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Falsely Normal Saturation Reading with the Pulse Oximeter

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Several studies have documented excellent correlation between pulse oximetry and simultaneous direct arterial samples for determining oxygen saturation.[1–3] This reliable non-invasive monitor has been known to be helpful in rapid detection of intraoperative and postoperative hypoxemia.[4–6] Despite its value, there are several well-known limitations to pulse oximetry.[7] We wish to report a case in which a pulse oximeter reading of 100% persisted in spite of clinical cyanosis and extubation of the trachea.

REPORT OF A CASE

The patient was a 6-day-old, 2.6-kg boy with choanal atresia brought to the operating room for direct examination and surgical treatment of this disorder. He was the product of a full-term, uncomplicated pregnancy and delivery, to a 35-yr-old, gravida 3, para I mother. The Apgar scores were 8 (at 1 min) and 9 (at 5 min). At 6 h of age, the infant was noted to have respiratory distress, and the diagnosis of choanal atresia was made when feeding catheters could not be passed through either nares. Other causes of neonatal respiratory distress were ruled out. A patent airway was maintained with the use of a McGovern nipple (a plastic nipple with a large hole cut in it).

On arrival in the operating room, the patient appeared comfortable in room air, with mild respiratory retractions. Arterial blood gases and oxygen saturation determined during the preoperative evaluation were normal. The rest of his physical examination was unremarkable, as were complete blood count, urinalysis, serum bilirubin, and a chest radiograph.

Induction of anesthesia was accomplished by allowing the child to spontaneously inhale halothane and nitrous oxide in oxygen. Pancuronium 0.3 mg was given iv, and a 3.0 mm I.D. oral RAE performed tracheal tube was inserted into the trachea. Following taping on the tracheal tube to the skin over the mandible, breath sounds were noted to be equal to auscultation bilaterally.

Monitors included a precordial stethoscope, electrocardiogram, automatic blood pressure cuff, temperature probe, and a pulse oximeter.§

The infant was positioned for surgery on a shoulder role with the head in extension and, shortly after, was noted to be cyanotic. Although the pulse oximeter§ indicated a pulse of 180 and a saturation of 100%, persistent cyanosis of the lips, tongue, and skin, and the decreased compliance of the bag with hand ventilation, suggested displacement of the tracheal tube. Accidental extubation of the trachea was confirmed by direct laryngoscopy, and the patient was reintubated without difficulty. Surgery proceeded without further incident. The immediate postoperative course, and a re-examination at 24 h, did not suggest any problems associated with the brief period of cyanosis.

During the surgery, it was recognized that, when the surgical light¶ illuminated the pulse oximeter sensor (Nellcor D-20 digit oxisensor), the display on the pulse oximeter would indicate 100% saturation and

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§ Nellcor Pulse Oximeter Model N-100c, Hayward, California (945454), with Nellcor D-20 digit oxisensor.

¶ Narco-Pilling *Source*, Narco Scientific, Fort Washington, Pennsylvania 19034.

a heart rate that varied between 180–255 bpm. This occurred even though the patient's foot and attached sensor were covered with a thin brown plastic bag. We have concluded that, when the patient was placed in position for surgery, the oxisensor was illuminated directly by the surgical light, resulting in a falsely elevated saturation, despite the presence of obvious cyanosis.

DISCUSSION

It was alarming to witness a high oxygen saturation reading in a patient who exhibited obvious clinical cyanosis. The reason for the falsely normal saturation reading has been confirmed to our satisfaction, because we have been able to produce similar artifactual readings using the same surgical light and many of the other sensors (Nellcor D-20, N-25, and I-20). This surgical light is present in only one of our ten operating rooms, and we have not elicited this type of interference with any of the other lights.

The Narco-Pilling surgical light that was associated with this problem is a xenon arc lamp. Similar to a strobe light, the arc lamp illuminates with rapidly repeated flashes. These flashes result when 7 kilowatt sparks, a product of several discharging capacitors, excite the xenon gas. The resulting light, although seemingly of constant intensity to the human eye, actually contains sharp-edged irregular modulations.

The Nellcor pulse oximeter measures hemoglobin oxygen saturation spectrophotometrically. Red and infrared light from two light emitting diodes (LEDs) is passed through a vascular bed to a photodetector. Although tissue and non-pulsatile venous blood will absorb most of the LED light, a phasic change in absorption occurs as the blood volume in the light path increases with the arterial pulse. These phasic changes in light absorption will not occur when the pulse is absent or decreased, rendering the oximeter incapable of determining arterial saturation.

Ambient light can interfere with accurate function of the pulse oximeter and, for this reason, the manufacturer suggests shielding of the probe. The oximeter also contains a design feature to minimize ambient light interference. By turning the LEDs on and off rapidly, the photodetector will receive both LED light and any ambient light when the LED is "on," but only ambient light will be detected when the LED is "off." Therefore, electronic subtraction of the "off" signal from the "on" signal will allow elimination of interference from an unvarying ambient light source. Nevertheless, a strong ambient light source can overpower the phasic changes that occur with arterial pulsation, resulting in the activation of the no-pulse alarm and low or absent saturation readings.

The unique situation that we experienced with our patient was the presence of a strong source of ambient light that had pulsatile quality. High frequency harmonics are produced when the sharp edged modulations of light from the Narco-Pilling lamp interact with the high frequency turning on and off of the LEDs. This is analogous to a motion picture of a television screen. The combination of the movement of the television electron gun across the picture screen with the changing frame of the film interacts, so that, if one views such a film, it appears as if shadows move across the television screen. In a similar way, in our patient, the net light incident to the photodetector had a pseudo-pulsatile quality to it.

We were aware that ambient sources of light and infrared irradiation might interfere with proper function of the pulse oximeter from a previous report,[8] information provided by the manufacturer and our own experience. A recent review of the limitations and disadvantages of pulse oximetry, however, did not include ambient irradiation as a source of potential problems.[7] The previous report and the common clinical experience with this type of interference has suggested that it will result in blank digital display with flashing of the pulse search alarm or, at worst, falsely low readings.[1] A falsely elevated saturation reading was unexpected.

The incident described is an important example of the pulse oximeter giving a falsely high reading. Although this resulted from a unique combination of circumstances, it is doubtful that such an event is unique to the products mentioned in our report. Adverse effects of hypoxia were avoided in this patient because the cyanosis was directly observed in the undraped infant. The importance of direct patient observation and redundancy of surveilance techniques in the anesthetized patient is again emphasized.

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