in the RUL compared to the LL. Additionally, at the beginning of anesthesia, the patient experienced two severe episodes of hypoxemia, which were managed with boluses of phenylephrine and ventilation using the mechanical ventilator in manual mode with higher pressures. It was then decided to initiate a continuous infusion of norepinephrine at 0.1 mcg/kg/min, increase the NO flow to 40 ppm, and optimize mechanical ventilation (MV) by raising the PEEP from 2 to 7 and the tidal volume to 10 mL/kg. These adjustments resulted in significant clinical improvement, and the patient remained stable throughout the procedure. During the intraoperative period, transcranial Doppler ultrasound (TCD) was performed through the temporal window to assess cerebral blood flow and provide an indirect estimate of cardiac output (CO), which indicated satisfactory blood flow [3]. Note the presence of diastolic flow and a time-averaged maximum velocity (TAMAX) of 24 cm/s, indicating satisfactory blood flow in figure 3 [4].

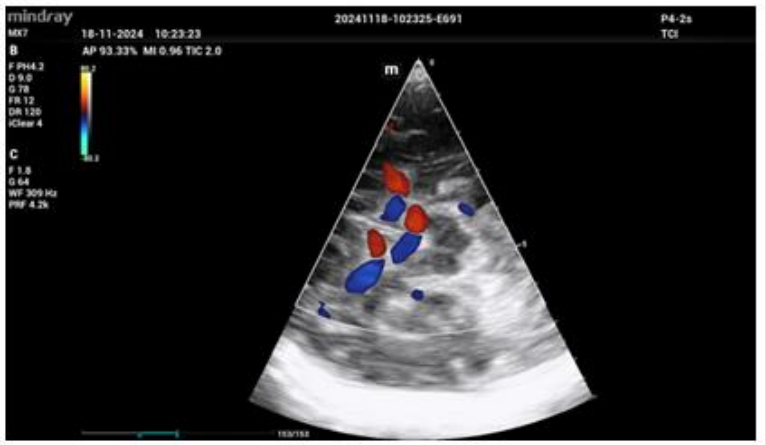

Figure 2: Transcranial Doppler Ultrasound (TCD) examination revealed flow patterns in the bilateral middle cerebral arteries, posterior cerebral arteries, and anterior cerebral arteries, which are key components of the circle of Willis.

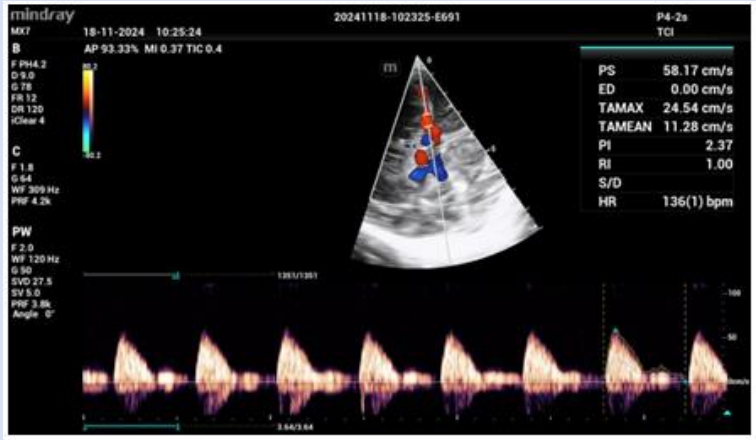

Figure 3: Middle cerebral artery (MCA) blood flow demonstrates regular flow patterns.

To support our hypothesis that the pulse oximeter may have been providing inaccurate information for the RUL, arterial blood gas analyses were performed on both the RUL and the LUL. The results revealed an SpO2 more than 4% higher in the RUL compared to the LUL, with a PaO2 of 152 mmHg in the RUL and 81 mmHg in the LUL.

Discussion

Oximetry measures hemoglobin oxygen saturation (SaO2). Pulse oximetry integrates the principles of oximetry and plethysmography, applying the Beer-Lambert law, which relates solute concentration in a solution to light transmission [2]:

$I_{TRANS} = I_{in}. e^{-DC\varepsilon}$

Where:

Itrans is the intensity of transmitted light (W/m^2).

I_{in} is the intensity of the incident light (W/m^2).

e is the base of the natural logarithm (dimensionless).

D is the distance the light is transmitted through the solution (m).

C is the concentration of the solute (Hb concentration) (mol/L).

ε is the extinction coefficient of the solute (L/(mol·m)).

Adult blood contains five different types of hemoglobin: sulfhemoglobin (SHb), methemoglobin (MetHb), carboxyhemoglobin (COHb), oxygenated hemoglobin (O2Hb), and deoxygenated hemoglobin (deO2Hb). Under typical conditions, the levels of COHb, MetHb, and SHb are low (less than 1% for MetHb and SHb, and 1%–3% for COHb). The quantity of O2Hb as a percentage of the total amount of O2Hb and deO2Hb is known as functional O2 saturation (SaO2) and is expressed as

Functional $S_aO_2 = [O_2Hb] / [O_2Hb] + [deO_2Hb] \times 100$

Utilizing the pulsatility of arterial blood flow, pulse oximetry distinguishes between light absorption by arterial blood and light absorption by other components to generate an estimate of SaO2 [2].

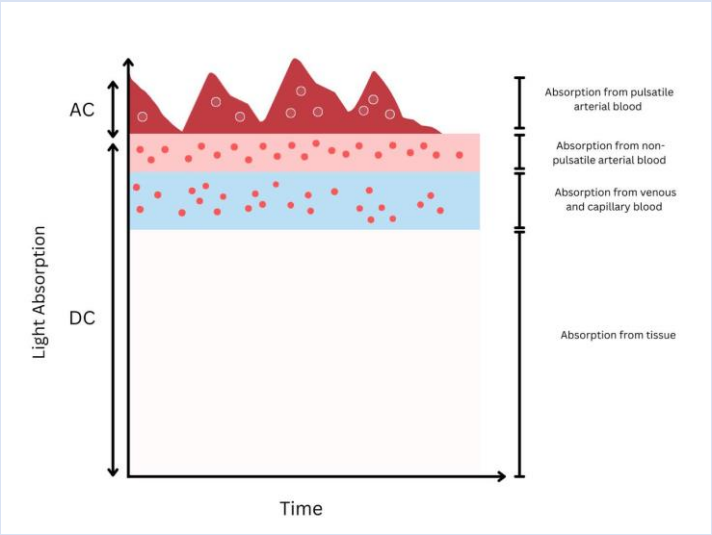

Figure 4: Schematic representation of the pulse oximetry principle.

Light absorption through tissue is divided into two components: pulsatile (AC) and nonpulsatile (DC). The pulsatile component reflects arterial blood, while the nonpulsatile component corresponds to venous blood and surrounding tissues. This diagram illustrates the pulse principle. (Adapted from kaczka *et al.* Respiratory monitoring, Miller 2025 10 ed.). Two of the most used light wavelengths are 660 and 940 nm. At 660 nm, deO2Hb absorbs lighter than O2Hb, and at 940 nm, O2Hb absorbs lighter than deO2Hb.

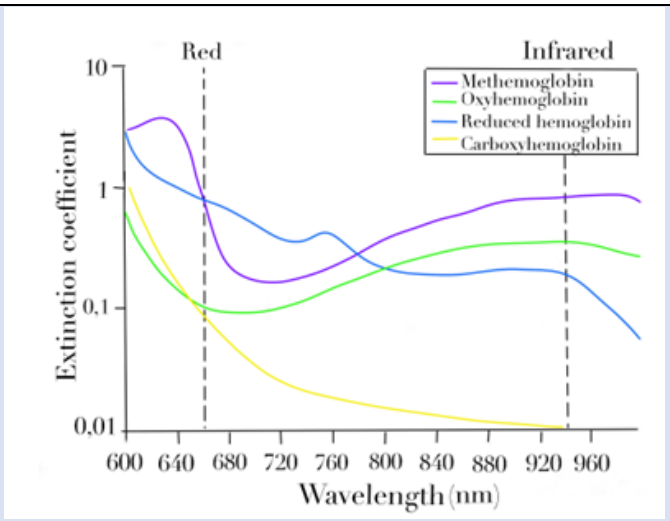

Figure 5: Extinction coefficients of hemoglobin species extending into the infrared spectrum, relevant for pulse oximetry.

The vertical lines indicate the specific red (660 nm) and infrared (940 nm) wavelengths utilized by pulse oximeters. At these wavelengths, distinct differences in the extinction coefficients of oxyhemoglobin and deoxygenated hemoglobin are evident. (Adapted from kaczka *et al.* Respiratory monitoring, Miller 2025 10 ed.). A photodetector and a light emitter compose a pulse oximeter probe. The emitter and detector are positioned on opposing sides of the tissue being measured, regularly a finger, in transmission pulse oximetry. The two wavelengths of light are emitted by two light-emitting diodes (LEDs) in a conventional pulse oximeter. Every LED is sequentially switched on and off when in use. Each LED's light transmittance is measured by the photodetector. The photodetector detects ambient light when both LEDs are out and deducts it from the signals it receives for the rest of the cycle [1]. A pulse oximeter probe consists of a photodetector and a light emitter positioned on opposite sides of the tissue being measured, typically a finger in transmission pulse oximetry. Two light-emitting diodes (LEDs) emit the light at the wavelengths. The LEDs alternate their emission, and the photodetector measures the transmitted light. Ambient light is accounted for by measuring it when both LEDs are off, subtracting this from the final signal [1].

Limitations and Sources of Error

The hemoglobin dissociation curve varies significantly in vivo, meaning that SpO2 (estimated saturation) and SaO2 (arterial saturation) do not always correlate precisely. Accurate interpretation of SaO2 and PaO2 (arterial oxygen pressure) depends on understanding the individual Hb dissociation curve. Additionally, pulse oximetry does not provide information on ventilation or acid-base status [2]. Pulse oximeters are calibrated using data from healthy individuals with SaO2 values as low as 70%. Consequently, their accuracy diminishes at SaO2 levels below this threshold [2]. Hypoperfusion reduces the amplitude of the pulsatile signal, often leading to absent or inaccurate readings. For example, systolic blood pressure below 80 mmHg can cause substantial SpO2 underestimations. This likely occurred during our patient's monitoring, where hypoperfusion in the right upper limb, secondary to severe aortic hypoplasia, led to underestimated oximetry readings [1].

Table 1: Common Sources of Pulse Oximetry Artifacts and Effects on SpO2 Measurements. Adapted from kaczka et al. Respiratory monitoring, Miller 2025 10 ed.

Source of Error	Effect on SpO2 Relative to SaO2
Hypotension	Decreases
Anemia	Decreases
Polycythemia	No significant effect
Motion	Decreases
Methemoglobinemia	Decreases /increases (SpO2 approaches 85%)
Carboxyhemoglobinemia	Increases
Cyanmethemoglobin	No significant effect
Sulfhemoglobin	No significant effect
Hemoglobin F	No significant effect
Hemoglobin S	No significant effect
Methylene blue	Decreases
Isosulfan blue	No significant effect/ decreases
Fluorescein	No significant effect
Nail polish	Black, dark blue, purple decreases
Acrylic fingernails	No significant effect
Skin pigmentation	At SaO2 >80%, no significant effect At SaO2 <80%, increases
Ambient light	No significant effect
Sensor contact	Decreases
IABP	Increases

Conclusion

Regarding the case under discussion, macro and microhemodynamic analyses, as well as transcranial Doppler examination, suggested adequate systemic perfusion and balanced hemodynamics. This left us with no more likely hypothesis than monitor inaccuracy to explain why the oximetry showed the opposite pattern of limb oxygenation measurements than expected. Given the aortic hypoplasia and coarctation restricting left-sided cardiac output, and considering the presence of both a patent foramen ovale and ductus arteriosus in the newborn, we hypothesize that the main cardiac output was diverted from the aortic arch through the right cardiac chambers, ultimately led by the ductus arteriosus to the systemic circulation. This physiology could explain our findings, as the right upper limb would be perfused, but at a lower pressure, which would consequently generate a lower quality plethysmography compared to the lower limbs or even the left upper limb. As previously demonstrated, plethysmography is crucial for the device's accuracy in differentiating arterial oxygen saturation from surrounding tissue oxygen saturation. Additionally, the inherently low arterial pressure values in newborns increase the likelihood that even a slightly reduced cardiac output could impair the measured arterial oximetry due to its effects on the plethysmographic curve. This hypothesis was corroborated by blood gas analysis and pressure measurements on both sides. It is important to note that the scarcity of literature regarding this specific finding significantly hindered the understanding of the patient's presentation, particularly in explaining why the differential oxygen saturation presented

inversely to what was expected. This led to erroneous conclusions by the team during care in the pediatric ICU. In our assessment, this provides sufficient justification for publishing this article and opening this appraisal to public scrutiny.

Declarations

Declaration of interest

The authors declare no conflicts of interest.

Acknowledgments

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None

References

1. Bagatini Airton, Cangiani Luiz Marciano, Carneiro Antônio Fernando, Nunes RR. (2016). Bases do Ensino da Anestesiologia, 131-160.
2. GROPPER MA, Michael A. Gropper, Lars I. Eriksson, Lee A. Fleisher, Neal H. Cohen, Kate Leslie OJ-A, et al. (2024). Miller's anesthesia. 10. ed., editor, 5546-5468.
3. Polito A, Ricci Z, Di Chiara L, Giorni C, Iacoella C, Sanders SP, et al. (2006). Cerebral blood flow during cardiopulmonary bypass in pediatric cardiac surgery: The role of transcranial Doppler - A systematic review of the literature. *Cardiovasc Ultrasound*, 4:1-11.
4. F. S. Ferreira, A. C. F. de Oliveira, M. A. Delgado, L. F. A. P. de Oliveira. (2023). Point of care transcranial doppler guiding the efficiency of selective cerebral perfusion during extracorporeal circulation for surgical repair of aortic arch hypoplasia with ligation of patent ductus arteriosus and pulmonary artery banding. *Int J Anesthesiol Pract*, 2(1):1-5.

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